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Airway Management in Athletes Wearing Lacrosse Equipment

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Context: Patient ventilation volume and rate have been found to be compromised due to the inability to seal a pocket mask over the chinstrap of football helmets. The effects of supraglottic airway devices such as the King LT and of lacrosse helmets on these measures have not been studied.

Objective: To assess the effects of different airway management devices and helmet conditions on producing quality ventilations while performing cardiopulmonary resuscitation on simulation manikins.

Design: Crossover study.

Setting: Simulation laboratory.

Patients or Other Participants: Thirty-six athletic trainers (12 men, 24 women) completed this study.

Intervention(s): Airway-management device (pocket mask, oral pharyngeal airway, King LT airway [KA]) and helmet condition (no helmet, Cascade helmet, Schutt helmet, Warrior helmet) served as the independent variables. Participant pairs performed 2 minutes of 2-rescuer cardiopulmonary resuscitation under 12 trial conditions.

Main Outcome Measure(s): Ventilation volume (mL), ventilation rate (ventilations/min), rating of perceived difficulty (RPD), and percentage of quality ventilations were the dependent variables.

Results: A significant interaction was found between type of airway-management device and helmet condition on ventilation volume and rate ($F_{12,408} = 2.902$, $P < .0001$). In addition, a significant interaction was noted between airway-management device and helmet condition on RPD scores ($F_{6,204} = 3.366$, $P = .003$). The no-helmet condition produced a higher percentage of quality ventilations compared with the helmet conditions ($P \leq .003$). Also, the percentage of quality ventilations differed, and the KA outperformed each of the other devices ($P \leq .029$).

Conclusions: The helmet chinstrap inhibited quality ventilation (rate and volume) in airway procedures that required the mask to be sealed on the face. However, the KA allowed quality ventilation in patients wearing a helmet with the chinstrap fastened. If a KA is not available, the helmet may need to be removed to provide quality ventilations.

Key Words: cardiopulmonary resuscitation, airway management, protective equipment

Key Points

- The helmet chinstrap inhibited quality ventilation (rate and volume) in airway procedures that required the seal of a mask on the face.
- The King LT-D airway device allowed quality ventilation in patients wearing a helmet with the chinstrap fastened.
- If a King airway device is not available, the helmet may need to be removed to provide quality ventilations.

Lacrosse carries a significant injury risk because it is a high-velocity collision sport. As such, injuries to the head and neck are not uncommon[1] and catastrophic injury is a risk.[2] Participation in the sport is also growing quickly, expanding rapidly in the South and Midwest and on the West Coast.[3] In sports such as lacrosse, in which participants wear equipment, obstacles can interfere with on-field emergency management. Men's lacrosse athletes are required to wear a helmet with a facemask, a potential obstacle when accessing a patient's airway. When cervical spine injury is suspected, health care providers must quickly gain access to the airway while limiting motion of the head and neck.[4]

To improve patient outcomes, it has recently been suggested[5] that all equipment be removed on-field before transport. However, equipment removal may be difficult as it requires 3 or more trained responders, and many athletic trainers (ATs) depend on emergency medical services (EMS) for assistance.[6] A lack of time for ATs and EMS to train together regularly as a team has been a barrier to collaboration between the groups.[6] However, ATs and local EMS staff should collaborate on scenario training to allow for safe equipment removal on the field.

Some evidence suggested that facemask removal (FMR) can be performed expediently[7–9] while creating little movement at the head and neck.[7] Results of another study,[10] however, supported leaving the helmet in place as helmet removal by 2 responders created more motion of the head and neck in the sagittal plane compared with FMR. Further, leaving the helmet and shoulder pads in place did not affect the space available for the spinal cord, which also supported leaving the helmet in place and performing FMR.[11] Once the airway is accessible, using the most common airway-management device, the pocket mask (PM), may not be feasible. Providing rescue breaths via a PM or bag valve mask may not be possible due to the

inability to perform a jaw-thrust maneuver and to maintain an adequate seal of the mask to the patient's face because of interference by the helmet chinstrap.[12,13] It is important to point out that neither group examined lacrosse helmets or used supraglottic airway devices for providing ventilations. Supraglottic airway devices are inserted blindly and in most states are considered within the ATs' scope of practice because they are used for basic life support.[14] Knowledge and skill in the use of supraglottic airways has been included in the formal education of ATs since 2011.[15]

The purpose of our study was to determine if quality ventilations (volume and rate) could be delivered to a lacrosse-helmeted simulation manikin with a suspected cervical spine injury using traditional airway-management (PMs) and airway-adjunct (oral pharyngeal airways and King airways) procedures. We also evaluated the rating of perceived difficulty experienced by the ventilator in each trial condition to identify which devices the participants found easiest to use. Lastly, we explored whether the percentage of quality ventilations would be different based on the airway-management device and helmet condition. We included this final analysis as it describes the percentage of ventilations that fell between 400 and 700 mL (American Heart Association [AHA] guideline for quality ventilation volume[16]) rather than only the average volume across all ventilations per trial.

