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Evaluation of Standard Endotracheal Intubation, Assisted Laryngoscopy (Airtraq), and Laryngeal Mask Airway in the Management of the Helmeted Athlete Airway: A Manikin Study

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Objectives: Physicians at sporting events must rarely manage the airway of a helmeted athlete. This poses challenges for providers who do not regularly engage in airway management. In a manikin model, our purpose was to determine (1) if standard endotracheal intubation (ETI) of a simulated helmeted athlete is adversely affected by bright-light conditions and (2) if the use of laryngeal mask airway (LMA) or Airtraq improves airway management success.

Design: This is a randomized, prospective, crossover study.

Setting: The study was conducted at a 500-bed community-based hospital with residency training programs in family medicine and emergency medicine, as well as a fellowship in sports medicine.

Participants: We randomized 42 residents to manage the airway of a simulated helmeted athlete in c-spine immobilization using ETI, Airtraq, and LMA. Each method was attempted under bright light and in standard light.

Main Outcome Measures: Our main outcomes were success or failure of airway and time to airway. Secondary outcome was perceived difficulty in airway management as a factor of environmental factors.

Results: Airway success rates were 93% for ETI, 99% for LMA, and 75% for Airtraq. Standard ETI was significantly faster than intubation using the Airtraq ($P = 0.0001$) and had greater success ($P = 0.004$). Time to airway was faster with LMA than with standard ETI ($P < 0.00001$). There was no impact of bright light on ETI time ($P = 0.61$).

Conclusions: These results suggest that both ETI and LMA may be acceptable choices for management of the airway in the helmeted athlete. Time to airway was significantly decreased with the use of LMA, regardless of the experience level of the intubator. Lighting conditions had no effect on success.

Key Words: airway, intubation, helmeted athlete, LMA, Airtraq, football

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INTRODUCTION

Sports medicine physicians must manage emergency situations such as airway compromise on the sidelines of athletic events. The precise numbers of sports-related injuries requiring airway management are unknown; however, it is recognized that catastrophic injuries do rarely occur during sporting events, with football reporting the greatest number in American sports, including 18 fatalities in 2009.[1] Although the actual risk of airway compromise during an athletic event is small, the associated morbidity and mortality are great. Therefore, it is critical that the management of the airway of an injured athlete be a high priority for those who care for athletes during competition.

The provider working at an athletic event is at a disadvantage in managing the airway of an athlete compared with in-hospital providers. Although hospital settings have an array of experienced personnel and equipment to secure an airway, athletic events are frequently poorly equipped to handle such emergencies. Many health care professionals who care for athletes on the sideline may not have opportunities to practice airway management techniques, unlike their hospital-based counterparts. Indeed, most physicians who cover sporting events do not manage patients with airway problems on a regular basis and are fairly inexperienced in this regard.

Additionally, there are factors related to the sport itself that may impact airway management. Environmental factors like lighting and weather might make airway management more technically difficult. When serious injury occurs in athletes involving the head and/or spine, protective equipments such as helmets and shoulder pads may provide a hindrance to safe airway management. However, because of the difficulty in removing equipment without further injuring the cervical spine, it is recommended that the helmet should not be removed initially unless airway management cannot be obtained with the helmet stabilized in place.[2] Methods of airway management not requiring facemask removal using the pocket mask have been studied, but most authorities recommend removal of the facemask

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and implementation of bag-valve-mask ventilation (BVM) and advanced airway maneuvers for airway control.[3,4]

Clearly, then, on-field airway management with cervical spine immobilization is not a simple task.[5] Two recent studies in unhelmeted trauma patients demonstrate a prehospital intubation failure rate of 3.2% to 31%,[6,7] and multiple intubation attempts have been associated with risk of hypoxia and aspiration, even in the hospital setting.[8] Therefore, airway control options in a field setting are needed.

