INTRODUCTION

Insertion of a surgical airway is required in patients with airway compromise where other less invasive procedures have failed. A study of patients over a 21 year period (1991-2012) suggested that surgical airway procedures were performed on average 2.4 times per year by a busy UK inner city Helicopter Emergency Medical team;[1] because of the nature of conflict, surgical airway procedures tend to be more common.[2,3] Airway compromise accounts for up to 2% of combat deaths,[2] and is the third leading cause of potentially preventable death in a combat zone.[4] The recent conflict in Afghanistan has led to severely injured patients being managed in the pre-hospital environment by British combat medical technicians and General Duties Medical Officers (GDMOs), prior to arrival of the Medical Emergency Response Team (MERT). These individuals are often required to perform time-critical interventions that would normally be done by experienced, senior clinicians in UK civilian practice.

The incidence of surgical airway insertion by British (UK) and United States (US) personnel was defined in 2012, when Mabry estimated that whilst the military rate of US surgical airway insertion was approximately double the civilian rate, it still occurred in less than 1% of all US military trauma admissions.[2] In addition to examining the actual numbers of surgical airways performed, work has also been undertaken to quantify the success rates when insertion of a surgical airway has been attempted. Studies of US military success rates from the recent conflicts in Iraq and Afghanistan have varied from 50 - 82%,[2,5,6] with another small study from Iraq showing a 100% failure rate across 5 cases.[4] In recognising the importance of 'first time insertion success' for this group of patients the US Tactical Combat Casualty

Care (TCCC) Committee has stated, "…a surgical airway is probably the most technically difficult life-saving intervention the combat medic must master." [7] It is also "…the preferred method for establishing a definitive airway during tactical field care or tactical evacuation."[8] It is practised as part of the UK Battlefield Advanced Trauma Life Support (BATLS) and the Military Operational Surgical Training (MOST) course. The indications for surgical airway are described in detail in the Clinical Guidelines for Operations (CGO's) and Difficult Airway Society (DAS) guidelines, and are summarised in Table 1.

Table 1: Indications for Pre-Hospital Surgical Airway[9,10]

Indications
• A casualty needing a definitive airway for resuscitation or evacuation, who is too awake to tolerate endotracheal intubation without an anaesthetic and specialist anaesthetic support is unavailable
• A casualty with face or neck burns who requires airway protection to pre-empt delayed obstruction, but expert anaesthetic help to facilitate intubation is unavailable
• Trauma to the face and neck makes endotracheal intubation impossible
• A 'can't intubate can't oxygenate' (CICO) situation.

The aim of this study was to evaluate surgical airways performed during the recent conflict in Afghanistan by UK military medical personnel, defining procedural success, survival rate to discharge from hospital and associated outcomes.

METHODS

The Joint Theatre Trauma Registry was used to identify all patients who underwent insertion of a surgical airway in Afghanistan by UK medical personnel in the pre-hospital environment between 2006 and 2014. Participants were excluded if their medical record identified that the procedure was not performed by UK practitioners, or if documentation was incomplete and therefore success could not be confirmed (Figure 1). A retrospective chart review was undertaken involving manual data collection from scanned medical notes at the Central Health Records Library (CHRL), a Ministry of Defence (MOD) establishment where military health records are stored. Where discrepancies existed, confirmation was obtained through analysis of the hard copy evacuation notes. Data collected included success of the procedure, survival to discharge from the military hospital, stage of care at which the procedure was performed, and experience of practitioner. Data were analysed using SPSS (v21). The study was registered as a service evaluation at the Royal Centre for Defence Medicine (RCDM/Res/Audit/1036/16/0458).

Figure 1: Study flowchart

RESULTS

Of the 201 patients who underwent a pre-hospital surgical airway procedure by UK medical personnel, 42.8% (n=86) met the inclusion criteria and were included in the final study analyses (Table 2). The median patient age was 25 years, (SD 5), with a median ISS of 62.5 (IQR 42). Blast was the principal mechanism of injury (MOI), contributing to injury in 73.3% of the patients. Significant injury to head, face and neck was noted in 68.6% (n=59) of patients receiving a surgical airway.