METHODS

We used a 3 (airway devices) $\times$ 4 (helmets) repeated-measures design to determine the effects of the airway-management device and helmet condition on ventilation volume (mL) and rate (ventilations/min) during cardiopulmonary resuscitation (CPR) performed on high-fidelity manikins. Our secondary aims were to determine the ratings of perceived difficulty (RPDs) and differences in percentage of quality ventilation due to the airway-management device and helmet condition. This study was approved by the institutional review boards at Seton Hall University and Lynchburg College before data collection.

Participants

We recruited 36 ATs (12 men, mean age = 33.3 $\pm$ 9.7 years; 24 women, mean age = 33.4 $\pm$ 9.8 years) via email. Each participant signed an informed consent form before starting the study. All participants held current professional rescuer-level CPR certification (26 from the AHA, 10 from the American Red Cross) and current state licenses to practice as ATs. To be included in the study, all participants self-reported being free of any diagnosed skeletal, muscular, cardiovascular, or neurologic condition that would impair their ability to kneel and perform CPR. Once we confirmed that all interested participants met all the inclusion criteria, they were paired based on availability for the duration of the study. Participant pairs were required to report to the laboratory 3 times (1 training session and 2 data-collection sessions). Sessions were spaced approximately 7 days apart.

Instruments

We used the Resusci Anne Q-CPR manikin with airway head and SimPad Reporter (Laerdal Medical, Wappingers Falls, NY) to collect the volume and rate of ventilations during the CPR trials. The manikin was placed in a supine position on the floor of the simulation laboratory to better replicate what might happen during athletic competition. The Q-CPR manikin provides reliable measures of ventilation volume and rate as well as other variables associated with the quality of CPR.[17] It is important to note that the manikin only registers a ventilation when the participant is able to supply $\geq$10-mL ventilation to the manikin lungs. Therefore, if a ventilation attempt does not reach the 10-mL threshold, no ventilation is registered, altering the ventilation rate. We integrated the Q-CPR manikin with the ETC Fusion Portable System (Kb Port, Allison Park, PA). The ETC Fusion Portable System had 3 digital video cameras (Logitech HD; Logitech International S.A., Lausanne, Switzerland) that captured manikin data simultaneously during each CPR trial.

The 36 participants were stratified into 3 equal groups of 6 pairs for helmet assignment. Each group was assigned 1 of the helmet brands and used the same helmet for each CPR trial throughout the study. We used 3 types of helmets in the study (Figure 1): Cascade R ([CH] Cascade, Inc, Liverpool, NY), Schutt Stallion ([SH] STX LLC, Baltimore, MD), and Warrior Evo ([WH] Warrior Inc, Boston, MA). We chose to study these 3 helmets based on anecdotal popularity and to allow our results to be more generalizable. The facemasks and chinguards of each of the helmets were removed from each helmet before it was fit to the manikin and were left off for data collection to simulate a condition in which the responder had already performed FMR to access the airway. The research team adjusted the helmets using the manufacturer-provided inserts to obtain a proper helmet fit to the head of the manikin. The chinstrap was centered on the chin, and all 4 snaps were fastened for a snug fit. The manikin also wore lacrosse shoulder pads for all helmeted trials because lacrosse rules require helmet and shoulder pad use during participation. In addition, we wanted to include shoulder pads to position the airway as would be likely in the event of a catastrophic injury when wearing lacrosse equipment.

We used 3 airway-management devices: adult-sized PM with 1-way valve (Laerdal Medical), No. 5 large adult (11-mm) emergency oral airway ([OPA] Dynarex Corporation, Orangeburg, NY), size 4 King LT-D airway ([KA] King Systems Corporation, Noblesville, IN) as seen in Figure 2. The PM condition required the participant to seal the mask to the face of the manikin while performing a jaw thrust to produce successful ventilations. The OPA was placed in the mouth of the manikin by the research team to simulate an unconscious patient with a tongue blocking the airway. After the OPA was inserted, the participant was required to seal the PM to the face of the manikin to produce successful ventilations; however, no jaw thrust was needed. The KA is a single-lumen tube that clinicians insert using a blind technique in unconscious patients with an absent gag reflex. The KA has distal and proximal balloons that occlude the esophagus and oropharynx, which allows for ventilation with a reduced risk of aspiration. We inserted the properly sized device and inflated the balloons with the recommended volume via a large syringe and attached the 1-way valve from the PM to the KA. We chose this method so that any differences in ventilation rate and volume could be attributed to the interaction between the airway-manage-

Figure 1. Helmets used in this study (from left to right): Cascade R (Cascade, Inc, Liverpool, NY), Schutt Stallion (STX LLC, Baltimore, MD), and Warrior Evo (Warrior Inc, Boston, MA).

ment device and the helmet condition and not to improper application of the device by the participants. All participants used each airway-management device in a no-helmet (NH) condition and with their assigned helmet.

