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The Assessment of Airway Maneuvers and Interventions in University Canadian Football, Ice Hockey, and Soccer Players

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Context: Managing an airway in an unconscious athlete is a lifesaving skill that may be made more difficult by the recent changes in protective equipment. Different airway maneuvers and techniques may be required to help ventilate an unconscious athlete who is wearing full protective equipment.

Objective: To assess the effectiveness of different airway maneuvers with football, ice hockey, and soccer players wearing full protective equipment.

Design: Crossover study.

Setting: University sports medicine clinic.

Patients or Other Participants: A total of 146 university varsity athletes, consisting of 62 football, 45 ice hockey, and 39 soccer players.

Intervention(s): Athletes were assessed for different airway and physical characteristics. Three investigators then evaluated the effectiveness of different bag-valve-mask (BVM) ventilation techniques in supine athletes who were wearing protective equipment while inline cervical spine immobilization was maintained.

Main Outcome Measure(s): The effectiveness of 1-person BVM ventilation (1-BVM), 2-person BVM ventilation (2-BVM), and inline immobilization and ventilation (IIV) was judged by each investigator for each athlete using a 4-point rating scale.

Results: All forms of ventilation were least difficult in soccer players and most difficult in football players. When compared with 1-BVM, both 2-BVM and IIV were deemed more effective by all investigators for all athletes. Interference from the helmet and stabilizer were common reasons for difficult ventilation in football and ice hockey players.

Conclusions: Sports medicine professionals should practice and be comfortable with different ventilation techniques for athletes wearing full equipment. The use of a new ventilation technique, termed *inline immobilization and ventilation*, may be beneficial, especially when the number of responders is limited.

Key Words: emergency management, ventilation, resuscitation

Key Points

- Control of a patient's compromised airway may be affected by factors such as the sport and protective equipment, number of people able to assist, individuals' experience with different airway techniques and equipment, and physical attributes and size of the clinician.
- Sports medicine professionals should be familiar with more than one basic airway maneuver; in general, 2-person bag-valve-mask ventilation or inline immobilization and ventilation may be more effective than 1-person bag-mask-valve ventilation.
- Inline immobilization and ventilation may be preferable to 1-person bag-valve-mask ventilation when the clinician is tall or 2 people are not available.

Maintaining an airway and assisting breathing in an athlete wearing protective equipment who has become obtunded or unconscious is a challenging yet essential skill for any health care professional covering sporting events. Available options include simple airway procedures such as a jaw-thrust maneuver; placement of an oral airway to improve ventilation; adjunctive airway devices, such as a bag-valve-mask (BVM), laryngeal mask airway, or Combitube (Kendall Sheridan, Argyle, NY); and, finally, definitive airway control with endotracheal intubation.[1–3] In an unconscious athlete, maintaining an adequate airway and assisting ventilation is a time-sensitive but often difficult procedure that is potentially lifesaving.

Immobilization of the cervical spine often complicates airway management in an injured athlete because the cervical spine is ideally splinted in a neutral position. This is most often accomplished by positioning someone at the head of the supine athlete to hold the helmet or head in a neutral (inline) position. Unfortunately, this necessary procedure allows for less access to the airway, with less physical space for the athletic trainer or physician to maintain or control the airway at the head of the athlete. In football and ice hockey players, the helmet and shoulder pads are typically left in place to maintain neutral cervical spine alignment. If the helmet is removed, the head and neck usually fall into an extended position,[4–10] possibly further complicating an existing cervical spine injury.[11] As such, most experts agree that when a football or ice hockey player has sustained a possible cervical spine injury, either the helmet should be left in place while the face mask or visor is removed[2,3,12–17] or both helmet and shoulder pads should be removed simultaneously.[3]

As technology advances, sport equipment evolves. Recently, football and ice hockey helmets have become larger in an effort to provide more protection.[18,19] The outer shells of many helmets now extend to cover more of the face and jaw area, often obscuring the angle of the mandible. Inflatable bladders near the ears and side of the face inside newer football helmets allow for better fit and protection, but they are not easy to remove and can interfere with access to the angle of the mandible. Access to the angle of the mandible is important because most rescue airway maneuvers involve pulling the mandible anteriorly by the angle to allow for better airflow and ventilation. Shoulder pads also have been getting larger, sometimes encroaching on the jaw and neck area of an unconscious supine athlete. All of these changes may adversely affect airway management in the obtunded or unconscious athlete.