Table 2: Demographics, Patient Classification and Mechanism of Injury

Demographics	No	%
Male	86	100
Female	0	0

Patient classification		
UK Military	49	57.0
Non UK Coalition Military	2	2.3
Afghan National Security Forces	21	24.4
Local nationals	14	16.3
Mechanism of Injury		
Explosive IED/Mine	55	64.0
Explosive RPG/Mortar/Grenade	8	9.3
Gunshot Wound	19	22.1
Road Traffic Collision	3	3.5
Trauma Other	1	1.2

Table 3 shows the Glasgow Coma Scale (GCS) score of patients undergoing the procedure. The median score recorded on the Patient Report Form (PRF) was 3. Out of the 86 patients on whom a surgical airway was performed 21 (24%) patients survived to discharge from hospital.

Table 3: Glasgow Coma Score as documented on PRF

GCS	No.	%	Survival (%)
15	4	4.7	100
8-14	2	2.3	50
4-7	1	1.2	100
3	75	87.2	16
Not recorded	4	4.7	NA

In all, 79 (92%) of all surgical airways were found to be inserted correctly. 7 (8%) were either inserted incorrectly or failed to perform adequately. 80 (93%) of these procedures were performed by combat medical technicians or General Duties Medical Officers (GDMOs) either at the point of wounding or Regimental Aid Post (RAP). 6 (7%) procedures were conducted by the Medical Emergency Response Team (MERT) en route to the Role 3 hospital.

DISCUSSION

This study describes the largest number of documented surgical airway procedures undertaken in a modern conflict by UK military personnel. The results reveal a high success rate for correct placement of a definitive surgical airway in challenging situations by relatively junior combat medical technicians and GDMOs with an overall success rate of 92%. These results compare favourably with other studies where success rates amongst coalition partners have been cited between 0% and 82%.[2,4,5,6]

This compares with previous published work where the median age of 25 and majority of male patients match those seen in other studies. The mechanism and patterns of injury seen in this retrospective review show a high proportion of blast-related injury (73%) followed by gunshot wounds (22%). Barnard's recent prospective study demonstrated a similarly high ratio of blast (79%), and penetrating injury (18%).[6] In an earlier study between 2007 and 2009, Mabry found that the majority of casualties requiring surgical airway had been exposed to a near equal percentage of blast (42%) and gunshot wounds (38%).[2] The differences in injury patterns between earlier and later studies are likely to be due to the evolution of tactics and the subsequent rise in the use of improvised explosive devices (IEDs) and indirect fire techniques by enemy combatants as conflicts in Iraq and Afghanistan matured. There is a noticeable contrast between military and civilian injury patterns. In Lockey's paper, of the 90 surgical airways undertaken over a 21-year period in London, only 7 (8%) were performed in patients incapacitated through penetrating trauma, with the vast majority of casualties 83 (92%) suffering blunt traumatic injury.[1]

Analysis of the pre-surgical airway insertion Glasgow Coma Score (GCS) and survival demonstrated that 16% of patients with GCS 3 (n=75) survived to hospital discharge. Of the small number of patients presenting with GCS 4-15, (n=7) all but one survived (86%). This is similar to Barnard's study where survival for patients with GCS 3 (including 4 sedated patients) was 23% (n=22) and 89% (n=10) for patients with GCS 4-15.[6]

In this study there was no discernible relationship between survival and the documented Injury Severity Score (ISS) prior to surgical airway insertion. ISS ranged from 9-75 with a median ISS of 62.5, indicating a particularly heavy injury burden among patients who undergo surgical airway placement. In an example of the poor correlation between ISS and survival, a patient with the lowest ISS (=9) died as a result of his injuries, whilst 24% of those with a higher ISS survived to discharge. This is consistent with previous papers where it was considered difficult to predict survival outcomes using the ISS alone.[11,12] The inaccuracy of predicting survival using ISS is further corroborated in the London HEMS observational study.[1] These issues notwithstanding, ISS is commonly used as an international measure for defining major trauma and predicting mortality and was therefore useful to measure UK military pre-hospital performance against other systems.

Patients with actual or impending airway obstruction against a background of severe head and neck trauma present one of the greatest challenges to pre-hospital care providers. Faced with a patient of this type, failure to insert the airway correctly will almost invariably result in hypoxia and death. Difficulties in performing the technique in the pre-hospital setting are compounded on the battlefield or in flight, where additional environmental factors can influence the likelihood of success. In our study, combat medical technicians and GDMOs performed the vast majority of procedures and had a 93% success rate (69 out of 74 cases). Whilst the London HEMS data demonstrated 100% success, our findings compare favourably with that described in pooled, civilian, pre-hospital data.[13] This success rate compares satisfactorily with previous studies where successful insertion of a surgical airway in patients arriving at a military hospital has been described as 0%,[4] 50%[5] and 68%.[2] In his recent paper, Barnard demonstrated a successful surgical airway insertion rate of 82%.[6] In 6 of the 24 patients (25%) the procedure was performed by a combat 'ground' medic in the pre-evacuation phase, whilst the remaining 18 (75%) were performed by evacuation helicopter medics. The paper does not specify whether the procedures undertaken in the evacuation phase were performed on the ground or in-flight whilst en route to the military hospital. Assuming that the majority of surgical airways were performed en route, this figure compares favourably with the small number successfully performed by MERT in flight (5/6; 83%).

