

Unplanned extubations in a level one trauma ICU

KM Köhne^{a*} and T Hardcastle^b 

^aDepartment of Anaesthesiology, Inkosi Albert Luthuli Central Hospital, University of KwaZulu-Natal, Durban, South Africa

^bTrauma Service, Inkosi Albert Luthuli Central Hospital and Department of Surgery, University of KwaZulu-Natal, Durban, South Africa

*Corresponding author, email: karlkohne@gmail.com



Background: Unplanned endotracheal extubation (UE) is the most common airway adverse event in ICU. This study aimed to determine the incidence, characteristics, complications and outcomes of UE in patients in a level one trauma ICU.

Methods: A chart review of all patients admitted to the Trauma ICU at Inkosi Albert Luthuli Central Hospital for a 24-month period was performed.

Results: Of the 534 patients admitted to the trauma ICU, 420 were intubated and mechanically ventilated for 4 484 days. Forty events of UE occurred in 33 patients. The incidence of UE per 100 ventilator days was 0.89. UE was reported as unplanned self-extubation in 70% of cases and accidental self-extubation in 30%. Reintubation was required in 78% of patients and was strongly associated with the accidental nature of extubation where 100% of cases were reintubated. Mortality was lower in patients with a UE than the total study population (15% vs. 27.65% $p = 0.12$). Patients that required reintubation had longer durations of mechanical ventilation (15.5 days vs. 6 days $p < 0.001$) and longer ICU stays (17 days vs. 9 days $p = 0.04$).

Conclusion: This study is in keeping with previously described incidences of UE in ICU; however, the rate is higher than suggested benchmarks. UE increased the need for mechanical ventilation and ICU care. Due to the increased incidence, ICU practices must be reviewed to improve this potentially modifiable adverse event.

Keywords: accidental extubation, endotracheal self-extubation, reintubation, trauma ICU, unplanned extubation

Introduction

Unplanned extubations are one of the most common adverse airway events to occur in ICU.¹ Elective removal of an endotracheal tube is performed as soon as the reason for the intubation has been resolved. If this happens earlier, it is termed an unplanned extubation (UE).² UE is a serious ICU complication. Many authors divide UE into two broad groups, namely endotracheal self-extubation (ESE) and accidental extubation (AE). Endotracheal self-extubation (ESE) is 'a deliberate action of premature removal of the endotracheal tube by patients'.³ Accidental extubation (AE) results in a dislodged endotracheal tube (ETT) due to procedural activities and is thus staff related.⁴ It is far less common than ESE. UE and its outcomes have been used as a monitoring tool for performance improvement and patient safety programmes.

The consequences of UE are numerous. An inflated ETT cuff may cause physical damage to airway structures, laryngospasm, aspiration, oedema and bleeding.^{5,6} UE may result in difficult reintubation and prolonged hospital stay,² and an increased risk of hospital-acquired pneumonia.⁷

Patients that needed reintubation after a UE had a higher mortality than patients that tolerated a UE.^{8–10} These patients also had a longer ICU stay, and an increased occurrence of ICU-acquired infections and rate of resource utilisation. However, patients not needing reintubation had a decreased mortality compared with patients that did not have a UE.¹⁰

The aim of this study was to describe the incidence and characteristics of unplanned extubations at a level one trauma intensive care unit (TICU).

Methods

To determine the incidence and characteristics of UE, all patients admitted to the TICU were reviewed for a 24-month period. The TICU is a 10-bed closed unit consisting of 8 ICU beds and 2 step-down high care beds. The ICU was staffed by trauma surgery consultants and registrars from orthopaedic surgery and anaesthesiology as well as other varying surgical disciplines. Nursing staff worked in two shifts, 07:00 to 18:00 and 18:00 to 07:00. During the study, the ICU nurse–patient ratio was 1:1. Maquet Servo-i (Getinge, Germany) ventilators were used throughout the ICU.