Very little has been published on airway management techniques in the helmeted football player. A recent article revealed that assisted laryngoscopy using the Airtraq (Prodol Meditec S.A., Guecho, Vizcaya, Spain) in novice laryngoscopists improved time to secure the airway in the operating room setting.[9] Numerous studies have looked at laryngeal mask airway (LMA) use by prehospital providers. After minimal instruction, correct placement with the LMA occurred between 90% and 99% of the time.[10–12]

PURPOSE

We sought in this randomized, nonblinded, crossover study using a manikin model to determine if management of the airway in a helmeted athlete using LMA or assisted laryngoscopy with Airtraq reduced the time to successful airway management and reduced the number of failures compared with standard endotracheal intubation (ETI) in the simulated helmeted athlete by providers with varied previous airway management experience. We additionally evaluated whether airway management is adversely affected by positioning and bright-light conditions, both typical of a prehospital sporting venue. We have included a brief summary of the devices used in this study for the education of the reader.

REVIEW OF THE AIRWAY DEVICES

Direct laryngoscopy achieves ETI via a properly positioned lighted blade with an attached handle to align the oral, pharyngeal, and laryngeal axes such that an operator may directly visualize the glottis and airway structures, passing the endotracheal tube between the cords under direct visualization. The safety of ETI has been well studied.[13,14]

The LMA is composed of a medical grade silicone tube with a cuffed mask at the distal end. It is inserted blindly into the pharynx and advanced until resistance is felt as the mask reaches the hypopharynx. The cuff is inflated, sealing the larynx and leaving the distal end of the tube above the glottis. A more advanced version of the LMA, the intubating LMA, allows for blind passage of an endotracheal tube through the LMA after placement (Figure 1).

The Airtraq is an optical laryngoscope designed to provide a view of the glottic opening without aligning the oral, pharyngeal, and laryngeal axes. Compared with the conventional direct laryngoscopy, rigid laryngoscopes require minimal head manipulation and positioning. The blade of the Airtraq has one channel acting as the housing for the placement and insertion of the endotracheal tube, whereas the other channel terminates in a distal lens. The image transmitted to a proximal viewfinder allows visualization of the glottis and surrounding structures, as well as the tip of the tracheal tube (Figure 2).

FIGURE 1. Laryngeal mask airway.

METHODS

This study was reviewed and approved by the institutional review board. It is a randomized, prospective, crossover study conducted at a 500-bed community hospital with residency and fellowship training programs in family medicine (FM), emergency medicine (EM), and sports medicine. Before data collection, FM and EM residents in their first through fourth years of training were shown training videos on proper insertion of an LMA, Airtraq, and ETI using direct laryngoscopy. No practice trials were given with the devices. Using a random number generator, 42 residents were randomized to manage the airway of a simulated helmeted athlete held in cervical immobilization on the ground using direct ETI, LMA, and the Airtraq optical laryngoscope. Each of these techniques was performed in 2 light conditions: bright light condition (using 2 standing spotlights with measured ambient light ~25 000 lux) and standard indoor light condition (ambient light ~40-80 lux). Residents were randomized to begin airway management trials under bright lights or standard lights. Endotracheal tube size was 7.5 mm or 8.0 mm as per the preference of the laryngoscopist, and both Macintosh and Miller blades were provided. Laryngeal mask airway size 4 was used in this study.

Cervical spine immobilization was maintained with in-line immobilization held by a second provider from the caudal position while lying on the floor. The second provider performed the task for each day of study protocol. Three providers held the c-spine in position as the second provider for all 249 airway attempts.

For simulation of the helmeted player, Laerdal Airway Management Trainer manikins were fitted with Riddell VSR-4 helmets with the facemasks removed, as well as Riddell Power

FIGURE 2. Airtraq optical laryngoscope.

shoulder pads and a jersey. The time to secure the airway (in seconds) and the number of failures were recorded. Time was defined as the last breath given via BVM to the first breath given once the airway was secured. Visualized manikin lung inflation signaled a secure airway. Failure was defined as having no airway at 5 minutes or having the resident give up the procedure as futile.