To our knowledge, we are the first to assess the effectiveness and practicality of different basic airway maneuvers in football, ice hockey, and soccer players who were wearing full protective equipment for their respective sports. By being aware of the potential hurdles to successful airway management in athletes and by having different BVM options, the sports medicine professional will be better prepared and will increase the chance of survival for the athlete.

METHODS

McGill University has men's and women's varsity soccer teams, men's and women's varsity ice hockey teams, and a men's varsity football team. Different airway procedures and devices were tested in healthy volunteers from these 5 teams. Protective equipment around the head and neck area in soccer is minimal, so we decided that soccer players would function as a control group. This study was approved by the Ethics Review Board of the McGill University School of Medicine.

We collected consent and baseline information including age, height, mass, and sex from the volunteers. Athletes were excluded if they had experienced a head or neck injury precluding active participation with the team; had recent or current symptoms indicating an upper or lower respiratory tract infection (eg, fever, sore throat, rhinorrhea, cough, shortness of breath, increased sputum production); had active oral or labial lesions or injuries (eg, canker, cold sores); or had eaten a meal within 120 minutes of the study. Noninvasive measures of specific airway characteristics often used to predict ease or difficulty in airway control, described in detail elsewhere,[20–23] were taken. These included a Mallampati score (from 1 to 4), which assesses the posterior pharyngeal structures visualized with maximal mouth opening. A high Mallampati score (class 4) is associated with more difficult ventilation and endotracheal intubation.[24] Also assessed were the size of oral opening (ability to insert 3 of the athlete's own fingers between the teeth), hyomental distance (ability to accommodate at least 3 finger breadths between the hyoid bone and the mentum), and upper lip test (ability to place the lower teeth over upper lip), all of which, when present, predict easier ventilation and endotracheal intubation.[25] The presence of a beard or moustache, overbite, or false teeth was also assessed because any of these can also affect ventilation effectiveness. These baseline characteristics and airway measurements provide information on the sample studied and may allow for comparisons with participants in future airway studies.

After the airway assessment was completed, athletes in full protective sports equipment were placed in a supine position on their field of play: a FieldTurf (Calhoun, GA) surface for soccer and football and the ice or hallway beside the ice surface for ice hockey. Data collection was usually done during or after practices, so that volunteers were in their own equipment and as sweaty as they might be during a game situation. The only substitution to the athletes' own protective equipment was that football players were asked to select and wear a properly fitting Riddell Revolution (Elyria, OH) helmet with the face mask already removed, whereas the ice hockey players were asked to select and wear a properly fitting Bauer (Mississauga, ON, Canada) helmet with the face mask/visor already removed. Although the usual standard of care for helmeted athletes with a possible cervical spine injury is to leave the chin strap in place, we undid or removed the chin straps because they interfere with access to the angle of the mandible and proper placement of the facial mask of the BVM device. The supine athlete then had his or her head and cervical spine immobilized by a physician, athletic trainer, or athletic therapist experienced with cervical immobilization. To ensure as uniform a cervical spine immobilization technique as possible, the most senior athletic trainer or athletic therapist involved with the sports teams reviewed the technique before the study. The physician, athletic trainer, or athletic therapist immobilized the head and cervical spine in the standard kneeling position at the head of the athlete by grasping both sides of the head or helmet, allowing himself or herself to stay at the top of the head or slightly off to the side.

The different BVM situations were assessed by 3 investigators with different clinical experiences and physical attributes. Investigator A (height = 170 cm, mass = 75 kg) was a recent male graduate in emergency medicine. Investigator B (height = 166 cm, mass = 62 kg) was a female athletic therapist with more than 15 years' experience covering football and ice hockey. Investigator C (height = 185 cm, mass = 95 kg) was a male emergency and sports medicine physician with more than 13 years' work experience. We felt that having 3 individuals with different airway experiences and physical attributes would help to imitate the range of experiences and sizes of sports medicine professionals called upon to maintain airways in emergency situations.

