ORIGINAL RESEARCH

Triage of Mechanical Ventilation for Pediatric Patients During a Pandemic

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ABSTRACT

Objective: The novel H1N1 influenza pandemic renewed the concern that during a severe pandemic illness, critical care and mechanical ventilation resources will be inadequate to meet the needs of patients. Several published protocols address the need to triage patients for access to ventilator resources. However, to our knowledge, none of these has addressed the pediatric populations.

Methods: We used a systematic review of the pediatric critical care literature to evaluate pediatric critical care prognosis and multisystem organ failure scoring systems. We used multiple search engines, including MEDLINE and EMBASE, using a search for terms and key words including including *multiple organ failure, multiple organ dysfunction, PELOD, PRISM III, pediatric risk of mortality score, pediatric logistic organ dysfunction, pediatric index of mortality pediatric multiple organ dysfunction score, "child+ multiple organ failure + scoring system."* Searches were conducted in the period January 2010-February 2010.

Results: Of the 69 papers reviewed, 22 were used. Five independently derived scoring systems were evaluated for use in a respiratory pandemic ventilator triage protocol. The Pediatric Logistic Organ Dysfunction (PELOD) scoring system was the most appropriate for use in such a triage protocol.

Conclusions: We present a pediatric-specific ventilator triage protocol using the PELOD scoring system to complement the NY State adult triage protocol. Further evaluation of pediatric scoring systems is imperative to ensure appropriate triage of pediatric patients.

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Key Words: pediatrics, pediatric intensive care units, triage, multiple organ failure, disaster planning, human influenza

The recent novel H1N1 influenza pandemic has once again raised the concern that during a severe pandemic respiratory illness, critical care (intensive care unit, ICU) and mechanical ventilation resources will be inadequate to meet the needs of patients. Fortunately, ventilator and ICU resources were not universally strained during the 2009 pandemic; however, shortages of isolation masks, vaccine doses, and other supplies led to rationing in several centers.

Several protocols for initial and ongoing triage of adult patients to critical care units or mechanical ventilator use during a pandemic respiratory illness have been published.[1,2] After the severe acute respiratory distress syndrome (SARS) epidemic in Toronto, Canada, Christian and colleagues[3] proposed a triage system for ventilator access based on preexisting health status and Sequential Organ Failure Assessment (SOFA) scores. The NY Department of Health was the first US governmental body to issue a proposed triage system for ventilator access during a pandemic influenza event.[4] This system is similar to the Toronto proposal[3] but has fewer exclusion criteria. Recent studies evaluating the performance of Toronto guidelines, as applied to retrospective patient populations,[5-7] have shown that these guidelines have overpredicted mortality. They have also shown that some patients who may have a significant chance of survival would be erroneously assigned to the "expectant management" category. The NY guidelines[4] use less stringent exclusion criteria and may assign fewer patients to the expectant category.

None of the triage criteria designed for infectious disease disasters has included pediatric-specific recommendations. As the 2009 pandemic showed, respiratory illnesses do not spare, and may even disproportionately affect, children under the age of 18 years. Children differ significantly from adults in their physiologic and pathologic responses to respiratory disease. Triage systems derived using only adult-based criteria are clearly inappropriate for young children and may be inappropriate for adolescents. A recent review of the ethics literature addressing pediatric triage suggests that exclusion criteria appropriate for adults may not be appropriate for pediatric patients.[8] The Utah Department of Health has proposed pediatric inclusion/exclusion criteria based on expert opinion, and uses a clinical judgment component during ongoing triage (www.uha-utah.org, accessed Oct 1, 2010). Kanter and Cooper[9] highlighted the need for pediatric-specific triage.

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We performed a systematic review of the pediatric literature to evaluate possible pediatric critical care prognostic scoring systems for use in triage guidelines for children. Based on the findings of this review, we propose a modification of the NY adult ventilator triage guidelines,[4] using appropriate pediatric criteria. Thus, we present a comprehensive triage system for all patients regardless of age. The results of the review and our proposed triage classification guidelines are presented here.