In our study, 21 (24%) of patients undergoing a surgical airway survived to discharge. This compares favourably with civilian studies [1,14] but is fewer than those cited by Mabry (33%) and Barnard (50%) whose study populations have similar characteristics but are smaller.[2,6]

Surgical airway insertion is the final common pathway for managing the compromised airway in both civilian and military systems.[15] The UK Defence Medical Services advocate a single, standardised approach to teaching the technique for surgical airway placement in battlefield casualties, as highlighted in table 4 and figure 2. The technique is taught on the Battlefield Advanced Trauma Life Support (BATLS) course in accordance with DMS Clinical Guidelines for Operations to all military medics, nurses and doctors deploying on operations. Competency is assessed in both the classroom and during realistic field training exercises which cover both care under fire and tactical field care phases. Certification is for 4 years, whereupon recertification is required prior to deployment. The course emphasises the need for a consistent approach using a standardised set of equipment. In doing so, the 'medic' is able to practise the procedure using the equipment that is available on operations whilst training in stressful scenarios encompassing a range of varying fidelity models. It can also be seen that many UK, Commonwealth and European civilian helicopter emergency medical services employ a single, standardised approach to ensure competency with pre-hospital advanced airway management resulting in documented high degrees of success.[1,14,16]

Table 4: Technique for insertion of Surgical Airway[9]

Surgical Cricothyroidotomy: Procedure
• Place the casualty supine with the neck in the neutral position. • If not contraindicated, extend the neck and place a pillow/rolled blanket (or suitable alternative) under the shoulders: this will bring the landmarks into more prominence. • Palpate the thyroid notch and cartilage, cricothyroid membrane and cricoid cartilage. • Clean the skin and infiltrate with local anaesthetic (unless the casualty is deeply unconscious.) • Stabilise the thyroid cartilage with the left hand. • Make a horizontal skin incision over the cricothyroid membrane. • Carefully incise through the membrane horizontally: open the incision with artery forceps.

- Insert a 6mm cuffed tracheostomy tube through the cricothyroid membrane incision, directing the tube distally into the trachea.
- Inflate the cuff. Secure the tube by tape or stitch, or both.

Figure 2: Surgical Cricothyroidotomy procedure[9]

In a recent small retrospective study, the authors noted that there were a significant number of procedural errors associated with surgical airway placement by non-UK partners. Discussion with multi-national senior clinicians based at both the Role 3 and Role 1 echelons identified the perception of a lack of standardised approach and equipment as potential reasons for the complications associated with their findings.[5] A review article in 2013 identified 12 distinct surgical cricothyroidotomy procedures and numerous variations of cricothyroidotomy equipment seemed to reinforce this concept.[17] Common themes have appeared where training, simulation and practice are described as imperative for success.[7,8,15,16,18] As industry and the US military continue to adapt training modalities with a standardised approach it is envisaged that pre-hospital surgical airway success rates will continue to increase.

STUDY LIMITATIONS

This retrospective study has certain limitations inherent in its methodology. A significant proportion of cases (111 / 55.2%) were excluded due to lack of complete data on the JTTR and in clinical notes. In part, some pre-hospital data omissions were due to the constraints of the operational and tactical environment that the medical teams were operating under; particularly in the earlier years of the conflict.

Other data were missing as a result of retrospective data entry and further information was found to be incomplete when the patients' medical records were examined at the Central Health Records Library. Deficiencies in military pre-hospital data collection and retrieval have been previously highlighted [19] and are in the process of being addressed.[20,21] It is hoped that improvements in data recording, collection, storage and retrieval will ensure that in future valuable data will help better inform and shape changes in battlefield pre-hospital medicine.

CONCLUSION

This study has demonstrated that even in hostile and austere conditions, correct placement of a surgical airway is achievable, with a success rate of 92% in this series. The results compare favourably with other non-UK partners, and this may be attributable to a standardised, robust approach to technical skills training and to the use of a single standardised set of equipment.

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