TACTICAL COMBAT CASUALTY CARE: TRANSITIONING BATTLEFIELD LESSONS LEARNED TO OTHER AUSTERE ENVIRONMENTS

Awake Cricothyrotomy: A Novel Approach to the Surgical Airway in the Tactical Setting

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Airway obstruction on the battlefield is most often due to maxillofacial trauma, which may include bleeding and disrupted airway anatomy. In many of these cases, surgical cricothyrotomy (SC) is the preferred airway management procedure. SC is an emergency airway procedure performed when attempts to open an airway using nasal devices, oral devices, or tracheal intubation have failed, or when the risks from intubation are unacceptably high. The aim of this overview is to describe a novel approach to the inevitably surgical airway in which SC is the first and best procedure to manage the difficult or failed airway. The awake SC technique and supporting algorithm are presented along with the limitations and future directions. Awake SC, using local anesthetic with or without ketamine, will allow the knowledgeable provider to manage patients with a compromised airway across the continuum of emergency care ranging from remote/en route care, austere settings, and prehospital to the emergency department.

Keywords: airway, obstruction, cricothyrotomy, cricothyroidotomy, trauma

Introduction

Historically, airway management has had top priority for the civilian emergency medical services (EMS) and military combat medicine, as indicated by the acronyms ABC (airway, breathing, circulation) and MARCH (massive bleeding, airway, respiration, circulation, head/hypothermia), respectively.^{1,2} The critical fundamentals of airway management are no different whether in the prehospital or hospital setting. However, the assessment techniques and airway devices vary based on the physical location of the trauma patient (eg, urban EMS, combat or tactical medicine, wilderness medicine, or hospital).

Norman McSwain, MD, developed the notion of *principles versus preferences* in medical care as a fundamental concept in critical thinking and decision

making in prehospital trauma care.³ This concept can be illustrated using surgical cricothyrotomy (SC) procedure as an example. The *principle* is to open the airway through the cricothyroid membrane with the understanding of 3 key priorities: 1) oxygenate, 2) ventilate, and 3) protect the airway. The *preference* is how the principle is realized using one of the many SC procedural steps, surgical tools selection, and airway tube of choice. Even though there are many commercial cricothyrotomy devices and surgical procedural steps to consider, not all are ideal for use based on the severity of patient trauma and physical location.⁴ Thus, the aim of this overview is to provide a rationale for considering an SC procedure for a semiconscious or awake airway-obstructed patient as a rapid and simple technique easily performed in austere conditions. Henceforth, this procedure is identified as an awake SC.

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Presented at the Tactical Combat Casualty Care: Transitioning Battlefield Lessons Learned to Other Austere Environments Preconference to the Seventh World Congress of Mountain & Wilderness Medicine, Telluride, Colorado, July 30–31, 2016.

Case vignettes

The following 3 cases present scenarios in both civilian and military austere environments where an awake SC procedure is rapidly needed to create a patent airway.

CASE 1

A law enforcement (LE) tactical team assembles to perform forced-entry outside a suspected drug laboratory. As the team makes entry into the laboratory, a device detonates, causing injury to several team members. The on-scene emergency physician (EP) observes blast trauma to one officer's neck and recognizes a possible need for a surgical airway intervention. As the immediate tactical situation comes under control with LE reinforcements, the EP returns attention to the officer's airway. The patient is conscious, but confused and agitated. With the patient's disrupted airway anatomy, altered mental status, and ongoing facial bleeding, the EP rapidly prepares for an emergent surgical airway.

CASE 2

A dismounted patrol consisting of US and coalition soldiers is conducting operations in a remote Afghan village. One of the coalition soldiers steps on an improvised explosive device and is badly wounded. As the surrounding soldiers secure the scene and begin to assess him, a combat medic arrives on scene, responding to the call for "Medic!" Even from a distance, the medic can see the soldier's badly injured facial anatomy and hear the raspy sonorous breathing. There is no active fire, and the patient has no exsanguinating hemorrhage. He remains unresponsive and has noisy, spontaneous breathing. Looking at his face, the medic cannot visualize where to begin to intubate and decides to prepare the soldier's neck for a surgical airway intervention.