Three BVM ventilation positions were assessed in a supine athlete with his or her head and neck maintained in a neutral position by a physician, athletic trainer, or athletic therapist. The positions were as follows:

a) One-person BVM ventilation (1-BVM). Each investigator attempted to place the BVM device in proper position by himself or herself. This involves holding the

Figure 1. Investigator A attempting 1-bag-valve-mask ventilation while inline immobilization of the cervical spine is maintained.

jaw, usually at the angle of the mandible with one hand, and thrusting it forward while holding the BVM device over the mouth with the same hand (usually the left). The other hand (usually the right) is typically used to pump the bag (Figure 1). However, the bag was not pumped in this study.

b) Two-person BVM ventilation (2-BVM). One investigator used both hands to control the jaw and maintain the mask over the mouth while a second investigator held the bag and would pump the bag in an actual emergency (Figure 2).

c) Inline immobilization and ventilation (IIV). This technique involved each investigator crouching behind and to the left side of the person maintaining the inline immobilization and attempting to place the BVM in proper position by himself or herself. Again, this involves holding the jaw, usually at the angle of the mandible, and thrusting it forward while holding the mask over the mouth with the same hand (usually the left), so the other hand can pump the bag. The arm of the hand holding the bag in this position is placed around and over the head of the person maintaining the inline immobilization of the cervical spine (Figure 3). This technique has not been described elsewhere in a review of the literature (PubMed, 1962–2009) or in our inquiries with other health care and sports medicine professionals.

Figure 2. Investigators A and C attempting 2-bag-valve-mask ventilation while inline immobilization of the cervical spine is maintained.

Figure 3. Investigator C attempting inline immobilization and ventilation while inline immobilization of the cervical spine is maintained.

The adequacy or effectiveness of each BVM situation was judged by each investigator in each situation. We developed a scale for this study because no similar research had been conducted in these circumstances. Adequacy was quantified using a simple 4-point scale and assessed the seal of the facial mask, the ability to grasp the angle of the mandible, the ability to pull the jaw forward, and the ability to hold the ventilation bag when necessary:

3 = very good likelihood of ventilating
2 = fairly good likelihood of ventilating
1 = difficulty predicted in ventilation
0 = inability to ventilate predicted

When the investigator did not judge the effectiveness of the different BVM scenarios to be a 3, he or she was asked to list the reasons for difficulty with the technique being attempted.

To determine reproducibility of results for each rater, intrarater reliability was evaluated using the weighted κ statistic. Kappa is a measure of the level of agreement that can be attributed to the reproducibility of the observations, rather than to chance agreement. Weighted κ is a modification that uses weights to quantify the relative differences between categories and is more appropriate for ordinal scales such as the one used here.[26] We computed linearly weighted κ values and 95% confidence intervals

Table 1. Player and Airway Characteristics

Characteristic	Sport		
	Football (n = 62)	Ice Hockey (n = 45)	Soccer (n = 39)
Age, y	20.4 ± 1.7	21.6 ± 2.0	19.9 ± 2.0
Height, cm	181.0 ± 13	173.6 ± 11.9	171.4 ± 11.8
Mass, kg	95.0 ± 16.5	78.5 ± 12.4	69.8 ± 8.9
Males, n (%)	62 (100.0)	26 (57.8)	20 (51.3)
Female, n (%)	0 (0.0)	19 (42.2)	19 (48.7)
Mallampati score, n (%)			
1	36 (58.1)	20 (45.5)[a]	17 (43.6)
2	15 (24.2)	14 (31.8)[a]	9 (23.1)
3	6 (9.7)	9 (20.5)[a]	9 (23.1)
4	5 (8.1)	1 (2.3)[a]	4 (10.3)
Hyomental distance, n (%)			
<3 fingers	1 (1.6)	9 (20.5)[a]	7 (17.9)
≥3 fingers	61 (98.4)	35 (79.5)[a]	32 (82.1)
Mouth opening, n (%)			
<3 fingers	0 (0.0)	2 (4.6)[a]	1 (2.6)
Upper lip test, n (%)			
Favorable	42 (67.7)	33 (75.0)[a]	31 (79.5)
Unfavorable	20 (32.3)	11 (25.0)[a]	8 (20.5)
Facial hair, n (%)			
Absent	31 (50.0)	39 (88.6)[a]	30 (76.9)
Present (eg, beard, goatee)	31 (50.0)	5 (11.4)[a]	9 (23.1)
Dentition, n (%)			
Normal	50 (80.7)	34 (79.1)[b]	35 (89.7)
Abnormal (eg, buck teeth, false teeth)	12 (19.3)	9 (20.9)[b]	4 (10.3)

