

A prolonged observational study of tracheal tube displacements: Benchmarking an incidence <math><0.5-1\%</math> in a medical-surgical adult intensive care unit

Farhad N. Kapadia, Pandurang C. Tekawade, Shruti S. Nath, Sharad S. Pachpute, Sanjay S. Saverkar, Rupali A. Bhise, Aarti C. Chavan, Sholly J. Varghese, Vidya U. Kantak, Rohini V. Kshirsagar, Vaishali A. Neve, Samona O. D'souza

Abstract

Background and Aims: Tracheal tubes are commonly used in intensive care unit (ICU) and lead to complications like displacements. The primary aim of the study was to evaluate if the rate of tracheal tube displacement benchmarked at <math><1\%</math> per patient and <math><0.5\%</math> per tracheal tube day, could be sustained over a prolonged period. The secondary aim was to document the patterns of all forms airway accident and to evaluate their consequences. **Subjects and Methods:** This was a prospective observational study of Intubated and ventilated patients in a General Medical-Surgical Adult ICU. The incidence of accidental extubation, self extubation, partial displacement and blockages of tracheal tubes were recorded. **Results:** The overall tracheal tube displacement rate was 61/10,112 (0.6%) per patient and 61/28,464 (0.22%) per tracheal tube day. There were 30 additional incidents of blockage, kinking or biting of the tracheal tube. Physiological consequences-69 were mild, 10 moderate, 12 major and one death. Of the 91 accidents, 30 were partly and 30 were completely preventable. 76 incidents involved an endotracheal tube (54 displaced, 12 blocked and 10 bitten-kinked) and 15 a tracheostomy tube (seven displaced and eight blocked). Accidents were more common in medical than surgical patients (medical = 48, cardiac surgical = 17 and other surgical/trauma = 26). **Conclusion:** Tracheal tube displacement rate in a mixed medical-surgical adult ICU was maintained below the pre-set benchmark of <math><1\%</math> per patient and <math><0.5\%</math> per intubated day over nearly a decade.

Keywords: Airway accidents, endotracheal tube, tracheostomy tube, unplanned extubation

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Introduction

We have twice previously reported airway accidents in our intensive care unit (ICU) over a 6 year period, 1994-7^[1] and 1998-9.^[2] The main finding of those studies was that the rates of accidents were low and the most common forms of accidents was unplanned extubation or displacement of the tracheal tube. Taken together there were a total of 41 incidents of tracheal tube displacement

in 7978 patients (0.51%) over 15,628 days (0.26%). Based on this, we benchmarked a target of <math><1</math> displacement per 100 patients (expressed as <math><1\%</math> per patient) and <math><1</math> displacement per 200 tracheal tube day (expressed as <math><0.5\%</math> per tracheal tube day).

The primary aim of this observational prospective study was to evaluate if this rate, (<math><1\%</math> per patient and <math><0.5\%</math> per tracheal tube day) was sustained for over a prolonged period. The secondary aims were to document the patterns of all forms airway accident and to evaluate their consequences.

Materials and Methods

All intubated ventilated patients in our general

From:
Department of Intensive Care, Hinduja Hospital, Mahim, Mumbai, Maharashtra, India

Correspondence:
Dr. Farhad N. Kapadia, Hinduja Hospital, Veer Savarkar Marg, Mahim, Mumbai - 400 016, Maharashtra, India.
E-mail: fnkapadia@gmail.com

Medical-Surgical Adult ICU from September 2002 to November 2011 were included. Airway care was done by the bed side nurses and a team of respiratory technicians present in the ICU around the clock. The number of patients, duration of intubation and type of tracheal tube was noted. Details of all airway accidents were recorded by the respiratory technician immediately after the patient care was completed and were discussed with a consultant intensivist in the next 12-24 h.

We categorized tracheal tube accidents as displacements or blocks. Displacements were either self extubation (SE), if the patient intentionally removed the tube, accidental extubation (AE) if caused by patient or nursing movement. A partial displacement was diagnosed if the tube appears to be in the airway, but there was a large tidal volume leak and the tip was displaced above the vocal cords on laryngoscopy. Blocked tubes were diagnosed if mechanical or manual bag ventilation became difficult with high airway pressures and this was rectified by suctioning out a mucous or blood clot from the tube, or by noting that the lumen of the replaced tracheal tube was occluded.

