Effect of technique and timing of tracheostomy in patients with acute traumatic spinal cord injury undergoing mechanical ventilation

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Objective: To assess the effect of timing and techniques of tracheostomy on morbidity, mortality, and the burden of resources in patients with acute traumatic spinal cord injuries (SCIs) undergoing mechanical ventilation.
Design: Review of a prospectively collected database.
Setting: Intensive and intermediate care units of a monographic hospital for the treatment of SCI.
Participants: Consecutive patients admitted to the intensive care unit (ICU) during their first inpatient rehabilitation for cervical and thoracic traumatic SCI. A total of 323 patients were included: 297 required mechanical ventilation and 215 underwent tracheostomy.
Outcome measures: Demographic data, data relevant to the patients' neurological injuries (level and grade of spinal cord damage), tracheostomy technique and timing, duration of mechanical ventilation, length of stay at ICU, incidence of pneumonia, incidence of perioperative and early postoperative complications, and mortality.
Results: Early tracheostomy (<7 days after orotracheal intubation) tracheostomy was performed in 101 patients (47%) and late (≥7 days) in 114 (53%). Surgical tracheostomy was employed in 119 cases (55%) and percutaneous tracheostomy in 96 (45%). There were 61 complications in 53 patients related to all tracheostomy procedures. Two were qualified as serious (tracheoesophageal fistula and mediastinal abscess). Other complications were mild. Bleeding was moderate in one case (late, percutaneous tracheostomy). Postoperative infection rate was low. Mortality of all causes was also low.
Conclusion: Early tracheostomy may have favorable effects in patients with acute traumatic SC. Both techniques, percutaneous and surgical tracheostomy, can be performed safely in the ICU.

Keywords: Spinal cord injuries, Cervical, Thoracic, Mechanical ventilation, Tracheostomy, Percutaneous, Surgical, Complications, Spine surgery

Introduction

Cervical and high thoracic spinal cord injuries (SCIs) severely compromise sensory and motor function and sympathetic activity. The interruption of spinal cord respiratory pathways produces the weakness of respiratory muscles and respiratory function impairment.[1,2]

Patients with acute cervical SCI frequently need prolonged mechanical ventilation (MV) due to paresis or paralysis of the respiratory muscles, worsening pulmonary vital capacity and severe impairment of peak cough flow, which is ineffective to clear tracheobronchial secretions.[3–7] In thoracic SCI, the severe deterioration of bronchial secretion clearance (due to inefficacy of expiratory abdominal muscles and the pulmonary injury caused by frequently associated chest trauma) is the cause of respiratory failure, which is also usually prolonged.[8] This results in a high incidence of respiratory complications (estimated prevalence 40–70% in patients with cervical lesions) such as respiratory infections (tracheobronchitis and pneumonia) and atelectasis.[9,10] In cases in which patients are unable to maintain adequate pulmonary ventilation, long-term MV is indicated.[1,11,12]

As MV is expected to be prolonged in acute SCI, tracheostomy is commonly performed in these patients, especially in individuals with high-level cervical lesions, thoracic lesions with chest trauma, and severe co-morbidities, or in the elderly.[13–16] The objectives are to improve artificial ventilatory support, to avoid complications of prolonged orotracheal intubation, to facilitate weaning from MV, to facilitate bronchial clearance, to

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DOI 10.1179/107902610X12886261091875

support phonation and swallowing,[17] and to reduce the length of sedation to prevent related complications.[18] In other words, tracheostomy is recommended as it has been shown to have beneficial effects, preventing complications and allowing early weaning, as well as reducing the utilization of resources.[2,11,13,19,20] Moreover, it eases nursing care, improves patient's comfort, facilitates tracheobronchial clearance, diminishes weaning period, and allows speech and oral nutrition.[13,21–25]

Tracheostomy is one of the more commonly performed procedures in modern intensive care units (ICUs), and it will likely become even more frequent as demand for intensive care services increases.[26–30] As it is an invasive procedure, it may cause some complications such airway stenosis, bleeding, and infection.[31] Percutaneous dilatational tracheostomy is a technique that is technically easy, has a very low rate of complications, is minimally invasive, and can be performed with the neck in a neutral position. Moreover, the procedure can be performed shortly after anterolateral cervical fixation surgery.[32–36]

The objective of this study was to assess the effect of the tracheostomy technique and timing in patients with traumatic SCI.

