

Emergency medicine procedural skills: what are residents missing?

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ABSTRACT

Objective: This study sought to establish the current state of procedural skills training in Canadian Royal College emergency medicine (EM) residencies.

Methods: A national Web-based survey was administered to residents and program directors of all 13 Canadian-accredited Royal College EM residency programs. Program directors rated the importance and experience required for competence of 45 EM procedural skills. EM residents reported their experience and comfort in performing the same procedural skills.

Results: Thirteen program directors and 86 residents responded to the survey (response rate of 100% and 37%, respectively). Thirty-two (70%) procedures were considered important by > 70% of program directors, including all resuscitation and lifesaving airway procedures. Four procedures deemed important by program directors, including cricothyroidotomy, pericardiocentesis, posterior nasal pack for epistaxis, and paraphimosis reduction, had never been performed by the majority of senior residents. Program director opinion was used to categorize each procedure based on performance frequency to achieve competence. Overall, procedural experience correlated positively with comfort levels as indicated by residents.

Conclusions: We established an updated needs assessment of procedural skills training for Canadian Royal College EM residency programs. This included program director opinion of important procedures and the performance frequency needed to achieve competence. However, we identified several important procedures that were never performed by most senior residents despite program director opinion regarding the experience needed for competence. Further study is required to better define objective measures for resident competence in procedural skills.

RÉSUMÉ

Objectif: L'étude visait à décrire l'état actuel de la pratique d'habiletés techniques dans le cadre des programmes

de résidence en médecine d'urgence (MU) du Collège royal.

Méthode: Une enquête nationale a été menée sur le Web parmi les résidents et les directeurs de programme des 13 programmes de résidence en MU, reconnus par le Collège royal. Les directeurs de programme ont évalué l'importance de 45 habiletés techniques en MU et l'expérience nécessaire à l'acquisition de la compétence en la matière. Les résidents, de leur côté, ont fait état de leur expérience et de leur degré d'aise à réaliser ces mêmes habiletés techniques.

Résultats: Treize directeurs de programme et 86 résidents ont répondu au questionnaire d'enquête (taux de réponse de 100% et de 37%, respectivement). Trente-deux (70%) interventions, notamment toutes les manoeuvres de réanimation et interventions salvatrices de maintien ou de rétablissement de la perméabilité des voies aériennes, ont été jugées importantes par plus de 70% des directeurs de programme. Par ailleurs, quatre interventions considérées comme importantes par les directeurs de programme n'avaient jamais été exécutées par la plupart des résidents seniors; il s'agit de la cricothyroïdectomie, de la péricardiocentèse, du tamponnement nasal postérieur en cas d'épistaxis, et de la réduction du paraphimosis. Le classement de chaque intervention en fonction de la fréquence d'exécution du geste pour l'acquisition de la compétence reposait sur l'opinion des directeurs de programme. Dans l'ensemble, l'expérience des techniques était en corrélation positive avec les degrés d'aise exprimés par les résidents.

Conclusions: Nous avons procédé à une mise à jour de l'évaluation des besoins en ce qui concerne la pratique d'habiletés techniques dans le cadre des programmes de résidence en MU, reconnus par le Collège royal. L'exercice comprenait aussi les interventions importantes et leur fréquence d'exécution pour permettre l'acquisition de la compétence, selon l'opinion des directeurs de programme.

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Toutefois, l'enquête a permis de dégager plusieurs interventions importantes jamais réalisées par la plupart des résidents seniors, et ce, malgré le fait que les directeurs de programme jugeaient l'expérience nécessaire à l'acquisition de la compétence. Il faut poursuivre la recherche afin de mieux définir des mesures objectives d'acquisition des

compétences par les résidents au regard de certaines habiletés techniques.

