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Virtual Simulation Training Using the Storz C-HUB to Support Distance Airway Training for the Spanish Medical Corps and NATO Partners

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Abstract. In medicine, the advancement of new technologies creates challenges to providers both in learning and in maintaining competency in required skills. For those medical providers located in remote environments, access to learning can be even more formidable. This work describes a collaboration created to facilitate the use of new communication technologies in providing distance training and support to health care personnel deployed in remote areas.

Keywords. Telemedicine, intubation, distance education, airway management

Introduction

Airway management is one of several core missions for a trauma provider. In civilian trauma management, inadequate airway management is a major contributor to pre-hospital morbidity and mortality. Studies examining pre-hospital deaths have concluded that as many as 85% of major trauma patients suffered from an obstructed airway which also contributed to their death [1, 2]. Similarly, airway management in the combat trauma arena has a significant impact. However, airway obstruction as the cause of death in potentially survivable combat injuries has been implicated at a lower frequency compared to the civilian trauma population. For example, analysis from the Vietnam era Wound Data and Munitions Effectiveness Team database revealed the primary cause of preventable death on the battlefield for airway obstruction was 6% [3]. A newer analysis by Kelly et al., however, revealed a much higher rate [4]. This study reported rates of preventable battlefield deaths for airway obstruction as 10% to 15%. This analysis reveals a higher potential number of preventable deaths with improved airway management. However this retrospective study, as well as others, has not analysed the potential improved neurological outcomes of soldiers suffering from

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traumatic brain injury (TBI) who have early definitive airway control. An inadequate airway can exponentially worsen an underlying brain injury for these patients, resulting in even poorer neurological outcomes.

The most significant impact of definitive airway control occurs at the initial point of care. However, airway control in the battlefield may be difficult to obtain because of a myriad of conditions which are unique to a combat situation. For example, a military medic has to consider enemy fire, austere environmental conditions, patient entrapment, and limited medical equipment. Additionally, combat-related injuries requiring emergent airway management are typically more severe than civilian injuries due to the nature of explosive and high velocity munitions. As well, these injuries characteristically occur in the head, neck and facial region, significantly degrading airway and facial anatomy [5]. Not surprisingly, tactical combat casualty care recommends early consideration of open surgical cricothyrotomy since an inexperienced military medic is unlikely to intubate battlefield trauma patients successfully [6]. However, battlefield cricothyrotomies are not uniformly successful and have a 33% failure rate [7].

Failure rates for orotracheal intubation are difficult to ascertain in the combat literature. The REACH database reviewed patients arriving at a combat support hospital and identified that 92% of intubations were placed correctly [8]. However, this study did not examine aborted or unsuccessful field intubations. An Israeli Defence Forces study discussed their unpublished first intubation attempt failure rate at as high as 40% [9]. This failure rate is higher than that determined in a study by Wang et al., which identified an overall failure rate of 23% in U.S. civilian pre-hospital intubations [10]. This study included non-trauma patients and airway procedures were performed by advanced paramedics (unlike their military medic counterparts trained only at the level of basic emergency medical technicians).

The need for improved training, including airway management for military medics, has been discussed in several publications [11, 12]. A military medic operates in extreme environments and cares for patients who typically suffer severe penetrating or blast injuries. Therefore, these medical providers should receive intensive advanced airway management training past basic emergency medical technician levels, since these skills have a significant impact on morbidity and mortality of an injured soldier. Unfortunately, these skills, especially orotracheal intubation, are very difficult to learn via traditional training modalities. This difficult learning curve in part is due to anatomical variations which often create difficult airway management situations for the laryngoscopist to visualize the glottic opening during intubation. In the non-combat arena, these anatomical challenges during intubation typically include: limited cervical spine mobility or trauma, a large tongue, a short neck, a neck of large circumference, protruding incisors, small mandible and other abnormalities of the neck or mouth. Therefore, it is difficult to align the oral, pharyngeal and laryngeal axis in order to perform intubation (Figure 1). These classic anatomical variations encountered in civilian medical care are exacerbated further by the environmental conditions and injury patterns which a military medic would commonly encounter.

The advancement of airway management equipment, namely videolaryngoscopy, may offer a potential solution for military medics attempting to become proficient in orotracheal intubation. Several studies have identified that the addition of videolaryngoscopy to training regimens has resulted in significant reductions in the time required to acquire the successful intubation skills [13-16]. As well, the application of this technology in the civilian pre-hospital arena has resulted in improved overall success rates and reduced intubation attempts [17, 18]. The videolaryngoscopes offer significant advantage over traditional laryngoscopes in visualizing the glottic opening during intubation. The videolaryngoscope has a camera on the distal laryngoscope blade which permits the laryngoscopist to overcome the geometric challenges which arise during intubation (Figure 2). With a direct vision laryngoscope, a ten degree view of the airway is seen, while the Karl Storz videolaryngoscope achieves a sixty degree view.

