ORIGINAL RESEARCH

Role of Early v/s Late Tracheostomy in Patients with Traumatic Brain Injury

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ABSTRACT
Tracheostomycanhelpweaninginlong-termventilatedpatients,reducingtheduration of mechanical ventilation and intensive care unit length of stay, and decreasing complications from prolonged tracheal intubation. Indications and optimal timing for tracheostomy in traumatic brain-injured (TBI) patients are uncertain. This study aims to describe the patients' characteristics,timing,andfactorsrelatedtothedecisiontoperformatracheostomyandassess the effect of the timing of tracheostomy on patients' outcomes. We selected TBI patientsfrom Neurosurgerydepartment,PDUmedicalcollegeandcivilhospital,aprospectiveobservational cohort study, with an intensive care unit stay≥72 h. Tracheostomy was defined as early (≤7 days from admission) or late (>7 days). The outcome was assessed at 6 months using the extended Glasgow Outcome Score. Comparative analyses were made among Early Tracheostomy (ET) and late tracheostomy (LT) groups. Our primary outcome was statistical difference of mortality and incidence of VAP between the ET and LT groups in acute brain injury patients. Secondary outcomes included the difference of the duration of mechanical ventilation, ICU length of stay (LOS), and hospital LOS. The total number of participants in the ET group was 149, while in the LT group it was 210. Early tracheostomy reduced risk for incidence of pneumonia, ICU length of stay, overall hospital length of stay and duration of mechanical ventilation, but not mortality. Patients with a late tracheostomy were more likely tohaveaworseneurologicaloutcome,i.e.,mortalityand poorneurologicalsequelsandlonger length of stay (LOS). Tracheostomy after TBI is routinely performed in severe neurological damagedpatients.InTBIpatients,earlytracheostomycomparedwithlatetracheostomymight reduce risk for VAP, ICU and hospital LOS, and duration of mechanical ventilation, but the causality of this relationship remains unproven.
Keywords: Traumatic Brain Injury; Early Tracheostomy; Late Tracheostomy; Tracheostomy Timing; Mortality; Ventilatory Acquired Pneumonia.

INTRODUCTION

Traumatic Brain Injuries (TBIs) are a major public health problem in India, resulting in deaths, injuriesanddisabilitiesofyoungandproductivepeopleofoursociety.ThemaincausesofTBIinclude road traffic accidents, falls from height and physical assaults [1]. The worldwide incidence of TBI is estimated at 939 cases per 100,000 people with the highest peak of incidence in North America and Europe[2].NationalleveldatainIndiaisnotavailablefortraumaticbraininjuriesasinmanydeveloped countries. At the national level, nearly two million people sustain brain injuries, 0.2 million lose their lives and nearly a million need rehabilitation services every year [3,4]. In patients with TBI, endotracheal intubation is often necessary to maintain airway patency and prevent hypoxia [5]. Other indications for tracheostomy in TBI patients include failure to wean invasive mechanical ventilation, absence of protective airway reflexes, impairment of respiratory drive, and difficulties in managing secretions [6]. Tracheostomy may facilitate weaning in long-term mechanical ventilated patients, reduce duration of intensive care unit (ICU) length of stay (LOS), and decrease complications from prolonged tracheal intubation

