

Comparison of Direct Laryngoscopy to Pediatric King LT-D in Simulated Airways

Donald V. Byars, MD,*† Richard A. Brodsky, MD,‡ David Evans, MD,* Bruce Lo, MD,*§
Theresa Guins, MD,‡ and Amy M. Perkins, MS||

Objectives: Previous reports have shown a high rate of ventilation failure via direct laryngoscopy as compared with the King LT-D airway. This difference is further divergent in the pediatric population. The goal of this study was to compare the difference in efficacy of ventilation by prehospital providers in a simulated environment between direct laryngoscopy and Pedi-King LT-D.

Methods: In this study, 37 paramedics were exposed to 2 identical 5-minute clinical scenarios in a simulation center using a pediatric simulation tool. In the first scenario, the provider was given all of the standard laryngoscopy equipment. In the second scenario, they were given access only to the Pedi-King LT-D. A comparison of adequate ventilation time between the scenarios was performed.

Results: A mean improvement of 102 seconds was found when using the Pedi-King airway, with a clinically significant $P < 0.0001$.

Conclusions: With a significant improvement in ventilation time in these simulated airways, consideration should be made to practice placement of the King Airway Device as first-line airway stabilization. Further live prospective studies would aid in this recommendation.

Key Words: prehospital care, pediatric airway, direct laryngoscopy, supraglottic airway device, simulation

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With inadequate ventilatory support in emergent situations, death and severe morbidity are common outcomes. This is especially true in the critically ill pediatric patient where respiratory compromise is one of the most common etiologies of cardiovascular arrest.^{1–3} Prehospital providers are often called upon to stabilize these critically ill pediatric patients. Bag-valve mask (BVM) ventilation may be insufficient and has its own complications, such as gastric distention, difficulties with seal, and inadequate ventilation; thus, prehospital providers prefer a superior airway. The tools available to the prehospital provider vary greatly, but the most popular methods include direct laryngoscopy and intubation, laryngeal mask airway device, esophageal-tracheal Combitube, and King Airway Device (King LT-D; King Systems, Noblesville, Ind).

Studies in adults and children have shown a high rate of failure with direct laryngoscopy in the prehospital environment.^{4,5} The Denver Metro Study Group showed a 20% failure rate with an additional 5.2% malpositioned tube. The malpositioned sta-

tistic more than doubled with pediatric patients (13%).⁵ A 31% failure rate was found at a major trauma center in Miami,⁶ and further studies show a failure rate between 22% and 40%.⁷ A recent study by Wang et al⁸ showed that pediatric endotracheal intubation by emergency medical services (EMS) workers was successful in 74.3% of children younger than 10 years and 78.9% in children 10 to 19 years old. Wirtz et al⁹ showed that these missed and misplaced intubations are frequently unrecognized at the time of arrival to the hospital. It has even been shown that intubation in the field in certain settings is not superior to BVM ventilation in the pediatric population.^{10,11} Although some studies show that regional success rates may be higher¹² or that survival rate is correlated with paramedic experience with the procedure,¹³ most data points to the conclusion that prehospital airway management is a realm that requires improvement.

Given the risk for adverse events with prehospital intubation of pediatric patients, further evaluation of supraglottic alternative stabilization devices is necessary. Previous comparison studies have shown that, in simulated pediatric patients, prehospital laryngeal mask airway device use provides quicker ventilation and fewer complications than does endotracheal tube placement.¹⁴ In adults, there has been a direct comparison of endotracheal tube placement, esophageal-tracheal Combitube, and the King Airway device, which showed significant advantage in time and airway placement with the King LT-D.¹⁵ Also, a recent study on the King LT-D placement by flight paramedics and nurses showed successful placement of 95.5% in a simulated pediatric airway.¹⁶

The objective of this study was to perform an observational crossover comparison between standard endotracheal tube placement and the pediatric King LT-D.

METHODS

For this study, paramedics from the City of Portsmouth Department of Fire and EMS volunteered to participate as part of a training exercise on the King Airway Device and underwent informed consent. The paramedics were assured that participation and performance in the study would have no impact upon their promotion or employment by the City of Portsmouth.

The paramedics were given an hourlong lecture on the use of airway devices and the pediatric King LT-D device. This instrument is a single-lumen supraglottic device that is secured with 2 air reservoirs (one in the esophagus and one in the posterior pharynx) with fenestration in between to allow the air to enter the trachea. After the lecture, the paramedics were given 2 near-identical clinical scenarios using a pediatric simulation mannequin (Sim Baby, Laerdal, Wappingers Falls, NY). The Sim Baby is a high-fidelity simulator with multiple capabilities including simulation of respiration, pulse rate, lung sounds, heart sounds, and airway difficulty (via increase in tongue swelling). For both clinical scenarios, the tongue swelling was set at the most difficult setting with a large protruding tongue. This was done to represent the extreme of the difficult airway rather than the typical pediatric patient requiring airway management.

