Original Article

Tracheal intubation practices and adverse events in trauma victims on arrival to trauma triage: A single centre prospective observational study

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ABSTRACT

Background and Aims: Trauma is one of the leading causes of global disease burden. Data on airway management in trauma patients from developing countries, particularly India is sparse. Hence, we planned a prospective observational study to assess the airway management practice patterns and associated complications. **Methods:** The study was conducted in trauma triage of a tertiary care hospital. Data was collected on all tracheal intubations occurring in trauma victims requiring definitive airway control, a detailed proforma including patient details, mode of injury, drugs used, intubation procedure, and complications were filled out for each patient. **Results:** We observed that the airway in trauma patients was primarily managed by non-anaesthesia speciality residents (426 patients); anaesthesia residents were primarily called for deferred or difficult intubations. The first attempt success rate of intubation by anaesthesia residents was significantly higher than speciality residents (P = 0.0001; 95% CI 9.02-24.66). Non-anaesthesia residents used midazolam in varying doses (3-12 mg) for intubation, whereas, rapid sequence intubation was the most common technique used by anaesthesia residents. Airway injuries were the most frequent complication observed in 32.8% of patients intubated by specialty residents compared to 5.9% of patients intubated by anaesthesia residents. **Conclusion:** The trauma triage is a high-volume area for frequent tracheal intubations which are manned by non-anaesthesia speciality teams. A number of factors related to the patient, staff, availability of airway equipment and unfavourable surroundings impact airway management and may explain the high incidence of airway complications, such as airway injuries in these trauma victims.

Key words: Airway management, head injury, intubation, polytrauma, trauma centre

INTRODUCTION

Emergency airway management is a priority in polytrauma and head injury patients.[1] Early and definitive airway control plays a key role in preventing further deterioration of head injury along with a reduction in preventable deaths by 42%.[2,3] Intubations outside the operating theatre, including trauma triage are challenging and associated with more risks due to the physiological perturbations, experience of the primary intubator, odd hours of intubation, logistic difficulties, immediate unavailability of difficult airway equipment and unfamiliarity with the use of drug assisted intubations.[4] All these factors have a significant impact on the already compromised condition of trauma victims due to limited oxygen reserves, low Glasgow coma scale (GCS), score and haemodynamic instability.[5]

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Early and effective airway control including prehospital airway management, intubation practices, and techniques in trauma victims is well evident from the western and developed world.[6,7] But the literature pertaining to such practices in the underdeveloped and developing world is scarce, with an urgent need to establish guidelines for delineating emergency residents dealing with airway control and intubation practices in trauma victims with severe traumatic brain injury.

We aimed to assess the current practices of airway management and to characterise the technique and the requirements of tracheal intubation and the challenges faced during airway management in the trauma triage area of a tertiary hospital in northern India. The secondary objectives were to determine the success rates of endotracheal intubation by anaesthesia and non-anaesthesia trainees, the incidence of adverse events observed while securing the airway.

METHODS

This observational study was conducted in the trauma triage of a level 1 tertiary care hospital over one year (October 2017 till September 2018) after approval from the Institutional Ethics Committee and registration in the Clinical Trials Registry of India (CTRI/2017/04/013155). The study design is in accord with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Written and informed consent was obtained from immediate legal relatives of eligible patients. Data was collected on all tracheal intubations occurring in trauma victims requiring definitive airway control with endotracheal intubation in red (life threatening injury requiring immediate emergency care) and yellow (do not have life threatening injury/do not require immediate emergency care) area of trauma triage. We excluded patients who were intubated before arrival in trauma triage, any missed documentation of intubation events, and incomplete data.

The data was collected by an independent observer who was not a part of data analyses. To minimise any missed intubations, different methods were adopted by the personnel responsible for the collection of data. These methods included a discussion with the staff performing and assisting the intubation, regular meetings with the trauma team during the end of each shift, and also during handover to the subsequent team and finally through the review of trauma triage records. Data were collected using specific proformas both for anaesthetists and speciality residents (neurosurgery, orthopaedics, cardio-vascular thoracic surgery, and plastic surgery). An anaesthesia resident [post graduate (PG)1] (with more than six months of training experience and minimum experience of 20 intubations) was considered to be an expert. We recorded the demographic profile of the patients, diagnosis, along with indication for intubation, mode of injury, presence of any head injury, drugs and equipment used for intubation, personnel performing intubation [Table 1], number of attempts, and complications during intubation [Table 2]. As per institutional practice, all patients received a fluid bolus of 500 ml crystalloid when received with trauma in the triage area, and before attempting intubation and giving drugs to prevent haemodynamic instability.