CASE 3

A local county search and rescue team member fell from a significant height while rappelling during high angle technical rescue training in the mountains of northern California. The team member sustained severe facial and head trauma. The members of the small climbing team, including the team paramedic, witnessed the fall and were able to rappel down 50 m to provide assistance. The initial responding team members conducted a rapid ABC assessment and noted no severe bleeding, but they observed facial contusions, a compound mandibular fracture, fractured teeth, and bleeding in the mouth resulting in an obstructed airway. The arriving paramedic conducted a rapid trauma assessment and found the patient with sonorous breathing, but alert to all questions. The team paramedic made a rapid decision to conduct an SC.

Background

Over a decade of lessons learned in combat casualty airway management clearly highlights the concepts of principles vs preferences about how best to manage a difficult airway. In particular, there is substantial airway management experience during the 3 phases of care as described in Tactical Combat Casualty Care (TCCC) Guidelines: 1) Care Under Fire; 2) Tactical Field Care; and 3) Tactical Evacuation Care. Airway management in the TCCC training curriculum discusses the use of traditional basic and advanced airway support techniques (eg, body repositioning such as leaning forward, chin lift, or jaw thrust; use of nasopharyngeal airways; and SC as the advanced airway procedure).^{2,5} See [Table 1](#) for an overview of the TCCC guidelines for airway management in the Tactical Field Care phase.

During the Afghanistan and Iraq conflicts (2001–2011), traumatic airway obstruction was responsible for 8% of fatalities caused by penetrating injury to the face and neck anatomy and was the second leading cause of preventable mortality.⁶ These findings are similar, but slightly greater than that previously reported for airway obstruction mortality (1%–2%). Airway obstruction is the third leading cause of preventable death on the battlefield.⁷ SC incidence rates in the military out-of-hospital setting are double that of paramedics in the civilian EMS.⁸ This is due to the high incidence of penetrating (fragments) trauma from improvised explosion devices and gunshot wounds. The face and anterior neck of combat personnel typically are not covered with protective armor, which increases the likelihood of upper airway structural injury and the need for rapid SC airway management.

The majority of US military combat medics are trained at the emergency medical technician (EMT)-basic level. Although outside the scope of US civilian EMT-basic training, SC is an essential battlefield medical skill. Although all combat medics learn standard open SC, the first opportunity to perform the procedure clinically is during austere combat conditions that often result in complications and failure to place the SC tube correctly in the trachea. The SC failure rate is reported to be 33% for ground-based combat medics⁸ and 18% for medical evacuation helicopter medics⁹ in the challenging combat environments of Iraq and Afghanistan. Reported complications include bleeding, incorrect anatomic placement, mainstem intubation, and damage to associated airway structures.^{8,10}

In addition to the lack of clinical SC experience, a recent review of the SC training procedures and techniques have identified 5 specific gap areas that might explain, in part, the high SC failure rates for US military

Table 1. Basic airway management plan for tactical field care

1. Casualties with an altered mental status should be disarmed immediately
2. Airway management
 - a. Unconscious casualty without airway obstruction:
 - Chin lift or jaw thrust maneuver
 - Nasopharyngeal airway
 - Place casualty in the recovery position
 - b. Casualty with airway obstruction or impending airway obstruction:
 - Chin lift or jaw thrust maneuver: nasopharyngeal airway
 - Allow a conscious casualty to assume any position that best protects the airway, including sitting upright
 - Place unconscious casualty in the recovery position
 - c. If the previous measures are unsuccessful, perform a surgical cricothyroidotomy using one of the following:
 - Cric-Key technique (preferred option)
 - Bougie-aided open surgical technique using a flanged and cuffed airway cannula of <10 mm outer diameter, 6 to 7 mm internal diameter, and 5 to 8 cm of intratracheal length
 - Standard open surgical technique using a flanged and cuffed airway cannula of <10 mm outer diameter, 6 to 7 mm internal diameter, and 5 to 8 cm of intratracheal length (least desirable option)
 - Use lidocaine if the casualty is conscious