Unfortunately, new technologies require instructors who are proficient with its use and able to convey this to a student audience. Therefore, introducing new technologies such as the videolaryngoscope may not be accessible to many individuals, such as deployed military medics. Fortunately, this set back can be overcome by the use of telemedicine and advanced communication technologies. Several civilian as well as military studies have identified the validity of performing remote orotracheal intubation training using the Storz C-MAC videolaryngoscope in conjunction with a telemedicine platform [19-22].

Continuing this research has led to a collaboration between the *Telemedicine Service of the Central Hospital of Defence* in Madrid, Spain (a part of the Spanish Ministry of Defence (MoD) which provides support to medical units of the Army, Navy and Air Force with the Spanish MoD Telemedicine System) and the *Centre for Advanced Technology & Telemedicine* (CATT) at the University of Nebraska Medical Centre, Omaha, Nebraska. One goal of this collaboration is to develop virtual airway training for far forward military personnel using the Karl Storz C-HUB and videolaryngoscope with the Spanish Military Telemedicine System [23-24]. This collaboration has attempted to set the groundwork to improve combat airway management by introducing new and innovative technology via remote telementoring. It is our hope that this research will ultimately improve combat airway management standards and practices, thereby reducing the third most common cause of preventable combat death—inadequate airway management.

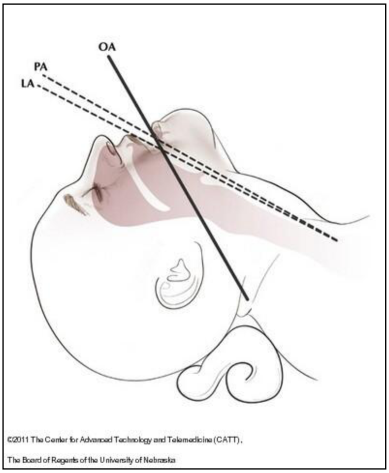

Figure 1. Anatomic variations create a situation in which the oral, pharyngeal, and laryngeal axes are difficult to be aligned during intubation.

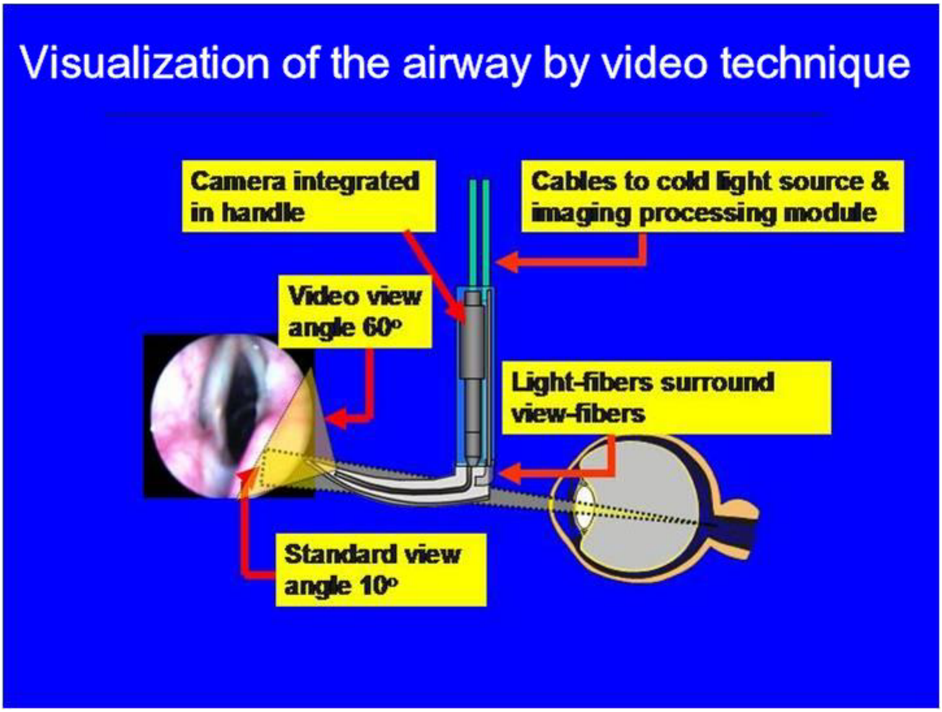

Figure 2. Visualization of the airway by the videolaryngoscope.

1. Materials and Methods

The Spanish Military Telemedicine System (SMTS) (Figure 3) is built into a rugged box with integration of the following equipment:

- videoconference Camera
- TV monitors
- personal Computer
- videoconference Software ClearSea™
- X-Ray picture scanner
- vital Signs monitor
- electrocardiography recorder
- router + Switch
- high resolution external exploration cameras
- ultrasound explorer machine
- DVD recorder
- email consultation inbox
- LAN access-IP serial converter (reception of Telemonitoring signals)
- surgical assistant tool which allows telestration from the reference hospital to the distant location.

Figure 3. Photo of Spanish Military Telemedicine System in rugged box.