Keywords: clinical competence, emergency medicine, medical education

Competence has become an increasingly important concept in postgraduate medical education (PGME) as it now forms the framework for resident curricula and assessment.¹ Competence in procedural skills has been recognized as especially valuable.²⁻⁴ This growing emphasis is partly related to an increased focus on patient safety along with more rigorous standards in the accreditation of residency programs.^{5,6} Furthermore, the importance of adequate procedural experience is highlighted by the significant effect of procedures on inpatient morbidity and mortality.^{7,8} Although debate exists regarding the precise definition of procedural competence, it frequently combines experience with the ability to successfully perform a procedural skill independently and appreciate potential complications.^{9,10}

In emergency medicine (EM), residents are required to achieve competence in an extensive number of procedural skills.^{11,12} Many of these procedures are lifesaving, and they must be performed with speed and accuracy. Despite the importance of procedural competence, the existing data primarily address attending EM physicians.¹³ Furthermore, the literature is limited regarding the procedural experience of EM residents.^{14,15} The most comprehensive study to address procedural experience among EM residents evaluated procedural logging systems from 92 US residency programs.¹⁶ More recently, the procedural experience of Canadian pediatric EM fellows has been published.¹⁷ Currently, only the Accreditation Council for Graduate Medical Education (ACGME) has published guidelines for procedural experience in EM, although it is unclear whether these guidelines are based on empirical data.¹⁸ The list includes 15 "critical" procedures as well as recommendations for the number of times each should be performed. However, no explicit relationship to competence is described.

The recognized importance of procedural competence, along with the paucity of data regarding the current state of EM procedure training, highlights the need for an updated assessment of EM resident procedural skills. Updating the importance of many

procedures during residency training is warranted as diagnostic and management processes have changed with the advent of newer technology. In addition, it remains unknown what minimum experience is necessary to achieve competence in a procedure.

In this study, by surveying Royal College of Physicians and Surgeons of Canada EM program directors and residents, we sought to provide an updated needs assessment of procedural skills training. We asked program directors their perceived importance of EM procedures and the performance frequency that would contribute to procedural competence. We asked residents to report experience and comfort for a variety of EM procedures.

METHODS

Study design and population

This study, conducted over 2 months (June–July 2010), was a two-part, Web-based survey designed to assess the current state of procedural skills training among Canadian Royal College EM residents and the opinions of Royal College EM program directors. Part 1 (program director survey), modeled after two previously published protocols,^{19,20} was administered to all 13 Canadian Royal College EM program directors. Part 2 (resident survey) was administered to all Canadian Royal College EM residents to evaluate their experience and comfort levels for specific procedures performed during postgraduate training.

Both surveys included the same list of 45 EM procedures. A single discriminator, a non-EM procedure (colonoscopy), was also listed as a control. Although it was not our intention to compile a comprehensive list of procedures, we chose a representative sample of procedures whereby technical difficulty and frequency of performance varied. The list was based on the *Objectives of Training in Emergency Medicine* developed by the Royal College.¹² A focus group of five experienced attending EM physicians

refined the list. A pilot survey was performed with one program director, two experienced attending EM physicians, and five EM residents for face and content validity, after which modifications were made.

Survey content and administration

The program director survey asked, "How important is it for EM residents to achieve competence for each listed procedure by the completion of residency?" Participants responded using a 5-point Likert scale (1 = not important at all, 5 = extremely important). We deemed a priori that a procedure was "important" when it was rated ≥ 4 by $\geq 70\%$ of program directors. Program directors were also asked, "How many times should each procedure be performed independently to achieve competence?" with the following intervals provided: 0, 1 to 3, 4 to 6, 7 to 9, 10 to 19, 20 to 29, 30, and more. The 70th percentile of responses by program directors for each procedure was used to establish a minimum experience frequency associated with procedural competence.

