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## PAEDIATRIC EMERGENCY MEDICINE

# Paediatric critical procedures in the emergency department: Incidence, trends and the physician experience

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## Abstract

***Objectives***: To analyse and provide current data surrounding paediatric critical procedures performed in three EDs of a single Victorian health network.

***Methods***: We conducted a retrospective study of every paediatric ED attendance requiring management in a resuscitation cubicle at three Victorian hospitals in 2013. The primary outcome measure was the frequency of each paediatric critical procedure performed in the ED during the 12 month study period. Additional outcome measures included details of the proceduralist and of patient presentations.

***Results***: Across the three EDs, there were 54 633 paediatric presentations during the study period. 5895 patients were assessed in a resuscitation cubicle and of these, only 37 presentations required one or more critical procedures (7/10 000 presentations). A total of 53 critical procedures were performed. 83% ($n = 43$) of emergency physicians did not perform a single paediatric critical procedure during the study period. Endotracheal intubation was the most commonly performed critical procedure with 40 attempts (74% of procedures); however, 83% of the full-time emergency physicians regularly exposed to paediatric presentations did not attempt or supervise a single paediatric intubation over the 12 months. 49% of patients who received a critical procedure were under 3 years of age and the most common diagnostic categories were seizure, respiratory and trauma.

***Conclusion***: Critical procedures in children occur infrequently. Clinical exposure in the ED is therefore unreliable as the sole source of experience for critical procedures.

**Key words:** *critical procedure, ED, paediatric critical care.*

### Key findings

- There is a limited frequency and spectrum of paediatric critical procedures occurring in the ED.
- Due to the rarity of paediatric critical procedures, most ED clinicians have no exposure to performing or supervising critical procedures on children during ED clinical hours in the average year.

## Introduction

Critical procedures are procedures necessary for the acute treatment or stabilisation of critical illness or injury.[1] Potentially life-saving, they form a core component of emergency medicine practice; however, there is currently limited information regarding their performance, particularly in settings outside the USA.

Emergency physicians may have insufficient opportunities to practice paediatric critical skills during their day-to-day work. Mittiga and colleagues conducted a study at a busy North American paediatric ED (annual census of 90 000) to assess the frequency and average clinical exposure to paediatric critical procedures. Their study recorded only 261 critical procedures in a year-long study period, making up only 0.22% of all ED evaluations. They also showed that individual clinician exposure to performing critical procedures on children was limited, with 61% of ED attending physicians not performing any paediatric critical procedures in a year.[2]

Recent Australasian papers provide some perspective on the performance of paediatric critical procedures. A recent survey of Australasian emergency physicians showed paediatric and neonatal emergencies to be areas of low confidence;[3] however, the cause of this was not assessed. A recent study at a high-volume Australian paediatric ED showed paediatric intubations to occur infrequently (approximately 9/10 000 presentations) with low rates of first pass success without adverse events such as desaturation or hypotension,[4] suggesting the potential need for skill optimisation.

Mittiga and colleagues' study provided an evidence base for discussion of alternative strategies for Paediatric

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Emergency Medicine (PEM) physician skill acquisition and maintenance. It is unclear whether these findings apply in healthcare settings outside the USA.

Given the differences in emergency medicine training and practice between the USA and Australia,[5] data from our setting would provide additional information and perspective regarding the performance of critical procedural skills on children. Moreover, additional data surrounding patient presentations and outcomes involving critical procedures may help guide the development and implementation of focussed educational interventions.

Our primary objective was to analyse and provide current data surrounding paediatric critical procedures performed in Australian EDs.

## Methods

We conducted a retrospective chart review, collecting data from existing patient records (both electronic and written). Prior to commencement, the project was approved by relevant hospital and university human research ethics committees.

We included all paediatric patients (<18 years old) treated in the ED resuscitation cubicles of our healthcare network between 1 January 2013 and 31 December 2013. Children who left the ED before admission or were assessed outside of a resuscitation cubicle were excluded.

The setting comprised the three hospital EDs of a single Victorian public health network—a community hospital, a secondary referral hospital and a tertiary referral centre. While the community and secondary referral hospital contain mixed EDs seeing both adults and children, the tertiary centre has a separately staffed paediatric ED (accredited for PEM training). All EDs are accredited for advanced training in emergency medicine by the Australasian College for Emergency Medicine (ACEM). Combined, the three EDs of this healthcare network see approximately 55 000 paediatric presentations annually.