From the *Department of Emergency Medicine, Eastern Virginia Medical School; †Tidewater EMS Council Inc; ‡Department of Pediatric Emergency Medicine, Children's Hospital of the King's Daughters, Eastern Virginia Medical School; §Department of Emergency Medicine at Sentara Hospital; and ||Eastern Virginia Medical School, Children's Hospital of the King's Daughters, Norfolk, VA.

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Reprints: Richard A. Brodsky, MD, Department of Pediatric Emergency Medicine St. Christophers Hospital for Children, 3601 A St, Philadelphia, PA 19134 (e-mail: Richard.Brodsky@DrexelMed.edu).

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During the clinical scenarios, the paramedics were faced with a case of an allergic and airway-compromising condition in a 6-month-old patient resulting in the need for a more definitive airway. In the first scenario, they had access to all airway management tools standard on the Advanced Life Support Ambulance. This included all materials necessary for direct laryngoscopy as well as BVM ventilation and other materials. During the second trial, the paramedics had access only to the pediatric King Airway Device and BVM ventilation.

For both clinical scenarios, the measured outcome was the number of seconds of adequate ventilation within a 5-minute period (300 seconds). Regardless of result, the scenario ended after 5 minutes. Physician investigators who were running the scenario using a stopwatch determined “adequate ventilation time.” Subjective observation and objective tools from the simulation mannequin, such as individual lung ventilation, aided in the determination of this result. If adequate ventilation and airway stabilization were reached before the end of 5 minutes, without signs of likelihood of changing status, the scenario was ended early, and remaining time was added to adequate ventilation time.

These results were analyzed using several tests for normality to see if the data could be compared using parametric tests for significance. The conclusion was reached that the standard “direct laryngoscopy” scenario followed a normal distribution, whereas the pediatric King data did not. However, even though the King data were not in a normal distribution, the difference between the clinical scenarios was (Table 1). Based on this, the data were analyzed using the paired *t* test.

RESULTS

Of the 37 volunteer paramedics, 2 were excluded because of inappropriately completed paperwork/consent forms. The remaining 35 paramedics completed both 5-minute clinical scenarios. The average number of seconds of adequate ventilation in the “standard direct laryngoscopy scenario” was 158.6 seconds with an SD of 53.5 seconds. The average number of seconds of adequate ventilation in the “pediatric King airway” scenario was 261.1 seconds with an SD of 20.8 seconds.

There was a very highly significant difference in the number of seconds of adequate ventilation between the standard direct laryngoscopy and pediatric King airway scenarios (*P* < 0.0001) with marked improvement in ventilation time using the pediatric King Airway Device (Table 2).

DISCUSSION

Given the large degree of improvement of ventilation time, a clear superiority can be seen in the use of the pediatric King Airway Device as a first-line rescue device. The investigators observed that most of the improvement in seconds was a decrease in the time to initial adequate ventilation. During the endotracheal tube scenario, subjects lost adequate ventilation time during 3 parts of the procedure: (1) setting up equipment, (2) searching

TABLE 2. Data Summary (Measured in Seconds of Adequate Ventilation Time)

	Mean	SD	Median	Interquartile Range	<i>P</i>
Standard data	158.6	53.5	148.0	121.0–207.0	
King data	261.1		267.0	260.0–272.0	
Difference	102.5	45.9	119.0	63.0–135.0	<0.0001*

**P* value calculated using paired *t* test.

for the vocal chords under direct laryngoscopy, and (3) misplacing the endotracheal tube and therefore forced to make multiple attempts.

The pediatric King Airway Device eliminated most of the seconds lost at these junctures. Setup was minimal, with only the need for lubrication. No visualization is necessary for placement, and the device may be used “blind.” The device was designed to be placed in the esophagus, greatly reducing the rate of “misplacement.” This is reflected in the average increase in ventilation time of over 1 minute 42 seconds.