METHODS

We used multiple search engines including MEDLINE and EMBASE, using a search for terms and key words including *multiple organ failure, multiple organ dysfunction, PELOD, PRISM III, pediatric risk of mortality score, pediatric logistic organ dysfunction, pediatric index of mortality pediatric multiple organ dysfunction score, "child+multiple organ failure + scoring system."* Limits on the searches included English language and patients younger than18 years of age. Other references were obtained by reviewing all reference bibliographies of the articles selected by the searches.

Searches were conducted in the period January 2010-February 2010 by one of us (K.M.K.). All references were evaluated for inclusion into the study by reading their abstracts. Articles were included in the evaluation if they described scoring systems for pediatric mortality or illness prediction in critically ill patients and if they had reasonably large validation and development populations (more than 20 patients for each population). Articles containing subsequent validations, applications, and comparisons of different scoring systems were also included. A report was excluded if it used the scoring system only to describe severity of illness in a particular cohort of patients rather than validating the scoring system. Articles were excluded if they examined only narrow diagnosis mortality (ie, postoperative cardiac mortality) rather than a more general population of critical care patients, with one exception. Reports looking at sepsis as a proxy model for patients with multiple organ failure were included, as sepsis is a general final pathway for many pediatric critical care patients.

We reviewed the final set of articles with a focus on which prognostic score would be most appropriate for use in a triage tool for pediatric patients during a respiratory pandemic. Several requirements must be met to have parity with the adult triage tools. First, because this score may be used to deny access to lifesaving care, the scoring system should be designed using a large population and be validated in multiple institutions. Second, the score should be easy and fast to calculate, as scores will be needed for all presenting patients and staff resources will be limited during a pandemic. For the same reason, the scoring system should use minimal radiology or laboratory resources. Third, as the adult triage tools require a re-assessment of patient improvement as a requirement for continued resource use, the scoring system must be able to follow the progress of the patient throughout the course of the illness as well as on presentation. The scoring systems found in our review were then evaluated to determine if they met these criteria. The most appropriate of the systems was used to modify the NY guidelines to be appropriate for pediatric patients. As patient information was not used either prospectively or retrospectively, no institutional review board approval was needed.

RESULTS

The initial search resulted in 69 separate references with publication dates from 1988-2010. Articles that met the stipulated requirements (22) were reviewed in full (K.M.K. and M.M.L.) (Table 1). The search revealed eight scoring systems, of which five were independently derived. All scoring systems were pediatric-specific and include Pediatric Logistic Organ Dysfunction (PELOD) score,[10,11] Pediatric Risk of Mortality Score (PRISM),[12] PRISM-III,[13] PRISM-III–Acute Physiology Score (PRISM-III-APS),[14] Pediatric Index of Mortality (PIM),[15] PIM-2,[16] Pediatric Multiple Organ Dysfunction Score (P-MODS),[17] and Signs of Inflammation in Children that can Kill (SICK).[18,19]

Several recent articles have compared the use of different scoring systems for description of multiorgan failure in pediatric populations. These articles were included in the review and were used to inform the choice of scoring system. The report from the 2002 International Pediatric Sepsis Consensus conference[20] reviewed the existing organ dysfunction scoring systems that could be used to track changes in organ function. They concluded that no single system was perfect but that the PELOD score was the only multicenter validated scoring system. Kanter and Cooper[9] reviewed several scoring systems for use in initial triage and determined that PIM-2 would be suitable for *initial* triage of pediatric patients. Lacroix and Cotting[21] reviewed the predictive scoring systems and descriptive scoring systems available to describe pediatric multiorgan dysfunction. The authors concluded that while PIM-2 and PRISM-III are both applicable for predicting mortality from initial presentation, only PELOD is validated to quantify severity of illness throughout the patient's progress. Dominguez and Huh[22] compared the P-MODS and PELOD scoring systems and concluded that the PELOD scoring system had the advantage of including neurologic impairment and had a broader validation population. PELOD was slightly better at predicting mortality than P-MODS. Table 2 describes the scoring system, development and validation populations, advantages, and disadvantages of each system for use in triage during a respiratory pandemic.

