



EACTA 2004 Abstracts

**The 19th Annual Meeting of the
European Association of Cardiothoracic Anaesthesiologists**

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The investigators of these abstracts have stated in their submission letter that prospective studies where patients are involved have institutional or Ethics Committee approval and informed patient consent, and that the studies using experimental animals have institutional approval.

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Contents

Haemodynamics

| | | |
|-----|---|---|
| 113 | Assessing volume responsiveness during open chest conditions in cardiac surgery patients <i>D.A. Reuter, T. Goresch, M.S.G. Goepfert, M. Schmoekkel, E. Kilger, A.E. Goetz</i> | 2 |
| 108 | Prediction of fluid responsiveness in patients after cardiac surgery and ventilated with low tidal volumes <i>S. Rex, S. Brose, S. Metzelder, G. Schaelte, R. Huenecke, R. Rossaint, W. Buhre</i> | 2 |
| 012 | Plasma and interstitial concentrations of vancomycin in diabetic vs. non-diabetic patients <i>K. Skhirtladze, D. Hutschala, B.X. Mayer-Helm, E. Tschernko</i> | 2 |
| 112 | The effects of levosimendan in cardiac surgery patients <i>C. Romana, J. Kokotsakis, M. Argyriou, C. Soutzopoulou, P. Stratigopoulou, E. Karamichali</i> | 3 |
| 084 | Inhaled iloprost in the management of pulmonary hypertension in infants undergoing congenital heart surgery <i>M. Mueller, C. Neuhaeuser, R. Noest, H. Akintuerk, I. Welters, G. Hempelmann</i> | 3 |
| 036 | Incentive spirometry for preoperative preparation of cardiac patients <i>A.E. Balandiuk, I.A. Kozlov</i> | 3 |
| 111 | Pulmonary thrombo-endarterectomy improves diastolic relaxation in the immediate postoperative patient <i>P.A. White, S. Kadiman, A. Vuylsteke, R.D. Latimer, J.J. Dunning, S.R. Large</i> | 4 |
| 119 | Description of the instantaneous pressure-flow relationship and critical occlusion pressure in arterial coronary bypass grafts <i>S. Kazmaier, G. Hanekop, K. Götze, D. Kettler, H. Sonntag, A. Weyland</i> | 4 |
| 082 | Effect of isoflurane on diastolic function in patients with concentric left ventricular hypertrophy: an echocardiographic study <i>C. Neuhaeuser, M. Mueller, M. Kwapisz, S. Scholz, G. Hempelmann</i> | 4 |
| 102 | Left ventricular diastolic function during negative pressure ventilation <i>A. Danella, R. Baldassarri, R. Gemignani, F. Guarracino</i> | 5 |
| 064 | Beating heart surgery with assistance of simplified bypass systems: effects on haemodynamics and pulmonary gas exchange <i>S. Rex, S. Brose, S. Metzelder, G. Schaelte, R. Autschbach, R. Rossaint, W. Buhre</i> | 5 |
| 008 | Aprotinin and the haemodynamic response to SIRS in patients undergoing on-pump CABG <i>S.E. Naumenko, K.S. Naumenko, M.G. Pokrovsky, S.F. Kim</i> | 5 |

Renal/Inflammation/Protection

| | | |
|-----|--|---|
| 043 | The effects of N-acetylcysteine on renal function during and after cardiac surgery. A pilot study <i>A. Ristikankare, A. Kuitunen, M. Salmenperä, R. Suojaranta-Ylinen, R. Pöyhä</i> | 6 |
| 066 | Methylprednisolone increases urinary nitrate/creatinine ratios in porcine infrarenal aortic ischaemia reperfusion <i>R.C. Baker, M.A. Armstrong, S.J. Allen, A.A.B. Barros D'Sa, W.T. McBride</i> | 6 |
| 105 | Preoperative ACE inhibition and renal dysfunction following cardiac surgery <i>S.P. Penugonda, N. Khalil, M.A. Armstrong, H. Gilliland, T.J. McMurray, W.T. McBride</i> | 7 |
| 100 | ACE inhibitors enalaprilat and quinaprilat inhibit monocyte surface receptor expression <i>I.D. Welters, C. Reyher, G. Hafer, G. Hempelmann, A. Menzebach, M. Müller, M.C. Heidt</i> | 7 |
| 094 | N-acetylcysteine decreases myocardial ischaemia-reperfusion injury in CABG patients <i>N. Yapici, T. Çoruh, G. Orhan, M. Sargin, M. Yüksel, H. Maçika, E. Kurç, O. Yücel, S.A. Aka, Z. Aykaç</i> | 7 |
| 071 | The efficiency of diltiazem on myocardial protection in off-pump coronary artery bypass grafting surgery <i>T. Alev, S. Goren, E.B. Mogol, G. Korfali</i> | 8 |
| 076 | Comparison of myocardial protective effects of TIVA, sevoflurane and isoflurane in CABG surgery <i>S. Koruk, A. Ozgok, Ö. Erdemli, D. Ozturk, G. Tuncer, O. Tufekcioglu, E. Sener</i> | 8 |

Coagulation

| | | |
|-----|---|----|
| 009 | A pilot double blind randomized placebo controlled trial of the use of recombinant factor VIIa (rfVIIa) in high transfusion risk cardiac surgery <i>P. Diprose, M. Herbertson, D. O'Shaughnessy, R. Gill</i> | 9 |
| 078 | Pre and postoperative iron status in patients presenting for cardiac surgery <i>M. Steven, I. Quasim, R. Soutar, L. Anderson</i> | 9 |
| 114 | Effects of diclofenac on platelet function and bleeding after cardiac surgery <i>M. Kamenik, I. Osojnik, D. Mekiš</i> | 9 |
| 032 | Determinant of antithrombin consumption in cardiac operations requiring cardiopulmonary bypass <i>M. Ranucci, G. Isgrò, A. Cazzaniga, G. Soro, D. De Benedetti, A. Pazzaglia</i> | 10 |
| 088 | Clopidogrel and perioperative transfusion requirements in cardio-pulmonary bypass surgery <i>R. Whitty, D. Harney, M.O. Connell, V. Young, E. McGovern, M. Tolan, F. Lyons, N. Dowd</i> | 10 |
| 090 | The impact of intra-operative red cell salvage on allogeneic blood requirements following cardiac surgery <i>D. Spackman, A. Powroznyk, C. Naughton, J. Vroemen, A. Morley, R.O. Feneck</i> | 10 |
| 075 | Ultra low dose aprotinin decreases blood loss and transfusion requirements in high risk two valve replacement surgery <i>K. Muralidhar, B.R. Harish, B. Sanjay, G. Rajnish, K. Murthy, S. Dhaded, C. John, K. Praveen, D.P. Shetty</i> | 11 |

Monitoring

| | | |
|-----|---|----|
| 027 | Early recognition of low cardiac output after cardiac surgery by using the arterial pressure waveform analysis <i>S. Scolletta, P. Giomarelli, B. Biagioli, S. Mario Romano</i> | 11 |
| 123 | Accuracy of arterial (or transthoracic) thermodilution cardiac output during aortic counterpulsation <i>W. Baulig, P. Schütt, O. Gödie, E.R. Schmid</i> | 11 |
| 055 | Which is the optimal device for carbon dioxide de-airing of the cardiothoracic wound and how should it be positioned? <i>J. van der Linden, M. Persson, P. Svenarud</i> | 12 |
| 039 | Evaluation of a new probe for continuous intravascular blood gas monitoring in jugular venous and arterial blood <i>A.C. Papadopoulos, M. Reizoglou, D. Kiskinis, V. Grossomanides, K. Karakoulas, D. Vassilakos, M.M. Giala</i> | 12 |
| 117 | Angle dependency in the ultrasound modality displacement evaluated in a dynamic test phantom <i>T.F. Pedersen, B. Jensen, K. Norrild, E. Sloth</i> | 12 |

Predictions and Outcome

| | | |
|-----|--|----|
| 033 | Does preoperative activity of the autonomic nervous system predict hypertension during CABG? <i>B. Akselrod, G. Babalian, A. Bunatian</i> | 13 |
| 062 | Evaluation of risk factors to predict haematocrit decrease in CPB <i>A. Flo, E. Massó, C. Cubells, E. Moret, V. Sanchez, M. Rodés, M.A. Castro, X. Ruyra, J. Canet</i> | 13 |
| 098 | Even low levels of preoperative troponin I predict postoperative myocardial ischaemia and cardiac complications in vascular surgery <i>P. Gaudard, F. Ryckwaert, P. Colson</i> | 14 |
| 028 | Estimation of morbidity risk factors in intensive care unit: a Bayesian discriminant approach <i>S. Scolletta, P. Giomarelli, G. Cevenini, B. Biagioli</i> | 14 |
| 089 | The impact of age on outcome of adult cardiac surgery patients <i>C. Naughton, J. Roxburgh, R.O. Feneck</i> | 14 |
| 017 | Long term outcome of patients who require renal replacement therapy after cardiac surgery <i>G. Landoni, G. Fracasso, M. Putzu, E. Dorigo, T. Bove, M.G. Calabrò, G. Marino, A. Zangrillo</i> | 15 |
| 070 | Is measuring cerebral oxygenation during off-pump cardiac surgery associated with ICU and hospital length of stay? <i>D. Szurlej, A. Węglarzy, W. Kruczak, L. Machej, J. Fryc-Stanek, M. Rudnicki</i> | 15 |

Pain and Epidural

| | | |
|-----|---|----|
| 011 | Failure rate and rate of minor complications of high thoracic epidural anaesthesia (HTEA) for cardiac surgery <i>L. Salvi, E. Sisillo, C. Beverini, F. Biolcati, M. Marino</i> | 15 |
| 087 | High thoracic epidural anaesthesia (HTEA) for cardiac surgery in patients with respiratory disease <i>S. de Paulis, M. Calabrese, L. Martinelli, R. Zamparelli, G. Arlotta, A. Cimino, R. Schiavello</i> | 16 |
| 025 | Reduction of pulmonary function after resection: less than expected in COPD patients <i>M.J. Jiménez, J.M. Gimferrer, G. Fita, I. Rovira, C. Gomar, N. de Riva, J. Fernandez, J.A. Barberá</i> | 16 |
| 073 | Tissue Doppler evaluation of myocardial function during high thoracic epidural analgesia <i>K. Norrild, H. Kirkegaard, E. Sloth</i> | 16 |
| 092 | The effect of magnesium sulphate on postoperative pain scores and requirement of analgesia following CABG <i>O. Yılmaz, N. Yapıcı, T. Çoruh, C. Yılmaz, H. Maçika, Z. Aykaç</i> | 17 |
| 124 | Tramadol hydrochloride for treatment of shivering after cardiac surgery <i>N. Trekova, A. Bunatian, A. Javorovsky</i> | 17 |
| 016 | Treatment of hyperhidrosis by transthoracic endoscopic sympathectomy <i>C. Gomar, C. Roux, M.J. Jiménez, M.A. Callejas, G. Fita, I. Rovira, P. Matute</i> | 17 |

Aspects of Cardiothoracic Anaesthesia

| | | |
|-----|---|----|
| 120 | Does cardiopulmonary bypass modify the anaesthetic state? <i>D.C. Smith, R.S. Pettit-Mills</i> | 18 |
| 029 | The use of near infrared spectroscopy (NIRS) in combined vascular and cardiac surgery <i>M. Portolan, C. Avallato, N. Barzaghi, M. Bertora, C. Frangioni, A. Gualco, F. Lemut, S. Neri, A. Locatelli</i> | 18 |
| 020 | Comparison of bispectral index during normothermic and hypothermic cardiopulmonary bypass <i>S.-H. Han, B.-M. Ham, Y.-R. Kim, C.-S. Kim, J.-H. Bahk, Y.-S. Oh, J.-L. Lee</i> | 19 |
| 048 | Phosphorylcholine coating preserves coagulation during cardiac surgery – a combined TEG and PFA-100 analysis <i>C. Corno, F. Pappalardo, A. Franco, G. Crescenzi, G. Piazza, G. Fracasso, A. Zangrillo</i> | 19 |
| 046 | Comparison of different forms of ondansetron for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia <i>A. Yavorovskiy, N. Trekova, T. Zjulyaeva, Z. Pavlova, A. Bunatian</i> | 19 |

| | | |
|-----|---|----|
| 096 | Depression and anxiety after cardiac surgery: second year follow up <i>A. Székely, E. Benkó, J. Till, R. Mészáros</i> | 20 |
| 095 | Levels of natriuretic peptides during paediatric open heart surgery <i>A. Székely, L. Seres, E. Székely, E. Sági, M. Toth, T. Breuer, L. Király, A. Szatmári</i> | 20 |
| 125 | Inaccuracy of cardiac output determination by transoesophageal echocardiography <i>D.A. Bettex, V. Hinsemann, J.P. Hellermann, R. Jenni, E.R. Schmid</i> | 20 |

Fast-Track/Off Pump/Prediction/Outcome

| | | |
|-----|--|----|
| 010 | Hydroxyethyl starch (HES) 130/0.4 reduces blood loss in off-pump coronary surgery <i>C. Meyer, M. Durand, O. Chavanon, Y. Tessier, M. Lefevre, D. Blin, P. Girardet</i> | 21 |
| 041 | Benefits of off-pump coronary artery bypass grafting (OPCABG) <i>C.K. Hofer, R. Tavakoli, M. Maloigne, M. Turina, A. Zollinger, M. Genoni</i> | 21 |
| 044 | Is off-pump coronary artery bypass grafting (OPCABG) more cost-effective than the on-pump procedure? <i>C.K. Hofer, R. Tavakoli, M. Maloigne, M. Turina, A. Zollinger, M. Genoni</i> | 22 |
| 072 | Alfentanil-based general anaesthesia for early extubation after valve surgery <i>T. Vanek, Z. Straka, P. Brucek, M. Jares, J. Votava</i> | 22 |
| 037 | Efficiency of early extubation in geriatric cardiosurgical patients <i>T.V. Klypa, I.A. Kozlov</i> | 22 |
| 026 | Evaluation of early extubation (fast-track) after cardiac surgery in a post-anaesthesia recovery unit <i>P. Matute, G. Fita, I. Rovira, C. Gomar, N. Peix, M. Basora, J. Fontanals, C. Roux, X. Sala</i> | 23 |
| 079 | Re-admission and mortality rate after a fast-track recovery protocol in off-pump coronary artery bypass surgery patients <i>M.A. Celkan, H. Kazaz, H. Ustunsoy, B. Daglar, H. Kocoglu</i> | 23 |
| 060 | The effects of remifentanil and fentanyl on postoperative pain and recovery in fast-track open heart surgery <i>S. Turan, Ü. Karadeniz, Ö.B. Soyak, Ö. Erdemli</i> | 23 |
| 049 | Effects of remifentanil and fentanyl on haemodynamics and cognitive functions in patients undergoing open-heart surgery <i>M. Koç, D. Karakaya, F. Güldoğan, E.B. Şener, S. Kocamanoglu, A. Tür</i> | 24 |
| 019 | Atrial fibrillation after beating heart CABG surgery <i>D. Sparicio, M. Crivellari, G. Aletti, G. Fracasso, C. Redaelli, M. Putzu, A. Zangrillo</i> | 24 |
| 059 | Problem-solving in cardiac surgery: empiricism vs. algorithm in the management of microvascular bleeding (MVB) <i>G. Finamore, M. Ferrante, E. Conti, V. Pede, R. Martinez, R. LaMonica, G. Rodella, B. Amari</i> | 24 |
| 045 | Prediction of mortality and prolonged intensive care unit stay after off-pump coronary artery bypass grafting <i>C.K. Hofer, L. Furrer, P. Rhombert, A. Zollinger, M. Genoni</i> | 25 |
| 005 | Prognostic value of low cardiac index early after cardiac surgery <i>M.C. Berthet, M. Gardellin, C. Meyer, M. Durand, D. Blin, P. Girardet</i> | 25 |
| 083 | Characteristics and outcome of admissions to general intensive care units following cardiac surgery <i>S.M. Walther, D.A. Harrison, A.R. Brady, K. Rowan</i> | 25 |
| 013 | Long term follow up of patients with short and long postoperative ICU stay after cardiac surgery <i>G.B. Villa, M. Mazzoni, R. De Maria, M. Parolini, R. Ceriani, C. Solinas, V. Arena, F. Bortone, O. Parodi</i> | 26 |

Brain/Metabolism

| | | |
|-----|--|----|
| 023 | Neuronal injury after ICD-implantation is associated with a deterioration of cognitive function after surgery <i>M. Weigl, G. Tenze, M. Bernardo, K. Skhirtladze, G. Reining, J. Kastner, M. Grimm, M. Dworschak</i> | 26 |
| 077 | Neurological outcome after coronary artery bypass grafting: sevoflurane versus total intravenous anaesthesia <i>B. Yamak, Ü. Karadeniz, Ö. Erdemli, I. Ayik, N. Pursuk, A.E. Demirbag</i> | 26 |
| 003 | The effects of normovolaemic haemodilution on degree of lymphocyte apoptosis during CABG <i>W. Dąbrowski, A. Korycińska, J. Bierunacka, M. Dragan, P. Pożarowski, J. Roliński, A. Nestorowicz</i> | 26 |
| 006 | Brain glucose and lactate gradient versus pressure gradient across the internal jugular valve during ECC <i>W. Dąbrowski, Z. Rzecki, J. Biernacka, J. Gąsowska, C. Jurko, M. Czajkowski, A. Nestorowicz</i> | 27 |
| 014 | Diabetes is an independent predictor of hospital mortality in patients with prolonged mechanical ventilation after cardiac surgery <i>L. Mantovani, F. Pappalardo, A. Franco, C. Gerli, W. Castracane, A. Zangrillo</i> | 27 |
| 061 | Comparison of serum lipids and glucose levels during propofol or midazolam infusions for cardiac surgery in hyperlipidaemic patients <i>H. Acarturk, I. Oztekin, S.D. Oztekin, H. Issever, S. Canik</i> | 27 |
| 056 | Can wound desiccation be averted during cardiac surgery? An experimental study <i>J. van der Linden, M. Persson</i> | 28 |
| 034 | Gastric acid aspiration risk following cardiac surgery <i>N.B. Marshall, J.D. Griffin, M.J. Bennett</i> | 28 |
| 004 | In-vivo measurement of levofloxacin penetration into lung tissue after cardiac surgery <i>D. Hutschala, K. Skhirtladze, B.X. Mayer-Helm, M. Grabenwöger, R. Seitelberger, E. Tschernko</i> | 28 |
| 057 | Carbon dioxide inhibits the growth rate of <i>Staphylococcus aureus</i> at body temperature <i>J. van der Linden, M. Persson, P. Svenarud, J.I. Flock</i> | 29 |

Epidural/Echo/Coagulation

| | | |
|-----|--|----|
| 058 | Preoperative CT or intraoperative epi-aortic ultrasound for the diagnosis of atherosclerosis of the ascending aorta? a preliminary report <i>P. Bergman, J. van der Linden, K. Forsberg, M. Öhman</i> | 29 |
| 093 | Two year experience and clinical impact of echocardiography in the cardiothoracic intensive care unit <i>G. Wagner, M. Hansen, H. Seibert, A. Ursulescu, G. Klein</i> | 29 |
| 051 | Intraoperative transoesophageal echocardiography in a case of pulmonary arteriovenous malformation <i>F. Silva, S. Morais, M. Granate, J. Cruz, J. Caldeira</i> | 30 |
| 018 | Perioperative transoesophageal echocardiography and post-infarct ventricular septal defect <i>J.W. Ragheb, M. Griffin</i> | 30 |
| 054 | Contractile function of the heart after cardioplegia is not determined by the extent of myocardial necrosis and lactate release <i>I. Karu, R. Loit, A. Paapstel, J. Starkopf</i> | 30 |
| 063 | An audit of central venous cannulation in Papworth Hospital from March to May 2003 <i>C.S. Moore, J. Graham, J. Cobain, S. Gray</i> | 31 |
| 074 | Modified distal carotid artery perfusion for combined carotid endarterectomy and off pump coronary artery bypass surgery <i>K. Muralidhar, B. Sanjay, G. Rajnish, K. Murthy, S. Ravindra, P.V. Rao, K. Praveen, D.P. Shetty</i> | 31 |
| 104 | Therapeutic coronary intervention after primary coronary angiography, TROMSØ 2000 <i>G. Bjørsvik, E. Arnesen</i> | 32 |
| 080 | Epidural infusion of ropivacaine or bupivacaine during major thoracic surgery <i>H. Misiołek, H. Kucia, J. Karpe, D. Budziński, M. Werszner, P. Knapik</i> | 32 |
| 030 | Inhaled nitric oxide for hypoxia treatment after open heart surgery <i>R. Mojasevic, Lj. Petrovic, N. Radovanovic</i> | 32 |
| 091 | Iloprost: a positive inotropic effect in isolated myocardium? <i>S. Müller-Späth, S. Schroth, S. Rex, T. Busch, R. Rossaint, W. Buhre</i> | 33 |
| 022 | Inhaled iloprost for testing vasodilator capacity in secondary pulmonary hypertension in children with congenital heart disease <i>I. Raileanu, D. Filipescu, M. Luchian, O. Ghenu, M. Cristea, S. Marin, I. Gheorghiu, P. Platon, S. Bradisteanu, D. Tulbure</i> | 33 |
| 002 | Aprotinin reduces bleeding after off-pump coronary artery bypass surgery <i>C. Meyer, M. Durand, O. Chavanon, M. Lefevre, M.C. Berthet, P. Girardet, D. Blin</i> | 33 |
| 050 | Recombinant activated factor VII in cardiac surgery: experience in 7 cases <i>T. Vanek, Z. Straka, P. Brucek, M. Jares, J. Hrabak</i> | 34 |
| 035 | Thromboelastography, PFA100 and whole-blood aggregometry in patients undergoing a thoracic aortic operation with deep hypothermic circulatory arrest <i>D. Szczurek, Ch. Diehl, L. Stolarski, A. Dongas, W. Prohaska, K. Inoue</i> | 34 |
| 038 | Heparin-induced thrombocytopenia after treatment with enoxaparin immediately after heart surgery: Case report <i>I. Husedzinovic, N. Nikic, N. Bradic, D. Tonkovic, S. Barisin</i> | 34 |
| 001 | Autologous blood donation in cardiac surgery: a cost-effective method to reduce allogeneic blood requirements <i>W. Dietrich, K. Thuermel</i> | 35 |
| 127 | Aortic valve surgery during pregnancy: a series of 5 patients <i>P. Prabhu, M. Jahangiri, J. Clarke</i> | 35 |
| 126 | Transmitral occluder device embolization during transcatheter closure of an atrial septal defect: role of transoesophageal echocardiography <i>M. Botero, D. Berson, J. Thomas</i> | 35 |
| 211 | Inhaled iloprost for pulmonary hypertension during cardiac surgery <i>D. Filipescu, I. Raileanu, M. Luchian, O. Ghenu, M. Cristea, S. Marin, V. Iliescu, A. Cornea, S. Bradisteanu, D. Tulbure</i> | 36 |

Subject Index 37

Author Index 42

Editorial

The abstract supplement to EACTA 2004 has a different appearance this year, and for a very good reason. The supplement represents the first issue of the European Journal of Anaesthesiology supplement in cardiothoracic anaesthesia, and this in turn signifies an even closer relationship between the *European Journal of Anaesthesiology* (EJA) and the European Association of Cardiothoracic Anaesthesiologists.

Initially, we intend to produce four issues of the supplement each. One issue will continue to contain the peer-reviewed abstracts of the EACTA annual scientific meeting. These abstracts will also be published on the web at www.eja-online.org in the normal manner. In future years, we expect to have additional material in the abstract issue. The remaining three issues will contain scientific and educational material relevant to cardiothoracic anaesthesia, including peer-review articles, special articles and reviews, editorials and other regular features. We believe that by providing this supplement to EACTA members and others we are able to continue to develop our educational services in cardiothoracic anaesthesia, for the benefit of all concerned.

The supplement will have its own editorial board, but will also be subject to the editorial scrutiny of the EJA, thereby ensuring a seamless process of quality control and peer review, and ensuring that the supplement carries the same impact factor as the parent journal.

As with any journal, the editorial board of the supplement together with the publishers will be responsible for organising the content of each issue. The editorial board itself will be drawn from an international panel of distinguished specialists in cardiothoracic anaesthesia and related fields, and we expect to announce the editorial board members shortly.

This is an exciting new collaboration for EACTA and the EJA. We hope we can rely on your help and support. EACTA will do its best to ensure that the supplement becomes the premier forum for exchange of information in cardiothoracic anaesthesia in Europe.

*Dr Rob Feneck MB BS FESC FRCA
President, EACTA*

113

Assessing volume responsiveness during open chest conditions in cardiac surgery patients

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Introduction: Assessment of heart–lung interactions under positive pressure ventilation by measurement of left ventricular stroke volume variations (SVV) is useful to optimize preload in patients following cardiac surgery [1]. The aim of the present study was to investigate the ability of SVV measured by arterial pulse contour analysis to detect volume responsiveness in patients undergoing coronary artery bypass grafting under open thorax conditions.

Method: With approval of the ethics committee and written informed consent we studied 22 patients immediately following sternotomy. SVV, central venous pressure (CVP), left ventricular end-diastolic area index (LVEDAI) by transoesophageal echocardiography, global end-diastolic area index (GEDVI) and cardiac index (CI) by thermodilution were measured after removal of 500 mL blood and after subsequent volume substitution with 500 mL hydroxyethyl starch 6%. The saved blood was retransfused after termination of cardiopulmonary bypass. Isovolemic haemodilution is performed in our service routinely to minimize the need of autologous blood transfusions.

Results: All data are expressed as mean \pm SD. One way ANOVA for repeated measurements with Bonferroni adjustment and Pearson product moment correlations were performed. Blood removal led to a significant increase of SVV from $6.7 \pm 2.2\%$ to $12.7 \pm 3.8\%$. CI (from 2.9 ± 0.6 to $2.3 \pm 0.5 \text{ L min}^{-1} \text{ m}^{-2}$) and GEDVI (from 650 ± 98 to $565 \pm 98 \text{ mL m}^{-2}$) decreased (all $P < 0.025$). LVEDAI and CVP did not change significantly. After volume loading SVV decreased significantly to $6.8 \pm 2.2\%$. Concomitantly, CI (to $3.3 \pm 0.5 \text{ L min}^{-1} \text{ m}^{-2}$), GEDVI (to $663 \pm 104 \text{ mL m}^{-2}$), and CVP (to $3 \pm 4 \text{ mmHg}$) increased significantly (all $P < 0.025$), whereas the increase in LVEDAI (to $11.3 \pm 4.8 \text{ cm}^2 \text{ m}^{-2}$) was not significant. We found a significant correlation between the increase in CI caused by volume loading (Δ CI) and SVV before volume loading ($R = 0.80$; $P < 0.001$). Modest correlations were found between Δ CI and GEDVI ($R = -0.44$; $P < 0.05$) and LVEDAI ($R = -0.52$; $P < 0.05$) before volume loading, whereas no correlation was found for CVP.

Discussion: These findings demonstrate that changes in CI caused by volume loading can be predicted by measurement of SVV under open thorax conditions. Thus, assessing heart lung interactions may improve hemodynamic management during surgical procedures requiring thoracotomy.

Reference:

- 1 Reuter DA, Felbinger TW, Schmidt C, et al. Stroke volume variations for assessment of cardiac responsiveness to volume loading in mechanically ventilated patients after cardiac surgery. *Intensive Care Med* 2002; **28**: 392–398.

108

Prediction of fluid responsiveness in patients after cardiac surgery and ventilated with low tidal volumes

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Introduction: Left ventricular stroke volume variation (SVV) has been shown to be superior compared to static preload indicators in predicting fluid responsiveness [1]. However, the assessment of SVV depends on both cardiac filling status and changes in intrathoracic pressure associated with mechanical ventilation [1]. The reliability and validity of SVV has therefore been questioned in patients ventilated with low tidal volumes.

Method: 16 patients after coronary artery bypass grafting (CABG) participated in the study. Patients were mechanically ventilated in a pressure-controlled mode (tidal volume: $7.5 \pm 1.2 \text{ mL kg}^{-1}$). SVV was assessed by pulse contour analysis. Left ventricular end-diastolic area index (LVEDAI) was determined by transoesophageal echocardiography. The thermodilution technique was used for measurements of cardiac index (CI), stroke volume index (SVI) and intrathoracic blood volume index (ITBI). All parameters were assessed before and after volume challenge induced by tilting the patients from anti-Trendelenburg (30° head-up) to Trendelenburg position (30° head-down).

Results: After change to the Trendelenburg position, SVV decreased significantly, while CI, SVI, ITBI, LVEDAI, central venous pressure (CVP) and pulmonary artery occlusion pressure (PAOP) increased significantly. Changes in

SVI were significantly correlated to changes in SVV ($r = -0.60$; $P < 0.0005$) and to changes in LVEDAI ($r = 0.92$; $P < 0.0001$), ITBI ($r = 0.87$; $P < 0.0001$), CVP ($r = 0.71$; $P < 0.0001$) and PAOP ($r = 0.58$; $P < 0.001$). Linear regression analysis of the dynamic relationship between changes in SVI induced by volume challenge and baseline values of SVV, CI, ITBI, LVEDAI, CVP and PAOP showed that only baseline values of SVV correlated with concomitant changes in SVI ($r = 0.62$; $P < 0.005$).

Discussion: The results strengthen the importance of functional haemodynamic monitoring. Assessment of hypovolaemia in the anti-Trendelenburg position by static preload parameters (CVP, PAOP, ITBI, LVEDAI) were not indicative to predict the dynamic response to volume challenge. Only baseline values of SVV correlated with the increase of SVI after the induced change in cardiac preload. The dynamic preload indicator SVV proved to be a reliable parameter in cardiac surgical patients ventilated with low tidal volumes.

Reference:

- 1 Bendjelid K, Romand JA. Fluid responsiveness in mechanically ventilated patients: a review of indices used in intensive care. *Intensive Care Med* 2003; **29**: 352–360.

012

Plasma and interstitial concentrations of vancomycin in diabetic vs. non-diabetic patients

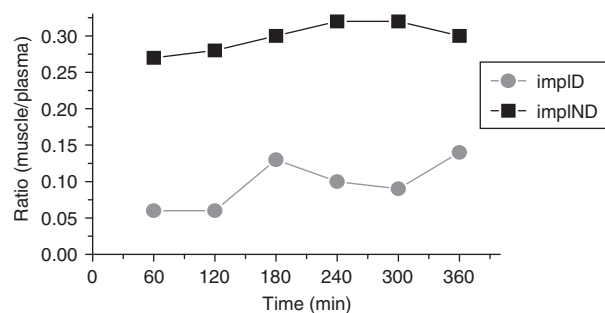
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Introduction: Insulin Dependent Diabetes Mellitus (IDDM) is one of the major risk factors, despite antibiotic prophylaxis, for wound infections after cardiac surgery. Vancomycin is used for the treatment of infections caused by *methicillin resistant staphylococcus aureus* (MRSA) and for antibiotic prophylaxis. However, it is unknown whether antimicrobial plasma concentrations reflect tissue concentration of vancomycin in IDDM patients. Therefore, we compared vancomycin tissue concentrations of 6 diabetic patients and 6 non-diabetics (ND).

Method: Vancomycin was administered continuously to achieve steady-state plasma concentrations (range 25–30 mg/L). To measure vancomycin tissue concentration we employed the microdialysis technique. Samples from the interstitial space of skeletal muscle were collected using a semipermeable membrane at the tip of a microdialysis probe. Simultaneously, plasma concentrations of vancomycin were evaluated. Samples were analysed by a fluorescence–polarisation immunoassay. Data are presented as medians and ranges. Mann-Whitney *U* test was used for statistical analysis.

Results: Vancomycin concentrations in IDDM patients (3.6 mg/L) were significantly lower compared with ND (11.4 mg/L; $P = 0.031$). Median vancomycin [tissue]/vancomycin [plasma] concentration ratios in IDDM was 0.1 in contrast to 0.3 in NDs.



Discussion: A vancomycin MIC $90 < 1 \text{ mg/L}$ is regarded as good susceptibility of the pathogen. Per definition a vancomycin MIC of $>4 \text{ mg/L}$ by micro-dilution in Mueller-Hilton broth read at 24 h is regarded as *glycopeptide-intermediate staphylococcus aureus* (GISA). Vancomycin tissue concentrations were sufficient in both groups for treatment of infections caused by *staphylococcus aureus* strains with good susceptibility. However, tissue concentrations in IDDM patients were insufficient for treatment of infections with GISA, whereas, NDs showed adequate tissue concentrations for treatment of these less susceptible strains of *staphylococcus aureus*.

Conclusion: Our study demonstrated that plasma concentrations derived during a continuous infusion of vancomycin with target levels of 25–30 mg/L do not reflect tissue concentrations in diabetic patients. Insufficient tissue concentration could possibly contribute to the development of antimicrobial resistance.

References:

- Zacharias A, Habib RH. Factors predisposing to median sternotomy complications. Deep vs. superficial infection. *Chest*, 1996; **110**: 1173–1178.
- Muller M, Schmid R, Georgopoulos A, et al. Application of microdialysis to clinical pharmacokinetics in humans. *Clin Pharmacol Ther* 1995; **57**(4): 371–380.
- Wysocki M, Delatour F, Faurisson F, et al. Continuous versus intermittent infusion of vancomycin in severe staphylococcal infections: prospective multicenter randomized study. *Antimicrob Agents Chemother* 2001; **45**: 2460–2467.

112**The effects of levosimendan in cardiac surgery patients**

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Introduction: The aim of the study was to evaluate the effects of levosimendan, a new calcium sensitizer, used during cardiac surgery to facilitate separation from cardiopulmonary bypass (CPB) [1].

Method: Twenty ASA II–III patients, undergoing elective CABG, received, after the aortic clamp release, the same loading dose of levosimendan of 24 $\mu\text{g kg}^{-1}$ over 10 minutes, followed by a continuous infusion of 0.1 $\mu\text{g kg}^{-1} \text{min}^{-1}$ (group I, n = 10) or 0.2 $\mu\text{g kg}^{-1} \text{min}^{-1}$ (group II, n = 10). All patients had measured ejection fraction >25%, sinus rhythm, cardiac index (CI) >1.8 L $\text{min}^{-1} \text{m}^{-2}$, mean arterial pressure (MAP) >60 mmHg and pulmonary capillary wedge pressure (PCWP) 8–20 mmHg. They all received the same anaesthetic scheme. Cardiac output (CO) was obtained by Swan-Ganz catheter and thermodilution (Baxter-Edwards Lab). Haemodynamic measurements: Heart Rate (HR), MAP, PCWP, CO, CI, stroke volume (SV), systemic vascular resistance (SVR) were performed at: T₀: baseline, T₁ at 15 min after infusion, T₂ at 60 min, T₃ after 12 h and T₄ at 24 h after the end of infusion. Statistical analysis was performed by ANOVA for repeated measurements, $P < 0.05$ was considered significant.

Results: There were no significant differences in the demographic data. Haemodynamic results are shown in the table.

| | Gp | T ₀ | T ₁ | T ₂ | T ₃ | T ₄ |
|--|----|----------------|----------------|----------------|----------------|----------------|
| Heart rate (beats/min) | I | 80 ± 2 | 78 ± 1.8 | 84 ± 3 | 84 ± 3.2 | 81 ± 3 |
| | II | 80 ± 3 | 89* ± 2.0 | 93* ± 4 | 94* ± 4 | 88 ± 3.8 |
| Mean arterial pressure (mmHg) | I | 85 ± 4 | 76 ± 3.8 | 73 ± 4 | 78 ± 5 | 78 ± 4.8 |
| | II | 82 ± 5 | 65* ± 5 | 73 ± 5 | 76 ± 5 | 74 ± 3.2 |
| Stroke volume (ml) | I | 55 ± 4 | 57 ± 4.2 | 58 ± 3.7 | 60* ± 5 | 58 ± 5.4 |
| | II | 56 ± 5.6 | 59 ± 7.1 | 60* ± 8.5 | 63* ± 9.9 | 59 ± 7 |
| Cardiac index (L $\text{min}^{-1} \text{m}^{-2}$) | I | 1.9 ± 0.3 | 2 ± 0.6 | 2.3* ± 0.6 | 2.5* ± 0.7 | 2.3* ± 0.4 |
| | II | 1.9 ± 0.6 | 2.2 ± 0.7 | 2.4* ± 0.7 | 2.6* ± 0.8 | 2.3* ± 0.8 |
| PCWP (mmHg) | I | 18 ± 4 | 12* ± 3 | 13* ± 5 | 13* ± 6 | 12* ± 4 |
| | II | 16 ± 3 | 11* ± 2.5 | 12* ± 4 | 12* ± 5 | 10* ± 5 |

* $P < 0.05$ in comparison to T₀

Conclusion: Both doses of levosimendan were effective, achieving a successful separation from CPB during the initial attempt. Levosimendan may offer an alternative inotropic therapy in patients following cardiac surgery. The effects of the drug were not abolished after terminating the infusion [2].

References:

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- Lilleberg J, Nieminen MS, Akkila J, et al. Effects of a new calcium sensitizer, levosimendan, on haemodynamics, coronary blood flow and myocardial substrate utilization early after coronary artery bypass grafting. *Eur Heart J* 1998; **19**: 660–668.

084**Inhaled iloprost in the management of pulmonary hypertension in infants undergoing congenital heart surgery**

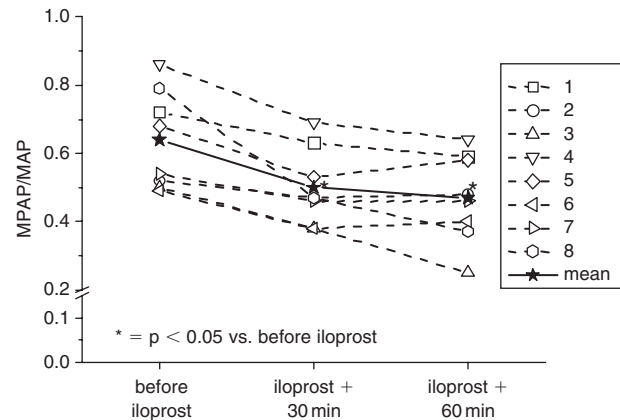
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Introduction: Impaired endothelium-dependant pulmonary artery relaxation is present in children with high pulmonary flow and pressure which might be exacerbated by cardiopulmonary bypass (CPB) [1]. The use of aerosolized iloprost has shown to be safe and effective in adults with pulmonary hypertension [2]. However, no data is available about the intra-operative use of inhaled iloprost in infants <1 year with pulmonary hypertension undergoing cardiac surgery.

Method: Eight infants with a median age of 6 months (range 3 days–8 months) undergoing cardiac surgery with CPB for congenital heart disease with increased pulmonary flow and/or increased pulmonary vascular resistance were included in this case-control-study. After weaning off CPB, infants with mean pulmonary artery pressure >15 mmHg received inhaled iloprost (2.5 $\mu\text{g kg}^{-1}$ over 15 min) using an ultrasonic nebulizer (Optineb®, Nebu-Tec, Elsenfeld, Germany). Mean pulmonary artery pressure (MPAP) and mean arterial pressure (MAP) were measured and the ratio MPAP/MAP was calculated before and 30 min and 60 min after starting iloprost inhalation. The need of vasoactive drugs after weaning off CPB was analysed. Repeated measures ANOVA with Tukey test was used to compare MPAP/MAP. $P < 0.05$ was considered significant.

Results: Mean MPAP/MAP decreased after inhaled iloprost from 0.64 ± 0.1 to 0.5 ± 0.1 at 30 min and 0.47 ± 0.1 at 60 min, respectively ($P < 0.05$). To keep MAP >45 mmHg a norepinephrine infusion was necessary in one patient. The individual courses of MPAP/MAP are demonstrated in the figure.



Discussion: A single dose inhaled iloprost decreases MPAP/MAP in infants after weaning off CPB by 21% and 25% after 30 min and 60 min, respectively. This indicates selective pulmonary vasodilating effects. However, vasopressor support was necessary in one infant. Although inhaled nitric oxide (iNO) is widely used to decrease pulmonary vascular resistance in infants undergoing cardiac surgery, the effects of iNO varies among patients, rebound phenomena have been described, and cumbersome devices are necessary to administer iNO safely. Inhaled iloprost may therefore be an alternative for selective pulmonary vasodilatation in infants undergoing cardiac surgery because it is effective, easy to use and long acting. Furthermore, from the economic point of view, inhaled iloprost may be attractive because iNO became very expensive after FDA approval.

References:

- Celermajer DS, Cullen S, Deanfield JE, et al. Impairment of endothelium-dependent pulmonary artery relaxation in children with congenital heart disease and abnormal pulmonary hemodynamics. *Circulation* 1993; **87**: 440–446.
- Olschewski H, Simonneau G, Galie N, et al. Inhaled iloprost for severe pulmonary hypertension. *N Engl J Med* 2002; **347**: 322–329.

036**Incentive spirometry for preoperative preparation of cardiac patients**

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Introduction: Arterial hypoxaemia is not a rare complication of CABG. Incentive spirometry (IS) is a simple and low cost training method, which encourages an increase of lung volumes and inspiratory capacity. The purpose of the study was to investigate the efficiency of preoperative IS in CABG patients [1].

Method: The study included 65 randomly selected CABG patients 41 to 73 years of age. Patients were divided into 2 groups: patients of group S (37) used IS before surgery, group C (28 patients) were controls. IS was administered to group S patients for 2 days before surgery. Spirometry training was performed for 10 min each hour. Further, we started IS training at the second postoperative day. Anaesthesia and ventilation parameters were the same in both groups. Oxygenation index $\text{PaO}_2/\text{F}_2\text{O}_2$, difference and Qs/Qt were observed at the following operation stages: before sternotomy (1), 10 min

after finishing CPB (2), at the end of operation (3), 3 and 6 hours after operation (4,5). Duration of MV was also observed. Statistical significance was calculated using Student's *t*-test.