Data-Collection Procedures

Training Session. During the first session, participants signed an informed consent form and completed a demographic questionnaire. They then watched an informational video created by the research team on the Resusci Anne Q-CPR manikin, which reviewed the components of high-quality CPR, as defined by the AHA.[16] The videos were created by 2 trained rescuers following standardized procedures from the AHA for CPR. The video specifically set the scenario as a "lacrosse athlete in cardiac arrest who has no pulse and is not breathing with a suspected cervical spine injury." After viewing the video, participants had the option to ask questions before performing a CPR-simulation test on the manikin. Each participant received a PM with 1-way valve and hydrophobic filter to use throughout the study to prevent cross-contamination. For the training session, we placed the manikin supine with no protective equipment in place on the floor of the simulation laboratory. We positioned foam mats at the manikin's head and to the left side for the ventilator and compressor to kneel on while performing 2-rescuer CPR. The ventilator was instructed to stabilize the head of the manikin during the 2-minute intervention because of the suspected cervical spine involvement. The simulation tests occurred with each participant randomly assigned as either a compressor or a ventilator during the CPR trial (approximately 5 cycles of CPR). Standard 2-rescuer AHA CPR protocol was used (30 compressions followed by 2 ventilations per cycle). Once the participants were in position, a member of the research team announced, "Begin CPR." The SimPad, which contained a visible 2-minute clock but provided no other feedback, was placed on the ground next to the participants. The timer started when the first compression was delivered.

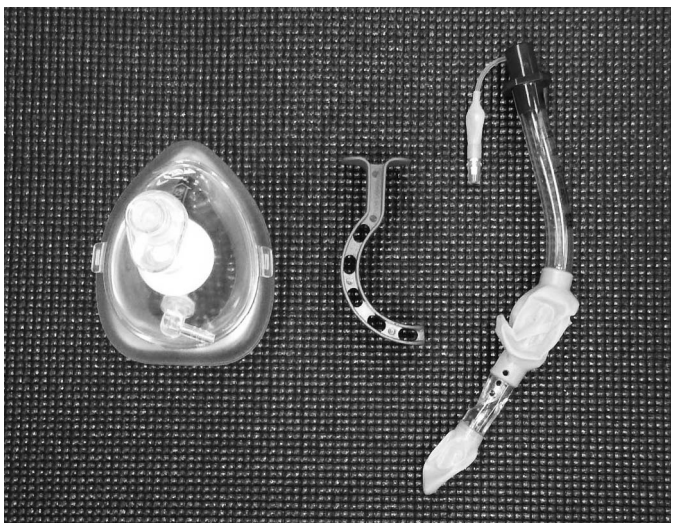

Figure 2. Airway-management devices used in this study (from left to right): adult-sized pocket mask with 1-way valve (Laerdal Medical, Wappingers Falls, NY), No. 5 large adult (11-mm) emergency oral airway (Dynarex Corporation, Orangeburg, NY), size 4 King LT-D airway (King Systems Corporation, Noblesville, IN).

Each pair had to earn an overall CPR score above 80% for the simulation trials. The score provided by the SimPad was calculated using an algorithm that takes into account incorrect compression depth, incorrect compression rate, incomplete release, inaccurate hand placement, flow-time fraction, incorrect ventilation volume, and incorrect ventilation rate. If a pair failed to reach 80%, they remediated by watching additional videos created by the research team on high-quality CPR and performing CPR on the manikin using the training mode, which allowed participants to view the volume and rate of ventilations in real time. Participants were allowed a maximum of 30