All patients requiring manual ventilation were orally intubated with high-volume, low-pressure endotracheal tubes. Tracheal tubes were secured using round-the-neck strapping with the Lillehei strapping technique (Figure 1).¹¹ Ventilatory parameters were set according to the attending physician. Ketamine and morphine were used as the primary sedative and analgesic drugs, and propofol, midazolam and haloperidol were added as needed. Sedation was titrated according to the Ramsay sedation scale¹² to a value of 2–3. The use of muscle relaxants was infrequent. Wrist restraints were used on all patients in keeping with local ICU protocols. ICU weaning was commenced as per a common weaning approach of progressive decrease in the pressure support till extubation was possible.

The study was approved by the University of KwaZulu-Natal Research Ethics Committee (BREC) using the BE207/09 class approval database.

This chart review was guided by morbidity tracking sheets that document adverse events in TICU. The charts and nursing notes of all patients admitted were also reviewed to ensure all UE were

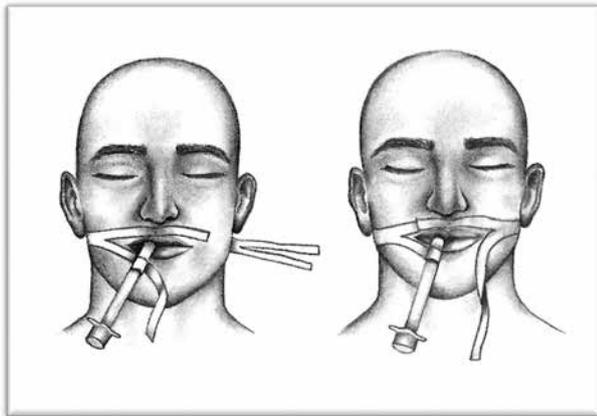


Figure 1: “Circumferential adhesive tape strapping technique as described by Lillehei¹¹”

Table 1: Data collection

All patients	Patients with UE
Age	Type of UE
Gender	GCS
Type and category of injury	Time to reintubation (immediate or delayed)
Injury severity score (ISS)	Mode of ventilation
Need for manual ventilation	Ventilatory settings prior to UE
Length of intubation	Most recent ABG prior to UE
Length of ICU stay	Need for reintubation
Tracheostomy insertion	Reason for reintubation
Outcome (deceased or discharged)	

ISS: injury severity score; ICU: intensive care unit; UE: unplanned extubation; GCS: Glasgow Coma Scale; ABG: arterial blood gas.

included. Data gathered on all patients included in the study are shown in Table 1.

We considered UE to be any unplanned removal of an endotracheal tube. These were divided into two groups, namely patient-related endotracheal self-extubation (ESE) where the patient deliberately pulled out the ETT, and accidental extubation (AE) where the ETT was accidentally dislodged by staff during

procedural work or transport. Reintubation within 1 hour was considered immediate. Common criteria for reintubation were used: increased work of breathing and respiratory distress, persistently low or decreasing oxygen saturation, inability to protect airway, severe arterial blood gas deterioration.

Statistics

A descriptive analysis consisting of central location (median) and dispersion (standard deviation, interquartile range and confidence intervals) was mostly applicable to continuous variables, and frequency tables for the categorical variables. Subgroup comparisons were made using chi squared test. A p-value of 0.05 was considered statistically significant. The data were analysed in STATA version 13 (StataCorp, College Station, TX, USA).

Results

During the 24-month period of the study, 534 patients were admitted to the TICU. Of these, 420 required MV and they were ventilated for a total duration of 4 484 days.

There were 40 UE events (9.4%) occurring in 33 patients. Five patients had two episodes and one patient had three episodes of UE. The incidence of UE was 0.89 per 100 ventilated days. Of the 40 events, 28 were deliberate ESE by the patient and 12 were AE. Patient-related data are described for the 33 patients. Data relating to the event of a UE are described for each of the 40 events.

Demographics and clinical characteristics are given in Tables 2 and 3. The median age for UE was 26 (IQR 12–31) and 4 years younger than the study population (30 IQR 21–40); 91% of patients with UE were male. The median ISS for UE was 32 (IQR 18–41), and blunt mechanism of injury accounted for 76% of patients.