Result: Are shown in the table:

| Stage | PaO ₂ /F _i O ₂ (mmHg) | | A-a difference (mmHg) | | Qs/Qt (%) | |
|-------|--|-----------|-----------------------|-----------|-------------|-------------|
| | S | C | S | C | S | C |
| 1 | 428 ± 20 | 429 ± 20 | 240 ± 20 | 233 ± 20 | 11.6 ± 1 | 12 ± 1 |
| 2 | 419 ± 20 | 380 ± 27 | 200 ± 20 | 228 ± 24 | 12.7 ± 1.1* | 16.7 ± 1.6^ |
| 3 | 399 ± 15* | 354 ± 17^ | 178 ± 15^ | 225 ± 17 | 10.1 ± 0.7* | 15 ± 1.4 |
| 4 | 341 ± 14^ | 298 ± 16^ | 129 ± 9^ | 179 ± 21 | 9.9 ± 0.8* | 14.5 ± 1.1 |
| 5 | 335 ± 19^ | 286 ± 15^ | 132 ± 7^ | 175 ± 20^ | 10.7 ± 0.7* | 13 ± 0.8 |

S = incentive spirometry; C = controls

**P* < 0.05 compared between groups, ^*P* < 0.05 compared to stage 1

Duration of CPB were 107 ± 6 min and 106 ± 5 min respectively. Haemodynamic parameters and left atrial pressure were the same in both groups during all observed time.

At the end of the second training day inspiratory capacity increased to 162% (*P* < 0.05). After operation inspiratory capacity was significantly lower and returned to baseline at the 6th postoperative day. No patients had severe myocardial failure after CPB (CI > 2.71 min⁻¹m⁻²). Arterial hypoxaemia with PaO₂/F_iO₂ < 200 were observed in 13.9% group S and in 32% group C patients at stage 3 (*P* < 0.05). Duration of MV in group S was 7.3 h, in C 10.4 h (*P* < 0.05). 32.5% of S and 13.3% of C group patients met the conventional criteria and were extubated in the OR (*P* < 0.05).

Discussion: Incentive spirometry significantly improved lung inspiratory capacity, arterial oxygenation and lung shunt after CPB. Spirometry training before and after operation is effective in decreasing the duration of MV.

Reference:

- 1 Crowe JM, Bradley CA. The effectiveness of incentive spirometry with physical therapy for high-risk patients after coronary artery bypass surgery. *Phys Ther* 1997; **77**(3): 260-268.

111

Pulmonary thrombo-endarterectomy improves diastolic relaxation in the immediate postoperative patient

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Introduction: Chronic pulmonary embolic disease causes pulmonary hypertension and heart failure. Pulmonary endarterectomy (PEA) is now established as an effective surgical treatment [1] by removing the obstacle to pulmonary blood flow and hence improving the symptoms of right sided heart failure. While it is understood that load dependent cardiac indices are positively affected, this study aimed at examining load independent indices by evaluating the immediate effect of PEA on right ventricle (RV) and left ventricle (LV) function by pressure volume loops.

Method: We studied RV function in 13 patients (5M:8F) (aged 28-72 years) undergoing elective PEA. Pressure volume loops were generated by a conductance catheter to assess load independent indices of systolic (end systolic pressure volume relationship, ESPVR - mmHg/mL; preload recruitable stroke work, PRSW) and diastolic function (end diastolic pressure volume relationship: EDPVR - mmHg/mL). The end diastolic volume (EDV - mL), dP/dT_{max} (mmHg/s), time constant of diastolic relaxation (tau - msec), effective arterial elastance (Ea, mmHg/mL), and a measure of ventriculo-arterial (V-A) coupling (Ea/Ees), (where Ees is the end systolic elastance) were also measured. In 6 of the patients the same measurements were obtained simultaneously in the LV. All measurements were made with the chest and pericardium open at held end expiration. Data are mean (SD) and statistical analysis was conducted using paired T test.

Results: Immediately after PEA the mean PA pressure was reduced from 50 (16) to 32 (10) mmHg (*P* < 0.001). Only RV and LV tau were significantly reduced by immediate surgical correction (RV: 48 (13) fell to 38 (10) ms; LV: 65 (47) fell to 38 (4) ms). There was a tendency for RVEDV to fall (149 (80) mL to 103 (62) mL. HR, dP/dT_{max}, Ea and Ea/Ees, ESPVR, EDPVR and PRSW were not significantly different.

Conclusion: In this study, load independent indices of systolic and diastolic function, as well as V-A coupling indices, were unchanged immediately after PEA. Bi-ventricular diastolic relaxation is however improved, presumably as a result of reduced RV afterload and dilatation.

Reference:

- 1 Jamieson SW, Kapelanski DP, Sakakibara N, et al. Pulmonary endarterectomy: experience and lessons learned in 1,500 cases. *Ann Thorac Surg* 2003; **76**: 1457-1462.

119

Description of the instantaneous pressure-flow relationship and critical occlusion pressure in arterial coronary bypass grafts

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Introduction: Until now, information on the determinants of blood flow in coronary artery bypass grafts has been limited [1]. Most intraoperative measurements of bypass flow are performed only to determine the graft patency. Therefore, the objective of this study was to describe the diastolic pressure-flow (P-F) relationship and to assess critical occlusion pressure (COP) in arterial coronary bypass grafts.

Method: After approval by the local ethics committee fifteen patients electively planned for CABG were studied. In each patient, flow measurements in the left internal mammary artery bypass (IMAB) to the left anterior descending artery were performed intraoperatively 15 minutes after discontinuation of extracorporeal circulation and prior to antagonising heparin. The flow measurements were performed by using ultrasound and calculations based on the transit time principle (Cardiomed 4008, Quick-Fit probes (size 2.0-3.0 mm), Medistim, Norway). Simultaneously, aortic pressure (AP), coronary sinus pressure (CSP), and left ventricular end-diastolic pressure (LVEDP) were recorded. The zero flow pressure intercept as a measure of COP was extrapolated from the linear regression analysis of the instantaneous diastolic P-F relationship. In order to avoid capacitance effects of the arterial vessel on the results of this study, the analysis of P-F relationship only included data from the highest diastolic flow rate in the arterial bypass graft until the end of diastole. Linear regression analysis was performed using flow as dependent variable and aortic pressure as independent variable. A *P* value of <0.05 was considered statistically significant.

Results: Five consecutive heart beats were analysed in each patient. Mean diastolic flow in the IMAB was 46 ± 17 mL/min, mean diastolic AP, mean heart rate, mean CSP and LVEDP were 60.5 ± 10.0 mmHg, 86.5 ± 7.5 beat/min, 10.9 ± 3.1 mmHg and 14.4 ± 5.8 mmHg, respectively. Diastolic blood flow was linearly related to the respective AP in all patients (R-values 0.7 to 0.99). The regression lines had a mean slope of 2.1 ± 1.2 mL min⁻¹ mmHg⁻¹. Mean COP was 32.3 ± 9.9 mmHg and exceeded mean CSP and mean LVEDP by a factor of 3.1 and 2.6, respectively.

Conclusions: Our data demonstrate the presence of a vascular waterfall phenomenon [2] in the coronary circulation after IMAB grafting. COP in arterial grafts considerably exceeds CSP as well as LVEDP and should thus be used as the effective downstream pressure. Our data further suggest that the slope of diastolic P-F relationships provides a more rational approach to assess regional coronary vascular resistance (CVR) than conventional calculations.

References:

- 1 Dole WP, Richards KL, Hartley CJ, et al. Diastolic coronary artery pressure-flow velocity relationship in conscious man. *Cardiovasc Res* 1984; **18**: 548-554.
- 2 Permutt S, Riley RL. Hemodynamics of collapsible vessels with tone: the vascular waterfall. *J Appl Physiol* 1963; **18**: 924-932.

082

Effect of isoflurane on diastolic function in patients with concentric left ventricular hypertrophy: an echocardiographic study

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Introduction: Diastolic dysfunction is common in left ventricles (LV) with concentric hypertrophy (CH). Isoflurane has been shown to be negatively lusitropic in a dose-dependent way. The clinical effect of isoflurane on LV with CH and impaired relaxation (IR) has not been studied so far.

Method: 15 patients scheduled for coronary-artery-bypass-graft-surgery were enrolled. All had LV-CH (septal wall thickness > 1.3 cm) with IR (E/A < 1, deceleration time (DT) > 240 ms, S/D > 1) determined by transthoracic echocardiography (TOE). They were anaesthetized with midazolam, sufentanil and pancuronium. Haemodynamics were monitored by ECG, invasive pressures and thermodilution cardiac output (CO). The systemic vascular resistance (SVR) was calculated. Before and after isoflurane (0.8-1.2% end-tidal) LV-End Diastolic-Area (LVEDA) and Fractional-Area-Change (FAC) were determined by 2D-TOE, E/A-ratio, DT and S/D-ratio by transmitral and pulmonary venous PW-Doppler, and Em/Am-ratio and isovolumetric relaxation time (IVRT) by tissue-Doppler. Filling pressures were kept constant during the study. Parameters before

and after isoflurane were compared by paired t-test ($P < 0.05$ was considered significant).

Results: 1 female and 14 males (age: 63 ± 9 years, BSA: 2 ± 0.2 m², EF: $61 \pm 12\%$) were studied. None had wall motion or mitral valve abnormalities during the study. The mean septal thickness was 1.44 ± 0.1 cm.

| | Baseline | Isoflurane | P |
|-------------------------------|----------------|----------------|---------|
| CO (L/min) | 4 ± 0.7 | 4.8 ± 0.8 | <0.01 |
| SVR (dyn s cm ⁻⁵) | 1591 ± 430 | 1195 ± 266 | <0.01 |
| TOE-data | | | |
| LVEDAI [cm ²] | 16.3 ± 4 | 17.7 ± 4 | <0.05 |
| FAC [%] | 49 ± 9 | 49 ± 8 | |
| E/A | 0.8 ± 0.2 | 1 ± 0.3 | <0.01 |
| DT [ms] | 276 ± 52 | 237 ± 45 | <0.01 |
| S/D | 1.3 ± 0.2 | 1.3 ± 0.5 | |
| Em/Am | 0.8 ± 0.2 | 0.9 ± 0.2 | <0.01 |
| IVRT [ms] | 129 ± 28 | 113 ± 21 | <0.01 |

Discussion: Isoflurane did not cause further diastolic impairment. In contrast, there was slight improvement in relaxation indicated by larger E/A-ratio, faster DT and shorter IVRT. With isoflurane LVEDAI increased while filling pressures were constant, implying larger LV-compliance. Since SVR reduction alone does not show the same effects, improved handling of intracellular calcium may be considered as an underlying mechanism. We conclude that clinical relevant concentrations of isoflurane have beneficial effects on diastolic function in LV-CH with IR.

Reference:

- 1 Pagel PS, Grossman W, Haering JM, et al. Left ventricular diastolic function in the normal and diseased heart. *Anesthesiology* 1993; **79**: 836–854 and 1104–1120. Review.

102

Left ventricular diastolic function during negative pressure ventilation

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Introduction: Changes of intra-thoracic pressures may affect cardiac function [1]. The aim of the present study was to evaluate the impact of negative pressure ventilation (NPV) by means of a cuirass ventilator on diastolic function of the left ventricle in patients (pts) undergoing laser therapy (LT) of lesions obstructing the airways tract.

Method: Six consecutive pts scheduled for elective LT were enrolled. Intra-operative monitoring consisted of two-leads ECG, NIBP, pulse-oximetry, ET-CO₂. Anaesthesia was performed by TCI of propofol at $1.5\text{--}2$ $\mu\text{g mL}^{-1}$ plasma target, fentanyl $50\text{--}100$ μg , atracurium 0.3 mg/Kg. Ventilation was performed by applying a negative pressure of $60\text{--}80$ mmHg to the anterior wall of the thorax through a cuirass at a rate of $12\text{--}14$ cycles min^{-1} with a NEV-100 ventilator.

At the end of the surgical procedure an omniplane transoesophageal echo probe was introduced in all pts. A study of LV function was then performed under NPV. We registered the LV propagation velocity (Vp) by colour M-mode, the early diastolic velocity of mitral annulus by Tissue Doppler, and the end diastolic area (EDA) in the transgastric mid-papillary view. Pts were then brought to spontaneous ventilation, and after 5–10 min the echo parameters were registered again. Echo data under spontaneous and negative ventilation were compared. Statistical analysis was performed with Student's *t* test ($P < 0.05$).

Results: Under NPV colour M-mode, evaluation showed an increase of Vp (from 38 ± 5.8 to 48 ± 13.1 cm/sec, $P < 0.05$) when compared with data under spontaneous ventilation. Early diastolic velocity of mitral annulus by Tissue Doppler was higher under NPV (9.2 cm sec^{-1} vs. 8.3 cm sec^{-1} under spontaneous ventilation, $P < 0.05$), and EDA was larger during NPV (13.8 cm² vs. 11.6 cm², $P < 0.05$). Blood gas data showed a decrease of pH (from 7.44 ± 0.05 to 7.35 ± 0.05), an increase of PO₂ (from 78.7 ± 35 to 118.6 ± 40) and of PCO₂ (from 39.2 ± 8 to 49.8 ± 2).

Discussion: NPV is a safe and feasible method for the management of lung ventilation during LT, although in a small group of patients, our preliminary experience showed that NPV may positively affect LV diastolic function. Being aware that a larger experience is necessary, we conclude that NPV seems to be a promising method of ventilation even in cardiac patients with diastolic impairment.

Reference:

- 1 Ambrosino N, Cobelli F, Torbicki A, et al. Hemodynamic effects of negative-pressure ventilation in patients with COPD. *Chest* 1990; **97**(4): 850–856.

064

Beating heart surgery with assistance of simplified bypass systems: effects on haemodynamics and pulmonary gas exchange

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Introduction: Cardiac surgery using cardiopulmonary bypass (CPB) and cardioplegic arrest is often associated with a hyperdynamic circulatory response and an impairment of myocardial function after CPB [1]. We therefore tested the effects of beating heart surgery (BHS) on cardiopulmonary performance after CPB. BHS was assisted by a simplified bypass system (SBS) consisting of only a blood pump and the oxygenator.

Method: 46 patients (age 63 ± 9 years) undergoing coronary artery bypass grafting were studied. 16 patients (group H) were randomized to a conventional CPB circuit (HL-20, Jostra, Germany). Cardiac arrest was induced by 2000 mL of crystalloid cardioplegic solution. 30 patients underwent BHS with assistance of a SBS: 15 patients (group D) were randomized to the DeltaStream™-system (Medos, Germany) and 15 patients (group C) to the CORx™-system (CardioVenton, USA). Haemodynamic monitoring consisted of transpulmonary thermodilution for assessment of stroke volume index (SVI), systemic vascular resistance index (SVRI) and intrathoracic blood volume index (ITBI). Fractional area change of the left resp. right ventricle (LV-resp. RV-FAC) was determined by transoesophageal echocardiography. Measurements were performed after induction of anaesthesia (IND), before (PRE) and after (POST) CPB and at end of surgery (EOS).

Results: Data (mean \pm SD) are presented in the table:

| | Group H | Group D | Group C |
|---|---|---------------------------------------|---------------------------------------|
| Time on CPB (min) | 107 ± 38 | 109 ± 18 | 107 ± 43 |
| Ischaemia time (min) | 58 ± 18 | – | – |
| Number of grafts | 3.3 ± 0.8 | 2.8 ± 0.8 | 2.9 ± 0.9 |
| SVI (mL m ⁻²) | IND 43 ± 10 EOS 42 ± 9 | 42 ± 12 42 ± 9 | 37 ± 11 35 ± 8 |
| SVRI | IND 2463 ± 527 EOS $1537 \pm 448^{**}$ | 2404 ± 660 $1663 \pm 416^{**}$ | 2365 ± 468 $1559 \pm 311^{**}$ |
| ITBI (mL m ⁻²) | IND 911 ± 134 EOS 883 ± 115 | 844 ± 218 862 ± 143 | 824 ± 148 $755 \pm 161^{*}$ |
| LV-FAC (%) | PRE 34 ± 8 POST 29 ± 6 | 34 ± 11 34 ± 10 | 31 ± 9 34 ± 14 |
| RV-FAC (%) | PRE 39 ± 8 POST 41 ± 9 | 42 ± 10 40 ± 10 | 42 ± 9 40 ± 10 |
| PaO ₂ /F _O ₂ | IND 373 ± 62 EOS $267 \pm 92^{**}$ | 412 ± 62 $366 \pm 58^{*++}$ | 369 ± 75 $296 \pm 78^{*+}$ |
| NE ($\mu\text{g kg min}^{-1}$) | EOS 0.02 ± 0.02 | $0.06 \pm 0.04^{*+}$ | $0.05 \pm 0.03^{+}$ |
| E ($\mu\text{g kg min}^{-1}$) | EOS 0.02 ± 0.01 | 0.01 ± 0.01 | 0.01 ± 0.01 |

* $(**)$ $P < 0.05$ (0.01) vs. IND; $^{+}(++)$ $P < 0.05$ (0.01) vs. H; $^{\#}$ $P < 0.05$ vs. D (MANOVA for repeated measurements; post-hoc: Fisher-LSD test); NE = norepinephrine; E = epinephrine

Discussion: BHS using SBS offered only few advantages with regard to haemodynamic stability after CPB. Pulmonary gas exchange was less impaired in one SBS-group.

Reference:

- 1 McBride WT, Elliott P. Advances in cardiopulmonary bypass circuitry. *Curr Opin Anaesth* 2003; **16**: 27–31.

008

Aprotinin and the haemodynamic response to SIRS in patients undergoing on-pump CABG

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Introduction: It was shown that aprotinin (A) prevents bradykinin formation during CPB, thus improving systemic vascular resistance (SVR) [1]. The purpose of this study was to investigate the efficiency of intraoperative A administration on postoperative prevention of haemodynamic effects of SIRS (decline of SVR) and to reveal an efficient dose of A to provide such protection.

Method: In a prospective, randomized clinical trial 73 patients (elective coronary bypass grafting with CPB) were assigned to one of three groups: group A6 ($n = 25$) received A intraoperatively in a total dose of 6×10^6 KIU. 1×10^6 KIU of A was infused before incision; next 2×10^6 KIU of A during surgery before CPB, and an additional dose of 3×10^6 KIU A was added to

the pump prime. Group A3 ($n = 24$, total dose of $A 3 \times 10^6$ KIU) was treated with A similarly to A6 before CPB, but A was not added to the pump prime. Group A0 ($n = 24$) did not receive A. A non-pulsatile roller pump (Cobe, USA) and hollow-fibre oxygenator (Terumo, Japan) were used in all patients ($2.5 \text{ L} \cdot \text{min}^{-1} \cdot \text{m}^{-2}$, $t = 34\text{--}35^\circ\text{C}$). If systolic blood pressure dropped below 90 mmHg postoperatively and infusion therapy was ineffective then an infusion of phenylephrine was started. Total dose of phenylephrine, duration and rate of its infusion were calculated. Haemodynamic measurements were performed using the thermodilution technique. The results were statistically analysed using ANOVA, LSD-test, chi-squared test for categorical variables, and expressed as $M \pm \text{SD}$.

Results: Groups did not differ significantly with respect to preoperative premedication and surgical data, blood loss, and infusion therapy. Baseline SVR were: A6 $1675 \pm 516 \text{ dyn sec cm}^{-5}$, A3 1685 ± 470 , A0 2014 ± 693 , $P > 0.05$ between groups. Dose of phenylephrine used during CPB was higher in A0 ($3.2 \pm 3.2 \text{ mg}$) and A3 ($2.9 \pm 3.7 \text{ mg}$) groups vs. A6 group ($1.1 \pm 1.2 \text{ mg}$); $P = 0.007$ and $P = 0.03$ respectively. The dose of phenylephrine used did not differ between groups in the postoperative period. CI increased postoperatively and SVR declined in all groups. ΔCI , ΔSI , ΔSVR were calculated for each group at 12 and 24 hours postoperatively ($\Delta = \text{value at 12 or 24 h. postop.} - \text{value preop.}$).

| Gp | Δ | Baseline | 12 h. postop. | 24 h. postop. |
|----|----------|----------------|----------------------|----------------------|
| A6 | CI | | $+1.0 \pm 0.6$ | $+1.0 \pm 0.7^{***}$ |
| | SI | | $-1.3 \pm 10.8^*$ | $+3.8 \pm 12.4$ |
| | SVR | 1675 ± 516 | $-620 \pm 512^{***}$ | $-602 \pm 448^{***}$ |
| A3 | CI | | $+1.05 \pm 0.8$ | $+0.98 \pm 0.9^{**}$ |
| | SI | | $+3.4 \pm 10.9$ | $+4.3 \pm 11.6$ |
| | SVR | 1685 ± 470 | $-721 \pm 545^*$ | $-765 \pm 524^{**}$ |
| A0 | CI | | $+1.38 \pm 0.7$ | $+1.65 \pm 0.9$ |
| | SI | | $+5.7 \pm 11.5$ | $+9.7 \pm 11.3$ |
| | SVR | 2014 ± 693 | -1123 ± 753 | -1251 ± 776 |

CI ($\text{L} \cdot \text{min}^{-1} \cdot \text{m}^{-2}$), SI ($\text{mL} \cdot \text{m}^{-2}$), SVR ($\text{dyn} \cdot \text{sec} \cdot \text{cm}^{-5}$) vs. A0 * $P < 0.05$; ** $P < 0.02$; *** $P < 0.01$

Conclusion: In our study only 6×10^6 KIU of A clearly diminished phenylephrine dose during CPB. Postoperatively aprotinin effectively protected SVR regardless of dose (3 or 6×10^6 KIU). We suppose that there are different mechanisms involved in the protective action of A during CPB and in the postoperative period.

Reference:

- 1 Nagaoka H, Katori M. Inhibition of kinin formation by a kallikrein inhibitor during extracorporeal circulation in open-heart surgery. *Circulation* 1975; **52**; 2; 325–332.

Renal/Inflammation/Protection

043

The effects of N-acetylcysteine on renal function during and after cardiac surgery. A pilot study

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Introduction: Acute renal failure (ARF) is a severe complication occurring in 4–15% after heart surgery. Preoperative renal dysfunction, advanced age and the duration of the procedure are known to increase the risk. One mechanism is the cytokine mediated inflammatory response in association with free oxygen radical formation during ischaemia and reperfusion. The free oxygen radicals are inactivated by glutathione peroxidase, which can be increased by N-acetylcysteine (NAC). NAC reduces the ARF caused by iopromide and acute liver failure. NAC may be beneficial in aortic surgery. No studies exist using NAC for renal protection in cardiac surgery. We studied the effects of intravenous NAC on renal function during and after open heart surgery in a randomized blinded and placebo controlled manner.

Method: Informed consent was obtained from 20 patients with serum creatinine above $>110 \mu\text{mol L}^{-1}$, scheduled for elective open heart surgery with CPB. Patients already on haemodialysis or at a predialysis state were excluded. Anaesthesia was standardized. Haemodynamics were controlled with norepinephrine, epinephrine and fluids on request. At the induction of anaesthesia either NAC or 0.9% NaCl infusions were started. NAC was given as a loading dose of 150 mg kg^{-1} followed by 50 mg kg^{-1} for the next 4 h and thereafter 100 mg kg^{-1} for 16 h. Serum creatinine, urine N-acetyl-beta-glucosaminidase (NAG), alpha-1-microglobulin and serum cystatin-C (cyst) were measured before the operation, during the procedure and post-operatively. The total volumes of fluids given and urine excreted during 24 h after surgery were recorded. T-test was used for statistics.

Results: No differences were found in the demographics, types of procedures or haemodynamics between the groups. No side effects by NAC were observed. NAG and alpha-1-microglobulin concentrations will be presented later.

Table 1. Mean % changes of creatinine (cr) and cystatin (cyst) from the baseline at 24 h and 3 day after the operation.

| | Cystatin (mg ml^{-1}) | | | Creatinine (mcg ml^{-1}) | | |
|------|----------------------------------|------|-----|-------------------------------------|------|-----|
| | Baseline | 24 h | 3d | Baseline | 24 h | 3d |
| NAC | 118 | 19↓ | 14↑ | 1.2 | 5↑ | 3↓ |
| NaCl | 127 | 20↓ | 14↑ | 1.5 | 4↑ | 20↑ |

↑ = increase ↓ = decrease.

The mean total volumes of urine excreted were 3358 and 2553 mL and the mean total volumes of fluids infused during 24 h after operation were 16260 and 13668 ml in the NAC and NaCl groups, respectively.

Discussion: No patient was dialyzed. No complications occurred. No significant differences in the renal function were found between the groups, yet in

the NAC group serum creatinine decreased while in the placebo group it increased by day 3 after surgery. More urine was excreted in the NAC group. A larger group of patients will be collected to increase the power of the study.

Reference:

- 1 Tepel et al. Prevention of radiographic-contrast-agent-induced reductions in renal function by acetylcysteine. *NEJM* 2000; **343**: 180–184.

066

Methylprednisolone increases urinary nitrate/creatinine ratios in porcine infrarenal aortic ischaemia reperfusion

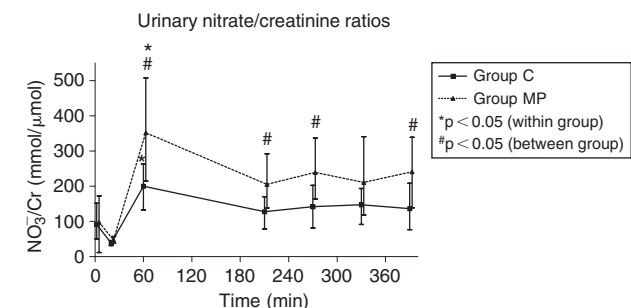
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Introduction: Urinary nitrate mainly arises from systemic eNOS activation with a small contribution from intrarenal iNOS induction. Increased venous eNOS activity is a normal physiological response to proinflammatory mediators [1]. Methylprednisolone's anti-inflammatory effects in mice have recently been shown to depend on eNOS activation, whilst reducing inflammatory mediators [2]. We wondered if urinary nitrate excretion increases during porcine infrarenal aortic ischaemia reperfusion and investigated the hypothesis that methylprednisolone accentuates this response.

Method: Forty-two anaesthetized pigs underwent laparotomy, fluid resuscitation for 60 min and then 150 min of infra-renal aortic cross-clamping followed by 180 min reperfusion. Urine samples were obtained for nitrate and creatinine measurement as follows: preoperative baseline (PB) and 30, 120, 220, 270, 330 and 390 min after induction of anaesthesia. Pigs were randomized to 2 groups. Group C received placebo and group MP received methylprednisolone 30 mg/kg, after obtaining the 30 min sample. Analysis between groups – Mann-Whitney U; within groups – Friedman's test.

Results: Compared with PB there was a significant increase in urinary nitrate/creatinine ratios in both groups at 60 min (pre-cross clamp) which in group MP only, showed significant elevation thereafter ($p < 0.05$). In group MP urinary nitrate/creatinine ratios were significantly higher than placebo.



Discussion: Perioperative rapid increases in urinary nitrate may reflect systemic eNOS activation and provide early evidence of an evolving inflammatory response. Since glucocorticoid beneficial anti-inflammatory effects appear to be eNOS dependent [2], urinary nitrate measurement may help determine the minimal steroid dose necessary for significant anti-inflammatory effects.

References:

- Bhagat K, Hingorani AD, Palacios M, et al. Cytokine-induced venodilatation in humans in vivo: eNOS masquerading as iNOS. *Cardiovasc Res* 1999; **41**(3): 754–764.
- Hafezi-Moghadam A, Simoncini T, Yang E, et al. Acute cardiovascular protective effects of corticosteroids are mediated by non-transcriptional activation of endothelial nitric oxide synthase. *Nat Med* 2002; **8**(5): 473–479.

105

Preoperative ACE inhibition and renal dysfunction following cardiac surgery

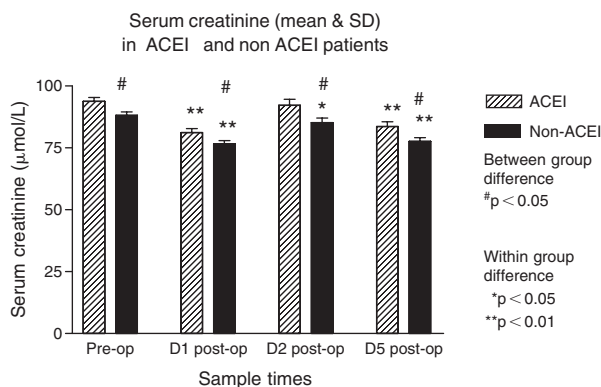
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Introduction: Commencement of angiotensin converting enzyme inhibitors (ACEIs) one day following cardiac surgery in patients with moderate preoperative impairment of renal and cardiac function increases postoperative renal dysfunction [1]. Since many cardiac surgery patients receive ACEIs up to the day before surgery we investigated the hypothesis that patients who last received ACEIs on the preoperative day, would have greater postoperative renal dysfunction than patients who never received ACEIs preoperatively. Recently change in serum creatinine (Δ Cr) has been shown to be a clinically useful measure of renal dysfunction after cardiac surgery [2].

Method: 244 patients undergoing elective cardiac surgery were consecutively enrolled. Exclusions were preoperative diabetes, liver or renal ($Cr > 125 \mu\text{mol/L}$) impairment. Serum creatinine was measured on the preoperative day (pre-op), and on the first (D1) second (D2) and fifth (D5) postoperative days respectively. The changes in serum creatinine (Δ Cr) from the preoperative baseline ($Cr_{\text{pre-op}}$) were calculated for D1, D2 and D5 (for example, Δ Cr on D1 (Δ Cr_{D1} = $Cr_{\text{D1}} - Cr_{\text{pre-op}}$)). Between and within group comparisons were determined using unpaired and paired T-tests respectively.

Results: As shown in the figure, pre- and post-operative serum creatinine values were higher in ACEI (n = 108) than non ACEI patients (n = 136). Five ACEI (4.6%) and 2 non ACEI patients (1.5%) had D2 Cr above $140 \mu\text{mol/L}$. No postoperative between group difference was noted in Δ Cr at D1, D2 and D5.



Discussion: The higher preoperative creatinine in the ACEI patients may arise directly from renal effects of the drug. Alternatively, hypertensive disease prior to ACEI administration may contribute. However preoperative ACEIs do not appear to increase Δ Cr. Further work will determine if discontinuing ACEIs for longer preoperatively would result in lower serum creatinine levels.

References:

- Manche A, Galea J, Busuttill W. Tolerance to ACE inhibitors after cardiac surgery. *Eur J Cardiothorac Surg* 1999; **15**(1): 55–60.
- Wijeyesundera DN, Rao V, Beattie WS, et al. Evaluating surrogate measures of renal dysfunction after cardiac surgery. *Anesth Analg* 2003; **96**(5): 1265–1273.

100

ACE inhibitors enalaprilat and quinaprilat inhibit monocyte surface receptor expression

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Introduction: Cardiac surgery with or without cardiopulmonary bypass (CPB) leads to activation of cellular as well as humoral components of the immune response. The majority of patients with coronary artery disease are treated with ACE inhibitors to optimize afterload. However, the possible immunomodulating effects of ACE inhibitors remain to be elucidated. The aim of this study was to investigate anti-inflammatory effects of the ACE inhibitors enalaprilat and quinaprilat on spontaneous and LPS-induced monocyte surface receptor expression.

Method: The study was approved by the local ethical board. After informed consent $100 \mu\text{L}$ whole blood from 12 healthy donors was incubated with different concentrations of enalaprilat and quinaprilat for 15 and 180 minutes respectively, where indicated, aliquots were stimulated with 100 ng/mL LPS. Blood incubated with a FITC-labelled non-specific antibody against IgG served as a control and for flow cytometer setup. Fluoresceine isothiocyanate (FITC) labelled antibodies against LPS receptor CD 14 and complement receptor 3 (CD11b/CD18) were used for determination of surface receptor expression. Median fluorescence intensities were determined to assess receptor expression.

Results: Enalaprilat and quinaprilat inhibited spontaneous CD14 expression in a time and concentration dependent manner:

| Incubation | Anti-CD14 | Q 100 ng/ml | E 100 ng/ml |
|------------|------------------|--------------------|--------------------|
| 15 minutes | 384.6 ± 32.2 | $316.6 \pm 33.2^*$ | $310.3 \pm 23.4^*$ |
| 30 minutes | 450.2 ± 34.8 | $347.6 \pm 40.1^*$ | $331.2 \pm 40.7^*$ |

* denotes $P < 0.05$ compared to FITC-anti-CD14 (Wilcoxon–Wilcoxon test and Bonferroni procedure). Q = quinaprilat, E = enalaprilat.

This decrease in CD14 expression correlated well with a reduced spontaneous CD11b expression:

| Incubation | Anti-CD11b | Q 100 ng/ml | E 100 ng/ml |
|------------|------------------|--------------------|--------------------|
| 15 minutes | 162.5 ± 60.2 | $128.8 \pm 51.6^*$ | $133.7 \pm 51.9^*$ |
| 30 minutes | 76.4 ± 24.4 | $63.3 \pm 18.1^*$ | $59.2 \pm 14.8^*$ |

LPS-induced CD11b expression was also significantly inhibited:

| Incubation | Anti-CD11b | Q 100 ng/ml | E 100 ng/ml |
|------------|-----------------|--------------------|--------------------|
| 15 minutes | 443.1 ± 169 | $201.8 \pm 62.1^*$ | $195.1 \pm 61.3^*$ |
| 30 minutes | 235.4 ± 120 | $169.3 \pm 81^*$ | $159.1 \pm 79.5^*$ |

Discussion: Immunoinhibitory effects of ACE inhibitors are at least partly mediated by reduced surface receptor expression. This anti-inflammatory mechanism may attenuate cell damage in ischaemia/reperfusion [1] syndromes as well as CPB-induced immune responses or cytokine production [2]. Further clinical studies are warranted to investigate whether CPB-induced monocyte activation may be influenced by pre- or intraoperative administration of ACE inhibitors.

References:

- Guba M, Steinbauer M, Buchner M, et al. Differential effects of short-term ace- and AT1-receptor inhibition on posts ischemic injury and leukocyte adherence in vivo and in vitro. *Shock* 2000; **13**: 190–196.
- Schindler R, Dinarello CA, Koch KM. Angiotensin-converting-enzyme inhibitors suppress synthesis of tumour necrosis factor and interleukin 1 by human peripheral blood mononuclear cells. *Cytokine* 1995; **7**: 526–533.

094

N-acetylcysteine decreases myocardial ischaemia-reperfusion injury in CABG patients

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Introduction: Perfusion of the myocardium after an ischaemic cross-clamp period, frequently results in depressed myocardial function [1]. N-acetyl-L-cysteine (NAC) has antioxidant, cytoprotective, and microcirculatory effects. It restores the cellular antioxidant potential by replenishing depleted

reduced glutathione (GSH) stores and scavenging of oxygen free radicals. It has an antioxidant effect and may limit organ dysfunction during ischaemia reperfusion (I/R) [2]. The aim of this randomized study was to investigate the antioxidant effects of NAC to prevent myocardial I/R injury after the cross-clamp period in CABG operations with CPB.

Method: After the ethic committee approval and informed consent, 20 patients undergoing elective coronary bypass operations with CPB were enrolled and divided into group NAC and group Control. Routine propofol based CABG anaesthesia was given to all patients. Group NAC received an iv. infusion at induction of anaesthesia until the end of CPB. Group Control received 5% dextrose in water. Blood samples were taken from the coronary sinus at the start of CPB, before aortic CC and 45 minutes after the completion of proximal anastomoses. Two myocardial biopsies were taken; with the start of CPB before aortic CC, and the second 30 minutes after the completion of proximal anastomoses. TNF- α was assayed with ELISA, reactive oxygen species (ROS) with Chemiluminescence (CML) Technique: Two types of enhancers can be used, Luminol for hydrogen peroxide and hypochloride, Lucigenin for superoxide. All the results are given as mean \pm SD. Data were analysed with one- and two-way analysis of variance, Student's unpaired *t*-test, the Fischer's exact test. *P* value less than 0.05 was considered significant.

| Results | Control | NAC | <i>P</i> |
|--|--------------------|--------------------|----------|
| Luminol (cpm \cdot mg ⁻¹) | | | |
| Basal | 189.3 \pm 137.07 | 180.5 \pm 90.5 | 0.86 |
| Reperfusion | 378.8 \pm 277.5 | 211.1 \pm 106.34 | 0.09 |
| Difference ratio | 96.5 | 18.9 | 0.03 |
| Lucigenin (cpm \cdot mg ⁻¹) | | | |
| Basal | 247.3 \pm 130.9 | 173.2 \pm 110.3 | 0.18 |
| Reperfusion | 458.7 \pm 247.32 | 211.8 \pm 115.23 | 0.01 |
| Difference ratio | 89.5 | 32.6 | 0.01 |
| TNF- α (pg \cdot mg ⁻¹) | | | |
| Basal | 1.21 \pm 0.38 | 1.46 \pm 0.26 | 0.09 |
| Reperfusion | 1.82 \pm 0.82 | 0.68 \pm 0.15 | <0.01 |
| Difference ratio | 147.45 | 47.59 | <0.01 |

Discussion: There are two main hypotheses, namely oxidative stress and Ca²⁺ overload which have been proposed to explain to pathogenesis of I/R injury. The role of NAC on the oxidative stress has shown as an O₂ free radical scavenger during open heart surgery. Its beneficial effects during hepatic I/R was written by Sener [1]. According to our data we suggested that NAC can be used as an agent to prevent the heart from I/R injury.

References:

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- Sener G, Tosun O, Sehirli AO, et al. Melatonin and N-acetylcysteine have beneficial effects during hepatic ischemia and reperfusion. *Life Sci* 2003; **72**: 2707–2718.

071

The efficiency of diltiazem on myocardial protection in off-pump coronary artery bypass grafting surgery

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Introduction: Off-pump coronary artery bypass graft surgery (OPCABG) causes less myocardial injury than surgery using bypass [1]. But ischaemia of the normothermic beating heart might be harmful. In this study, we compared the efficacy of diltiazem and nitroglycerin for myocardial protection by measuring creatine phosphokinase-myocardial isoenzyme (CKMB), troponin-I and myoglobin during OPCABG.

Method: After ethics approval, 32 patients (ASA II–III; LVEF > 40%; LVEDP < 18 mmHg) scheduled for OPCABG were randomized in two groups prospectively. Patients received an infusion of either nitroglycerin (1 μ g kg⁻¹ min⁻¹, group N, n = 16) or diltiazem (0.1 mg kg⁻¹ hr⁻¹, group D, n = 16), after anaesthesia induction, during surgery and 24 hours postoperatively. Haemodynamic measurements including HR, MAP, CVP, MPAP, PCWP, CO and blood sampling for determination of CK-MB, troponin-I and myoglobin levels were made at the following times: before the anaesthesia induction (1), before and after the myocardial revascularization (2,3) and at 1, 4, 12 and 24 hours after surgery (4–7). Also cardiac complications (hypotension, hypertension, dysrhythmia, pulmonary hypertension, myocardial ischaemia) observed perioperatively were recorded. Wilcoxon's signed rank, Mann-Whitney *U*, chi-squared and Fisher's exact tests were used for statistical analysis.

Result: The two study groups did not differ with respect to demographic data and preoperative properties of patients. The increases in myoglobin, troponin-I and CK-MB, especially after the second measurement point, were significant in both groups (*P* < 0.05, *P* < 0.01, *P* < 0.001 in Group N and D).

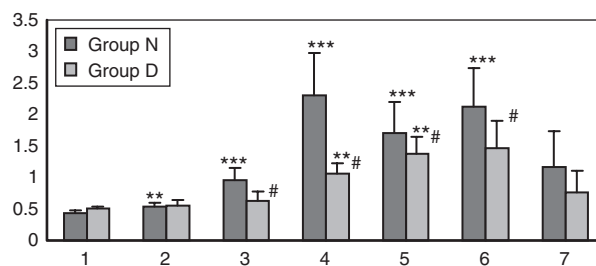


Figure 1. Serum troponin-I levels (ng mL⁻¹; mean \pm SE) **P* < 0.05, ***P* < 0.01, ****P* < 0.001 vs Baseline (1); #*P* < 0.05 Group N vs Group D

No haemodynamic parameters differed significantly between the two groups. Observed cardiac complications were similar, except the lower postoperative incidence of dysrhythmia in Group D (8 vs. 2 patients; *P* < 0.05).

Discussion: The results showed that diltiazem infusion is more efficient for myocardial protection than nitroglycerin in OPCABG patients.

Reference:

- Czerny M, Baumer H, Kilo J, et al. Inflammatory response and myocardial injury following coronary artery bypass grafting with or without cardiopulmonary bypass. *Eur J Cardiothorac Surg* 2000; **17**: 737–742.

076

Comparison of myocardial protective effects of TIVA, sevoflurane and isoflurane in CABG surgery

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Introduction: There is an increasing number of studies about the ischaemic preconditioning-like effects of volatile anaesthetic agents. In this study we compared the myocardial protective effects of TIVA, sevoflurane and isoflurane in clinical practice.