COMMENT

Of the possible scoring systems applicable for the generalized pediatric critical care population, the only score that fulfills all criteria required for use in modifying the NY state triage tool[4] is the PELOD score.[10,11] Although PIM-2 is easy to calculate and can be determined at initial presentation, it does not follow the patient course or allow interval calculation. Table 3 evaluates the criteria for each scoring system.

The PELOD score was developed and validated using a multicenter, international design and has been validated in inter-

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national studies.[10,11,19] It has not been validated in the US population but has been evaluated in Canadian ICU studies. It is easily calculated and is in the public domain, making it useable even in community hospitals with a small pediatric population. Drawbacks to the PELOD score include the fact that it requires laboratory values including arterial blood gases, alanine aminotransferase/aspartate aminotransferase, prothrombin time, creatinine, and complete blood cell count. It was designed and tested in 1999; the field of pediatric critical care medicine has improved during the past 10 years and thus PELOD scores may overpredict mortality. A recent external validation study[19] showed that PELOD both overpredicted mortality and cannot distinguish predicted mortality in the range of 40% to 80% due to the discontinuous scoring system. These findings become an issue when comparing pediatric to adult patients, as the concern is that the mortality predicted by PELOD is too high compared with that of the SOFA scoring system. However, even with these limitations, the PELOD score is the best multiorgan failure prediction tool for ongoing triage of limited resources.

At this time, our recommendation is to base the pediatric triage ventilator guidelines on the PELOD scoring system.[10,11] Table 4 shows the PELOD scoring system.

We suggest matching the pediatric triage level for mortality with the adult SOFA mortality scoring to allow parity of triage guidelines for pediatric and adult patients. The calculation for determining predicted likelihood of mortality from PELOD scores is:

$$P = \frac{1}{1 + \exp(7.64 - 0.3 \times \text{PELOD score})}$$

The PELOD scores are a discontinuous measure, and several intervals of predicted mortality are not calculable (40%-80%). To use the PELOD scoring system on a daily basis, the daily score is calculated in the same fashion as it is calculated at the initial presentation. If new data are not available (ie, new laboratory values) the value can either be assumed to be unchanged or normal, depending on the physician's clinical judgment.

The NY triage tool[4] uses SOFA score cutoff points of less than 11 (predicted mortality of >90%)[24] and 7 or less (predicted mortality of <20%). To match the predicted mortality of greater than 90% at a SOFA score greater than 11,[24] we suggest using a PELOD score of 33. This score is a compromise of the predicted mortality of 100% using the development population of critical care patients in 1999 and using the recent validation study from South America,[19] which suggests that the actual mortality at a PELOD score of 33 is 90.6%. Likewise, a PELOD score of less than 21 has a predicted mortality of less than 20%, which is on par with a SOFA score of less than 8. The predicted mortality, as from the initial PELOD model,[10,11] and the recent validation[19] are both less than 20% at the PELOD score of 21, and no modification is needed.

TABLE 1

Articles Included in Systematic Review

Bhal S, Tygai V, Kumar N, et al. Signs of inflammation in children that can kill (SICK score): Preliminary prospective validation of a new non-invasive measure of severity-of-illness. *J Postgrad Med* 2006; 52(2):102-105.

Dominguez TE and Huh JW. Do we need another pediatric severity of illness score? *Crit Care Med*. 2005;33(7):1643-1645.

Garcia PC and Piva JP. Pediatric index of mortality 2 (PIM2)–A prognostic tool for developing countries: Easy, efficient, and free! *Pediatr Crit Care Med*. 2007;8(1):77-78.

Garcia PC, Eulmesekian P, Branco RG, et al. External validation of the pediatric logistic organ dysfunction score. *Intensive Care Med*. 2010; 36(1):116-122.

Goldstein B, Giroir B, Randolph A, and the members of the International Consensus Conference on Pediatric Sepsis. International pediatric sepsis consensus conference: Definitions for sepsis and organ dysfunction in pediatrics. *Pediatr Crit Care Med*. 2005;6(1):1.

Graciano AL, Balko JA, Rahn DS, Ahmad N, Giroir BP. The pediatric multiple organ dysfunction score (P-MODS): Development and validation of an objective scale to measure the severity of multiple organ dysfunction in critically ill children. *Crit Care Med*. 2005;33(7):1484-1491.