As shown in Table 3, 28 events (70%) were classified as endotracheal self-extubations (ESE) and 12 (30%) were accidental extubations (AE). Of these AE, two cases (16%) were dislodged while re-securing the endotracheal tube, two (16%) dislodged during transport (CT scanner and theatre) and one endotracheal tube (8%) was coughed out by the patient – probably related to poor fixation. ESE occurred two days later than AE. ESE was more common in the patients undergoing weaning and on PS/CPAP mode of ventilation. Extubation was unsuccessful in 59% of the ESE group whereas all the AE patients required reintubation. The

Table 2: Demographics and clinical characteristics of patients

Factor	UE patients		Non-UE patients		p value	Total patients	
	n	median (IQR)	n	median (IQR)		n	median (IQR)
Age	33	26.0 (12–31)	387	30.0 (21–40)	0.03	420	30 (21–40)
Sex (patients):							
Male	30	91%	313	81%	0.2	343	82%
Female	3	9%	74	19%		77	18%
Total	33	100%	387	100%		420	100%
Mechanism of injury:							
Blunt	25	76%	307	79%	0.8	332	79%
Penetrating:	8	24%	71	18%		79	19%
Both	0	0%	4	1%		4	1%
Other	0	0%	5	1%		5	1%
Total	33	100%	387	100%		420	100%
ISS	33	32 (18–41)	387	29.0 (22–41)	0.7	420	29 (22–42)

UE: unplanned extubation; n: number; IQR: interquartile range; ISS: injury severity score.

Table 3: Comparison between ESE and AE

Factor	ESE		AE		p-value
	n = 28	Median (IQR)	n = 12	Median (IQR)	
ISS	22	31.0 (18–41)	11	32 (14–41)	0,8
Day of event	28	4.5 (4–7)	12	2.5 (2–4.5)	0,04
GCS	28	9 (7–10)	12	7 (3–8)	0,01

Factor	ESE		AE		p-value
	n	n (%)	n	n (%)	
Reintubation, n (%)	28	19 (68%)	12	12 (100%)	0,01
Deceased	22	1 (4.5%)	11	3 (27%)	0,1
Mode of ventilation:					
SIMV	11	11 (39%)	6	6 (50%)	0,2
PS/CPAP	17	17 (61%)	5	5 (42%)	
T-piece	0	0 (0%)	1	1 (8%)	
Total	28	28 (100%)	12	12 (100%)	
Reason for reintubation:					
Respiratory distress	19	14 (74%)	12	6 (50%)	0,4
Low GCS	19	4 (21%)	12	5 (42%)	
Difficult airway	19	1 (5%)	12	1 (8%)	
Complications of reintubation:					
Desaturation	4	2 (50%)	4	3 (75%)	0,9
Hypotension	4	1 (25%)	4	0 (0%)	
Aspiration	4	1 (25%)	4	1 (25%)	

ESE: endotracheal self-extubation; AE: accidental extubation; IQR: interquartile range; ISS: injury severity score; SIMV: synchronised intermittent mandatory ventilation; PS/CPAP: pressure support/continuous positive airway pressure ventilation; GCS: Glasgow Coma Scale.

most common reasons for reintubation in both these groups were respiratory distress and a low GCS. Both groups had four complications during reintubation, which included desaturation, hypotension and aspiration.

Reintubation was performed in 78% (31) of cases of UE, divided as 68% (19 episodes) of ESE and 100% of cases (12 episodes) of AE. The main reasons for reintubation were the presence of respiratory distress (65% of cases) and decreased level of consciousness (29%). Reintubation was immediate in 30 cases and only delayed in one case, where non-invasive ventilation was unsuccessfully attempted for 5 hours. Complication rates of reintubation were higher in the AE group at 33% of reintubations. Patients had a lower level of consciousness with a GCS of 7 (IQR 3–8) versus 9 (IQR 7–10) and were less likely to be able to protect their own airways.

When comparing the reintubated group with the non-reintubated group of UE, it is notable that patients requiring

reintubation were younger than those not requiring reintubation, or compared with the total study population (25.5 vs. 30; $p = 0.1$). Sex and mechanism of injury (blunt or penetrating trauma) were not significantly different from each other or the total study population. Length of total intubation (15.5 days vs. 4 days) as well as ICU stay (17 days vs. 11 days) were significantly longer in the reintubated group when compared with the non-reintubated group as well as the study population. The injury severity score (ISS) was higher and the level of consciousness lower in the reintubated group. The day of complication (UE) was the same for both (Table 4).