Method: 57 patients, scheduled for elective coronary artery bypass graft surgery (CABG), were enrolled. Patients were randomized into three groups: Group I (TIVA n = 17): fentanyl, midazolam iv. infusion and pancuronium were given for maintenance. Group II (sevoflurane n = 20): sevoflurane was administered at 1 MAC for maintenance. Group III (isoflurane n = 20): isoflurane at 1 MAC. Fentanyl and pancuronium were given repeatedly as required in Groups II and III. In these two groups, the volatile anaesthetics were given until CPB was started. After unclamping the aortic cross clamp, sevoflurane and isoflurane were given in groups II and III until the end of the operation. In group I, the agents were infused during the same periods. ST segment changes were recorded electronically. Transthoracic echocardiography was done preoperatively and on the 3rd day postoperatively in order to assess left ventricular systolic functions and cardiac scores. Biochemical parameters, cardiac Troponin I (cTnI) and creatine kinase MB fraction (CK-MB), were determined before and after CPB, 6 h after surgery, and 1st, 2nd and 3rd day postoperatively. Blood samples from arterial and retrograde coronary cannula were obtained simultaneously for lactate levels (before CPB and after unclamping the aorta).

Results: All demographic parameters were similar in the three groups. On the 1st day postoperatively, CK-MB levels were higher in group I than groups II & III (46.4 \pm 8.8 vs. 31.5 \pm 3.1 and 38.2 \pm 3.1 U mL⁻¹, *P* < 0.05). At 6 hours after surgery, cTnI levels in group I were significantly higher (41.3 \pm 5.1 vs. 24.0 \pm 3.2 and 28.1 \pm 3.4 ng mL⁻¹, *P* < 0.05). ST segment analysis and echocardiographic evaluations showed no difference between the groups. After unclamping the aorta, lactate level of arterial blood sample was higher in group I than group III. Lactate level from the sample of retrograde cannula was significantly higher in group I than groups II & III (3.8 \pm 0.3 vs. 3.1 \pm 0.2 and 2.8 \pm 0.8 mg dL⁻¹, *P* < 0.05).

Conclusion: Because of the higher biochemical parameters related with myocardial injury in TIVA group, it can be postulated that the volatile anaesthetic agents sevoflurane and isoflurane have a myocardial protective effect. In our study, sevoflurane showed no difference from isoflurane group and it has a similar ischaemic preconditioning-like effect as isoflurane in CABG operations.

Reference:

- Julier K, da Silva R, Garcia C, et al. Preconditioning by sevoflurane decreases biochemical markers for myocardial and renal dysfunction in coronary artery bypass graft surgery: a double-blinded, placebo-controlled, multicenter study. *Anesthesiology* 2003; **98**: 1315–1327.

Coagulation

009

A pilot double blind randomized placebo controlled trial of the use of recombinant factor VIIa (rFVIIa) in high transfusion risk cardiac surgery

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Introduction: Peri-operative bleeding can be severe in patients undergoing complex cardiac surgery. The causes for this are multi-factorial. As would be expected, initial open label reports of the use of rFVIIa after cardiac surgery were encouraging [1,2]. We report the first double blind randomized use of this novel haemostatic agent in the setting of cardiac surgery.

Method: After institutional approval and informed consent, 20 patients were randomized to receive either placebo or 90 mcg/kg of rFVIIa after protamine following the end of CPB. Patients were included if they were scheduled to have surgery with a high risk of transfusion (including double valve replacements, acute endocarditis and aortic root replacements). Primary end points were the proportion of patients exposed to blood or blood products, the total number of allogeneic units transfused per patient, and the quantity of shed mediastinal blood. Fisher's exact test was used to compare proportions exposed to products, and the Mann-Whitney *U* test for comparing number of allogeneic units exposed to each patient and mediastinal drainage.

Results: A total of 19 patients completed the study and were analysed (one patient was excluded due to protocol violation). Results are summarized in the table below.

| | rFVIIa | Placebo | <i>P</i> value |
|-------------------------------------|----------------|----------------|----------------|
| No. exposed to blood | 2 | 8 | 0.037 |
| No. exposed to products | 1 | 5 | 0.183 |
| No. exposed to any transfusion | 2 | 8 | 0.037 |
| No. of units exposed median (range) | 0 (0–12) | 7 (0–27) | 0.013 |
| Total drainage (mL) median (range) | 240 (140–1000) | 630 (240–2320) | 0.095 |

Discussion: rFVIIa significantly reduces transfusion requirements in complex cardiac surgery. This supports the positive reported findings of the open label compassionate use of rFVIIa in cardiac surgery. rFVIIa has a well defined place in the management of the haemophilic patient with inhibitors. This study begins to define possible new indications for its use. Further studies in this area are required.

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078

Pre and postoperative iron status in patients presenting for cardiac surgery

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Introduction: The West of Scotland has one of the highest incidences of coronary artery disease in Europe due, in part, to poor diet. It was decided to assess the iron status of our patients as part of our blood use audit with a view to perioperative optimization of iron status. It was hoped not only to assess the proportion of our patients presenting for surgery who were iron deficient but also to assess if those patients had increased red cell requirements during their hospital stay or had lower discharge haemoglobin (Hb) or lower Hb at 6 weeks.

Method: All patients presenting for surgery in our unit have data collected for audit including demographic data, preoperative and discharge Hb, blood and blood product use whilst in hospital and Hb 6 weeks post discharge. Ferritin assay was added to our preoperative work-up and to the 6-week post discharge assessment.

Results: While the median ferritin level preoperatively was 117 ng mL⁻¹, 22% of patients had low (<30 ng mL⁻¹) or borderline (31–50 ng mL⁻¹) ferritin levels. Those with low ferritin levels preoperatively had significantly lower admission Hb (11.8 g dL⁻¹) than those with normal levels (13.9 g dL⁻¹) using

Minitab statistical software; ANOVA where *P* < 0.05. Those with low or borderline ferritin were transfused more red cells and had lower discharge Hb than those with normal levels. Six weeks post discharge those with normal ferritin levels had significantly higher Hb (12.8 vs. 11.4 g dL⁻¹). The median post discharge ferritin had fallen to 48% of the initial value and almost half of patients now had low or borderline ferritin levels. Of those patients who we considered anaemic (<11.0 g dL⁻¹) at 6 weeks, 75% had low or borderline ferritin levels preoperatively.

| Preoperative ferritin levels | <50 ng mL ⁻¹ (n = 21) | ≥50 ng mL ⁻¹ (n = 74) |
|------------------------------------|----------------------------------|----------------------------------|
| Hb admission (g dL ⁻¹) | 11.8 | 13.9* |
| Discharge | 9.0 | 9.6 |
| 6 weeks | 11.4 | 12.8* |
| Units red cells transfused/patient | 2.4 | 1.0 |

Discussion: Currently less than 2% of our patients are discharged on iron replacement therapy, largely due to anticipated gastrointestinal upset. Previous work has suggested no benefit in postoperative iron therapy [1] but, in contrast to our findings, ferritin levels in their control group were within the normal range. Our data suggests that it may be worthwhile discharging all patients on iron, or at least those whose ferritin levels are low preoperatively. Where time permits, there may also be a case for preoperative iron therapy given the significant proportion of our patients who are iron deficient. Since these patients have lower admission Hb and higher red cell demands it may be possible to reduce red cell use.

Reference:

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114

Effects of diclofenac on platelet function and bleeding after cardiac surgery

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Introduction: One of the side effects of non steroidal anti-inflammatory drugs (NSAIDs) is the inhibition of platelet aggregation, which could increase bleeding after cardiac surgery [1]. The aim of our study was to analyse the effects of diclofenac on coagulation, platelet function and blood loss after cardiac surgery.

Method: In a controlled, blinded, randomized trial we studied 39 patients undergoing elective cardiac surgery using an extracorporeal circuit. Patients were randomly assigned to one of the two treatment groups. The diclofenac (D) group received 75 mg of diclofenac intravenously 3 hours after surgery and the control (C) group received no diclofenac. We registered haemodynamic data and blood loss hourly for 16 hours after surgery. Blood samples for coagulation tests including platelet function were taken before, immediately after, 5 hours after and 16 hours after surgery. Statistical analysis was by ANOVA, Student's *t*-test and χ^2 test.

Results: 21 patients were in the D group and 18 patients in the C group. There were no differences between the groups with respect to demographic data, concurrent disease and medication used by the patients.

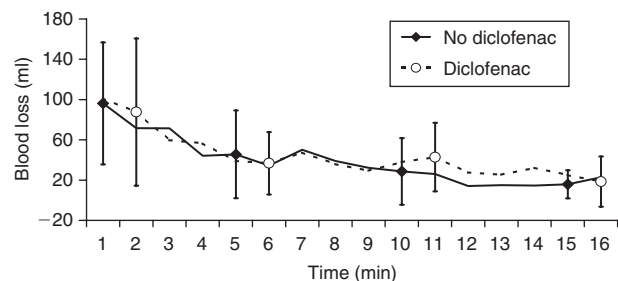


Figure 1. The time course of blood loss within 16 hours after surgery.

The time course of blood loss (Figure 1) and the volume of blood lost within 16 hours after surgery were similar in both groups. PTT, aPTT and platelet count decreased significantly after surgery and recovered gradually after 16 hours but no differences were found between the groups. Aggregation of platelets decreased significantly after surgery. After administration of

diclofenac aggregation of platelets to hidon and nefrin decreased in the D but not in the C group. The difference between the groups was significant only for the nefrin test 5 hours after surgery.

Discussion: The impairment of platelet function caused by diclofenac was not associated with clinically important increase in bleeding after cardiac surgery. The power of the study was set to 0.8 to detect a difference in bleeding of 300 mL within 16 hours between the two groups.

Reference:

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032

Determinant of antithrombin consumption in cardiac operations requiring cardiopulmonary bypass

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Introduction: Antithrombin is a natural anticoagulant that is consumed during cardiac operations with cardiopulmonary bypass. The aim of this observational study was to identify the factors determining antithrombin (AT) consumption during cardiac operations.

Method: 250 consecutive adults patients undergoing cardiac operations with cardiopulmonary bypass (CPB) were admitted to the study. Preoperative and intraoperative variables were tested with respect to their role in determining the AT activity at the end of the operation. No fresh frozen plasma nor purified AT were administered.

Results: With univariate analysis, 8 predictors of the AT activity at the end of the operation have been identified: preoperatively: AT activity; age; diabetes on medication; preoperative haematocrit value; preoperative dialysis; combined operation; CPB duration; lowest temperature on CPB. The multivariate model identified in our study includes five predictors of AT consumption after cardiac operation with CPB: preoperative AT activity; age; diabetes; CPB duration; combined operation. The highest significance was reached for the preoperative AT activity; age is the second independent factor determining the AT activity in the intensive care unit (ICU-AT) with a decrease of 1.5% for every decade, while, from our analysis, diabetes on medication introduces a predictable decrease of AT activity of about 6%. CPB duration is inversely correlated to ICU-AT with a predictable reduction of 3% for every hour on CPB. Combined operation carries a decrease of AT activity at the end of operation of 4% regardless of the CPB duration.

Discussion: At present, there is a great deal of information demonstrating that low levels of AT during CPB are responsible for heparin resistance and there are some reports of oxygenator failure in patients with very low AT activity levels. Conversely, despite several indications that at the end of cardiac operation with CPB many patients may experience extremely low level of AT activity there is not evidence-based information linking low levels of AT to a bad outcome. A "safe" AT activity threshold has not yet been defined during or after the operation. A postoperative target value of 50% appears empirically reasonable, and on this value we have settled the predictive tables for AT replacement. Nevertheless, we believe that it is time to design a large prospective trial aimed at determining if a low postoperative AT level is associated with a bad outcome, and if so, which complications are related to an AT deficiency and what is a "safe" postoperative AT activity level in cardiac surgery.

Reference:

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088

Clopidogrel and perioperative transfusion requirements in cardio-pulmonary bypass surgery

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Introduction: Clopidogrel is a non-competitive antagonist of P2Y₁₂, the platelet adenosine diphosphate receptor and a potent inhibitor of platelet aggregation. Clopidogrel is used in the prevention of thrombotic events in patients with recent myocardial infarction, stroke, and in patients with established peripheral arterial disease. Clopidogrel is also utilized in patients with acute coronary syndromes and those undergoing percutaneous coronary intervention. After discontinuation of the drug, recovery of platelet function takes from 7 to 14 days. The anti-platelet effect of clopidogrel is additive to

that of aspirin and has shown clinical benefit in the setting of cardiovascular disease [1]. Thus, the two agents are being administered in combination with increasing frequency. Accordingly, more patients now present for cardiac surgery on combined aspirin and clopidogrel antiplatelet therapy and this may lead to increased perioperative blood loss and transfusion requirement.

The aim of this study was to evaluate the effect of preoperative clopidogrel on bleeding and transfusion requirements after coronary artery bypass graft (CABG) surgery.

Method: We prospectively analysed 200 consecutive cardiac patients undergoing first time CABG surgery. Bleeding rates and blood ± blood product transfusion requirements in patients taking clopidogrel and aspirin were compared to those on aspirin alone. Aspirin and clopidogrel were discontinued 7 days prior to surgery as per departmental protocol. Blood loss was determined by recording maximum blood volume collected by chest drain in the 24-hour intra-operative and post-operative period.

Results: Results are reported as percentages for discrete variables and mean and standard deviation for continuous variables. Student's *t*-test was used to compare continuous data and Fisher's exact test for discrete data. A two-tailed *P* < 0.05 was considered statistically significant. Categorical data is presented as percentage.

Table:

| | Aspirin (n = 59) | Clopidogrel & Aspirin (n = 62) | <i>P</i> |
|--|------------------|--------------------------------|----------|
| Blood/blood product (%) | 33.9 | 46.8 | <0.05 |
| RBC rate %pts | 33.9 | 38.7 | NS |
| RBC units/pt (mean ± SD) | 1.85 ± 0.25 | 2.75 ± 0.19 | <0.05 |
| Blood loss (ml) first 24 hours (mean ± SD) | 725 ± 328 | 837 ± 449 | NS |

RBC = red blood cells.

Patient requirement for transfusion (overall transfusion rate) was significantly higher in the clopidogrel and aspirin group when compared to aspirin only.

Conclusion: The combination of clopidogrel with aspirin in patients presenting for cardiac surgery results in increased requirement for perioperative blood transfusion. There is also a trend towards increased blood loss in the peri-operative period. These findings raise concerns about continued clopidogrel administration in the immediate pre-operative period and have particular implications for patients undergoing non-emergent CABG [2]. As our study is in effect only a pilot study it cannot make definitive recommendations, however we feel that a large multicentred clinical trial would support our research findings.

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- 3 Yusuf S, Mehta SR, Zhao F, et al. Early and late effects of clopidogrel in patients with acute coronary syndromes. *Circulation* 2003; **107**: 966–972.

090

The impact of intra-operative red cell salvage on allogeneic blood requirements following cardiac surgery

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Introduction: The impact of cross infection screening and other factors have caused a large increase in the cost of allogeneic red cells (ARC). Many institutions have developed multi-modal strategies for reducing ARC requirements following cardiac surgery [1,2]. We recently introduced intra-operative cell salvage (ICS) for routine use in all adult cardiac surgery and examined the impact of ICS on blood product consumption, haemoglobin concentrations and coagulation parameters by way of a closed loop observational study.

Method: 108 consecutive patients (control group) undergoing elective cardiac surgery were studied and data collected on blood product use (intra-operative, in ITU and cumulative) and haemoglobin (Hb) concentration changes (pre-operatively, on ITU admission, 24 hours post-operatively and on discharge from hospital). ICS equipment was subsequently purchased and made available to all patients undergoing cardiac surgery. We studied the impact of this by repeating our original observations over a four-week period (n = 91; ICS group).

Results: ICS patients received an average of 8.8 mL kg⁻¹ (SD = 3.6 mL kg⁻¹) of processed autologous blood following cardio-pulmonary bypass (CPB). Table shows the number (%) of patients given ARC.

| | Intra-operative | ITU | Total |
|-------------------------|-----------------|----------|----------|
| Control Group (n = 108) | 29 (27%) | 72 (67%) | 85 (79%) |
| ICS group (n = 91) | 27 (30%) | 38 (42%) | 60 (66%) |
| P | 0.78 | <0.001 | 0.06 |

The mean Hb concentration on ITU admission was significantly higher in the ICS group ($10.3 \text{ gm dL}^{-1} \pm 1.63$ vs. $9.1 \text{ gm dL}^{-1} \pm 1.36$; $P < 0.001$). ARC use was significantly lower in the ICS group (42%) compared to the control group (67%) during the first 24-hour period following surgery ($P < 0.001$), and the percentage of patients receiving no allogeneic blood prior to hospital discharge was 21% in the control group as compared to 34% in the ICS group ($P = 0.06$). In the ICS group the volume of cell salvaged blood given was significantly correlated with APTT (regression equation $P = 0.018$) and INR (regression equation $P = 0.015$) as measured on admission to ITU, but not with platelet count or fibrinogen concentration.

Conclusion: ICS significantly reduced the use of ARC in the early postoperative period following elective cardiac surgery. This was associated with significantly higher Hb concentrations on admission to ITU. The volume of ICS blood given correlated with APTT and INR abnormalities which may indicate a dilutional coagulopathy as a result of clotting factor clearance by the cell salvage process. Large volumes of ICS blood may be an indication for fresh frozen plasma.

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075

Ultra low dose aprotinin decreases blood loss and transfusion requirements in high risk two valve replacement surgery

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Introduction: Antifibrinolytics have been extensively used in cardiac surgery involving cardiopulmonary bypass, orthotopic liver transplantation and in extensive surgical procedures to decrease perioperative bleeding. This study was conducted to assess the safety and efficacy of ultra low dose aprotinin in reducing postoperative blood loss in patients undergoing 'high-risk' two valve replacements.

Method: Forty patients of NYHA class IV undergoing elective combined mitral and aortic valve replacement surgery were randomized into 2 groups of twenty each. Group I received aprotinin in a dose of 1 million KIU (after anaesthetic induction prior to initiation of cardiopulmonary bypass); Group II received no antifibrinolytic. A standard technique of anaesthesia and extracorporeal circulation was instituted. Tests of coagulation were done at periodic intervals, quantity of blood and blood products transfused were recorded postoperatively. Numerical data were statistically analysed (Student's *t* test) and $P < 0.05$ was considered significant.

Results: The demographic data were comparable in the two groups. There was significant reduction in mediastinal drainage and blood or blood products transfusion requirements with the use of low dose aprotinin (Table 1). There were no significant differences regarding duration of ventilation, duration of ITU stay and morbidity in the two groups. There was reduction in cost associated with use of aprotinin.

Table 1.

| | Group I (aprotinin) | Group II (control) |
|----------------------------|---------------------|--------------------|
| Age (years) | 38 ± 5 | 39.6 ± 12 |
| Wt (Kg) | 54 ± 13 | 56 ± 9 |
| BSA (m ²) | 1.52 ± 0.2 | 1.56 ± 0.1 |
| CPB (min) | 104 ± 19 | 104 ± 16 |
| AXC (min) | 83 ± 14.5 | 75 ± 8.7 |
| Surgery duration | 180 ± 35 | 198 ± 24 |
| Blood products (units) | 1.3 ± 1.5 | 3.2 ± 2* |
| Drainage (ml) in 24 h | 203 ± 35 | 490 ± 104* |
| Pre op Hb (gm%) | 13.5 ± 2 | 13.5 ± 1 |
| Post op Hb (gm%) at 24 hrs | 11.8 ± 1.5 | 10.5 ± 1.5 |

* $P < 0.05$

Conclusion: The routine use of aprotinin 1 million KIU in coronary artery bypass grafting with left internal mammary artery has been recommended to reduce cost and transfusion requirements [1]. Prophylactic administration of ultra low dose aprotinin reduced transfusions in patients undergoing repeat operations or complex procedures [2]. Our data support routine use of ultra low dose aprotinin in "high risk" two-valve replacement surgery to reduce postoperative blood loss and to decrease the number of blood or blood product transfusions.

References:

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Monitoring

027

Early recognition of low cardiac output after cardiac surgery by using the arterial pressure waveform analysis

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Introduction: A less-invasive method for monitoring cardiac output (CO) has been developed. This new method, called PRAM (pressure recording analytical method), can derive beat-to-beat values of CO from the arterial pressure waveform analysis [1]. The concept behind the measurement and monitoring of CO based on the analysis of arterial blood pressure waveform is not new and similar approach has been studied by several authors. However, PRAM does not require any external calibration and can be implemented in various conditions of flow [1]. Our purpose were (1) to assess the accuracy of PRAM in cardiac surgery using the bolus thermodilution (TD) and the roller pump device (RP) as the reference gold standard methods; and (2) to identify patients developing low cardiac output during weaning from extra-corporeal circulation (ECC).

Method: In 20 patients undergoing cardiac surgery, CO values obtained by PRAM from the analysis of radial artery were compared with TD (a series of five thermal indicator injections) before and after ECC, and with the RP readings during ECC before and after aortic clamping. During spontaneous circulation, PRAM results were based on the simultaneous evaluation of the pulsatile and continuous components of cardiac output flow as expressed by the arterial waveform [1]. During ECC, in the absence of cardiac activity, a sinusoidal waveform was produced by the pump, representing only the continuous component of flow. Thus, PRAM flow measurements during ECC were based on the determination of the stroke volume (obtained by

each sinusoidal wave), multiplied by the number of sinusoidal waves (i.e. the number of the roller pump revolutions per minute). No clinical decision was taken based on PRAM results.

Results: The estimates of blood flow measured by PRAM closely agreed with TD ($r^2 = 0.71$; $P < 0.0001$; at Bland-Altman analysis mean = 0.06, +2SD = 0.74, -2SD = 0.66) and simultaneous RP readings ($r^2 = 0.70$; P -value < 0.0001 ; at Bland-Altman analysis mean = 0.09, +2SD = 0.71, -2SD = 0.53). During weaning from ECC, two patterns of haemodynamic adaptation were documented by PRAM following resumption of cardiac contraction. (1) Most patients had a rapid and stable recovery of CO (a reduction $< 10\%$ as compared to ECC flow) at the decreasing of RP-infused volumes. (2) Four patients showed a marked fall in CO $> 10\%$ up to 40% and required longer ECC assistance, weaning time and inotropic support.

Conclusions: PRAM seems to provide accurate and continuous quantification of flow during each phase of cardiac surgery and may allow early recognition of low CO during weaning from ECC.

Reference:

- 1 Romano SM, Pistolesi M. Assessment of cardiac output from systemic arterial pressure in humans. *Crit Care Med* 2002; **30**: 1834–1841.

123

Accuracy of arterial (or transthoracic) thermodilution cardiac output during aortic counterpulsation

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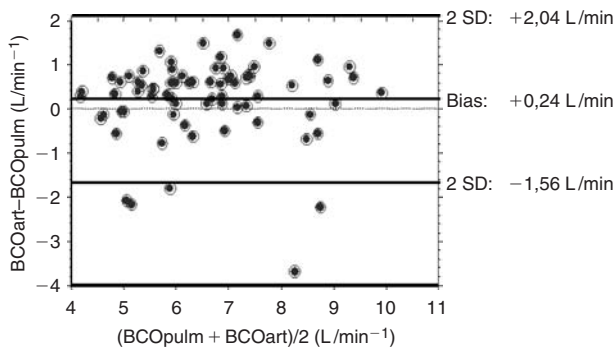
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Introduction: Previous investigators reported a satisfactory agreement between arterial (or transthoracic) (BCOart [PiCCO, Pulsion]) and standard

pulmonary artery bolus thermodilution (BCOpulm) in critically ill patients [1,2]. It is unknown, however, whether BCOart is also reliable under the condition of intra-aortic balloon counterpulsation (IABP). It was the aim of this study to approve accuracy of BCOart in patients subjected to IABP.

Method: Eight patients, 37 to 80 (mean 54.8) years old, scheduled for IABP prior to coronary artery bypass surgery were included. A thin thermistor was introduced through the pressure channel to the tip of the 8Fr IABP device, and the pump rate set at 1:1. Cardiac output (CO) was assessed under haemodynamic steady state conditions before surgery and hourly for 8 to 10 hours after admission to the intensive care unit. BCOpulm and BCOart were determined using the average cardiac output (CO) value after 3 to 5 right atrial bolus injections of 10 (BCOpulm) or 15 mL (BCOart) iced saline, respectively. Agreement of BCOart and BCOpulm was assessed by Bland Altman analysis.

Results: Seventy-three data pairs were obtained. Mean BCOpulm was 6.41 (range 4.0 to 10.1) and mean BCOart 6.64 (4.0 to 10.1) L/min. Bias was +0.24 L/min, the limits of agreement ($\pm 2SD$) ± 1.8 L/min, and the mean error (2SD/mean [(BCOpulm + BCOart)/2]) 27.6%. At BCOpulm < 6 L/min, bias was +0.48 L/min, the limits of agreement ± 0.86 L/min and the mean error 15.9%, whereas at BCOpulm > 6 L/min, bias was +0.06 L/min, the limits of agreement ± 2.2 L/min and the mean error 29.9%.



Conclusion: In accordance with previous reports in patients without IABP [2], the agreement we found between BCOart and BCOpulm during IABP was satisfactory. In the sub group of CO values < 6 L/min, the overestimation of BCOart was higher but with better precision.

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055

Which is the optimal device for carbon dioxide de-airing of the cardiothoracic wound and how should it be positioned?

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Introduction: Carbon dioxide (CO₂) insufflation into the cardiothoracic wound is used in cardiac surgery in order to improve de-airing of the heart and great vessels. The objective of this study was to compare the de-airing efficiency of various insufflation devices.

Method: De-airing was assessed by measuring the remaining air content (O₂-analysis) at the right atrium in a full-size torso with a cardiothoracic wound cavity and in 10 patients undergoing cardiac surgery. CO₂ was insufflated into the wound cavity model at 2.5, 5, 7.5, and 10 L min⁻¹ with a multi-perforated catheter, and a 2.5 mm tube with either a gauze sponge or a gas-diffuser of polyurethane foam at its end. The devices were tested when positioned at the level of the wound opening and 5 cm below, and after exposure to fluid.

Results: With the multi-perforated catheter, the gauze sponge, and the gas-diffuser, the lowest median air content in the torso was 8.4%, 2.5%, and 0.3%, respectively ($P < 0.001$, Wilcoxon's test), when positioned inside the wound cavity. When exposed to fluid, the gauze sponge and the multi-perforated catheter immediately became inefficient (70% and 96% air, respectively), whereas the gas-diffuser remained efficient (0.4% air). During

surgery the gas-diffuser provided a median air content of 1.0% at 5 L min⁻¹, and 0.7% at 10 L min⁻¹.

Conclusions: For efficient de-airing, CO₂ has to be delivered from within the wound cavity. The gas-diffuser was the most efficient device. In contrast to a gas-diffuser, a multi-perforated catheter or a gauze sponge is unsuitable for CO₂ de-airing since they will stop functioning when they get wet in the wound.

References:

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039

Evaluation of a new probe for continuous intravascular blood gas monitoring in jugular venous and arterial blood

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Introduction: Recently, the manufacturer of the only commercially available continuous intravascular blood gas monitoring system introduced a new, pure optode probe, the Paratrend P7+ (Diametrics Medical, High Wycombe, UK). We performed a comparison between intermittent blood gas analyses (IBGA) using a conventional blood gas analyser (ABL5, Radiometer, Copenhagen) and the results of the P7+ probe, by simultaneous measurements. The aim of our study was to evaluate the applicability and performance of the new probe for jugular venous and arterial blood gas determinations [1].

Method: Ten patients (7 male, 3 female) aged 68.9 ± 5.6 years old, ASA II–III, undergoing carotid endarterectomy under general anaesthesia were studied. After surgical exposure of the internal carotid artery, a 6.0 Fr introducer sheath was inserted into the ipsilateral jugular vein. The tip of P7+ was advanced through and placed into the jugular bulb. Oxygen was administered to the patient at inspiratory oxygen concentration (F_IO₂) of 1.0. Before surgical closure of the wound the probe was repositioned backwards in protective tubing. All patients were extubated and transferred to ICU where supplemental oxygen at F_IO₂ 0.7 to 0.3 was administered through a Venturi mask. A 20G arterial catheter was introduced in the radial artery and patient's own P7+ probe was advanced through it. Simultaneous recording of P7+ readings and IBGA using commercially prepared syringes (Quik A.B.G.TM, MarquestTM) were performed at both insertion sites. Statistical analysis with the method of Bland and Altman was employed.

Results: The P7+ probe could be placed in the jugular vein and subsequently in the radial artery with neither malfunction due to kinking or "wall effect", nor complications. Mean monitoring time was for jugular vein 40 ± 4.5 min and for radial artery 420 ± 45 min. We analysed a total of 97 parallel blood gas samples (43 venous and 54 arterial). The ranges for IBGA were: PO₂ 3.7 to 47.3 kPa (mean 17.3 ± 12.7), PCO₂ 4.5 to 7.5 kPa (mean 5.7 ± 0.5), and pH 7.25 to 7.5 units (mean 7.38 ± 0.04). The coefficient correlation (*r*) between continuous and conventional blood gas measurements was for PO₂ 0.97, for PCO₂ 0.63, and for pH 0.6. The calculated bias and precision values (1 SD of bias) were for PO₂ 0.82/3.4 kPa, for PCO₂ -0.51/0.48 kPa and for pH 0.052/0.03 units, respectively.

Discussion: According to our data, the PO₂ values as measured by the new Paratrend P7+ probe and conventional blood gas analyser, correlated sufficiently for both jugular and arterial blood. The precision of the sensor for PO₂ was less satisfactory than for PCO₂ and pH.

Reference:

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117

Angle dependency in the ultrasound modality displacement evaluated in a dynamic test phantom

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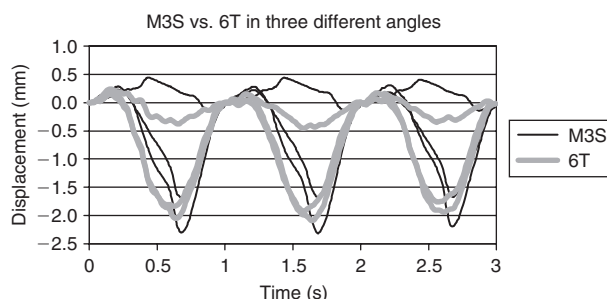
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Introduction: Tissue velocity imaging (TVI) and derived parameters (tissue deformation, deformation rate and tissue displacement) have recently been

introduced in clinical practice to provide quantitative assessment of myocardial deformation and thereby contractility [1]. Transoesophageal echocardiography (TOE) with TVI is a promising future tool for perioperative monitoring of myocardial performance. TVI data is based on the Doppler equation and therefore angle dependent. This may cause an error, which must be evaluated before implementation of TVI in experimental and clinical practice. Thus it is important to evaluate the accuracy of TVI in an experimental *in vitro* model. The aim of the present study was to investigate angle dependency in a TVI phantom using a TOE and a transthoracic probe.

Method: Our dynamic test phantom consisted of a cylinder shaped "tissue-like" mimicking core of a polyurethane alloy. This core was compressed by a shaker in a controlled setting. The compression reduced the height and increased the radius. This results in radial deformation (equal for all radial directions) perpendicular to cylinder height. The measured displacement should be equal for all segments of the phantom, in the same distance from phantom centre. All measurements were done using Vivid-7 echocardiographic equipment and dedicated software (GE-Ultrasound, Horten, Norway). The transthoracic transducer (M3S) and the transoesophageal transducer (6T) was tested and compared for angle dependency.

Results: The figure displays the results from the TOE and the transthoracic probe. Displacement was measured at 0, 45 and 90 degrees from transducer view. Only 90 degrees showed significant TVI (displacement) measurement error.



Discussion: The results show that the displacement measured with the M3S or the 6T does not differ. Both transducers show some angle dependency. The use of TVI has to be further investigated before used in clinical practice, but the error seems to be minor at measurement angles below 45 degrees from transducer view.

Reference:

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Predictions and Outcome

033

Does preoperative activity of the autonomic nervous system predict hypertension during CABG?

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Introduction: Achievement of haemodynamic stability is a major problem in cardiac surgery. Perioperative hypertension is a frequent complication of CABG [1]. The purpose of this study was to determine the role of preoperative autonomic nervous system (ANS) activity in the appearance of intraoperative hypertension (IHP) during CABG.

Method: The active tilt-test was performed the day before operation in 75 ASA physical status III and IV patients undergoing CABG surgery. Power spectral analysis of the short-term records (5 min) of heart rate variability has been used to study ANS during the active tilt-test. High Frequency (HF), Low Frequency (LF) in normalized unit, LF/HF and Total Power were analysed. The preoperative treatment for all patients included beta-blockade (atenolol), nitrate and ACE-inhibitors. The premedication included diazepam 10 mg, trimeperidine hydrochloride 20 mg and atropine 0.3 mg. Anaesthesia was induced with midazolam 0.1–0.15 mg/kg, fentanyl 4–6 µg/kg, ketamine 0.7 mg/kg and maintained with halothane/O₂, pipecuronium bromide and fentanyl. We diagnosed IHP when MAP was more than 110 mmHg, or/and SAP or DAP increased more than 20% from preoperative level. Statistical analysis was performed using Student's *t*-test.

Results: The active tilt-test has shown that 58.7% of patients (gr. 1, n = 44) had high activity of sympathetic nervous system (SNS), 18.7% (gr. 2, n = 17) had high activity of parasympathetic nervous system (PSNS) and 22.6% (gr. 3, n = 14) had a balanced type of responsive ANS. Total incidence of intraoperative hypertension (IHP) was 49% (n = 37). There were no cases of IHP in gr. 3. IHP was registered in 23 patients in gr. 1 (52.7%, *P* < 0.05 versus gr. 3) and in 14 patients in gr. 2 (82%, *P* < 0.05 versus gr. 3).

Discussion: Perioperative hypertension during CABG may be caused by high activity of SNS. Preoperative beta-blocking medications must control the increased SNS activity [2]. However more than 80% patients need anti-hypertensive therapy during CABG [1]. Our study has shown that a reduced activity of SNS not always reduces the frequency of intraoperative hypertension. It is possible that another mechanism is responsible for elevation blood pressure. This hypothesis had confirmed that the incidence IHP was registered in patients with high PSNS activity.

Conclusion: We suppose that for patients undergoing CABG, preoperative high activity of the SNS does not always determine intraoperative hypertension. Preoperative high activity PSNS may accompany intraoperative hypertension. Hypertension is a minimal probability in patients who have a balanced type of ANS response.

References:

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- 2 Wallace A, Layug B, Tateo I, et al. Prophylactic atenolol reduces postoperative myocardial ischemia. McSPI Research Group. *Anesthesiology* 1998; 88: 7–17.

062

Evaluation of risk factors to predict haematocrit decrease in CPB

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Introduction: Many efforts have been made in cardiac surgery to avoid allogeneic RBC transfusion. However blood product transfusion after cardiopulmonary bypass (CPB) is a common event. Its cause is multifactorial but the haemodilution effect of the extracorporeal circuit on blood volume has been implicated as one of the major contributions for the need of transfusion. Nevertheless a low haematocrit (hct) during CPB has been associated with increased difficulty of weaning from CPB and with an increased postoperative morbidity and mortality [1].

The objective of the current study was to identify the clinical and demographic variables that let us determine patients at risk of having a critically low hct during CPB.

Method: We prospectively followed up all patients undergoing cardiac surgery under CPB in a 1 year period (334 patients). The CPB prime volume in all cases was 1450 mL. We determined the hct decrease after CPB haemodilution by measuring hct just before cannulation, and just after beginning CPB. We evaluated in a multivariate analysis, using a multiple linear regression model, which factors other than the haemodilution would contribute to the hct decrease, such as age, sex (0 = men, 1 = women), body surface area (BSA), body mass index, ejection fraction, kind of surgery (0 = coronary, 1 = valvular, 2 = mixed, 3 = other), medical history of hypertension or diabetes, and previous administration of beta-blocking agents, calcium channel blockers, nitrates, diuretics, angiotensin-converting enzyme inhibitors and inotropes (0 = no, 1 = yes).

Results: We obtained a statistically significant predictive model that includes female sex, low BSA, low previous hct, β blockers and coronary surgery as risk factors implicated in hct decrease on CPB.

Hct on CPB = $-11.1 + 0.7 \times \text{hct} + 5.8 \times \text{BSA} - 0.7 \times \beta \text{ block} - 0.8 \times \text{sex} + 0.3 \times \text{surgery}$. ($r^2 = 0.802$ and $P < 0.001$).

The cross-validation with 20% of the cases got a r^2 of 0.788 that means a shrinkage of 1.3%.

Discussion: The applicability of our model in predicting the hct decrease is highly accurate and it led us to identify patients at risk in order to use more aggressive measures to minimize intraoperative haemodilution and to prevent critically low hct during CPB.

Reference:

- 1 R.C. Groom. High or low hematocrits during cardiopulmonary bypass for patients undergoing coronary artery bypass graft surgery? An evidence-based approach to the question. *Perfusion* 2001; **16**: 339–343.

098

Even low levels of preoperative troponin I predict postoperative myocardial ischaemia and cardiac complications in vascular surgery

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Introduction: Cardiac troponin I (cTnI) is a highly sensitive and specific marker of myocardial injury in patients who have undergone vascular surgery. Sixty percent of these patients have severe coronary artery diseases and commonly have postoperative myocardial ischaemia [1]. We evaluated the association between a preoperative low positive level of cTnI without unstable angina and postoperative cardiac complications (CC) after vascular surgery.

Method: Fifty-five consecutive patients with or at high risk for coronary artery disease undergoing carotid endarterectomy or abdominal aortic surgery were prospectively studied. The cTnI levels were measured with an Access AccuTnI assay (Beckman Coulter) the day before the surgery, 6 hours after the procedure and on postoperative days 1, 2 and 5. The AccuTnI assay was a new generation test with a functional sensitivity known at 0.02 ng mL^{-1} , upper reference limit 99 percentile = 0.04 ng mL^{-1} , myocardial infarction (MI) = 0.5 ng mL^{-1} . The level of preoperative cTnI defined two groups of patients: either $<0.02 \text{ ng mL}^{-1}$, or between 0.02 and 0.5 ng mL^{-1} . We have compared these two groups for the incidence of increased cTnI level in the first 48 h, and incidence of MI and CC (MI, congestive heart failure and severe arrhythmia). Statistical analysis consisted of ANOVA, and Fisher's exact test when appropriate.

Results: 14 patients (25%) had preoperative cTnI $\geq 0.02 \text{ ng mL}^{-1}$ (0.02 to 0.07) and the cTnI was $<0.02 \text{ ng mL}^{-1}$ in 41 patients (75%). An early postoperative increased of cTnI was observed in 8 patients (57%) of the $\geq 0.02 \text{ ng mL}^{-1}$ cTnI group and only 4 patients (10%) in the other group. The relative risks for MI and CC are presented in Table 1. No other preoperative factor was found to predict postoperative ischaemic complications. All CC during the postoperative period occurs in patients with increased cTnI during the first postoperative 48 h. Only one death occurred in the cTnI positive group.

Table 1. Predictive value of preoperative cTnI for postoperative MI and CC.

| Preoperative cTnI | N patients | MI | CC |
|---------------------------------------|-------------|-------------|-------------|
| $<0.02 \text{ ng mL}^{-1}$ | 41/55 (75%) | 2/41 (5%) | 3/41 (7%) |
| $0.02\text{--}0.5 \text{ ng mL}^{-1}$ | 14/55 (25%) | 4/14 (28%)* | 5/14 (35%)* |
| Relative risk | | 5.84 | 4.89 |

* P value < 0.05 .

Discussion: The study shows that even low levels of preoperative cTnI can identify patients at high risk of developing postoperative CC after vascular surgery. Besides, postoperative monitoring of cTnI is useful for detecting precociously severe myocardial ischaemia, which is associated with delayed CC.

Reference:

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028

Estimation of morbidity risk factors in intensive care unit: a Bayesian discriminant approach

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Introduction: Most risk stratification scores are based on unmodified preoperative patient variables. However, there are a number of intra- and postoperative physiologic variables that might influence operative morbidity. Higgins and colleagues evaluated the relative contribution of preoperative condition, operating room events, and physiologic measurements at Intensive Care Unit (ICU) admission to outcome [1]. Our goals were: 1) to evaluate the validity of Cleveland Clinic Scores in our patients population; and

2) to develop a Bayesian risk model able to predict the independent risk factors of morbidity after coronary artery bypass graft (CABG).

Method: We selected over 80 perioperative variables that could potentially be associated with postoperative morbidity, and analysed the influence of each risk factor on outcome at ICU discharge. 1,090 consecutive adult patients underwent CABG were analysed. A training data set (740 patients, who had surgery between January 2000 and December 2001) was used for designing a Bayesian probability model. A testing data set (350 patients, operated on between January and December 2002) was employed for evaluating the prognostic power of the Bayesian approach and comparing it with Cleveland Clinic Scores. The classification performances of both Cleveland Clinic Scores and Bayesian model were assessed by ROC curve analysis.

Results: The in-ICU morbidity rate was 20.5% (223/1090). The Cleveland Clinic Scores had a good discriminant power, and the comparison of two ROC areas gave no statistical significance ($P < 0.48$). At Bayesian discriminant analysis, stepwise feature selection procedure stopped with 12 variables able to discriminate morbidity: 1) postoperative decreased oxygen delivery and 2) need for inotropic support after surgery were the most significant predictive variables. The Bayesian model showed an excellent ability to recognize morbidity risk (sensitivity and specificity = 72%), and the comparison of areas enclosed by ROC curves between Bayesian and Cleveland Clinic Scores showed high statistical significance ($P < 0.001$).

Conclusions: Most prediction rules use sequential numerical risk scoring to quantify the patient's prognosis, and when appropriately used may represent an advanced form of audit. Cleveland Clinic Score seemed to be a suitable tool for predicting morbidity in our CABG patients. The Bayesian approach identified the major clinical predictors of morbidity and was a better-designed risk prediction score for discriminating patient's subsequent progress.