[a] Data missing for 2 athletes.
[b] Data missing for 1 athlete.

using the approach and FORTRAN program of Mielke et al[27] for each scale and rater by sport on a subset of randomly selected athletes. Each athlete was assessed 3 times by the same practitioner. The results for the weighted κ values are listed in the Appendix and show substantial agreement or higher.[28] In all instances, we observed good agreement; the few disagreements involved a 1-point difference. We know,[28] however, that κ can sometimes be unreliable when complete agreement is observed or a rare disagreement occurs within a set of nearly identical values because κ depends on the prevalence of each category. Thus, κ may not be reliable for these rare observations. This situation occurred in our data when, within a particular scale and rater, all value points were identical, or identical save for one. In order to provide a picture of the reproducibility of the scales within each rater when this occurred, we report percentage agreement values and 95% confidence intervals. All descriptive statistics were computed using SAS software (version 9.2; SAS Institute Inc, Cary, NC).

Table 2. Combined Investigators' and Individual Investigator's Assessments of 1-Person Bag-Valve-Mask Ventilation Airway Maneuver[a]

Sport	Investigator(s)	Technique Assessment (4-Point Scale)[b]			
		0	1	2	3
Football	Combined	2	59	98	27
	A	0	9	46	7
	B	2	9	31	20
	C	0	41	21	0
Ice hockey	Combined	0	8	75	52
	A	0	2	19	24
	B	0	4	22	19
	C	0	2	34	9
Soccer	Combined	0	0	19	98
	A	0	0	6	33
	B	0	0	5	34
	C	0	0	8	31

[a] Each investigator attempted each maneuver once, so the total attempts were 186 for football, 135 for ice hockey, and 117 attempts for soccer.
[b] Scoring: 3 = very good likelihood of ventilating, 2 = fairly good likelihood of ventilating, 1 = difficulty predicted in ventilation, 0 = inability to ventilate predicted.

Table 3. Combined Investigators' and Individual Investigator's Assessments of 2-Person Bag-Valve-Mask Ventilation Airway Maneuver[a]

Sport	Investigator(s)	Technique Assessment (4-Point Scale)[b]			
		0	1	2	3
Football	Combined	1	10	96	79
	A	0	0	30	32
	B	1	2	18	41
	C	0	8	48	6
Ice hockey	Combined	0	0	4	131
	A	0	0	1	44
	B	0	0	2	43
	C	0	0	1	44
Soccer	Combined	0	0	0	117
	A	0	0	0	39
	B	0	0	0	39
	C	0	0	0	39

[a] Each investigator attempted each maneuver once, so the total attempts were 186 for football, 135 for ice hockey, and 117 attempts for soccer.
[b] Scoring: 3 = very good likelihood of ventilating, 2 = fairly good likelihood of ventilating, 1 = difficulty predicted in ventilation, 0 = inability to ventilate predicted.

RESULTS

At the beginning of the 2007 season, there were 74 football players, 52 ice hockey players, and 44 soccer players on the varsity teams. Due to absences on the days of recruitment and attrition, 62 athletes were fully recruited for football, 45 for ice hockey, and 39 for soccer. Their baseline and airway characteristics are listed in Table 1. Combined and individual investigator assessments of difficulty of each airway maneuver are listed in Tables 2 through 4. Combined investigator assessments of the different airway maneuvers as a percentage of the total for each sport are shown in Figures 4 through 6. Difficulties for each situation are listed in Tables 5 through 7.