[7,8]. However, the beneficial effects, timing and indications of tracheostomyinTBIarestilldebating[9,10].The proportionofTBIpatientswhomightbenefitfroma tracheostomy,andthemostappropriatetimingfortheproc edurearestillundefined,andrelevantbiases confoundthelimited,mainlyretrospective,availabledata onthisissue.Moreover,policiesandclinical practice vary among different centres, and the optimal indications for tracheostomy remain uncertain [11,12].In ICU patients, the use of tracheostomy may improve the comfort of patients, allow more effective secretions suctioning and a more secure airway, decrease airway resistance, enhance patient mobility, opportunities for eating orally. Early and late complications after tracheotomy include bleeding, wound infection, subcutaneous emphysema, laryngeal nerve or esophageal injury, and tracheal stenosis. Conventionally, tracheostomies performed in the first week are classified as early, while tracheostomies performed later than 7 days are defined as late [13]. Evidence on the advantages of early over late tracheostomy is conflicting [8], and there are limited robust data to guide the ideal timingtoperformatracheostomy.Systematicreviewsofra ndomizedcontrolledtrials(RCTs)ingeneral criticalcarepopulationshavegenerallynotfoundbenefitfr omearlytracheostomy[10],buttheseresults cannotbegeneralizedtotraumaticbrain-injuredpatients,whotypicallyrequiretracheostomyforair way protection for depressed airway reflexes rather than respiratory failure. Observational studies in traumatic brain-injured patients suggest that tracheostomy performed earlier may be associated with lower in-hospital morbidity and improved clinical outcomes [14–17], but the best timing for tracheostomy continues to be debated. This study aims to describe the characteristics of those TBI patientswhoundergoatracheostomyandthecurrentstateo fitstiming;toidentifythefactorsinvolved in performing the procedure to assess the effect of the timing on patients'outcome.

MATERIALS AND METHODS

We performed a pre-planned analysis focusing on tracheostomy practice for TBI patients in the Neurosurgery department, PDU civil hospital-TBI cohort during the ICU stay.

INCLUSION CRITERIA

1. AclinicaldiagnosisofTBIwithanindicationforabrainComputedTomographyscan(CT);
2. Presentation to thehospitalwithin 24 h (hrs) post-injury;
3. ICU admission with alength ofstay (LOS)≥72h.

EXCLUSION CRITERIA

1. Death in the first 72h;
2. Short ICU LOS (<72h)

These exclusion criteria were defined to exclude patients in whom tracheostomy was never likely to have been considered, either because of extremely severe injury and rapid death, or those in whom the injury was not severe enough.

DATA EXTRACTION

Detailed data were collected on pre-injury factors and patient's characteristics, injury details, Glasgow coma scale (GCS) at time of ICU admission, pre-hospital care, clinical care, post-acute care, patient's demographics, mean time between admission and tracheostomy, neurologic assessment at admission, confirmed VAP, median ICU stay, median hospital stay, mortality rates, and ICU or hospital costs and outcome. Hypoxemia was defined as a documented partial pressure of oxygen (PaO_2) < (60 mmHg), oxygen saturation (SaO_2) <90 %, or both; hypotension was defined as a documented systolic blood pressure <90 mmHg.

OBJECTIVES

1. Describe the patients' characteristics and timing of tracheostomy in TBIpatients;
2. Identify the factors related to the decision to perform atracheostomy
3. Assess the effect of the timing of tracheostomy on patients'outcomes.

OUTCOMES

Theprimaryendpointwasthepatients'functionaloutcome assessedbytheExtendedGlasgowOutcome Score (GOSE) at 6 months. An unfavourable outcome was defined as GOSE ≤ 4, which takes into account both poor neurological outcome and mortality together. All responses were obtained by study personnelfrompatientsorfromaproxy(patient'scaretaker/relative--whereimpairedcognitivecapacity prevented patient interview), during a face-to-face visit, by telephone interview, or by postal questionnaire at 6 months (range 5–8 months) after injury [18]. All outcome evaluators who were part ofthisstudyhadreceivedtrainingintheuseoftheGOSE.WealsokeptrecordofmortalityatGmonths, and the ICU and hospitalLOS.

STATISTICAL ANALYSIS

Continuous variables are described with median and interquartile range (IQR), or mean and standard deviation (SD), as appropriate, and categorical data were reported as absolute and relative frequencies. The nature of the variables guided the choice of the test for the comparison among groups.