Reference:

- 1 Higgins TL, Estafanous FG, Loop FD, et al. ICU admission score for predicting morbidity and mortality risk after coronary artery bypass grafting. *Ann Thorac Surg* 1997; **64**: 1050–1080.

089

The impact of age on outcome of adult cardiac surgery patients

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Introduction: The adult cardiac surgery population is becoming increasingly aged. Advanced age has been shown to correlate with co-morbidity, increased hospital stay and adverse outcome [1]. We have analysed our recent database in order to establish relative risk of surgery in the elderly, and to identify areas amenable to improvement.

Method: We compared 411 patients aged over 75 years (Group 1) with 1466 patients aged 60–75 yrs (Group 2), undergoing cardiac surgery over 30 months. We recorded the minimum dataset for the Society of Cardiothoracic Surgeons of Britain and Ireland. All surgical procedures were included.

Data from the 2 groups were compared using Pearson chi-squared statistic for categorical and Mann-Whitney U test for continuous variables. The association between mortality and each variable was calculated using logistic regression. Multivariate modelling was used to identify the role of age as a risk factor for in-hospital mortality. Variables were added to the model in a step-wise sequence. Variables remaining in the model were tested consecutively for evidence of interaction with age. The analysis was carried out using STATA Vs 6.0.

Results: Group 1 patients had a significantly greater incidence of the following ($P < 0.001$); female gender, low BMI, severe cardiac symptoms including angina, breathlessness, arrhythmia and previous smoking. There was no difference in the incidence of diabetes, hypertension, renal, respiratory, peripheral vascular and cerebrovascular disease. Simple and age-adjusted EuroSCORE and Parsonnet scores were significantly higher ($P < 0.01$) in Group 1. Group 1 patients had a higher incidence of aortic valve and combined CABG and valve surgery ($P < 0.001$), longer bypass and cross clamp times ($P < 0.01$) and a higher incidence of non-elective surgery ($P < 0.001$). In the univariate analysis, age >75 was associated with a higher in-hospital mortality risk (Group 1–11%; Group 2–5%; $P < 0.001$).

Discussion: We found that older patients had double the mortality risk of the younger patients. Older patients are more likely to suffer severe cardiovascular symptoms and more urgent operations. These independent predictors of adverse outcome may be amenable to better preoperative medication. Older patients undergo longer operations and more combined operations which also correlate with poor outcome. This may be altered by more rigorous perioperative decision making.

Reference:

- 1 Mortasawi A, Amrich B, Rosendahl U, et al. Is age an independent determinant of mortality in cardiac surgery as suggested by the EuroSCORE? *BMC Surg* 2002; 2: 8.

017**Long term outcome of patients who require renal replacement therapy after cardiac surgery**

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Introduction: Acute renal failure is one of the most serious complications of cardiac surgery. We studied the long term survival and quality of life of patients with a complicated postoperative course after cardiac surgery requiring renal replacement therapy, since they represent a heavy burden on hospital resources.

Method: Out of 7846 consecutive cardiac surgical patients, 126 (1.6%) required postoperative renal replacement therapy. Their preoperative status and hospital course was compared with patients who had no need of postoperative renal replacement therapy. Only patients who were on preoperative dialysis were excluded from this study. A multivariate forward stepwise analysis was used to identify predictors of renal replacement therapy (SAS 1999 programme for statistical analysis). Long term (34 ± 18 months) follow up information was collected and quality of life and prevalence of deafness (because we use high doses furosemide in patients with an oligoanuric state) were assessed. The ethical committee approved the study and patients signed a written informed consent.

Results: Hospital mortality in the study group was 84/126 (66.6%) versus 118/7720 (1.5%) in the control population ($P < 0.001$). Predictors of renal replacement therapy (with odds ratio and 95% CI) were: blood transfusion (OR: 28.7 95% CI 8.9–92.8), emergency surgery (OR 4.2 95% CI 2.3–7.6), preoperative renal impairment (OR 3.7 95% CI 2.2–6.1), reopening (OR 2.9 CI 1.6–5.1), mitral valve disease (OR 2.6 CI 1.6–4.2), low ejection fraction (OR 2.1 CI 1.3–3.6), IABP positioning (OR 1.8 CI 1.07–3.2) and duration of CPB (OR 1.007 per minute 1.002–1.01).

Patients who underwent renal replacement therapy and were discharged from the hospital had an excellent long term follow up with 70% survival at 34 ± 18 months, with only 9.5% of survivors on dialysis, 28.6% complaining of moderate deafness and no other reported limitation in daily living.

Discussion: Blood transfusion represented a strong predictor of postoperative renal replacement therapy. This could be attributed to the known transfusion related renal damage or to the epi-phenomenon of a pre-existent anaemia and poor general condition with hypoxia affecting the kidney perioperatively. The hospital mortality of patients requiring renal replacement therapy is high. The long term survival of patients discharged from the hospital is excellent (70% at 3 years) with good quality of life.

Reference:

- 1 Chertow GM, Lazarus JM, Christiansen CL, et al. Preoperative renal risk stratification. *Circulation* 1997; 95: 878–884.

070**Is measuring cerebral oxygenation during off-pump cardiac surgery associated with ICU and hospital length of stay?**

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Introduction: Due to the increased risk of neurological complications related to cardiac surgery and extracorporeal circulation, monitoring of cerebral oxygenation during these procedures is highly significant. However the risk of complications is also noted during off-pump surgery. The use of continuous non-invasive cerebral oxygenation monitoring with near-infrared spectroscopy may affect the postoperative patient condition and ICU and hospital length stay [1].

Method: 42 patients with good heart function chosen for off-pump CABG operations were included for the study, having local ethical committee approval and patient informed consent. Patients were randomized and divided into two groups of 21, control (C) and investigated (I). Group I patients had bilateral frontal electrodes to measure rSO₂ using INVOS 4100 apparatus (Somanetics). Values of rSO₂ ≥75% compared to the pre-induction value was maintained by using blood pressure elevation (fluids and medicaments), PaCO₂ change and surgical technique modification (stabilizer position). The anaesthetic method was the same for both groups. Artificial ventilation time, ICU and hospital length of stay, serious neurological complications after the operation and frequency of necessary rSO₂ elevation interventions in group I were observed. ANOVA and Student's *t*-tests were used.

Results: Both groups were homogeneous regarding age, sex, number of bypasses and operation time. Artificial ventilation after the operation (5.7 h vs. 11.9 h in group C $P < 0.05$), ICU (47.2 h vs. 58.2 h in group C $P < 0.05$) and hospital length stay (6.8 day vs. 8.4 day in group C $P < 0.05$) were various. There was one ischaemic stroke in group C. There were no deaths. There were rSO₂ interventions in 50% of group I.

Discussion: The posterior heart wall exposure by the surgeon during the off-pump procedure often leads to transient episodes of CVP elevation and blood pressure decrease and as a result, perfusion pressure drops and cerebral oxygenation decreases [2]. Typical ICU extubation criteria were chosen after the operation and ICU stay length was related to the patient's condition. Due to the use of INVOS 4100 and cooperation with the surgeon the reduction of postoperative ICU stay may lead to a shorter hospital length of stay. Possible economic benefit and decrease of neurological complications such as frequency of stroke and the degree of cognitive dysfunction in off-pump operations using cerebral oxygenation monitoring requires further investigations.

References:

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Pain and Epidural**011****Failure rate and rate of minor complications of high thoracic epidural anaesthesia (HTEA) for cardiac surgery**

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Introduction: Although the major risk, still unreported, of HTEA for coronary surgery is the development of epidural/spinal haematoma leading to paraplegia, this technique has indeed a failure rate and a rate of minor complications reported only by a few authors.

Method: To determine the failure rate of HTEA and the rate of minor complications, we retrospectively reviewed the database of all the patients undergoing HTEA for coronary surgery at this Institution from November 1999 to December 2003. In the morning of surgery, in the OR, in the sitting position, HTEA was performed (max three attempts) at the T1–T2 or T2–T3 interspace employing the median approach and the hanging-drop technique, inserting a 19-gauge flexible-tip polyurethane catheter through a 17-gauge Tuohy needle. Fifteen min after bolus (0.1 mL Kg⁻¹ LA plus opioid) loss of sensation

to cold was tested. Definition of failed puncture was either inability to find the epidural space (Fail. space) or to place the catheter (Fail. cath.). Failed block was described either as an incomplete block (less than T1–T7) as assessed by ice test preoperatively, or evidence of insufficient sympathetic blockade (HR >80 beat min⁻¹ and hypertension at sternotomy), or poor analgesia after surgery). Minor complications included dural puncture, bloody tap and vagal symptoms during puncture.

Results:

| Pts | Fail space | Fail cath. | Fail block | Dural puncture | Blood tap |
|-----|------------|------------|------------|----------------|-----------|
| 462 | 3.8% | 1.0% | 2.1% | 1.0% | 1.0% |

Discussion: Rate of failed puncture (Fail space plus Fail cath.), even subtracting pts returned to the supine position for vagal symptoms, is higher than reported [1] and could reflect difference in technique and the fact that even the junior anaesthetists performed HTEA. Failed block included not only scarce postoperative analgesia but also insufficient sympathetic blockade, a cornerstone of HTEA not considered by others [1,2]. Blood tap (1%), even if venous, prompted us to a 24-hour delay in surgery, and dural puncture required

a change in interspace. In conclusion the rate of failure and minor complications lower the efficacy of HTEA to 91% of the pts submitted to epidural puncture. However, so long as a strict protocol for anticoagulation is followed, and awaiting future studies to demonstrate a better patient outcome, we consider HTEA an effective adjunct for anaesthesia for coronary surgery.

References:

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087

High thoracic epidural anaesthesia (HTEA) for cardiac surgery in patients with respiratory disease

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Introduction: Preoperative respiratory dysfunction is a significant risk factor for increased post-cardiac surgery morbidity and mortality [1]. We evaluated the effects of HTEA on the postoperative course of patients with preoperative respiratory disease undergoing elective cardiac surgery.

Method: Between March 2001 and November 2003, 270 patients scheduled for cardiac surgery at our institution were enrolled in a prospective randomized trial comparing an opioid-based balanced general anaesthetic (GA, 130 patients) with a HTEA plus general anaesthesia technique (140 patients). Patients with the following criteria were included: COPD (GOLD stage I–III), obesity (BMI > 30 kg/m²), smoking (>30 packs-years), any other clinically significant pulmonary disease. On the day of surgery, a thoracic (C7–T4) epidural catheter was inserted in the HTEA patients. Epidural anaesthesia was induced with bupivacaine or levobupivacaine 0.25% 10 mL + morphine 2.5 mg and maintained with bupivacaine or levobupivacaine 0.5% + morphine 0.02% 1–5 mL/hour. HTEA patients received epidural bupivacaine or levobupivacaine 0.125% + morphine 0.012% 1–5 mL/hour for postoperative analgesia. GA patients were given an iv. opioid (morphine, tramadol) bolus when needed. Patient and surgical characteristics, postoperative course, complications and mortality data were collected. Statistical analysis was performed with the ANOVA and chi-squared test.

Results: There were no differences in patients and surgical characteristics. HTEA patients had shorter awakening (16 vs. 84 minutes) and intubation (11 vs. 23 hours) times ($P < 0.001$). In the GA group, there was a higher incidence of postoperative sinus tachycardia (20% vs. 9%, $P < 0.05$) and anti-arrhythmic drugs use (48% vs. 28%, $P < 0.05$). GA group patients had a higher incidence of atelectasis (segmental or plate-like) on the post-extubation chest X-ray (16% vs. 6%, $P < 0.05$). Postoperative PaO₂/F_iO₂ ratio was higher in the HTEA group before (299 vs. 265 mmHg, $P < 0.05$) and soon after extubation (333 vs. 278 mmHg, $P < 0.01$). VAS scores after extubation were significantly lower in the HTEA group (0.5 vs. 4.5, $P < 0.001$) as well as the need for iv. opioids (2 vs. 89%, $P < 0.001$). There were 3 dural punctures and 1 bloody tap without any immediate or delayed neurological signs and symptoms.

Discussion: HTEA is a technique that can benefit cardiac surgery patients. In our study, HTEA provided excellent pain control, allowed earlier extubation, decreased the incidence of supraventricular tachyarrhythmias and better preserved respiratory function. Patients with respiratory disease undergoing cardiac surgery can benefit from HTEA with no significant catheter-related complications.

Reference:

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025

Reduction of pulmonary function after resection: less than expected in COPD patients

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Introduction: Patients often undergo limited lung resection (LR) instead of lobectomy for non-small cell lung cancer (NSCLC) because of a low FEV₁. However paradoxical improvement of pulmonary function after LR surgery has been reported in some patients, especially those with advanced emphysema [1]. Experience with Lung Volume Reduction Surgery suggests that predicted

postoperative FEV₁ (ppoFEV₁) may underestimate pulmonary function after lung resection [2]. Our aim was: 1) to study changes in pulmonary function after LR, 2) to compare predicted postoperative FEV₁ and diffusing capacity of the lung for carbon monoxide (DLCO), with values measured 6 months after surgery and 3) to identify which preoperative pulmonary function test (PFTs) may help to predict patients likely to have less decrease in postoperative pulmonary function.

Method: Seventy three patients undergoing lung resection were studied. We prospectively studied: 1) PFTs (FEV₁, DLCO, FEV₁/FVC ratio) prior to and 6 months after surgery; 2) ppoFEV₁ and ppoDLCO calculated by the perfusion scan. Preoperative, predicted postoperative and 6 months postoperative values were compared.

Results: A loss of 15 ± 17% of FEV₁ and 20 ± 17% of DLCO were observed 6 months after resection. Correlation with the predicted postoperative values were: $r = -0.787$ and $r = -0.493$ respectively ($P < 0.001$), although measured values were higher than the predicted (280 ± 50 ml and 8 ± 2% respectively). Preoperative FEV₁ (as % of predicted) was the best correlated parameter to functional impairment after resection ($r = -0.421$, $P < 0.01$). The decrease of FEV₁ (in mL/removed segments) was 75 mL/segment if preoperative FEV₁ > 60% and 26 mL/segment if FEV₁ < 60%.

Table 1

| | Preoperative | Predicted postoperative | 6 months postoperative |
|-----------------------|--------------|-------------------------|------------------------|
| FEV ₁ (%) | 68 ± 15 | 53 ± 12 | 58 ± 14* |
| FEV ₁ (L) | 2.20 ± 0.56 | 1.73 ± 0.50 | 1.89 ± 0.63 |
| DLCO (%) | 73 ± 18 | 54 ± 18 | 60 ± 15* |
| FEV ₁ /FVC | 67 ± 10 | | 67 ± 11* |

Mean values ± SD; Pearson's correlation test * $P < 0.05$

Discussion: A good correlation was found between postoperative predicted PFTs and the measured values 6 months after surgery, the last being underestimated. A decrease in postoperative FEV₁ after LR surgery was lower in severe COPD patients. These findings suggest that properly selected patients with a low preoperative FEV₁ could undergo lung resection.

References:

- Carretta A, Zannini P, Puglisi A, et al. Improvement of pulmonary function after lobectomy for non-small cell lung cancer in emphysematous patients. *Eur J Cardiothorac Surg* 1999; **15**: 602–607.
- Edwards JG, Duthie DJ, Waller DA. Lobar volume reduction surgery: a method of increasing the lung cancer resection rate in patients with emphysema. *Thorax* 2001; **56**: 791–795.

073

Tissue Doppler evaluation of myocardial function during high thoracic epidural analgesia

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Introduction: The aim of the present study was to evaluate myocardial function using Tissue Doppler echocardiography imaging during high thoracic epidural analgesia (HTEA) before coronary artery bypass graft surgery (CABG). HTEA of the segments Th1–4 attenuates the sympathetic response during coronary heart surgery, and is believed to reduce the risk of perioperative myocardial ischaemia and to improve left ventricular (LV) function. Tissue Doppler derived modalities have appeared promising for detailed information on systolic and diastolic myocardial function [1]. Tissue tracking, a Tissue Doppler based modality, depicts the myocardial baso-apical displacement, which correlates with global left ventricular function [2]. We therefore hypothesized that tissue tracking would detect changes in myocardial performance during test and induction of HTEA.

Method: Six patients, one female and five male, scheduled for elective CABG, were included in the study after having signed informed consent. An epidural catheter (Th1–2 or 2–3) was inserted the day before surgery. On the day of surgery, the patients underwent transthoracic echocardiography (TTE) immediately before catheter test with 3 mL of lidocaine/epinephrine 2% and further induction of analgesia with 7 mL of bupivacaine (4.75 mg/mL)/sufentanil (2.5 µg/mL). Analgesia from Th1 to Th10 was achieved after 20 minutes, and TTE thereafter repeated before induction of standardized general anaesthesia. All recordings were carried out using Vivid-7 echocardiography technology with activated Tissue Doppler and high frame rate >216 frames per second. Data were post-processed for assessment of tissue tracking using dedicated software. Regional systolic displacement in the apical longitudinal axis was quantified for the basal septal segment before and after induction of HTEA.

Results: 5 of 6 patients demonstrated increased basal septal displacement after HTEA, in an average range from 1.63–3.09 mm. In one patient displacement decreased after induction of analgesia. All but one had normal or nearly normal ejection fraction (EF) before HTEA. The one patient with reduced EF of 35% had evident reduced displacement before induction, which further diminished after induction of HTEA.

Discussion: Tissue tracking seems to demonstrate increased septal displacement after HTEA. This increment may reflect improved contractility of longitudinal myocardial fibres in response to reduced afterload and/or enhanced myocardial oxygen supply. Tissue tracking is a very easy manageable method, which allows rapid objective assessment of regional myocardial displacement. The possible role of tissue tracking and other Tissue Doppler modalities in perioperative monitoring of myocardial performance depend on future studies.

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092

The effect of magnesium sulphate on postoperative pain scores and requirement of analgesia following CABG

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Introduction: It has been shown that patients who have undergone non-cardiac surgery had decreased postoperative pain and needed less opioid treatment when given magnesium sulphate ($MgSO_4$) [1,2]. We investigated the possible effects of postoperative $MgSO_4$ infusion on pain management following coronary artery bypass graft surgery (CABG).

Method: After approval of the Ethics Committee and informed consent, 50 patients undergoing elective CABG, who were classified as ASA III, and had preoperative EF > 40% were selected. The patients were prospectively randomized to group I (n = 25) as control and to group II (n = 25) given $MgSO_4$ ($15 \text{ mg kg}^{-1} \text{ h}^{-1}$). Anaesthesia and cardiopulmonary bypass were standardized. Before surgery, detailed information was given to all of the patients about using patient controlled analgesia (PCA). In the intensive care unit, continuous morphine infusion ($0.07 \text{ mg kg}^{-1} \text{ h}^{-1}$) was started by PCA (Abbott Medical). The apparatus was set up to a dose of $0.005 \text{ mg kg}^{-1} \text{ h}^{-1}$ with a 10 minute-locked time. We evaluated pain scores just after and at 2, 6 and 12 hours after extubation by the Visual Analog Scale (VAS). The number of analgesia requests by the patient, granted requests and the amount of total morphine were also recorded at the same time intervals. Student's *t*-test and two-way ANOVA were used for statistical analysis. All variables were expressed as mean \pm sd. $P < 0.05$ was considered significant.

Results: Results are summarized in the following tables.

| | VAS | | | |
|----------|---------------|--------------------------|----------------|----------------|
| | At extubation | After extubation (hours) | | |
| | | 2 | 6 | 12 |
| Control | 3.4 \pm 3.4 | 3.3 \pm 2.7 | 4.5 \pm 3.2 | 3.4 \pm 2.9 |
| $MgSO_4$ | 2.5 \pm 2.2 | 2.5 \pm 2.6 | 1.5 \pm 2.1* | 0.7 \pm 1.3* |

* $P < 0.005$

| Gp | Morphine | Extubation | 2nd h | 6th h | 12th h |
|----|----------|---------------|---------------|-----------------|-----------------|
| I | Request | 2.6 \pm 5.2 | 8.9 \pm 15 | 15.6 \pm 21.6 | 27.4 \pm 35.7 |
| | Granted | 0.6 \pm 0.8 | 2.1 \pm 2.7 | 5.2 \pm 6.9 | 7.8 \pm 11.4 |
| | Total mg | 5.5 \pm 3.1 | 7.8 \pm 4.3 | 12.1 \pm 7 | 18 \pm 9.5 |
| II | Request | 1.1 \pm 2.5 | 4 \pm 8.2 | 7 \pm 15.3 | 8.5 \pm 18.2 |
| | Granted | 0.5 \pm 0.8 | 1 \pm 1.7 | 2.4 \pm 4.5 | 3.3 \pm 6.3 |
| | Total mg | 4.2 \pm 1.4 | 5.4 \pm 1.3 | 7.7 \pm 1.4 | 11.1 \pm 2 |

I = Group I control; II = Group II $MgSO_4$

The amount of total morphine and frequency of PCA use were less in the magnesium group than the control group. However these differences were not statistically significant.

Discussion: We suggest that magnesium therapy for postoperative analgesia could be a useful option.

References:

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124

Tramadol hydrochloride for treatment of shivering after cardiac surgery

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Introduction: Postoperative shivering after cardiac surgery following hypothermic cardiopulmonary bypass (CPB) occurs in 40–50% of patients. The efficacy of the opioid meperidine in cardiac surgery patients for the treatment of shivering is not more than 50% [1]. The aim of this study was to assess by a clinical estimation [2], the therapeutic efficacy of the opioid tramadol in the management of postoperative shivering in cardio-surgical patients.

Method: 50 adult patients with postoperative shivering after coronary and valvular surgery with hypothermic CPB were assigned to two equal groups. Group 1 were treated with a bolus of 100 mg tramadol (Tramal Grunenthal GmbH, Germany). Group 2 received a bolus of saline placebo. The study was conducted in double blind fashion. Intensity of shivering was estimated in accordance with a previous classification [3]: grade 1 – mild fasciculation of face and neck; grade 2 – shivering involving face, neck, upper extremities or thorax; grade 3 – generalized shivering. All patients were mechanically ventilated. Data (mean and SD) were analysed with Student's *t*-test.

Results: The demographic and clinical data of patients in the two groups were comparable. Tramadol was administered in a dose of $1.48 \pm 0.25 \text{ mg/kg}$. The incidence of postoperative shivering and efficacy of tramadol are presented in the table.

| Groups | Tramadol (1) | Placebo (2) |
|--|--------------|-------------|
| Number of pts. | 25 | 25 |
| Onset of shivering after surgery (min) | 73 \pm 48 | 88 \pm 51 |
| Intensity of shivering: | | |
| Grade 1 (pts) | 4 (16%) | 3 (12%) |
| Grade 2 (pts) | 10 (40%) | 15 (60%) |
| Grade 3 (pts) | 11 (44%) | 7 (28%) |
| Shivering ceased or decreased to grade 1 (pts) | 22 (88%)* | 2 (8%) |

* $P < 0.01$

Analysis did not show significant changes in the mean values of ABP and HR. There was a slight increase of sedation in 10 patients.

Discussion: Tramadol has a dual mechanism of action. In addition to an affinity for opioid receptors it also inhibits reuptake of serotonin and norepinephrine that play a certain role in thermoregulation. Perhaps this mechanism explains why tramadol is more effective than pure opioids.

Conclusion: Tramadol was highly effective in decreasing shivering after cardiac surgery and it did not have significant effect on blood pressure or heart rate. Tramadol is useful in the management of postoperative shivering in cardio-surgical patients.

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016

Treatment of hyperhidrosis by transthoracic endoscopic sympathectomy

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Introduction: Endoscopic transthoracic sympathectomy (SYMP) is a treatment for palmar hyperhidrosis and blush [1]. The aim of our study is to present our experience in the anaesthetic management and surgical outcome.

Method: We studied 315 patients with hyperhidrosis and blush. All patients were undergoing bilateral thoracoscopy with general anaesthesia using a

total intravenous technique and one lung ventilation for the first 144 patients and tracheal intubation for the last 171 patients. We do not use CO₂. ECG, non-invasive arterial pressure, SpO₂ and end-tidal CO₂ were monitored. We also monitored the temperature (T°) in both hands to check the efficiency of the SYMP. An increase in palmar T° of more than 1°C was considered evidence of a successful sympathectomy. Temperature of the hands was recorded after anaesthesia induction (Basal); before T2 sympathectomy (Pre); and at 10 and 20 min. post-sympathectomy (10' and 20' Post). An intercostal block with 20 mL of bupivacaine 0.5% was made before surgery, to best control postoperative pain.

Results: The average T° increase was about 3°C post-SYMP (see Table 1). All patients were extubated in the operating room. No intraoperative anaesthetic complications were recorded. Two patients (0.6%) required assisted thoracotomy for pleural adhesions. Three patients (0.9%) had a haemothorax and four patients (1.3%) developed chest wall discomfort and needed analgesia treatment for more than one week. Two more patients (0.6%) had a temporary palpebral ptosis. One patient (0.3%) developed a chylothorax, requiring pleural drainage for six days. The mean stay in the hospital was 1.4 days. Only two patients (1.4%) developed compensatory sweating and four patients (1.3%) continued to sweating. Table 2 shows patients' satisfaction regarding surgery results.

Table 1. Temperature changes in both hands.

| | Basal | Pre- | 10' Post | 20' Post |
|-----------|------------|------------|-------------|-------------|
| T° R hand | 30.6 ± 2.9 | 30.9 ± 2.5 | 32.6 ± 2.2* | 33.6 ± 2.2* |
| T° L hand | 29.1 ± 2.8 | 29.0 ± 3.0 | 31.4 ± 3.8* | 32.5 ± 2.2* |

Mean (±SD). *P = .01. Paired Student's t-test

Table 2. Patients' satisfaction regarding surgery results.

| | n | Good | Fair | Poor |
|-----------|-----|-------------|----------|----------|
| 3 months | 160 | 151 (94.4%) | 8 (5.0%) | 2 (1.1%) |
| 12 months | 103 | 97 (94.2%) | 4 (3.9%) | 2 (1.9%) |
| 2 years | 50 | 48 (96%) | 2 (4.0%) | 0 (0%) |

Conclusions: In our study, hand T° monitoring detected SYMP effectiveness. The rate of complications was low but significant. Patient satisfaction was good. The follow-up is still short.

Reference:

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Aspects of Cardiothoracic Anaesthesia

120

Does cardiopulmonary bypass modify the anaesthetic state?

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Introduction: The state of anaesthesia may be altered by CPB [1]. We sought to investigate this further.

Method: We studied 20 adult patients undergoing cardiac surgery with CPB. Premedication of oral diazepam 10 mg plus intramuscular morphine 10 mg and prochlorperazine 12.5 mg, was given 90 min before induction of anaesthesia. Anaesthesia was induced with 0.5–1.0 mg kg⁻¹ of propofol, then maintained with isoflurane throughout the procedure. Fentanyl was infused using a Graseby 3400 syringe driver controlled by STANPUMP [2], to maintain an effect site concentration of 3 ng ml⁻¹ using Shafer's pharmacokinetic model. The PaCO₂ was maintained between 4.5 and 5.5 kPa and alpha-stat blood gas management was used on CPB.

The isoflurane concentration was titrated to maintain the Bispectral Index (Aspect, A-2000) at 45 throughout surgery. BIS, nasopharyngeal temperature and end-tidal isoflurane concentrations were recorded on four occasions (1 before sternotomy, 2 after sternotomy, 3 at normothermia before the end of CPB, 4 after weaning from CPB) at one-minute intervals and the mean value calculated. The same pair of isoflurane vaporizers were used throughout the study and the end-tidal isoflurane concentration was measured using the same anaesthetic gas module (SMART, Marquette-Hellige).

Blood pressure was maintained within acceptable values using phen-tolamine 0.5–1.0 mg and phenylephrine 50–100 µg. Heart rate was controlled where necessary using esmolol 0.5–1.0 mg kg⁻¹ or glycopyrrolate 0.6–1.2 mg.

Results: Data were obtained from 14 men and 6 women with a mean age of 67 yr (range 49–78) and are presented as mean values with 95% confidence intervals.

| Time | ET Isoflurane (%) | BIS | Temp (°C) |
|------|--------------------------------|------------------|-----------|
| 1 | 0.74 (0.60–0.89) [#] | 44.9 (42.9–46.9) | 35.5 |
| 2 | 0.84 (0.67–1.02) ^{^S} | 44.2 (42.3–46.1) | 35.5 |
| 3 | 0.45 (0.38–0.52) ^{^A} | 43.5 (42.2–44.7) | 36.9 |
| 4 | 0.59 (0.51–0.67) ^{^S} | 45.4 (44.0–46.7) | 36.7 |

[#]P = 0.026, ^{^S}P < 0.001 (Student's t-test).

Discussion: The mean isoflurane concentration was significantly lower post-CPB than pre-CPB. This may be due to changes in blood solubility of isoflurane or the pharmacokinetics of fentanyl during CPB, or factors related to CPB itself.

References:

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029

The use of near infrared spectroscopy (NIRS) in combined vascular and cardiac surgery

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Introduction: NIRS has recently been described as a non-invasive means of brain function monitoring [1]. The ability to measure changes in brain regional oxygen saturation (rSO₂) and express them within short time intervals (30 seconds) makes it a useful trend monitor especially where an interruption of flow in the carotid artery is anticipated [2].

Method: Between November 2000 and November 2003 we used NIRS (INVOS 4100, SOMANETICS) in 58 consecutive patients who underwent combined elective surgery (carotid thromboendarterectomy – TEAC – and open heart surgery). All the TEACs were performed under general anaesthesia by the vascular surgery team before the beginning of the open heart procedure. 45 patients had an aorto-coronary bypass graft (ACBPG), 36 with cardiopulmonary bypass and 9 off-pump procedures. Of the remaining patients, 5 were operated on for valvular disease and 8 for complex procedures (ACBPG with valvular or left ventricular aneurysmectomy). We considered as a cut-off point for cerebral ischaemia a reduction > of 15% in rSO₂ from the baseline value in the first 5 minutes after carotid cross-clamping (CC). An intravascular shunt was placed in patients in whom the cut-off point was reached and in 5 high risk patients electively (bilateral symptomatic disease).

Results: We divided the patients in two groups according to the placement of a shunt: group A (with shunt) and group B (without shunt). Group A comprised 29 patients (50%), of whom 24 (41.3%) were positive for ischaemia and 5 (8.7%) who had an elective shunt. Group B comprised 29 patients (50%) negative for ischaemia, without shunt. None of the patients from group B had complications whereas 3 patients from group A (shunt) had a major neurologic outcome (stroke) in the dependent side. A CT scan and angiography described the nature of the lesion as most probably embolic. Specificity for this cut-off was 61%.

Discussion: INVOS is a useful non-invasive method of brain haemodynamic monitoring in combined surgery (TEAC + heart surgery). In our patients we were able to restrict to less than half, the indication for an intravascular shunt (a method not free from risk, especially embolic) with a favourable neurologic outcome.

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020

Comparison of bispectral index during normothermic and hypothermic cardiopulmonary bypass

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Introduction: Because of the reports of improved myocardial performance, cardiopulmonary bypass (CPB) with systemic normothermia is being increasingly used in many institutions recently [1]. During hypothermic CPB anaesthetic requirements are reduced by hypothermia itself [2]. However, during normothermic CPB, anaesthetic requirements should not be changed, thus the anaesthetic requirements may be higher than that during hypothermic CPB. To investigate the difference in anaesthetic requirements, we performed a prospective, randomized study of bispectral index (BIS) changes in patients with either normothermic or hypothermic CPB.

Method: Patients scheduled for elective coronary artery bypass graft surgery were randomly allocated to a normothermic group (GN; $n = 20$) or hypothermic group (GH; $n = 20$). Anaesthesia was maintained with isoflurane (0.5–1.2% volume) and supplemented with fentanyl (0.1–0.3 $\mu\text{g kg}^{-1} \text{min}^{-1}$). The fentanyl infusion rate and the concentration of isoflurane were not changed from the period 15 min before starting CPB and throughout CPB. In GH, hypothermia was induced with a target rectal temperature of 30°C. The anaesthesiologist in charge was blinded to BIS. Change in BIS, mean arterial pressure (MAP), and nasopharyngeal temperature were recorded at the following times: (1) pre-CPB; after induction when vital signs were stable, (2) CPB 10; 10 min after start of CPB, (3) CPB 60; 60 min after start of CPB, (4) CPB off; 30 min after weaning from CPB.

Results: There was no difference in patients' demographic data, duration of CPB or MAP nor in isoflurane concentration or fentanyl requirement between the two groups. In the follow-up, no patients could recall anything from the operation.

Table 1. Change in nasopharyngeal temperature (Temp) and BIS.

| | | Pre-CPB | CPB 10 | CPB 60 | CPB off |
|------|---|-----------------|-------------------|------------------|---------------|
| Temp | N | 36.1 \pm 0.5 | 35.9 \pm 0.9 | 36.1 \pm 1.1 | 36 \pm 0.9 |
| | H | 35.3 \pm 0.9* | 33.2 \pm 1.3*† | 31.3 \pm 1.7*† | 36 \pm 1.3 |
| BIS | N | 45.1 \pm 9.8 | 63.2 \pm 10.1*† | 65.1 \pm 9.7*† | 52.7 \pm 14 |
| | H | 45.6 \pm 8.3 | 44.7 \pm 8.1 | 43.9 \pm 7.2 | 48.5 \pm 13 |

* $P < 0.05$ between two groups by Wilcoxon rank sum.† $P < 0.05$ vs. pre-CPB by repeated measures of ANOVA.

Discussion: During CPB, GN showed higher BIS values than GH. Our results suggest that during normothermic CPB, anaesthetic requirements may be greater than that of hypothermic CPB.

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048

Phosphorylcholine coating preserves coagulation during cardiac surgery – a combined TEG and PFA-100 analysis

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Introduction: In recent years, different strategies have been proposed to reduce the interaction between blood and foreign material during cardiopulmonary bypass (CPB), such as binding of heparin to the material. More recently, a new approach has been proposed: phosphorylcholine (PC) coating, which mimics the main lipid head group of the natural cell membrane, known for its non-thrombogenicity. Up to now, some experience with PC-coated circuits is available [1]. The purpose of this study was to investigate the effect of oxygenator coating with PC on blood coagulation in patients at high risk for bleeding.

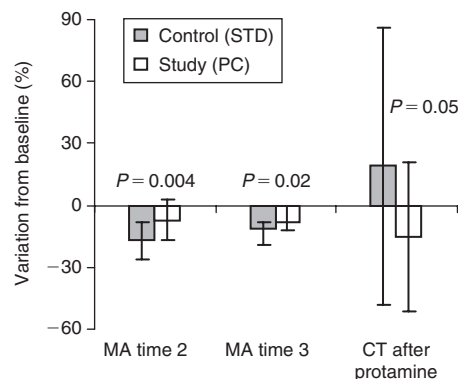
Method: 42 patients were randomized to undergo cardiac operations with either a standard (AVANT, STD group) or a PC-coated (AVANT PHISIO, Dideco, Mirandola, Italy, PC group) membrane oxygenator. Only patients belonging to Hardy class IV for bleeding risk (combined procedure and redo valve surgery) were included. The coagulation process was assessed by

standard laboratory assays, thromboelastography® (TEG) and platelet function analyser (PFA-100) tests.

TEG measures shear elastic modulus of whole blood samples during clot formation. In particular, clot haemostatic mechanical characteristics are assessed by maximum amplitude (MA) value.

PFA-100 is a system designed to measure platelet-related primary haemostasis. The platelet function is inversely related to the test duration (closure time, CT).

Coagulation analyses were performed at baseline (1), at the end of CPB (2) and at ICU arrival (3). PFA analyses were also performed at additional times. Statistical analyses for continuous data were performed by means of unpaired *t*-test and Mann-Whitney test for normally and non-normally distributed data, respectively. Pearson's correlation test was performed to quantify the association between variables.



Results: Three patients with evident surgical bleeding were excluded from analyses. A good correlation was found between MA and platelet count ($r = 0.7$, $P < 0.001$). Patients belonging to PC group had a significantly lower reduction of MA from baseline than patients in STD group both at times 2 and 3, and a significantly lower increase of CT after protamine administration (see Figure). A good correlation was found between MA and platelet count ($r = 0.7$, $P < 0.001$).

Discussion: The most important consequence of CPB on blood coagulation and therefore on postoperative bleeding is platelet dysfunction. Our study shows that PC coating of the oxygenator contributes to a superior platelet preservation for patients with increased risk of bleeding. This finding was well demonstrated by the lower reduction in TEG parameter MA and by a decrease of PFA parameter CT using PC-coated oxygenator while STD increased.

Reference:

- Albes JM, Stohr IM, Kaluza M, et al. Physiological coagulation can be maintained in extracorporeal circulation by means of shed blood separation and coating. *J Thorac Cardiovasc Surg* 2003; **126**: 1504–1512.

046

Comparison of different forms of ondansetron for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesiaA. Yavorovskiy, N. Trekova, T. Zjulyaeva, Z. Pavlova, A. Bunatian
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Introduction: Despite continuous advances in anaesthetic and surgical procedures, the incidence of postoperative nausea and vomiting (PONV) has not changed accordingly, and continues to be a cause of distress for patients and to delay early postoperative recovery.

The aim of the present study was to assess the efficacy of two forms of ondansetron (i.v. and suppository) for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia.

Method: Patients were divided into three equal groups. Before induction of anaesthesia patients of Gp I received a single i.v. dose of ondansetron 4 mg, patients of Gp II received a suppository of 16 mg at night before operation and patients of a control group received nothing. Anaesthesia was induced with propofol 1 mg/kg and maintained by a combination of high thoracic epidural (ropivacaine 2% 60 mg plus morphine 3 mg) and general anaesthesia (isoflurane 0.6 to 1% in oxygen). Orotracheal intubation was facilitated by vecuronium.

Results: The characteristics of the patient groups are shown in table 1 and the incidence of PONV in table 2.

Table 1. Patient characteristics (mean \pm SD).

| | Control (n = 30) | Gp I (n = 30) | Gp II (n = 30) |
|-------------------|------------------|---------------|----------------|
| Age (yr) | 63 \pm 16 | 59 \pm 15 | 61 \pm 13 |
| Sex (m/f) | 27/3 | 27/3 | 28/2 |
| Weight (kg) | 79 \pm 19 | 79 \pm 14 | 81 \pm 17 |
| Anaesthesia (min) | 285 \pm 57 | 260 \pm 58 | 279 \pm 67 |

Table 2. The incidence of PONV in Gp I and Gp II.

| | Control (n = 30) | Gp 1 (n = 30) | Gp 2 (n = 30) |
|--------------|------------------|---------------|---------------|
| Symptom-free | 14 (46%) | 22 (73%) | 21 (70%) |
| Mild nausea | 3 (10%) | 3 (10%) | 1 (3%) |
| Moderate | 2 (6%) | 2 (6%) | 3 (10%) |
| Severe | 1 (3%) | 1 (3%) | 2 (6%) |
| Vomiting | 7 (23%) | 2 (6%) | 3 (10%) |

Discussion: The results of this study demonstrate that both forms of ondansetron are effective for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia.

Reference:

- Gan TJ, Collis R, Hretred M. Double-blind comparison of ondansetron, droperidol and saline in the prevention of postoperative nausea and vomiting. *Brit J Anaesth.* 1994; **72**: 544–547.

096**Depression and anxiety after cardiac surgery: second year follow up**A. Székely, E. Benkó¹, J. Till, R. Mészáros

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Introduction: Depression and anxiety play important roles in the immediate postoperative period of patients after cardiac surgery [1]. The aim of our study was to investigate long-term influence of these mood disorders.

Method: Following Ethic Committee approval 193 patients were prospectively studied between May 2000 and July 2001. Depression and anxiety scores were measured by pure mail survey before surgery, 6 weeks, 6 months, one and two years after discharge from the hospital. Beck depression Inventory Test, based on cognitive behaviour theory and Spielberger state-trait anxiety inventory test (STAI and STAI-t) were used. The following factors were considered and compared with the follow-up scores: age, gender, type of surgery, marital state, education, preoperative disorders. Additional data collected were: neuropsychiatric disorders, hospitalization, cardiovascular and non-cardiovascular events and death after discharge. Statistical analysis was performed with simple and multiple logistic regressions.

Results: 98 patients responded. During the last year 3 patients died, the overall 2nd year (July 2003) mortality of the study group was 8.2%. The mean BDI score was 8.9 (range: 0–30), 29 patients had mild depressive symptoms (BDI: 10–20), and 9 patients had major depressive problems (BDI: >20). The mean anxiety score was 40.3 (range: 20–71), and 47 patients fell above the anxiety level. (STAI and STAI-t above 40 points are abnormal). According to the results of multiple regression, 2nd year BDI scores correlated with neuropsychiatric disorders (OR: 7.6; *P* 0.01) and with arrhythmia (OR: 7.5; *P* 0.01). Anxiety scores were high among patients, who were hospitalized with angina (OR: 12.7; *P* 0.004) and with arrhythmia (OR: 5.2; *P* 0.04). 14 responders showed worsened BDI values, and it was correlated with new hospitalization because of angina (OR: 8.7; *P* 0.007). Increase in the annual anxiety scores occurred less frequently in educated patients (OR: 0.1; *P* 0.02), but more frequently in patients who had new developed of arrhythmia (OR: 10.2; *P* 0.05).

Conclusions: Our 2nd year results of the follow up data indicate that depression and anxiety are well-recognized independent cardiovascular risk factors, which strongly influence the long-term medical outcome.