The resident survey (part 2) asked for demographic information, including age, gender, and year of training. Program-specific information was purposefully omitted to ensure anonymity. For each procedure, residents were asked to rate their comfort level in performing the skill independently using a 5-point Likert scale. A rating of 1 represented "extremely uncomfortable," whereas 5 represented "extremely comfortable." We decided a priori that a score of ≥ 4 represented comfort in performing the procedure. Residents were also asked the number of times that they had "performed independently (with or without supervision) each procedure as a resident" during both EM and off-service rotations using the following intervals: 0, 1 to 3, 4 to 6, 7 to 9, 10 to 19, 20 to 29, 30, and more. Residents were also asked, using a 5-point agreement scale (ranging from strongly disagree to strongly agree), "Do you receive adequate procedural skills during your residency?" Finally, residents were asked to rank the rotations during which they acquired the majority of their procedural skills.

Using a modified Dillman technique,²¹ program directors were asked to distribute the resident survey to residents via email. The email invitation contained an introductory letter and an electronic link to the survey. Program directors received three email reminders at

2-week intervals. All surveys were entirely anonymous. This study was approved by the Research Ethics Board at our institution.

Data analysis

For each procedure, analysis of variance (ANOVA) was performed to compare resident mean comfort scores with resident experience for all residents. Comfort scores using the 1 to 5 scale (as above) were compared to each procedure experience interval (0, 1–3, 4–6, 7–9, 10–19, 20–29, ≥ 30). Descriptive statistics were analyzed using Microsoft *Excel* 2007 (Redmond, WA), and *SAS* version 9.2 (SAS Institute, Cary, NC) was used for ANOVA. To study the association between minimum performance frequency and resident comfort, the Yates corrected chi-square or Fisher exact test was used for categorical testing depending on expected values. These data were analyzed using *OpenEpi* (Dean AG & Sullivan KM, Atlanta, GA) version 2.3.1.

RESULTS

Response and demographic characteristics

All 13 Royal College EM program directors completed the program director survey and confirmed that the initial invitation and the reminder emails were forwarded to their residents. The response rate for the resident survey was 37% (86 of 232). The demographics for resident respondents are provided in Table 1.

Program director survey: procedural importance and minimum experience for competence

Program directors designated 70% (32 of 46) of procedures as "important" for EM residents to achieve competence by the completion of residency (Table 2). The remaining procedures not considered important are listed in Table 3 and included colonoscopy, the non-EM procedure control. The minimum performance frequency to achieve competence for each important procedure is also listed in Table 2. For example, the 70th percentile of program directors responded that arthrocentesis should be performed at least seven to nine times before competence could be achieved.

Table 1. Demographics of resident respondents

Characteristic	No. (%) of respondents*
Gender (n = 85)	
Male	53 (62.4)
Female	32 (37.6)
Mean age, yr (range) (n = 85)	30.3 (25–40)
Postgraduate year (n = 86)	
1	22 (25.6)
2	13 (15.1)
3	28 (32.6)
4	11 (12.8)
5	12 (14.0)

*Respondent numbers vary as it was not mandatory to complete each question.

Resident survey: experience and comfort levels

A majority of senior residents (PGY4–5) reported never having performed four procedures deemed important by program directors: pericardiocentesis, cricothyroidotomy, posterior nasal pack for epistaxis, and paraphimosis reduction (Table 4). In addition to these procedures, half of senior residents were not comfortable performing intraosseus line insertion. For important procedures, mean comfort levels among all residents were strongly associated with experience ($p < 0.001$).

Comparison between program director and resident responses

Program director opinions regarding competence were compared to resident comfort and experience. The minimum necessary experience expected by program directors was compared to resident comfort levels. For most procedures, residents were significantly more likely to report comfort performing a procedure if they had met the program director minimum frequency required for competence (see Table 2). For example, residents who performed at least 20 intubations (minimum performance frequency for competence) were 2.2 times more likely to report comfort with the procedure compared to residents who performed less than 20 intubations.

Among procedures considered important by program directors, senior residents achieved the minimum performance frequency more often than junior residents in 23 (71%) procedures. Three procedures (abscess incision and drainage, regional nerve block, electrical defibrillation) were performed at a high frequency by both junior and senior residents. In contrast, six procedures were performed at low rates by

both senior and junior residents: pediatric trauma resuscitation, pediatric endotracheal intubation, intraosseus line insertion, posterior nasal pack for epistaxis, paraphimosis reduction, and upper airway foreign body removal.