FACTORS RELATED TO THE DECISION TO PERFORM A TRACHEOSTOMY

A Cox regression model was used to identify the key factors that affected the decision and timing of tracheostomy during ICU stay. Time origin was ICU admission, and patients who did not receive the procedure were censored at discharge from ICU or at death, whichever occurred first. Variables significantintheunivariateanalysis,andothersjudgedclinicallyrelevant,wereinitiallyidentified,and theselectionofthecovariatesforthefinalmodel(including age,GCS,pupillaryreactivity,hypoxemia, thoracic, and facial trauma) was based on the likelihood ratio test (LRT) and Akaike Information Criterion (AIC). Assumptions regarding the proportionality of the hazards and the linearity of effects were investigated using the Schoenfeld test and the Martingale residuals, respectively [19]. For variablesviolatingtheproportionalhazardsassumption,thetimedependenceoftheeffectwasadjusted by including a term for the interaction of the variable and time[19].

OUTCOMES

The role of timing of tracheostomy on different outcomes was explored on the subset of patients who underwent a tracheostomy. The time to the procedure was evaluated both as a discrete (i.e., days from ICU admission) and as a categorical variable (i.e., ≤7 vs.>7 days). A logistic regression model was applied to the odds of an unfavourable GOSE (GOSE≤4), while we performed a Cox model on the 6- month mortality from ICU admission, with patients contributing to the risk set from the day of tracheostomy. Mortality from any cause was the event of interest, and patients alive at 6 months from ICU admission were censored. A linear regression model was used for the evaluation of LOS in both ICU and hospital. LOS was calculated from ICU admission (and from tracheostomy) to discharge or death in ICU, with a sensitivity analysis that excluded patients who died in ICU or hospital [20].

RESULTS

Ofthe1777consecutivepatientsrequiringICUcare,1131hadanICULOS≥72h.Ofthese,359subjects (31.8% of the study cohort, 20.2% of the overall ICU population) underwent a tracheostomy and were included in the analysis (ESM Figure S1). Details regarding the screening and enrolment process are described in themanuscript.

PATIENTS' CHARACTERISTICS

Patients' characteristics at ICU admission are summarized in Table 1 (both overall and stratified by whether or not they received a tracheostomy). Patients who received or did not receive a tracheostomy were similar in terms of age, sex, pre-injury American Society of Anaesthesiologists' physical status (ASAPS) score, mechanism of injury, and pre-injury clinical history. Patients receiving tracheostomy more frequently had lower median GCS at arrival (median 5 vs. 8, p <0.001), and abnormal pupillary reactivity (at least one unreactive pupil in 27.6% vs. 15.2%, p p<0.001). Moreover, patients who underwent tracheostomy had a higher rate of early hypoxemia (19.5% vs. 13.0%, p=0.004), early hypotension(21.1%vs.12.0%,p<0.001)andhigher InjurySeverityScore(ISS;meanof 38.4vs.33.5, p<0.001) due to more extra-cranial traumatic injury (67.2% vs. 56.8%, p<0.001), especially facial (29.6% vs. 22.7%, p=0.008) and thoracic trauma (47.6% vs. 36.6%, p<0.001).

During their ICU stay, patients receiving tracheostomy more frequently suffered from ventilator acquired pneumonia (VAP; 34.5% vs. 14.0%, p <0.001), and respiratory failure (47.8% vs. 24.2%, p <0.001) (Table 1).

TIMING OF TRACHEOSTOMY

The median (IQR) time to tracheostomy of the 359 patients was 9 (5–14) days from ICU admission, with 25 (6.9%) of the patients receiving tracheostomy on the day of ICU admission and the last procedure performed after 39 days in ICU. Details on the characteristics of the tracheotomised patients are reported separately for early (149 patients, 41.5%) and late (210 patients, 58.5%) procedures in Table2.Patientsreceivingearlytracheostomieswereolder (30.6%vs.17.4%aged≥65years,p=0.002), with a higher incidence of hypoxemia (24.4% vs. 16.1%, p=0.054) andhypotension (25.9% vs. 17.6%, p=0.059) in the pre-hospital and emergency department settings, and had facial injuries (34.4% vs. 26.1%, p=0.076). Patients receiving a late tracheostomy had a higher rate of ventilator-associated pneumonia (39.7% vs. 27.2%, p=0.01), and respiratory failure (52.2% vs. 41.7%,p=0.039).

