RESEARCH ARTICLE

Outcomes and follow-up for children intubated in an adult-based community hospital system: A retrospective chart review

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Objectives: Emergency intubation is a high-risk procedure in children. Studies describing intubation practices in locations other than pediatric centres are scarce and varied. This study described pediatric intubations in adult-based community emergency departments (EDs) and determined what factors were associated with intubated-related adverse events (AEs) and described outcomes of children transferred to a quaternary care pediatric institution.

Methods: This is a retrospective review of data collected between January 2006 and March 2017 at Lakeridge Health and Hospital for Sick Children (SickKids). Patients were <18 years and intubated in Lakeridge Health EDs; those intubated prior to ED arrival were excluded. Primary outcomes were intubation first-pass success (FPS) and AEs secondary to intubation.

Results: Patients (n = 121) were analyzed, and median (interquartile range (IQR)) age was 3.7 (0.4–14.3) years. There were 76 (62.8%) FPS, with no difference between pediatricians (n = 25, 23%) or anaesthetists (n = 12, 11%), versus all other providers (paramedic n = 13 (12%), ED physician n = 37 (34%), respiratory therapist n = 20 (18%), transfer team n = 2 (2%)). The proportion of AEs was 24 (19.8%, n = 21 minor, n = 3 major), with no significant difference between pediatricians or anaesthetists versus all other providers. Data from 68 children transferred to SickKids were available, with the majority extubated within a short median (IQR) time of admission, 1.2 (0.29–3.8) days.

Conclusions: Pediatric intubations were rare in a Canadian adult-based community hospital system. Most intubations demonstrated FPS with relatively few AEs and no significant differences between health provider type. Future investigations should utilize multi-centred data to inform strategies suited for organizations' unique practice cultures, including training programs.

Key Words: *intubation; pediatrics; emergency service; hospital; retrospective studies; hospitals; community; patient outcome assessment*

INTRODUCTION

Intubation is the placement of an endotracheal tube (ETT) into an airway, with the majority occurring during non-emergency elective surgery (>90%), with a small percentage in emergency departments (EDs), intensive care units (ICUs), and by Emergency Medical Services (EMS) [1, 2]. Emergency intubation is a high-risk procedure and may cause adverse outcomes such as cardiac arrest [3–6]. This is of particular concern in children because they reach hypoxemia more quickly than adults [7–9]. Additionally, poor intubation technique can cause dental and laryngeal trauma [10] and may necessitate multiple attempts or prolonged intubation duration (which are associated with airway trauma, desaturation, or bradycardia [11]). An association between intubation success and patient outcomes has been demonstrated, including impact on hospital length of stay (LOS), duration of mechanical ventilation, and mortality [12].

Performance and outcome data on pediatric intubation and airway management are lacking, despite the acknowledged patient safety risks in children [9]. This includes patient-, provider-, and practice-associated complications and the influence of pediatric trainee education [13]. Prior studies suggest that tracheal intubation success rates of trainees such as pediatric residents vary in both neonates [14–16] and children [17], ranging from 24% [16] to 50% [17]. Another factor may be the practice location where intubation takes place, such as adult-based community or tertiary care centres. Studies describing intubation practices (from various locations) prior to admission to a tertiary care pediatric ICU (PICU) are scarce and varied. In Easley et al.'s [8] prospective study, there were 54% adverse events (AEs) during intubations performed in both community and pediatric EDs. Nishisaki et al.'s [18] retrospective study found 18% AEs in referring (community) hospitals, with similar incidence in tertiary

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care PICUs (15%). We could not find studies comparing intubation practices and complications between different types of EDs.

Training and educating providers to be competent in advanced airway management can be a challenge in pediatric EDs [19–21], where emergency intubations are rare [1, 2, 22]. This is especially true in adult-based community EDs where intubations (pediatric and adults) are even more scarce, and the opportunities for training with pediatric patients is low [18, 23]. Understanding the frequency, proportion, and factors of successful tracheal intubations in the pediatric population may help inform unique training programs and/or airway safety bundles to mitigate the risks associated with pediatric emergency intubation at both specialty and community-based centres [24–26].

The primary objective of this study was to describe pediatric intubations in an adult-based community hospital system, with the primary outcomes being first-pass success (FPS) and AEs. The secondary objectives were to determine what factors were associated with intubated related AEs and to describe the outcomes of children transferred to a pediatric quaternary-care institution.

METHODS

This was a retrospective chart review at Lakeridge Health (Bowmanville, Oshawa, and Port Perry sites), and the Hospital for Sick Children (SickKids). Lakeridge Health is a five-hospital (four EDs) adult-based community healthcare system serving the Durham Region in Southern Ontario (Canada). SickKids is a quaternary care centre and is the only pediatric centre serving the Greater Toronto Area. Data were collected from the electronic medical records and manually extracting data from medical charts.

Inclusion criteria included data on patients <18 years old, intubated in Lakeridge Health EDs (1 January 2006 to 31 March 2017). Patients intubated prior to local EMS encounter or ED admission were excluded. Patients meeting eligibility criteria were initially identified by Decision Support who pulled data from the Lakeridge Health Electronic Medical Records (intubations were documented as a specific procedure). Additional variables were extracted chart-by-chart by a member of the study team.