All TCCC Guidelines can be viewed at: http://www.naemt.org/education/TCCC/guidelines_curriculum.

medics: 1) limited gross airway anatomy review; 2) lack of “hands-on” human laryngeal anatomy familiarization; 3) nonstandardized step-by-step surgical incision skill procedures; 4) inferior standards for anatomically correct cricothyroid training mannequins; and 5) lack of standardized refresher training frequency.¹¹ Others have noted that common SC tools were not designed for this procedure, nor are they standardized in training or clinical use, and tools are being developed to address this gap.^{12–14} Consequently, there is significant variance in the type of equipment and techniques used for SC. For providers performing SC infrequently, variance increases the risk of poor outcomes. This variance adds to another aspect of high failure rates in this procedure.⁴ Standardizing the equipment and the approach reduces variance and therefore reduces the risk of suboptimal outcomes.

Awake surgical cricothyrotomy procedure

SC is an emergency airway procedure performed when attempts at intubation have failed or when the risk of intubation is not acceptable. It is often referred to as the “last resort” of definitive airway management and is not attempted until all other techniques have failed.^{15,16} The indications, contraindications, and approaches associated with cricothyrotomy are well described (Table 2).^{4,10,16}

Overall, SC is not a common procedure in clinical practice, ranging from 1% to 2% of ED intubations and 11% to 15% of prehospital intubations.^{10,17,18} With the evolution of noninvasive airway techniques and video laryngoscopy, it is likely that SC rates will remain low in civilian emergency medical settings. As infrequently as it is performed, the time-sensitive and life-saving nature of SC demands proficiency. In comparison with the

Table 2. Indications and contraindications to surgical cricothyrotomy

Indications	Facial fractures Blood or vomitus in airway Clenched teeth Traumatic airway obstruction Inability to maintain >90% oxygen saturation between intubation attempts or after 3 attempts Inability to ventilate the patient with a bag-valve-mask device between intubation attempts or after 3 attempts Multiple failed attempts at endotracheal intubation
Relative contraindications	Tracheal transection, fracture, or obstruction below the cricothyroid membrane Age <5 to 12 years, due to anatomic considerations (depending on reference)

battlefield⁸ setting, the SC failure rate in the ED/hospital-based^{18,19} and EMS prehospital⁴ setting is 4 to 10% and 7 to 11%, respectively.

As mentioned, SC is considered a last resort procedure in a difficult airway algorithm.¹¹ However, in certain situations it may be counterproductive for patients' well-being to delay a surgical airway intervention. In such circumstances, SC actually may be the best "first resort" in definitive airway management. Most physicians think of SC as the final step in the "failed airway" pathway. Field medics may need to think of SC as their primary option in specific settings, in which the airway procedure will have to be surgical. Thus, we describe a novel approach in of a life-saving intervention in which SC is performed first. Because it is inevitable that a surgical airway will be the best option, we describe it as the "inevitably surgical airway." It is often the best approach to manage what is sometimes referred to as the surgically inevitable airway.²⁰ The indications for an inevitably surgical airway are not only the result of trauma, but also infection, acute illness, or situational and patient-related factors. However, the inevitably surgical airway in the civilian EMS or combat setting is most likely caused by maxillofacial trauma in which a surgical airway is needed acutely, often in an awake patient (eg, Glasgow Coma Score = 9–15) to prevent death. One example is a severe blast injury to the lower face and neck. Distorted anatomy coupled with blood/vomit in the airway is a serious problem that creates additional challenges and complications when using, for example, laryngoscopy, supraglottic airway devices, or mask ventilation. The awake SC procedure is considered a novelty because it is not well described in the literature. The lone case report describing "awake"

cricothyrotomy is from a hospital-based setting in which the patient was sedated with ketamine and received full neuromuscular blockade.²¹