Patients and methods

We performed a retrospective review of a prospectively collected specific database (tracheostomy-related data of all patients admitted to the study). All patients admitted to the ICU, a seven-bed polyvalent unit of the National Hospital of Paraplegics de Toledo (Spain), a monographic hospital for the treatment of patients with spinal cord damage. These data were gathered during a 3-year period from June 2006 through May 2009. All patients had been referred from the ICU of another general hospital.

The inclusion criterion was recent traumatic SCI at cervical or thoracic level admitted to the ICU during their first inpatient episode. The exclusion criteria were history of emergency tracheostomy or prior airway problems, coagulopathies, and previous tracheostomy. Two patients were excluded due to emergency tracheostomy as a consequence of severe maxillofacial traumatic injury that compromised the airway.

Timing and type of technique were decided by the physician in-charge of each patient. Surgical tracheostomy was defined as a technique performed in the operating room or at the bedside in ICU according to a surgical open protocol following the standard technique described elsewhere.[37] Percutaneous tracheostomy was performed using the progressive percutaneous dilatational technique. In 61 cases tracheostomy was performed in the referring hospital before transfer to our ICU, and so it was necessary to obtain the relevant data from the referring physician through a telephone interview. Once clinically stable, all patients dependent upon permanent respiratory support were discharged from the ICU to an intermediate care unit in our own hospital for rehabilitation before being discharged from our center.

Outcome measures

Data collected were demographic data (age and sex), data relevant to the patients' neurological injuries (level and grade of spinal cord damage according to the classification system used by the American Spinal Injury Association – ASIA scale),[38] timing of tracheostomy and type of technique, duration of MV (total time and post-tracheostomy time), length of stay in ICU (total time and post-tracheostomy time), incidence of pneumonia, mortality, incidence of perioperative and early postoperative complications (recollected in the first week), and stoma infections (during first week and after 6 months' follow-up). Tracheal stenosis was detected by a systematic screening method that included clinical signs (stridor and dyspnea), functional respiratory tests (forced expiratory volume (FEV), forced vital capacity (FVC), FEV/FVC) and bronchoscopy.

Clinical definitions and parameters of study

Early tracheotomy was defined as any procedure performed on days 1–7 after orotracheal intubation, and late any time after the first week.[19,39–42] Acute Physiology and Chronic Health Evaluation II (APACHE II), a simplified score for determining the severity of patient's physiologic state widely used in ICUs,[43] was calculated during the first 24 hours after admission in our ICU. Wound infection was defined with the following criteria: infection taking place within 30 days of surgery involving the skin and subcutaneous tissue and fulfilling at least one of the following subcriteria: (1) purulent discharge from a superficial infection, (2) organisms isolated from aseptically obtained wound culture, and (3) at least one of the following signs: pain or tenderness, localized swelling, redness, or heat. Severe or life-threatening bleeding was defined as bleeding that caused hemodynamic compromise and required surgical intervention for its control. Moderate bleeding was defined as bleeding that required blood transfusion but did not result in hemodynamic compromise; mild bleeding was defined as bleeding that did not meet criteria for severe or moderate bleeding. Diagnosis of pneumonia required a radiographic image of a new and persistent infiltrate and at least two of the following criteria: temperature >38 or <35.5°C, leukocytosis >12 000 or <4000 cells/mm^3, and new onset of purulent bronchial secretions or change in its character.[44] Tracheal stenosis was defined as narrowing of the tracheal canal due to granuloma and/or concentric stenosis, assessed by functional respiratory tests and bronchoscopy. For the analysis of the duration of MV patients with spinal cord lesion higher than the C4 level were excluded, as in most cases they require indefinite or permanent respiratory support.

Data presentation and statistical analysis

Continuous variables have been expressed as mean ± SD (standard deviation) and have been compared for statistical analysis with Student's *t*-test. Categorical variables have been expressed as absolute frequency and percentage and have been compared using the χ^2 test. Odds ratio (ORs) are expressed as absolute value within 95% confidence interval (CI 95%). A multivariate analysis was performed to determine whether univariate significant differences between factors are independent predictors of prolonged MV and ICU stay and a higher rate of tracheostomy complications. We considered statistical significance to be $P \leq 0.05$. The statistical package SPSS, version 15.0 for Windows, was used for the analysis.