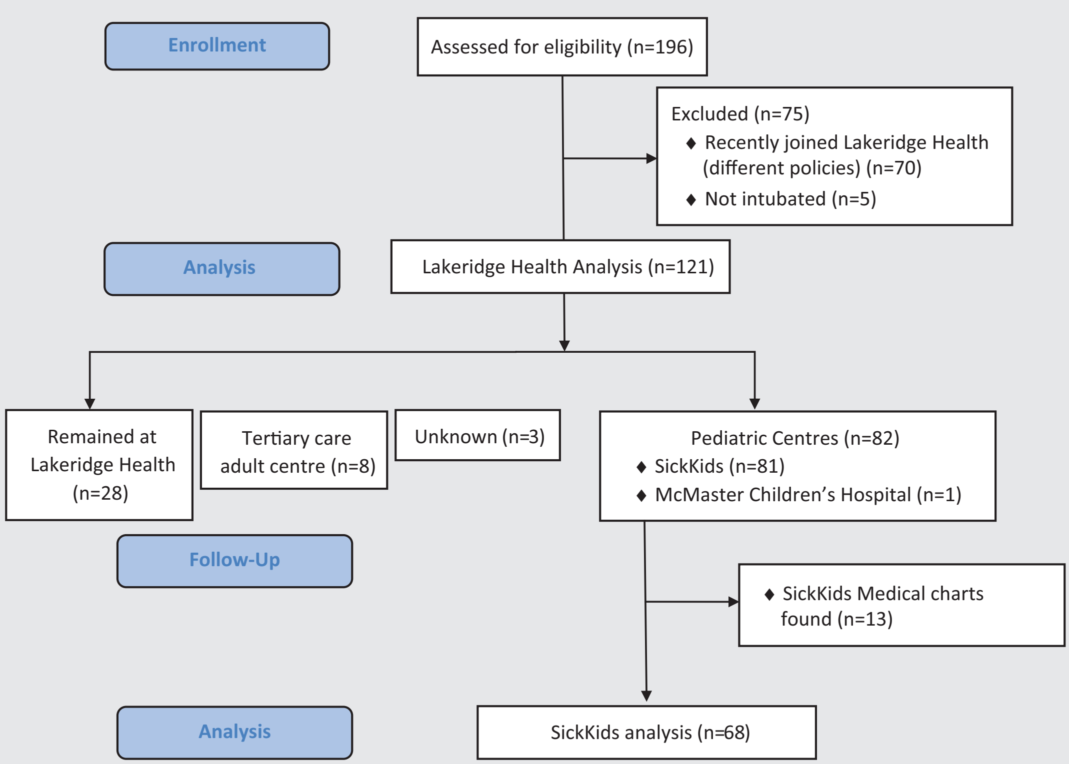
Primary outcomes were intubation FPS and the presence of AEs secondary to the intubation. Major AEs included oxygen saturation (SpO_2) <90% or >5% decrease from baseline, hypotension, aspiration, pneumothorax/chest tube placement, cardiac arrest, or death (related to intubation only). Minor AEs included desaturation where the SpO_2 was >90% or there was <5% decrease from baseline, hypertension, cardiac arrhythmia, nasal/facial injury, dental damage (broken teeth), esophageal intubation, or airway trauma (bleeding).

Secondary outcomes included patient demographic and institutional data. These were age, reason for admission/admitting diagnosis, indication for intubation, mortality, date and time of ED arrival, ED admission, intubation, and transport to tertiary or quaternary care centre. Clinical variables included SpO_2 upon admission, venous and arterial blood gas (VBG, ABG), lactate levels, respiratory rate (RR), heart rate (HR), and blood pressure (BP). Intubation data included number of intubation attempts (at minimum, laryngoscope placed in mouth with an attempt to visualize pharynx), intubation device, ETT placement and airway securement methods, healthcare provider who intubated, and drugs used for intubation.

For the other secondary outcome, data were collected to describe the outcomes of children transferred from Lakeridge Health to SickKids including unit of admission, diagnosis, if ETT tip position required readjustment, if patient was extubated, date and time of extubation, if ETT tube change was required, if tracheostomy was required, interventions (e.g., mechanical ventilation, oxygen therapy, surgery, diagnostic testing), date and time of unit and hospital discharge, and mortality.

FIGURE 1

Participant flow diagram.



DATA ANALYSIS

Patient characteristics and descriptive variables are presented using means and standard deviations (SD), or medians and interquartile ranges (IQR), or counts and proportions. Patients with and without FPS or AEs were compared using χ^2, two-sample *t*-test, or Wilcoxon rank sums tests. To compare professions intubating, a χ^2 test was completed across all providers, between pediatricians and all others and anaesthetists and all others (as we believed these providers had more opportunities to intubate). Because of the limited sample size, analyses were not adjusted for potential confounders. Missing data were excluded from the analyses. IBM SPSS Statistics 27 was used, with $p < 0.05$ considered significant.

The available number of patients intubated at Lakeridge Health's three ED locations limited the sample size for this study. All available intubations at these locations over the 11-year period were included and data extracted.