FACTORS RELATED TO THE DECISION TO PERFORM A TRACHEOSTOMY

Age had a statistically significant impact, indicating a 4% increase in the hazard of tracheostomy for each5-yearincreaseinage.Thehazardforrequiringatracheostomywassignificantlylowerinpatients with GCS>8 vs. those with GCS≤8 (p<0.001). The effect of pupillary reactivity was also not constant in time, and the study indicate that patients with at least one unreactive pupil have a higher hazard (p<0.001) as compared to those with both reacting pupils. The hazard of tracheostomy was 1.24 times higher in patients with thoracic trauma as compared to those without, while the two-timing groups did not show a significant difference in the incidence of facial trauma. Finally, hypoxemia was associated with an increased hazard of undergoing atracheostomy.

OUTCOMES

The univariate analyses showed no significant effect of early vs. late tracheostomy on ICU mortality, 6-month mortality, or 6-month GOSE. However, patients who received a late tracheostomy had a statisticallysignificantlongermeanLOSinICU(19.6vs.26.7days,p<0.001)andinhospital(38.5vs. 49.4days,p=0.003)whenmeasuredfromthepointofICUadmission.Thesedifferenceswereabolished when LOS was measured fromtracheostomy.

Theadjustedregressionanalysesdemonstratedanassociat ionbetweenanearlytracheostomyand a better neurological outcome captured by the GOSE. Patients with a late tracheostomy were more likelytohaveaworseneurologicaloutcome,andtheanalysisusingdaytotracheostomyasacontinuous variable showed that every day of delay in performing tracheostomy was associated with an unfavourable outcome. The multivariable Cox analysis on mortality at 6 months found that tracheostomy performed after 1 week was not associated with a significant increase of the hazard of mortality. However, study showed that each increase of a day in the timing of tracheostomy was associated with an increase in the hazard of mortality. Late tracheostomy was associated with an increase in the mean ICU LOS of 6.9 days, and an increase in hospital LOS of 11.45 days; each 2 days deferral in tracheostomy was associated with a 1-day increase in ICU LOS, and a 2 day increasein hospital LOS. LOS after tracheostomy in ICU was shorter in the late tracheostomy group, while the hospital LOS was similar between the two groups. Similar results were obtained when excluding ICU deaths. Sensitivity analyses on all the outcomes considering complete data gave consistent results.

Table 1: Features at admission and during ICU stay in patients who received and did not receive tracheostomy and the overall population