In certain situations, the medical intervention of choice is a definitive airway with tracheal intubation, but rapid sequence intubation (RSI) is not practical in all situations (eg, multiple trauma patients for one individual to acutely manage or medications are not available for use).⁸ In the 3 case vignettes given earlier, the patients have what can be described as a "inevitably surgical airway." Successful attempts with other airway management techniques would be considered very low when there is disrupted anatomy. In those situations, rather than persisting in treating SC as the last resort, the EP, combat medic or EMS paramedic provider should recognize the inevitably surgical airway and start with an awake SC technique.

To date, there are only 2 civilian case reports in the literature that describe using SC techniques in trauma patients (one conscious and one unresponsive patient). Both case reports describe using improvised procedures in austere environments.^{22,23} Based on military experience, we recommend an open, surgical technique employing a bougie or guide and a tube specifically made for cricothyrotomy (Table 3).²⁴ A wire-guided technique may be appropriate if the clinician is trained adequately and skilled using that approach, but it is generally not the preferred prehospital procedure.⁴ For comparison, consider an awake bedside tracheostomy, a well-described part of the difficult/failed airway armamentarium.²⁵ That approach requires local anesthesia and can be performed with or without sedation. EPs are experienced not only in local anesthetic but also sedation techniques and would be able to perform either or both in the course of an awake SC.

Table 3. Steps to perform an awake cricothyrotomy

1	After donning appropriate personal protective equipment, prepare and clean the area from the hyoid bone to the sternal notch along the entire anterior neck.
2	Administer ketamine (1 to 2 mg/kg intravenous or 4 to 5 mg/kg intramuscular). ²⁴ The time to onset of dissociative state is 3 to 8 minutes. This step may or may not be indicated based on the clinical setting.
3	Identify anterior neck anatomic landmarks. Once the cricothyroid membrane is identified, mark the overlying skin with a permanent marker.
4	Introduce subcutaneous bupivacaine superficial to the cricothyroid membrane and then advance the needle through the skin and cricothyroid membrane. Aspirate air to verify location of the needle tip in the trachea and apply intratracheal bupivacaine, continuing to introduce medication as needle is withdrawn. Allow 1 minute for bupivacaine to take effect.
5	Use good judgment to safely position the patient to optimize procedural success.
6	Make a vertical skin incision at the predesignated location, identify the cricothyroid membrane, and make a horizontal stab through the cricothyroid membrane.
7	Insert bougie into the patient's trachea followed by advancing the airway tube over the guide.
8	Verify tube placement/functionality and secure tube to prevent dislodgement.
9	Once the sedation wears off, the local anesthetic should continue to provide patient comfort for 4 to 6 hours.

Discussion

Emergency airway situations, such as in these 3 case vignettes, require immediate intervention and success depends on proper preparation. The EP must already have mentally established that he or she is ready to perform a surgical airway and have a kit (either commercially available or locally created) on hand even before such a patient arrives. Because emergent airways are not exclusive to intensive care units and surgical suites, it is likely that the provider performing the SC will not be a trained surgeon. For EPs and those who do not routinely perform this procedure, the technique must 1) maximize visibility and access, 2) minimize steps and equipment exchanges, and 3) be performed rapidly by a single provider. For these reasons, we recommend an open SC technique as superior to needle or wire-guided methods in prehospital or hospital settings.^{26,27} In addition, we advise the use of a vertical, midline skin incision to optimize visualization and palpation of the cricothyroid membrane and surrounding anatomy.⁴ Such an incision may be extended, if needed; minimizes the risk of bleeding; and obviates the need for multiple horizontal incisions on a patient in extremis.²⁸

In our experience, simplifying the procedure and using dedicated equipment is essential. Often a “cric kit” consists of little more than a scalpel and a 6.0 endotracheal tube, and improvisation is sometimes required in untoward circumstances.^{22,23} In general, however, it is not advisable to leave the preparation for such a critical procedure up to improvisation under stress. There are now several small commercial SC kits that are clearly superior to improvised equipment from a trauma kit or survival gear. This is especially true under the most challenging circumstances when rapid access to trauma equipment is essential. One newly developed SC device

set is the Control-Cric kit¹² (Pulmodyne, Indianapolis, IN; [Figure 1](#)). The Control-Cric kit effectively combines the functions of a tracheal hook, stylet, dilator, bougie, and a scalpel specifically designed for cricothyrotomy.