Airway injuries included observation for lip, oropharyngeal, dental, and vocal cord trauma. Bradycardia was defined as heart rate (HR) ≤40/min

Table 1: Data collected for each endotracheal intubation

Data collected for each intubation
Details of procedure
GCS prior to intubation
Indication of intubation
Time of intubation (Day/night)
Details of intubator
First intubator
Grade and speciality
Second intubator
Grade and speciality
Level of training of assisting personnel
Details of intubation
Monitoring present or not (capnography/ECG/NIBP/Pulse oximetry)
Availability of suction apparatus
Patent intravenous access available or not
Fluid preloading done during intubation or not
Intubation done on trolley or bed
Whether the height of intubating trolley/bed appropriate
Presence of bar on head axis of trolley/bed
Position of intubator during intubation
Availability of adequate surrounding space
Preoxygenation done or not
Intubating position- neutral/sniffing/head extension
Method of intubation used- awake/sedated/paralysed
Drugs used
Use of external laryngeal manipulation
Use of cricoid pressure during intubation
Cormack Lehane grading
Use of airway adjuncts- stylet/bougie/LMA
Number of attempts of intubation

GCS- Glasgow coma scale, ECG – electrocardiography, NIBP- noninvasive blood pressure, LMA – laryngeal mask airway

or 20% decrease in pre-intubation HR; hypotension was considered when systolic blood pressure (SBP) ≤90 mm Hg and significant hypoxaemia was defined as peripheral oxygen saturation (SpO_2) value <90% during intubation attempt [Table 2]. Visualisation of newly regurgitated contents or the bleed due to trauma during suction via endotracheal tube was considered as aspiration.[8]

Use of rapid sequence intubation (RSI) or manual in-line stabilisation whenever performed were recorded.[9,10] Urgent intubations were defined as the immediate requirement of intubation, difficult intubations were those requiring ≥ three attempts of intubation, attempts taking >10 minutes, or need for an airway adjunct or another airway manager. Failed intubation was defined as failure to place an endotracheal tube after multiple attempts (≥3 attempts).[5] Completed proformas were collected on a daily basis. The triage registry was reviewed for any missed documentation of intubation events.

Statistical analysis was carried out using International Business Machines Statistical Package for the Social Sciences (IBM SPSS Inc, Chicago, version 21.0). The continuous data were presented as mean ± standard deviation (SD) or median and interquartile range, as appropriate. The normality of quantitative data was checked by Kolmogorov Smirnov tests of normality. Categorical and classified data were compared using Chi-Square test. *P* value <0.05% was considered statistically significant with 95% confidence interval. Skewed data were expressed as median, interquartile range.

RESULTS

The trauma triage registry recorded a total of 12,916 trauma patients during the 12 months study period out of which 1,236 patients required endotracheal intubation [Figure 1]. On arrival, 436/527 (82.7%) intubations were considered urgent and 426/527 (80.8%) intubations were attempted by first responders (general surgery residents (PG resident 3/4 semester)), the most common indications were low GCS score and failure to protect the airway. Around 48/426 (9.1%) intubations were reported as challenging, and on-call, anaesthesia resident was summoned to reattempt intubation. As primary responders, anaesthesia residents performed 101/527 (19.1%) intubations. Preoxygenation was done in 80% (422/527) patients. All intubations were carried out on a stretcher with

Table 2: Data collected on adverse events during endotracheal intubation

Data collected on adverse events during each intubation
Significant hypotension
Significant hypoxaemia (SpO_2<90%)
Aspiration of gastric contents
Dental injury
Significant bleeding
Challenging intubation
Cardiac arrest