LEMO connectors are present to allow interface with various telemedicine devices. The TM64 serves as the link between medical personnel at remote, deployed locations and the reference hospital [24]. In using this device, it is possible to support:

- real time audiovisual conferences
- visual Explorations: general explorations, endoscopies, teledermatology, teleotolaryngology
- diagnostic imaging: radiology, ultrasound explorations, computerized tomography (CT), MRIs, PET-CT
- telemonitoring of vital signs: 12 lead electrocardiogram, heartbeat, blood pressure, oxygen saturation
- consultations by email
- surgical indications for the remote centre with the virtual assistant board
- recording of consultations.

Connectivity is achieved via satellite connection to provide a communications link between the deployed units and the national military hospitals. The Spanish Military Satellite Network and Inmarsat technology are used for this purpose with a bandwidth of 128-512 Kbps and the videoconference system applies video codec H-264 [23]. For our pilot telemedicine connection to Herat, Afghanistan, we will use a SECOMSAT, Spanish Military Satellite System using the X band frequency. The system provides 512 Kbps for Telemedicine.

Use of the Karl Storz C-HUB with the Spanish Military Telemedicine System (SMTS). The Storz C-HUB provides the connection of most Karl Storz imaging devices to the computer and allows transmission of these images through a computer or telemedicine system (Figure 4).

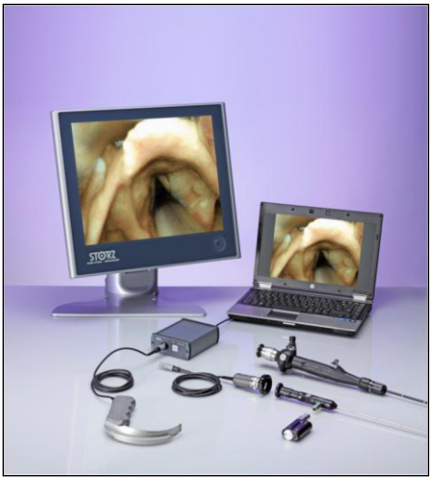

Figure **4.** The Karl Storz C-Hub (photo provided courtesy of Karl Storz Endoscopy, Tuttlingen, Germany).

Figure 5 shows the C-HUB attached via a USB port to the TM64 telemedicine system. The videolaryngoscope (or other endoscopic instrument) can be attached to the C-HUB, allowing the image to be viewed on the computer screen and transmitted, allowing telemedical applications. The video laryngoscope camera is supported by the HIPPA compliant LifeSize® ClearSea™ desktop and mobile video conferencing software program (*LifeSize Communications*, Austin, TX). In our previous work, we have used the *Adobe Connect* program to support the videolaryngoscope camera in a similar fashion [25-26].

Figure 5. The Karl Storz C-HUB and C-MAC Videolaryngoscope connecting by USB to the telemedicine computer.

The C-HUB expands the capabilities of the SMTS by allowing projection of endoscopic surgical images, thereby facilitating telementoring or diagnostic applications. A virtual airway training simulation laboratory was created at each site by using a Laerdal Difficult Airway Manikin and the same videolaryngoscope intubation equipment. This uniformity allows the intubation trainer to explain and demonstrate the use of the videolaryngoscope by videoconferencing with the distant training site. The students at the distant site can perform the intubation manoeuvres after watching the trainer. By creating identical simulation laboratories, intubation trainers can teach students through videoconferencing, creating a learning environment in which location is no longer a limitation. In addition, the Madrid Spanish MoD Telemedicine Service created a videolaryngoscope training video which is played before the training session. The Spanish team's 'Telestration' uses a dual screen to point out vital anatomic structures to the students.

2. Results

This work demonstrates a teleconference between the Central Hospital of Defence, Madrid and a deployed team at a NATO Forward Support Base in Herat, Afghanistan. In the near future, we plan to perform videolaryngoscope training from the University of Nebraska Medical Centre in Omaha, NE and the Central Hospital of Defence, Madrid to the Herat deployed hospital. The C-HUB connecting the Karl Storz video laryngoscope to the SMTS system will be used to support just-in-time training for insertion of novel airway support equipment to the forward operating base in Afghanistan.

Our project will demonstrate that we are able to perform complex medical training to a deployed team using low bandwidth (128 kbps) connectivity. This system will be utilized to ensure that all members of the deployed medical team are able to operate a video laryngoscope, thereby enabling them to perform emergency airway support. In phase two of this project, we will begin supporting tele ENT training and distant support to the deployed team.

3. Conclusion

The concept of creating identical laboratories for teachers and students allows an intubation trainer at a medical centre to train personnel at deployed military locations. In this demonstration, the simulation laboratory set up was a low cost training package, which consisted of an intubation manikin and airway management equipment. This virtual demonstration concept can have many training applications. Use of virtual simulation training with ClearSea™ or *Adobe Connect* can be a valuable resource in providing efficient training to deployed personnel in remote locations in a cost effective fashion.

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