Limitations to this study include factors that brought the paramedics outside their normal practice environment. The study was performed in a simulation laboratory and not upon live subjects. Also, each clinical scenario was given to a single paramedic. Many of the subjects commented that they would normally have a second paramedic available to perform BVM ventilation, while the tested provider set up for the intubation. Also, although different investigators varied their sequence as to which scenario was first, randomization was not included in the study design. Therefore, some of the paramedics may have learned from their first simulation experience and have improved results on the second. Although this is a possibility, it is unlikely to explain the large gap noted in ventilation time. Finally, the investigators who were recording adequate ventilation time were utilizing subjective measurements (adequate chest wall rise, unilateral chest rise, proper BVM technique) and were not

TABLE 1. Tests for Normality of Data

Normality Test	Standard	King	Difference
Skewness (statistic)	0.031	-2.028	-0.449
Kurtosis (statistic)	-0.491	4.724	-0.646
Shapiro-Wilk (<i>P</i>)	0.51	<0.0001	0.0586
Anderson-Darling (<i>P</i>)	0.26	<0.0001	0.0122
Pearson χ^2 (<i>P</i>)	0.24	<0.001	0.1046

Histogram of Direct Laryngoscopy Results (Seconds)

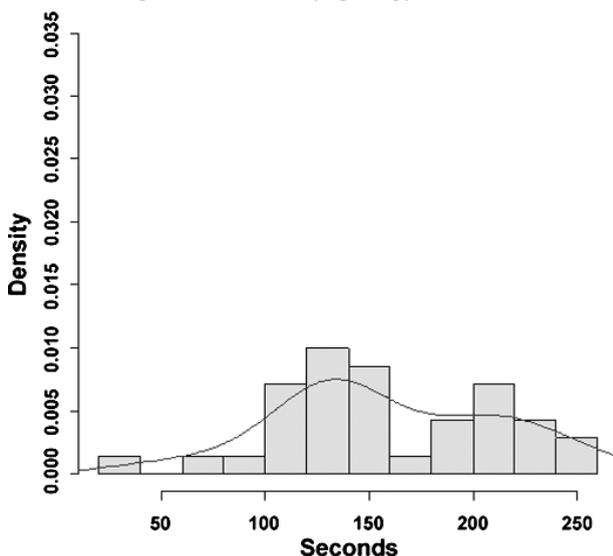


FIGURE 1. Adequate ventilation time (in seconds) using direct laryngoscopy.

blinded to the device. The inclusion of subjective data is an unfortunate necessity with simulation tools as the mannequin was not equipped to translate the ventilatory effort to an equivalent pulse oximetry or other objective measurement.

Multiple studies have shown that there is increased risk of adverse events and outcomes when EMS providers perform direct laryngoscopy in the field. This effect is magnified even more for the pediatric population. The data from this study show that, in simulated conditions of a difficult airway, adequate ventilation time is increased significantly if the first-line airway attempt is made with a pediatric King airway device. This type of scenario may lend itself to favor the King airway because visualization is not required. However, it should be noted that the Pedi-King LT-D is not a definitive airway. If efforts to ventilate via a supraglottic device fail, then definitive airway management should be attempted (Figs. 1 and 2).

While there are many supraglottic devices on the market, it would be impossible to stock an ambulance with them all. Currently, there is very little research in prehospital supraglottic device use in pediatrics. For this study, the investigators chose to compare a single device (in this case, the King airway), to direct laryngoscopy, which is the criterion standard of airway stabilization, rather than compare these multiple options. Perhaps, once this supraglottic airway device has been shown to have better outcomes, a comparison study between it and the other devices will be called for to establish which is superior.

Although further studies are required to prospectively evaluate the improvement in live subjects, this initial simulated trial may indicate that the King airway may have value as first-line

airway stabilization over direct laryngoscopy. However, more data in the form of live, prospective trials will need to be collected before a definitive recommendation can be made.

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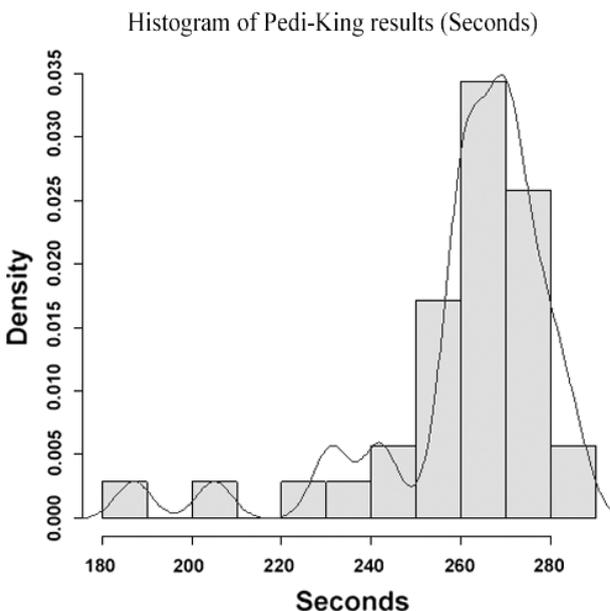


FIGURE 2. Adequate ventilation time (in seconds) using pediatric King Airway Device.