Resident opinion regarding procedural skills training

Half (52%) of residents reported receiving adequate procedural skills training during residency. However, 29% disagreed and the remainder (19%) reported feeling neutral, with no significant difference in the response distribution between junior and senior residents ($p = 0.233$).

The emergency rotation was most frequently ranked first by 41% of residents as the top rotation for procedural skill acquisition, whereas the intensive care unit was top-ranked by 37% of respondents. Other highly ranked rotations were anesthesia, trauma surgery, and orthopedics.

DISCUSSION

This study is the most current assessment of procedural skills training in Canadian Royal College EM residency programs. Previous studies of procedural skills among residents have typically addressed only program director opinion or resident experience.^{13,19} We studied both groups to better understand the present state of procedural skills training in residency. The procedural skill experience required for competence was asked of program directors for a variety of EM procedures. This is an important step in an era of competency-based education in which objective assessment methods should be used in procedural skill evaluation. Although experience does not equate to competence, experience is considered a necessary component.^{9,10,22} As a result, these findings provide an initial context for future research in procedural skills training.

In non-EM specialties, several advanced metrics have been used to more accurately describe the experience necessary for procedural competence. A study of anesthesia residents employed the cumulative sum (Cusum) technique that trends success and failure over time for proficiency in epidural performance.²³ Other studies in the surgical literature have analyzed learning curves and successful completion rates.^{24,25} Although each of these techniques relies primarily on

Table 2. Procedures ranked by minimum performance frequency deemed important to achieve competence by majority of program directors

Procedure	Residents who achieved minimum performance frequency, <i>n</i> (%)	Residents who reported comfort with procedure performance, <i>n</i> (%), 95% CI	Association between minimum performance frequency and comfort, relative risk (95% CI)
Electrical defibrillation	73 (87)	69 (82, 72–89)	1.9 (1.0–3.7)
Pericardiocentesis	15 (18)	9 (11, 6–19)	9.2 (2.6–32.7)
Abscess incision and drainage*	77 (90)	84 (98, 91–100)	1.1 (0.9–1.5)
Anterior pack for epistaxis	45 (54)	63 (75, 65–83)	1.9 (1.4–2.5)
Corneal foreign body removal†	43 (51)	42 (49, 39–60)	3.1 (1.8–5.5)
Cricothyroidotomy†	3 (4)	6 (7, 3–15)	13.7 (3.9–47.5)
Ear/nose foreign body removal†	35 (41)	50 (59, 48–69)	1.8 (1.3–2.6)
Electrical cardioversion	60 (71)	68 (81, 71–88)	2.1 (1.3–3.2)
Intraosseus line insertion*	4 (5)	20 (23, 16–33)	3.6 (1.8–7.3)
Nail procedures	38 (45)	41 (48, 38–59)	3.0 (1.8–5.0)
Paraphimosis reduction*	4 (5)	21 (24, 17–35)	4.8 (3.2–7.4)
Posterior nasal pack for epistaxis	6 (7)	19 (23, 15–33)	4.6 (2.6–8.4)
Transcutaneous pacing†	26 (31)	53 (62, 51–72)	1.9 (1.4–2.5)
Upper airway foreign body removal	7 (8)	30 (36, 26–46)	3.4 (2.4–4.7)
Arthrocentesis	31 (37)	56 (67, 56–76)	1.5 (1.1–2.0)
Chest tube insertion†	47 (55)	59 (69, 59–78)	2.4 (1.6–3.5)
Fracture reduction†	61 (72)	69 (81, 71–88)	2.6 (1.6–4.4)
Joint reduction†	57 (67)	71 (84, 74–90)	1.8 (1.3–2.6)
Regional nerve block	43 (51)	48 (57, 46–67)	3.6 (2.1–6.3)
Arterial line insertion	59 (70)	67 (80, 70–87)	2.4 (1.5–3.9)
Lumbar puncture†	47 (55)	71 (84, 74–90)	1.6 (1.2–2.0)
Procedural sedation†	52 (61)	70 (82, 73–89)	1.5 (1.1–1.9)
Central line insertion (US guided)	48 (57)	63 (75, 65–83)	2.2 (1.5–3.2)
Central line insertion (landmark technique)	38 (45)	57 (68, 57–77)	2.1 (1.5–2.9)
Adult endotracheal intubation	63 (71)	69 (82, 72–89)	2.2 (1.4–3.7)
Adult medical resuscitation	20 (24)	60 (71, 52–75)	1.5 (1.2–1.8)
Adult trauma resuscitation	17 (20)	50 (60, 39–62)	1.9 (1.4–2.4)
Pediatric endotracheal intubation†	23 (27)	42 (49, 39–60)	2.2 (1.5–3.2)
Pediatric medical resuscitation	4 (5)	18 (21, 14–31)	4.0 (1.9–8.3)
Pediatric trauma resuscitation	1 (1)	17 (20, 13–30)	5.2 (3.3–8.1)
FAST†	48 (56)	72 (85, 75–91)	1.4 (1.1–1.7)