Characteristics	No tracheostomy (n=772)	Tracheostomy (n=359)	P value	Overall (n=1131)	n missing
At admission					
Age (years), median (I–III quartiles)	50 (29–65)	45 (29–63)	0.102	49 (29–64)	00
Age≥65 years, n (%)	194 (25.1)	82 (22.9)	0.413	276 (24.4)	
Sex: male, n (%)	565 (73.2)	276 (76.9)	0.163	841 (74.4)	00
Pre-injury ASAPS, n (%)			0.235		30
Normal healthy patient	408 (52.8)	220 (61.2)		628 (55.5)	
Patient with mild systemicdisease	248 (32.2)	108 (30)		356 (31.5)	
Patient with severe systemicdisease	86 (11.1)	31 (8.8)		117 (10.3)	
Cause of injury, n (%)			0.229		01
Road traffic accident	353 (45.7)	182 (50.8)		535 (47.3)	
Fall from height (Incidental)	316 (41)	126 (35)		442 (39.1)	
Violence/assault	29 (3.8)	15 (4.3)		44 (3.9)	
Suicide attempt	13 (1.7)	10 (2.8)		23 (2.1)	
Other	60 (7.8)	26 (7.3)		86 (7.6)	
Alcohol involved, n (%)	233 (30.2)	99 (27.6)	0.392	332 (29.4)	
Hypoxemia: yes, or suspected, n (%)	100 (13)	70 (19.5)	0.004	170 (15)	
Hypotension: yes, or suspected, n (%)	93 (12)	75 (21.1)	<0.001	168 (14.9)	
Severity TBI, n (%)			<0.001		02
Mild	236 (30.6)	46 (12.9)		282 (24.9)	
Moderate	129 (16.7)	56 (15.6)		185 (16.4)	
Severe	406 (52.7)	256 (71.5)		662 (58.5)	
Pupillary reactivity, n (%)			<0.001		02
Both reactive	654 (84.8)	260 (72.4)		914 (81)	
One reactive	46 (6)	36 (10.2)		082 (7.2)	
Both unreactive	71 (9.2)	62 (17.4)		133 (11.7)	
GCS, median (I–III quartile)	8 (3–13)	5 (3–9)	<0.001	7 (3–12)	04
Any extra-cranial injury, n(%)	438 (56.8)	241 (67.2)	<0.001	679 (60)	
Facial trauma, n (%)	175 (22.7)	106 (29.6)	0.008	281 (24.8)	
Thoracic trauma, n (%)	282 (36.6)	170 (47.6)	<0.001	452 (40)	
In ICU					
Cranial surgery, n (%)	307 (39.8)	217 (60.4)	<0.001	524 (46.3)	
Extra-cranial surgery, n (%)	199 (25.8)	188 (52.5)	<0.001	387 (34.2)	
Reintubation, n (%)	56 (7.3)	42 (11.7)	0.010	098 (8.7)	
Ventilator acquired pneumonia, n (%)	108 (14)	124 (34.5)	<0.001	232 (20.5)	
Respiratory failure, n (%)	187 (24.2)	171 (47.8)	<0.001	358 (31.6)	

ASAPS American Society of Anaesthesiologists' Physical Status, TBI Traumatic Brain Injury

Table 2: Features at admission and during ICU stay for early and late tracheostomy

Characteristics	Early tracheostomy (n=149)	Late tracheostomy (n=210)	P value	n missing
Age (years), median (I– III quartiles)	48.5 (31–67)	44.0 (28–59)	0.024	00
Age≥65 years, n (%)	45 (30.6)	36 (17.4)	0.002	
Sex: male, n (%)	109 (73.2)	161 (76.9)	0.987	00
Pre-injury ASAPS, n (%)			0.948	03
Normal healthy patient	89 (60.3)	129 (61.8)		