When the 1-BVM assessment was not a 3, we assumed that 2-BVM and IIV would offer improvements over standard 1-BVM ventilation. For football players, after switching from 1-BVM to 2-BVM, the assessment improved by at least 1 point 64.2% (102/159) of the time. Investigator A improved 36 of 55 attempts, investigator B improved 29 of 42 attempts, and investigator C improved 37 of 62 attempts. For ice hockey players, the assessment improved at least 1 point 95.2% (79/83) of the time (20 of 21 attempts for investigator A, 24 of 26 attempts for investigator B, and 35 of 36 attempts for investigator C). For soccer players, switching to 2-BVM improved the assessment by at least 1 point 100% (19/19) of the time. Similarly, switching from 1-BVM to IIV frequently changed the assessment by at least 1 point. For football players, the assessment improved at least 1 point after switching from 1-BVM to IIV 59.1% (94 of 159 attempts) of the time. Investigator A improved 18 of 55 attempts, investigator B improved 26 of 42 attempts, and investigator C improved 50 of 62 attempts. For ice hockey players, switching from 1-BVM to IIV improved the assessment 79.5% (66/83) of the time (15 of 21 attempts for investigator A, 17 of 26 attempts for investigator B, and 34 of 36 attempts for investigator C). For soccer players, switching to IIV improved the assessment by at least 1 point 94.7% (18 of 19 attempts) of the time (6 of 6 attempts for investigator A, 5 of 5 attempts for investigator B, and 7 of 8 attempts for investigator C).

DISCUSSION

Our results reveal general trends and the individual variability of investigator success in airway management using 3 basic airway maneuvers. Overall, with the basic airway maneuvers (1-BVM, 2-BVM, IIV), soccer players

Table 4. Combined Investigators' and Individual Investigator's Assessments of Inline Immobilization and Ventilation Airway Maneuver[a]

Sport	Investigator(s)	Technique Assessment (4-Point Scale)[b]			
		0	1	2	3
Football	Combined	0	5	105	76
	A	0	3	43	16
	B	0	2	18	42
	C	0	0	44	18
Ice hockey	Combined	0	5	24	106
	A	0	2	11	32
	B	0	3	11	31
	C	0	0	2	43
Soccer	Combined	0	0	1	116
	A	0	0	0	39
	B	0	0	0	39
	C	0	0	1	38

[a] Each investigator attempted each maneuver once, so the total attempts were 186 for football, 135 for ice hockey, and 117 attempts for soccer.
[b] Scoring: 3 = very good likelihood of ventilating, 2 = fairly good likelihood of ventilating, 1 = difficulty predicted in ventilation, 0 = inability to ventilate predicted.

Table 5. Combined Investigators' and Individual Investigator's Reasons for Difficulties With 1-Person Bag-Valve-Mask Ventilation Airway Maneuver[a]

		Reason for Difficulty				
Sport	Investigator(s)	Angle of Jaw	Stabilizer	Helmet	Hands Too Small	Unable to Determine
Football	Combined	9	65	147	0	0
	A	4	5	55	0	0
	B	5	3	41	0	0
	C	0	57	51	0	0
Ice hockey	Combined	21	52	14	2	2
	A	6	11	5	0	1
	B	12	8	4	2	1
	C	3	33	5	0	0
Soccer	Combined	10	7	NA	1	0
	A	5	1	NA	1	0
	B	4	0	NA	0	0
	C	1	6	NA	1	0

Abbreviation: NA, not applicable.

[a] Each investigator attempted each maneuver once, so the total attempts were 186 for football, 135 for ice hockey, and 117 for soccer.

were the least difficult to ventilate. Although ice hockey players were more difficult to ventilate than soccer players, football players were the most difficult for all 3 investigators to ventilate. In all sports and for all investigators, switching from 1-BVM to 2-BVM or IIV usually improved the assessment of airway maneuvers (Figures 4 through 6).

All 3 investigators listed stabilizer interference as a common cause of difficulty in 1-BVM in both football (65 of 186 attempts, 34.9%) and ice hockey (52 of 135 attempts, 38.5%) players, but helmet interference in football players caused the most problems. The helmet was listed as a cause for difficulty with 1-BVM in only 14 of 135 (10.4%) attempts in ice hockey, compared with 147 of 186 (79.0%) attempts in football. The newer football helmets have nonremovable air bladders at the jaw and ear and a hard shell that now covers more area along the jaw, which may make it more difficult to adequately grasp the angle of the mandible for airway control. These newer helmets have proven to be more effective at reducing concussions,[18] but sports medicine professionals should be aware that they may cause more difficulty in maintaining an airway in an emergency situation. Although switching from 1-BVM to 2-BVM or IIV almost eliminated the helmet as a cause of difficulty in ice hockey players, it remained a common problem in football players.