Across the three sites there are 13 resuscitation cubicles—seven at the tertiary site (three paediatric and four adult), four at the secondary referral hospital and two at the community hospital. All resuscitation cubicles are equipped for emergent critical care interventions. At all sites, emergency physicians are present 8 a.m. to midnight, 7 days/week.

On presentation to the ED, patients are triaged according to the Australasian triage scale.[6] Children that require (or have the potential to require) management such as resuscitation, emergent intervention or procedural sedation are often managed in a resuscitation cubicle; however, bed allocation for initial ED management can be reliant on the availability of a resuscitation cubicle.

In the event of a critical presentation of a child in ED, it is common for other specialty staff external to the ED to be involved in patient management during ED admission. Availability of such external support varies between sites. All three sites have a paediatric registrar for the wards. The tertiary centre has Paediatric Intensive Care Unit (PICU), paediatric anaesthetic and Neonatal Intensive Care Unit (NICU) services. The secondary referral hospital has adult Intensive Care Unit (ICU) and anaesthetic services. The community hospital has anaesthetics services only. Consultants or senior trainees in these disciplines are available on-site 24 h a day.

An initial database was established from the institution's ED electronic medical records (Symphony Version 2.29, Ascribe, Bolton, UK, 2014). Medical and nursing notes were examined to identify all presentations that involved a critical procedure. The primary investigator was not blinded to the study objective.

Critical procedures encompassed the following list of interventions: endotracheal intubation, laryngeal mask airway (LMA) insertion, surgical airway—needle, open or percutaneous cricothyrotomy—change of tracheostomy, thoracostomy (needle/tube), defibrillation/electrical cardioversion, transcutaneous pacing, intraosseous line insertion, venous cutdown, central venous access, umbilical venous access, arterial line placement, pericardiocentesis and ED thoracotomy. Cardiopulmonary resuscitation (CPR) and basic life support (BLS) were excluded from this list.

Our list was determined by procedures that appear in widely used emergency medical textbooks as standard critical procedures[7–9] and described in the Advanced Paediatric Life Support manual.[10] Moreover, the Royal Australasian College of Physicians (RACP) lists these procedures as necessary procedural skills under the Resuscitation and Critical Care for Paediatric Emergency Medicine Advanced Training Curriculum.[11]

For each patient presentation that was identified as involving a critical procedure, important details surrounding presentation, patient demographics, medical staff involvement and the progression of acute ED management were recorded.

A second investigator (also not blinded) crosschecked the final data.

Details on staffing were established from hospital administration records of ED staff rosters.

We defined an emergency physician as a clinician regularly in charge of the ED and who had completed specialist training as defined by fellowship with ACEM or RACP.

Our primary measure was to identify the frequency of each listed paediatric critical procedure performed in the ED during a 12 month study period. Pre-hospital critical procedures that occurred in the care of Metropolitan Ambulance Service staff and procedures performed by Neonatal Emergency Transport Services/Paediatric Emergency Transport Services staff were excluded. All critical procedure attempts that occurred from time of patient admission up until discharge from the ED were included. Patients who received critical procedures in theatre were excluded.

Additional outcome measures included the following: frequency of supervision of each procedure, description of physician types performing (and supervising) each critical procedure, outcome of critical procedure attempts and distribution of patient age.

All data were tabulated into Microsoft Excel for Mac 2011 (Version 14.1.0, Washington, DC, USA), and descriptive statistics for all outcomes of interest were obtained.

## Results

In 2013 there were 54 633 paediatric presentations. There were 5895 paediatric patients assessed in a resuscitation

**TABLE 1.** *Number of paediatric critical procedures in the ED by type and proceduralist (NETS, Neonatal Emergency Transport Services; PETS, Paediatric Emergency Transport Services; NICU, Neonatal Intensive Care Unit)*

| | Endotracheal intubation | Intraosseous line insertion | Thoracostomy | Arterial line | Central venous access | Total |
|---|---|---|---|---|---|---|
| ED physicians | 18 | 2 | 1 | 1 | 1 | 23 |
| Anaesthetics | 15 | 0 | 0 | 1 | 0 | 16 |
| ED junior medical staff † | 5 | 5 | 2 | 1 | 0 | 13 |
| NICU | 1 | 0 | 0 | 0 | 0 | 1 |
| Total | 39 | 7 | 3 | 3 | 1 | 53 |

†ED junior medical staff included ED registrars, paediatric registrars and career medical officers.

cubicle and of these, 37 children received a total of 53 critical procedures during 37 presentations (Table 1).