SpO_2 – pulse oximetry

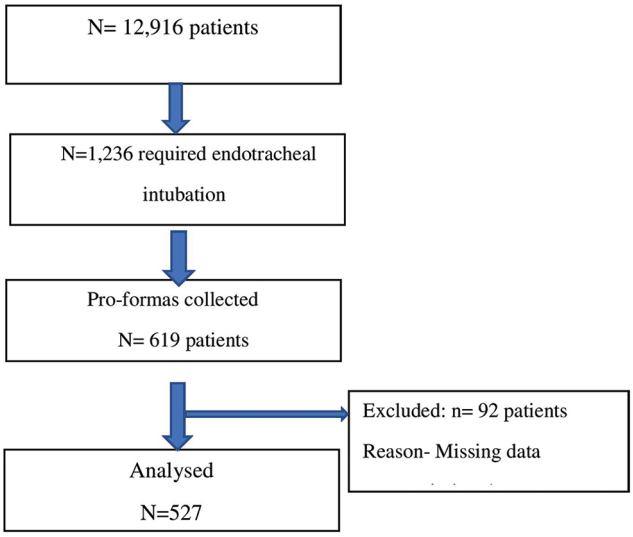

Figure 1: STROBE flow chart

head position in extension in 64.3% (339/527); neutral in 28.8% (152/527); neutral with manual in line stabilisation in 2.27% (12/527) and sniffing position in 13.6% (72/527) patients. All patients were monitored using pulse oximetry and non-invasive blood pressure, but due to non-availability, electrocardiogram and end tidal carbon dioxide were not recorded. The adequacy of surrounding space was another technical issue, with adequate space in 96 cases (18.2%), whereas, in the rest of the cases the surrounding area was occupied by patient relatives and trollies.

The most common mode of injury was road traffic accidents in 459 (87.1%) cases. GCS scores of the patients at the time of intubation ranged from 3-15 with a median of 8. The most common reason for intubation was a low GCS score in 361 (68.5%) patients, followed by respiratory distress in 108 (20.5%) cases [Table 3].

During intubation, in a majority of patients, (509 (96.5%)) SpO_2 was monitored using pulse oximetry, whereas blood pressure measurement was done for 420 (79.6%) patients. Haemodynamic

instability was present in 73/527 (13.8%) patients prior to the intubation attempt. Peri-intubation hypotension was documented in 99 (23.57%) patients out of 420 patients. Similarly, hypoxaemia during intubation was documented in 21.21% (108/509) patients.

All intubations were carried out using a direct laryngoscope. The majority of intubations were done by general surgery residents (PG 4) 338/527 (64.1%) followed by anaesthesia residents (PG 3) 115/527 (21.8%). Anaesthesia resident was present in 149 cases (101 cases as primary intubation and in 48 cases as the second intubator) for intubation [Table 4]. The first attempt success rate of intubation for general surgery residents was 63.1% (269/426) and that of anaesthesia residents was 80.5% (120/149), $P = 0.0001$ with 95% confidence interval (CI) 9.02-24.66. Similarly, the second attempt success rate was also higher for anaesthesia residents compared to general surgery residents, $P = 0.043$ (95%CI 0.23-10.46).

External laryngeal manipulation during intubation was done in 315/527 cases (59.8%), the stylet was used in 383/527 (72.6%), bougie was used only by anaesthesia residents in 19 cases, three patients required placement of laryngeal mask airway as a rescue device (difficult intubation), four patients needed front of neck access, in the form of surgical tracheostomy, however in one patient surgical access also failed leading to severe hypoxaemia and cardiac arrest.

A majority (95.7%) of patients intubated by speciality residents received injection midazolam for assisting intubation; (408/426) of these, 13.48% (51/408) patients received ≥5 mg dose of midazolam. In patients intubated by anaesthesia residents, induction agents (thiopentone and ketamine) and muscle relaxants (succinylcholine and vecuronium) were used. Of this, rapid sequence induction (RSI) was performed in 99/149 (66.4%) patients.