The PF ratio is a marker of acute lung injury. Patients who had a UE and needed to be reintubated had a lower PF ratio (median 272; IQR 172.9–355; $p = 0.07$) than those that did not require reintubation (PF median 390; IQR 200–452; $p = 0.07$). Positive end expiratory pressure prior to UE was the same in both groups. The pre-UE respiratory rate was lower in the group of patients not requiring reintubation (16 vs. 20). Positive end

Table 4: Comparison between reintubated and non-reintubated patients

Factor	Reintubated (n:31)		Non-reintubated (n:9)		Study population		p-value
	n	Median (IQR)	n	Median (IQR)	n	Median (IQR)	
Age (years) patients	24	25.5 (17–30)	9	30.0 (8.0–37.0)	387	30 (21–40)	0.1
ISS (patients)	24	32.0 (20.5–41)	9	30.0 (18.0–41.0)	387	29 (22–41)	0.8
GCS (episodes)	31	7 (6.0–10.0)	9	9 (8.0–10.0)			0.2
Day of MV prior to complication (episodes)	31	4.0 (2.0–6.0)	9	4.0 (4.0–9.0)			0.3
Length of intubation (total days) (patients)	24	15.5 (8.5–20.5)	9	4.0 (4.0–9.0)	387	6 (3–13)	0.001
Length of ICU stay (patients)	24	17.0 (13.5–28.5)	9	11.0 (8.0–16.0)	387	9 (5–16)	0.04

IQR: interquartile range; ISS: injury severity score; MV: mechanical ventilation; GCS: Glasgow Coma Scale; ICU: intensive care unit.

expiratory pressure and blood gas parameters of pH, partial pressure of arterial oxygen and carbon dioxide were similar in both groups.

Mortality was lower in patients that experienced a UE than the rest of the study population (15% vs. 27.65%; $p = 0.1$). Mortality was higher in the AE group (27%) versus the ESE group (4.5%). Patients that needed reintubation after a UE had a higher mortality (13% vs. 0%; $p = 0.3$). Twenty-one percent (21%) of patients that required reintubation also had a tracheostomy inserted, a higher rate than the total study population at 15%.

Discussion

Most studies of unplanned extubation in ICUs were performed in medical or mixed ICU populations. The data on purely trauma patients is limited. Looking at a systematic review by Da Silva *et al.*,¹³ of the 50 studies included in their review, only eight studies involved purely surgical ICU of multiple surgical disciplines and none specifically a trauma population.

This study was designed as an audit of the TICU's quality of nursing and medical care. All adverse events are recorded in the morbidity and mortality statistics of the ICU. Weekly academic morbidity and mortality meetings are held and involve discussions around safe-practice pitfalls that arise with each UE. If most of the patients do not require reintubation, weaning and extubation protocols should be addressed.¹⁴ If a high proportion do require reintubation, sedation, methods of securing the endotracheal tube, transport and staff training issues need to be addressed.³ A high incidence of AE would particularly alert to securing of endotracheal tube and staff training.⁴

In this study, the aim was to describe the incidence of unplanned extubation in TICU. Many different methods have been described to assess the incidence of UE. The first is the method of the number of events of accidental extubation per intubated patients as a percentage. In a review by Kiekkas *et al.*¹⁵ the incidence had a wide range between 0.5% and 14.2%. We found an incidence of 40 incidents of UE in the 420 ventilated patients (9.4%). A method that more accurately couples unplanned extubations to time at risk (i.e. days on manual ventilation) is the incidence per 100 ventilator days. This reveals a much narrower range of 0.3–4.2.¹⁵ Our study found an incidence of 0.89 events per 100 ventilator days. Both values are higher than the suggested, but unvalidated, 'benchmark' set by Kapadia *et al.*¹⁶ in a general medical and surgical ICU of 1% per patient and 0.5 incidents per 100 ventilator days. This benchmark was for a different patient population. Trauma patients are on average younger, predominantly male and have few comorbidities.¹⁷ We would suggest using the current rates as a baseline for future trauma studies as a comparison.