Individually, each investigator had specific difficulties with certain techniques and certain athletes. Not all athletes were rated the same by all investigators for the different BVM scenarios, as evidenced by the different subtotals for each investigator listed in Tables 2 through 4. The tallest investigator (investigator C) listed stabilizer interference as a cause of difficulty more often than the other investigators, especially for 1-BVM. Longer arms may make it more challenging for the sports medicine professional to position his or her arms in the limited space due to the presence of the person providing inline immobilization. The wrist and hand are forced into a more flexed and awkward position when attempting to hold the angle of the jaw (Figure 7). This flexed-wrist position is eliminated in the IIV positioning and, thus, investigator C was most aided by switching from 1-BVM to IIV. Conversely, the arms of the shorter investigators (A and B) were occasionally not long enough to comfortably reach around the stabilizer to ventilate the bag during IIV.

In an athlete who is not breathing, time is essential and only a few minutes are available to reestablish ventilation

Table 6. Combined Investigators' and Individual Investigator's Reasons for Difficulties With 2-Person Bag-Valve-Mask Ventilation Airway Maneuver[a]

		Reason for Difficulty			
Sport	Investigator(s)	Angle of Jaw	Stabilizer	Helmet	Unable to Determine
Football	Combined	2	36	92	1
	A	0	1	29	1
	B	2	0	20	0
	C	0	35	43	0
Ice hockey	Combined	1	0	3	0
	A	0	0	1	0
	B	1	0	1	0
	C	0	0	1	0
Soccer	Combined	0	0	NA	0
	A	0	0	NA	0
	B	0	0	NA	0
	C	0	0	NA	0

Abbreviation: NA, not applicable.

[a] Each investigator attempted each maneuver once, so the total attempts were 186 for football, 135 for ice hockey, and 117 for soccer.

Table 7. Combined Investigators' and Individual Investigator's Reasons for Difficulties With Inline Immobilization and Ventilation Airway Maneuver[a]

Sport	Investigator(s)	Reason for Difficulty					
		Angle of Jaw	Stabilizer	Helmet	Arms Too Short	Hands Too Small	Unable to Determine
Football	Combined	1	1	96	10	0	2
	A	0	0	37	8	0	1
	B	1	0	17	2	0	0
	C	0	1	42	0	0	1
Ice hockey	Combined	4	4	1	17	3	0
	A	1	2	0	10	0	0
	B	2	2	0	7	3	0
	C	1	0	1	0	0	0
Soccer	Combined	1	0	NA	0	0	0
	A	0	0	NA	0	0	0
	B	0	0	NA	0	0	0
	C	1	0	NA	0	0	0

Abbreviation: NA, not applicable.

[a] Each investigator attempted each maneuver once, so the total attempts were 186 for football, 135 for ice hockey, and 117 for soccer.

and oxygenation before permanent sequelae occur. Proponents of fully removing the helmet (and possibly shoulder pads) in an airway emergency may correctly point out how often interference from the helmet was listed as a cause for difficulty in BVM ventilation, but sports medicine professionals should know that removing a helmet and shoulder pads takes time and people, neither of which may be available in an airway emergency. Also, removing or cutting equipment may not always improve airway access as much as anticipated. This point was underscored in soccer players: not all soccer players were rated a 3 for 1-BVM, and switching to a 2-BVM or IIV did improve the effectiveness of ventilation in all but 1 case. Thus, switching to a different airway maneuver may provide a more rapid improvement in ventilation than removing equipment.

LIMITATIONS

Several limitations were present in this study. First, the helmeted athletes already had their face masks or visors removed. An unconscious athlete who is wearing a helmet and face mask will require immediate airway intervention, such as removal of a mouthguard and a jaw-thrust maneuver before or during face-mask removal. Removing a face mask also takes time, and as indicated previously,[29] can be rife with its own complications and delays.

Only 3 investigators were studied, which limits the generalization of the results to all sports medicine professionals. Although the investigators were blinded to the results of the other investigators during 1-BVM and IIV assessments, they could not be blinded to other investigators' opinions on 2-BVM when 2 investigators were required to perform the intervention.