FAST = focused assessment with sonography in trauma; US = ultrasonography.
n = 84 for all procedures unless indicated (**n* = 86; †*n* = 86).

trainee experience as a surrogate for competence, the incorporation of well-defined success and failure rates over time enhances their utility.

The concept of procedural skills competence, however, remains complex. In addition to performance experience, there must be knowledge regarding the management of potential complications. For example, complications associated with chest tube insertion and central line placement may have high morbidity.^{26,27} Thus, educators must strive to incorporate the evaluation of such components into the competency assessment. Furthermore, competency evaluation may benefit from assessment under stress as a recent study demonstrated

that some skills are impaired when participants exhibit subjective and physiologic stress responses.²⁸

Although our study did not address these more complex stress responses, we did examine resident-reported comfort in association with procedural experience. Interestingly, residents who met the minimum performance frequency for competence (based on the 70th percentile of program director responses) were significantly more likely to report comfort in performing the procedure. More detailed assessments of comfort levels for various aspects of the procedure may be valuable to educators as they design more learner-focused curricula.

Table 3. Procedures not deemed important by majority of program directors

Emergency department thoracotomy
Extensor tendon repair
Gastric lavage
Compartment pressure measurement
Peripheral venous cut-down
Thoracentesis
Transvenous pacing
Vaginal delivery
Diagnostic peritoneal lavage
Suprapubic bladder catheterization
Nasogastric tube insertion
Escharotomy
Lateral canthotomy
Colonoscopy*

*Included as a control to verify respondents' reading and understanding of each question.

The breadth of procedural skills required in EM will undoubtedly pose challenges for educators and teachers as they incorporate the use of competency-based assessments. The list of procedures required of Canadian Royal College EM residents to achieve competence likely requires reassessment. Several studies outside of EM have sought program director opinions in an effort to define “important” procedures and to better establish a focus for procedural skills curricula.^{19,20} This approach is valuable as program directors are well acquainted with the resident training environment and responsible for resident competence. Our data suggest that nearly 30% of procedures listed in current EM residency training requirements may no longer be important. A comprehensive EM study conducted over 10 years ago sought to redefine the procedure requirements based on opinions of both the EM program director and practicing EM physicians.¹³ The authors concluded that nearly 20% of procedures were deemed unnecessary. Interestingly, several procedures previously considered necessary, including

venous cut-down and diagnostic peritoneal lavage, were not felt to be important in our study. This may be explained, in part, by improved access to advanced imaging and the increase in bedside ultrasonography. EM educators and accreditation bodies must continually reassess the list of essential procedures to ensure that only relevant and important procedures are included residency training requirements.