Results

The characteristics of 323 patients who complied with the inclusion criteria admitted for this study are shown in Table 1. Of the 208 patients with cervical SCI, 23 (11%) had severe chest trauma. Of the 115 with thoracic injury, 25 (22%) had severe chest trauma. This difference was statistically significant ($P = 0.008$; OR: 0.40 (95% CI: 0.23–0.87)).

MV was required for 297 patients of our cohort and 215 of these underwent tracheostomy. The demographic and clinical characteristics of patients with or without tracheostomy are shown in Table 2. In patients without associated lesions, 74 of the 97 who had cervical SCI (76%) needed tracheostomy. For patients with thoracic injuries, only 4 of the 40 cases (10%) without associated injuries required tracheostomy, a statistically significant difference ($P < 0.0001$; OR: 28.96; CI 95%: 10.81–77.57).

Perioperative complications (early and late) of the procedure included stomal cellulitis in 28 cases, minor bleeding in 14 cases, and tracheal stenosis in 19 cases. Only eight patients suffered serious complications: tracheoesophageal fistula that required surgical repair in one, mediastinal abscess that required further surgical drainage in another, and late tracheal stenosis that required repair with surgical laser along with endotracheal stent in six cases.

Table 1 Patient characteristics

Total number	323
Age in years	
Range	14–81
Mean ± SD CI 95%	42.3 ± 13.7
Median	39
Sex	*n* (%)
Male	256 (79.3)
Female	67 (20.7)
SCI level	
Cervical	208 (64.8)
C1–C3	19 (9.1)
C4–C5	139 (66.8)
C6–C8	50 (20.0)
Thoracic	115 (35.6)
T1–T5	96 (83.5)
T6–T12	19 (16.5)
ASIA score	
A	228 (70.6)
B	44 (13.6)
X	41 (12.7)
Δ	10 (3.1)
Trauma-associated injuries	
Yes*	154 (47.7)
Brain injury	103 (31.9)
Maxillofacial	9 (2.8)
Thoracic and pulmonary	48 (14.9)
Abdominal	11 (3.4)
Pelvis, large bones	21 (6.5)
No	169 (52.3)
Traumatic cause	
Road trauma	190 (58.8)
Fall injury	108 (3.0)
Blunt trauma	17 (53.3)
Gunshot wound	2 (0.6)
Other	6 (1.9)
Interval from injury to admission (days)	
Range	2–43
Mean ± SD 95% CI	11.4 ± 14.7
Median	12
	n (%)
Need for mechanical ventilation	297 (91.9)
With tracheostomy	215 (72.4)
Without tracheostomy	82 (27.6)
Mortality (5)	5 (1.5)

*Some patients had associated injuries located in 2 or more distinct anatomic regions.

Tracheostomy was placed early (days 1–7 from intubation) in 101 (47%) patients and late (after day 7) in 114 (53%) cases. The demographic and clinical data of these patients are listed in Table 3. The statistically significant differences between the early and late tracheostomy groups were the length of time on MV and ICU stay (total and post-tracheostomy time in both cases). There were no other statistically significant differences with respect to demographic data, location and severity of SCI, associated lesions, or needs of stabilization spinal surgery.

Total number of complications was rather high in patients in which delayed tracheostomy was performed

Table 2 Characteristics of patients with/without tracheostomy

	Tracheostomy		
	No *n* (%)	Yes *n* (%)	*P*
Total number: 323	82 (27.6)	215 (72.4)	
Age (years; mean ± SD)	39.4 ± 16.7	43.6 ± 17.8	0.06
Sex			
Male	64 (78.0)	174 (80.9)	0.76
Female	18 (21.9)	41 (19.0)	
SCI level			
Cervical	27 (32.9)	171 (79.5)	<0.001
Thoracic	55 (67.1)	44 (20.5)	OR: 0.13 (0.06–0.23)
ASIA score			
A	42 (56.5)	167 (77.7)	
B	16 (19.5)	26 (12.1)	<0.001
C	17 (20.4)	20 (9.3)	
D	7 (3.7)	2 (0.9)	
Associated injuries			
Yes	51 (62.2)	94 (43.7)	0.003
No	31 (37.8)	121 (56.3)	OR: 2.18 (1.26–3.55)
Traumatic cause			
Road trauma	49 (59.8)	129 (60)	
Fall injury	27 (32.9)	71 (33.0)	
Blunt trauma	4 (4.9)	11 (5.1)	0.97
Gunshot wound	1 (1.2)	1 (0.5)	
Others	1 (1.2)	3 (1.4)	
APACHE II	6.1 ± 4.4	7.4 ± 4.7	0.03
ISS	28.3 ± 4.7	29.19 ± 4.81	0.14
Mortality			
Yes	1 (1.2)	4 (1.9)	0.58
No	81	211	

ASIA, American Spinal Injury Association; APACHE II, Acute Physiology and Chronic Health Evaluation II; ISS, injury severity score.