The following critical procedures were not attempted: LMA insertion, surgical airway (needle, open or percutaneous cricothyrotomy), change of tracheostomy, ED thoracotomy, defibrillation/electrical cardioversion, transcutaneous pacing, venous cutdown, umbilical venous access and pericardiocentesis.

Thirty-eight per cent ($n = 14$) of children who received critical procedures were below the age of 2 years. Twenty per cent ($n = 7$) were children over the age of 16 years.

ED medical staff attempted 68% of all recorded critical procedure attempts. Endotracheal intubation was the most common critical procedure consistent throughout all proceduralist groups (Table 2). NICU performed one of four critical procedures attempted during one presentation of shortness of breath in a 1 month old child. During this presentation a femoral central venous access (unsuccessful), intraosseous line (unsuccessful) and two endotracheal intubations (one successful, one unsuccessful) were performed in ED.

Emergency physicians attempted 23 procedures (median = 1) and supervised three (thoracostomy-2, endotracheal intubation-1). Overall, 17 critical procedures were supervised (by anaesthetics–14, emergency physicians-3). Fifty-two per cent ($n = 12$) of critical procedures performed by emergency physicians had supervision by anaesthetics, and all were endotracheal intubations. ED junior medical staff (JMS) were not supervised as often, only four (31%) critical procedure attempts were supervised by senior staff (emergency physicians–3, anaesthetics–1).

Excluding those who work part-time, work only in the tertiary adult ED and locums, there were 52 emergency physicians considered to be full-time and regularly exposed to paediatric patients across the three sites. Nine full-time emergency physicians performed 20 critical procedures. Full-time emergency physicians performed 87% of all procedures attempted by emergency physicians, and 43% of all procedures recorded in the 12 month period (range: 1–9, median: 1).

Despite this, 83% ($n = 43$) of full-time emergency physicians with regular exposure to paediatric patients did not attempt a single paediatric critical procedure over 12 months and 81% ($n = 42$) did not attempt or supervise a single paediatric critical procedure.

Fifty-seven per cent ($n = 30$) of all critical procedures were performed on patients under 3 years old (Fig. 1).

Discharge outcomes are summarised in Table 3. Patients discharged to the ICU were typically younger; over half (52%, $n = 13$) were aged less than 3 years. In contrast, patients who were discharged home after a critical procedure were older (between 15 and 18 years).

Only one critical procedure performed in ED resulted in transfer to theatre. This intubation was performed by anaesthetic staff in ED prior to transfer. The patient was a 7 year old child presenting with status epilepticus and blocked ventriculoperitoneal shunt.

Table 4 summarises presentations by final diagnosis. The most common diagnosis categories that received a critical procedure performed by ED staff were respiratory and seizure presentations (28 and 28% respectively).

**TABLE 2.** *Critical procedures attempted in the ED during a 12 month study period*

| Critical procedure | Successful | Unsuccessful | Total |
|---|---|---|---|
| Endotracheal intubation | 35 | 4 | 39 |
| Intraosseous line insertion | 5 | 2 | 7 |
| Arterial line | 3 | 0 | 3 |
| Thoracostomy† (tube/needle) | 3 | 0 | 3 |
| Central venous access‡ | 0 | 1 | 1 |
| Total | **46** | **7** | **53** |

†Thoracostomy included pleural drainage and intercostal catheter insertion. ‡Central venous access was a femoral central venous catheter insertion.