The details recorded per accident were as follows, date and time of the accident, diagnostic category (medical, cardiac surgical or other surgical-trauma), type of tracheal tube (endotracheal or tracheostomy), duration for which the tube was *in situ*, description of the type of accident, the severity of the accident and its impact on the course of the patient's illness, whether the patient needed reintubation and whether the accident was completely preventable, partly preventable or unpreventable. The airway accident rate was calculated both in terms of accidents per patient and in terms of accidents per intubated days. These intubated days were taken as the period from intubation or tracheostomy until either extubation, removal of the tracheostomy tube, or death. The categorization of severity and protocols for tracheal tube care were as follows.

Severity of airway accident

An airway accident was considered as mild if there was little or no physiological consequence to the accident and the appropriate remedy, if required, was taken by the on call resident. An accident was considered moderate if there was significant cardio-respiratory decompensation or if an experienced or senior person was needed to deal with the problem. An accident was considered major if it leads to a drastic deterioration culminating in a near or actual cardiorespiratory arrest.

Preventability of airway accident

An airway accident was considered completely preventable if there was a clear and unequivocal breach of protocol and considered partly preventable if it was retrospectively felt that either adherence to protocol or the level of medical and nursing supervision was inadequate. The accident was considered unpreventable if all appropriate care had been taken and realistically one could not prevent the accident in the given working conditions.

Protocols of airway care

The airway care protocols were as follows. All endotracheal tubes (ETTs) were secured with an adhesive dynaplast tape as well as a roller tape which was tied around the neck or above the ears in patients with intracranial problems. All ventilated patients were kept adequately sedated with benzodiazepines, opiates, propofol, or occasionally haloperidol. Over the decade, there were a few modifications to the protocols. In keeping with the emerging literature sedation scores and daily sedation breaks were introduced. Lighter sedation scores were targeted and weaning was done by protocol. Relaxant agents were used in addition when indicated. Patients were repeatedly asked if they were comfortable with the tracheal tube, and requested not to touch it. Conscious or drowsy patients were never restrained by having their hands tied down to the bed. Restless patients had a roller bandage applied as a mitten to allow free movement, but prevent gripping of the tubes. Only delirious and extremely agitated neurological or neurosurgical patients had their hands tied down to the bed. This was released as soon as the delirious state improved.

Portex profile cuff tubes were used for endotracheal intubation. The length mark at the teeth was adjusted so that the tip was kept 2-2.5 cm above the carina on the chest X-ray. Tracheostomies were inserted percutaneously or surgically. All percutaneous tracheostomies were done with size eight adjustable length tubes. For surgical tracheostomies, none were simple slit tracheostomies, and in all procedures either a disc of trachea was removed or a flap was created. All tracheostomy tubes were secured with a tie around the neck, and the flange of some fixed length tubes were additionally sutured to skin. The length was adjusted so that the tip was kept 2-3 cm above the carina. If this adjustable length tube needed to be changed after an adequate tract was formed, it was replaced by a fixed length Portex profile cuff tube. A tracheostomy was usually done after 10-20 days of endotracheal intubation or earlier if it was apparent that the patient was likely to require it for a

long period. Humidification was provided with heat and moisture exchange filters in the majority of patients. If felt clinically appropriate, alternative methods like hot water humidifiers or nebulizers were used.

Staffing levels and supervision

In addition to the sister in charge, the nurse to patient ratio varied between 1:1.4 and 1:1.8. Normally, a single nurse would care for one ventilated and one non ventilated patient. One or two respiratory technicians were on the unit in any given shift. They assisted the nurses in care of the tracheal tube. The ICU was staffed by resident doctors who were either postgraduate qualified physicians (internists) or anesthetists. Airway protocols were strictly followed and constantly reinforced. All accidents, however trivial, were immediately reported by the patient’s nurse and the doctor on call to the senior sisters and the consultant in charge of the ICU. Each accident was later discussed by these ICU personnel to review how and why it had occurred, to analyze if it could have been prevented, and to categorize the severity of the incident.

This ongoing observational study was granted wavier of approval by the institutional review board.

Results

A total of 10,112 patients were ventilated for 28,464 days. The total duration of ETT tube use was 19,283 days and tracheostomy use was 9,181 days. The overall incidence of airway accidents is shown in Table 1 and the nature of airway accidents as per diagnostic category and need for reintubation is shown in Table 2.