The type of airway employed merits comment as well. Tracheostomy tubes are not shaped for use via the cricothyroid membrane, and most are too rigid to adapt to the anatomy of the cricothyroid membrane. Endotracheal tubes, though commonly used in improvised cricothyrotomy, are too long. Even when cut to a smaller length, the endotracheal tube can leave 10 to 12 cm of tubing outside the incision, increasing the risk of tube dislodgement or advancement into the pulmonary right mainstem. It is best to employ a cuffed Melker (Cook Critical Care, Bloomington, IN) or similar airway designed for insertion into the cricothyroid membrane.

There are several benefits to awake SC. First, it allows for the rapid and effective placement of a definitive airway. Second, the use of local anesthesia and ketamine significantly reduces the risks associated with traditional RSI (hypotension during induction and loss of respiratory effort with full neuromuscular blockade). Third, awareness of this technique allows clinicians to save precious time establishing a definitive airway, rather than linearly proceeding down a failed airway algorithm with a late decision and untoward performance of a cricothyrotomy; [Figure 2](#) depicts an awake surgical cricothyrotomy algorithm used in critical thinking and decision making. Fourth, this simplified approach using proven sedation techniques is universally applicable across the spectrum of emergency care, whether in a level 1 regional trauma center, in small community EDs, or in remote, resource-constrained settings. Finally, this approach will streamline postprocedure care. As is well known to experienced clinicians, the less time the provider is required to spend on postprocedure management, the better.

Figure 1. (A and B) Control-Cric kit (Pulmodyne, Indianapolis, IN). Photos used with permission from R. Levitan, MD.

Figure 2. An awake patient surgical airway algorithm.

Emergent airway compromise is rapidly lethal in any setting. In prehospital or remote access settings, providers must identify and treat the surgically inevitable airways under the most challenging circumstances. Even resource-rich trauma centers encounter patients with an array of conditions in which traditional airway management approaches cannot be applied.

There are limitations to this technique as well. Awake SC applies only to a specific subset of patients in whom traditional approaches to definitive airways will not work. Initial training, sustainment training, and education could pose a challenge depending on provider level of proficiency, access to simulation or hands-on opportunities, and volume of personnel being trained. With more

providers attempting awake SC in non-last-resort situations, there is the potential for increase in morbidity and mortality, although most of that potential can be mitigated with education, training, and quality assurance efforts.

Future directions include education across the continuum of emergency care, standardization of training and sustainment models, fielding, follow-up, and sharing of experience to create best practices. With adequate education and training, providers across several levels of care can learn this straightforward and effective approach to managing this critical subset of difficult airway patients. There are numerous ED, military, tactical EMS, and remote access care applications for the awake SC.

Conclusions

The obstructed or damaged airway in prehospital EMS or hospital settings, as well as on the battlefield or in other limited resource environments, typically is managed with various progressive approaches as indicated in the traditional difficult airway algorithm. These approaches include head and body repositioning, use of nasal and various oral airways, tracheal intubation, and finally, SC as the terminal management procedure. For inevitably surgical airways (airways altered by severe trauma or other disruption of the airway anatomy), this SC procedure is clearly indicated as the first approach to open the airway. We propose the awake SC as a novel application of a life-saving intervention when compared with the traditional difficult airway algorithm. A rapid, reproducible awake SC technique, as described in this article, along with a recommended algorithm, will allow clinical providers to intervene rapidly to save patients across the spectrum civilian or military treatment settings.

Financial/Material Support: None.

Disclosures: None.

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