An important finding in our study was that the majority (> 50%) of senior residents had never performed, and were uncomfortable performing, four important procedures. Although these findings do not directly reflect a lack of competence, both experience and comfort have been associated with procedural competence that requires the participant to “safely prepare for, perform and navigate the complications of a procedure.”¹⁰ Adequate experience and comfort are especially important given that several of these procedures are lifesaving and must be performed without delay. In a recent study that quantified the overall clinical experience of EM residents, several high-risk conditions were never encountered prior to residency completion.²⁹ Similarly, our data suggest that a majority of EM residents will graduate lacking real-time clinical experience in several essential procedures. These findings differed from program director perceptions, which indicated that some clinical experience was required for procedural competence. The identification of rarely performed, high-stakes procedures is critical to ensure that competence is achieved irrespective of real-time clinical opportunities. Consequently, educators must seek alternative venues for training for such procedures that may include task trainers and simulation.

Ultimately, the establishment of procedural competence requires a composite of experience in a variety of settings with acknowledgement that stressors and complications must also be evaluated. As competency-based curricula are integrated into residency programs, objective measures and properly defined learning

Table 4. Experience and comfort reported by senior residents for rarely performed but important procedures

Procedure	% senior residents without experience (n = 23)*	% senior residents not comfortable performing each procedure (n = 22)*
Posterior nasal pack for epistaxis	78	55
Cricothyroidotomy	74	82
Pericardiocentesis	61	73
Paraphimosis reduction	52	59
Intraosseous line insertion	39	50

*The number of respondents differs as each question was not mandatory; senior residents are those in the fourth or fifth year of postgraduate training.

curves are needed to better assess procedural competency. Residency training requirements could include a “number needed to learn”³⁰; however, it remains important to realize that competence is often individualized. Such complexities may require the incorporation of direct observation at intermittent stages of training.³¹

LIMITATIONS

This study has several important limitations. Expert consensus was that of program director opinions who typically work in academic centres. As a result, the relative importance of each procedure may be applicable only for residents who will continue to work in academic centres. There is a clear focus on academic settings in the existing Royal College EM specialty training requirements as residents are mandated to complete only 1 month of EM in a community setting of the 24 months of EM training that are required. The decision to seek expert consensus from academic EM physicians reflects these current Royal College requirements. Notwithstanding, it remains the imperative of program directors to ensure that residents are competent in any emergency department. This study is not unique in surveying program directors regarding resident procedural skills training as they are continually involved in resident evaluation, remediation, and promotion.^{19,20}

The survey included only 45 of nearly 130 procedures outlined for resident competence by the Royal College. We sought to establish current performance frequencies and perceived importance of a range of high- and low-acuity procedures. For example, the Royal College list includes nearly 10 different joint reductions. However, it was our goal to understand general trends of exposure and accessibility to procedures through a pragmatic approach useful in curriculum design. We anticipated that an exhaustive list would reduce resident completion rates. Similar studies involving residents used abbreviated lists of procedures.^{17,22,32}

Instead of free text, intervals were used to provide respondents with some structure and to facilitate survey completion. Potential bias exists in our frequency scale given that unequal intervals were used. However, these intervals were purposefully selected to discriminate frequencies more accurately when procedures were performed less often. In keeping with other technical skill learning curves,³³ significant information would be obtained by establishing how infrequently

some procedures were performed. Similar scales with unequal intervals have been used previously in procedural skill studies.^{13,34}

Respondents were not asked to provide any information regarding their program or training site. Given Canada’s relatively small number of EM residency programs, details regarding hospital size and patient volume may have allowed for program identification. The decision to omit this information was purposeful in an effort to maintain anonymity and gain support from program directors.

Finally, our response rate from residents was low despite multiple reminders and support from all program directors. Despite this, our sample represents the expected range of gender and level of training, except for the number of PGY2 residents (15%) compared to the national distribution (29%). Most Canadian EM residency programs consist of less than 20 residents.