Primary end point

The overall tracheal tube (either ETT or tracheostomy) displacement rate was 61/10, 112 (0.6%) per patient and 61/28, 464 (0.22%) per tracheal tube day.

Secondary end points

There were 30 additional incidents of blockage, kinking or biting of the tracheal tube.

In terms of consequences, combining all airway accidents (displacements and blockage) 69 were categorized as mild (no physiological consequences related to accidents), 10 as moderate (cardio-respiratory decompensation) and 12 as major (resulting in a cardio respiratory arrest). There was one death directly related to the airway accident. This patient with an aneurysm clipping after a subarachnoid hemorrhage had an adjustable length tracheostomy tube. He deteriorated on the 15th day and needed cardiopulmonary resuscitation. He could not be ventilated with a manual resuscitator and the suction catheter could not be negotiated through the tube. The tracheostomy tube was removed and replaced with an ETT, but he could not be resuscitated. The removed tracheostomy tube was not blocked and we believe it was displaced out of the trachea, which lead to the event. Of the 91 accidents, 30 were considered partly and 30 were considered completely preventable. Of the total of 91 accidents, 76 involved an ETT (54 displaced, 12 blocked and 10 bitten-kinked) and 15 a tracheostomy

Table 2: Nature of airway accidents, diagnostic categories, and need for reintubation

| Nature of airway accident | Number of airway accidents | Number of re-intubations needed |
|-----------------------------|------------------------------|---------------------------------|
| Tracheal tube displacements | | |
| Self-extubation | 32 (M=15, C=8, S=9) | 10 (M=5, C=3, S=2) |
| Accidental extubation | 3 (M=2, C=0, S=1) | 1 (M=1, C=0, S=0) |
| Partial displacement | 26 (M=12, C=7, S=7) | 16 (M=8, C=4, S=4) |
| Tracheal tube blockages | | |
| Blocked tracheal tube | 20 (M=,12 C=3, S=5) | 15 (M=8, C=2, S=5) |
| Kinked/bitten tracheal tube | 10 (M=6, C=2, S=2) | 10 (M=6, C=2, S=2) |
| Total | 91 (M=47, C=20, S=24) | 52 (M=28, C=11, S=13) |

M: Medical; C: Cardiac surgical and S: Other surgical and trauma

Table 1: Yearly and total incidence of airway accidents

| Year | No. of ventilated patients | Tracheal tube data (days) | | Airway accident data | | Total accidents | |
|---------------------------|----------------------------|---|---------------|----------------------|-----------|-----------------|--------------|
| | | Total no. of tracheal tube (ETT+tracheostomy) | ETT | Tracheostomy | ETT | | Tracheostomy |
| 2002 (September-December) | 344 | 1339 | 1055 | 284 | 11 | 2 | 13 |
| 2003 | 1023 | 3148 | 2044 | 1104 | 11 | 3 | 14 |
| 2004 | 1021 | 2405 | 1463 | 942 | 6 | 0 | 6 |
| 2005 | 1131 | 2525 | 1323 | 1202 | 6 | 01 | 7 |
| 2006 | 1098 | 3181 | 2394 | 787 | 10 | 2 | 12 |
| 2007 | 1157 | 2917 | 2018 | 899 | 10 | 1 | 11 |
| 2008 | 1127 | 2557 | 1564 | 993 | 8 | 2 | 10 |
| 2009 | 1082 | 4414 | 3182 | 1232 | 3 | 3 | 6 |
| 2010 | 1058 | 4032 | 3030 | 1002 | 5 | 0 | 5 |
| 2011 (January-November) | 1071 | 1946 | 1210 | 736 | 6 | 1 | 7 |
| Total | 10,112 | 28,464 | 19,283 | 9,181 | 76 | 15 | 91 |

ETT: Endotracheal tube

tube (seven displaced and eight blocked). Cuff leaks due to biting were not included specifically as an airway accident.

We do not have complete data for diagnostic categories of all patients ventilated in this decade. Representative data projects a distribution as follows (rounded of to 5%). Tracheal tube days: Cardiac surgical 45%, medical 45% and other surgical-trauma 10%. Patients: Cardiac surgical 75%, medical 15%, and other surgical-trauma 10%.

Discussion

The main finding was that the rate of tracheal tube displacements and unplanned extubations was sustained below the preset benchmark of 0.5-1%, obtained from our earlier studies.