Patient with mild systemicdisease	45 (30.5)	62 (29.7)		
Patient with severe systemicdisease	14 (9.2)	17 (8.5)		
Previous TBI, n (%)	11 (7.5)	14 (6.5)	0.833	39
Use of anticoagulants, n (%)	8 (5.2)	7 (3.3)	0.465	16
Use of antiplatelets' drugs, n (%)	(10.5)	(7.8)	0.449	16
Hypoxemia: yes, or suspected, n(%)	(24.4)	(16.1)	0.054	30
Hypotension: yes, or suspected, n (%)	(25.9)	(17.6)	0.059	21
Cardiovascular history, n (%)	(25.6)	(21.1)	0.343	09
Severity of TBI, n (%)			0.863	20
Mild	19 (13.1)	27 (12.8)		
Moderate	25 (16.7)	31 (14.8)		
Severe	104 (70.2)	152 (72.4)		
Cause of injury, n (%)			0.511	09
Road traffic accident	76 (51.4)	106 (50.4)		
Fall from height (Incidental)	48 (32)	78 (37.1)		
Violence/assault	7 (4.6)	8 (4)		
Suicide attempt	6 (4)	3 (1.6)		
Other	12 (8)	14 (6.9)		
Pupillary reactivity, n (%)			0.675	19
Both reactive	105 (70.6)	155 (73.7)		
One reactive	15 (10)	22 (10.3)		
Both unreactive	29 (19.4)	34 (16)		
GCS, median (I–III quartile)	5.5 (3–10)	5 (3–9)	0.934	20
Any extra-cranial injury, n(%)	100 (67.2)	141 (67.2)	1.000	0
Facial trauma, n (%)	51 (34.4)	55 (26.1)	0.076	0
Thoracic trauma, n (%)	69 (46.7)	101 (48.2)	0.825	0
Cranial surgery, n (%)	84 (56.7)	132 (63.1)	0.212	1
Extra-cranial surgery, n (%)	79 (53.3)	109 (52)	0.858	1
Reintubation, n (%)	11 (7.4)	31 (14.8)	0.029	1
Days with tracheostomy, median (I–III quartiles)	12.0(6.8–18.3)	12.0 (6–20)	0.795	0
Tracheostomy at Discharge from hospital, n(%)	79 (53.3)	108 (51.8)	0.825	0
Intubated, n (%)	144 (96.6)	204 (97.2)	0.948	1
Ventilator acquired pneumonia, n(%)	40 (27.2)	83 (39.7)	0.010	1
Cardiac arrest, n (%)	21 (13.9)	24 (11.5)	0.545	0
Respiratory failure, n (%)	62 (41.7)	110 (52.2)	0.039	0
Marshall score, n (%)	0.757	75		
1	7 (4.9)	10 (4.7)		
2	69 (46.9)	85 (40.8)		
3	16 (11.2)	27 (13.1)		
4	1 (0.7)	5 (2.3)		
5	1 (0.7)	1 (0.5)		
6	53 (35.7)	81 (38.5)		
Antibiotics used, n (%)	134 (90.3)	206 (98)	0.001	9
H2 Receptor antagonist used, n (%)	34 (22.7)	74 (35.2)	0.008	9
Neuromuscular blockade used, n (%)	66 (44.3)	119 (56.7)	0.016	9
PPI used, n (%)	91 (61.4)	125 (59.5)	0.778	9
Prokinetics used, n (%)	75 (50.6)	126 (59.9)	0.070	9
Sedation used, n (%)	144 (96.6)	207 (98.4)	0.385	9
Steroids used, n (%)	36 (23.9)	71 (33.6)	0.040	9

ASAPS American Society of Anaesthesiologists' Physical Status, GCS Glasgow coma scale, PPI proton-pump inhibitor, TBI Traumatic Brain Injury

DISCUSSION

In this study, our main findings are:

1. Tracheostomy iscommonly performed in TBI patientsin ICU, and ismost frequently undertaken after the first week inICU;
2. The likelihood of receiving a tracheostomy increases significantly with age, the severity of neurological injury (expressed as lower GCS and pupillary abnormalities), extra-cranial injury (particularly thoracic trauma), and early secondary insults (such ashypoxemia);
3. Whenassessedasadiscretevariable,latertracheostomiesareassociatedwithanincreasein unfavourable outcome and LOS.

We found that tracheostomy was frequent amongst TBI patients in the ICU. The procedure was undertakenin31.7%ofourstudycohort,whichismorefrequentthaninstudiesingeneralICUcohorts, wherepastliteraturereportsratesofabout10%[21,22].TisincreasedneedfortracheostomyintheTBI population is attributable to a higher rate of extubation failure and the need for prolonged protection of theairwayssecondarytoneurologicalinjury.IngeneralICUpatients,tracheostomyismostcommonly performed after 14 days from admission [22,23], with only a quarter of tracheostomies delivered on or before day 7 [21]. In contrast, only 26% of our TBI cohort underwent tracheostomy later than 14 days from admission, and in 41%, tracheostomy was undertaken before day7.