Residents were surveyed regarding background training, subjective opinion of their intubation skills, and previous airway experience with the 3 airway techniques (Table). These surveys used Likert scales or multiple-choice questions from a closed list. Residents also rated the quality of their glottic view with standard ETI and Airtraq using the Cormack–Lehane scale (1, cords; 2, arytenoids; 3, epiglottis; and 4, nothing). Residents also rated ease and comfort of the devices. The easiest method speaks to which of the airway methods each provider felt was simplest to perform. Comfort speaks to what the provider preference would be if given the choice between the 3 airway procedures. For data analysis, residents were categorized based on survey answers as either experienced or inexperienced laryngoscopists, with "experience" defined as having >40 previous ETIs. This value was chosen to coincide with Accreditation Council for Graduate Medical Education (ACGME) requirements for graduation proficiency in EM.[15] Data were also analyzed with regard to previous LMA experience, with "experienced" defined as having placed greater than 5 LMAs previously. This value was chosen because LMA placement has been shown to have a lower learning curve, although there are no set ACGME requirements for this skill for EM or FM training. We also analyzed resident performance based on reported previous experience using Airtraq, with data noted as simply either "any experience" (n > 1) and "no experience." This was done because very few residents had previous experience with Airtraq. We did not seek more experienced providers to enroll in the study because we wanted to determine whether the airway interventions could be used by providers with minimal airway experience, such as might be found at a sporting event. Because our data were not normally distributed, nonparametric statistical analysis was used for ordinal data. Fisher exact test was used for categorical data. Wilcoxon rank sum test was used for comparison of identical airway interventions in different lighting conditions. Descriptive statistics are also reported. Statistical significance was defined as analyses yielding $P < 0.05$.

TABLE. Level of Experience of the Laryngoscopists/Operators Grouped by Number of Previous "Intubations"

No. Prior Uses	ETI	Airtraq	LMA
>40	18	0	1
21-40	9	0	4
11-20	4	1	9
6-10	3	2	11
1-5	6	10	14
0	2	29	3

RESULTS

Twenty-nine EM residents and 13 FM residents participated in the study. Twenty residents were randomized to begin their airway attempts at the standard lighting station, and 22 residents were randomized to begin their airway attempts at the bright-light station. One resident did not complete both stations, yielding 41 residents with complete data sets. The data for the resident who did not complete both stations were included for all global analyses (ie, success rates and time to completion for the different modalities) but were not included for any repeated measures analyses (ie, time to completion of task on first attempt vs second attempt). The 2 groups were similar with regard to previous direct laryngoscopy experience (P = 0.76), previous assisted laryngoscopy experience (P = 0.74), previous LMA experience (P = 1), and type of training program (P = 0.51, Fisher exact test). The overall rate of successful airway management was 89%.

Standard Endotracheal Intubation

Median values and interquartile ranges (IQRs) are reported for objective data. Standard ETI was successful in 93% of airway attempts. Experienced laryngoscopists (n = 18) secured the airway in a median of 32 seconds (IQR, 23.5-38 seconds) compared with inexperienced laryngoscopists (n = 24), who secured the airway in a median of 44 seconds (IQR, 31-67 seconds, P = 0.001, Mann–Whitney test; Figure 3). Six failures occurred in the inexperienced group compared with none in the experienced group (P = 0.03, Fisher exact test; Figure 4). There was no significant difference in time to airway between EM and FP residents (P = 0.26, Mann–Whitney test). There was a decrease in standard ETI time between residents' performance at their first and second assigned stations, with medians of 39.5 and 31.5 seconds (P = 0.01, Wilcoxon rank sum test), regardless of initial lighting condition. There was no impact of bright light on ETI time (P = 0.61, Wilcoxon rank sum test). Endotracheal intubation under bright lights was not felt to be more difficult, with a mean Likert rating of 3.8 [confidence interval (CI), ±0.34]. This perception was the same, regardless of experience ($P > 0.9$). Participants reported that ETI was more difficult on the ground, regardless of skill level, with a mean Likert rating of 2.33 (median, 2.0; CI, ±0.38).