We categorized tracheal tube displacements as SE, AE or partial displacement. Various studies report SE alone or combined with AE, sometimes labeled as unplanned extubation. Partial displacement is a less obvious event, as the tube appears to be in the patient, but the tip is displaced out of the vocal cords and needs repositioning. We have clubbed all these three categories as tracheal tube displacement and used this value to compare to the benchmark of 0.5-1%.

When we reviewed the literature^[1,2] we noted that the rates of unplanned extubations from the 70s to the 90s were variable and relatively high, ranging from 3% to 16%.^[3-17] We had also speculated that this relatively high rate could represent a bias as conceivably, ICUs which had effective protocols did not report their low UE rates.^[18] This speculation was later borne out by the Australian Council for Health Care Standards,^[19] albeit not in the peer reviewed literature. They recorded a total of 258 unplanned extubations over 69,462 ICU days (0.37%) from 56 ICUs. Newer data from the last decade suggest that the rates of these events have fallen close to or below the 1% benchmark we had targeted. Bouza,^[20] in 344 patients ventilated for 3710 days, noted a rate of 0.92 of 100 days of ventilation and like us, concluded that "it does not confirm the highest rates of UE previously reported in orally intubated medical patients in the ICU." Mion *et al.*,^[21] did a much larger 90 days national prevalence study. They studied any device removal from a total of 49 adult ICUs from a random sample of 39 hospitals in five states in the USA. Specifically regarding endotracheal or tracheostomy tubes, they noted that 181 patient-initiated self-extubation episodes during 18,308 ventilator days, yielding an overall rate of 9.9 self-extubations/1000. They also noted that five units reported no self-extubation episodes and that the rates in

various ICUs ranged from 0 to 60.0 self-extubations/1000 ventilator days.

Another area of focus in the last decade has been the use of physical and chemical restraints as a technique in preventing ETT, displacements. The last decade has seen a fall in the use of sedatives and one study^[22] evaluated no routine sedation (only bolus doses of morphine as required) in a medical-surgical ICU. The investigators demonstrated a decrease of the duration of mechanical ventilation without undue adverse effects. They reported an overall AE rate of 13/113 and no difference was recorded in the occurrence in those without and with sedation (7/55 vs. 6/58 $P = 0.69$).

In terms of physical restraints, use of mittens are often clubbed with the patients limbs being tied to the bed, though intuitively, the latter is much worse for the patient. This ICU practice of physical restraint to avoid unplanned extubation has been shown to contribute to posttraumatic stress disorder in survivors of ICU.^[23] Recent studies have questioned their efficacy and have evaluated strategies to decrease their use.^[24,25] Our data, with physical restraints limited to mittens only, support the contention that physically tying the patients limbs to the bed is unnecessary, at least in terms of tracheal tube displacements.

The other main form of airway accidents was the tracheal tube blockage. Invariably the tube is blocked because of thick secretions or blood clot, but on occasion can be blocked because it is kinked or bitten. These blocked tubes contributed to one-third the total airway accidents. We have previously speculated on the potential role of humidification in tube blockage,^[26,27] and our current study does not have new data on this aspect.

When comparing total accidents (displacements and blockages), we noted that they were more frequent in ETT 76/19283 (0.39%) versus tracheostomy tubes 15/9181 (0.16%). We have evaluated a difference between medical surgical patients previously^[28] and speculated that this difference may be due to differing protocols in medical and surgical ICUs. In the study, we only had projected data for the numbers of patients in each category without airway accidents. In terms of overall numbers with airway accidents we noted it was more frequent in medical patients, (medical = 48, Cardiac surgical = 17 and other surgical/trauma = 26). This was in keeping with the literature in which these events occur more commonly in medical ICUs compared to mixed or surgical ICUs.^[21] Our data is in keeping with the literature that the majority of the accidents

are mild with little physiological consequence, and are preventable and often do not need reintubation.^[21] It is plausible that those who did not need reintubation could have been electively extubated earlier. In our study, a minority (23/61) needed reintubation in response to a tube displacement but the majority (25/30) of those with a blocked tube required reintubation.

Conclusions

We conclude that a tracheal tube displacement rate in a mixed medical-cardiac and other surgical adult ICU was maintained below the preset benchmark of <1% per patient and <0.5% per intubated day over a period of nearly a decade.

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