RESULTS

A total of 196 patients over the 11 years were initially identified. We excluded 5 that were not intubated and 70 patients from one site because it had recently joined the Lakeridge Health System and had different policies and practices (Figure 1). The final 121 cohort had a median (IQR) age of 3.7 (0.4–14.3) years. The most common admitting diagnoses were head injury (n = 22; 18.2%), seizure (n = 18; 14.9%), and cardiorespiratory failure or arrest (n = 17; 14%). The primary indications for intubation were respiratory and/or oxygenation failure (n = 54; 44.6%) and airway protection (n = 51; 42.1%). Use of specialized intubation equipment was used for 19 patients (n = 12 first attempts, n = 8 second attempts, n = 4 third attempts), where 13 (68%) experienced first-pass failure. No accidental extubations occurred, but the ETT was repositioned in 33 patients (27%) after the first intubation. Documented medications provided during first intubations (n = 102) were anaesthetic (n = 27; 22%), analgesic (n = 26; 22%), paralytic (n = 19; 16%), epinephrine (n = 17; 14%), benzodiazepine (n = 12; 10%), atropine (n = 11; 9%), and other (n = 7; 6%). Further details are provided in Table 1.

First pass success

The proportion of FPS was n = 76 (62.8%). When comparing intubations by pediatricians or anaesthetists, there was no difference in first pass or second pass success between pediatricians and all other providers (p = 0.319 and p = 0.833, respectively), and between anaesthetists and all other providers (p = 0.278 and p = 0.868, respectively). There was also no significant difference in the proportion of FPS in patients 12 months or older versus less than 12 months (p = 0.098) or in those who died compared to those that did not die (p = 0.179; Table 2).

Adverse events

The proportion of AEs was n = 24 (19.8%), where n = 21 were minor and n = 3 major (Table 1). There was a significant difference in mean (SD) number of intubations between patients who did 2.2 (1.4), versus did not 1.5 (1.2) have an AE (p = 0.001). There was no significant difference in the proportion of AEs between pediatricians and all other providers (p = 0.899), or between anaesthetists and all other providers intubating (p = 0.712). There was also no significant difference in the proportion of AEs in patients 12 months or older versus less than 12 months (p = 0.450) or in those who died versus did not die (p = 0.921; Table 2).

Mortality

The proportion of children who died was n = 21 (17.4%), consisting of cardiopulmonary arrest (n = 9; 60.0%), trauma (n = 3; 20.0%), drowning (n = 1; 6.7%), sudden infant death (n = 1; 6.7%), and congenital heart defect (n = 1; 6.7%), with 15 (13.3%) unknown or missing data. There was a significant difference in the proportion of the different professions intubating on morality (p < 0.0001); however, we found no significant difference between pediatricians and all other providers (p = 0.748) or between anaesthetists and all other providers intubating (p = 0.349). There was no significant difference in the number of intubations

TABLE 1

Characteristics of the intubations (n = 121)

Characteristic	N (%), unless specified
Age (years), mean (SD), median (IQR)	6.9 (6.8), 3.7 (0.4–14.3)
No. intubations, mean (SD), median (IQR)	1.6 (1.3), 1.0 (1.0–2.0)
Admitting diagnosis	
Head injury	22 (18.2)
Seizure	18 (14.9)
Cardiorespiratory failure or arrest	17 (14)
Respiratory symptoms	11 (9.1)
Other traumatic injury	9 (7.4)
Respiratory infection	9 (7.4)
Toxic exposure	8 (6.6)
Sepsis	5 (4.1)
Viral infection	4 (3.3)
Other[a] or unknown	18 (14.9)
Indication for intubation (n = 112)	
Respiratory and/or oxygenation failure	54 (44.6)
Airway protection	51 (42.1)
Airway obstruction	4 (3.3)
Cardiorespiratory arrest	2 (1.7)
Unknown or missing	10 (8.2)
Intubation success (% based on totals within success subgroup)	
1st pass success	76 (62.8)[b]
2nd pass success	33 (73.3)
3rd pass success	6 (46.2)
4th pass success	2 (33.3)
5th pass success	2 (66.7)
6th pass success	1 (100.0)
Adverse events (AE)[c]	
All AE (patients)	24 (19.8)
Major AE (patients)	3 (2.5)
Cardiac arrest	2 (1.7)
Moderate to severe hypoxemia (SpO_2 <90% or >5% decrease from baseline)	1 (0.08)
Minor AE (patients)	21 (17.4)
Blood incidents	10 (8.3)
Mild hypoxemia (SpO_2 ≥90% or <5% decrease from baseline)	8 (6.6)
Facial injury	2 (1.7)
Air leak	2 (1.7)
Bradycardia	2 (1.7)
Sinus tachycardia	2 (1.7)
Swollen vocal cords	1 (0.08)
Esophageal intubation	1 (0.08)
Died	
Yes	21 (17.4)
No	100 (82.6)
Specialized equipment[c]	
GlideScope®	16 (13.2)
Specialized laryngoscope & related (Miller blade, McGill forceps)	3 (2.5)
Laryngeal mask	2 (1.7)
C-MAC®	1 (0.8)
Other[d]	1 (0.8)
Intubation confirmation[c]	
Chest X-ray	72 (59.5)
End-tidal carbon dioxide	58 (47.9)
Auscultation	45 (37.2)
Direct visualization	20 (16.5)
Tube condensation	4 (3.3)
Improvement in oxygen saturation	4 (3.3)
Not done	13 (10.7)
ETT readjustment (1st attempt)	
Yes, too low	23 (19)
Yes, too high	10 (8.3)

Note: ETT = endotracheal tube, SD = standard deviation, IQR = interquartile range.
[a]Congenital disorders, cardiac arrythmia, foreign body airway obstruction, complications from prematurity, decreased level of consciousness, surgical complications, shock, vitamin deficiency, ketoacidosis.
[b]n = 1 missing.
[c]Some patients had multiple items/techniques.
[d]White Broselow tape.