Among intubations done by speciality residents, the most common adverse event was airway injury [140/426 (32.8%) patients] followed by hypotension in 58/426 (13.8%) patients. The intubations indicated for low GCS score ≤5 (n = 28/120, 23.3%) recorded lesser airway injuries than those with GCS ≥6-8 (n = 92/120, 78.7%) [($P = 0.0001$; Chi-square test); 95% CI: 41.6-62.8)]. We found a significant association between the choice of drugs used and the rate of adverse events. In 99/149 patients who were intubated using RSI, 77% patients had no complications (77/149), followed by airway injuries in 8% (8/99), oesophageal intubation in 4% (4/99), hypoxaemia in 5% (5/99) and hypotension in 3% (3/99) patients. Complications were directly linked with the number of attempts at intubation (>2 attempts at intubation, $P = 0.0001$, 95% CI 30.2-51.7) [Table 5].

Table 3: Demographic data of trauma victims requiring intubation

Parameter	Patients *n*=527*
Age (years)	32 (22-45) **
Male/female	398/129*
Type of injury	
Head injury	415 (78.7%) *
Blunt trauma chest	133 (25.2%) *
Blunt trauma abdomen	103 (19.5%) *
Cervical spine injury	17 (3.2%) *
Facial burns	15 (2.8%) *
Faciomaxillary injury	5 (0.9%) *
Isolated bone fractures	5 (0/9%) *

All data are represented as n=number of patients*, percentage and median with interquartile range**

DISCUSSION

In a tertiary care hospital of a low resource country, the first responders are usually non-anaesthesia, speciality residents who cater to the immediate needs of the trauma victims. A total of 527 patients were analysed, and out of these, 426 intubations were considered urgent. The majority of intubations (76.4%) were performed by speciality residents (general surgery)

Table 4: Grade and specialityof 1st and 2nd intubator; *n*=number of intubations, (%, depicts percentage of intubations out of 527 total intubations)

Grade and specialty	1st intubator *n*=527	2nd intubator *n*=79
GS residents with 12 months experience	27 (5.1%)	-
GS residents with 18 months experience	338 (64.1%)	-
GS residents with 24 months experience	38 (7.2%)	15 (19.2%)
GS residents with 30 months experience	-	34 (43.5%)
Anaesthesia residents with 6 months experience	9 (1.7%)	7 (8%)
Anaesthesia residents with 12 months experience	115 (21.8%)	19 (24.3%)
SR anaesthesia	Nil	4 (3.8%)

Data depicted as *n*=number, GS -general surgery, SR – senior resident

Table 5: Adverse events during intubation attempts in trauma victims by both speciality and anaesthesia residents. Data are represented as, *n* (%)=number of patients (percentage)

Complications	By specialty residents**n*=426	By anaesthesia residents *n*=149
No complications	228 (53.5%)	92 (61.7%)
Airway injuries	140 (32.8%)	13 (8%)
Hypotension	57 (26.0%) **	6 (4%)
Failed intubation	48 (11.2%)	4 (2.6%)
Desaturation	42 (9%)	8 (5.3%)
Oesophageal intubation	22 (5%)	7 (4.6%)
Aspiration of blood	19 (4.4%)	3 (2%)
Aspiration of gastric contents	5 (1.1%)	1 (0.2%)

Data depicted as *n*=number, (%)=Percentage *The incidence of complications was significantly more in intubations by speciality residents compared to anaesthetists

and 28.27% by anaesthesia residents. The first attempt success rate for speciality and anaesthesia residents was 63.1% and 80.5%, respectively.

These findings reflect the different staffing levels and the limited expertise available on arrival to trauma triage. An observational study in the emergency department of an academic centre, reported the working of various levels of health care professionals as a team.[11] Whereas, in accordance to our research, Walls *et al*.[12] reported that anaesthesiologists performed only 3% of the intubations, and the remaining 97% of the intubations were performed by emergency physicians (87%) and physicians from other specialities (10%).

The level of experience for airway management requires a learning curve of 150 intubations for the success of intubation.[13] A United Kingdom based guideline suggested training for a minimum of two years in emergency specialities and at least one year in anaesthesia for airway management.[14] Ono *et al*.,[15] reported that the experience of the laryngoscopist plays a pivotal role, and hence their finding that the success rate of intubation increases when an anaesthesiologist performed intubation; this is supported by our data too.