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095**Levels of natriuretic peptides during paediatric open heart surgery**A. Székely¹, L. Seres², E. Székely¹, E. Sági¹, M. Toth², T. Breuer¹, L. Király³, A. Sztármán⁴

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Introduction: Concentrations of atrial (ANP) and brain (BNP) natriuretic peptides characterize chronic heart failure, which relates to outcome in

patients with congenital heart defects. Time course and relation to peri-operative parameters of these hormones have not been investigated during paediatric cardiac surgery [1].

Method: Following Ethic Committee approval and patient informed consent the data of 58 infants and children undergoing open heart surgery were prospectively investigated. ANP and BNP were measured before skin incision (T_{-1}) at the end of surgery (T_0) and 6, 12, 24 hours after surgery (T_1 , T_2 , T_3 , respectively). The following data was collected: demographics, diagnosis, intra-operative parameters (operation time, time of aorta cross-clamp and cardiopulmonary bypass (CPB), haemodynamics, inotropic support, fluid balance, transfusion). Blood samples were also drawn at T_0 and T_3 and creatine kinase and MB isoenzyme (CK, CKMB), lactate-dehydrogenase (LDH) and its heart isoenzyme (aHBDH), renal function, blood sugar, C reactive protein (CRP) were measured. Fluid balance, transfusion and inotropic support of the first 72 hours were also noted. Duration of mechanical ventilation (MV) and intensive care stay were also investigated. Statistical analysis consisted of Mann-Whitney *U* test and Spearman correlation and simple linear regression.

Results: Preoperative ANP levels were significantly higher in pulmonary hypertension (*P* < 0.001), in Down syndrome (*P* < 0.003), and in congestive heart failure (*P* < 0.02). BNP gave similar results (*P*: 0.01, 0.02 and 0.01, respectively). Increased duration of aorta cross-clamp time resulted in higher ANP concentrations at T_2 , T_3 points (*r*: 0.61 and 0.65). ANP showed marked association with each LDH and aHBDH value (*r*: 0.36–0.57, *P* < 0.006), but neither with blood sugar, nor with CRP levels. BNP significantly correlated with the amount of inotropic support (T_3 *r*: 0.56, *P* < 0.001), CKMB (T_0 *r*: 0.44, *P* = 0.01) and renal function. ANP levels at each time point and BNP T_0 – T_3 were significantly correlated with the duration of MV and intensive care stay. The best estimation for MV gave ANP (*r*: 0.69) and BNP (*r*: 0.71) at T_2 time point.

Discussion: Our results indicate that ANP and BNP levels were proper indicators with respect to incidence of postoperative heart failure during paediatric cardiac surgery. Further investigations are needed to find the “normal” values and ranges of these hormones.

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125**Inaccuracy of cardiac output determination by transoesophageal echocardiography**D.A. Bettex¹, V. Hinselmann¹, J.P. Hellermann², R. Jenni², E.R. Schmid¹

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Introduction: Determination of cardiac output (CO) by transoesophageal echocardiography (TOE) has revealed varying degrees of accuracy [1,2]. The purpose of this randomized, single blinded, double controlled study was to compare and establish prospectively the best TOE methods to determine CO in patients after cardiac surgery.

Method: Thirty consecutive patients undergoing coronary artery bypass grafting were included. Measurements were done postoperatively, after stabilization in the intensive care unit (ICU). TOE measurements were initiated and analysed on-line by a single observer, blinded to the thermodilution CO (TCO) values. A second analysis was later performed off-line by the initial as well as a second blinded observer. TOE and TCO measurements were executed in triplicates and averaged. TOE CO was obtained in randomized order through the aortic, mitral, and pulmonary valves, right and left ventricular outflow tracts, trans-gastric surface areas of the left ventricle (LV) and LV bi-dimensional (2D) volumes (Simpson's rules). An “eye-ball guessing” was obtained off-line from the 2D ventricular views. Pairs of values were compared according to the method of Bland and Altman. Bias, standard deviation (SD) and percent of error defined as 2SD/average CO were given.

Results: Complete measurement series were obtained in 19 (63.3%) patients; one measurement failed in 10 (33.3%) patients and two in 1 (3.3%) patient. Mean TCO was 5.43 \pm 1.11 L/min. The best results were achieved by trans-aortic measurements with the use of the triangular shape assumption of opening surface (bias –0.36 to 0.5; percent error 37.0 to 42.5%) but bias values deviated considerably from zero, and none of these approaches reached the limit of agreement set at 30%. Eye-ball guessing was comparable with the best TOE measurements (bias –0.12 to –0.8; percent error 36.0 to 44.0%). Bland-Altman of most relevant data are reported in figure 1. No significant difference in the Bland-Altman test was found between on-line and off-line measurements, with respect to inter-observer variability.

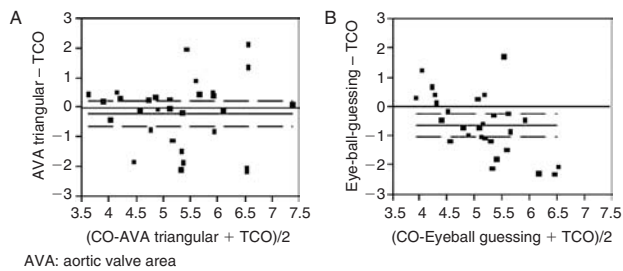


Figure 1. Bland and Altman plots of matched TOE and TCO trans-aortic (A) and eye-ball guessing (B) data in L/min.

Discussion: Our results show that in a post cardiac surgery ICU, TOE is an unreliable tool for CO determination. Although the measurements through the aortic valve, considering the aortic valve opening as a triangular surface [1], offered slightly better results, they remain in the range of clinical unreliability and are not better than eye-ball guessing. Off-line inter- and intra-observer control of our data revealed no significant difference.

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Fast-Track/Off Pump/Prediction/Outcome

010

Hydroxyethyl starch (HES) 130/0.4 reduces blood loss in off-pump coronary surgery

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Introduction: Post operative bleeding is attenuated in off-pump coronary artery bypass (OPCAB) but OPCAB is still associated with haemorrhagic complications and a need for blood transfusion [1]. The new HES 130 is now available and its use is associated with less postoperative bleeding [2]. The aim of this study was to assess the haemostatic effect of HES130 after OPCAB.

Method: Fifty two patients who had received intra and postoperatively HES 130/0.4 were compared to an historic control group of fifty two patients who had received standard HES 200/0.5. Three senior surgeons performed all procedures. Packed red blood cells were transfused when haemoglobin concentration was less than 80 g L^{-1} . Fresh frozen plasma was given when bleeding was associated with a prothrombin time over 20 sec. Transfusion of platelets was decided in case of abnormal postoperative bleeding with a platelet count below $50 \times 10^3 \text{ mL}^{-1}$. Statistical analysis was performed with t and χ^2 test and logistic regression models.

Results: The main results are summarized in the table. Use of HES 130 was significantly associated with reduced bleeding in univariate and multivariate analysis.

| | HES 200 | HES 130 | P |
|--------------------------|------------|------------|--------|
| Colloids intra op (mL) | 1230 ± 390 | 1290 ± 370 | 0.88 |
| Colloids post op (mL) | 390 ± 420 | 330 ± 350 | 0.43 |
| Blood loss at 12 h (mL) | 700 ± 380 | 530 ± 210 | 0.005 |
| Median | 580 | 495 | |
| Blood loss at 24 h (mL) | 930 ± 460 | 680 ± 260 | 0.0009 |
| Median | 775 | 675 | |
| Total blood loss (mL) | 1130 ± 790 | 720 ± 340 | 0.0009 |
| Median | 840 | 675 | |
| FFP | 5.8% | 3.8% | 0.65 |
| Platelets | 11.5% | 0 | 0.036 |
| RBC (units) | 1.2 ± 2.0 | 0.5 ± 1.2 | 0.056 |
| RBC transfusion | 37% | 21% | 0.08 |
| Allogeneic blood product | 28.8% | 13.5% | 0.055 |
| Postop haematocrit (%) | 29.9 ± 5.0 | 29.7 ± 5.0 | 0.85 |

Discussion: Using the HES 130 in OPCAB surgery allows a significant reduction in postoperative bleeding and a tendency to reduce exposure to blood product.

References:

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041

Benefits of off-pump coronary artery bypass grafting (OPCABG)

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Introduction: To avoid harmful effects of cardiopulmonary bypass (CPB) off-pump coronary artery bypass grafting (OPCABG) is becoming increasingly important. However, effects on outcome improvement using this technique are controversial [1;2]. The aim of this observational data base analysis was to determine the short-term outcome in patients undergoing CABG using CPB or OPCABG.

Method: 697 patients undergoing CABG procedures were available for statistical analysis from 1/2001 to 12/2001. In 269 patients (38%) cardiopulmonary bypass and aortic cross-clamping (ACC) (group A), in 116 patients (17%) cardiopulmonary bypass without ACC (group B) and in 312 patients (45%) the off-pump technique (group C) was used. In 95% of patients multiple grafting (≥ 2 grafts) was performed. EuroSCORE, 30-day mortality, ischaemia 24 h after the intervention, transfusion requirements, duration of respiratory support and hospital stay were compared using Kruskal-Wallis and χ^2 -test. $P < 0.05$ was considered statistically significant.

Results: EuroSCORE was comparable for the 3 groups (A = 4.2 ± 0.9 , B = 4.7 ± 0.9 , C = 4.6 ± 1.0).

| | CPB + ACC | CPB | Off-pump |
|-------------------|----------------|----------------|--------------------|
| No | 269 (38%) | 116 (17%) | 312 (45%) |
| EuroSCORE | 4.2 ± 0.9 | 4.7 ± 0.9 | 4.6 ± 1.0 |
| Mortality% | 1.6 | 2.6 | 1.4 |
| Ischaemia% | 5.8 | 7.8 | 3.3 |
| RBC units | 2.1 ± 0.7 | 3.6 ± 0.7 | $1.5 \pm 0.4^*$ |
| FFP units | 2.0 ± 0.4 | 4.1 ± 0.8 | $1.2 \pm 0.4^*$ |
| Platelets units | 1.0 ± 0.2 | 2.4 ± 0.4 | $0.4 \pm 0.2^*$ |
| Resp. support hrs | 14.2 ± 4.5 | 21.4 ± 6.3 | 11.4 ± 4.1 |
| Hosp. stay days | 10.5 ± 1.4 | 11.0 ± 1.6 | $9.9 \pm 1.3^{**}$ |

* $P < 0.0001$; ** $P < 0.0006$.

Discussion: In this series of patients undergoing CABG procedures a significant reduction of transfusion requirements, shortening of respiratory support duration as well as shorter hospital stay were found in patients using the off-pump approach.

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044

Is off-pump coronary artery bypass grafting (OPCABG) more cost-effective than the on-pump procedure?

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Introduction: Patients undergoing OPCABG benefit in terms of postoperative recovery, myocardial ischaemia and blood transfusion requirements [1,2]. The aim of this investigation was to compare the expenses for OPCABG and the conventional on-pump CABG (ONPUMP) procedures.

Method: Cost calculation was performed using a model of a standard patient undergoing CABG with four anastomoses and data (mean values) derived from a prospective database of a one-year period. Intraoperative routine costs (operative material and anaesthesia), expenses for transfusion requirements, intensive care unit (ICU) and hospital stay were evaluated. Costs for human resources, local facilities (i.e. OR utilization) and expenses for interventions deviating from the routine procedure were not considered.

Results: 255 OPCABG and 24 ONPUMP were performed from 01/2002–12/2002.

Table. Summary of costs.

| | OPCAB | ON pump |
|-----------------------------------|------------|-----------|
| Number of patients | 255 | 24 |
| ICU stay (days) | 1.8 ± 0.9 | 2.2 ± 0.8 |
| Hospital stay (days) | 10.5 ± 1.4 | 9.9 ± 1.3 |
| Operative material € | 1950 | 2970 |
| Anaesthesia (incl. transfusion) € | 1640 | 1570 |
| ICU/patient € | 5091 | 6178 |
| Hospital stay cost/patient € | 11090 | 11710 |
| Total cost/patient € | 19770 | 22425 |

€ = £0.6659.

Discussion: The present cost calculation model for CABG procedures demonstrates that OPCABG operations may actually be more cost-effective than conventional on-pump CABG interventions.

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072

Alfentanil-based general anaesthesia for early extubation after valve surgery

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Introduction: New approaches are being continuously developed in cardiac anaesthesia, with early extubation and rapid mobilization of the patient being two of the most important and popular topics. Many authors focussed on off-pump coronary surgery [1,2]. Here we report a review of our first 100 patients who underwent heart valve/aorta or combined procedures with alfentanil-based fast-track general anaesthesia without the use of an epidural catheter.

Method: One hundred unselected patients undergoing elective valve surgery (15 low risk patients with additive EuroSCORE 0–2, 39 medium risk patients with EuroSCORE 3–5, 46 high risk patients with EuroSCORE 6 plus) of a consecutive series, were anaesthetized by general anaesthesia based on alfentanil, midazolam, isoflurane and atracurium.

Criteria for extubation were:

- Normotension, heart rate <120/min., no signs of LCO
- PaO₂ > 80 mmHg and PaCO₂ < 45 mmHg at F_O₂ 0.5
- Spontaneous smooth ventilation, patient can lift the head
- Full contact with the patient responsive to simple command
- Bleeding <100 mL within last 30 mins.

Results: The average total dose of alfentanil per procedure was 10.5 ± 3.4 mg, i.e. 134 ± 36 µg kg⁻¹. Eighty-four (84%) patients (i.e. 14 [93.3%] low risk, 33 [84.6%] medium risk, 37 [80.4%] high risk patients) were extubated within 30 minutes from the end of surgery. Fifty-eight out of these patients were extubated in the operating room less than 10 minutes after

skin closure and 26 were extubated in the intensive care unit (ICU). One patient was re-intubated and ventilated for a further 24 hours because of transient cerebral ischaemia. Five patients were re-intubated because of the need for early surgical re-exploration (bleeding or cardiac tamponade). Two high risk patients died of heart failure without any attempt at extubation. Ten patients (of those extubated within 30 minutes) were successfully discharged from ICU on day 0 (4 low risk, 4 medium risk, 2 high risk patients).
Discussion: Alfentanil-based general anaesthesia seems to be readily reproducible and can be recommended for on-pump procedures as well as for high risk patients. Fast-track with early extubation of patients is the first step on the way to reducing ICU length of stay and achieving savings in cardiac surgery [3]. Based on our experience with 100 patients, the method is promising in terms of safe ICU discharge on the day of surgery for selected cases.

References:

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037

Efficiency of early extubation in geriatric cardiothoracic patients

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Introduction: Fast-track anaesthesia protocols in patients undergoing surgery with cardiopulmonary bypass (CPB) are effective in reducing postoperative complications and decreasing hospital stay [1]. The purpose of this study was to investigate the efficiency of early extubation in geriatric patients after CPB.

Method: The randomized study involved 52 geriatric patients (75–82 years old) divided into 2 groups. Group F included 20 males and 5 females (mean age 76.8 ± 1.6) with a fast-track anaesthesia protocol (low-dose fentanyl, propofol or midazolam, isoflurane, vecuronium) and early extubation. The control group C included 23 males and 4 females (mean age 76.2 ± 1.2) with a prolonged ventilation protocol (high-doses fentanyl, diazepam, ketamine, pancuronium). NYHA physical status of patients was 3.1 ± 0.1 in both groups. Coronary artery bypass grafting was performed in 52% of group F patients, and in 55.5% of group C patients, 1–2 valves replacements were performed in 48% and 44.5% of groups, respectively. Statistical significance was calculated using Student's *t*-test.

Results: Our investigation demonstrated a decrease in some postoperative cardiovascular, pulmonary and cerebral complications in group F. The length of stay in intensive care unit in patients older 75 years with early extubation was shorter. There was no difference in postoperative hospital stay in groups (table).

| | Fast track (n = 25) | Control (n = 27) |
|--|---------------------|------------------|
| Postop. dopamine µg kg ⁻¹ min ⁻¹ | 1.8 ± 0.4 | 3.5 ± 0.6 |
| Postop. complications % | | |
| cardiovascular | 12 | 63* |
| pulmonary | | 11* |
| renal | 12 | 15 |
| cerebral | 4 | 15* |
| gastroduodenal | | 7.4 |
| ICU stay: days | 1.1 ± 0.1 | 2.6 ± 0.4* |
| Hospital stay: days | 17 ± 1 | 19 ± 1 |

*P < 0.05.

Discussion: Fast-track anaesthesia protocols as used in many clinics for patients undergoing surgery and CPB lead to a decrease in hospital stay. Elderly patients have more co-morbid conditions, yet a significant number can be extubated early, with a resulting shorter length of stay in hospital [1,2]. Our investigation demonstrated a decrease in some postoperative complication and mean length of stay in intensive care unit in patients 75 years or older with early extubation, but with no difference in postoperative hospital stay.

Conclusion: This study confirms the safety and efficacy of early extubation among elderly patients operated with CPB.

Reference:

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026

Evaluation of early extubation (fast-track) after cardiac surgery in a post-anaesthesia recovery unit

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Introduction: The advances in anaesthetics, surgery and extracorporeal techniques have allowed early extubation of patients undergoing cardiac surgery. The goal of this study was to compare the outcome of patients with early extubation in a general post-anaesthesia recovery unit (RR) with patients extubated in a cardiac intensive care unit (ICU).

Method: During 2002, 657 patients were scheduled for cardiac surgery and 109 (16.6%) of them (group I) with fast-track protocol were extubated early in the RR. Group I was compared with a historical case control of 40 patients (6%) (group II) that were managed in the ICU with the same extubation criteria. Data recorded were: time to extubation (TE), ICU + High Dependence Unit and hospital length of stay (ICU/HDU and HS respectively), postoperative complications (PC), number of re-intubations (NR) and deaths. Demographic data, ASA status, type of surgery, type of anaesthesia and time of extracorporeal circulation (ECC) were also recorded. Data are expressed as mean \pm SD, Student's *t*-test and chi-squared test were used for statistical analysis. $P < 0.05$ was significant.

Results: Results are shown in Table 1. Demographic data were similar. Both groups were similar in ASA status, type of surgery, type of anaesthesia (balanced anaesthesia) and time of ECC. Time from the end of surgery to extubation was significantly shorter in group I (2.1 hr) than in group II (8.8 hr). ICU/HDU stay, hospital stay, number of re-intubations and deaths were similar in both groups.

Table 1.

| | ET (hr) | ICU/HDU (days) | HS (days) | PC | NR | Deaths |
|---------|----------------|----------------|---------------|-------|----|--------|
| Group 1 | 2.1 \pm 0.8* | 3.3 \pm 2.7 | 6.8 \pm 5.7 | 12.8% | 1 | 0 |
| Group 2 | 8.8 \pm 6.1* | 4.6 \pm 2.5 | 5.2 \pm 4.0 | 20% | 1 | 1 |

* $P < 0.001$ between both groups.

Regarding the postoperative complications, atrial fibrillation was significantly more frequent in group II with 5 patients vs. 0 patients in group I. For termination of atrial fibrillation 2 patients needed cardioversion and 2 patients pharmacological treatment.

Conclusions: In our study the fast-track technique for early extubation is the RR is safe and does not increase postoperative morbidity and mortality, but in this study the fast-track technique does not decrease the ICU/HDU and hospital stay.

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079

Re-admission and mortality rate after a fast-track recovery protocol in off-pump coronary artery bypass surgery patients

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Introduction: Development of off-pump cardiac surgery and fast-track recovery has contributed to a significant reduction in postoperative intensive care unit and hospital length of stay after cardiac surgery. The aim of this study was to identify the hospital mortality and readmission rate after off-pump coronary revascularization and a fast-track recovery protocol.

Method: After approval of the ethical committee, 80 consecutive patients undergoing off-pump coronary artery bypass surgery were included in the study, and followed a fast track protocol defined as successful extubation within 6 hours postoperatively, length of stay in intensive care unit less than 24 hours, and hospital discharge within 5 days [1,2]. Patients were extubated when they fulfilled the extubation criteria (responsive and cooperative, negative inspiratory force > -20 cm H₂O, vital capacity > 10 mL kg⁻¹, arterial oxygen tension > 80 mmHg, F_{O₂} < 0.50 , pH > 7.30 , chest tube drainage < 100 mL h⁻¹ \times 2 h). Hospital readmission and the reason for readmission were recorded together with the mortality rate during the following 30 days. Those patients who had not met the protocol were excluded from the study. Patients were premedicated with midazolam (0.1 mg kg⁻¹, im).

Anaesthesia was induced with fentanyl (2 μ g kg⁻¹) and propofol (1–2 mg kg⁻¹), and maintained with fentanyl (0.1 μ g kg⁻¹ min⁻¹, iv.) and isoflurane 0.6–1.0% with 100% oxygen. Neuromuscular blockade was achieved by vecuronium bromide (0.1 mg kg⁻¹, iv.) and maintained by bolus administration (0.03 mg kg⁻¹) at 30 min. intervals. Statistical analysis was performed using SPSS statistical software programme with chi-squared test and Fischer's exact test for univariate and multivariate logistic regression analysis.

Results: Seventy patients (87.5%) were extubated in the postoperative first six hours. Mean mechanical ventilation time was 4.5 \pm 2.4 hours. Three patients died before discharge from the hospital giving a hospital mortality rate of 3.85%. The causes of hospital death were stroke and sepsis. Mean hospital length of stay was 4.2 \pm 1.1 days. Thirteen patients were not discharged within five postoperative days. Postoperative blood transfusion was found to be significantly associated with prolonged hospital stay. During the 30-day observation period from the day of discharge, 7 patients (10%) were readmitted to the hospital. The reasons for readmission were sternum infections and dehiscence (3 patients), pleural effusions and pneumonia (2 patients), chest pain (1 patient), and subcutaneous emphysema (1 patient). One of the readmitted patients died on postoperative 45th day because of mediastinitis and sepsis.

Discussion: The mortality and readmission rates in this observational study were found to be similar to the previously reported findings [2]. We conclude that off-pump CABG surgery with this fast track protocol can be performed with similar outcome as reported earlier.

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060

The effects of remifentanyl and fentanyl on postoperative pain and recovery in fast-track open heart surgery

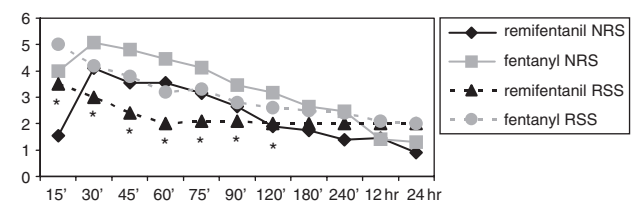
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Introduction: In this study, we compared the effectiveness of remifentanyl infusion and fentanyl bolus provided by patient-controlled analgesia device, for postoperative pain and recovery after fast-track cardiac surgery.

Method: This prospectively randomized, double blinded study was made in 42 ASA II group patients, undergoing fast-track Coronary Artery Bypass Grafting (CABG) surgery. Anaesthesia was induced with sevoflurane and remifentanyl. After operation, the patients were divided into two groups. In Group 1 (remifentanyl group), constant continuous infusion of 0.1 μ g \cdot kg⁻¹ \cdot min⁻¹ remifentanyl was given by patient controlled analgesia device. In Group 2 (fentanyl group), 10 μ g loading dose of fentanyl was administered 5 minutes before the end of the surgery. After fentanyl administration, we gave 0.1 μ g \cdot kg⁻¹ fentanyl bolus doses with 8 minutes lockout time without continuous infusion. Pain scores, sedation level and analgesic requirements were recorded for the first 4 hours period in every 15 minutes and then 12 and 24 hours postoperatively.

Results: We found no difference between the groups for analgesic effectiveness. The sedation levels were lower for the postoperative first two hours in Group 1. After two hours, sedation levels were similar in the two groups.



* Lower than the other group ($p < 0,05$)

NRS: Numeric Rating Scale, RSS: Ramsey Sedation Scale

Discussion: Fentanyl is a well known and used agent for pain control in cardiac surgery. In our study we compared its postoperative effectiveness on analgesia and sedation with remifentanyl. We concluded that remifentanyl can be used at analgesic doses, as well as fentanyl, during recovery of patients undergoing fast-track cardiac surgery.

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049

Effects of remifentanyl and fentanyl on haemodynamics and cognitive functions in patients undergoing open-heart surgery

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Introduction: The application of a “Fast-track” anaesthetic protocol has been common [1]. Impaired postoperative cognitive function has been related to many factors [2]. However, no optimal anaesthetic regime has been determined for both a “Fast-track” protocol and for cognitive function preservation.

Method: After ethical committee approval, 40 ASA II–III patients were randomly included in the study. Anaesthesia was induced with 0.1 mg kg⁻¹ midazolam, 1 mg kg⁻¹ propofol and 0.1 mg kg⁻¹ vecuronium in all patients. In addition 1 µg kg⁻¹ remifentanyl iv. was given to the patients in Group I (n 20) and remifentanyl infusion at a rate of 0.25–0.5 µg kg⁻¹ min⁻¹ was given throughout the operation. 5 µg kg⁻¹ fentanyl iv. was given to the patients in Group II (n 20) and 3 µg kg⁻¹ h⁻¹ was infused throughout the operation. Anaesthesia was maintained by propofol 2 mg kg⁻¹ h⁻¹ and 0.2–0.5% isoflurane. 50% O₂ in air was given to all patients before and after CPB. Under 30–32°C hypothermic CBP, propofol infusion rate was reduced to 1 mg kg⁻¹ h⁻¹.

Pulmonary capillary wedge pressure (PCWP), mean pulmonary artery pressure (MPAP), mean arterial pressure (MAP) and heart rate (HR) were recorded at 12 different periods. In addition, intra-operative and postoperative cardiac output (CO) and cardiac index (CI), extubation times (ET) and onset times of spontaneous breathing (OTSB) of all patients were measured.

Cognitive functions were evaluated according to a standard neuropsychiatric test scale consisting of 9 different tests, preoperatively and 5 days postoperatively.

Results: Haemodynamic parameters are shown in Table 1.

Table 1. Haemodynamic parameters (mean ± SD).

| | HR (bpm) | MAP (mmHg) | CO (L min ⁻¹) | CI (L min ⁻¹ m ²) |
|-----------------|--------------|--------------|---------------------------|--|
| <i>Group I</i> | | | | |
| T1 | 84.0 ± 13.3 | 99.7 ± 14.7 | 4.1 ± 0.9 | 2.3 ± 0.5 |
| T2 | 66.4 ± 8.7 | 90.7 ± 18.2 | – | – |
| T3 | 76.1 ± 15.3 | 97.9 ± 18.2 | – | – |
| T4 | 86.0 ± 8.1 | 77.3 ± 8.2 | 5.6 ± 1.4** | 3.3 ± 0.6** |
| <i>Group II</i> | | | | |
| T1 | 74.5 ± 13.1 | 102.6 ± 15.3 | 3.7 ± 1.3 | 1.9 ± 0.7 |
| T2 | 54.9 ± 8.5* | 81.1 ± 12.8 | – | – |
| T3 | 59.9 ± 10.2* | 94.9 ± 17.5 | – | – |
| T4 | 84.0 ± 11.9 | 77.2 ± 11.9 | 6.0 ± 1.2** | 3.1 ± 0.7** |

T1: Preoperatively, T2: After incision, T3: After sternotomy, T4: Postoperatively.
 *P < 0.05 versus Group I, **P < 0.01 versus preoperatively.

ET and OTSB were shorter in Group II than Group I (P < 0.05). Cognitive function tests of both groups were defective at the 5th postoperative day compared with the preoperative period (P < 0.01).

Conclusion: Haemodynamic stability was established with fentanyl and remifentanyl in patients undergoing CABG surgery. However, remifentanyl was superior to fentanyl because of shorter ET and OTSB. Neither remifentanyl nor fentanyl was superior in preservation of cognitive function.

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019

Atrial fibrillation after beating heart CABG surgery

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Introduction: Atrial fibrillation (AF) is the most common complication after coronary artery bypass grafting surgery. Older age is the only variable consistently associated with the development of postoperative atrial fibrillation. The purpose of this study was to identify perioperative characteristics associated

with new-onset atrial fibrillation in patients undergoing isolated off pump (OP) coronary artery bypass grafting.

Method: Data of 382 consecutive elective CABG who had complete revascularization with the OP-technique and who had no history of AF, have been prospectively collected (April 2001–December 2002). Standard anaesthesia was followed by an overnight ICU stay. Postoperative AF occurrence requiring oral or intravenous drug treatment or cardioversion for rate control was followed up until discharge from the hospital. Data were analysed with the SAS statistical software package for multivariate stepwise forward analysis. **Results:** AF was recorded in 84/382 patients (22%), 5 of them were discharged in AF. By univariate analysis the patients who developed AF differed from those who did not by the following variables: age (68 ± 9.1 vs. 64 ± 9.4 P = 0.01); preoperative renal impairment defined as creatinine >120 µmol/L (25% vs. 12% P = 0.006); re-intervention (8.3% vs. 3.4% P = 0.05); revascularization of the diagonal branch (32% vs. 22% P = 0.05); use of postoperative epinephrine (8.3% vs. 1.7% P = 0.006). Patients who developed atrial fibrillation had a prolonged hospital stay (7 ± 3.4 vs. 6 ± 3.6 days, P = 0.03). Overall mortality was 0.5% (2 patients who had no AF). Stroke was recorded in 2 patients (one who had developed AF and one in the non-AF group). On a multivariate analysis the predictors of AF were the following: age (OR 1.04 per year; 95% CI 1.01–1.07 P = 0.004); preoperative renal impairment (OR 1.9; 95% CI 1.04–3.7 P = 0.04); postoperative epinephrine infusion (OR 4.0; 95% CI 1.2–13.5 P = 0.02).

Discussion: This study confirms that the incidence of post-operative AF after CABG is still high even when the OP-technique is used, occurring in 22% of our patients. Even when AF is uncomplicated, its treatment requires additional medical and nursing time and a prolonged hospitalization (7 ± 3.4 vs. 6 ± 3.6 days in our experience P = 0.03). There is no explanation for some patients developing postoperative AF whereas others, having the same surgical intervention, remain in sinus rhythm. The present study confirms the association of AF with increasing age, explained by the age-related structural changes in the atrium such as dilatation, muscle atrophy, decreased conduction tissue and fibrosis. In our study AF is also predicted by preoperative renal impairment and postoperative epinephrine infusion.

059

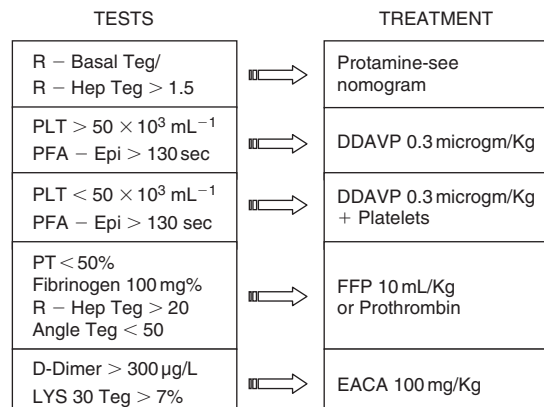
Problem-solving in cardiac surgery: empiricism vs. algorithm in the management of microvascular bleeding (MVB)

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Introduction: Abnormal blood losses are frequent after cardiac surgery and can increase morbidity and mortality as well as adding the risks of transfusions and re-exploration. Multi-factorial genesis warrants a systematic approach and a targeted therapy. Use of algorithms could be an answer [1]. We have analysed the clinical impact of our diagnostic-therapeutic algorithm for management of MVB.

Method: We compared 100 pts (Algorithm Group) who underwent cardiac surgery in a two months period with 81 pts (Control Group) having operations in the two previous months and without a standardized protocol. The algorithm was made on the basis of literature and our Point of Care (POC) tests availability (TEG, PFA100). The use of the algorithm was triggered in the operating room by the persistence of MVB after heparin neutralization, or in ICU by bleeding > 150 mL/h.



We examined blood losses, number and kind of transfusions and number of re-explorations.

Results: Main results are listed in the table.

| | Control group | Algorithm group | P |
|--------------------|---------------|-----------------|-------|
| N off pump | 37 (45%) | 44 (44%) | |
| Blood losses/12 h | 399 ± 120 ml | 404 ± 162 ml | NS |
| Total transf/48 h | 2.19 ± 3 U | 1.85 ± 2 U | NS |
| RBC transf/48 h | 1.56 ± 2 U | 1.6 ± 1.8 U | NS |
| FFP transf/48 h | 0.61 ± 1.4 U | 0.2 ± 0.9 U | <0.01 |
| PLT transf/48 h | 0 | 1 pool | NS |
| Pts not transfused | 51% | 45% | NS |
| Pts transf FFP | 19% | 5% | <0.01 |
| Unit/pt transf | 4.3 ± 3 | 3.4 ± 2.8 | 0.02 |
| Re-explorations | 3 | 2 | |

RBC: red blood cell; FFP: fresh frozen plasma; PLT: platelets.

No correlation was found between transfusions and blood losses.

Discussion: Fewer pts treated according to the algorithm received FFP and those that did received less, as a result of more targeted therapy. Main advantages of algorithm implementation appeared to be: 1) Systematic identification of mechanism of bleeding; 2) Targeted and standardized therapy; 3) Identification of patients who needed reexploration. Besides evaluating platelet function by POC, it had a pivotal role as a guide for the targeted use of low cost therapy, DDAVP. The real clinical and economic impact of a "rational" vs. "empirical" approach should be weighed up in the future.

Reference:

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045

Prediction of mortality and prolonged intensive care unit stay after off-pump coronary artery bypass grafting

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Introduction: Prolonged intensive care unit (ICU) stay contributes to increased cost and resource utilization in cardiac surgery [1,2]. The aim of this study was to evaluate prediction of outcome, i.e. 30 day mortality, and post-operative duration of ICU stay in patients undergoing off-pump coronary artery bypass grafting (OPCABG) using the European System of Cardiac Operative Risk Evaluation (EuroSCORE) [3].

Method: From Jan 1st, 2001 to Dec 31st, 2002 398 patients underwent OPCABG in our institution (78% of all isolated CABG procedures performed during this period). Patients were scored using the simple additive EuroSCORE. 30-day mortality and duration of ICU stay were recorded. The discriminative power of the score was assessed by calculating the area under the receiver operating characteristic curve (ROC). $P < 0.05$ was considered significant.

Results: EuroSCORE was 4.6 ± 3.6 for these patients (age = 64.3 ± 9.7 years, female/male ratio = 89/309, ejection fraction = $58.1 \pm 15.3\%$). The preoperative risk profile was equally distributed (low risk [EuroSCORE 0–2] = 30.4%, medium risk [EuroSCORE 3–5] = 33.4% and high risk group [EuroSCORE > 6] = 36.2%). Predicted 30-day mortality was 5.3%, observed 30-day mortality was 1.5% (6 death during follow-up period). ROC for EuroSCORE to predict mortality was 66% ($P = 0.17$; i.e. no significant difference from 0-hypothesis: ROC area = 50%). Duration of ICU stay was 1.7 ± 1.4 dy. ICU stay and EuroSCORE correlated positively (Pearson correlation coefficient $[r] = 0.48$, $P < 0.001$). ROC to predict ICU stay > 1 dy was 66.3% ($P < 0.001$). For ICU stay > 2 dy ROC was 74.8% ($P < 0.001$), for > 3 dy, > 4 dy and > 5 dy 80.2%, 90.4%, and 91.7% ($P < 0.01$).

Discussion: The power of EuroSCORE to predict mortality in this sample of patients undergoing OPCABG was weak. By contrast, discriminative power to predict prolonged postoperative ICU stay was good. Use of the score might allow for more efficient allocation and thus cost reduction.

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005

Prognostic value of low cardiac index early after cardiac surgery

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Introduction: The benefit of routine right heart catheterization (RHC) after cardiac surgery is discussed [1] but clinical prediction of cardiac output is

poor after cardiac surgery [2]. The aims of the present observational study were to verify if the commonly accepted lowest value of cardiac index (CI) of $2.2 \text{ L min}^{-1} \text{ m}^{-2}$ [3] at the arrival in ICU was a predictor of complications after cardiac surgery and which haemodynamic value was the strongest predictor of complications.

Method: Patients admitted in our ICU after cardiac surgery were included if they had a CI < $2.3 \text{ L min}^{-1} \text{ m}^{-2}$ at the arrival. RHC was decided preoperatively if the patient had risk factors. Haemodynamic measurements including arterial and mixed venous blood gases were performed at arrival in ICU, 2, 6 and 18 hours later. Inotropic agents were used if CI was below $2 \text{ L min}^{-1} \text{ m}^{-2}$ despite adequate volume expansion. Postoperative complications were defined as death, renal insufficiency, need for prolonged mechanical ventilation or high inotropic support. T test and logistic regression were used for statistical comparison.

Results: 51 patients had no complication (Gr 1). 22 patients (Gr 2) presented a postoperative complication (including 4 deaths). No difference was found between the 2 groups for pre or intra-operative data (including ejection fraction, age, EuroSCORE, length of bypass) or in blood lactate level, pH or base-excess and haemoglobin level (Gr 1: $103 \pm 16 \text{ g L}^{-1}$, Gr 2: 100 ± 19 , $P = 0.52$). Gr 2 had lower CI (2.1 ± 0.4 vs 2.6 ± 0.6 , $P = 0.003$) and SVO_2 (62.9 ± 7.6 vs 66.6 ± 6.7 , $P = 0.048$) 6 hours after arrival in ICU. In the logistic regression analysis, reduced cardiac index at 6 hours after admission to ICU had the strongest predictive value for postoperative complications.

Discussion: A low cardiac index 6 hours after the arrival in ICU is associated with a high level of postoperative complications. Using RHC allows early prediction and treatment of low CI in order to prevent postoperative complications [2].

References:

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083

Characteristics and outcome of admissions to general intensive care units following cardiac surgery

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Introduction: Although admission to cardiac intensive care (CICU) is standard after cardiac surgery, significant numbers of patients are admitted to general intensive care units (ICU). The purpose of the present study was to examine mortality and factors that influence mortality in this patient group.

Method: Admissions to ICUs directly from theatre after surgery of the heart or thoracic aorta were identified in the database of the national audit of intensive and high-dependency care in Great Britain (the Case Mix Programme). Significance for mortality of factors that reflected unit characteristics, circumstances at admission, patient status at admission and during the initial 24 hours were analysed with multiple logistic regression.

Results: Between 1996–2001 there were 2697 admissions to 58 ICUs, 2420 of these admissions were to 11 ICUs in hospitals having a CICU. The number of admissions per unit and main surgical group is shown in table below.

| Surgical group | No. of ICUs | Admissions/unit median (range) |
|----------------|-------------|--------------------------------|
| CABG | 12 | 7 (1–880) |
| Isolated valve | 19 | 1 (1–185) |
| Valve + CABG | 6 | 17 (1–84) |
| Thoracic aorta | 40 | 2 (1–91) |
| Other | 35 | 1 (1–29) |

The number of admissions and mortality per surgical group were CABG 1749, 4.8%; isolated valve 432, 9.0%; valve plus CABG 172, 9.5%, thoracic aorta 228, 29.0% and other 116, 17.7%. Corresponding mortality figures in the National Adult Cardiac Surgical Database Report 2000–2001 [1] were for CABG 2.3%, isolated valve 4.8% and valve plus CABG 7.8%. Significant determinants of mortality were urgency of admission, age, serum creatinine, blood glucose, heart rate and arterial acid-base status.

Discussion: The substantial numbers of cardiac surgery patients admitted to ICUs indicated lack of beds in CICUs.

Reference:

- NACSD Report 2000–2001, page 50 (downloaded from [www.ctsnet.org/file/SCTS2000 pages 46–59.pdf](http://www.ctsnet.org/file/SCTS2000%20pages%2046-59.pdf) accessed Feb 26, 2004).

013

Long term follow up of patients with short and long postoperative ICU stay after cardiac surgery

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Introduction: Several models have been validated to predict in-hospital mortality in cardiac surgical patients [1] and in those requiring prolonged ICU stay for perioperative multiple organ dysfunction [2]. However, risk factors of long term outcome have not been fully elucidated. In a cohort of cardiac surgical patients, we evaluated the impact of prolonged postoperative intensive care on long term outcome.

Method: Adult patients (n = 90) with a postoperative ICU stay longer than 96 hours were matched according to gender, age, EUROScore and type of surgery (coronary, valvular, mixed, thoracic aorta) with a group of patients (n = 180) with ICU stay <96 hours. We assessed by a multivariate Cox proportional hazard model the impact of left ventricular ejection fraction (EF), diabetes, ICU stay >96 hours, comorbidities and preoperative renal dysfunction on all-cause mortality and on a combined end point of mortality and cardiovascular events.

Results: The two groups of patients were comparable according to presence of one or more comorbidities, no comorbidity, previous or <3 months

acute myocardial infarction, previous cardiac surgery, systemic or pulmonary hypertension, peripheral arteriopathy and chronic obstructive pulmonary disease. Patients with longer ICU stay more frequently had diabetes ($P = 0.006$) or creatinine level $>200 \mu\text{mol/L}$ ($P = 0.001$) preoperatively. In hospital mortality was 2.8%.

At mean follow up of 19 ± 10 months, survival was 89% in those requiring short ICU stay and 79% ($P = 0.009$) in the long ICU stay group. Need of ICU stay >96 hours was the only independent predictor of long term mortality by multivariate analysis (RR 2.36, C.I. 1.17–4.78, $P = 0.016$).

Long term event free survival was 67% in those with short ICU stay and 41% ($P = 0.0001$) in the long ICU stay group. By multivariate analysis the only independent factor predictive of long term outcome was postoperative ICU stay >96 h (RR 2.20, 95% C.I. 1.46–3.30, $P = 0.0001$), whereas higher EF had a protective effect (RR 0.97, 95% C.I. 0.95–0.99, $P = 0.003$).