Patients with UE were four years younger (26 years vs. 30 years) than the total study population average and considerably younger than previously described at-risk age groups in medical ICUs of 70.9 ± 17.2 years.^{4,17}

In their systematic review, Da Silva *et al.*¹³ found a rate of 69%–95% for ESEs. A high rate of ESE has been associated with inadequate patient comfort: inadequate sedation, unnecessary restraints. Sedation needs to be titrated finely to achieve optimum results. Over-sedation increases ventilator days and the attendant adverse effects of prolonged intubation, such as

ventilator-associated pneumonia. Under-sedation, whilst potentially decreasing ventilator days and allowing for more rapid weaning, results in agitation, delirium and an increase in the rate of ESE.¹⁸ A sedation protocol linked to the Ramsay Scale was shown to reduce the incidence of unplanned extubation by more than 50% in one year.¹⁹

ESE is more common in patients in the weaning phase of ventilation and with a higher GCS. In this study, 70% of the UE were ESEs. This is in the lower range of previously described studies and may show that sedation and restraint protocols are adequate in the ICU to keep patients comfortable. It could also, however, be because of the higher proportion of AE. A higher percentage of patients with ESE were in the weaning phase of ventilatory support when compared with AE (61% vs. 42%). High-risk patients for ESE also include those with GCS scores of 9–15.^{20,21} The median GCS of ESE in this study was 9 (IQR 7–10) compared with the lower GCS of AE of 7 (IQR 3–8). Interestingly, AE occurred 2 days before ESE (day 2.5 [IQR 2–4.5] vs. day 4.5 [IQR 4–7]). Christie *et al.*² found that AE occurred 2 days later on average than ESE (7 vs. 5). There is little other literature concerning the relative timing of these events but, because many procedures, transfers and operations happen early in the ICU stay, this could be in keeping with the nature of an AE. Similarly, the lower GCS during the early admission and ICU stay of patients is in keeping with the nature of the event, being staff or procedure related. Other described risk factors for UE such as burns,²² older patients, chronic respiratory failure⁴ and chronic obstructive pulmonary disease⁸ were not relevant to this study.

The AEs were in the higher distribution of ranges described by Da Silva.¹³ Contributing factors are therefore interrogated. The ICU physicians are made up of surgical, orthopaedic and anaesthetic trainees, many relatively junior in their training with limited prior ICU experience. Two AE occurred during patient transfer from CT and theatre. These transfers are overseen by the ICU trainees. Two AE also happened during re-securing of endotracheal tubes by nurses. In a prospective, questionnaire-based study that explored the roles of nursing in the occurrence of UE, Yeh *et al.*²³ showed that 98% of UE occurred when nurses with less than 4 years' experience were looking after the patient. This concern can be extrapolated to any medical staff working in an ICU setting. Experience is important in preventing these avoidable AE.

In previous studies, rates of reintubation after UE are varied from 28% to 74%.¹⁵ Reintubation rates after UE differed according to the type of patient population (medical vs. surgical), the type of unplanned extubation (ESE vs. AE) and the level of support of ventilation required by the patient (weaning vs. full mechanical ventilation).¹³ In their study of a majority trauma population ICU (71% of patients), Fontenot *et al.*³ hypothesised that surgical and trauma patients would cope better with UEs than other ICU population patients. However, they found that 54% of patients still needed intervention after a UE. In this study, 78% of patients required reintubation after UE. This is a higher rate than they found, but their average ISS was 22 ± 2.4 , whereas the ISS in this study was 32 (IQR 18–41), showing the increased severity of injury in this study population. The main reasons for reintubation were the presence of respiratory distress (65% of cases) and decreased level of consciousness (29%).

Reintubation rate was higher in the AE group and in those requiring full ventilatory support. The most common reason

for reintubation in the ESE group is respiratory insufficiency, in keeping with our study.^{21,24} In accidental extubation the most common indication for reintubation is airway protection due to a decreased level of consciousness.²¹ Respiratory insufficiency was the most common reason for reintubation in the AE group in our study, accounting for 50%, although closely followed by decreased level of consciousness at 42%. Due to the retrospective nature of the study, a patient with a low GCS and poor respiratory effort may have been incorrectly documented as a reintubation due to decreased saturation. This could not be interrogated.