Table 3 Demographics and clinical data according to tracheostomy timing (early vs. late)

	Tracheostomy		
	Early *n* (%)	Late *n* (%)	*P*
Total patients: 215	101 (47.0)	114 (53.0)	
Sex			
Male	81 (80.2)	91 (79.8)	0.94
Female	20 (19.8)	23 (20.2)	
Mean age (years)	39.2 ± 8.9	43.7 ± 9.2	0.003
Level of spine lesion			
Cervical	87 (86.1)	85 (74.6)	0.034
Thoracic	14 (13.9)	29 (25.4)	
SCI grade			
Motor complete (ASIA A + B)	84 (83.2)	104 (91.2)	0.11
Motor incomplete (ASIA C + D)	17 (16.8)	10 (8.8)	
APACHE II	6.86 ± 4.11	8.04 ± 5.3	0.07
Associated lesions			
Yes	65 (64.4%)	86 (75.4)	0.10
No	36 (35.7%)	28 (24.6)	
Fixation spinal surgery			
Yes	76 (75.3)	75 (65.8)	0.08
No	25 (24.8)	39 (34.2)	
Tracheostomy type			
Percutaneous	45 (44.5)	52 (45.6)	0.87
Surgical	56 (55.5)	62 (54.4)	
Total time of MV (days): mean ± SD	26.1 ± 11.7	48.8 ± 13.5	<0.001
Post-tracheostomy duration of MV (days)	22.1 ± 11.2	34.0 ± 12.3	<0.005
Total ICU stay (days): mean ± SD	36.5 ± 21.6	54.6 ± 24.9	<0.001
Post-tracheostomy ICU stay (days)	30.6 ± 19.6	39.3 ± 23.0	0.003
Mortality rate	1 (1)	*n*: 4 (3.5)	0.22
Post-tracheostomy pneumonia	75 (74.2)	*n*: 83 (72.8)	0.81
Stomal cellulitis	15 (14.9)	13 (11.4)	0.45
Bleeding	6 (5.9)	8 (7.0)	0.96
Tracheal stenosis	3 (3)	16 (14.0)	0.003

SCI grade, severity score according to the American Spinal Injury Association (ASIA); APACHE II, Acute Physiology and Chronic Health Evaluation II; ISS, injury severity score; MV, mechanical ventilation; ICU, intensive care unit.

(38 complications in 32 patients, 28%) vs. early procedure (25 complications in 21 patients, 21%), but without statistical significance ($P = 0.14$). In each group, there was one case of prolonged bleeding, which stopped spontaneously within 24 hours.

Multivariate analysis showed that tracheal stenosis was associated as an independent variable with late tracheostomy placement, with $P < 0.003$ and OR: 5.33 (95% CI: 1.58–18.04). It also showed that shorter duration of MV and ICU stay could be identified as independent variables associated with early tracheostomy, either if we considered the total time of MV ($P < 0.005$ and OR: 6.73 (95% CI: 2.42–16.61)) or the post-tracheostomy time ($P < 0.005$ and OR: 5.88 (95% CI: 2.33–14.28)).

Tracheostomy was performed according to the standard surgical technique in 119 (55%) patients and percutaneous in 94 (45%) cases. The demographic and clinical data are shown in Table 4. The only statistically significant difference between the surgical and percutaneous tracheostomy groups was higher ICU stay, both total and post-tracheostomy stay, in the surgical tracheostomy group. There were no other statistically significant differences with respect to sex or age, location and severity of SCI, length of time in MV, procedure timing, associated lesions, or need of stabilization spinal surgery.

We did not find statistically significant differences in tracheostomy-related complications. Two severe early complications were registered, first a tracheoesophageal fistula in a patient who had a percutaneous tracheostomy (who was treated with surgical reparation), and second a mediastinal abscess, in which methicillin-resistant *Staphylococcus aureus* grew in culture, treated with surgical drainage and intravenous vancomycin in a patient who had a surgical tracheostomy.