Discussion: Patients requiring prolonged ICU stay after cardiac surgery are at increased risk of mortality and cardiovascular events after hospital discharge. Measures directed at limiting perioperative complications, particularly preservation of left ventricular performance, should be maximized in an effort to improve long term outcome of cardiac surgical patients.

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Brain/Metabolism

023

Neuronal injury after ICD-implantation is associated with a deterioration of cognitive function after surgery

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Introduction: It has been shown that neurocognitive function deteriorates after implantation of an ICD device [1]. Furthermore, it was noted that serum neurone specific enolase (NSE), a marker of neuronal injury, increases after surgery [2]. However, a direct relationship between these two alterations has not yet been evaluated.

Method: We therefore studied 19 ICD patients scheduled for elective ICD placement in monitored anaesthesia care because of drug-refractory ventricular fibrillation. NSE was determined preoperatively, immediately after surgery, and again 2, 6 and 24 hours after the operation. Additionally, concentration and attention were evaluated pre- as well as two days postoperatively with the help of the forward and backward Digit-Span Memory Test, in which the subject must absorb and recall a string of digits in the original and the reverse order, respectively. The highest obtainable score is 60 (forward test) and 50 points (backward test).

Results: On average, 3 episodes of ventricular fibrillation were induced in each patient during ICD testing. Baseline NSE determined before surgery was $9.9 \pm 2.8 \mu\text{g/L}$ (mean \pm SD). Increased levels could already be measured immediately after surgery ($13.4 \pm 6.1 \mu\text{g/L}$, $P < 0.05$ vs. baseline, Repeated measures ANOVA with Bonferroni t -test). It remained elevated in the same range throughout the observation period. Concomitantly, the forward and the backward Digit-Span score declined from 44 to 37, and from 37 to 31 points, respectively.

Discussion: Obviously, these brief recurrent episodes of cerebral hypoperfusion during ICD placement are associated with neuronal injury. This may result in a deterioration of concentration and attention postoperatively without major neurological deficits.

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077

Neurological outcome after coronary artery bypass grafting: sevoflurane versus total intravenous anaesthesia

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Introduction: Perioperative neurological and neuro-physiologic dysfunctions are of great importance, as they influence both the patient's quality of

life and the usage of economic resources. In experimental animal studies; when volatile anaesthetics were administered during ischaemic states, they have prevented or reduced brain damage. The aim of our study was to see whether sevoflurane improves neurological outcome after coronary artery bypass surgery (CABG) or not.

Method: 42 patients; aged 42–65, ASA II–III, undergoing CABG, were selected for the study. Patients were randomly divided into two groups as either sevoflurane or total intravenous anaesthesia (TIVA). Anaesthesia was maintained by fentanyl, midazolam and pancuronium in the TIVA group and by fentanyl, sevoflurane and pancuronium in the sevoflurane group. Middle cerebral artery blood flow rates were measured by transcranial Doppler; before induction of anaesthesia, 10 minutes after induction of anaesthesia, after aortic cannulation, 20 minutes after the beginning of CPB and at the end of the surgery. Samples for S100 β protein measurements were taken; before induction of anaesthesia, at the end of the CPB and postoperative 24th hour. Serial Digit Learning (SDL) test and Raven's Standard Progressive Matrices (SPM) test, were done; 1 day before the operation and 10 weeks after the operation.

Results: In the TIVA group, mean arterial pressure (MAP) and mean middle cerebral arterial flow rates (Vmean) both decreased after the induction of anaesthesia. In the sevoflurane group, MAP and Vmean changes showed a parallel progress in all measurement periods. Statistical analysis made with neurocognitive test scores showed a decrease only in TIVA group's SPM test ($P < 0.05$). All of the S100 β protein values which were measured before and 24 hours after the operation were below the pathological level. Measurements made at the end of CPB showed a statistically significant increase above the pathological level but there were no significant difference between the groups.

Discussion: Progression of MAP and Vmean changes during operation make us think that sevoflurane disturbs the cerebral autoregulation. In this situation, cerebral blood flow becomes dependent on systemic arterial blood pressure. On the contrary, neurocognitive tests for systematic and accurate intelligence evaluation did not change in isoflurane patients, but decreased in TIVA patients. In conclusion, further investigations should focus on whether cerebral autoregulation should be maintained or not.

Reference:

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003

The effects of normovolaemic haemodilution on degree of lymphocyte apoptosis during CABG

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Introduction: The influence of normovolaemic haemodilution (NH) on lymphocyte apoptosis (LA) is not clear. The aim of this study was to assess lymphocyte apoptosis intensity during CABG and NH.

Method: Twenty male patients aged 53 to 70 underwent CABG under general anaesthesia and extracorporeal circulation (ECC) with NH. A priming volume of 1800 mL was used for all patients. Patients were divided into two groups: A—patients weighing 75 kg or less and B—more than 75 kg or more. The degree of NH resulting from different body mass was confirmed by haematocrit (Hct). Lymphocyte esterase (EL) and mitochondrial transmembrane potential (MTP) were used as apoptosis markers. Flow cytometric method and reagents such as FDA (fluorescein diacetate) and CMX-ROS (chloromethyl-X-rosamine) were used for EL (FDA) and MTP (CMX-ROS) measurement. The EL, MTP, Hct and lymphocyte count were noted at seven stages: 1. before anaesthesia; 2. during NH; 3. after surgery; 4. the evening after surgery; 5. the morning of the first postoperative day; 6. the evening of the first postoperative day and 7. the morning of the second postoperative day. The Wilcoxon and Mann-Whitney tests were used for statistical analysis.

Results: In all patients the statistically significant increases of LA were noted from stages 2 to 7. LA increased in stages 2, 3, 4, fell in stage 5 and increased again in stages 6, 7. The inter-groups comparison shows significant differences in stages 6 and 7. The number of lymphocytes decreases in stage 2, 5, 6, 7.

Table:

| Median: Stages | FDA(%) | | ROS (%) | | LY (10 ³ /μl) | | Hct | |
|----------------|--------|---------|---------|---------|--------------------------|--------|-------|---------|
| | A | B | A | B | A | B | A | B |
| 1 | 5.31 | 1.85 | 5.24 | 4.5 | 26.5 | 26 | 40.75 | 40.2 |
| 2 | 4.51 | 2.36 | 7.75* | 7.7 | 21* | 23.5** | 20.6* | 28** |
| 3 | 8.33* | 6.97** | 8.65* | 8.9* | 25.5 | 25.5 | 28.8* | 30.1** |
| 4 | 12.98* | 8.14** | 17.23* | 12.32** | 26.5 | 25.5 | 35.9* | 34.55** |
| 5 | 9.82* | 4.14** | 10.43* | 10.13** | 19.5* | 23.5** | 37.35 | 36.6** |
| 6 | 18.09* | 8.89** | 22.72* | 13.1** | 17.5* | 22** | 37* | 39* |
| 7 | 19.41* | 10.66** | 17.18* | 13.13** | 20* | 23** | 38.1 | 39.65 |

*P < 0.05; **P < 0.01; ***P < 0.001 – comparison with stages 1.

Discussion: There are only few studies describing phenomenon of LA during different kind of surgery [1]. The cardiocirculatory procedures are connected with NH. Our study shows that the LA is not only depended on surgical stress but on degree of NH as well.

Reference:

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006

Brain glucose and lactate gradient versus pressure gradient across the internal jugular valve during ECC

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Introduction: Glucose is the main metabolic substrate and its extraction depends on brain metabolism. The influence of venous hypertension resulting from altered internal jugular vein valve function on brain metabolism has been described [1,2]. The aim of the study was to analyse relationships between brain glucose extraction (a-v) Gluc, gradient of lactate concentrations (a-v) Lact and pressure gradient across the internal jugular valve (JP-CVP) during CABG.

Method: 15 patients, aged 47–72 underwent CABG. The (a-v) Gluc, (a-v) Lact, JP-CVP were noted at the following 11 stages: 1. induction of anaesthesia – initial values, 2. surgery before ECC, 3. ECC commencement, 4. aorta cross clamping, 5. aorta declamping, 6. end of ECC, 7. end of surgery, 8. the evening after surgery, 9. the morning of the first postoperative day, 10. the evening of the first postoperative day and 11. the morning of the second postoperative day. Pressure in the jugular vein was measured in the jugular bulb. CVP was obtained by cannulation of the opposite jugular vein. The Wilcoxon test was used for statistical analysis.

Results: In comparison with initial values, significant increases of JP-CVP gradient were observed in stages 4, 5, 8, 9, 10 and 11. These changes were accompanied in all but stage 10 by elevated (a-v) Gluc extraction. Initial increase of (a-v) Gluc in stages 4 and 5 was followed by elevated (a-v) Lact recorded in stages 5, 6 and 7.

| Interstages relationship (with stage 1) (median values) | | | | | | | | | | | |
|---|------|------|------|------|-------|-------|-------|------|------|------|------|
| Stages | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| (a-v) Gluc | 6 | 6 | 11 | 19** | 17** | 6 | 5 | 13* | 17** | 13 | 15* |
| (a-v) Lact | 0.12 | 0.09 | 0.10 | 0.06 | 0.32* | 0.47* | 0.06* | 0.21 | 0.16 | 0.22 | 0.22 |
| JP-CVP | 0 | -1 | -1 | 4** | -3* | -1 | -1 | 2*** | 3*** | 4*** | 6*** |

*P < 0.05; **P < 0.01; ***P < 0.001.

Discussion: Obstructed outflow of the brain circulation is one of the deleterious factors affecting brain metabolism. Sum-Ping's study [2] emphasises the relationship between brain pathology and jugular valve insufficiency. Our study shows that the changes of JP-CVP and (a-v) Gluc occur simultaneously and, at least with intra-operative measurements, can reflect brain metabolism pathology.

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014

Diabetes is an independent predictor of hospital mortality in patients with prolonged mechanical ventilation after cardiac surgery

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Introduction: While most patients have a rapid postoperative recovery after cardiac surgery, some require extended postoperative treatment in the ICU. The burden on hospital resources is enormous for this category of patients. The aim of this study was to evaluate the hospital course of patients who required prolonged postoperative mechanical ventilation and to identify the perioperative factors associated to hospital mortality.

Method: Data of 6404 consecutive adult cardiac surgical cases performed over a 5-yr period at Vita-Salute University, IRCCS San Raffaele Hospital, have been prospectively collected after Ethical Committee approval and individual informed consent. Standard anaesthesia with propofol and medium dose opiates was used in all patients. Patients were weaned from the ventilator as they met the following criteria: haemodynamic stability, no major bleeding, normothermia, and consciousness with adequate pain control. Patients who required prolonged mechanical ventilation (>7 days) were identified. Data were stored electronically and analysed by use of SAS 1999 programme by univariate and multivariate analysis.

Results: Of the 6404 patients who underwent cardiac surgery at our hospital from January 1998 to July 2002, only 179 (2.8%) required prolonged (>7 days) postoperative mechanical ventilation, overall Hospital mortality was 2.9% (183 patients), with significant difference (p < 0.001) between the study group (45.3%) and the control population (2%). Within the study group a stepwise logistic regression analysis identified renal failure (OR 8.1, 95% CI 4.0–16.4), diabetes (OR 3.0, 95% 1.1–8.4), age (OR 1.05, 95% CI 1.01–1.08 per year).

The strain these patients place on personal, system, and financial resources is extreme with disproportionate consumption of ICU resources (54% of ICU ventilators occupied by 3% of the population and 31% bed occupation of the cardio thoracic ICU in the period studied).

Discussion: The main result of this study is that patients with a complicated postoperative course after cardiac surgery, requiring prolonged MV, have a dismal prognosis (45.3% hospital mortality). Preoperative predictors of hospital death among this high risk population are represented by diabetes, older age and acute renal failure that can be either an indicator or a pre-existent factor of MOF.

The knowledge of long-term outcome in patients who have sustained major complications after cardiac surgery could help physicians to treat patients and permit more realistic counselling of relatives to better allocate resources toward those with the best chances for acceptable recovery. This could result in more appropriate and enthusiastic use of resources in those likely to recover.

Reference:

- Engoren M, Buderer NF, Zacharias A. Long-term survival and health status after prolonged mechanical ventilation after cardiac surgery. *Crit Care Med* 2000; **28**: 2742–2749.

061

Comparison of serum lipids and glucose levels during propofol or midazolam infusions for cardiac surgery in hyperlipidaemic patients

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Introduction: The aim of our study was to document changes in serum lipids and glucose levels during propofol or midazolam infusions for cardiac surgery in hyperlipidaemic patients.

Method: After approval by the hospital ethics committee, 30 hyperlipidaemic patients undergoing elective coronary artery bypass graft surgery were randomly assigned into two groups. One group of 15 patients received a continuous propofol infusion and the other group of 15 patients received a midazolam infusion as hypnotic agent for induction and maintenance of anaesthesia. Serum total cholesterol, triglyceride, HDL, LDL, VLDL and glucose levels were measured at seven periods perioperatively and postoperatively until postoperative day 3. For statistical analysis of the results, analysis of variance for repeated measures and t test for coupled series were used. $P < 0.05$ was accepted as statistically significant.

Results: Serum lipid levels were found to be decreased in both groups but there was no significant difference between the two groups except HDL levels. The decrease in triglyceride levels in the midazolam group was lower than the propofol group but not statistically significant. Glucose levels were found to be elevated perioperatively and until the 3rd postoperative day but there was no significant difference between the two groups.

| * Group | Glucose mg/dL | Trigly mg/dL | Cholest mg/dL | HDL mg/dL | LDL mg/dL |
|---------|---------------|--------------|---------------|-----------|-----------|
| 1 P | 124 ± 18 | 215 ± 54 | 237 ± 30 | 33 ± 5 | 149 ± 4 |
| M | 113 ± 23 | 2386 ± 47 | 236 ± 43 | 32 ± 9 | 150 ± 41 |
| 2 P | 141 ± 20 | 211 ± 9 | 186 ± 40 | 39 ± 11 | 102 ± 38 |
| M | 127 ± 37 | 186 ± 69 | 179 ± 33 | 29 ± 7 | 121 ± 33 |
| 3 P | 180 ± 44 | 145 ± 75 | 135 ± 27 | 25 ± 10 | 83 ± 27 |
| M | 164 ± 31 | 96 ± 29 | 143 ± 36 | 23 ± 9 | 101 ± 29 |
| 4 P | 184 ± 39 | 146 ± 46 | 119 ± 19 | 27 ± 11 | 64 ± 3 |
| M | 159 ± 29 | 114 ± 51 | 134 ± 29 | 23 ± 6 | 88 ± 25 |
| 5 P | 175 ± 26 | 150 ± 48 | 118 ± 27 | 28 ± 10 | 63 ± 27 |
| M | 158 ± 23 | 129 ± 55 | 124 ± 34 | 23 ± 8 | 76 ± 36 |
| 6 P | 165 ± 26 | 145 ± 47 | 113 ± 21 | 25 ± 6 | 60 ± 19 |
| M | 136 ± 23 | 116 ± 43 | 117 ± 26 | 24 ± 5 | 70 ± 23 |
| 7 P | 130 ± 24 | 162 ± 31 | 143 ± 25 | 25 ± 5 | 77 ± 26 |
| M | 123 ± 28 | 137 ± 1 | 130 ± 25 | 25 ± 6 | 79 ± 21 |

*1–7; measurement points.

Discussion: We can say that a propofol infusion does not increase significantly the risk of hyperlipidaemia when used in cardiac surgery.

References:

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056

Can wound desiccation be averted during cardiac surgery?

An experimental study

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Introduction: During cardiac surgery the wound is exposed to desiccation, in particular as a result of operating room ventilation and because dry carbon dioxide is sometimes insufflated for de-airing. The objectives were to quantify and compare the desiccation rates during these conditions, and to determine the influence of insufflation of humidified carbon dioxide.

Method: In a fully ventilated operating room we studied humidity (Hygropalm3, RotronicAG, Switzerland) and desiccation rate of a cardiothoracic wound model, which included two standard blood agar plates. We compared the effect of dry and humidified carbon dioxide (bubbled through sterile water), respectively, with a control. Gas was supplied to the model at 10 L min^{-1} via a standard open-ended tube or a low velocity-outlet device (a gas-diffuser), and we also compared the effect of these two delivery systems.

Results: The accumulated water loss $\text{mg (cm}^2\text{)}^{-1}$ in the model increased almost linearly with time, irrespective of the humidity of the gas or the vehicle for its supply ($R^2 = 0.97$). Significant differences appeared between the five groups as to their desiccation rate (water loss expressed in $\text{mg (cm}^2\text{ min}^{-1}\text{)}^{-1}$, i.e., the inclination of the water loss curves ($P < 0.001$, Wilcoxon's test). Dry (3%) and humidified (76%) carbon dioxide insufflation via the open-ended tube resulted in much higher rates than the control. When insufflated via a gas-diffuser, dry carbon dioxide gave a slightly higher desiccation rate but humidified carbon dioxide lowered the rate to $<10\%$ of the control.

Conclusions: Humidified carbon dioxide may be used to avert desiccation of the cardiothoracic wound. The humidified gas is effective only when delivered via a low-velocity outlet device.

References:

- Svenarud P, Persson M, van der Linden J. Intermittent or continuous carbon dioxide insufflation for de-airing of the cardiothoracic wound cavity? An experimental study with a new gas-diffuser. *Anesth Analg* 2003; **96**: 321–327.
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034

Gastric acid aspiration risk following cardiac surgery

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Introduction: A key feature of gastric acid aspiration that result in chemical pneumonitis is aspiration of a high volume $>50 \text{ mL}$ [1] at a pH of <2.5 [2]. Prevention of acid aspiration following cardiac surgery is variable even within the same unit. All patients for routine cardiac surgery are starved for a minimum of 6 hours, and may be prescribed anxiolytics and H_2 -receptor antagonists. Following surgery, patients remain intubated and ventilated for variable periods of time. We therefore decided to assess the risk of gastric acid aspiration at the time of extubation in our cardiac surgical unit.

Method: 45 non-randomized patients undergoing routine cardiac surgery in our unit were studied. Premedication, anaesthetic management and post-operative care were unaltered by the study and were as prescribed by the individual anaesthetist. Current policies regarding extubation criteria were followed. Just prior to extubation the gastric contents were aspirated via an oro-gastric tube, the volume noted and its pH measured. Data is mean and range and analysed using Student's t-test assuming equal variance.

Results: Data was collected from 45 patients. 19 did not receive any pre-medication, and 26 were given temazepam (10–30 mg) and ranitidine (150–300 mg) preoperatively. The duration of starvation prior to surgery, the length of operation and the time from ICU admission to extubation were not different between groups.

Just prior to extubation the pH of the residual gastric contents in unpremedicated patients was significantly lower (pH 4.9, range 1–8) than in premedicated patients (pH 7.8, range 6–10). The volume of the residual gastric contents was higher in unpremedicated patients (23 mL, range 0–150 mL) with a wider distribution, than in premedicated patients (11 mL, range 0–80 mL), but this was not statistically significant. There was no correlation between time to extubation and either gastric residual volume or pH.

Conclusions: Before cardiac surgery routine use of anxiolytics together with H_2 -receptor antagonists prevents the residual gastric contents having a clinically significant acidity. In addition premedication also appears to reduce the wide variability in residual volumes seen in unpremedicated patients and in the majority of patients (25 out of 26 patients) premedication reduces this volume to less than the perceived 'at risk' volume ($<50 \text{ mL}$) identified by Raidoo et al [1].

References:

- Raidoo DM, Rocke DA, Brock-Utne JG, et al. Critical volume for pulmonary acid aspiration: reappraisal in a primate model. *Br J Anaesth* 1990; **65**: 248–250.
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004

In-vivo measurement of levofloxacin penetration into lung tissue after cardiac surgery

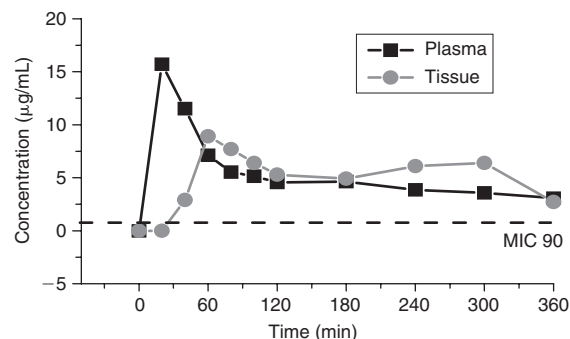
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Introduction: Postoperative pneumonia is a severe complication after cardiac surgery (CS) [1]. Therefore, antibiotic prophylaxis is common in patients with increased pulmonary risk. Levofloxacin, a fluoroquinolone, qualifies for perioperative pulmonary prophylaxis due to its activity against gram-positive and gram-negative bacteria. However, penetration properties of levofloxacin to the lung tissue could be affected by CS: atelectasis, changes in circulation, high volume loads and inflammatory capillary leak influencing drug distribution. Therefore, we measured plasma and lung concentrations of levofloxacin in patients undergoing CS.

Method: Six patients undergoing CS on cardiopulmonary bypass participated in the study. Levofloxacin (500 mg) was administered in addition to the standard antibiotic immediately after the end of surgery. Thereafter, we measured time versus concentration profiles of levofloxacin in interstitial lung tissue and plasma. Microdialysis was used for lung interstitial concentration measurements. Microdialysis is based on sampling of analytes from the interstitial space fluid by means of a semi-permeable membrane.

Results: Patients were 61 ± 8 years of age and had a body mass index of 19.6. Levofloxacin concentrations in lung interstitial tissue were well above the MIC₉₀ (fig). Microdialysis-procedure was well tolerated by all patients.



Conclusion: This study showed the feasibility and the safety of microdialysis in human lung tissue after CS. Data corroborate the use of levofloxacin as a valuable agent in the treatment of bacterial lung infections in high risk patients.

Reference:

- Müller M, Haag O, Burgdorff T, et al. Characterization of peripheral-compartment kinetics of antibiotics by in vivo microdialysis in humans. *Antimicrob Agents Chemother* 1996; **40**: 12: 2703–2709.

057

Carbon dioxide inhibits the growth rate of *Staphylococcus aureus* at body temperature

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Introduction: Since the 1930s CO₂ has been combined with cold storage for the preservation of food. Its use for the prevention of surgical wound infection was considered impractical. Now CO₂ is used in endoscopic surgery and a method has been developed to create a CO₂ atmosphere in an open cardiothoracic wound cavity. Therefore we studied the effect of CO₂ on the growth of *Staphylococcus aureus* at body temperature.

Method: Firstly, *S. aureus* inoculated on blood agar was exposed to carbon dioxide (100%), standard anaerobic gas (5% CO₂, 10% hydrogen, 85% nitrogen), or air at 37°C during 24 hours, whereupon a viable count was made. Secondly, *S. aureus* inoculated in brain-heart infusion broth cultures, kept at 37°C, was exposed to CO₂ or air for 0, 2, 4, 6, and 8 hours when optical density was measured.

Results: After 24 hours the number of *S. aureus* on blood agar was about 100 times lower in CO₂ than in anaerobic gas ($P = 0.001$, Wilcoxon's test), and about 1000 times lower than in air ($P = 0.001$). Also in broth there were fewer bacteria with CO₂ than with air ($P < 0.01$). After 2 hours the number of bacteria was increased with air ($P < 0.001$) but not with CO₂ ($P = 0.13$). After 8 hours the optical density had increased from zero to 1.2 with air and to 0.01 with CO₂ ($P = 0.001$).

Conclusions: 100% CO₂ significantly decreased the growth rate of *S. aureus* at body temperature. The inhibiting effect of CO₂ increased exponentially with time. Its bacteriostatic effect may help to explain the low infection rates in endoscopic surgery.

References:

- Coyne FP. The effect of carbon dioxide on bacterial growth. *Proc Royal Soc Series B* 1933; **113**: 196–217.
- Persson M, van der Linden J. De-airing of a cardiothoracic wound cavity model with carbon dioxide: theory and comparison of a gas diffuser with conventional tubes. *J Cardiothorac Vasc Anesth* 2003; **17**: 329–335.
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Epidural/Echo/Coagulation

058

Preoperative CT or intraoperative epi-aortic ultrasound for the diagnosis of atherosclerosis of the ascending aorta? a preliminary report

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Introduction: Extensive atherosclerotic disease, usually first diagnosed intraoperatively, is the most important risk factor for postoperative stroke after cardiac surgery. The aim of this study was to investigate if preoperative computer tomography (CT) is comparable with intraoperative epi-aortic ultrasound to diagnose severe atherosclerosis in the ascending aorta.

Method: The study included 20 consecutive patients undergoing elective coronary artery bypass surgery (CABG). Preoperative CT evaluation of the ascending aorta was compared with intraoperative epi-aortic ultrasound findings. The ascending aorta was divided into 12 segments per patient giving in total 240 segments to compare.

Results: Epi-aortic ultrasound detected atherosclerosis in $16.7 \pm 2.4\%$ of the segments, which was significantly higher than with CT ($P \leq 0.03$). There was a low reliability between the two methods with Kappa Coefficients of 0.45 or lower.

Conclusions: The CT method is inferior to epi-aortic ultrasound, today's gold standard, in diagnosing the extent and location of atherosclerosis of the ascending aorta. Other methods should be sought, possibly magnetic resonance imaging.

References:

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093

Two year experience and clinical impact of echocardiography in the cardiothoracic intensive care unit

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Introduction: Evaluation of acute, persistent and life-threatening haemodynamic disturbances is a class I indication for echocardiography according to the 2003 guideline update for the clinical application of echocardiography [1].

Method: Retrospective analysis of all cardiac surgical patients in the intensive care unit (ICU) who received urgent echocardiography done by two anaesthesiologists with advanced training. Indications were classified into four groups:

- 1) haemodynamic instability
- 2) exclusion of valvular pathology
- 3) exclusion of vegetation or thrombus
- 4) exclusion of aortic dissection

The changes in treatment resulting from echocardiography findings were classified into medical (A) and surgical (B) interventions:

A1: volume management; **A2:** inotrope therapy; **A3:** early coronary angiography because of severe regional wall motion abnormalities;

A4: cardioversion; **B1:** evacuation of haemopericardium; **B2:** mitral valve replacement; **B3:** insertion of an intra-aortic balloon pump; **B4:** coronary revascularization.

Results: From 01/2002 to 12/2003 2157 patients were treated in our cardiac surgical ICU. We surveyed a total of 61 patients (3%) with 67 echocardiographic examinations in the ICU. 19 were transthoracic (TTE) and 48 were transoesophageal echocardiographic studies (TOE). Six patients could not be adequately imaged by TTE. TOE was required to make the diagnosis.

Table. Indications (n of patients)/changes in treatment (n).

| | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 |
|--------|----|----|----|----|----|----|----|----|
| 1 (44) | 10 | 17 | 2 | | 10 | | 3 | 1 |
| 2 (11) | 4 | 5 | | | | 2 | | |
| 3 (4) | 2 | 1 | | 1 | | | | |
| 4 (2) | | 1 | | | | | | |

In 32 (52.5%) of our patients, medical management was changed, most commonly by an alteration in inotrope therapy and/or iv. fluid load but also by immediate coronary angiography. In two cases systolic anterior motion of the mitral valve was detected triggering a complete change in haemodynamic management. 15 (24.6%) patients had a surgical intervention. 13 returned to the operating room mostly because of cardiac tamponade. There were two mitral valve replacements and one case with coronary revascularization plus intra-aortic balloon pump. In 14 patients TOE findings were considered lifesaving.

Discussion: In our cardiac surgical ICU echocardiographic findings had a significant clinical impact, especially in the haemodynamically unstable patient. TOE often provides the most definitive diagnosis and may improve survival.

Reference:

- 1 Cheitlin MD, Armstrong WF, Aurigemma GP, et al. ACC/AHA/ASE 2003 guideline update for the clinical application of echocardiography. *J Am Soc Echocardiogr* 2003; **16**: 1091–1110.

051

Intraoperative transoesophageal echocardiography in a case of pulmonary arteriovenous malformation

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Case report: A 44-year-old woman was admitted for surgical correction of a pulmonary arteriovenous malformation (PAVM).

This patient had a previous history of cerebral ischaemic attacks resulting in right hemiparesis and seizures. A misdiagnosis of patent foramen ovale was made and the patient was submitted to surgery. However, no patent foramen ovale was found. She was then submitted to further investigations.

As the chest X-ray demonstrated an opacity in the right lower lung field and the patient had a low arterial saturation, a PAVM was highly suspected and confirmed by computed tomography.

A pulmonary angiogram was also performed and according to the report, revealed an enlarged right pulmonary artery feeding a large fistula (aneurysmal sac 23 × 24 mm), which directly drained to the left atrium through a large anomalous communication, 18 mm in diameter. The fraction of the cardiac output that shunted from right-to-left was estimated to be 50%.

The patient underwent a right lateral thoracotomy with selective one lung ventilation. Intraoperative transoesophageal echocardiography (TOE) was used. With TOE no abnormal conduit could be found entering the left atrium. However, a large right lower pulmonary vein was seen, with turbulent flow on colour Doppler and increased flow velocity on pulsed wave Doppler.

The central localization of the PAVM made the surgical exploration difficult. The surgeon was not able to find any anomalous vessel directly connecting the fistula to the left atrium. Isolation and clamping of the feeding arteries (arising from the lower lobe branch of the right pulmonary artery) resulted in a minimal blood flow in the right lower pulmonary vein visualized by TOE. The same result was obtained with clamping of what seemed to be the efferent vessel of the PAVM.

The afferent arteries and the right lower pulmonary vein were ligated and a lower lobectomy performed.

TOE has been described as a useful tool in diagnosis of PAVM [1]. In this case report the intraoperative use of TOE proved useful, helping the surgeon to clarify the vascular anatomy of the PAVM, namely its drainage through a pulmonary vein.

Reference:

- 1 Chessa M, Drago M, Krantunkov P, et al. Differential diagnosis between patent foramen ovale and pulmonary arteriovenous fistula in two patients with previous cryptogenic stroke caused by presumed paradoxical embolism. *J Am Soc Echocardiogr* 2002; **15**: 845–846.

018

Perioperative transoesophageal echocardiography and post-infarct ventricular septal defect

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We report on 2 patients who presented with ventricular septal defects complicating acute myocardial infarction, in whom transoesophageal echocardiography (TOE) impacted significantly on their management.

Case Reports: An 82 year old female patient with no past medical history presented with acute anterior myocardial infarction. Twenty-four hours later a new onset holosystolic murmur was noted and the diagnosis of a new onset ventricular septal defect was confirmed using TOE and ventriculogram. Emergency surgical repair was carried out.

The second patient was a 79 year old male patient who presented with acute inferior myocardial infarction and post-infarction ischaemia. Emergency revascularization was carried out and postero-septal ventricular septal defect was diagnosed intra-operatively using TOE. Both patients made an uneventful postoperative recovery.

Preoperative management and optimization of both patients for emergency surgery required the use of both inotropic support to increase cardiac output and the judicious use of vasodilators to reduce ventricular afterload and to decrease left to right shunt.

An intra-aortic balloon pump was inserted perioperatively to optimize coronary blood flow. Intraoperatively, cardiopulmonary bypass was rapidly established, the defects were surgically repaired adequately as confirmed by TOE post bypass. In the second case revascularization was also carried out.

Postoperatively both patients required inotropic support. Milrinone was our inotrope of choice as it also provided vasodilatation and a decrease of ventricular afterload.

Discussion: Ventricular septal defect complicates 2% of all acute myocardial infarctions. The incidence is higher in patients with single vessel disease namely the left anterior descending artery. Anterior myocardial infarction is complicated by antero-apical ventricular septal defect while inferior myocardial infarction is complicated by postero-septal ventricular septal defect. The mortality rate is high and early surgical intervention has been shown to decrease the mortality rate from 85% to 25% if treated within the first 24 hours post onset. The anaesthetic management of patients with ventricular septal defects complicating acute myocardial infarction is complex and challenging. The anaesthetist is involved in every stage of management. In the first case we used TOE to confirm the location and the size of the defect and to guide surgical intervention. In the second case we used TOE to make the unexpected diagnosis intraoperatively and subsequently to guide surgical management.

Reference:

- 1 Bouchart F, Besson JP, Tabley A, et al. Urgent surgical repair of postinfarction ventricular septal rupture: early and late outcome. *J Card Surg* 1998; **13**: 104–112.

054

Contractile function of the heart after cardioplegia is not determined by the extent of myocardial necrosis and lactate release

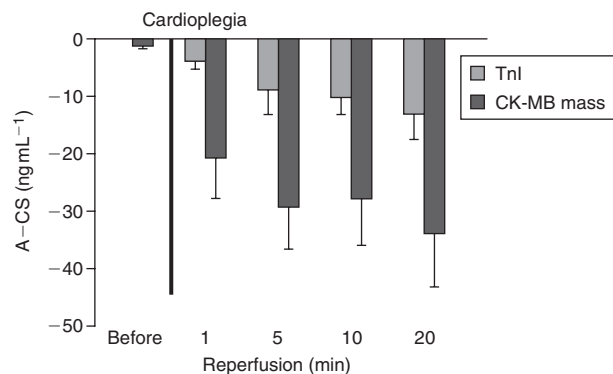
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Introduction: Perioperative myocardial infarction has a prognostic value for morbidity and mortality after cardiac surgery [1]. The present study was undertaken to investigate whether cardioplegia related myocardial necrosis and lactate release [2] are predictive for early cardiac dysfunction after CABG surgery.

Method: 20 patients with stable angina underwent scheduled CABG with cardiopulmonary bypass (CPB). Cold antegrade and retrograde crystalloid cardioplegia with St. Thomas' solution II was used. Mean cardioplegia time was 84 (50–126) min. Blood for cardiac troponin I (Tn I), creatine kinase MB isoenzyme mass (CK-MB) and lactate was simultaneously sampled from arterial and coronary sinus (CS) cannulae before CPB, and at 1, 5, 10, 20 minutes of reperfusion. Arterio-CS differences were calculated. Cardiac index (CI) and right and left ventricular stroke work indices (RVSWI, LVSWI) were measured by thermodilution technique before sternotomy, 15 minutes and 1, 2, 4, 6, 9, 12 hours after discontinuation of CPB.

Results: Before cardioplegia, myocardial necrosis and lactate release were not detectable. Remarkable release of both Tn I and CK-MB to CS appeared from the 1st minute of reperfusion (Fig.). Release of lactate was maximal on the 1st minute of reperfusion (-1.59 ± 0.71 mmol/L), then decreased to pre-clamping values. Early postoperative performance of the heart, in contrast, was not inferior to pre-clamping values. Mean (\pm SD) pre-CPB CI was 3.14 ± 0.80 L min^{-1} m^{-2} , while after reperfusion the values were 3.99 ± 1.03 at 15 minutes, 4.37 ± 1.29 at 2 hours, 3.67 ± 0.91 at 6 hours, 3.72 ± 0.80 at 9 hours, and 3.99 ± 0.84 at 12 hours, respectively. No correlation between release of Tn I and CK-MB and CI was found.



Discussion: Cardioplegia is associated with irreversible myocardial injury and temporary lactate release. Contractile function of the heart evaluated by pulmonary artery catheter provides little information of the extent of the myocardial damage.

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063

An audit of central venous cannulation in Papworth Hospital from March to May 2003

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Introduction: NICE [1] guidelines published in September 2002 recommend that ultrasound guidance is the preferred method for the insertion of central venous catheters (CVCs). Papworth currently uses the anatomical landmark method for insertion of CVCs. This audit is to establish the quality of our practice by assessing the success and complication rates in order to determine whether introducing ultrasound locating devices to Papworth would be beneficial.

Method: Anaesthetic specialist registrars and consultants were asked to complete an audit form for every CVC insertion during the 3 month audit period 10/03/03–31/05/03. Data gathered included patient demographics, anaesthetists' experience, site attempted, number of attempts, use of a seeker needle, previous CVCs and complications. Where two CVCs were inserted at the same time in the same patient, the second catheter has not been analysed.

Results: In total, 476 forms were completed during the audit period, which we estimate to be 80% compliant. These forms gave details of 505 approaches including 2nd and 3rd attempts. Of these, 481 used anatomical landmarks, one used pre-procedure ultrasound and 23 forms did not specify but it is assumed it would have been the anatomical landmark method. All but one patient was successfully cannulated. 68 patients had 2 CVCs inserted (CVC and Pulmonary Artery (PA) catheter). All internal jugular approaches were from the anterior but height was not specified. Vessels attempted, success rates and complication rates are shown in table 1; number (%).

| Vessel | Attempts | Success | 1st pass success* | Arterial puncture | Pneumothorax |
|--------|----------|-----------|-------------------|-------------------|--------------|
| RIJ | 401 | 381 (95) | 306 (76.3) | 8 (2) | 1 (0.25) |
| LIJ | 54 | 49 (90.7) | 41 (75.9) | 1 (1.9) | 0 (0) |
| R/L S | 46 | 42 (91.3) | 25 (54.3) | 2 (4.3) | 1 (2.2) |
| FV | 3 | 3 (100) | 2 (66.6) | 1 (33.3) | 0 (0) |

RIJ = Right internal; LIJ = left internal; R/L S = right or left subclavian; FV = femoral vein; *number successful with 1st pass large needle.

Discussion: The data this audit has collected has confirmed that the current practice at Papworth Hospital using the anatomical landmark method for CVC insertion is acceptable with both the success and complication rates being comparable to findings in other published audits. However, it is possible that the 20% of CVC insertions that the audit did not capture could have been the cases with higher complication rates.

Reference:

- 1 National Institute for Clinical Excellence (NICE) Guidance on the use of ultrasound locating devices for placing central venous catheters. Technology Appraisal Guidance September 2002; **49**.

074

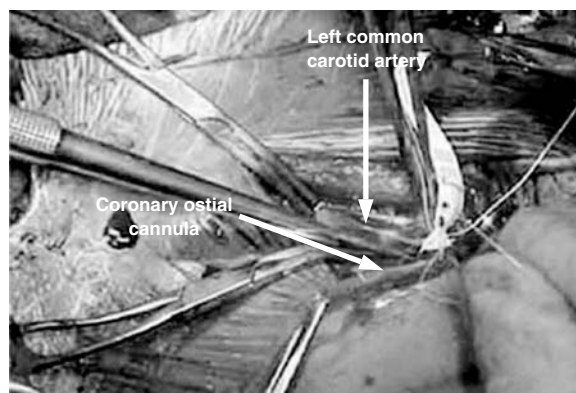
Modified distal carotid artery perfusion for combined carotid endarterectomy and off pump coronary artery bypass surgery

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Introduction: Conventionally, a combined carotid endarterectomy (CEA) and coronary artery bypass grafting (CABG) is performed as a one stage procedure [1]. Here, we describe a technique that uses a combined 'off-pump' CABG and a modified distal carotid artery perfusion without the use of cardio pulmonary bypass.

Method: Between Sept 2001 and Sept 2003, patients who had documented coronary artery disease and significant carotid artery disease (demonstrated by carotid duplex scanning and carotid angiography) underwent a combined 'off-pump' CABG and CEA. The CEA was done prior to 'off-pump' CABG under standard general anaesthesia. After sternotomy, a 24-F antero-grade cardioplegia cannula (Chase medical, Ref: ANT-10145, Richardson, Texas, USA) was placed in the ascending aorta and its distal end was connected to a coronary ostial perfusion cannula (Medtronic, DLP, Minneapolis, MN, USA) (COPC) through a 3-way stopcock connection. The other end of COPC was placed into the distal internal carotid artery (ICA) and was snugged (figure). CEA was performed under the control of vascular clamps and distal ICA was perfused during the time of CEA and repair. 'Off-pump' CABG was then performed using the octopus II stabilizing device. All patients were electively ventilated and early extubation of the trachea was achieved after satisfying the standard criteria.



Results: During a 2 year period 9 patients underwent combined CEA and off-pump CABG. Mean age, sex (M/F), weight, BSA and number of grafts were 68.5 ± 7.7 years, 7/2, 65 ± 4.6 kg, 1.6 ± 0.9 m² and 2.4 ± 0.5 respectively. All patients woke up after surgery in 2.3 ± 1 hr and then were successfully extubated. There were no residual sequelae, neurological or otherwise. Postoperative carotid Doppler showed a normal flow pattern in the carotid system in all patients.

Conclusion: Traditionally, cerebral perfusion is maintained during CEA by the use of shunts inserted into the proximal and distal carotid arteries. In our technique, proximal carotids are not cannulated thereby improving the surgical access and avoiding disruption of plaques, if any. The technique of distal internal carotid after perfusion using the method described above is safe, easily reproducible and cost effective.

Reference:

- 1 Brodtkin AI, Murkin JM. Protection of the brain during cardiac surgery. In: Hensley FA, Martin DE eds. A practical approach to cardiac anesthesia, Boston: Little Brown & Company, 1995; 599.

104

Therapeutic coronary intervention after primary coronary angiography, TROMSØ 2000

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Introduction: This study presents the therapeutic consequences of primary coronary angiography (CA) in 1230 individuals living in the northern region of Norway, having their first CA at the University Hospital in Tromsø in 2000.

Method: A total of 1588 individuals having undergone CA in 2000 were identified by searching the data registry at the hospital. Those having undergone CA, percutaneous coronary intervention (PCI) or coronary artery bypass surgery (CABG) prior to the year 2000 and residents from other regions of Norway were excluded. The findings were validated by reading all available information in the medical records. By this, additionally 96 individuals were excluded. By comparing the laboratory protocols with the medical records another 44 individuals were included, expanding the total number of primary CA to 1230 individuals. These individuals were followed to register the frequency of primary interventional treatment, PCI or CABG.

All percentages are age-adjusted by the direct method and CI 95% [1].