Assisted Laryngoscopy

Assisted laryngoscopy with the Airtraq had an overall success rate of 75%. Although most residents had never performed intubation with Airtraq before, 13 of the 42 residents had used the device at least once in the past. In comparing residents who had performed assisted laryngoscopy before and those who never had, there were no differences in time to securing an airway (P = 0.19, Mann–Whitney test), with inexperienced residents requiring a median of 110 seconds (IQR, 60-141 seconds) and those who had used the device before requiring a median of 57.5 seconds (IQR, 38-96 seconds). Four failures occurred in the 13 residents who had performed assisted laryngoscopy in the past, and 15 failures occurred in the 29 residents who had never used assisted laryngoscopy (P = 0.19, Fisher exact test). Residents who were experienced in standard ETI performed better with Airtraq

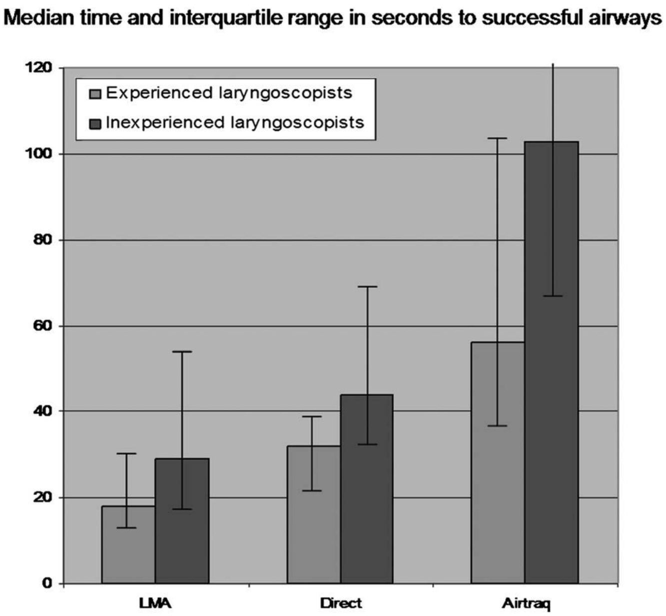

FIGURE 3. Graph demonstrates the median time to successful airway management and IQR for the different methods of airway management for residents of different levels of airway management experience.

than those who were inexperienced. The median time to successful ETI using the Airtraq for experienced laryngoscopists was 53.5 seconds (IQR, 35-104 seconds) compared with 103 seconds (IQR, 66-153.5 seconds) for inexperienced laryngoscopists (*P* = 0.0008, Mann–Whitney test). Six failures occurred with Airtraq in the experienced group of