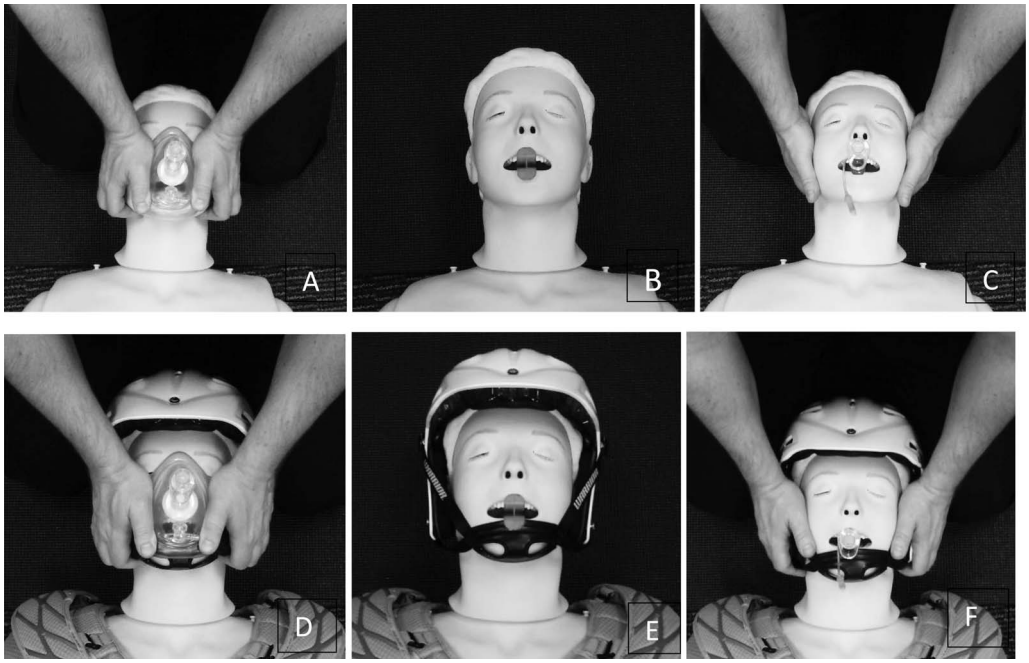

Figure 3. Ventilation trials completed by participants. A, pocket mask (PM; Laerdal Medical, Wappingers Falls, NY) without equipment; B, oral pharyngeal airway (OPA; Dynarex Corporation, Orangeburg, NY) without equipment (participants had to use the PM over the OPA); C, King LT-D airway (KA; King Systems corporation, Noblesville, IN) without equipment; D, PM with equipment; E, OPA with equipment (participants had to use the PM over the OPA); F, KA with equipment.

minutes of remediation time for practicing CPR on the simulation manikin in the training mode. When the pair felt comfortable, they took a 3-minute break and then completed another CPR-simulation test. If remediation was required again, these steps were repeated until the pair achieved a score of 80% or above. No group required more than 3 remediation sessions or total remediation that lasted longer than 30 minutes. After the first successful simulation test (overall score above 80%) and a 3-minute break, the participants switched positions to allow each to provide ventilations. We followed the same steps to complete the simulation test with the participant roles reversed. The CPR proficiency testing was performed on the manikin only in the no-equipment condition.

Data-Collection Sessions. Approximately 7 days after the training session, participants reported to the simulation laboratory for the first data-collection session. The session started with participants viewing the video created by the research team. Afterward, the participant pairs performed 6 trials (3 each as ventilator) of CPR on the manikin with the airway-management device and helmet condition counterbalanced. The manikin was positioned the same way it was in the training session. If the helmet and shoulder pads were in place, the participant performing ventilations was not allowed to manipulate or remove the chinstrap because a properly fitted helmet provides stability to the head and neck with a suspected spine injury.[4,18] For trials involving the OPA or KA, members of the research team properly inserted the device. Participants received no feedback on performance after each data-collection trial. After a trial, the participant was given a 3-minute rest period and the role of the compressor changed to allow the participant additional rest to prevent any influence of fatigue. During the 3-minute rest period, the participants completed an RPD form that consisted of a scale from 0 to 10 (0 = *rest*, 10 = *maximal difficulty*). Approximately 7 days later, the participants returned for the second and final data-collection session. The procedures for the second session replicated the first: 6 CPR trials with different combinations of airway-management device and helmet condition after watching the same informational video. Figure 3 depicts the 6 trials performed by each participant. The airway-management device and helmet conditions were counterbalanced across the 2 data-collection sessions.

Statistical Analysis

We used a multivariate analysis of variance to evaluate the main and interactive effects of airway-management device (PM, OPA, or KA) and helmet condition (NH, CH, SH, or WH) on the ventilation volume (mL) and rate (ventilations/min). This analysis was conducted because of the moderate relationship between the 2 dependent variables ($r = 0.57$). Univariate analyses and Bonferroni adjusted post hoc tests were calculated when the results from the multivariate analysis of variance were significant. Before performing all analyses, we conducted assumption testing of multicollinearity between variables, multivariate normality, and homogeneity of variance-covariance matrices. We then used a 2-way analysis of variance to assess differences in RPD scores based on airway-management device and helmet condition. Finally, nonparametric tests were used for all analyses of the variable percentage of quality ventilations, which was classified as a categoric variable. The percentage of quality ventilations measured the ventilation volumes that fell between 400 and 700 mL over the 2-minute trial. A Kruskal-Wallis analysis was applied to each independent variable (airway-management