TABLE 2

Comparisons between groups for first pass success, adverse events, and mortality

<table>
<tr><th></th><th>Yes FPS (n = 76)</th><th>No FPS (n = 44)</th><th>p value</th><th>Yes AE (n = 24)</th><th>No AE (n = 97)</th><th>p value</th><th>Died (n = 21)</th><th>Not dead (n = 100)</th><th>p value</th></tr>
<tr><td>Age (years), Mean (SD),</td><td>7.2 (6.7)</td><td>6.1 (7.1)</td><td>0.303</td><td>6.3 (6.6)</td><td>7.0 (6.9)</td><td>0.680</td><td>5.6 (6.8)</td><td>6.6 (6.7)</td><td>0.431</td></tr>
<tr><td>Median (IQR)</td><td>4.4 (0.8–14.1)</td><td>2.3 (0.1–14.9)</td><td></td><td>3.3 (0.9–13.6)</td><td>3.8 (0.3–15.0)</td><td></td><td>2.0 (0–13.5)</td><td>3.0 (0–14)</td><td></td></tr>
<tr><td>No. intubations</td><td>1.0 (0.12)</td><td>2.7 (1.6)</td><td><0.0001</td><td>2.2 (1.4)</td><td>1.5 (1.2)</td><td>0.001</td><td>1.5 (1.1)</td><td>1.7 (1.3)</td><td>0.211</td></tr>
<tr><td></td><td>1.0 (1.0–2.0)[a]</td><td>2.0 (2.0–3.0)</td><td></td><td>2.0 (1.0–3.0)</td><td>1.0 (1.0–2.0)</td><td></td><td>1.0 (1.0–1.5)</td><td>1.0 (1.0–2.0)</td><td></td></tr>
<tr><td>Profession intubating[b]</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>n = 66</td><td>n = 43</td><td></td><td>n = 23</td><td>n = 87</td><td></td><td>n = 20</td><td>n = 90</td><td></td></tr>
<tr><td>Paramedic</td><td>6</td><td>7</td><td>0.384</td><td>1</td><td>12</td><td>0.469</td><td>7</td><td>6</td><td><0.0001</td></tr>
<tr><td></td><td>(46.2|9.1)</td><td>(53.8|16.3)</td><td></td><td>(7.7|4.3)</td><td>(92.3|13.8)</td><td></td><td>(53.8|35.0)</td><td>(46.2|6.7)</td><td></td></tr>
<tr><td>ED physician</td><td>25</td><td>12</td><td></td><td>7</td><td>31</td><td></td><td>1</td><td>37</td><td></td></tr>
<tr><td></td><td>(67.6|37.9)</td><td>(32.4|27.9)</td><td></td><td>(18.4|30.4)</td><td>(81.6|35.6)</td><td></td><td>(2.6|5.0)</td><td>(97.4|41.1)</td><td></td></tr>
<tr><td>Pediatrician</td><td>13</td><td>12</td><td></td><td>5</td><td>20</td><td></td><td>4</td><td>21</td><td></td></tr>
<tr><td></td><td>(52.0|19.7)</td><td>(48.0|27.9)</td><td></td><td>(20.0|21.7)</td><td>(80.0|23.0)</td><td></td><td>(16.0|20.0)</td><td>(84.0|23.3)</td><td></td></tr>
<tr><td>RT</td><td>11</td><td>9</td><td></td><td>7</td><td>13</td><td></td><td>7</td><td>13</td><td></td></tr>
<tr><td></td><td>(55.0|16.7)</td><td>(45.0|20.9)</td><td></td><td>(35.0|30.4)</td><td>(65.0|14.9)</td><td></td><td>(35.0|35.0)</td><td>(64.0|14.4)</td><td></td></tr>
<tr><td>Anaesthetist</td><td>9</td><td>3</td><td></td><td>3</td><td>9</td><td></td><td>1</td><td>11</td><td></td></tr>
<tr><td></td><td>(75.0|13.6)</td><td>(25.0|7.0)</td><td></td><td>(25.0|13.0)</td><td>(75.0|10.3)</td><td></td><td>(8.3|5.0)</td><td>(91.7|12.2)</td><td></td></tr>
<tr><td>Transfer team</td><td>2</td><td>0</td><td></td><td>0</td><td>2</td><td></td><td>0</td><td>2</td><td></td></tr>
<tr><td></td><td>(100.0|3.0)</td><td></td><td></td><td></td><td>(100|2.3)</td><td></td><td></td><td>(100.0|2.2)</td><td></td></tr>
<tr><td>12 months of age</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td><12 months</td><td>20</td><td>18</td><td>0.098</td><td>6</td><td>32</td><td>0.450</td><td>8</td><td>30</td><td>0.467</td></tr>
<tr><td></td><td>(52.6|26.3)</td><td>(47.7|40.9)</td><td></td><td>(15.8|25.0)</td><td>(84.2|33.0)</td><td></td><td>(21.1|38.1)</td><td>(78.9|30.0)</td><td></td></tr>
<tr><td>≥12 months</td><td>56</td><td>26</td><td></td><td>18</td><td>65</td><td></td><td>13</td><td>70</td><td></td></tr>
<tr><td></td><td>(68.3|73.7)</td><td>(31.7|59.1)</td><td></td><td>(21.7|75.0)</td><td>(78.3|67.0)</td><td></td><td>(15.7|61.9)</td><td>(84.3|70.0)</td><td></td></tr>
<tr><td>Died</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Yes</td><td>16</td><td>5</td><td>0.179</td><td>4</td><td>17</td><td>0.921</td><td></td><td></td><td></td></tr>
<tr><td></td><td>(76.2|21.1)</td><td>(23.8|11.4)</td><td></td><td>(19.0|16.7)</td><td>(81.0|17.5)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>No</td><td>60</td><td>39</td><td></td><td>20</td><td>80</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>(60.6|78.9)</td><td>(39.4|88.6)</td><td></td><td>(20.0|83.3)</td><td>(80.0|82.5)</td><td></td><td></td><td></td><td></td></tr>
</table>

Note: Reported as row | column *N* (%) unless specified. AE = adverse event, ED = emergency department, FPS = first pass success, IQR = interquartile range, RT = respiratory therapist, SD = standard deviation.