CONCLUSIONS

We report a needs assessment of Royal College of Physicians and Surgeons EM residents and program directors regarding procedural experience and competence. These data will guide future research for the procedures component of a competency-based curriculum. Program director opinion identified the minimum procedure performance frequency to achieve competence and re-evaluated the importance of a variety of EM procedures. Several procedures no longer deemed important by program directors serve as a reminder that frequent curriculum evaluations are required to ensure that resident training addresses only relevant and essential procedures. Finally, we identified four essential EM procedures that had never been performed by the majority of senior residents despite program director perceptions of a minimum procedural performance required for competence. As competency-based medical education is incorporated in residency training, improved metrics must be implemented to ensure competence in procedural skills.

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REFERENCES

1. Epstein RM. Assessment in medical education. *N Engl J Med* 2007;356:387-96, doi:10.1056/NEJMe078002.

2. Bancroft GN, Basu CB, Leong M, et al. Outcome-based residency education: teaching and evaluating the core competencies in plastic surgery. *Plast Reconstr Surg* 2008; 121:441e-8e, doi:10.1097/PRS.0b013e318170a778.
3. Shah VA, Reddy AK, Bonham AJ, et al. Resident surgical practice patterns for vitreoretinal surgery in ophthalmic training programs in the United States. *Ophthalmology* 2009; 116:783-9, doi:10.1016/j.ophtha.2008.11.010.
4. Sherbino J, Bandiera G, Frank JR. Assessing competence in emergency medicine trainees: an overview of effective methodologies. *CJEM* 2008;10:365-71.
5. Goroll AH, Sirio C, Duffy FD, et al. A new model for accreditation of residency programs in internal medicine. *Ann Intern Med* 2004;140:902-9.
6. Reznick RK, MacRae H. Teaching surgical skills—changes in the wind. *N Engl J Med* 2006;355:2664-9, doi:10.1056/NEJMr054785.
7. Leape LL, Brennan TA, Laird N, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *N Engl J Med* 1991; 324:377-84, doi:10.1056/NEJM199102073240605.
8. Nettleman MD, Bock MJ, Nelson AP, et al. Impact of procedure-related complications on patient outcome on a general medicine service. *J Gen Intern Med* 1994;9:66-70, doi:10.1007/BF02600202.
9. Dijksterhuis MG, Voorhuis M, Teunissen PW, et al. Assessment of competence and progressive independence in postgraduate clinical training. *Med Educ* 2009;43:1156-65, doi:10.1111/j.1365-2923.2009.03509.x.
10. Mourad M, Kohlwes J, Maselli J, et al. Supervising the supervisors—procedural training and supervision in internal medicine residency. *J Gen Intern Med* 2010;25:351-6, doi:10.1007/s11606-009-1226-z.
11. Thomas HA, Beeson MS, Binder LS, et al. The 2005 Model of the Clinical Practice of Emergency Medicine: the 2007 update. *Acad Emerg Med* 2008;15:776-9, doi:10.1111/j.1553-2712.2008.00194.x.
12. Royal College of Physicians and Surgeons. *Objectives of training in emergency medicine*. Ottawa: Royal College of Physicians and Surgeons; 2008.
13. Farion K, Morrison LJ. Redefining emergency medicine procedures: Canadian competence and frequency survey. *Acad Emerg Med* 2001;8:731-8, doi:10.1111/j.1553-2712.2001.tb00193.x.
14. Dire DJ, Kietzman LI. A prospective survey of procedures performed by emergency medicine residents during a 36-month residency. *J Emerg Med* 1995;13:831-7, doi:10.1016/0736-4679(95)02012-8.