Table. Descriptive Statistics of Helmet Conditions and Airway-Management Devices for Ventilation, Volume, and Rating of Perceived Difficulty Scores, Mean ± SD[a]

Helmet[b] Condition	Ventilation Rate, ventilations/min			Mean Volume, mL			Rating of Perceived Difficulty Score		
	PM	OPA	KA	PM	OPA	KA	PM	OPA	KA
No helmet	5.0 ± 1.2	5.3 ± 1.1	5.7 ± 1.5	554.1 ± 193.3	550.3 ± 162.4	632.7 ± 250.7	1.8 ± 1.0	1.8 ± 0.9	1.3 ± 0.8
Cascade helmet	3.0 ± 2.2	2.8 ± 2.6	5.3 ± 0.9	277.6 ± 149.3	254.5 ± 211.6	597.1 ± 217.1	4.3 ± 2.3	4.1 ± 2.5	1.3 ± 0.7
Schutt helmet	3.8 ± 1.5	3.6 ± 2.3	5.2 ± 0.8	354.6 ± 75.3	404.7 ± 197.5	788.0 ± 294.0	4.2 ± 2.3	3.3 ± 1.7	2.0 ± 1.4
Warrior helmet	2.8 ± 2.8	2.5 ± 2.5	5.9 ± 0.7	249.3 ± 269.3	267.2 ± 215.3	605.7 ± 248.8	2.6 ± 1.4	2.1 ± 1.5	1.3 ± 1.9

Abbreviations: KA, King airway; OPA, oral pharyngeal airway; PM, pocket mask.

[a] PM (Laerdal Medical, Wappingers Falls, NY); OPA (Dynarex Corporation, Orangeburg, NY); KA (King Systems Corporation, Noblesville, IN).

[b] Cascade R (Cascade, Inc, Liverpool, NY); Schutt Stallion (STX LLC, Baltimore, MD); and Warrior Evo (Warrior Inc, Boston, MA).

device and helmet condition) separately with a Mann-Whitney test post hoc. Data were analyzed using SPSS (version 22.0; IBM Corp, Armonk, NY). An α of .05 was used for all analyses.

RESULTS

All 36 participants started and completed the research project with their assigned partner. In total, 216 trials were performed (6 trials by each of the 36 participants). Each participant performed 1 trial with each airway-management device (PM, OPA, or KA) in both the NH condition and with the manikin wearing the assigned helmet model (CH, SH, or WH). Descriptive statistics for the 3 continuous dependent variables are shown in the Table. All assumptions were met except for the homogeneity of variance-covariance matrices; therefore, the Pillai trace is presented. A significant interaction was observed between the type of airway-management device and helmet condition for ventilation volume and rate ($F_{12,408} = 2.902$, $P < .0001$). For both ventilation rate ($F_{6,204} = 3.468$, $P = .003$) and mean volume ($F_{6,204} = 3.735$, $P = .002$), significant interactions were present between the type of airway-management device and helmet condition.

Ventilation Rate

Results from post hoc testing with Bonferroni adjustment suggested that during the NH condition, no pairwise comparisons were different ($P > .05$), as seen in Figure 4. In the CH and WH conditions, the ventilation rates for both the PM ($P = .002$ for CH and $P < .0001$ for WH) and OPA ($P < .0001$ for CH and $P < .0001$ for WH) devices were lower than for the KA device. For the SH, no pairwise comparisons for ventilation devices were different ($P > .05$). Using the KA device produced the highest ventilation rate in all 4 conditions.

Ventilation Mean Volume

Measures of ventilation mean volume were not different ($P > .05$) during the NH condition, as seen in Figure 5. For all helmet conditions (CH, WH, and SH), differences occurred between the PM and KA ventilation devices ($P < .0001$) as well as between the OPA and KA devices ($P < .0001$). The ventilation mean volume was lower for the OPA and PM devices compared with the KA device for all helmet conditions.

Rating of Perceived Difficulty Scores

A significant interaction was noted between the airway-management device and helmet condition ($F_{6,204} = 3.366$, $P = .003$) for the RPD score. The RPD score was lower using the KA device compared with the PM ($P < .0001$) or the OPA ($P < .0001$) device used with the CH. The KA device used with the SH also produced a lower RPD score compared with the PM ($P = .001$). Pairwise comparisons of devices produced equal RPD scores for the NH and WH conditions ($P > .05$). Overall, the KA device used with the CH or the SH produced the lowest RPD scores.