## Discussion

We found paediatric critical procedures to occur infrequently in the ED. Interestingly, while our rate of paediatric intubations was comparable to a recent Australian study,[4] we recorded a significantly lower rate of paediatric

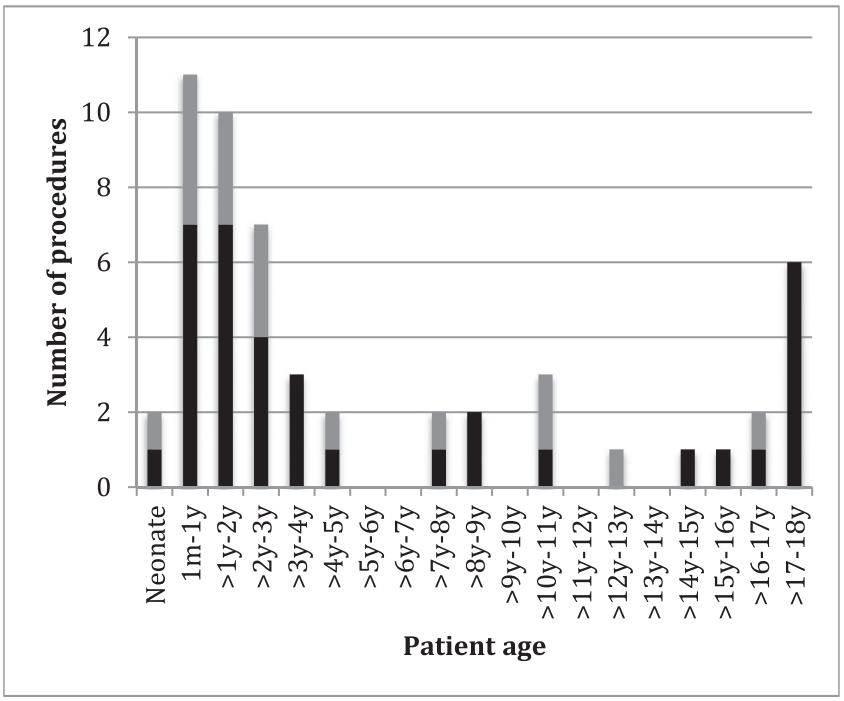


**Figure 1.** *Critical procedures in the ED according to age and proceduralist type. (■), Non-ED proceduralist; (■), ED proceduralist.*

critical procedures than Mittiga *et al.*'s American study (7/10 000 paediatric presentations and 22/10 000 respectively).[2] This may be partially attributed to the exclusion of pharmacological cardioversion from our study, as we wished to focus on invasive critical procedures. However, pharmacological cardioversion only made up 23 of 261 Mittiga *et al.*'s recorded critical procedures.

It may be that North American paediatric EDs treat more children for serious trauma-related injuries. While we found that 14% of presentations requiring a critical procedure were trauma-related, Mittiga and colleagues recorded almost double this percentage (24%). Indeed, in Australia, congenital anomalies, malignancy and infection were reported as the most common causes of death in the 1 to 4 year age group,[12] while unintentional injury, congenital abnormalities and homicide were the most common causes of death for the same age group in the USA, with unintentional injury the most common cause of death for all paediatric age groups above the age of 1 year in North America.[13]

**TABLE 3.** *Discharge outcomes of patient presentations requiring critical procedure(s) during ED admission*

| Discharge outcome | Total |
|---|---|
| Intensive Care Unit | 25 |
| Hospital Ward (including hospital in home) | 4 |
| Other hospital campus | 4 |
| Other operating theatre/ procedure room | 1 |
| Home | 3 |
| Grand total | 37 |

Differences between healthcare systems may also contribute to higher rates of paediatric critical procedures in the USA. Compared with Australia where there is a well-established publically funded healthcare system,[14] the USA health system has a population of uninsured people.[15] It has been suggested that uninsured children are more likely to delay seeking care because of parental concerns with financial cost, thereby increasing the potential for higher acuity at time of ED presentation.[15]

Our results also show a limited range of critical procedures being performed. More than half (64%) of investigated procedures were not attempted. No surgical airways nor umbilical venous access were performed, a likely explanation for a recent Australasian survey of FACEM reporting 'surgical and advanced airway' and neonatal emergencies as desirable topics for further skill development.[3]

Literatures recommending number of attempts required to reach an acceptable skill level have mostly examined intubation skill acquisition, with recommendations ranging between 40 and 57.[16–18] Only five ED JMS attempted an intubation during the year (one each), despite intubation making up 74% of all attempted procedures. This suggests that exposure to paediatric critical procedures in the ED clinical setting alone is inadequate. This is already accounted for, in part, by the ED training programme that includes a minimum of 6 months at an ICU or anaesthetic placement;[19] however, exposure to paediatric critical procedures in these settings was beyond the scope of this study.