Kanter RK and Cooper A. Mass critical care: Pediatric considerations in extending and rationing care in public health emergencies. *Disaster Medicine & Public Health Preparedness*. 2009; 3(suppl 2):S166-171.

Kumar N, Thomas N, Singhal D, et al. Triage score for severity of illness. *Indian Pediatr*. 2003;40:204-210.

Lacroix J. Cotting J. for the Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network. 2005. Severity of illness and organ dysfunction scoring in children. *Pediatr Crit Care Med*. 2005; 6(3 suppl):S126-134.

Leteurtre S, Martinot A, Duhamel A. Erratum: Validation of the pediatric logistic organ dysfunction (PELOD) score: Prospective, observational, multicenter study (*Lancet* (2003) 362 (192-197)). *Lancet*. 2006;367(9514):902.

Leteurtre S, Duhamel A, Grandbastien B, et al. Paediatric logistic organ dysfunction (PELOD) score. *Lancet*. 2006; 367 (9514):897.

Leteurtre S, Leclerc F, Martinot A, et al. Can generic scores (pediatric risk of mortality and pediatric index of mortality) replace specific scores in predicting the outcome of presumed meningococcal septic shock in children? *Crit Care Med*. 2001;29(6):1239-1246.

Leteurtre S, Martinot A, Duhamel A, et al. Development of a pediatric multiple organ dysfunction score: Use of two strategies. *Medical Decision Making*. 1999;19(4):399-410.

Leteurtre S, Martinot A, Duhamel A, et al. Validation of the pediatric logistic organ dysfunction (PELOD) score: Prospective, observational, multicenter study.[erratum appears in *Lancet*. 2006 mar 18;367 (9514):897; author reply 900-2; PMID: 16546531]. *Lancet*. 2003;362(9379):192-197.

Pollack MM, Patel KM, Ruttimann UE. The pediatric risk of mortality III–acute physiology score (PRISM III-APS): A method of assessing physiologic instability for pediatric intensive care unit patients. *J Pediatr*. 1997;131(4):575-581.

Pollack MM, Patel KM, Ruttimann UE. PRISM III: An updated pediatric risk of mortality score. *Crit Care Med*. 1996;24(5):743-752.

Pollack MM, Ruttimann UE, Getson PR. Pediatric risk of mortality (PRISM) score. *Crit Care Med*. 1998;16(11):1110-1116.

Randolph AG. Paediatric index of mortality (PIM): Do we need another pediatric mortality prediction score? *Intensive Care Med*. 1997;23:141-142.

Shann F, Pearson G, Slater A, Wilkinson K. Paediatric index of mortality (PIM): A mortality prediction model of children in intensive care. *Intensive Care Med*. 1997;23:201-207.

Slater A, Shann F, Pearson G, for the PIM Study Group. PIM2: A revised version of the pediatric index of mortality. *Intensive Care Med*. 2003; 29:278-285.

Tibby SM. Does PELOD measure organ dysfunction . . . and is organ function a valid surrogate for death? *Intensive Care Med*. 2009;1-4.

Typpo KV, Petersen NJ, Hallman DM, et al. Day 1 multiple organ dysfunction syndrome is associated with poor functional outcome and mortality in the pediatric intensive care unit. *Pediatr Crit Care Med*. 2009;10(5):562-570.

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We propose a pediatric triage system for access to ventilators or ICU level care that mirrors the NY guidelines.[4] We would use the same exclusion criteria proposed in the guidelines, with the modification of using a PELOD score less than 33 as a substitute for the SOFA score of less than 11. Appropriateness of these criteria for pediatric patients must be addressed in future