Percentage of Quality Ventilations

The 4 helmet conditions varied in the percentage of quality ventilations ($\chi^2_3 = 25.350$, $P < .0001$). Pairwise comparisons showed differences between the NH and each of the helmet conditions ($P < .0001$ for CH, $P = .003$ for SH, and $P < .0001$ for WH). However, no pairwise comparisons between helmets were different ($P > .05$) for the percentage of quality ventilations. The percentage of quality ventilations ($\chi^2_2 = 9.926$, $P = .007$) differed among the 3 ventilation devices. The pairwise comparisons suggested differences for the KA versus the other devices ($P = .029$ for OPA, $P = .003$ for PM). However, the PM and OPA were not different for the percentage of quality ventilations ($P = .310$).

DISCUSSION

We evaluated the effectiveness of several airway-management devices used by ATs who performed ventilations on a simulation manikin under different helmet conditions. When the manikin wore equipment, the KA allowed for a greater ventilation volume and a higher ventilation rate than did the PM and OPA, both of which required the participant to make a seal with the mask. Of at least equal importance to the statistically significant findings, our results also carry clinical significance. Specifically, the 2015 AHA guidelines[16] recommended a ventilation volume between 400 and 700 mL and a rate of 5 or 6 breaths/min. Only the participants using the OPA in the SH condition (404.7 ± 197.5 mL) achieved the recommended 400-mL volume, even though the mean ventilation rate was below the AHA recommended rate (3.6 ± 2.3 breaths/min).

These results demonstrate that the chinstrap of the helmet interfered with the ability to provide quality ventilations using a mask device (PM or OPA) to lacrosse-helmeted

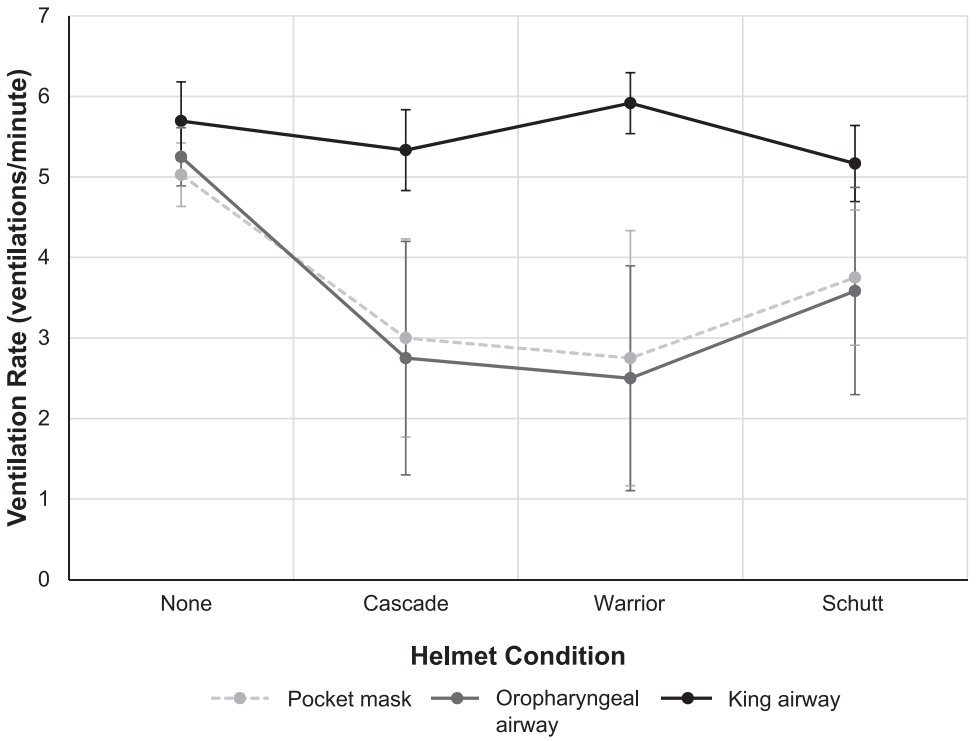

Figure 4. Comparisons of ventilation rate (ventilations/minute) for airway-management device and helmet condition.

athletes. Further, based on the lack of differences between the PM and OPA, when a helmet and chinstrap were in place, performance of a jaw thrust was not the cause of the inability to provide quality ventilations. A jaw thrust is not required when using the OPA but is required when only the PM is used. However, neither the OPA nor the PM permitted quality ventilations to the manikin, leading us to believe that creating a seal was the main hindrance to providing CPR when the helmet and chinstrap were in place.