There is an emphasis on the need for proper pre-oxygenation for successful and complication-free out-of-theatre emergency intubation.[16] The incidence of desaturation varied significantly between speciality (12.96%) and anaesthesia residents (8.25%). It could be attributed to the higher proportion of patients pre-oxygenated in a standardised manner by anaesthesia residents. Literature supports the use of techniques like 25° head-up position or the use of non-invasive ventilation techniques, including positive end-expiratory pressure, during preoxygenation in emergency intubations.[17,18]

Midazolam was used by speciality residents in 77.4% (408/527) patients, which was given in variable doses, resulting in peri-intubation hypoxia in 61/395 (15.44%) cases, hypotension in 57/395 (14.43%) cases and other airway related complications. Also, the use of midazolam for intubation is not supported by literature in emergency settings.[19] Nevertheless, the extensive use of midazolam in our environment may be due to the lack of familiarity with anaesthetic drugs among speciality residents.

Most of the intubations carried out by anaesthesia residents were drug assisted along with the use of muscle relaxants which resulted in lesser complications and trauma. Literature supports the use of neuromuscular blockers in 62-77% of cases, with a strong association being reported between the use of neuromuscular blocking agents, especially depolarising agents and fewer adverse effects.[20,21]

The National Audit Projects 4 data indicates that airway interventions outside the operation theatre are more likely to result in adverse events.[22] In the current study, the incidence of adverse events and complications were higher in intubations by speciality residents (46.4%), which were probably due to inexperience, improper positioning of the patient, inadequate oxygenation, absence of adequate monitoring, unfamiliarity with drug-assisted intubations and unavailability and inexperience with the usage of airway adjuncts. Use of better and minimum standards of monitoring, including capnography are required in emergency intubations to reduce adverse events and better patient services.[23]

Recently, Russotto *et al*.[24] conducted an observational study to evaluate the incidence of adverse peri-intubation events during intubation of critically injured patients. Primary outcome included the incidence of major adverse events within 30 minutes of tracheal intubation, which included cardiovascular instability (SBP <65, or <90 for 30 minutes, increased need of vasopressors) or hypoxaemia (SpO_2 <80%) and cardiac arrest. The authors reported, 45.2% of patients experienced at least one major peri-intubation event, most common was cardiovascular instability in 42.6% of cases. In the present study, airway-related injuries were most common; the probable reason for this could

be that only trauma victims were included, whereas Russotto *et al*.[24] included all critically ill patients in intensive care units.

Bougie was used only by anaesthesia residents in case of failure to intubate in the first attempt. Early and better use of airway manoeuvres and airway adjuncts (bougie) played an important role in an increased first attempt success rate of intubation in emergency areas.[25,26] Trauma triage teams should be provided with better airway adjuncts and should be made familiar with their use so as to improve patient care. Bernhard *et al*.[27] highlighted the difficulties posed in the real-world scenario with regards to equipment availability, practical issues at resuscitation bay as well as costs incurred in procuring the equipment.

Emergency cricothyrotomy is the final step in the emergency airway management algorithm.[28] Specialised training along with equipment should be available at the trauma triage centers.[29] The incidence of failed intubations requiring surgical airway was 0.75% in the current study, which was less when compared to previous studies reporting 1.7% by Ono *et al*.[15] Similarly, the incidence of cardiac arrest in our study was reported in 0.9% of patients when compared to 1.7% in the previous research.[8] But whether the cardiac arrest resulted due to patients' underlying physiological state or due to attempts at intubation could not be deciphered from the data collected.

The findings of this study support the need for the development of an emergency response system and team in emergency departments in low resource settings, regular simulation-based training in advanced trauma life support and airway management and the presence of difficult airway cart in trauma triage bay.[3] The rate of complications can also be reduced by the adaptation of a checklist and a standardised protocol for the formulation and usage of drugs.

This study has a few limitations. There was a lack of proper airway assessment and a self-reporting bias which could have led to possible underestimation of failed intubations and adverse events which were not reported as these practices were judged by residents to be below the standard of care. Also, the knowledge about the study being conducted could have altered the practices of physicians.

CONCLUSION

The trauma triage is a high-volume area for frequent tracheal intubations which is manned by non-anaesthesia speciality teams. A number of factors related to the patient, staff, availability of airway equipment and unfavourable surroundings impact airway management and may explain the high incidence of airway complications, such as airway injuries in these trauma victims.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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