TABLE 2

Possible Pediatric Scoring Systems for Use in Triage Assignment

Name	Description	Variables Used	Advantages	Drawbacks
PELOD[10,11]	Logistic regression model of organ dysfunction; can be used initially and daily to predict mortality	SBP, HR GCS, pupil reaction Prothrombin time WBC, platelets Creatinine Bilirubin,SGOT Pa co_2, Pa o_2/F IO_2 ratio	Simple to calculate Can be used to follow patient course Multiple PICU development/ validation	Multiple data points Overprediction of mortality Score is not continuous
PRISM[12]	Logistic regression model; uses worst scores for first 24 h to predict mortality			Proprietary Cannot be used to follow patient course
PRISM- III[13]	Proprietary logistic regression model; use either initial 12 h or 24 h worst scores for prediction of mortality	SBP, HR Temperature GCS, pupil reaction Creatinine, BUN WBC, platelets pH, P CO_2,Pa O_2 Acidosis Glucose CO_2, K Other factors[a] PT or PTT	Multiple PICU development/ validation	Proprietary; requires purchase to use Significant data collection burden Cannot be used to follow patient course
PRISM- III-APS[14]	Logistic regression model that predicts physiologic state; not appropriate for prediction of mortality	SBP, DBP, HR Temperature GCS, pupil reaction, WBC, Plt, Hgb BUN, creatinine pH, P CO_2, Pa O_2, CO_2, glucose, K, Ca, Na PT, PTT	Multiple PICU development/ validation Looks for illness severity	Uses only first 24 h of data 21 variables
P-MODS[17]	Uses varying levels of organ dysfunction to predict mortality; uses worst score for each PICU stay	Lactic acid Pa O_2/ F IO_2 ratio Total bilirubin Fibrinogen BUN	Simple to use Accounts for varying levels of organ dysfunction Does not include neurologic system	Cannot be used to follow patient course Single-center development and validation
PIM 2[15,16]	Revised version of PIM; logistic regression model to predict mortality from initial evaluation; uses value at presentation to PICU for each variable	SBP-120 mm Hg Pupil reaction Absolute base excess F IO_2/Pa O_2 ratio Ventilation Elective admission? Postop recovery admission H/O cardiac bypass High-risk/low-risk diagnosis[b]	Uses minimal laboratory data Simple to use Developed and validated in multiple ICU's in several countries Recently revised	Cannot be used to follow patient course Not applicable to pandemic conditions (nonemergent and elective surgeries will likely be canceled)
SICK[18,23]	Severity of illness score using multiple logistic regression to predict mortality; developed in India	Temperature HR Respiratory rate SBP Sp O_2 Capillary refill time AVPU score	Uses no laboratory data Uses only physical variables	Not validated outside of development population Cannot be used to follow patient course

Abbreviations: PELOD, Pediatric Logistic Organ Dysfunction; PRISM, Pediatric Risk of Mortality Score; P-MODS, Pediatric Multiple Organ Dysfunction Score; PIM, Pediatric Index of Mortality; SICK, Signs of Inflammation in Children that can Kill; SBP, systolic blood pressure; HR, heart rate; GCS, Glasgow coma scale; WBC, white blood cell; SGOT, aspartate aminotransferase; Pa CO_2, partial pressure of carbon dioxide, arterial; Pa O_2/F IO_2, partial pressure of oxygen, arterial/fraction of inspired oxygen; PICU, pediatric intensive care unit; BUN, serum urea nitrogen; K, potassium; PT, prothrombin time; PTT, partial throboplastin time; DBP, diastolic blood pressure; plt, platelets; Hbg, hemoglobin; Ca, calcium; Na, sodium; H/O, hydrogen/oxygen; Sp O_2, saturation of peripheral oxygen; AVPU, alert, responding to voice, responding to pain, unconscious.

[a] Other factors include nonoperative cardiovascular disease, chromosomal anomaly, cancer, previous PICU admission, pre-ICU cardiopulmonary resuscitation, postoperative acute diabetes, admission from inpatient unit (not postoperative).

[b] High-risk diagnosis: in-hospital cardiac arrest, liver failure; low-risk diagnosis: asthma, bronchiolitis, croup, obstructive sleep apnea, diabetic ketoacidosis.

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studies. We consider a similar four-category triage system using the same categories of Blue—expectant/palliative care only, Red—highest priority for scarce critical care resources, Yellow—intermediate priority for critical care resources, and Green—discharge from critical care (no significant organ failure). We also use a re-assessment of the patient's condition at 48 and 120 hours to ensure that patients demonstrate improvement with use of the resource. Lack of improvement may require re-assignment of the ventilator or other resource to other patients who are at higher priority for the resource. The triage decision tool for pediatric patients is detailed in the Figure.