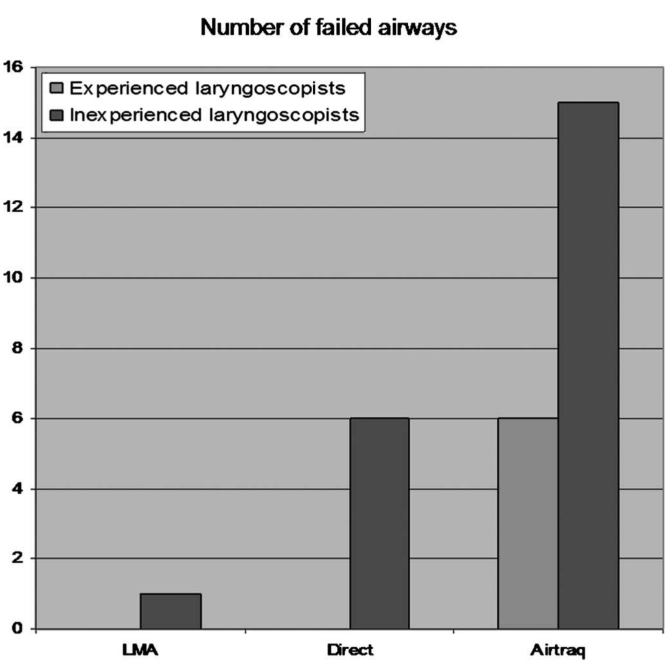

FIGURE 4. Graph demonstrates the number of failed airways for the different methods of airway management for residents of different levels of airway management experience.

laryngoscopists and 15 with the inexperienced group (*P* = 0.08, Fisher exact test). There was no difference in time to successful airway management between residents' first and second stations (*P* = 0.51, Mann–Whitney test); however, residents were more likely to fail on their initial station (*P* = 0.04, Fisher exact test). Bright lighting had no effect on likelihood of successful intubation with the Airtraq (*P* = 0.61, Fisher exact test).

For the 24 residents who were successful at both stations with the Airtraq, bright lighting had no effect on time to intubation (*P* = 1, Wilcoxon rank sum test). Comparing all successful intubations using Airtraq, bright lighting did not affect time to intubation (*P* = 0.91, Mann–Whitney test). Airtraq use with bright lighting was not perceived as more difficult, with mean/median Likert ratings of 3.6/4 (CI, ±0.3).

Laryngeal Mask Airway

Residents using LMA had an airway management success rate of 99%. The median time to LMA placement was 19 seconds (IQR, 14.5-35.5 seconds) in those with previous LMA experience (n = 25) and a median of 35 seconds (IQR, 21-60 seconds) in those without previous LMA experience (n = 17, *P* = 0.0001, Mann–Whitney test). There were no differences in failure rates between the experienced and inexperienced groups, with a single failure occurring in the experienced group. Previous ETI experience did not affect time to LMA placement (*P* = 0.06). Bright light did not have an effect on time to LMA placement, and residents did not think bright lighting made placement more difficult (mean Likert rating, 4.1; median, 4).

Intergroup Comparisons

Using the Cormack–Lehane scale, operators rated the quality of glottic view similarly between standard ETI and Airtraq, with most operators able to visualize cords (mean, 1.45; median, 1 for direct ETI; mean, 1.37; median, 1 for Airtraq). Time to airway management was faster with standard ETI compared with Airtraq (median, 36 vs 81.5 seconds, *P* = 0.0001). Failure rate with Airtraq was higher than that with standard ETI (*P* = 0.004). The time to airway management was faster with LMA than with standard ETI (median, 23 vs 36 seconds, $P < 0.00001$). Failure rates were not significantly different between these 2 groups (*P* = 0.12). Subjectively, 21 residents (50%) reported standard ETI to be the easiest airway management method, and 21 (50%) reported LMA to be the easiest. No one thought Airtraq was the easiest. Thirty-one residents (74%) stated that they were most comfortable with standard ETI when confronted with an airway management task, and 10 (24%) were most comfortable with LMA. One resident (2%) was most comfortable using the Airtraq. Thirty residents (71%) stated that airway management was hardest with the Airtraq, and 32 (76%) stated that they were least comfortable with this method.

LIMITATIONS

Our study is limited by our choice of simulator model. This study incorporated a torso-only model, and although this was consistent between the groups, there may be differences in airway position and alignment in our model versus a typical helmeted athlete with padding. The torso-only model also made it straightforward to assess a successful airway intervention because the lungs are visible. Airway assessment after intubation may be much more difficult in the fully geared athlete, and our recorded times to airway success may not reflect actual circumstances in recognizing a successful or failed attempt. The results of this manikin study may not be totally extrapolated to an actual on-field airway emergency, where conditions such as weather, proper equipment fit, other injuries, and patient size may affect the ability to manage the airway. Our study did not evaluate cervical spine movement during airway manipulation. All airway maneuvers will result in some degree of neck movement. The amount of movement is small and may be restrained by in-line immobilization, but it is not eliminated. Although immobilization was established consistently in both groups, our choice of simulator model may not have accurately reflected the movement of the cervical spine during airway attempts. It is unclear if the degree of neck movement in our study model could have affected the success of the various airway techniques.