The scales used are surrogates for actual successful BVM ventilation. The players were not ventilated in the study and, as such, adequate oxygenation and ventilation cannot be guaranteed by a higher score on our scale. We can hypothesize that those athletes with higher scores on our scale would be more likely to have successful BVM

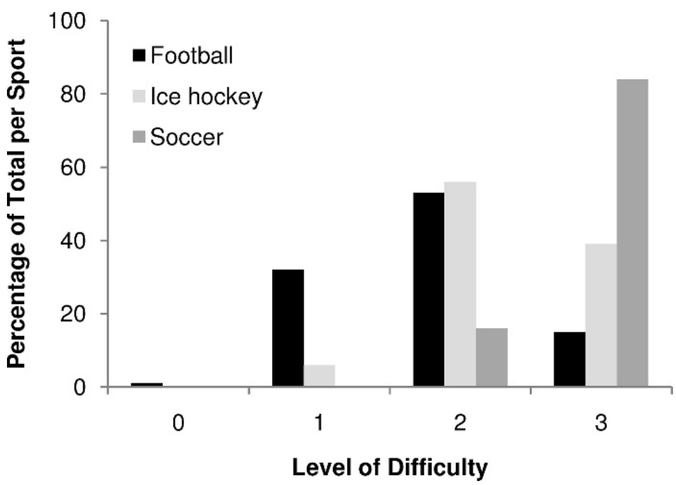

Figure 4. Combined investigators' assessments of 1-bag-valve-mask ventilation. The assessments of investigators A, B, and C are combined for each sport. The sum of the technique assessments is 100%. Technique assessment: 3 = very good likelihood of ventilating, 2 = fairly good likelihood of ventilating, 1 = difficulty predicted in ventilation, 0 = inability to ventilate predicted.

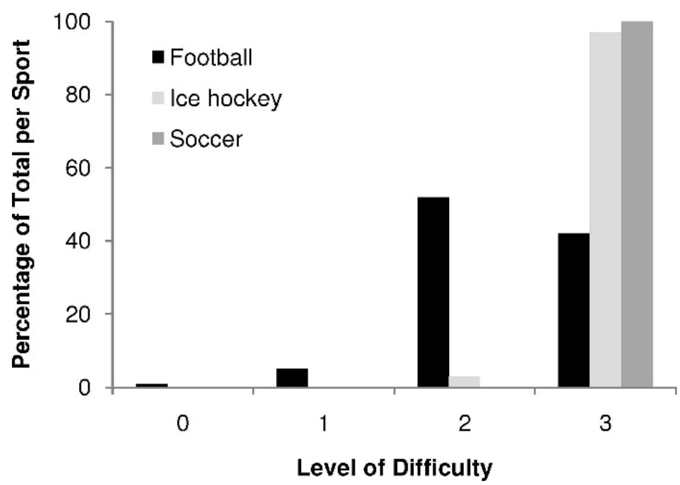

Figure 5. Combined investigators' assessments of 2-bag-valve-mask ventilation. The assessments of investigators A, B, and C are combined for each sport. The sum of the technique assessments is 100%. Technique assessment: 3 = very good likelihood of ventilating, 2 = fairly good likelihood of ventilating, 1 = difficulty predicted in ventilation, 0 = inability to ventilate predicted.

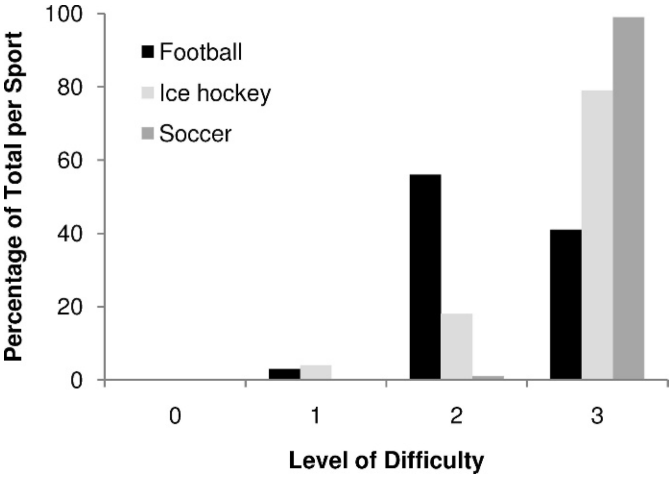

Figure 6. Combined investigators' assessments of inline immobilization and ventilation. The assessments of investigators A, B, and C are combined for each sport. The sum of the technique assessments is 100%. Technique assessment: 3 = very good likelihood of ventilating, 2 = fairly good likelihood of ventilating, 1 = difficulty predicted in ventilation, 0 = inability to ventilate predicted.