[a]One patient had FPS; however, they required a second intubation due to airway obstruction.

[b]Pairwise tests between pediatricians and all other providers, and anaesthetists and all other providers were not significant.

(p = 0.211), or in the proportion of deaths in patients 12 months or older versus less than 12 months (p = 0.467; Table 2).

Clinical variables

There were no significant differences in any clinical variable (SpO_2, HR, RR, or BP) or blood gas measures at any time points, between those with and without FPS or between those who did or did not have an AE (Table 3). Of interest, clinical variables were completed at a wide range of time points, with the first set assessed and documented within a median (IQR) time of 20 (5–80) min after intubation. First and second ABG results were documented within 58 and 103 min, respectively, after intubation (Table 4).

Follow-up cohort

From the initial 121 patients admitted to Lakeridge Health, 82 (67.7%) were transferred to pediatric centres, 8 (6.6%) to a tertiary care adult centre, 28 (23.1%) stayed at Lakeridge Health, and 3 were unknown (Figure 1). Of the 28 children who stayed at Lakeridge Health, 19 died, 8 were transferred to the ICU and extubated within 24 h (all 17 years old), and 1 had a diagnostic procedure and subsequently extubated in the ED.

Of the 82 children admitted to pediatric centres, 81 went to SickKids and 1 to McMaster Children's Hospital. We obtained data from SickKids on 68 of these children (13 could not be found in the SickKids' electronic medical system based on information provided by Lakeridge Health, i.e., Ontario Health Insurance Plan numbers). The median (IQR) age of these children was 2.5 (0.25–11) years, with 29 (42.6%) females. Fourteen (20.6%) patients had their ETTs re-adjusted. Most children (n = 65; 95.6%) were extubated with a short median (IQR) time of admission at 1.2 (0.29–3.8) days (Figure 2). Sixty-one (89.7%) were admitted to the Critical Care Unit, 5 (7.4%) to the neonatal ICU, and 2 (2.9%) to other hospital departments. The total median hospital LOS was 8.6 (3.6–12.9) days, and 4 (5.9%) died. During their stay, all 68 patients received invasive ventilation, 35 (51.5%) non-invasive ventilation, 3 (4.4%) high flow nasal cannula oxygen therapy, and 3 (4.4%) low flow oxygen therapy.

DISCUSSION

This retrospective study described pediatric intubations in an adult-based community hospital and explored factors associated with FPS and intubated related AEs. The study sample included 121 children (median age 4.4 years) intubated and admitted to Lakeridge Health EDs. The proportion of FPS was n = 76 (63%), with n = 24 (20%) experiencing an AE. There were significantly more intubation attempts between patients who had an AE compared to those that did not. This study found no significant differences in FPS, AEs, and mortality between pediatrician or anaesthesia intubators, compared to all others (ED physician, respiratory therapist (RT), transfer team, or paramedic). There were no significant differences in any clinical variable measures at any time point, between those with and without FPS or between those who did or did not have an AE. Eighty-two children (68%) were transferred to a quaternary care pediatric centre (SickKids), for which we obtained data on 68 children. Most children (n = 65; 96%), were extubated within a short time of admission (median 1.2 days).

First pass success

Pediatric intubation in the EDs of adult-based community hospitals are rare events, with limited numbers conducted outside tertiary/quaternary care centres. Our study found a FPS rate of 63%, over a 10-year timeframe. The literature is variable with respect to FPS rates, likely because of the different institutional settings, sample sizes, time frames, and providers intubating. Our results are higher, lower, and

TABLE 3

Clinical variables for the whole cohort (*n* = 121) and FPS (*n* = 44) and AEs (*n* = 97)