We acknowledge the significant limitations to the proposed pediatric triage tool presented here. All of the scoring systems described were developed to predict the likely prognosis for a cohort rather than individual patients. As with any mass disaster protocol, it is impossible to fully test or validate the tool except by simulation until the disaster happens. Several recent reports have shown that the performance of the adult triage tools using retrospective studies may inappropriately triage patients.[5-7] The ease of implementation can be approximated but

TABLE 3

Evaluation of Scoring Systems for Triage Tool Use

Scoring System	Calculate at Presentation?	Follow Patient Course?	Multicenter Validation?	Simple to Calculate?
PELOD[10,11]	Yes	Yes	Yes	Yes
PRISM[12]	No	No	Yes	No
PRISM-III[13]	No	No	Yes	No
P-MODS[17]	No	No	Yes	Yes
PIM 2[15,16]	Yes	No	Yes	Yes
SICK[18,23]	Yes	No	No	Yes

Abbreviations: PELOD, Pediatric Logistic Organ Dysfunction; PRISM, Pediatric Risk of Mortality Score; P-MODS, Pediatric Multiple Organ Dysfunction Score; PIM, Pediatric Index of Mortality; SICK, Signs of Inflammation in Children that can Kill.

TABLE 4

PELOD Scoring System[11]

Organ System	Variable	Score 0	Score 1	Score 10	Score 20	Maximum System Score
Neurologic						20
	Glasgow coma score	12-15	7-11	4-6	3	
		AND		OR		
	Papillary reaction	Both reactive		Both fixed		
Cardiovascular						20
	Heart rate					
	<12 y	≤195 bpm		>195 bpm		
	>12 y	≤150 bpm		>150 bpm		
		AND		OR		
	Systolic blood pressure					
	<1 mo	>65 mm Hg		35-65 mm Hg	<35 mm Hg	
	≥1mo &<1y	>75 mm Hg		35-75 mm Hg	<35 mm Hg	
	≥1 y &<12 y	>85 mm Hg		45-85 mm Hg	<45 mm Hg	
	≥12 y	>95 mm Hg		55-95 mm Hg	<55 mm Hg	
Renal						10
	Creatinine					
	<7d	<1.59 mg/dL		≥1.59 mg/dL		
	≥7 d &<1 y	<0.62 mg/dL		≥0.62 mg/dL		
	≥1 y &<12 y	<1.13 mg/dL		≥1.13 mg/dL		
	≥12 y	<1.59 mg/dL		≥1.59 mg/dL		
Pulmonary						10
	Pa o_2/F IO_2 ratio	>70 mm Hg		≤70 mm Hg		
		AND		OR		
	Pa co_2	≤90 mm Hg		>90 mm Hg		
		AND				
	Mechanical vent	No	Yes			
Hematologic						10
	WBC	≥4.5K	1.5-4.4 K	<1.5		
		AND	OR			
	Platelets	≥35 K	<35			
Hepatic						1
	AST	<950 IU/L	≥950 IU/L			
		AND				
	Prothrombin time	>60%	≤60%			

Abbreviations: PELOD, Pediatric Logistic Organ Dysfunction; bpm, blood pressure monitor; Pa o_2/F IO_2, partial pressure of oxygen, arterial/fraction of inspired oxygen; Pa co_2, partial pressure of carbon dioxide, arterial; WBC, white blood cells; AST, aspartate aminotransferase.

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FIGURE

Critical Care Triage Tool – Pediatric Patients (<18 y) (Top), and Exclusion Criteria (Bottom).