ventilation, but the possibility exists that actual BVM ventilation in the unconscious athlete may not be effective. The scale we used is new, and even though we calculated weighted κ values and percentage agreement for intrarater variability, we did not do the same for interrater variability because we assumed that individual investigators would have different success with different BVM scenarios, given their different skill sets and physical attributes. We believe this to be one of the important findings of the research: Each sport medicine professional may have his or her own difficulties with an individual BVM technique and must be prepared to alter the technique if needed. The weighted κ values and percentage agreement for intrarater variability were calculated using only a portion of the sample due to the limited numbers of athletes available and, therefore, may account for the wide confidence intervals for each individual rater for each sport and airway maneuver.

The helmets tested were the models most commonly worn by each team, yet only one model each of football and ice hockey helmets was used in this study. It is possible that different makes and models of helmets would be associated with less difficulty or different types of problems.

CONCLUSIONS

Sports medicine professionals should be aware that control of a compromised airway may be affected by many factors, including the sport and the protective equipment used, the number of people able to assist, the experience of the individual with different airway techniques and equipment, and likely the physical attributes and size of the physician, athletic trainer, or athletic therapist. Clinicians should become familiar with more than one basic airway maneuver, remembering that 2-BVM and IIV may be more effective in most circumstances than traditional 1-BVM. When necessary, especially for taller sports medicine professionals, IIV may be a better alternative to 1-BVM, particularly if numbers do not allow for 2-BVM.

Figure 7. Investigator C attempting 1-bag-valve-mask ventilation while inline immobilization of the cervical spine is maintained. Notice how the left wrist must be placed in a more flexed position due to limited space available for the left arm.

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Appendix. Intrarater Weighted κ Values and Percentage of Agreement for the Airway Maneuvers (95% Confidence Intervals)[a]

Airway Maneuver	Investigator	Football (n = 11)[b]	Hockey (n = 9)[b]	Soccer (n = 10)[b]
1-person bag-valve-mask	A	0.72 (0.46, 0.98)	0.79 (0.50, 1.0)	0.85 (0.48, 1.0)
	B	0.84 (0.57, 1.0)	0.74 (0.46, 1.0)	0.69 (0.33, 1.0)
	C	0.83 (0.56, 1.0)	0.90 (0.60, 1.0)	0.81 (0.44, 1.0)
2-person bag-valve-mask	A	0.80 (0.51, 1.0)	0.67 (0.29, 1.0)	0.93[c] (0.79, 0.98)
	B	0.76 (0.47, 1.0)	0.65 (0.26, 1.0)	0.93[c] (0.79, 0.98)
	C	0.88 (0.56, 1.0)	0.84 (0.45, 1.0)	0.93[c] (0.79, 0.98)
Inline immobilization and ventilation	A	0.72 (0.42, 1.0)	0.74 (0.40, 1.0)	1.0[c] (0.89, 1.0)
	B	0.78 (0.46, 1.0)	0.73 (0.39, 1.0)	0.93[c] (0.79, 0.98)
	C	0.77 (0.42, 1.0)	0.81 (0.42, 1.0)	1.0[c] (0.89, 1.0)

[a] Interpretation of weighted κ is as follows[28]: <0, less than chance agreement; 0.01–0.20, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; 0.81–0.99, almost-perfect agreement; 1.0, perfect agreement.
[b] The number of athletes in each group is a subset of randomly selected athletes from the larger groups. These subsets were used to calculate intrarater reliability.
[c] Total agreement occurred for each individual rater (rating = 3) and one instance of 1-point disagreement for each rater (rating = 2). Kappa returned no value due to the very small prevalence of the ratings of 0, 1, and 2. In these instances, average percentage of agreement was used.

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