Results: Coronary interventional treatment was performed in 58.5% of women and in 83.3% of men. The age-adjusted difference between men and women was 24.8% (CI 95% 19.2–30.4). PCI was performed in 39.8% women and in 53.3% men. The age-adjusted difference was 13.5% (CI 95% 7.5–19.5). CABG was performed in 15.7% of women and in 25.6% of men. Combined heart-valve surgery and CABG was performed in 3.0% of women and in 4.4% of men.

Table 1. Intervention after primary CA, distributed on sex, with age-adjusted percentages (%), Tromsø 2000.

| | Women | | Men | |
|----------------------------|-------|-------|------|-------|
| | N | % | N | % |
| No intervention | 148 | 41.5 | 148 | 16.7 |
| PC | 153 | 39.8 | 456 | 53.3 |
| CABG | 60 | 15.7 | 215 | 25.6 |
| CABG + Heart-valve surgery | 15 | 3.0 | 35 | 4.4 |
| All | 376 | 100.0 | 1230 | 100.0 |

Discussion: The results in this study confirm the findings from others that there is an increasing frequency of patients with coronary artery disease being treated with PCI. Among patients having their first CA in Tromsø in 2000, 49.4% were treated with PCI, whereas 26.7% had either CABG (22.6%) or combined CABG and heart-valve surgery (4.1%). This study also supports the observation and the ongoing discussion on sex differences in invasive interventions for coronary artery disease [2]. More men than women were treated with PCI or CABG (or combined CABG and valve surgery) in all age groups.

References:

- Kirkwood BR. *Essentials of Medical Statistics*. Oxford: Blackwell, 1998.
- Malenka DJ, Wennberg DE, Quinton HA, et al. Gender-related changes in the practice and outcomes of percutaneous interventions in Northern New England from 1994 to 1999. *J Am Coll Cardiol* 2002; **40**: 2092–2101.

080

Epidural infusion of ropivacaine or bupivacaine during major thoracic surgery

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Introduction: Ropivacaine is a new local anaesthetic with reduced cardio- and neurotoxicity. The aim of this study was to compare the course of thoracic epidural anaesthesia (TEA) with ropivacaine and bupivacaine for major thoracic surgery.

Method: After Ethical Committee approval and written informed consent 40 patients scheduled for antero-lateral thoracotomy were enrolled. Group I (n = 20) underwent TEA with 0.375% bupivacaine while group II (n = 20) underwent TEA with 0.375% ropivacaine. An epidural catheter was inserted at Th4–Th8 and 8 segments were blocked. Volume of the local anaesthetics were calculated according to Bromage rule (1 mL/segment + 0.1 mL/segment for each 5 cm of height above 150 cm). 5 mL (250 µg) of fentanyl were mixed with each 10 mL of 0.5% local anaesthetic. Propofol was used for anaesthetic induction and for maintenance of anaesthesia. Muscle relaxation was achieved with rocuronium. Continuous infusion of the study drug (rate of infusion – 0.8 mL/segment/h) was used throughout the procedure and no opioids were used intravenously.

Results: No differences in heart rate values were found during anaesthesia between study groups. However systolic blood pressure was found to be significantly lower in the bupivacaine group in a measurement taken 45 minutes after induction of anaesthesia.

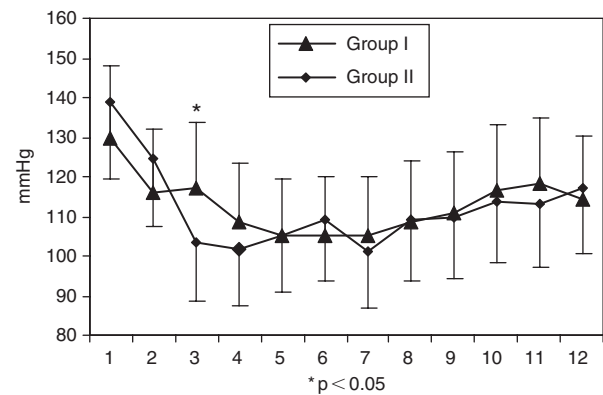


Figure 1.

Conclusion:

Ropivacaine and bupivacaine provided similar haemodynamic stability during major thoracic procedures.

References:

- Fernandez-Guisasola J, Serrano ML, Cobo B, et al. A comparison of 0.0625% bupivacaine with fentanyl and 0.1% ropivacaine with fentanyl for continuous epidural labor analgesia. *Anesth Analg* 2001; **92**(5): 1261–1265.
- Pinder AJ, Dresner M. Ropivacaine and bupivacaine with fentanyl for labor epidural anesthesia. *Anesth Analg* 2000; **91**(5): 1310–1311.

030

Inhaled nitric oxide for hypoxia treatment after open heart surgery

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Introduction: Arterial hypoxaemia is not a rare complication after open heart surgery. The aim of the study was to evaluate the efficacy of nitric oxide inhalation (iNO) in patients with a low index of oxygenation ($\text{PaO}_2/\text{F}_i\text{O}_2$).

Method: The study included 17 pts, 14 males (82.4%) and 3 females (17.6%) with the mean age of 59 years (43–75) who underwent open heart surgery between October 2001 and October 2003 at our Clinic. The mean duration of aortic cross clamping time was 86.4 ± 20.2 minutes and the mean time of cardiopulmonary bypass 94.3 ± 21.4 minutes. Ventilation parameters were the same in all patients: minute volumen 10–12 mL/kg, frequency 12–14/min, I:E ratio 1:1 and positive end-expiratory pressure (PEEP) + 5 cmH₂O. A low $\text{PaO}_2/\text{F}_i\text{O}_2 < 8$ kPa was the indication for iNO. A pulmonic device was used to deliver NO continuously through the precise mass flow controller to the inspiratory limb of the ventilator. $\text{PaO}_2/\text{F}_i\text{O}_2$, iNO dose and the duration of mechanical ventilation were observed. The starting dose of 15 ppm was gradually decreased by 3 ppm. Data is expressed as mean \pm SD. Statistical significance was calculated to values before iNO therapy using paired t-test.

Results: Values of $\text{PaO}_2/\text{F}_i\text{O}_2$ (kPa) during iNO therapy in ICU

| Time | Mean | SD | P |
|----------------|------|-------|---------|
| Before iNO | 7.76 | 0.93 | |
| After 30 min | 10.2 | 1.98 | < 0.001 |
| After 1 hour | 12.2 | 3.00 | < 0.001 |
| After 2 hours | 15.8 | 9.04 | < 0.001 |
| After 6 hours | 18.5 | 8.44 | < 0.001 |
| After 16 hours | 24.1 | 7.22 | < 0.001 |
| After 24 hours | 29.2 | 6.48 | < 0.001 |
| After 48 hours | 41.8 | 17.87 | < 0.001 |

The average duration of iNO therapy was 50 ± 29 (min = 18, max = 89) hours and mechanical ventilation 51 ± 27 (min = 20, max = 93) hours. All patients were successfully extubated.

Conclusion: The iNO administration significantly improved arterial oxygenation and was effective in correcting hypoxia in patients after open heart surgery.

Reference:

- Prendergast B, Scott DH, Mankad PS. Beneficial effects of inhaled nitric oxide in hypoxaemic patients after coronary artery bypass surgery. *Eur J Cardiothorac Surg* 1998; **14**(5): 488–493.

091**Iloprost: a positive inotropic effect in isolated myocardium?**

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Introduction: Iloprost, a stable derivate of prostacyclin (epoprostenol), is known to diminish PVR. In addition, improvement of right ventricular function has been observed after inhaled administration [1]. Direct inotropic actions have not been studied until now. In the present experimental study the dose-dependent contractile response of human atrial and rabbit ventricular trabeculae to iloprost was investigated.

Method: 17 trabeculae from right atrial appendices and 25 preparations from rabbit right ventricle were studied. Developed force was continuously registered at a pacing frequency of 1 Hz at 37°C. Iloprost concentration was increased stepwise from 10^{-11} to 10^{-7} M. Results are given as mean \pm SEM. Statistical analysis was performed by ANOVA for matched values.

Results: Baseline values were 8.52 ± 1.4 mN/mm² for human trabeculae and 11.5 ± 1.5 mN/mm² for rabbit trabeculae. Iloprost exerted a positive inotropic effect in 10 of 17 human trabeculae ("responders"). In 7 trabeculae no change in contractility was observed, despite a positive effect of recalcification. At higher concentrations after-contractions were seen in 29% of all human trabeculae. In 15 of 25 rabbit trabeculae iloprost increased contractility developed ("responders"), in 10 trabeculae no positive effect was achieved. After-contractions were not seen in rabbit trabeculae.

Table 1. Developed force in percent of baseline values at a Iloprost concentration of 10^{-9} M.

| | | Developed force (%) 10^{-9} M Iloprost |
|-------------------|--------------------------|---|
| Human trabeculae | All (n = 17) | 122 \pm 12.8 |
| | Only responders (n = 10) | 142.5 \pm 19.6 *** |
| Rabbit trabeculae | All (n = 25) | 116.7 \pm 4.5 |
| | Only responders (n = 10) | 126.9 \pm 5.3*** |

***: $P < 0.001$

Discussion: Our data suggest that iloprost exerts direct positive inotropic effects in a subset of human atrial and rabbit right ventricular trabeculae. However, species-independent, a relevant number of trabeculae did not respond to iloprost. Further investigations concerning the underlying mechanism of iloprost induced positive inotropism are necessary.

Reference:

- Olschewski H, Simmonneau G, Galie N, et al. Inhaled iloprost for severe pulmonary hypertension. *N Engl J Med* 2002; **347**: 322–329.

022**Inhaled iloprost for testing vasodilator capacity in secondary pulmonary hypertension in children with congenital heart disease**

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Introduction: The assessment of pulmonary vascular reactivity plays an important role in the management of patients with pulmonary hypertension (PHT) related to congenital heart disease. Inhaled iloprost, a stable prostacyclin analogue, may be an alternative to inhaled nitric oxide for early testing of vascular reactivity and for perioperative treatment of PHT [1]. We present the first cases in which we used inhaled iloprost to test pulmonary vascular reactivity.

Method: Three children with congenital heart disease (1st. and 2nd. with ventricular septal defect, 3rd. with aortopulmonary window) and high values of pulmonary vascular resistance were first given oxygen for 10 minutes. After baseline values were reached again, they were given inhaled iloprost at a concentration of 4 μ g/mL with an average nebulization rate of 0.6 mL/min for 5 minutes. Haemodynamic data were recorded before and after each treatment.

Results: Baseline and after oxygen and iloprost administration haemodynamics are given in Table 1.

Table 1.

| | Baseline | | | After O ₂ | | | After iloprost | | |
|----|----------|-------------------------|-------|----------------------|-------------------------|-------|----------------|-------------------------|-------|
| Pt | Qp/Qs | PVR (U/m ²) | Rp/Rs | Qp/Qs | PVR (U/m ²) | Rp/Rs | Qp/Qs | PVR (U/m ²) | Rp/Rs |
| 1 | 2.71 | 7.7 | 0.3 | 12 | 1.4 | 0.05 | 3.63 | 5 | 0.22 |
| 2 | 2.45 | 5.3 | 0.38 | 4.68 | 2.9 | 0.16 | 3.24 | 4.1 | 0.22 |
| 3 | 0.93 | 8.5 | 0.64 | 1.38 | 4.9 | 0.23 | 0.86 | 8.8 | 0.57 |

Qp/Qs = intracardiac shunt; PVR = pulmonary vascular resistance

In patient 1 and 2, PVR decreased after O₂ as well as after iloprost administration. The intracardiac shunt Qp/Qs increased due to a decrease of Rp/Rs. In patient 3 PVR decreased after O₂ but not after iloprost.

Conclusion: The present report of a small number of cases is by no means conclusive, but raises the possibility that inhaled iloprost may decrease the pulmonary vascular resistance in patients with PHT related to congenital heart disease.

Reference:

- Rimensberger PC, Spahr-Schopfer I, Berner M, et al. Inhaled nitric oxide versus aerosolized iloprost in secondary pulmonary hypertension in children with congenital heart disease: vasodilator capacity and cellular mechanisms. *Circulation* 2001; **103**: 544–548.

002**Aprotinin reduces bleeding after off-pump coronary artery bypass surgery**

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Introduction: Aprotinin is an antifibrinolytic agent which reduces blood loss after cardiac surgery under CPB [1]. Only one study has evaluated the effect of aprotinin during off-pump (OPCAB) surgery. The aim of this study was to evaluate the efficacy of aprotinin in reducing blood loss after OPCAB.

Method: A retrospective study based on our prospective database compared 40 patients operated on before the routine use of aprotinin (Group O) to 40 patients who received a full dose of aprotinin (Group A). Post operative blood loss, transfusion rate and troponin levels were compared between the 2 groups. 90% of the patients received aspirin until the day of surgery. During operation, patients received 300 UI/kg of heparin and complete reversal with protamine at the end of surgery. Packed red blood cells were transfused when haemoglobin concentration was less than 80 g L⁻¹. Groups were compared with t test or χ^2 test when appropriate. Results are given as mean \pm SD.

Results: Aprotinin significantly reduces blood loss but not transfusion. Main results are summarized in the table.

| Operative data | Gr A | Gr O | P |
|--|----------------|----------------|-------|
| Age | 67 \pm 14 | 66 \pm 12 | 0.69 |
| EuroSCORE | 3.9 \pm 2.2 | 4.5 \pm 3.0 | 0.35 |
| Preop haemoglobin (g L ⁻¹) | 136 \pm 15 | 135 \pm 19 | 0.77 |
| Grafts number | 2.6 \pm 0.7 | 2.0 \pm 0.8 | 0.003 |
| Length surgery (min) | 266 \pm 52 | 236 \pm 59 | 0.02 |
| Aprotinin (Million UI) | 3 \pm 1 | 0 | – |
| Crystalloid (ml) | 860 \pm 580 | 780 \pm 400 | 0.48 |
| Colloid (ml) | 1270 \pm 470 | 1270 \pm 360 | 0.97 |
| Lowest T (°C) | 34.7 \pm 0.7 | 34.8 \pm 0.9 | 0.68 |

Postoperative data

| | | | |
|---|-----------------|-----------------|--------|
| Bleeding at 6 h (mL) | 270 \pm 60 | 400 \pm 170 | 0.001 |
| Bleeding at 24 h (mL) | 520 \pm 270 | 710 \pm 270 | 0.002 |
| Total blood loss (mL) | 550 \pm 210 | 730 \pm 350 | 0.0004 |
| Troponin at arrival (μ g · L ⁻¹) | 0.6 \pm 1.2 | 0.6 \pm 0.6 | 0.81 |
| Troponin at 6 h (μ g · L ⁻¹) | 1.4 \pm 2.0 | 2.6 \pm 3.4 | 0.08 |
| Troponin at 18 h (μ g · L ⁻¹) | 2.0 \pm 2.7 | 2.1 \pm 2.7 | 0.84 |
| Post op haemoglobin (g · L ⁻¹) | 103 \pm 14 | 103 \pm 13 | 0.95 |
| Packed red blood cells | 0.15 \pm 0.48 | 0.20 \pm 0.65 | 0.70 |
| Blood transfusion | 15% | 25% | 0.39 |

Discussion: Aprotinin significantly reduces blood loss after OPCAB surgery. Using aprotinin with a full dose of heparin did not increase postoperative values of troponin.

References:

- Dietrich WJ, Barankay A, Hähnel Ch, et al. High-dose aprotinin in cardiac surgery: three years' experience in 1784 patients. *J Cardiothorac Vasc Anesth* 1992; **6**(3): 324–327.
- Englberger L, Makart P, Eckstein FS, et al. Aprotinin reduces blood loss in off-pump coronary artery bypass (OPCAB) surgery. *Eur J Cardiothorac Surg* 2002; **22**(4): 545–551.

050

Recombinant activated factor VII in cardiac surgery: experience in 7 cases

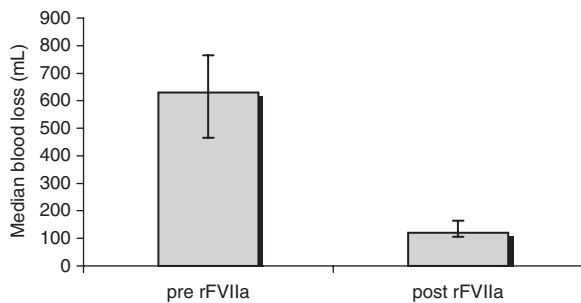
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Introduction: Recombinant activated factor VII (rFVIIa) is a potent anticoagulant, active at sites of tissue damage with expression of the tissue factor. The use of rFVIIa results in occupation of most tissue factor molecules. Initiation of the extrinsic pathway leads in turn to activation of maximum quantities of factor X with subsequent massive generation of thrombin. At the same time, factor IX of the intrinsic pathway is also activated and consequently, procoagulation activity increases. The use of supra-normal-therapeutic doses of rFVIIa is currently suggested for management of life-threatening bleeding refractory to both surgical intervention and conventional pharmacotherapy.

Method: Experience gained with administration of $90 \mu\text{g kg}^{-1}$ rFVIIa in 7 cardiac surgery patients (5 valve operations, 2 coronary artery bypass grafting) is presented. The patients were given rFVIIa postoperatively for bleeding, which was considered as continuous and intractable (e.g. in 2 cases total blood loss 2450 mL and 3200 mL, respectively, in another patient bleeding 1000 mL within 1.5 h after triple re-exploration). Five patients underwent surgical revision before rFVIIa administration, frequently repeated. Before the use of rFVIIa, all of the other haemotherapeutic and pharmacological strategies (blood derivatives including apheresis platelets, factors II, VII, IX and X, antithrombin III) were attempted, based on laboratory results.

Results: Administration of rFVIIa was associated with significant reduction in blood loss; no other haemostatic agents were instituted afterwards. Median blood loss was 630 mL [465–765] [25–75 percentile] over 4 hours prior to administration of rFVIIa and 120 mL [105–165] over 4 hours after administration of rFVIIa ($P < 0.05$, Paired Wilcoxon test). None of the patients needed additional re-operation.



Discussion: The use of rFVIIa proved highly effective in the management of massive postoperative haemorrhage. No clinical signs of general hypercoagulation were noticed, although laboratory tests showed shortening of coagulation times, mainly of prothrombin time expressed as INR (1.19 ± 0.1 vs. 0.82 ± 0.2).

References:

- Hendriks HG, van der Maaten JM, de Wolf J, et al. An effective treatment of severe intractable bleeding after valve repair by one single dose of activated recombinant factor VII. *Anesth Analg* 2001; **93**: 287–289.
- Dietrich W, Spannagl M. Caveat against the use of activated recombinant factor VII for intractable bleeding in cardiac surgery. *Anesth Analg* 2002; **94**: 1369–1370.

035

Thromboelastography, PFA100 and whole-blood aggregometry in patients undergoing a thoracic aortic operation with deep hypothermic circulatory arrestD. Szczurek, Ch. Diehl, L. Stolarski, A. Dongas, W. Prohaska¹, K. Inoue*Departments of Anaesthesiology and ¹Laboratory Medicine, Heart and Diabetes Centre NRW, University of Bochum, Bad Oeynhausen, Germany*

Introduction: Patients undergoing repair of an aortic aneurysm with deep hypothermic circulatory arrest (DHCA) often develop coagulation disturbances and require transfusion of many blood products [1]. Thromboelastography (TEG, RoTEG) is an established bedside monitor of haemostasis, which has been used successfully in cardiac surgery. The PFA100 and whole-blood impedance aggregometry are simple and rapid tests of platelet-related haemostasis. The purpose of this study was to evaluate haemostatic changes during thoracic aortic surgery using these three tests.

Method: After approval by the local Ethics Committee and informed consent, 18 patients undergoing operations of the ascending aorta with DHCA and, as a control group, 9 patients undergoing similar procedures without DHCA were enrolled in this study. For each variable obtained, ANOVA for repeated measurements was used to assess changes from baselines. Differences between the DHCA and control groups were analysed with unpaired Student's *t*-test. $P < 0.05$ was considered significant.

Results: The mean DHCA time was 13 min with the mean nasopharyngeal temperature of 24°C . The mean duration of cardiopulmonary bypass (CPB) was 150 min in the DHCA group and 105 min in the control group ($P = 0.000$). The mean total postoperative chest tube drainage amounted to 973 mL in the DHCA group and 603 mL in the control group ($P = 0.005$). All TEG variables changed negatively during CPB but returned within the normal ranges postoperatively. Impedance values were abnormal postoperatively in the DHCA group, though normal in the control group. PFA values were abnormal preoperatively in both groups but became normal postoperatively.

| | R (sec) | K (sec) | MA (mm) | Alpha ($^\circ$) | PFA1 (sec) | PFA2 (sec) | Impedance (ohm) |
|-----------------|---------|---------|---------|--------------------|------------|------------|-----------------|
| Normal baseline | <190 | <110 | 53–74 | 70–85 | 60–175 | 50–110 | 13–23 |
| H | 168 | 66 | 61 | 78 | 239 | 145 | 17 |
| C | 177 | 66 | 61 | 77 | 207 | 155 | 17 |
| post H | 193* | 180* | 47* | 63* | 300* | 266* | 6* |
| end CPB | | | | | | | |
| H | 194* | 111* | 53* | 71* | 280 | 198* | 9* |
| C | 195 | 95* | 57* | 73* | 262 | 180 | 13** |
| 2 h p CPB | | | | | | | |
| H | 186* | 90* | 57* | 74* | 171* | 94* | 12* |
| C | 183 | 81* | 58* | 75* | 131* | 95* | 16** |

H = DHCA; C = control. Mean values shown PFA1: epinephrine-PFA, PFA2: ADP-PFA, * different within each group, ** different between the two groups.

Discussion: TEG (e.g. MA), PFA100 and aggregometry are influenced not only by platelet function but also other factors which may influence these tests differently. The discrepancies in the results might have been caused by such factors.

Reference:

- Westaby S. Coagulation disturbances in profound hypothermia: the influence of anti-fibrinolytic therapy. *Semin Thorac Cardiovasc Surg* 1997; **9**: 246–256.

038

Heparin-induced thrombocytopenia after treatment with enoxaparin immediately after heart surgery: case report

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Introduction: Heparin-induced thrombocytopenia (HIT) type II, induced by heparin therapy, may lead to haemorrhagic and thrombotic complications which are potentially life threatening. The reported incidence in the literature varied from 0.2–31% [1]. Because administration of low-molecular-weight heparins (LMWH) is now more frequent, this complication has also been reported in several cases after LMWH administration.

Case report: A male patient, 55 years old, with unstable angina pectoris, received 60 mg of enoxaparin eighteen days before coronary artery bypass surgery. On the day of surgery, platelets values were within normal ranges. Cardiac surgery was performed using cardiopulmonary bypass (CPB) and the patient received 300 U kg^{-1} of unfractionated heparin before cannulation. Eight hours after surgery, the platelet count had fallen to zero. Immediately the administration of LMWH and any other contact with heparin was stopped. The appearance of anti-platelet antibodies was confirmed with direct and indirect platelet microimmunofluorescence test (PSIFT) made by Jackson ImmunoResearch Lab. Inc., Baltimore, USA, and both tests were highly positive. Platelets value was zero during the next 36 hours, then increased until the fifth day, when values reached $100 \times 10^9 \text{ L}^{-1}$. By that time, the patient was without anticoagulation therapy, and did not develop any kind of thrombosis. Regular blood tests were performed throughout the stay in ICU. The patient was discharged from hospital on the tenth day after surgery.

Discussion: Although there is a relatively low incidence of HIT in the population, especially after LMWH usage, pre-surgery testing is strongly advocated for all patients who receive unfractionated or LMWH before surgery, to prevent serious and life-threatening complications during and after CPB. The use of alternative agents (lepirudin, danaparoid, argatroban, fondaparinux) are still not absolute substitutes for traditional heparin in patients

undergoing CPB. Furthermore, lack of a specific antidote to return the activated clotting time to the normal range after CPB makes these agents insufficient for use for cardiac surgery. Delaying surgery and clearing the antibodies from the circulation is still the only safe procedure for these patients.

Reference:

- 1 Warkentin TE, Levine MN, Hirsh J, et al. Heparin-induced thrombocytopenia in patients treated with low-molecular-weight heparin or unfractionated heparin. *N Eng J Med* 1995; **332**: 1330–1335.

001

Autologous blood donation in cardiac surgery: a cost-effective method to reduce allogeneic blood requirements

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Introduction: Predonation of autologous blood is an effective method to reduce allogeneic blood transfusion in open-heart surgery [1]. However, the cost effectiveness of this method has been questioned [2]. The aim of the present study was to evaluate the influence of autologous pre-donation on transfusion requirements and to investigate the cost-effectiveness of this method from the hospital perspective.

Method: With institutional approval 4878 consecutive patients undergoing different open-heart procedures between 1995 and 2000 were retrospectively investigated. Data were prospectively collected in the department database. Pre-donation was performed within the hospital by anaesthesiologists familiar with the type of the planned operative procedure. A decision tree model was developed to analyse the propensity of receiving allogeneic blood transfusions. Patients were stratified for gender, preoperative risk, and type of operation. A transfusion trigger of 80–90 g/L was used in haemodynamically stable patients. Costs associated with blood transfusion as well as transfusion-related data were recorded. The endpoint was the number of autologous units necessary to avoid the transfusion of one unit of allogeneic blood and the costs associated with autologous pre-donation. Unpaired t-test and Chi-square test were used to compare patients with and without pre-donation.

Results:

| | Allogeneic transfusion | Admission Hb (g/L) |
|----------------------------|------------------------|--------------------|
| Pre-donation (n = 868) | 13%* | 130 ± 13* |
| No Pre-donation (n = 4010) | 48% | 136 ± 18 |

* $P < 0.05$.

The difference in transfusion requirement remained significant even after adjustment for preoperative risk. The donation of 1, 2 or 3 autologous units reduced the transfusion frequency to 24%, 14%, or 9%, respectively. It was estimated that with the donation of 1.5 units autologous blood the transfusion of one allogeneic unit was avoided. The additional transfusion cost, calculated from the hospital perspective, were 19 € (£13) per patient. Female patients donating 2 units produced equal transfusion costs compared to female patients without pre-donation with a significant reduction in allogeneic blood transfusions (22% transfused vs. 68%; $P < 0.05$). On the other hand, pre-donation in patients with ASD closure was not cost-effective.

Discussion: Autologous blood donation is a very effective method to reduce allogeneic blood transfusion in cardiac surgery. With appropriate organization, pre-donation is cost-effective even from the hospital perspective. Decision tree analysis enables tailoring a pre-donation programme according to the specific needs of a department.

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- 1 Dietrich W, Luth JU, Kormann J, et al. [Intraoperative blood requirements and allogeneic blood transfusion in cardioanaesthesia surgery. Data analysis of 7729 patients in 12 cardiac surgical clinics.] *Anaesthesist* 1999; **48**: 876–883. German.
- 2 Etchason J, Petz L, Keeler E, et al. The cost effectiveness of preoperative autologous blood donations. *N Engl J Med* 1995; **332**: 719–724.

127

Aortic valve surgery during pregnancy: a series of 5 patients

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Introduction: Pregnancy can severely exacerbate pre-existing cardiac disease leading to possible decompensation in the mother and a high risk of foetal death. We describe the anaesthetic management of 5 patients who underwent cardiopulmonary bypass (CPB) to replace the aortic valve. In all cases the relative risks of continuing or terminating the pregnancy or undergoing valve surgery were discussed with the patients and the risks explained.

Method: All patients underwent standard perioperative care and monitoring. During surgery the foetal heart rate and blood flow in the uterine arteries, foetal aorta, ductus venosus and cerebral arteries were measured by either trans-vaginal or trans-abdominal ultrasound. CPB utilized a standardized technique of pulsatile flow, mean arterial pressures of 65 mmHg, maternal haemoglobin >10 gm/dL and mild hypothermia of 35°C. Anaesthesia was maintained with high dose fentanyl and propofol infusions. A low dose GTN infusion to promote uterine blood flow and prevent uterine contractions was used in all cases.

Results: All patients were extubated within 8 hours of surgery and had an uneventful postoperative course. All patients maintained normal uterine blood flow during CPB. Only case 3 demonstrated signs of severe foetal distress during CPB despite increasing both flow and maternal blood pressure and the foetus died 10 days postoperatively. In case 5 the foetus tolerated CPB well and appeared normal for the first 4 days. It died of an unknown cause on day 5.

Table:

| | Age | Operation | Gestation | Foetus | Mother |
|---|-----|-------------------------------|-----------|--------------|--------|
| 1 | 24 | redo AVR | 19/40 | alive LSCS | alive |
| 2 | 31 | AVR + aortic root replacement | 9/40 | alive LSCS | alive |
| 3 | 39 | AVR + MVR | 15/40 | died day 10 | alive |
| 4 | 25 | redo AVR | 16/40 | alive | alive |
| | | | | EDD 01/04/04 | |
| 5 | 29 | AVR | 26/40 | died day 5 | alive |

Discussion: The challenge of these cases is to understand the physiological changes of normal pregnancy, maintain maternal well being during surgery and CPB and to manipulate maternal physiology to ensure foetal well being. Despite case reports and reviews [1], the effects of cardiopulmonary bypass on the foetus is still poorly understood.

Reference:

- 1 Strickland RA, Oliver WC, Chantigen RC, et al. Anaesthesia, cardiopulmonary bypass and the pregnant patient. *Mayo Clin Proc* 1991; **66**: 411.

126

Transmitral occluder device embolization during transcatheter closure of an atrial septal defect: role of transoesophageal echocardiography

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Introduction: Transoesophageal echocardiography (TOE) is a reliable imaging technique for guidance of transcatheter closure of secundum-type atrial septal defect (ASD) [1,2]. Embolization of the occluder device to an unreported location, which required emergent surgical intervention is described.

Case Report: A 35 yr old man was admitted to the hospital for elective transcatheter closure of a secundum type ASD. His history was significant for hypertension, intermittent atrial fibrillation and occasional shortness of breath and chest pain. Cardiac catheterization was performed under conscious sedation using intracardiac echocardiography. Except for a 16 mm secundum type defect, normal cardiac anatomy was confirmed and a slightly elevated right ventricular pressure was found. A Qp/Qs of 15:1 was calculated. A 32 mm Amplatzer septal occluder device (AGA Medical, Golden Valley, MN) was prepared. During deployment and release of the device through a 7 Fr sheath, it failed to align parallel to the septum, dislocating towards the left atrium. Several attempts to retrieve the device were unsuccessful. The patient was transferred emergently to the operating room for surgical intervention. General anaesthesia was accomplished with oxygen, isoflurane and fentanyl. Pancuronium was used for muscle relaxation. Intraoperative TOE showed that the occluder device was migrating through the mitral annulus (Figure 1).

Any manipulation of the left side of the heart worsened the mitral inflow obstruction and caused severe hypotension.

Cardiopulmonary bypass (CPB) was instituted rapidly. The device was removed. The ASD was closed. The patient was separated from CPB without difficulty.

Discussion: The Amplatzer septal occluder device consists of a self-expanding double disk made of nitinol wire mesh. A short and thin waist links the two disks which are filled with polyester patches. Although rare, reports of complications with the Amplatzer septal occluder device includes left atrial thrombus, incidental device infection secondary to generalized septicemia, embolization to the left atrium and right ventricle [3], and cardiac perforation. This to our knowledge is the first reported case of trans-mitral embolization of this device requiring emergent surgical intervention.

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- 3 Kapoor MC, Singh S, Sharma S, et al. Embolization of an atrial occluder device. *J Cardiothorac Vasc Anesth* 2003; **17**: 755–763.

211**Inhaled iloprost for pulmonary hypertension during cardiac surgery**

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Introduction: In cardiac surgery, patients with pulmonary hypertension (PHT) have markedly increased morbidity and mortality. The conventional therapy with intravenous vasodilators has limited results because of lack of pulmonary selectivity. We present our experience with inhaled iloprost, an analogue of prostacyclin, in significant secondary PHT (mean pulmonary artery pressure > 30 mmHg).

Method: Three adult patients, NYHA III, with moderate to severe PHT scheduled for elective valve replacement surgery maintained high values of pulmonary artery pressure after cardiopulmonary bypass (CPB). Iloprost was administered, after protamine, by an ultrasonic nebulizer at a concentration of 2 µg/mL. With an average nebulization rate 0.6 mL/min after 20 min

a cumulative dose of 24 µg had been delivered. The following variables were measured or calculated: cardiac output and index (CO, CI); systolic and mean arterial blood pressures (SAP, MAP); systolic and mean pulmonary artery pressure (SPAP, MPAP); systemic and pulmonary vascular resistance (SVR, PVR).

Results: Patients were weaned from CPB on dobutamine and epinephrine to maintain a MAP greater or equal to 60 mmHg. Haemodynamic data of the patients after protamine use and after inhaled iloprost are presented in Table 1.

Table 1.

| Pt | | SPAP | MPAP | SAP | PVR | PVR/SVR | CO/CI |
|----|---------------------|------|------|-----|-----|---------|---------|
| 1 | before ¹ | 51 | 33 | 98 | 190 | 0.22 | 6.0/3.0 |
| | after ² | 37 | 20 | 110 | 155 | 0.19 | 6.7/3.2 |
| 2 | before ¹ | 60 | 40 | 89 | 284 | 0.3 | 5.4/2.6 |
| | after ² | 44 | 25 | 90 | 180 | 0.2 | 7.6/3.8 |
| 3 | before ¹ | 50 | 32 | 90 | 327 | 0.28 | 4.4/2.6 |
| | after ² | 37 | 27 | 106 | 250 | 0.24 | 5.1/3.0 |

¹Before prostacyclin (after protamine); ²after prostacyclin

Inhaled iloprost decreased MPAP by 30.8%, PVR by 26% and increased CI by 17%. Systemic arterial pressures were stable.

Conclusion: Inhaled iloprost appears to be a selective pulmonary vasodilator. The procedure is simple. Further studies are needed to promote routine use of inhaled iloprost in patients with perioperative moderate to severe secondary PHT in cardiac surgery.

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SUBJECT INDEX

- ACE inhibition**, Preoperative ACE inhibition and renal dysfunction following cardiac surgery, Penugonda SP, *et al.* 7
- ACE inhibitors, enalaprilat**, ACE inhibitors enalaprilat and quinaprilat inhibit monocyte surface receptor expression, Welters ID, *et al.* 7
- ACE inhibitors, quinaprilat**, ACE inhibitors enalaprilat and quinaprilat inhibit monocyte surface receptor expression, Welters ID, *et al.* 7
- Alfentanil**, Alfentanil-based general anaesthesia for early extubation after valve surgery, Vanek T, *et al.* 22
- Allogeneic blood**
- , The impact of intra-operative red cell salvage on allogeneic blood requirements following cardiac surgery, Spackman D, *et al.* 10
 - , Autologous blood donation in cardiac surgery: a cost-effective method to reduce allogeneic blood requirements, Dietrich W, Thuermel K, 35
- Anaesthesia**, Comparison of different forms of ondansetron for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia, Yavorovskiy A, *et al.* 19
- Anaesthetic state**, Does cardiopulmonary bypass modify the anaesthetic state?, Smith DC, Pettit-Mills RS, 18
- Analgesia**, The effect of magnesium sulphate on postoperative pain scores and requirement of analgesia following CABG, Yilmaz O, *et al.* 17
- Angle dependency**, Angle dependency in the ultrasound modality displacement evaluated in a dynamic test phantom, Pedersen TF, *et al.* 12
- Antithrombin consumption**, Determinant of antithrombin consumption in cardiac operations requiring cardiopulmonary bypass, Ranucci M, *et al.* 10
- Anxiety**, Depression and anxiety after cardiac surgery: second year follow up, Székely A, *et al.* 20
- Aortic counterpulsation**, Accuracy of arterial (or transthoracic) thermodilution cardiac output during aortic counterpulsation, Baulig W, *et al.* 11
- Aortic valve surgery**, Aortic valve surgery during pregnancy: a series of 5 patients, Prabhu P, *et al.* 35
- Aprotinin**
- , Aprotinin and the haemodynamic response to SIRS in patients undergoing on-pump CABG, Naumenko SE, *et al.* 5
 - , Aprotinin reduces bleeding after off-pump coronary artery bypass surgery, Meyer C, *et al.* 33
 - , Ultra low dose aprotinin decreases blood loss and transfusion requirements in high risk two valve replacement surgery, Muralidhar K, *et al.* 11
- Arterial blood**, Evaluation of a new probe for continuous intravascular blood gas monitoring in jugular venous and arterial blood, Papadopoulos AC, *et al.* 12
- Arterial coronary bypass grafts**, Description of the instantaneous pressure-flow relationship and critical occlusion pressure in arterial coronary bypass grafts, Kazmaier S, *et al.* 4
- Arterial pressure waveform analysis**, Early recognition of low cardiac output after cardiac surgery by using the arterial pressure waveform analysis, Scolletta S, *et al.* 11
- Atherosclerosis**, Preoperative CT or intraoperative epi-aortic ultrasound for the diagnosis of atherosclerosis of the ascending aorta? a preliminary report, Bergman P, *et al.* 29
- Atrial fibrillation**, Atrial fibrillation after beating heart CABG surgery, Sparicio D, *et al.* 24
- Atrial septal defect**, Transcatheter occluder device embolization during transcatheter closure of an atrial septal defect: role of transoesophageal echocardiography, Botero M, *et al.* 35
- Autologous blood donation**, Autologous blood donation in cardiac surgery: a cost-effective method to reduce allogeneic blood requirements, Dietrich W, Thuermel K, 35
- Autonomic nervous system**, Does preoperative activity of the autonomic nervous system predict hypertension during CABG?, Akselrod B, *et al.* 13
- Beating heart CABG surgery**, Atrial fibrillation after beating heart CABG surgery, Sparicio D, *et al.* 24
- Beating heart surgery**, Beating heart surgery with assistance of simplified bypass systems: effects on haemodynamics and pulmonary gas exchange, Rex S, *et al.* 5
- Bispectral index**, Comparison of bispectral index during normothermic and hypothermic cardiopulmonary bypass, Han S-H, *et al.* 19
- Bleeding**
- , Aprotinin reduces bleeding after off-pump coronary artery bypass surgery, Meyer C, *et al.* 33
 - , Effects of diclofenac on platelet function and bleeding after cardiac surgery, Kamenik M, *et al.* 9
- Blood loss**
- , Hydroxyethyl starch (HES) 130/0.4 reduces blood loss in off-pump coronary surgery, Meyer C, *et al.* 21
 - , Ultra low dose aprotinin decreases blood loss and transfusion requirements in high risk two valve replacement surgery, Muralidhar K, *et al.* 11
- Bupivacaine**, Epidural infusion of ropivacaine or bupivacaine during major thoracic surgery, Misiółek H, *et al.* 32
- CABG**
- , Does preoperative activity of the autonomic nervous system predict hypertension during CABG?, Akselrod B, *et al.* 13
 - , The effect of magnesium sulphate on postoperative pain scores and requirement of analgesia following CABG, Yilmaz O, *et al.* 17
 - , The effects of normovolaemic haemodilution on degree of lymphocyte apoptosis during CABG, Dąbrowski W, *et al.* 26
- CABG patients**, N-acetylcysteine decreases myocardial ischaemia-reperfusion injury in CABG patients, Yapici N, *et al.* 7
- CABG surgery**, Comparison of myocardial protective effects of TIVA, sevoflurane and isoflurane in CABG surgery, Koruk S, *et al.* 8
- Carbon dioxide de-airing**, Which is the optimal device for carbon dioxide de-airing of the cardiothoracic wound and how should it be positioned?, van der Linden J, *et al.* 12
- Carbon dioxide**, Carbon dioxide inhibits the growth rate of *Staphylococcus aureus* at body temperature, van der Linden J, *et al.* 29
- Cardiac complications**, Even low levels of preoperative troponin I predict postoperative myocardial ischaemia and cardiac complications in vascular surgery, Gaudard P, *et al.* 14
- Cardiac index**, Prognostic value of low cardiac index early after cardiac surgery, Berthet MC, *et al.* 25
- Cardiac operations**, Determinant of antithrombin consumption in cardiac operations requiring cardiopulmonary bypass, Ranucci M, *et al.* 10
- Cardiac patients**, Incentive spirometry for preoperative preparation of cardiac patients, Balandiuk AE, Kozlov IA, 3
- Cardiac surgery**
- , A pilot double blind randomized placebo controlled trial of the use of recombinant factor VIIa (rFVIIa) in high transfusion risk cardiac surgery, Diprose P, *et al.* 9
 - , Autologous blood donation in cardiac surgery: a cost-effective method to reduce allogeneic blood requirements, Dietrich W, Thuermel K, 35
 - , Can wound desiccation be averted during cardiac surgery? An experimental study, van der Linden J, Persson M, 28
 - , Comparison of serum lipids and glucose levels during propofol or midazolam infusions for cardiac surgery in hyperlipidaemic patients, Acarturk H, *et al.* 27
 - , Failure rate and rate of minor complications of high thoracic epidural anaesthesia (HTEA) for cardiac surgery, Salvi L, *et al.* 15
 - , High thoracic epidural anaesthesia (HTEA) for cardiac surgery in patients with respiratory disease, de Paulis S, *et al.* 16
 - , Inhaled iloprost for pulmonary hypertension during cardiac surgery, Filipescu D, *et al.* 36
 - , Phosphorylcholine coating preserves coagulation during cardiac surgery – a combined TEG and PFA-100 analysis, Corno C, *et al.* 19
 - , Pre and postoperative iron status in patients presenting for cardiac surgery, Steven M, *et al.* 9
 - , Problem-solving in cardiac surgery: empiricism vs. algorithm in the management of microvascular bleeding (MVB), Finamore G, *et al.* 24
 - , Recombinant activated factor VII in cardiac surgery: experience in 7 cases, Vanek T, *et al.* 34
 - , The use of near infrared spectroscopy (NIRS) in combined vascular and cardiac surgery, Portolan M, *et al.* 18
- Cardiac surgery patients**
- , Assessing volume responsiveness during open chest conditions in cardiac surgery patients, Reuter DA, *et al.* 2
 - , The effects of levosimendan in cardiac surgery patients, Romana C, *et al.* 3
 - , The impact of age on outcome of adult cardiac surgery patients, Naughton C, *et al.* 14
- Cardio-pulmonary bypass surgery**, Clopidogrel and perioperative transfusion requirements in cardio-pulmonary bypass surgery, Whitty R, *et al.* 10