	Initial Assessment		48-h Assessment		120-h Assessment	
Color Code	Criteria	Priority/Action	Criteria	Priority/Action	Criteria	Priority/Action
Blue	Exclusion criteria or PELOD ≥33	Medical management +/- palliate & discharge from critical care	Exclusion criteria or PELOD >33 or PELOD 21-33 & no change	Palliate & discharge from critical care	Exclusion criteria or PELOD >33 or PELOD 21-33 and no change	Palliate & discharge from critical care
Red	PELOD ≤ 21 or Single organ failure	Highest	PELOD <33 and decreasing	Highest	PELOD <33 and decreasing progressively	Highest
Yellow	PELOD 21-33	Intermediate	PELOD <21 no change	Intermediate	PELOD <21 minimal decrease (<3-point decrease in past 72 h)	Intermediate
Green	No significant organ failure	Defer or discharge, reassess as needed	No longer ventilator dependent	Discharge from critical care	No longer ventilator dependent	Discharge from critical care

Exclusion Criteria	
Patient is excluded from admission or transfer to critical care if *any* of the following is present:	
A	Severe trauma
B	Severe burns of patient with any 2 of the following: • Age > 60 y • > 40% of total body surface area affected • Inhalation injury
C	Cardiac arrest • Unwitnessed cardiac arrest • Witnessed cardiac arrest, not responsive to electrical therapy (defibrillation or pacing) • Recurrent cardiac arrest
D	Metastatic malignant disease with poor prognosis
E	Advanced and irreversible immunocompromise
F	Severe and irreversible neurologic event or condition with highly expected mortality
G	End-stage organ failure meeting the following criteria: *Heart* • NYHA class III or IV heart failure *Lungs* • Severe chronic lung disease with FEV_1 <25% predicted, baseline Pao_2 <55 mm Hg, or secondary pulmonary hypertension • Previously diagnosed primary pulmonary hypertension with NYHA class III or IV heart failure, or mean pulmonary arterial pressure >50 mm Hg *Liver* • Child-Pugh score 7 or MELD score of >20

NYHA, New York Heart Association; FEV_1 forced expiratory volume in the first second of expiration; MELD, model for end-stage liver disease.

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cannot be fully tested under the controlled case of a time-limited simulation. Christian et al[5] showed that for providers not involved in the development of the Toronto[3] triage tool, there may be significant inter-rater variability. We are also concerned that the significant progress and improvements in pediatric critical care during the past 10 years may lead to the PELOD scores being an overestimation of mortality risk for pediatric patients, which may put them in higher jeopardy when compared with adult patients using a SOFA scoring system. Several recent reports have shown that the performance of the adult triage tools using retrospective studies may inappropriately triage patients.[5-7] Some recent evidence has shown that the Toronto[3] triage guidelines may overestimate mortality for the excluded or expectant (Blue) group and poorly discriminate between patients who should be in the Red vs Yellow group.[6] We believe that we have somewhat ameliorated this aspect by using the adjusted limit of PELOD = 33 in keeping with the most recent PELOD validation study.[19] We believe that extensive testing of our proposed pediatric tool using existing PICU patient groups concurrently with adult patient triage tools is needed to ensure accurate and fair triage for adult and pediatric patients.

CONCLUSIONS

After an extensive search of the literature, we found eight pediatric multiorgan dysfunction scoring systems. Of these, the one most amenable to use as a ventilator triage tool for pediatric patients during a respiratory pandemic is the PELOD score system. We have proposed a pediatric-specific triage protocol that may be implemented in parallel with the NY state triage protocol for adults[4] so that pediatric and adult patients can be triaged for ventilator or critical care resources with parity during an epidemic. Further evaluation of this tool for both adults and children must be undertaken in the future to ensure an ethical distribution of critical resources. Re-evaluation and improvement in pediatric critical care prognostic scoring systems is also needed to provide accurate estimates of mortality in pediatric patients.