Residents' previous airway experience may have affected our results. Most residents have more familiarity and experience with standard ETI than with other airway devices. This is likely why they felt more confident with standard ETI and LMA over the Airtraq. It is fair to say that if participants had similar previous training opportunities with the Airtraq as with standard ETI, the success rate for this adjunct may have been different. Although this did not seem to affect the success rates of the LMA, this method may require less anatomic knowledge or technical expertise and be more appropriate for novices. Although it seems that the lighting conditions made no difference with respect to subjective assessment by participants or successful airway intervention times, this may not be consistent with all lighting conditions. Our study was conducted indoors using spotlights for the bright-light group, which may not be representative of a bright outdoor environment. Our measured lighting was consistent with outdoor lighting; however, our lights were concentrated on our study area and were not diffuse as one might encounter midday when out-of-doors. Perhaps if this study were conducted outside, we may have appreciated differences in groups attributable to lighting.

DISCUSSION

Our results suggest that both ETI and LMA may be acceptable choices for airway management in the helmeted athlete. Time to airway was significantly decreased with the use of the LMA, regardless of previous experience. Other studies suggest that the LMA is easily taught to even novice practitioners and is a safe alternative to direct laryngoscopy in unhelmeted patients.[16] This article supports LMA use as a reasonable alternative to direct laryngoscopy for most physicians who cover sporting events and who do not intubate patients on a regular basis. Note the LMA does not prevent aspiration and thus is usually only used as a temporary ventilation device until a definite airway can be placed, although an intubation LMA is available and can be used after airway control to facilitate ETI for a definitive airway if needed. Relative contraindications for the LMA and other airway devices are discussed elsewhere.[16] It was hypothesized that assisted laryngoscopy with Airtraq might be a quicker and thus safer mode of airway control in practitioners who are not as experienced in the techniques of ETI via direct laryngoscopy. Some studies have found that the Airtraq is a safe alternative to direct laryngoscopy with good success rates even in novice laryngoscopists.[11,17,18] Other studies looking at different video laryngoscopy tools have shown similar positive conclusions,[16,19–22] especially in emergency department patients.[23,24] However, not all studies looking at video laryngoscopy are so positive.[25] Our data were not supportive because the Airtraq performed poorly in this setting compared with ETI and LMA. The preference for direct laryngoscopy over Airtraq may be due in part to the lack of experience with this device, as well as the difficulty simulating actual intubation feel and experience using a Laerdal Airway Management Trainer manikin.

Lighting conditions in this study had no effect on airway success. Two light conditions were chosen to represent the most extreme but common potential prehospital settings: outdoor night setting (ambient lighting of ~40 lux) and outdoor day setting (ambient lighting of ~25 000 lux).[26] The night setting of 40 lux approximates the illumination of a lighted street at midnight, and the day setting of 25 000 lux is similar to the illumination of a street at noon on a clear sunny day. The out-of-hospital setting is often very different with regard to background lighting conditions and patient positioning. Brighter ambient conditions have been shown to be associated with a slightly longer time to intubation,[27] although this was not found in our study.

CONCLUSIONS

Laryngeal mask airway was more successful in less time in the management of the airway of the simulated helmeted athlete, regardless of provider experience. Airtraq use was less successful and took significantly more time, despite providing equivalent visualization compared with standard ETI. There was no impact of bright light on airway management, and it was not felt to be more difficult under different lighting conditions, although airway management was felt to be more difficult on the ground.

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