Table 4 Characteristics of patients undergoing percutaneous and surgical tracheostomy

	Percutaneous *n* (%)	Surgical *n* (%)	*P*
Total patients: 215	96 (44.65)	119 (55.35)	
Sex			
Male	78 (81.25)	96 (80.67)	0.53
Female	18 (18.75)	23 (19.33)	
Mean age (years)	42.96 ± 14.16	44.40 ± 17.71	0.51
Level of spine lesion			
Cervical	76 (79.17)	95 (79.83)	0.91
Thoracic	20 (20.83)	24 (20.17)	
APACHE II	7.04 ± 4.78	7.45 ± 4.80	0.53
Associated lesions			
Yes	48 (50)	73 (61.34)	0.06
No	48 (50)	46 (38.66)	
Fixation spinal surgery			
Yes	75 (78.12)	85 (71.43)	0.14
No	21 (21.88)	34 (28.57)	
Timing			
Early	50 (52.08%)	59 (49.58%)	0.41
Late	46 (47.92%)	60 (50.42%)	
Total time of MV (days): mean ± SD	33.79 ± 29.62	40.73 ± 22.71	0.06
Post-tracheostomy duration of MV (days)	25.51 ± 28.08	31.69 ± 20.07	0.07
Total ICU stay (days): mean ± SD	40.31 ± 26.49	49.42 ± 19.24	0.004
Post-tracheostomy ICU stay (days)	29.85 ± 25.70	38.19 ± 15.07	0.005
Deceased	3 (3.12)	2 (1.68)	0.39
Post-tracheostomy pneumonia	57 (59.37)	89 (74.79)	0.011
Stomal cellulitis	10 (10.4)	18 (15.13)	0.31
Bleeding	7 (7.29)	7 (5.88)	0.74
Tracheal stenosis	7 (7.29)	12 (10.08)	0.29

APACHE II, Acute Physiology and Chronic Health Evaluation II; MV, mechanical ventilation; ICU, intensive care unit.

Of these 215 patients, 28 underwent tracheostomy just after spinal cervical stabilization surgery by anterior or anterolateral approach. All tracheostomies in these patients were performed following the percutaneous technique. Two of these suffered from stomal infection that did not involve the surgical wound. No other complication took place despite the proximity of the two surgical incisions (Table 5).

Discussion

Patients with cervical SCI have significantly reduced vital capacity and ventilatory reserve because of interruption of neural pathways to the diaphragm and respiratory muscles of chest and abdomen, resulting in a restrictive ventilatory impairment.[15] The ensuing respiratory insufficiency directly correlates with the level of the injury and the degree of motor severity damage. In thoracic SCI, respiratory insufficiency is more related to direct chest trauma and pulmonary injury.[6,45] MV with intermittent positive pressure is often required for treatment.

Table 5 Clinical data for patients with tracheostomy post-cervical stabilization surgery

Variable	Result
Total number of patients	28
Duration of translaryngeal intubation (days): mean ± SD	8.61 ± 6.8
Duration of post-tracheostomy ventilation (days): mean ± SD	25.4 ± 32.1
ICU length of stay (days): mean ± SD	33.83 ± 11.65
Mortality rate (%)	2/28 (7.1)
Interval from trauma to surgery (days): mean ± SD	2.25 ± 2.35
Interval from trauma to tracheostomy (days): mean ± SD	8.25 ± 5.57
Associated lesions	*n* (5)
Traumatic brain injury	11 (39.3)
Maxillofacial trauma	1 (3.6)
Chest trauma	4 (14.3)
Abdominal trauma	1 (3.6)
Pelvic or large bone trauma	2 (7.1)

ICU, intensive care unit.

If prolonged mechanical respiration is needed, tracheostomy may improve respiration and facilitate weaning by reducing airway resistance,[46] as well as prevent complications from prolonged orotracheal intubation. It has also been reported to reduce mortality rate.[47–49] Other additional benefits are represented by facilitation of nursing care, possibility of suctioning respiratory secretions, and improvement of patient's comfort, swallowing, and early phonation.[50] It is, however, an invasive procedure with intrinsic risks: misplacement of needle, wire, dilator or canula, fracture of tracheal ring, posterior tracheal wall injury, bleeding, pneumothorax, subcutaneous emphysema, hypoxia, wound infection, mediastinitis, and death. The incidence of these complications often depends on the experience of the physician.[31,51–54] The decision to convert a translaryngeal intubation to a tracheostomy requires to anticipate the duration of expected MV and to assess the benefits and risks of the procedure.