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REFERENCES

1. Hick JL, O'Laughlin DT. Concept of operations for triage of mechanical ventilation in an epidemic. *Acad Emerg Med.* 2006;13(2):223-229.
2. Talmor D, Jones AE, Rubinson L, Howell MD, Shapiro NI. Simple triage scoring system predicting death and the need for critical care resources for use during epidemics. *Crit Care Med.* 2007;35(5):1251-1256.
3. Christian MD, Hawryluck L, Wax RS, et al. Development of a triage protocol for critical care during an influenza pandemic. *CMAJ.* 2006;175 (11):1377-1381.
4. Powell T, Christ KC, Birkhead GS. Allocation of ventilators in a public health disaster. *Disaster Med Public Health Prep.* 2008;2(1):20-26.
5. Christian MD, Hamielec C, Lazar NM, et al. A retrospective cohort pilot study to evaluate a triage tool for use in a pandemic. *Crit Care.* 2009; 13(5):R170.
6. Guest T, Tantam G, Donlin N, Tantam K, McMillan H, Tillyard A. An observational cohort study of triage for critical care provision during pandemic influenza: "clipboard physicians" or "evidenced based medicine"? *Anaesthesia.* 2009;64(11):1199-1206.
7. Khan Z, Hulme J, Sherwood N. An assessment of the validity of SOFA score based triage in H1N1 critically ill patients during an influenza pandemic. *Anaesthesia.* 2009;64(12):1283-1288.
8. Antommaria AH, Sweney J, Poss WB. Critical appraisal of: triaging pediatric critical care resources during a pandemic: ethical and medical considerations. *Pediatr Crit Care Med.* 2010;11(3):396-400.
9. Kanter RK, Cooper A. Mass critical care: pediatric considerations in extending and rationing care in public health emergencies. *Disaster Med Public Health Prep.* 2009;3(suppl 2):S166-S171.
10. Leteurtre S, Duhamel A, Grandbastien B, Lacroix J, Leclerc F. Paediatric logistic organ dysfunction (PELOD) score. *Lancet.* March 18, 2006; 367 (9514):897, author reply 900-902.
11. Leteurtre S, Martinot A, Duhamel A, et al. Development of a pediatric multiple organ dysfunction score: use of two strategies. *Med Decis Making.* 1999;19(4):399-410.
12. Pollack MM, Ruttimann UE, Getson PR. Pediatric risk of mortality (PRISM) score. *Crit Care Med.* 1988;16(11):1110-1116.
13. Pollack MM, Patel KM, Ruttimann UE. PRISM III: an updated pediatric risk of mortality score. *Crit Care Med.* 1996;24(5):743-752.
14. Pollack MM, Patel KM, Ruttimann UE. The Pediatric Risk of Mortality III--Acute Physiology Score (PRISM III-APS): a method of assessing physiologic instability for pediatric intensive care unit patients. *J Pediatr.* 1997; 131(4):575-581.
15. Shann F, Pearson G, Slater A, Wilkinson K. Paediatric index of mortality (PIM): a mortality prediction model for children in intensive care. *Intensive Care Med.* 1997;23(2):201-207.
16. Slater A, Shann F, Pearson G; Paediatric Index of Mortality (PIM) Study Group. PIM2: a revised version of the paediatric index of mortality. *Intensive Care Med.* 2003;29(2):278-285.
17. Graciano AL, Balko JA, Rahn DS, Ahmad N, Giroir BP. The Pediatric Multiple Organ Dysfunction Score (P-MODS): development and validation of an objective scale to measure the severity of multiple organ dysfunction in critically ill children. *Crit Care Med.* 2005;33(7):1484-1491.
18. Kumar N, Thomas N, Singhal D, Puliyel JM, Sreenivas V. Triage score for severity of illness. *Indian Pediatr.* 2003;40(3):204-210.
19. Garcia PC, Eulmesekian P, Branco RG, et al. External validation of the paediatric logistic organ dysfunction score. *Intensive Care Med.* 2010; 36(1):116-122.
20. Goldstein B, Giroir B, Randolph A; and the members of the International Consensus Conference on Pediatric Sepsis. International pediatric sepsis consensus conference: definitions for sepsis and organ dysfunction in pediatrics. *Pediatr Crit Care Med.* 2005;6(1):1.
21. Lacroix J, Cotting J; for the Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network. Severity of illness and organ dysfunction scoring in children. *Pediatr Crit Care Med.* 2005;6(3)(suppl):S126-S134.
22. Dominguez TE, Huh JW. Do we need another pediatric severity of illness score? *Crit Care Med.* 2005;33(7):1643-1645.
23. Bhal S, Tygai V, Kumar N, Sreenivas V, Puliyel JM. Signs of inflammation in children that can kill (SICK score): preliminary prospective validation of a new non-invasive measure of severity-of-illness. *J Postgrad Med.* 2006;52(2):102-105.
24. Vincent JL, Moreno R, Takala J, et al. The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. *Intensive Care Med.* 1996;22(7):707-710.

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