	Whole cohort (*n* = 121)		Yes FPS (*n* = 76)		No FPS (*n* = 44)			Yes AEs (*n* = 24)		No AEs (*n* = 97)		
Variable	***N***	**Mean (SD)**	***N***	**Mean (SD)**	***N***	**Mean (SD)**	***p***	***N***	**Mean (SD)**	***N***	**Mean (SD)**	***p***
SpO_2 time 1	89	93.9 (9.8)	51	94.2 (9.9)	38	93.6 (9.7)	0.876	18	93.3 (13.1)	71	94.1 (8.9)	0.187
SpO_2 time 2	48	93 (18.3)	26	94.1 (19.7)	22	91.6 (16.9)	0.289	11	94.2 (18)	37	92.6 (18.6)	0.273
SpO_2 time 3	59	94.8 (10.7)	30	97.4 (5.7)	29	92.2 (13.8)	0.089	16	94.4 (11.7)	43	95 (10.5)	0.549
SpO_2 time 4	41	96.2 (6.8)	22	96.9 (5.9)	19	95.4 (7.8)	0.332	11	95.8 (8.8)	30	96.3 (6.1)	0.874
SpO_2 time 5	27	95.8 (8.5)	16	97.4 (5.3)	11	93.5 (11.7)	0.233	10	94.1 (12.4)	17	96.8 (5.3)	0.955
SpO_2 time 6	12	92.5 (15.4)	4	98 (2.8)	8	89.7 (18.5)	0.481	6	88.5 (21.7)	6	96.4 (3.5)	0.868
RR time 1	68	30 (19)	40	29.9 (20.5)	28	30.1 (16.9)	0.649	14	29.9 (14.5)	54	30 (20.1)	0.403
RR time 2	13	27.5 (14.9)	8	24.8 (17.4)	5	32 (10)	0.122	3	21 (7)	10	29.5 (16.4)	0.444
RR time 3	13	28.2 (15.8)	7	28.7 (20.7)	6	27.5 (9)	0.720	5	23.2 (7.2)	8	31.3 (19.2)	0.462
HR time 1	90	134.7 (46.3)	54	130.4 (47.8)	36	141.2 (43.8)	0.519	19	134.3 (38.9)	71	134.8 (48.4)	0.496
HR time 2	84	133.1 (37.3)	50	133.6 (38.8)	34	132.5 (35.5)	0.524	18	123.6 (38.4)	66	135.7 (36.9)	0.883
HR time 3	66	140.7 (38)	39	142.2 (39.1)	27	138.6 (37)	0.564	15	135.5 (34.3)	51	142.3 (39.3)	0.723
HR time 4	50	138.6 (35.8)	28	132 (37.2)	22	147 (32.7)	0.368	13	140.7 (31)	37	137.8 (37.7)	0.365
HR time 5	31	134.6 (41.5)	16	134.3 (32)	15	134.8 (50.9)	0.026	9	137.7 (40.5)	22	133.3 (42.7)	0.602
HR time 6	15	134.2 (43.3)	5	138.4 (37.1)	10	132.1 (47.8)	0.431	6	133.3 (40.7)	9	134.7 (47.3)	0.848
SBP time 1	95	69.2 (61.7)	59	73.8 (61)	36	61.6 (62.8)	0.606	19	66.3 (68.4)	76	69.9 (60.3)	0.223
DBP	58	64.2 (25)	37	67.2 (20.9)	21	58.9 (30.7)	0.112	10	77.9 (17.5)	48	61.3 (25.5)	0.321
SBP time 2	31	115.5 (27.7)	21	120.3 (26.2)	10	105.4 (29.5)	0.344	7	129.6 (35.9)	24	111.4 (24.3)	0.282
DBP	31	65.5 (24.2)	21	69.2 (26.8)	10	57.9 (16)	0.084	7	74 (24.9)	24	63.1 (24)	0.981
SBP time 3	22	116.5 (25)	14	121.3 (28.4)	8	108.3 (16)	0.028	7	122 (23.6)	15	114 (26)	0.975
DBP	20	70.1 (20.8)	14	68.4 (23.6)	6	74 (13.1)	0.162	7	74.7 (11.5)	13	67.5 (24.5)	0.106
SBP time 4	16	107.9 (31.5)	10	105.4 (35)	6	112 (27.1)	0.829	6	106.7 (21.3)	10	108.6 (37.4)	0.442
DBP	13	56.8 (21.1)	9	56.8 (23)	4	57 (19.4)	0.610	5	57.2 (16.2)	8	56.6 (24.8)	0.103
SBP time 5	22	108.3 (29.3)	13	110.7 (30.7)	9	104.9 (28.5)	0.226	9	118.2 (17.9)	13	101.5 (34.1)	0.015
DBP	13	69.3 (20.3)	8	67.5 (24.1)	5	72.2 (14.2)	0.132	7	72.4 (18.6)	6	65.7 (23.3)	0.537
pH time 1	47	7.1 (1.1)	29	6.9 (1.4)	18	7.3 (0.1)	0.411	10	7.2 (0.3)	37	7 (1.2)	0.420
$PaCO_2$	47	53.6 (25)	29	56.3 (30)	18	49.2 (13.3)	0.751	10	54.2 (21.4)	37	53.4 (26.2)	0.856
HCO_3	42	21.1 (6.3)	24	21 (7.5)	18	21.3 (4.2)	0.888	10	21.2 (7.5)	32	21.1 (6)	0.929
PaO_2	47	170.6 (122)	29	189.4 (138.5)	18	140.2 (84.3)	0.457	10	105.6 (76.2)	37	188.1 (126.8)	1.000
SaO_2	45	85.3 (31.4)	28	85.3 (31.6)	17	85.3 (32.2)	0.294	9	74.2 (42.5)	36	88.1 (28.1)	0.254
pH time 2	15	6.7 (1.9)	10	6.4 (2.3)	5	7.3 (0.1)	0.327	2	7 (0.5)	13	6.6 (2)	0.497
$PaCO_2$	15	56.5 (46.2)	10	62 (55.5)	5	45.6 (17)	0.902	2	55.5 (17.7)	13	56.7 (49.6)	0.552
HCO_3	13	16.9 (7.7)	8	15.1 (9.4)	5	19.8 (2.6)	0.378	2	15 (9.9)	11	17.3 (7.8)	0.692
PaO_2	15	175.9 (123.6)	10	169.3 (132.8)	5	189.2 (116.1)	0.806	2	216 (226.3)	13	169.8 (115.1)	0.063
SaO_2	15	88.8 (27.2)	10	84.1 (32.7)	5	98.2 (2.7)	0.410	2	77 (32.5)	13	90.6 (27.3)	0.792