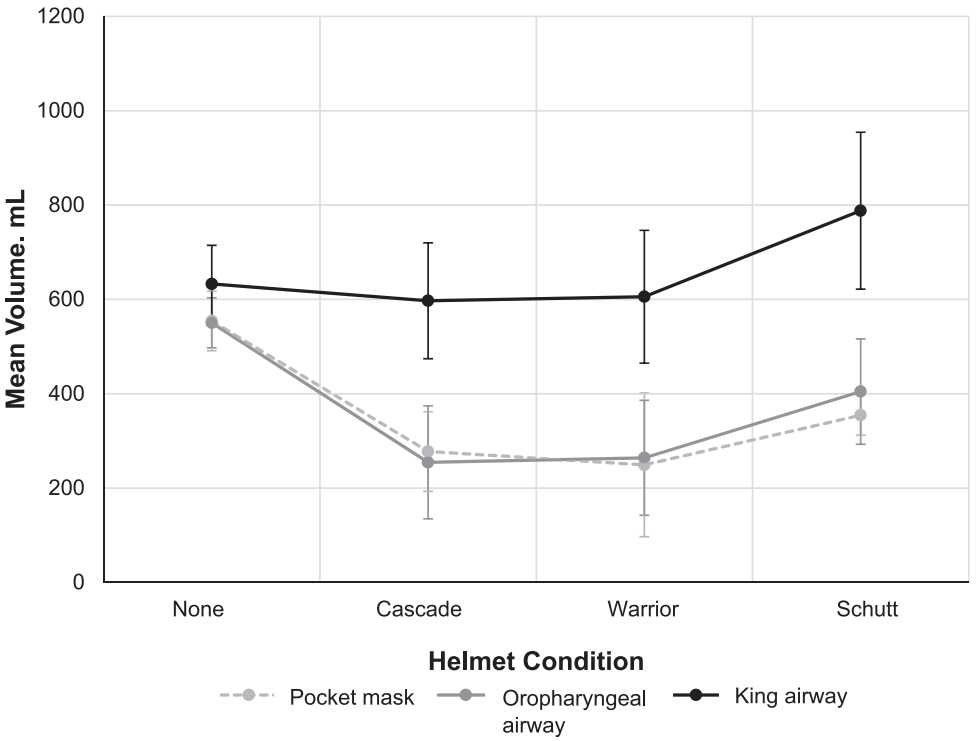

Figure 5. Comparisons of mean volume (mL) for airway-management device and helmet condition.

Lacrosse-helmeted athletes can be successfully ventilated using the KA, which is placed supraglottically. Additionally, the participants' RPD scores for the KA were less than those for the PM and OPA in the helmeted conditions, indicating that the ATs struggled less with this airway-management device. In the NH condition, we found that participants were able to deliver the AHA-recommended ventilation rate and volume using all devices (PM, OPA, and KA). Furthermore, the participants had lower RPD scores (indicating less difficulty providing ventilations) in the NH condition compared with the helmeted conditions, regardless of the airway-management device, which helps to confirm that the helmet with chinstrap created an airway-management challenge.

The interactive effect of the airway-management device and helmet condition on the combined ventilation volume and rate demonstrates the interrelationship of the independent variables on these dependent variables in providing quality ventilations to a patient. When the manikin wore a helmet and the mask needed to be sealed, the ventilation rate was less than the recommended 2 ventilations per CPR cycle. The manikin failed to register a ventilation volume, which, in turn, affected the ventilation rate. Failure to register a ventilation volume was most often a result of the inability of the participant to make a seal of the PM over the helmet chinstrap. We believe the low ventilation rate was not the result of a lack of participants' CPR skill proficiency. We reviewed video of all trials, and in every case, the participants performed the 2 rescue breaths after the 30 compressions; in some instances, if they failed to see the chest raise, they attempted a third ventilation. Our participants all tested at a score of 80% or better before the study, indicating CPR proficiency. The fact that the RPD scores were all higher in the helmet conditions compared with the NH condition when using the PM demonstrates that the participants found it difficult to seal the mask over the helmet chinstrap.

Our data support the findings of other authors[12,13] who suggested the helmet chinstrap inhibited the ability to provide quality ventilations using a PM. The results of a study[13] using football helmets caused the researchers to recommend that the entire helmet be removed to provide ventilations when using any mask device (bag valve mask or PM). We agree that the helmet may need to be removed when the only available airway-management devices require a seal against the patient's face.