Cardiopulmonary bypass

- , Comparison of bispectral index during normothermic and hypothermic cardiopulmonary bypass, Han S-H, *et al.* 19
- , Determinant of antithrombin consumption in cardiac operations requiring cardiopulmonary bypass, Ranucci M, *et al.* 10
- , Does cardiopulmonary bypass modify the anaesthetic state?, Smith DC, Pettit-Mills RS, 18

Cardiothoracic wound, Which is the optimal device for carbon dioxide de-airing of the cardiothoracic wound and how should it be positioned?, van der Linden J, *et al.* 12

Carotid artery perfusion, Modified distal carotid artery perfusion for combined carotid endarterectomy and off pump coronary artery bypass surgery, Muralidhar K, *et al.* 31

Carotid endarterectomy, Modified distal carotid artery perfusion for combined carotid endarterectomy and off pump coronary artery bypass surgery, Muralidhar K, *et al.* 31

Central venous cannulation, An audit of central venous cannulation in Papworth Hospital from March to May 2003, Moore CS, *et al.* 31

Cerebral oxygenation, Is measuring cerebral oxygenation during off-pump cardiac surgery associated with ICU and hospital length of stay?, Szurlej D, *et al.* 15

Clopidogrel, Clopidogrel and perioperative transfusion requirements in cardio-pulmonary bypass surgery, Whitty R, *et al.* 10

Cognitive function

- , Effects of remifentanyl and fentanyl on haemodynamics and cognitive functions in patients undergoing open-heart surgery, Koç M, *et al.* 24
- , Neuronal injury after ICD-implantation is associated with a deterioration of cognitive function after surgery, Weigl M, *et al.* 26

Congenital heart disease, Inhaled iloprost for testing vasodilator capacity in secondary pulmonary hypertension in children with congenital heart disease, Raileanu I, *et al.* 33

Congenital heart surgery, Inhaled iloprost in the management of pulmonary hypertension in infants undergoing congenital heart surgery, Mueller M, *et al.* 3

Contractile function, Contractile function of the heart after cardioplegia is not determined by the extent of myocardial necrosis and lactate release, Karu I, *et al.* 30

COPD, Reduction of pulmonary function after resection: less than expected in COPD patients, Jiménez MJ, *et al.* 16

coronary artery bypass grafting, sevoflurane, Neurological outcome after coronary artery bypass grafting: sevoflurane versus total intravenous anaesthesia, Yamak B, *et al.* 26

coronary artery bypass grafting, total intravenous anaesthesia, Neurological outcome after coronary artery bypass grafting: sevoflurane versus total intravenous anaesthesia, Yamak B, *et al.* 26

Coronary intervention, Therapeutic coronary intervention after primary coronary angiography, TROMSØ 2000, Bjørsvik G, Arnesen E, 32

Coronary surgery, Comparison of different forms of ondansetron for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia, Yavorovskiy A, *et al.* 19

CPB, Evaluation of risk factors to predict haematocrit decrease in CPB, Flo A, *et al.* 13

CT, Preoperative CT or intraoperative epi-aortic ultrasound for the diagnosis of atherosclerosis of the ascending aorta? a preliminary report, Bergman P, *et al.* 29

Deep hypothermic circulatory arrest, Thromboelastography, PFA100 and whole-blood aggregometry in patients undergoing a thoracic aortic operation with deep hypothermic circulatory arrest, Szczurek D, *et al.* 34

Depression, Depression and anxiety after cardiac surgery: second year follow up, Székely A, *et al.* 20

Diabetes, Diabetes is an independent predictor of hospital mortality in patients with prolonged mechanical ventilation after cardiac surgery, Mantovani L, *et al.* 27

Diastolic function

- , Effect of isoflurane on diastolic function in patients with concentric left ventricular hypertrophy: an echocardiographic study, Neuhaeuser C, *et al.* 4
- , Left ventricular diastolic function during negative pressure ventilation, Danella A, *et al.* 5

Diclofenac, Effects of diclofenac on platelet function and bleeding after cardiac surgery, Kamenik M, *et al.* 9

Diltiazem, The efficiency of diltiazem on myocardial protection in off-pump coronary artery bypass grafting surgery, Alev T, *et al.* 8

Dynamic test phantom, Angle dependency in the ultrasound modality displacement evaluated in a dynamic test phantom, Pedersen TF, *et al.* 12

ECC, lactate gradient, Brain glucose and lactate gradient versus pressure gradient across the internal jugular valve during ECC, Dağbrowski W, *et al.* 27

ECC, pressure gradient, Brain glucose and lactate gradient versus pressure gradient across the internal jugular valve during ECC, Dağbrowski W, *et al.* 27

Echocardiographic study, Effect of isoflurane on diastolic function in patients with concentric left ventricular hypertrophy: an echocardiographic study, Neuhaeuser C, *et al.* 4

Echocardiography, Two year experience and clinical impact of echocardiography in the cardiothoracic intensive care unit, Wagner G, *et al.* 29

Enoxaparin, Heparin-induced thrombocytopenia after treatment with enoxaparin immediately after heart surgery: Case report, Husedzinovic I, *et al.* 34

Epi-aortic ultrasound, Preoperative CT or intraoperative epi-aortic ultrasound for the diagnosis of atherosclerosis of the ascending aorta? a preliminary report, Bergman P, *et al.* 29

Extubation

- , Alfentanil-based general anaesthesia for early extubation after valve surgery, Vanek T, *et al.* 22
- , Efficiency of early extubation in geriatric cardiosurgical patients, Klypa TV, Kozlov IA, 22
- , Evaluation of early extubation (fast-track) after cardiac surgery in a post-anaesthesia recovery unit, Matute P, *et al.* 23

Fentanyl

- , The effects of remifentanyl and fentanyl on postoperative pain and recovery in fast-track open heart surgery, Turan S, *et al.* 23
- , Effects of remifentanyl and fentanyl on haemodynamics and cognitive functions in patients undergoing open-heart surgery, Koç M, *et al.* 24

Fluid responsiveness, Prediction of fluid responsiveness in patients after cardiac surgery and ventilated with low tidal volumes, Rex S, *et al.* 2

Gastric acid aspiration, Gastric acid aspiration risk following cardiac surgery, Marshall NB, *et al.* 28

General anaesthesia, Alfentanil-based general anaesthesia for early extubation after valve surgery, Vanek T, *et al.* 22

Geriatric cardiosurgical patients, Efficiency of early extubation in geriatric cardiosurgical patients, Klypa TV, Kozlov IA, 22

Glucose

- , Brain glucose and lactate gradient versus pressure gradient across the internal jugular valve during ECC, Dağbrowski W, *et al.* 27
- , Comparison of serum lipids and glucose levels during propofol or midazolam infusions for cardiac surgery in hyperlipidaemic patients, Acarturk H, *et al.* 27

Haematocrit, Evaluation of risk factors to predict haematocrit decrease in CPB, Flo A, *et al.* 13

Haemodilution, The effects of normovolaemic haemodilution on degree of lymphocyte apoptosis during CABG, Dağbrowski W, *et al.* 26

Haemodynamics

- , Aprotinin and the haemodynamic response to SIRS in patients undergoing on-pump CABG, Naumenko SE, *et al.* 5
- , Beating heart surgery with assistance of simplified bypass systems: effects on haemodynamics and pulmonary gas exchange, Rex S, *et al.* 5
- , Effects of remifentanyl and fentanyl on haemodynamics and cognitive functions in patients undergoing open-heart surgery, Koç M, *et al.* 24

Heart surgery, Heparin-induced thrombocytopenia after treatment with enoxaparin immediately after heart surgery: Case report, Husedzinovic I, *et al.* 34

Heparin, Heparin-induced thrombocytopenia after treatment with enoxaparin immediately after heart surgery: Case report, Husedzinovic I, *et al.* 34

High thoracic epidural anaesthesia, High thoracic epidural anaesthesia (HTEA) for cardiac surgery in patients with respiratory disease, de Paulis S, *et al.* 16

High thoracic epidural analgesia, Tissue Doppler evaluation of myocardial function during high thoracic epidural analgesia, Norrild K, *et al.* 16

Hospital mortality, Diabetes is an independent predictor of hospital mortality in patients with prolonged mechanical ventilation after cardiac surgery, Mantovani L, *et al.* 27

Hydroxyethyl starch, Hydroxyethyl starch (HES) 130/0.4 reduces blood loss in off-pump coronary surgery, Meyer C, *et al.* 21

- Hyperhidrosis**, Treatment of hyperhidrosis by transthoracic endoscopic sympathectomy, Gomar C, *et al.* 17
- Hyperlipidaemic patients**, Comparison of serum lipids and glucose levels during propofol or midazolam infusions for cardiac surgery in hyperlipidaemic patients, Acarturk H, *et al.* 27
- Hypertension**, Does preoperative activity of the autonomic nervous system predict hypertension during CABG?, Akselrod B, *et al.* 13
- Hypothermic cardiopulmonary bypass**, Comparison of bispectral index during normothermic and hypothermic cardiopulmonary bypass, Han S-H, *et al.* 19
- Hypoxia treatment**, Inhaled nitric oxide for hypoxia treatment after open heart surgery, Mojasevic R, *et al.* 32
- ICU**
- , Is measuring cerebral oxygenation during off-pump cardiac surgery associated with ICU and hospital length of stay?, Szurlej D, *et al.* 15
 - , Long term follow up of patients with short and long postoperative ICU stay after cardiac surgery, Villa GB, *et al.* 26
- Iloprost**
- , Iloprost: a positive inotropic effect in isolated myocardium?, Müller-Späth S, *et al.* 33
 - , Inhaled iloprost for pulmonary hypertension during cardiac surgery, Filipescu D, *et al.* 36
 - , Inhaled iloprost for testing vasodilator capacity in secondary pulmonary hypertension in children with congenital heart disease, Raileanu I, *et al.* 33
- Intensive care unit**
- , Characteristics and outcome of admissions to general intensive care units following cardiac surgery, Walther SM, *et al.* 25
 - , Estimation of morbidity risk factors in intensive care unit: a Bayesian discriminant approach, Scolletta S, *et al.* 14
 - , Prediction of mortality and prolonged intensive care unit stay after off-pump coronary artery bypass grafting, Hofer CK, *et al.* 25
 - , Two year experience and clinical impact of echocardiography in the cardiothoracic intensive care unit, Wagner G, *et al.* 29
- Intra-operative red cell salvage**, The impact of intra-operative red cell salvage on allogeneic blood requirements following cardiac surgery, Spackman D, *et al.* 10
- Intravascular blood gas**, Evaluation of a new probe for continuous intravascular blood gas monitoring in jugular venous and arterial blood, Papadopoulos AC, *et al.* 12
- Iron status**, Pre and postoperative iron status in patients presenting for cardiac surgery, Steven M, *et al.* 9
- Ischaemia–reperfusion**
- , Methylprednisolone increases urinary nitrate/creatinine ratios in porcine infrarenal aortic ischaemia reperfusion, Baker RC, *et al.* 6
 - , N-acetylcysteine decreases myocardial ischaemia–reperfusion injury in CABG patients, Yapici N, *et al.* 7
- Isoflurane**
- , Comparison of myocardial protective effects of TIVA, sevoflurane and isoflurane in CABG surgery, Koruk S, *et al.* 8
 - , Effect of isoflurane on diastolic function in patients with concentric left ventricular hypertrophy: an echocardiographic study, Neuhaeuser C, *et al.* 4
- Jugular venous blood**, Evaluation of a new probe for continuous intravascular blood gas monitoring in jugular venous and arterial blood, Papadopoulos AC, *et al.* 12
- Left ventricular hypertrophy**, Effect of isoflurane on diastolic function in patients with concentric left ventricular hypertrophy: an echocardiographic study, Neuhaeuser C, *et al.* 4
- Levofloxacin**, In-vivo measurement of levofloxacin penetration into lung tissue after cardiac surgery, Hutschala D, *et al.* 28
- Levosimendan**, The effects of levosimendan in cardiac surgery patients, Romana C, *et al.* 3
- Lung tissue**, In-vivo measurement of levofloxacin penetration into lung tissue after cardiac surgery, Hutschala D, *et al.* 28
- Lymphocyte apoptosis**, The effects of normovolaemic haemodilution on degree of lymphocyte apoptosis during CABG, Dałbrowski W, *et al.* 26
- Mechanical ventilation**, Diabetes is an independent predictor of hospital mortality in patients with prolonged mechanical ventilation after cardiac surgery, Mantovani L, *et al.* 27
- Methylprednisolone**, Methylprednisolone increases urinary nitrate/creatinine ratios in porcine infrarenal aortic ischaemia reperfusion, Baker RC, *et al.* 6
- Microvascular bleeding, algorithm**, Problem-solving in cardiac surgery: empiricism vs. algorithm in the management of microvascular bleeding (MVB), Finamore G, *et al.* 24
- Microvascular bleeding, empiricism**, Problem-solving in cardiac surgery: empiricism vs. algorithm in the management of microvascular bleeding (MVB), Finamore G, *et al.* 24
- Monocyte surface receptor**, ACE inhibitors enalaprilat and quinaprilat inhibit monocyte surface receptor expression, Welters ID, *et al.* 7
- Mortality**
- , Re-admission and mortality rate after a fast-track recovery protocol in off-pump coronary artery bypass surgery patients, Celkan MA, *et al.* 23
 - , Prediction of mortality and prolonged intensive care unit stay after off-pump coronary artery bypass grafting, Hofer CK, *et al.* 25
- Myocardial function**, Tissue Doppler evaluation of myocardial function during high thoracic epidural analgesia, Norrild K, *et al.* 16
- Myocardial ischaemia**, Even low levels of preoperative troponin I predict postoperative myocardial ischaemia and cardiac complications in vascular surgery, Gaudard P, *et al.* 14
- Myocardial protection**, The efficiency of diltiazem on myocardial protection in off-pump coronary artery bypass grafting surgery, Alev T, *et al.* 8
- Myocardium**, Iloprost: a positive inotropic effect in isolated myocardium?, Müller-Späth S, *et al.* 33
- N-acetylcysteine**
- , N-acetylcysteine decreases myocardial ischaemia–reperfusion injury in CABG patients, Yapici N, *et al.* 7
 - , The effects of N-acetylcysteine on renal function during and after cardiac surgery. A pilot study, Ristikankare A, *et al.* 6
- Natriuretic peptides**, Levels of natriuretic peptides during paediatric open heart surgery, Székely A, *et al.* 20
- Near infrared spectroscopy**, The use of near infrared spectroscopy (NIRS) in combined vascular and cardiac surgery, Portolan M, *et al.* 18
- Negative pressure ventilation**, Left ventricular diastolic function during negative pressure ventilation, Danella A, *et al.* 5
- Neurological outcome**, Neurological outcome after coronary artery bypass grafting: sevoflurane versus total intravenous anaesthesia, Yamak B, *et al.* 26
- Neuronal injury**, Neuronal injury after ICD-implantation is associated with a deterioration of cognitive function after surgery, Weigl M, *et al.* 26
- Nitric oxide**, Inhaled nitric oxide for hypoxia treatment after open heart surgery, Mojasevic R, *et al.* 32
- Normothermic cardiopulmonary bypass**, Comparison of bispectral index during normothermic and hypothermic cardiopulmonary bypass, Han S-H, *et al.* 19
- Occlusion pressure**, Description of the instantaneous pressure–flow relationship and critical occlusion pressure in arterial coronary bypass grafts, Kazmaier S, *et al.* 4
- Off-pump cardiac surgery**, Is measuring cerebral oxygenation during off-pump cardiac surgery associated with ICU and hospital length of stay?, Szurlej D, *et al.* 15
- Off-pump coronary artery bypass grafting**
- , Benefits of off-pump coronary artery bypass grafting (OPCABG), Hofer CK, *et al.* 21
 - , Is off-pump coronary artery bypass grafting (OPCABG) more cost-effective than the on-pump procedure?, Hofer CK, *et al.* 22
 - , Prediction of mortality and prolonged intensive care unit stay after off-pump coronary artery bypass grafting, Hofer CK, *et al.* 25
 - , The efficiency of diltiazem on myocardial protection in off-pump coronary artery bypass grafting surgery, Alev T, *et al.* 8
- Off-pump coronary artery bypass surgery**
- , Aprotinin reduces bleeding after off-pump coronary artery bypass surgery, Meyer C, *et al.* 33
 - , Modified distal carotid artery perfusion for combined carotid endarterectomy and off pump coronary artery bypass surgery, Muralidhar K, *et al.* 31
 - , Re-admission and mortality rate after a fast-track recovery protocol in off-pump coronary artery bypass surgery patients, Celkan MA, *et al.* 23
- Ondansetron**, Comparison of different forms of ondansetron for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia, Yavorovskiy A, *et al.* 19
- On-pump CABG**, Aprotinin and the haemodynamic response to SIRS in patients undergoing on-pump CABG, Naumenko SE, *et al.* 5
- Open chest conditions**, Assessing volume responsiveness during open chest conditions in cardiac surgery patients, Reuter DA, *et al.* 2

Open-heart surgery

- , Effects of remifentanyl and fentanyl on haemodynamics and cognitive functions in patients undergoing open-heart surgery, Koç M, *et al.* 24
- , Inhaled nitric oxide for hypoxia treatment after open heart surgery, Mojasevic R, *et al.* 32

Open heart surgery, fast-track, The effects of remifentanyl and fentanyl on postoperative pain and recovery in fast-track open heart surgery, Turan S, *et al.* 23

Open heart surgery, paediatric, Levels of natriuretic peptides during paediatric open heart surgery, Székely A, *et al.* 20

Pain scores, The effect of magnesium sulphate on postoperative pain scores and requirement of analgesia following CABG, Yılmaz O, *et al.* 17

Papworth Hospital, An audit of central venous cannulation in Papworth Hospital from March to May 2003, Moore CS, *et al.* 31

PFA100, Thromboelastography, PFA100 and whole-blood aggregometry in patients undergoing a thoracic aortic operation with deep hypothermic circulatory arrest, Szczurek D, *et al.* 34

Phosphorylcholine coating, Phosphorylcholine coating preserves coagulation during cardiac surgery – a combined TEG and PFA-100 analysis, Corno C, *et al.* 19

Pilot study, The effects of N-acetylcysteine on renal function during and after cardiac surgery. A pilot study, Ristikankare A, *et al.* 6

Platelet function, Effects of diclofenac on platelet function and bleeding after cardiac surgery, Kamenik M, *et al.* 9

PONV, Comparison of different forms of ondansetron for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia, Yavorovskiy A, *et al.* 19

Post-anaesthesia recovery unit, Evaluation of early extubation (fast-track) after cardiac surgery in a post-anaesthesia recovery unit, Matute P, *et al.* 23

Postoperative pain, The effects of remifentanyl and fentanyl on postoperative pain and recovery in fast-track open heart surgery, Turan S, *et al.* 23

Postoperative patient, Pulmonary thrombo-endarterectomy improves diastolic relaxation in the immediate postoperative patient, White PA, *et al.* 4

Pregnancy, Aortic valve surgery during pregnancy: a series of 5 patients, Prabhu P, *et al.* 35

Pressure-flow relationship, Description of the instantaneous pressure-flow relationship and critical occlusion pressure in arterial coronary bypass grafts, Kazmaier S, *et al.* 4

Prophylaxis, Comparison of different forms of ondansetron for the prophylaxis of PONV in patients undergoing coronary surgery under fast track anaesthesia, Yavorovskiy A, *et al.* 19

Pulmonary arteriovenous malformation, Intraoperative transoesophageal echocardiography in a case of pulmonary arteriovenous malformation, Silva F, *et al.* 30

Pulmonary function, Reduction of pulmonary function after resection: less than expected in COPD patients, Jiménez MJ, *et al.* 16

Pulmonary gas exchange, Beating heart surgery with assistance of simplified bypass systems: effects on haemodynamics and pulmonary gas exchange, Rex S, *et al.* 5

Pulmonary hypertension

- , Inhaled iloprost for pulmonary hypertension during cardiac surgery, Filipescu D, *et al.* 36
- , Inhaled iloprost for testing vasodilator capacity in secondary pulmonary hypertension in children with congenital heart disease, Raileanu I, *et al.* 33
- , Inhaled iloprost in the management of pulmonary hypertension in infants undergoing congenital heart surgery, Mueller M, *et al.* 3

Pulmonary thrombo-endarterectomy, Pulmonary thrombo-endarterectomy improves diastolic relaxation in the immediate postoperative patient, White PA, *et al.* 4

Re-admission, Re-admission and mortality rate after a fast-track recovery protocol in off-pump coronary artery bypass surgery patients, Celkan MA, *et al.* 23

Recombinant factor VII

- , A pilot double blind randomized placebo controlled trial of the use of recombinant factor VIIa (rFVIIa) in high transfusion risk cardiac surgery, Diprose P, *et al.* 9
- , Recombinant activated factor VII in cardiac surgery: experience in 7 cases, Vanek T, *et al.* 34

Remifentanyl

- , Effects of remifentanyl and fentanyl on haemodynamics and cognitive functions in patients undergoing open-heart surgery, Koç M, *et al.* 24

- , The effects of remifentanyl and fentanyl on postoperative pain and recovery in fast-track open heart surgery, Turan S, *et al.* 23

Renal dysfunction, Preoperative ACE inhibition and renal dysfunction following cardiac surgery, Penugonda SP, *et al.* 7

Renal function, The effects of N-acetylcysteine on renal function during and after cardiac surgery. A pilot study, Ristikankare A, *et al.* 6

Renal replacement therapy, Long term outcome of patients who require renal replacement therapy after cardiac surgery, Landoni G, *et al.* 15

Respiratory disease, High thoracic epidural anaesthesia (HTEA) for cardiac surgery in patients with respiratory disease, de Paulis S, *et al.* 16

Risk factors

- , Evaluation of risk factors to predict haematocrit decrease in CPB, Flo A, *et al.* 13
- , Estimation of morbidity risk factors in intensive care unit: a Bayesian discriminant approach, Scolletta S, *et al.* 14

Ropivacaine, Epidural infusion of ropivacaine or bupivacaine during major thoracic surgery, Misiołek H, *et al.* 32

Serum lipids, Comparison of serum lipids and glucose levels during propofol or midazolam infusions for cardiac surgery in hyperlipidaemic patients, Acarturk H, *et al.* 27

Sevoflurane, Comparison of myocardial protective effects of TIVA, sevoflurane and isoflurane in CABG surgery, Koruk S, *et al.* 8

Simplified bypass systems, Beating heart surgery with assistance of simplified bypass systems: effects on haemodynamics and pulmonary gas exchange, Rex S, *et al.* 5

SIRS, Aprotinin and the haemodynamic response to SIRS in patients undergoing on-pump CABG, Naumenko SE, *et al.* 5

Spirometry, Incentive spirometry for preoperative preparation of cardiac patients, Balandiuk AE, Kozlov IA, 3

Staphylococcus aureus, Carbon dioxide inhibits the growth rate of *Staphylococcus aureus* at body temperature, van der Linden J, *et al.* 29

Thermodilution, Accuracy of arterial (or transthoracic) thermodilution cardiac output during aortic counterpulsation, Baulig W, *et al.* 11

Thoracic aortic operation, Thromboelastography, PFA100 and whole-blood aggregometry in patients undergoing a thoracic aortic operation with deep hypothermic circulatory arrest, Szczurek D, *et al.* 34

Thoracic surgery, Epidural infusion of ropivacaine or bupivacaine during major thoracic surgery, Misiołek H, *et al.* 32

Thrombocytopenia, Heparin-induced thrombocytopenia after treatment with enoxaparin immediately after heart surgery: Case report, Husedzinovic I, *et al.* 34

Thromboelastography, Thromboelastography, PFA100 and whole-blood aggregometry in patients undergoing a thoracic aortic operation with deep hypothermic circulatory arrest, Szczurek D, *et al.* 34

Tidal volumes, Prediction of fluid responsiveness in patients after cardiac surgery and ventilated with low tidal volumes, Rex S, *et al.* 2

Tissue Doppler, Tissue Doppler evaluation of myocardial function during high thoracic epidural analgesia, Norrild K, *et al.* 16

TIVA, Comparison of myocardial protective effects of TIVA, sevoflurane and isoflurane in CABG surgery, Koruk S, *et al.* 8

Tramadol hydrochloride, Tramadol hydrochloride for treatment of shivering after cardiac surgery, Trekova N, *et al.* 17

Transcatheter closure, Transmitral occluder device embolization during transcatheter closure of an atrial septal defect: role of transoesophageal echocardiography, Botero M, *et al.* 35

Transfusion requirements

- , Clopidogrel and perioperative transfusion requirements in cardiopulmonary bypass surgery, Whitty R, *et al.* 10
- , Ultra low dose aprotinin decreases blood loss and transfusion requirements in high risk two valve replacement surgery, Muralidhar K, *et al.* 11

Transmitral occluder device, Transmitral occluder device embolization during transcatheter closure of an atrial septal defect: role of transoesophageal echocardiography, Botero M, *et al.* 35

Transoesophageal echocardiography

- , Inaccuracy of cardiac output determination by transoesophageal echocardiography, Bettex DA, *et al.* 20
- , Intraoperative transoesophageal echocardiography in a case of pulmonary arteriovenous malformation, Silva F, *et al.* 30
- , Perioperative transoesophageal echocardiography and post-infarct ventricular septal defect, Ragheb JW, Griffin M, 30
- , Transmitral occluder device embolization during transcatheter closure of an atrial septal defect: role of transoesophageal echocardiography, Botero M, *et al.* 35

Transthoracic endoscopic sympathectomy, Treatment of hyperhidrosis by transthoracic endoscopic sympathectomy, Gomar C, *et al.* 17

- Transfusion risk**, A pilot double blind randomized placebo controlled trial of the use of recombinant factor VIIa (rFVIIa) in high transfusion risk cardiac surgery, Diprose P, *et al.* 9
- TROMSØ 2000**, Therapeutic coronary intervention after primary coronary angiography, TROMSØ 2000, Bjørsvik G, Arnesen E, 32
- Troponin I**, Even low levels of preoperative troponin I predict postoperative myocardial ischaemia and cardiac complications in vascular surgery, Gaudard P, *et al.* 14
- Urinary nitrate/creatinine ratios**, Methylprednisolone increases urinary nitrate/creatinine ratios in porcine infrarenal aortic ischaemia reperfusion, Baker RC, *et al.* 6
- Vancomycin, diabetic patients**, Plasma and interstitial concentrations of vancomycin in diabetic vs. non-diabetic patients, Skhirtladze K, *et al.* 2
- Vancomycin, non-diabetic patients**, Plasma and interstitial concentrations of vancomycin in diabetic vs. non-diabetic patients, Skhirtladze K, *et al.* 2
- Valve replacement surgery**, Ultra low dose aprotinin decreases blood loss and transfusion requirements in high risk two valve replacement surgery, Muralidhar K, *et al.* 11
- Valve surgery**, Alfentanil-based general anaesthesia for early extubation after valve surgery, Vanek T, *et al.* 22
- Vascular surgery**, Even low levels of preoperative troponin I predict postoperative myocardial ischaemia and cardiac complications in vascular surgery, Gaudard P, *et al.* 14
- Vasodilator**, Inhaled iloprost for testing vasodilator capacity in secondary pulmonary hypertension in children with congenital heart disease, Raileanu I, *et al.* 33
- Ventricular septal defect**, Perioperative transoesophageal echocardiography and post-infarct ventricular septal defect, Ragheb JW, Griffin M, 30
- Volume responsiveness**, Assessing volume responsiveness during open chest conditions in cardiac surgery patients, Reuter DA, *et al.* 2
- Whole-blood aggregometry**, Thromboelastography, PFA100 and whole-blood aggregometry in patients undergoing a thoracic aortic operation with deep hypothermic circulatory arrest, Szczurek D, *et al.* 34
- Wound desiccation**, Can wound desiccation be averted during cardiac surgery? An experimental study, van der Linden J, Persson M, 28

AUTHOR INDEX

- Acarturk, H. 27
 Aka, S.A. 7
 Akintuerk, H. 3
 Akselrod, B. 13
 Aletti, G. 24
 Alev, T. 8
 Allen, S.J. 6
 Amari, B. 24
 Anderson, L. 9
 Arena, V. 26
 Argyriou, M. 3
 Arlotta, G. 16
 Armstrong, M.A. 6, 7
 Arnesen, E. 32
 Autschbach, R. 5
 Avallato, C. 18
 Ayik, I. 26
 Aykaç, Z. 7, 17
- Babalian, G. 13
 Bahk, J.-H. 19
 Baker, R.C. 6
 Balandiuk, A.E. 3
 Baldassarri, R. 5
 Barberá, J.A. 16
 Barisin, S. 34
 Barros D'Sa, A.A.B. 6
 Barzaghi, N. 18
 Basora, M. 23
 Baulig, W. 11
 Benkó, E. 20
 Bennett, M.J. 28
 Bergman, P. 29
 Bernardo, M. 26
 Berson, D. 35
 Berthet, M.C. 25
 Berthet, M.C. 33
 Bertora, M. 18
 Bettex, D.A. 20
 Beverini, C. 15
 Biagioli, B. 11, 14
 Biernacka, J. 26, 27
 Biolcati, F. 15
 Bjørsvik, G. 32
 Blin, D. 21, 25, 33
 Bortone, F. 26
 Botero, M. 35
 Bove, T. 15
 Bradic, N. 34
 Bradisteanu, S. 33, 36
 Brady, A.R. 25
 Breuer, T. 20
 Brose, S. 2, 5
 Brucek, P. 22, 34
 Budziński, D. 32
 Buhre, W. 2, 5, 33
 Bunatian, A. 13, 17, 19
 Busch, T. 33
- Calabrese, M. 16
 Calabrò, M.G. 15
 Caldeira, J. 30
 Callejas, M.A. 17
 Canet, J. 13
 Canik, S. 27
 Castracane, W. 27
 Castro, M.A. 13
 Cazzaniga, A. 10
 Celkan, M.A. 23
 Ceriani, R. 26
 Cevenini, G. 14
 Chavanon, O. 21, 33
 Cimino, A. 16
 Clarke, J. 35
- Cobain, J. 31
 Colson, P. 14
 Connell, M.O. 10
 Conti, E. 24
 Cornea, A. 36
 Corno, C. 19
 Çoruh, T. 7, 17
 Crescenzi, G. 19
 Cristea, M. 33, 36
 Crivellari, M. 24
 Cruz, J. 30
 Cubells, C. 13
 Czajkowski, M. 27
- Daglar, B. 23
 Danella, A. 5
 Dąbrowski, W. 26, 27
 De Benedetti, D. 10
 De Maria, R. 26
 de Paulis, S. 16
 de Riva, N. 16
 Demirbag, A.E. 26
 Dhaded, S. 11
 Diehl, Ch. 34
 Dietrich, W. 35
 Diprose, P. 9
 Dongas, A. 34
 Dorigo, E. 15
 Dowd, N. 10
 Dragan, M. 26
 Dunning, J.J. 4
 Durand, M. 21, 25, 33
 Dworschak, M. 26
- Erdemli, Ö. 8, 23, 26
- Feneck, R.O. 10, 14
 Fernandez, J. 16
 Ferrante, M. 24
 Filipescu, D. 33, 36
 Finamore, G. 24
 Fita, G. 16, 17, 23
 Flo, A. 13
 Flock, J.I. 29
 Fontanals, J. 23
 Forsberg, K. 29
 Fracasso, G. 15, 19, 24
 Franco, A. 19, 27
 Frangioni, C. 18
 Fryc-Stanek, J. 15
 Furrer, L. 25
- Gardellin, M. 25
 Gaudard, P. 14
 Gąsowska, J. 27
 Gemignani, R. 5
 Genoni, M. 21, 22, 25
 Gerli, C. 27
 Ghenu, O. 33, 36
 Gheorghiu, I. 33
 Giala, M.M. 12
 Gill, R. 9
 Gilliland, H. 7
 Gimferrer, J.M. 16
 Giomarelli, P. 11, 14
 Girardet, P. 21, 25, 33
 Gödie, O. 11
 Goepfert, M.S.G. 2
 Goetz, A.E. 2
 Gomar, C. 16, 17, 23
 Goren, S. 8
 Goresch, T. 2
 Götze, K. 4
 Grabenwöger, M. 28
- Graham, J. 31
 Granate, M. 30
 Gray, S. 31
 Griffin, J.D. 28
 Griffin, M. 30
 Grimm, M. 26
 Grossomanides, V. 12
 Gualco, A. 18
 Guarracino, F. 5
 Güldoğan, F. 24
- Hafer, G. 7
 Ham, B.-M. 19
 Han, S.-H. 19
 Hanekop, G. 4
 Hansen, M. 29
 Harish, B.R. 11
 Harney, D. 10
 Harrison, D.A. 25
 Heidt, M.C. 7
 Hellermann, J.P. 20
 Hempelmann, G. 3, 4, 7
 Herbertson, M. 9
 Hinselmann, V. 20
 Hofer, C.K. 21, 22, 25
 Hrabak, J. 34
 Huenecke, R. 2
 Husedzinovic, I. 34
 Hutschala, D. 2, 28
- Iliescu, V. 36
 Inoue, K. 34
 Isgrò, G. 10
 Issever, H. 27
- Jahangiri, M. 35
 Jares, M. 22, 34
 Javorovsky, A. 17
 Jenni, R. 20
 Jensen, B. 12
 Jiménez, M.J. 16, 17
 John, C. 11
 Jurko, C. 27
- Kadiman, S. 4
 Kamenik, M. 9
 Karadeniz, Ü. 23, 26
 Karakaya, D. 24
 Karakoulas, K. 12
 Karamichali, E. 3
 Karpe, J. 32
 Karu, I. 30
 Kastner, J. 26
 Kazaz, H. 23
 Kazmaier, S. 4
 Kettler, D. 4
 Khalil, N. 7
 Kilger, E. 2
 Kim, C.-S. 19
 Kim, S.F. 5
 Kim, Y.-R. 19
 Király, L. 20
 Kirkegaard, H. 16
 Kiskinis, D. 12
 Klein, G. 29
 Klypa, T.V. 22
 Knapik, P. 32
 Koç, M. 24
 Kocamanoglu, S. 24
 Kocoglu, H. 23
 Kokotsakis, J. 3
 Korfali, G. 8
 Koruk, S. 8
 Korycińska, A. 26

- Kozlov, I.A. 3, 22
 Kruczak, W. 15
 Kucia, H. 32
 Kuitunen, A. 6
 Kurç, E. 7
 Kwapisz, M. 4
- LaMonica, R. 24
 Landoni, G. 15
 Large, S.R. 4
 Latimer, R.D. 4
 Lee, J.-L. 19
 Lefevre, M. 21, 33
 Lemut, F. 18
 Locatelli, A. 18
 Loit, R. 30
 Luchian, M. 33, 36
 Lyons, F. 10
- Machej, L. 15
 Maçika, H. 7, 17
 Maloigne, M. 21, 22
 Mantovani, L. 27
 Marin, S. 33, 36
 Marino, G. 15
 Marino, M. 15
 Mario Romano, S. 11
 Marshall, N.B. 28
 Martinelli, L. 16
 Martinez, R. 24
 Massó, E. 13
 Matute, P. 17, 23
 Mayer-Helm, B.X. 2, 28
 Mazzoni, M. 26
 McBride, W.T. 6, 7
 McGovern, E. 10
 McMurray, T.J. 7
 Mekiš, D. 9
 Menzebach, A. 7
 Mészáros, R. 20
 Metzelder, S. 2, 5
 Meyer, C. 21, 25, 33
 Misiófek, H. 32
 Mogol, E.B. 8
 Mojasevic, R. 32
 Moore, C.S. 31
 Morais, S. 30
 Moret, E. 13
 Morley, A. 10
 Mueller, M. 3, 4
 Müller, M. 7
 Müller-Späth, S. 33
 Muralidhar, K. 11, 31
 Murthy, K. 11, 31
- Naughton, C. 10, 14
 Naumenko, K.S. 5
 Naumenko, S.E. 5
 Neri, S. 18
 Nestorowicz, A. 26, 27
 Neuhaeuser, C. 3, 4
 Nikic, N. 34
 Noest, R. 3
 Norrild, K. 12, 16
- O'Shaughnessy, D. 9
 Oh, Y.-S. 19
 Öhman, M. 29
 Orhan, G. 7
 Osojnik, I. 9
 Ozgok, A. 8
 Oztekin, I. 27
 Oztekin, S.D. 27
 Ozturk, D. 8
- Paapstel, A. 30
 Papadopoulos, A.C. 12
- Pappalardo, F. 19, 27
 Parodi, O. 26
 Parolini, M. 26
 Pavlova, Z. 19
 Pazzaglia, A. 10
 Pede, V. 24
 Pedersen, T.F. 12
 Peix, N. 23
 Penugonda, S.P. 7
 Persson, M. 12, 28, 29
 Petrovic, Lj. 32
 Pettit-Mills, R.S. 18
 Piazza, G. 19
 Platon, P. 33
 Pokrovsky, M.G. 5
 Portolan, M. 18
 Powroznyk, A. 10
 Pöyhä, R. 6
 Pożarowski, P. 26
 Prabhu, P. 35
 Praveen, K. 11, 31
 Prohaska, W. 34
 Pursuk, N. 26
 Putzu, M. 15, 24
- Quasim, I. 9
- Radovanovic, N. 42
 Ragheb, J.W. 30
 Raileanu, I. 33, 36
 Rajnish, G. 11, 31
 Ranucci, M. 10
 Rao, P.V. 31
 Ravindra, S. 31
 Redaelli, C. 24
 Reining, G. 26
 Reizoglou, M. 12
 Reuter, D.A. 2
 Rex, S. 2, 5, 33
 Reyher, C. 7
 Rhomberg, P. 25
 Ristikankare, A. 6
 Rodella, G. 24
 Rodés, M. 13
 Roliński, J. 26
 Romana, C. 3
 Rossaint, R. 2, 5, 33
 Roux, C. 17, 23
 Rovira, I. 16, 17, 23
 Rowan, K. 25
 Roxburgh, J. 14
 Rudnicki, M. 15
 Ruyra, X. 13
 Ryckwaert, F. 14
 Rzecki, Z. 27
- Sala, X. 23
 Salmenperä, M. 6
 Salvi, L. 15
 Sanchez, V. 13
 Sanjay, B. 11, 31
 Sági, E. 20
 Sargin, M. 7
 Schaelte, G. 2, 5
 Schiavello, R. 16
 Schmid, E.R. 11, 20
 Schmoeckel, M. 2
 Scholz, S. 4
 Schroth, S. 33
 Schütt, P. 11
 Scolletta, S. 11, 14
 Seibert, H. 29
 Seitelberger, R. 28
 Sener, E. 8
 Şener, E.B. 24
 Seres, L. 20
 Shetty, D.P. 11, 31
 Silva, F. 30
- Sisillo, E. 15
 Skhirtladze, K. 2, 26, 28
 Sloth, E. 12, 16
 Smith, D.C. 18
 Solinas, C. 26
 Sonntag, H. 4
 Soro, G. 10
 Soutar, R. 9
 Soutzopoulou, C. 3
 Soyak, Ö.B. 23
 Spackman, D. 10
 Sparicio, D. 24
 Starkopf, J. 30
 Steven, M. 9
 Stolarski, L. 34
 Straka, Z. 22, 34
 Stratigopoulou, P. 3
 Suojarant-Ylilinen, R. 6
 Svenarud, P. 12, 29
 Szatmári, A. 20
 Szczurek, D. 34
 Székely, A. 20
 Székely, E. 20
 Szurlej, D. 15
- Tavakoli, R. 21, 22
 Tenze, G. 26
 Tessier, Y. 21
 Thomas, J. 35
 Thuermel, K. 35
 Till, J. 20
 Tolan, M. 10
 Tonkovic, D. 34
 Toth, M. 20
 Trekova, N. 17, 19
 Tschernko, E. 2, 28
 Tufekcioglu, O. 8
 Tulbure, D. 33, 36
 Tuncer, G. 8
 Tür, A. 24
 Turan, S. 23
 Turina, M. 21, 22
- Ursulescu, A. 29
 Ustunsoy, H. 23
- van der Linden, J. 12, 28, 29
 Vanek, T. 22, 34
 Vassilakos, D. 12
 Villa, G.B. 26
 Votava, J. 22
 Vroemen, J. 10
 Vuylsteke, A. 4
- Wagner, G. 29
 Walther, S.M. 25
 Węglarzy, A. 15
 Weigl, M. 26
 Welters, I. 3
 Welters, I.D. 7
 Werszner, M. 32
 Weyland, A. 4
 White, P.A. 4
 Whitty, R. 10
- Yamak, B. 26
 Yapici, N. 7, 17
 Yavorovskiy, A. 19
 Yilmaz, C. 17
 Yilmaz, O. 17
 Young, V. 10
 Yücel, O. 7
 Yüksel, M. 7
- Zamparelli, R. 16
 Zangrillo, A. 15, 19, 24, 27
 Zjulyaeva, T. 19
 Zollinger, A. 21, 22, 25