Note: Only included variables with over 10 valid numbers included in analysis. Time points varied (see Table 4). AE = adverse effects, DBP = diastolic blood pressure (mmHg), FPS = first pass success, HCO_3 = bicarbonate, HR = heart rate (beats per min), $PaCO_2$ = partial pressure of arterial carbon dioxide (mmHg), RR = respiratory rate (breaths per min), SaO_2 = oxygen saturation arterial (%), SBP = systolic blood pressure (mmHg), SD = standard deviation, SpO_2 = oxygen saturation pulse (%).

similar compared to other studies, though patient characteristics such as age and reason for admission are similar. Long et al. [27] found a 49% FPS in 71 children before implementing a quality improvement initiative in a pediatric ED (78% in 46 children post-intervention). The specific providers intubating were not identified in this study, only that two "operators" were required. Guilfoyle et al. [28], in a 1-year retrospective chart review (also in a tertiary care pediatric ED), found an 81% FPS rate (*n* = 99), with intubations performed by residents, pediatric ED physicians, and fellows. Pallin et al. [29] completed a study assessing pediatric intubations using 10 years of adult tertiary and community-based hospital data (*n* = 1053) from the National Emergency Airway Registry (NEAR) [30], though only 1% of intubations came from adult-based community EDs like Lakeridge Health. They found an 83% FPS rate, with intubations primarily done by physicians and physician trainees. Finally, our numbers are similar with Lee et al. [31] who found a 60% FPS (1256 out of 2080) based on the National Emergency Airway Registry for Children (NEAR4KIDS) [32] of 19 PICUs worldwide over 3 years. Like Pallin et al. [29], the majority of intubations were done by physicians and physician trainees.

In our study, health providers intubating varied and included ED physicians (34%), pediatricians (23%), RTs (18%), paramedics (12%), anaesthetists (11%), and transfer team personnel (2%). In PICU settings,

TABLE 4

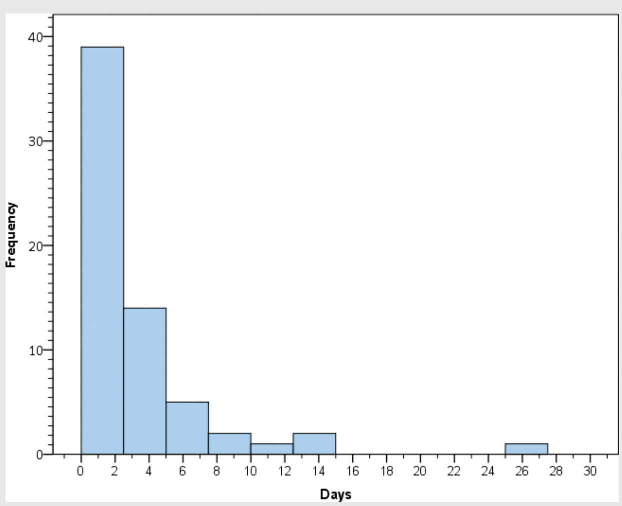
Time points clinical variables and blood gases were assessed

Variable (min)	Valid	Missing	Median (IQR)	Minimum	Maximum
Time of 1st clinical variables	98	23	20 (4.8–80)	0.00	698.00
Time of 2nd clinical variables	90	31	6 (2–15)	0.00	1452.00
Time of 3rd clinical variables	72	49	5 (2–16.5)	0.00	1447.00
Time of 4th clinical variables	55	66	10 (3–15)	0.00	1442.00
Time of 5th clinical variables	33	88	12 (7.5–21)	0.00	1437.00
Time of 6th clinical variables	16	105	16.5 (11.5–26.5)	7.00	1430.00
Time of 1st ABG	42	79	57.5 (30.5–105.3)	4.00	1018.00
Time of 2nd ABG	11	110	103 (82–127)	55.00	225.00

Note: Clinical variables included: oxygen saturation (pulse), respiratory rate, heart rate, blood pressure, temperature. ABG = arterial blood gas, IQR = interquartile range, SD = standard deviation.

FIGURE 2

Time (days) between SickKids admission and extubation.



Miller et al. [22] completed a secondary analysis of the NEAR4KIDS database and found the rate of intubations by RTs much lower than our study (109 out of 12,056; 0.9%), with lower FPS compared to other providers (61 vs. 69%, p = 0.051), especially critical care or emergency physicians and subspecialists. However, RTs had higher FPS compared to resident physicians (61% vs. 48%, p = 0.01) and similar rates compared to nurse practitioners (61% vs. 64%, p = 0.56) or hospitalists (61% vs. 57%, p = 0.77). We could not find literature reporting pediatric intubation prevalence and FPS rates in adult-based community hospitals, especially with intubators other than physician or physician trainees.