Although it has recently been suggested[5] that equipment should be removed during on-field emergencies to improve patient outcomes, we believe that FMR to gain access to the airway of a helmeted patient is useful during the initial management of cervical spine injuries because most ATs will require assistance from EMS staff to remove equipment.[6] Leaving a well-fitted helmet in place and performing FMR should limit cervical spine motion and maintain a neutral alignment.[4] In an airway-management investigation[13] of football helmets, only a small subsample with chinstrap conditions using a 2-person bag valve mask procedure was tested because they had such difficulty performing a modified jaw thrust and ventilating the patient. In a study[19] of airway management with lacrosse helmets, participants had similar difficulty ventilating patients using a bag valve mask but were highly successful using a King airway. Similarly, our data suggested that the clinician can provide quality ventilations using a King airway when performing FMR and that the helmet and chinstrap should be left intact to stabilize the head and neck with a suspected cervical spine injury. However, the helmet can be removed more quickly than the facemask.[10] If the facemask cannot be removed quickly without substantial motion, helmet removal should be considered. For a player wearing football equipment, towels can be placed under the occiput when the helmet is removed but shoulder pads are left in place.[20] Perhaps a similar method can be used to support the heads of patients wearing lacrosse equipment if only the helmet is removed and the shoulder pads are left in place.

One other group[21] assessed the success and failure rates of time to first ventilation by residents in a hospital setting using various airway-management devices on a manikin wearing a football helmet after FMR. Instead of a King airway, the participants used another supraglottic airway (laryngeal mask airway). First-time placement of the supraglottic airway was accomplished more successfully and faster than the direct laryngoscopes and the Airtraq system (Prodol Meditec, SA, Getxo, Spain). The supraglottic airway had a 99% success rate and median time of placement of just 19 seconds.[21] We believe the results from this study and our current study offer promise for the use of supraglottic airways in the acute management of airway emergencies; however, further work will be needed to determine the success rates and placement times when used by ATs.

The specific use of the KA is further supported by multiple studies.[22–24] Emergency medical services personnel took 18.4 seconds to insert the King LT airway in a simulation manikin,[22] whereas EMT-Bs had a 100% success rate in placing the device and a time of 22.5 seconds.[24] Lastly, in an in vivo study[23] by a large urban EMS agency, the first-time success rate for placement of the King LT-D in 167 adult patients was 87.8%. Although King LT airway placement has not been studied in ATs to our knowledge, these results suggest that ATs may be successful in its use.

Supraglottic airways such as the King airway are relatively new to athletic training education[15,25] but offer clinicians a modern set of skills to use during respiratory emergencies.[14] Given that these airway-management devices are inserted blindly by the clinician, they are viewed in many states as within the scope of practice for ATs,[14] but we encourage individuals to read their state practice acts carefully. Unfortunately, researchers[26] have identified a knowledge gap in the use of airway adjuncts among ATs. Those who used lifesaving skills more often were more knowledgeable about airway adjuncts.[26] Many of our participants knew what a KA was but had never practiced with one. Similar to previous investigators,[25,26] we see a need for continuing education courses for ATs who may not have been taught under the fifth (or later) edition of the *Education Competencies*.[15] Improving ATs' skills in the use of all airway adjuncts will improve patient care in the future.

Limitations and Future Directions

This was a controlled laboratory simulation that tested ATs performing 2-rescuer CPR on a high-fidelity manikin using new lacrosse equipment that was already prepared for the intervention by the research team, making the scenario

different from what would be encountered clinically. In a real-life emergency, FMR would have to be performed on used equipment and then the appropriate airway-management device applied. Lacrosse helmet FMR with a cordless screwdriver may be prone to failure[27]; however, when successful, it can be performed quickly to access the airway.[7–9] Clinicians should consider FMR failure and have a contingency alternative in emergency action plans. All participants had vast experience using a PM; yet some had never trained with a KA, although it is included in the fifth[15] and later editions of the *Athletic Training Education Competencies*. Because members of the research team inserted the KA, we do not know if ATs would be successful in inserting the KA to provide quality ventilations to patients. Therefore, we caution against generalizing our results. Lastly, use of the KA by ATs may be limited by state practice acts, and we encourage ATs to seek clarity before adopting the KA or other supraglottic devices so as to avoid legal concerns.

Future authors should look at ATs' success and failure rates when using a KA. The time required to insert a KA is also an important factor to explore, as is whether the KA can provide quality ventilations to a patient wearing other sport equipment (football and hockey). Finally, understanding the emergency action plans of ATs who provide health care for athletes in equipment-intensive sports as well as the emergency equipment (ie, airway-management supplies) they have available are also important areas of future research.

CONCLUSIONS

It is critical that ATs are able to manage the airways of helmeted athletes during emergency situations. In the event of a suspected cervical-spine injury, FMR should be performed while leaving the chinstrap in place to maintain the stability of the head and neck, and the KA should be inserted to ventilate an unconscious patient if there are not enough trained professionals to remove the equipment on site. We believe it is important for ATs to train with a KA to ensure competence. In the absence of a KA, the helmet and shoulder pads may need to be removed and a PM should be used with a modified jaw thrust to provide high-quality ventilations. If the helmet will be left in place, we do not suggest removing the chinstrap to make a better seal with a PM because this would affect the ability of the helmet to stabilize the head and neck.[4,13]

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