15. Langdorf MI, Montague BJ, Bearie B, et al. Quantification of procedures and resuscitations in an emergency medicine residency. *J Emerg Med* 1998;16:121-7, doi:10.1016/S0736-4679(97)00252-7.
16. Hayden SR, Panacek EA. Procedural competency in emergency medicine: the current range of resident experience. *Acad Emerg Med* 1999;6:728-35, doi:10.1111/j.1553-2712.1999.tb00444.x.
17. Al-Eissa M, Chu S, Lynch T, et al. Self-reported experience and competence in core procedures among Canadian pediatric emergency medicine fellowship trainees. *CJEM* 2008;10:533-8.
18. Accreditation Council for Graduate Medical Education. *Emergency medicine guidelines - procedures and resuscitations*. Available at: <http://www.acgme.org/acgmeweb/tabid/292/ProgramandInstitutionalGuidelines/Hospital-BasedAccreditation/EmergencyMedicine/EmergencyMedicineGuidelines.aspx> (accessed February 14, 2013).
19. Gaies MG, Landrigan CP, Hafler JP, et al. Assessing procedural skills training in pediatric residency programs. *Pediatrics* 2007;120:715-22, doi:10.1542/peds.2007-0325.
20. Wigton RS, Blank LL, Nicolas JA, et al. Procedural skills training in internal medicine residencies. A survey of program directors. *Ann Intern Med* 1989;111:932-8.
21. Dillman DA. *Mail and Internet surveys: the tailored design method*. New York: John Wiley & Sons; 2000.
22. Huang GC, Smith CC, Gordon CE, et al. Beyond the comfort zone: residents assess their comfort performing inpatient medical procedures. *Am J Med* 2006;119:71 e17-24, doi:10.1016/j.amjmed.2005.08.007.
23. Naik VN, Devito I, Halpern SH. Cusum analysis is a useful tool to assess resident proficiency at insertion of labour epidurals. *Can J Anaesth* 2003;50:694-8, doi:10.1007/BF03018712.
24. Spier BJ, Benson M, Pfau PR, et al. Colonoscopy training in gastroenterology fellowships: determining competence. *Gastrointest Endosc* 2010;71:319-24, doi:10.1016/j.gie.2009.05.012.
25. Zevin B, Aggarwal R, Grantcharov TP. Simulation-based training and learning curves in laparoscopic Roux-en-Y gastric bypass. *Br J Surg* 2012;99:887-95, doi:10.1002/bjs.8748.
26. Ball CG, Lord J, Laupland KB, et al. Chest tube complications: how well are we training our residents? *Can J Surg* 2007;50:450-8.
27. Leung J, Duffy M, Finckh A. Real-time ultrasonographically-guided internal jugular vein catheterization in the emergency department increases success rates and reduces complications: a randomized, prospective study. *Ann Emerg Med* 2006; 48:540-7, doi:10.1016/j.annemergmed.2006.01.011.
28. Harvey A, Bandiera G, Nathens AB, et al. Impact of stress on resident performance in simulated trauma scenarios. *J Trauma* 2012;72:497-503.
29. Tintinalli JE, Shofer F, Biese K, et al. Toward a new paradigm: goal-based residency training. *Acad Emerg Med* 2011;18 Suppl 2:S71-8.
30. Luyet C, Schupfer G, Wipfli M, et al. Different learning curves for axillary brachial plexus block: ultrasound guidance versus nerve stimulation. *Anesthesiol Res Pract* 2010;2010: 309462. Epub 2011 Jan 20.
31. McLeod R, Mires G, Ker J. Direct observed procedural skills assessment in the undergraduate setting. *Clin Teach* 2012;9:228-32, doi:10.1111/j.1743-498X.2012.00582.x.
32. Druck J, Valley MA, Lowenstein SR. Procedural skills training during emergency medicine residency: are we teaching the right things? *West J Emerg Med* 2009;10:152-6.
33. Baciarello M, Zasa M, Manferdini ME, et al. The learning curve for laryngoscopy: Airtraq versus Macintosh laryngoscopes. *J Anesth* 2012 Feb 21. [Epub ahead of print]
34. Reeder TJ, Brown CK, Norris DL. Managing the difficult airway: a survey of residency directors and a call for change. *J Emerg Med* 2005;28:473-8, doi:10.1016/j.jemermed.2004.11.027.