The development of the percutaneous technique has facilitated and popularized this procedure, which is rapidly spreading in ICUs due to its lower complexity (can be performed at bedside without surgery).[55] This trend was confirmed in our study, which showed that tracheostomy is performed in most patients with cervical SCI and at a lower rate in patients with thoracic SCI, who often also have pulmonary injury due to associated chest trauma.

The total rate of complications was 25% (63 complications in 53 patients); only 8 of which (7 patients, 3%) were moderate or severe: 6 tracheal stenosis, 1 tracheoesophageal fistula, and 1 mediastinal abscess. The perioperative mortality of tracheostomy ranges from

0.2 to 0.7%.[56] Mortality for all causes in our patients was very low, although patients were admitted after the period when mortality is higher (the first days post-trauma). In our series no death was attributed to tracheostomy (specific mortality: 0%).

In the past, tracheostomy was delayed as long as possible in ventilator-dependent patients, trying to minimize procedure-related airway damage, but prolonged intubation in itself was the main risk factor for multiple complications.[49,52,57,58] Recognition of the benefits of tracheostomy has promoted its earlier performance. Widespread diffusion of the percutaneous technique has also contributed to boost its popularity.[28,41,59–61] Nowadays, early tracheostomy has become the most recommended strategy for patients on prolonged mechanical ventilation.[54,62]

However, optimal timing for tracheostomy in SCI, as well as in other critical ill patients, is still controversial due to lack of evidence.[17,28,48,59,63] Some authors have suggested that early tracheostomy decreases ICU mortality rate[23,64,65] and overall in-hospital mortality,[26,66] whereas other studies have reported a mortality rate reduction on a long-term basis, but not on a short-term basis.[41,55,67] And finally, these observations were not confirmed by other authors who could not demonstrate any significant association between timing of tracheostomy and reduction of mortality rate following surgery, polytrauma, and severe head injury.[19,40,68–71]

The benefits of early tracheostomy for patients who require extended periods of MV, compared to prolonged translaryngeal intubation have been debated.[19,47,72] A meta-analysis of the efficacy of early tracheostomy reported that patients could benefit from reduction of MV and ICU stay, while there were no changes in the rate of pneumonia or mortality.[19,69] Consistent with these previous observations, we have found that early tracheostomized patients have a statistically significant shorter MV (both as total time and post-tracheostomy time) ($P < 0.001$ and $P = 0.004$, respectively). They also have a statistically significant reduced ICU stay with respect to late tracheostomized patients, both as total time and when we considered only the post-tracheostomy time ($P < 0.001$ and $P = 0.003$, respectively) (Table 3).

It has been suggested that early tracheostomy might lower the rate of ventilatory-associated pneumonia as it could reduce lower respiratory tract colonization. This opinion is controversial: some authors reported a reduced rate of pneumonia with early tracheostomy,[40,42,47,62,64,73–76] whereas other studies could not confirm these observations.[19,39,68–70,77] In our study we observed that the number of patients who suffered pneumonia was not statistically different (early vs. late: 74 vs. 73%, $P = 0.81$; OR: 0.93 (CI 95%: 0.51–1.71)). Therefore, our results support the opinion that tracheostomy timing does not prevent the development of pneumonia.

Main side effects of tracheostomy may occur early (misplacement, subcutaneous emphysema, wound infection, and bleeding) or late (tracheal stenosis, especially subglottic, stoma infection, swallowing problems, tracheoesophageal fistula, and mediastinitis).[31,51–54] In our study, late tracheostomy had a higher total number of complications (37 complications in 32 patients) than early tracheostomy (24 complications in 21 patients), although this difference is not statistically significant ($P = 0.21$). According to our results prevalence was similar regarding bleeding and stoma infection, whereas the development of tracheal stenosis was clearly associated with late tracheostomy ($P = 0.003$; OR: 5.33 (CI 95%: 1.57–18.02)), which requires more prolonged translaryngeal intubation. Our study shows better results for early tracheostomy vs. longer translaryngeal intubation with late tracheostomy regarding this specific complication, a finding that is consistent with that of a previous study.[58]