The risk of receiving a tracheostomy was related to the severity of the neurological injury, quantifiedusing GCSandpupillaryreactivityatadmission,andthepresence ofearlysecondaryinsults (such as hypoxemia). Non-neurological drivers of the decision to perform a tracheostomy include age and the occurrence of thoracic trauma, which may adversely affect respiratory weaning and extubation success. While the effect of non-neurological factors and hypoxemia on the risk of receiving tracheostomy was constant over time, the Cox model indicated that both GCS and pupillary reactivity hadatime-dependenteffect,withanincreasedimpactontheHRoftracheostomywithincreasingtime from admission. These findings suggest that both the initial severity of the neurological injury and probably its trajectory, play a role in the decision process. The result that the median time to tracheostomy was 9 days post-admission probably reflects a change in treatment targets. In the initial phase, the aim is to manage acute intracranial emergencies, and tracheostomy at this stage could increase intracranial pressure and adversely affect the outcome. Once this phase is complete, cessation of sedation, weaning from ventilator support, and initiation of rehabilitation become key treatment targets. This timing of tracheostomy also prevents the use of the procedure in patients with lesser severities of injury, who might achieve successful extubation, and in those who have a rapidly progressive course and succumb early to their injuries. This process of selection still leads to tracheostomy at an earlier stage than commonly observed in non-TBI patients but allows the selection of a cohort most likely susceptible to the potential benefits of the procedure on the patients' outcomes [24, 25], by dealing with ongoing failure to protect the airway and the consequent risk of extubation failure[26–29].

Our results suggest that the current, local medical practices influence the decision to perform a tracheostomy,alongwiththeethicalandlegalimplications context,clinicalexpertise,andcostsrelating to the procedure and equipment, replicating past findings in the general ICU population [21, 22,30].

The literature suggests that early tracheostomy may potentially reduce hospital stay, duration of mechanical ventilation and mortality rates [31, 32, 33, 34]. In a propensity-matched cohort study on TBIpatients,earlytracheostomy(≤7 days)wasassociatedwithshortermechanicalventilationduration (10vs.16days,RR=0.70,95%CI=0.66–0.75),ICUandhospitalLOS(RR=0.75,CI=0.66–0.75,and RR=0.80, 95% CI=0.74–0.86), but did not affect mortality [35]. While the results of a Cochrane meta-analysisingeneralICUpatients[36]showedapossiblemortalitybenefitfromatracheostomy,ourdata replicate smaller studies that specifically addressed TBI. A meta-analysis by McCredie et al. [31] concluded that early tracheostomy might reduce the long-term mortality, duration of mechanical ventilation, and LOS. However, waiting longer, i.e., excluding patients probably improving or dying for brain damage, leads to fewer tracheostomy and similar short-termoutcomes.

Each increase of 1 day in tracheostomy timing was significantly associated with a 4% increase in the risk of an unfavourable outcome with a 6% increase in the hazard of death. While this association maysuggestabenefitfromanearliertracheostomy,weshouldbecautiousaboutassigningcausalityto this association, since there may be competing confounds. Patients with more severe injury may have had a more prolonged need for therapies directed toward limiting the intracranial damage evolution (thus delaying tracheostomy) or might have a worse expected outcome (leading to a higher number of attempts to withholdtracheostomy).

In our study, patients who received late tracheostomy had a statistically significant longer mean LOS in ICU (by nearly 1 week) and in hospital (by about 11 days), with each 2 days deferral in tracheostomy associated with about 1- and 2-days' increase in LOS in ICU and hospital, respectively. InthisdirectionalsogoestheintervalbetweentracheostomyanddischargefromICU,whichisshorter in the "later tracheostomy" group, along with the information that withdrawal of treatment ismore frequent in patients without tracheostomy. Mortality in the ICU of tracheotomised patients was minimal.

CONCLUSIONS AND FUTUREPERSPECTIVES

PatientswithTBIundergoatracheostomy,moreoftenthan ingeneralICUpopulations.Severalpatient- and injury-related factors are associated with the decision to perform a tracheostomy in this group of patients. However, an analysis that adjusts for these covariates still shows substantial between-centre differences,whichprobablyreflectinadequateevidence,alackofconsensus,andtheabsenceofstrong guidelines in this setting. The later performance of tracheostomy is associated with increased LOS and worse functional neurological outcome, but the causality of this relationship remains unproven. Randomizedcontrolledtrialsexploringtheeffectoftracheostomyanditstimingonpatients'outcomes arewarranted.

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