Identifying common clinical presentations and age groups for which critical procedures are necessary may be useful in targeting specific learning objectives. Most patients were younger children, and 44% of procedures were performed on patients under 2 years, consistent with past intubation studies.[20] As children under the age of two are the most developmentally, anatomically and physiologically different to adults,[20] exposure specific to the paediatric population may be essential. Currently, we are unaware of any studies that have assessed the relationship between experience of critical procedures in the adult population and paediatric critical procedural skills.

While the majority of clinicians performed no paediatric critical procedures, others performed substantially more than their peers; one clinician (FACEM working in the paediatric ED) performed nine during the year, almost half of total procedures performed by full-time emergency physicians. This may be entirely because of chance or because of comfort levels that come from experience; clinicians that perform more procedures are more likely to be comfortable performing such high-risk procedures in the future. As such, this may further compound the paucity of experience for many clinicians and

**TABLE 4.** *Number of presentations and critical procedures according to diagnosis in the ED*

| Diagnosis | Number of procedures | Number of presentations |
|---|---|---|
| Seizures | 16 | 13 |
| Respiratory | 11 | 8 |
| Bronchiolitis | 4 | 3 |
| Pertussis | 2 | 1 |
| Asthma | 2 | 1 |
| Pneumothorax (non-traumatic) | 2 | 2 |
| Respiratory failure because of pneumonia | 1 | 1 |
| Trauma | 8 | 5 |
| Substance toxicity | 7 | 6 |
| Cardiac | 5 | 1 |
| Anaphylaxis | 3 | 1 |
| Dehydration | 2 | 1 |
| Sepsis | 2 | 2 |

unintentionally perpetuate a cycle for infrequent experience.

With such a low frequency of critical procedures in children, a high percentage of clinicians have no exposure to performing or supervising paediatric critical procedures in the average year. This may put ED physicians' critical procedure skills at risk of deterioration as practical procedural skills need to be frequently revisited in order to avoid skill decay.[21–23]

There may not be an easy solution to such limited opportunities to practice in the ED. The overall exposure of Australian ED physicians is not only limited but also lower than that of their North American counterparts.[2] Moreover, the rarity of such events means that it is also impractical to expect an adequate amount of experience to come from increased ED clinical hours alone.

Other learning modalities such as simulation may be useful for maintaining skill levels.[21,24,25] Alternatively, practice in other settings, such as the operating theatre, may also be useful, allowing ED clinicians to practice skills on real patients.

### *Limitations*

Our study has several limitations. First, it was conducted at a single health service, potentially exaggerating the paucity of critical procedures in the general population. However, this is unlikely as our tertiary centre is one of only two places in Victoria with a PICU and therefore more likely to be treating critically ill children.

Second, our results rely solely on chart review and the completeness of clinical records. Although unsuccessful attempts and rates of supervision may be underestimated, we determine that it is unlikely that many successful critical procedures would not be recorded given the low frequency and high acuity of such events.

Third, the investigators were not blinded to study aims; however, our details of interest were collected retrospectively and not reliant on subjective interpretation. Accuracy of our data collection is also reliant on the primary investigator. However, our study outcomes were straightforward, and so the reliability of data abstraction is likely to be high.

Fourth, we did not include bag-valve mask ventilation or CPR. Although often necessary in critical care, non-physicians can perform them, and physician presence is often difficult to determine.

Fifth, our study design only assessed critical procedures that were performed on patients treated in a resuscitation cubicle. While it is possible that patients treated in other ED beds required a critical procedure, most patients are moved to a resuscitation bay for management either before or after a critical procedure.

Last, the high volume of training staff that move through these teaching EDs limited our descriptions of staffing and exposure, particularly that of ED JMS.

## Conclusion

We found that paediatric critical procedures occur infrequently in the EDs of an Australian healthcare network. With rare opportunities to practice these skills, the ability of ED clinicians to perform critical procedures on children may be at risk. Given the unreliability of the ED setting as a primary source of practice, more investigations need to be performed to understand the exact clinical ramifications of such limited exposure to paediatric critical procedures.

### *Author contributions*

SC conceived the study and designed the methodology. LDN conducted the data collection, analysis of data and drafted the manuscript. SC edited the paper and contributed substantially to its revision.

### *Competing interests*

None declared.

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