Nowadays, both surgical and percutaneous tracheostomies can be safely performed at the bedside by experienced, skilled practitioners, with low complications rates.[78] The optimal tracheostomy method in critically ill patients remains, however, a subject of debate. The traditional method of performing this procedure was surgical. With percutaneous tracheostomy the limited dissection results in less tissue damage, lowers the risk of bleeding and wound infection, and can be safely performed at the bedside in the ICU, which may overcome the risks associated with the transport of a critically ill patient to the operating room.[55,78] For these reasons, this technique is being increasingly performed in ICUs.[55]

In this series, we did not find statistically significant differences between the two techniques at study entry in terms of age, sex, level, and degree of SCI; severity of the illness; need of surgery for spinal stabilization; or existence of associated injuries. In this study, the duration of ICU stay was lower when tracheostomy was performed by the percutaneous dilation technique, but both groups showed no difference in the duration of MV, both total and post-tracheostomy time. We also saw a lower incidence of pneumonia in patients undergoing percutaneous tracheostomy (59 vs. 75%, $P = 0.011$, OR: 0.49 (CI 95%: 0.27–0.89)), whereas others authors have found no difference in the incidence.[79,80] We did not find any difference in terms of mortality and perioperative complications. According to our results, percutaneous tracheostomy, performed in the ICU, should be considered the procedure of choice for performing elective tracheostomies in critically ill adult patients, an action also recommended by other authors.[54,78]

When a tracheostomy is performed after anterolateral cervical spine fixation, the two incisions come in very close contact, which poses the potential risk of cross-contamination and, therefore, of much feared infection of the osteosynthetic material.[81] That is why in daily clinical practice there is a trend to delay the procedure until the healing process following fixation surgery is completed or at a very advanced stage, which could increase the complications of prolonged translaryngeal intubation.

There are, however, authors who advise that percutaneous tracheostomy shortly after osteosynthetic cervical surgery ought to be the technique of choice,[82] because this technique minimizes damage to adjacent structures, as it is less aggressive to tissues than the conventional surgical technique. This fact alone would be enough to explain the lower rate of complications. Our results (Table 5) showed very low infection rates in early tracheostomy after cervical spinal stabilization by the anterolateral approach, which supports the view that this procedure is safe and effective. Other authors have reached similar conclusions.[83,84]

Limitations

A number of potential limitations in our study warrant discussion. First, ICU medical staff who treated our study population before its admission to our hospital did not have homogeneous treatment strategies or skill regarding the tracheostomy technique. So the influence that the experience of the physicians may have had on the outcomes could not be quantitatively assessed in our analysis. Second, since our study was observational, the decision to perform tracheostomy (timing and type of technique) was taken on a clinical basis by the physician in-charge, without previous randomization, and so our results, even if statistically significant and based on a population that can be compared regarding its baseline characteristics, may have potential biases. Third, the resources that were quantitatively analyzed were the durations of MV and ICU stay; other costs were not considered in this study. Finally, the statistical analysis of mortality was possible due to the low mortality rate in our study population.

Conclusions

This study shows that tracheostomy is a common procedure in patients with traumatic SCI during their first inpatient rehabilitation period, especially in cervical SCI or thoracic level with associated injuries. Tracheostomy is performed in the more severely injured patients.

Tracheostomy is a safe procedure in this type of patient, with very low mortality and morbidity: in our series no death was attributed to tracheostomy (specific mortality: 0%). The total rate of complications was significant, but only in 3% of patients were they moderate or severe. Both surgical and percutaneous tracheostomies can be safely performed at the bedside.

In SCI, early tracheostomy offers the advantages of shortening MV, reducing ICU stay, and lowering rates of severe translaryngeal intubation complications such as tracheal stenosis. On the other hand, we could not demonstrate that early tracheostomy lowered the risk of ventilator-associated pneumonia.

On the basis of the benefits demonstrated in this prospective observational study, we suggest that tracheostomy be performed as soon as possible in patients who may require prolonged MV. Percutaneous early tracheostomy should be the method of choice in critically ill patients.

Our results also confirm that tracheostomy does not have deleterious effects when performed shortly after cervical spine fixation surgery. Percutaneous dilatational tracheostomy is a safe technique after cervical osteosynthesis by the anterolateral or anterior approach, and it does not encourage cross-infection despite the proximity of the incisions involved.

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