Adverse events

Our study found the number of AEs due to intubation was 24 out of 121 patients (20%), with 3 (2%) major and 21 (17%) minor. Like FPS, the rates of AEs vary in the literature [8, 33, 34]. Nett et al. [34] conducted a study across 15 PICUs using the NEAR4KIDS registry (physician or physician trainees intubating, n = 1720), focussing on intubation related AEs and institutional site level. They found similar results with an overall prevalence of 20% and 7% for minor and major AEs, respectively. However, they found significant variation across the 15 sites from 0% to 44% for minor and 0% to 20% for major AEs. A multivariate analysis showed that only the presence of cardiac surgery increased the odds of having an intubation related AE (no significant impact of admission numbers or number of ICU beds). There are few studies within institutions outside pediatric centres. Matettore et al. [33] completed a multicentre observational study over 2 years (n = 1051), describing ED intubations at "non-specialist" centres, subsequent to admission to pediatric centres. They found 312 (30%) AEs occurred in 239 patients, with 170 being major (16%) and 142 minor (14%). Easley et al. [8] completed a prospective study over 18 months following 250 children requiring intubation in locations prior to admission to a PICU, focussing on AEs. Sixty percent of the intubations occurred outside a tertiary/quaternary pediatric institution, with a mix of providers intubating (like our study). Fifty-four percent of children intubated had an AE with 37% major and 17% minor. In contrast to Matattore et al. [33], institutional site had an impact; intubations occurring outside a tertiary care pediatric institute had a significantly greater odds (65%) of more AEs. Results from prior literature may have varied because definitions of AEs differed, including what qualifies as major/severe or minor/not severe [8, 33, 34]. Even if we included a more extensive list of AE criteria, it is likely we could not identify different characteristics of intubation AEs because of our retrospective design. For example, continuous SpO_2 or verbal statements like "Can't intubate, Can ventilate" [33] were likely not documented during ED intubations at Lakeridge Health.

Transfer to pediatric centre

Our study found most children transferred to SickKids (96%) were extubated within a short time of admission (median (IQR) 1.2 (0.29–3.8) days). This is similar to Nishisaki et al. [18], who found that 70% (123/216) of patients transferred from a referring to a tertiary care PICU were extubated within 48 h (median (IQR) 0.63 (0.28–2.5) days). It may be cost and time-efficient [35, 36], with less strain on caregivers [37], to create and implement strategies that avoid transfer and allow pediatric patients to stay at adult-based community hospitals for short durations (24 h), especially for children that can effectively be medically managed there. This can be done in collaboration with pediatric centres, especially with teams that have experience with pediatric airway management [23].

Strengths and limitations

This study is one of few that describes pediatric intubation practices and clinical outcomes at an adult-based community hospital over a 10-year period. This includes information on a range of professions intubating, including physicians and allied health providers. It also provides descriptions of morbidity and mortality for children transferred to a quaternary pediatric centre. The results should be interpreted considering important limitations. Given this study was a retrospective chart review, the accuracy of the results is not known, and there may be inconsistencies in health provider documentation practices and reporting of missing data. Although one of the study's strengths is its breadth over 10 years, variability in practices and policies may have occurred over time and/or between different sites. We had a limited sample size for strong inferences in our statistical analyses such as profession intubating, medication use, and children transferred to SickKids. This is also true given the numerous analyses comparing different clinical variables. There was a wide range of time points for which clinical variables were assessed. Having set assessment time points may provide consistency, especially with respect to follow-up after intubation. Finally, this study took place at one adult-based community health centre in a regional municipality in Ontario, Canada, and may not be generalizable to other institutions and/or geographical regions.

Future implications

Our FPS and AE rates likely varied because of various factors: different definitions, practice location (policies), health providers, and patient characteristics. Girrbach et al. [38] conducted a literature review (2007–2017) and included publications using airway registries (pre-hospital, ED, and/or PICU airway management). The studies included in this review identified 11 airway registries, which utilized them to different degrees (0.2%–10.5%) over variable observation periods (18–156 months). In addition, characteristics of the intubations varied, e.g., rapid sequence induction rates between 28% and 100%, FPS rates varied between 69% and 89%, and use of video laryngoscopy from 0% to 73%. Because of this high variability, comparability (including our study) is "only possible to a limited extent" (Girrbach et al. [38], p. 664). Despite the broad range of results, future investigations should utilize airway registries because they include multi-centred data with larger sample sizes. Organizations could then identify similar institutional and patient characteristics within these registries, to help describe the burden of the problem, and plan implementation strategies suited for their practice culture. This includes developing ways to increase exposure through high fidelity simulation [39] and "live" training programs [40], especially in adult-based community hospitals where pediatric intubations are high stakes, low frequency events.

CONCLUSIONS

Pediatric intubation is a difficult practice that requires specialized training but is rare in an adult-based community hospital system, resulting in limited opportunity for skill maintenance among healthcare providers. Most intubations demonstrated FPS, and there was no significant difference in success between healthcare provider type. Intubations requiring greater than two attempts were rare, and there were relatively few minor and major AEs. This study provides insight on pediatric intubation in the ED of an adult-based community hospital system and will help to inform future strategies for training and education for pediatric airway management, as well as ways to enhance patient outcomes in this type of ED.

DISCLOSURES

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Contributors

VK conceptualized the study. MN, VK, EP, and NK. ST (undergraduate student trainee) collected, cleaned, and summarized data. All authors reviewed and revised the manuscript. MN cleaned and analyzed the data, drafted the initial manuscript, and finalized the manuscript. All authors approved of the final manuscript and agreed to be accountable for all aspects of the work.

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Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years and no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval

This study was approved by the Research Ethics Boards of Lakeridge Health (# 2017-011), Ontario Tech University (#14497), and SickKids (#1000062907). Informed consent was not obtained from participants; ethical requirement of Research Ethics Board approval for informed consent was formally waived because of the retrospective study design.

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