Reintubated patients had a longer ICU stay than the general population and the UEs that did not require reintubation. In keeping with literature,²⁵ those patients who did not require reintubation also had a shorter overall ventilation period (4 days vs. 6 days) and a shorter total ICU stay than the general population (9 days vs. 11 days).¹⁰ As 22% of patients had a successful UE, this could indicate that weaning protocols could be even more effective as these patients would have spent a longer duration on the ventilator than necessary had they not self-extubated. A Cochrane review showed that protocolised weaning is better than physician-based weaning.²⁶

All patients with AE were reintubated. As these are totally preventable and serious complications, an emphasis on training and suitable vigilance is essential for junior ICU staff. Christie *et al.*² found a reduction in AE of 33% over a 12-month period after nursing training as the sole intervention.

Reintubation was more likely in those patients with lower PF ratio prior to UE (272 vs. 390), in keeping with predictors of failed elective extubation.^{24,27} The ISS was higher in the reintubated group (32 vs. 30; $p = 0.8$), in keeping with the increased need for support for injuries sustained.⁸ Other predictors such as age older than 65 years, arterial pH greater than 7.45 before UE, non-surgical patients, and the presence of three or more comorbidities as described by Da Silva *et al.*¹³ were not found in this population.

The use of non-invasive positive pressure ventilation (NIV) in patients in whom an unplanned extubation occurred during the weaning period has been shown to significantly decrease the need for reintubation.²⁸ NIV was only attempted in one patient in this study and was unsuccessful. Due to level of consciousness or facial fractures NIV is not used often in this ICU after UE.

Complications of reintubation have been well described. Vassal *et al.*⁴ described a rate of 15% of complications on reintubation after UE. In our study, 20% of reintubation resulted in complications, which included desaturation, hypotension and aspiration. The complication rate for reintubation after AE was more than double that of ESE (33% vs. 14%). AE had a lower GCS, decreased airway protection and respiratory drive than the more awake ESEs, resulting in more rapid decompensation. Most patients needed reintubation within 1 hour of UE, resulting in the need for airway experts to be available on site for patients after a UE.

Most of the patients who had a UE were discharged from the ICU (88%), although some with significant morbidity; 77% of the general ICU population were discharged alive. This difference is not statistically significant as the study was underpowered for mortality. It may, however, be explained by the high number of successful self-extubations (22% of UE), decreasing

the patient's time at risk on a ventilator and in ICU and resulting in a low mortality of these patients (4.5%) and overall in the UE group. This suggests more effective weaning protocols could improve overall patient outcome as these patients could have been electively extubated at an earlier stage. Although these patients had a higher ISS on admission, they were on average four years younger (26 years vs. 30 years), which could possibly account for an increased reserve. We could suggest that more aggressive weaning, resulting in earlier extubation in younger patients with PF ratios of greater than 300, should be attempted. The AE group, having a 100% reintubation rate, had a higher mortality at 27%, the same as the overall study population. Patients that successfully self-extubated did not require tracheostomies. Those that required reintubation after UE had a higher rate of tracheostomy insertion (23%) than the general TICU population (15%).

As this study is a retrospective chart review, no causation of UE can be determined; only associations are possible. A single-centre study may also lead to bias. The retrospective nature of the study relies on the clinicians' and nurses' accuracy in reporting the incidents. Thus, not all information is readily available. This may result in under-reporting, lower rates of UE than expected and inaccurate data on patients. The sample size is also relatively small, as data were collected for 24 months and 40 events were noted in this time, which is often insufficient to gain significance in the data presented.

Conclusion

This study has higher rates of UE than the benchmark suggested but similar rates to other previous surgical ICU studies, although the population is entirely different from other studies. In keeping with the literature, reintubation after UE resulted in increased length of ventilation and ICU stay when compared with the general ICU population. Preventable risk factors such as staff training and vigilance could decrease this serious and potentially fatal adverse event.

ORCID

T. Hardcastle  <http://orcid.org/0000-0002-3967-0234>

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