

Indicators for Tracheostomy in Patients with Traumatic Brain Injury

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Our objective was to develop criteria to identify patients with traumatic brain injury (TBI) who require a tracheostomy (TR). From January 1994 to May 2000 all TBI patients requiring intubation on presentation and who survived >7 days were identified from our trauma registry. Demographics, Glasgow Coma Score (GCS), Injury Severity Score (ISS), and ventilator days, ICU days, hospital days, need for TR, and development of pneumonia were statistically analyzed. Of 246 patients with TBI 211 without TR and 35 with TR were identified (mean time to TR 13.3 ± 7.0 days). Logistic regression analysis identified presenting GCS ≤ 8 , ISS ≥ 25 , and ventilator days >7 as significant predictors for TR. Applying these three predictors to our population identified 48 patients (21 with TR, 18 without TR, and nine who died on the ventilator without TR) with a sensitivity of 60 per cent, a specificity of 87 per cent, a positive predictive value of 44 per cent, and a negative predictive value of 93 per cent. Patients with TR had lower presenting GCS and higher ventilator, ICU, and hospital days ($P < 0.05$). Pneumonia rates were similar. Time to neurologic recovery (GCS ≥ 9) was longer for the TR patients as compared with the patients without TR. We conclude that patients with TBI presenting with a GCS ≤ 8 , an ISS ≥ 25 , and ventilator days >7 are more likely to require TR. Performing TR late did not reduce pneumonia rates or ventilator, ICU, or hospital days. By identifying the at-risk population early TR could be performed in an attempt to decrease morbidity and length of stay.

CONTROVERSY EXISTS OVER the indications and timing of tracheostomy (TR) in patients with traumatic brain injury (TBI). To avoid secondary brain injury from hypoxia and to provide a secure airway most patients with Glasgow Coma Score (GCS) ≤ 8 are intubated and ventilated in the trauma bay during their evaluation and resuscitation. In addition to the severity of the brain injury associated injuries, operations, and subsequent pulmonary complications determine the length of time these patients with TBI remain intubated and ventilated. Some of these patients require only a secure airway whereas other patients need prolonged ventilatory support. Early and late TR are both recommended in the literature.¹⁻⁴ The time range recommended for conversion to TR is from 3 days to 21 days.^{4,5} Broad general guidelines from a consensus conference on artificial airways recommends the use of translaryngeal tubes for airways up to 10 days and

if the anticipated need for artificial airway will be greater than 21 days TR is preferred.⁶ Advocates of early TR (within one and 7 days) claim the advantage of lower incidence of pneumonia and shorter duration of mechanical ventilation, intensive care unit (ICU) stay, and hospital stay.¹⁻³ TR provides a secure airway and facilitates airway suctioning, mouth care, and patient mobility. Furthermore TR decreases the damage to the vocal cords seen with endotracheal tubes.^{5,7,8}

Advocates of late TR claim the avoidance of unnecessary operations in patients with uncertain prognosis.⁸ Given time many patients will be weaned and extubated, whereas other patients may die early from the TBI or other associated injuries. Complications of TR including pneumothorax, bleeding, and tracheal stenosis are also cited as reasons to delay conversion to TR.⁷

The development of percutaneous TR techniques, which converts a procedure usually done in the operating room to a bedside procedure, has renewed investigation into the timing of TR conversion. Because the demand for percutaneous TR has increased in our institution we wanted to examine our current practice for airway conversion in our patients with TBI with the intent to develop criteria that would identify those patients who will most likely require TR.

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Methods

The trauma registry of an urban Level I hospital was retrospectively queried for all neurologically injured patients from January 1994 through May 2000. Of this population only patients with TBI requiring intubation and ventilation upon presentation and surviving more than 7 days were selected for our study. Patients were also excluded if they sustained isolated spine, face, or soft-tissue neck injuries, were incorrectly classified as having neurologic injuries, were transferred to our institution with a TR in place, or were unable to be completely evaluated because of unavailable medical records. For each patient, we recorded demographic information; mechanism of injury; presenting GCS; Injury Severity Score (ISS); ventilator, ICU, and hospital days; discharge disposition; need for TR; day of tracheostomy; development of pneumonia; and number and type of operations. Beyond the presenting GCS a daily modified GCS (m-GCS) was calculated for each patient using the regression model determined by Meredith et al.⁹ which calculates a modified total GCS from motor and eye scores for intubated (non-verbal) patients:

$$\text{m-GCS} = \text{Motor} + \text{Eye} + [-0.3756 + (\text{Motor} \times 0.5713) + (\text{Eye} \times 0.4233)]$$

This score was tracked daily until extubation, TR, or 14 days of mechanical ventilation. Student's *t* test, chi square test, Wilcoxon two-sample test, Fisher's exact test, and logistic regression were used to compare the patients who underwent TR with those who did not. A *P* value less than 0.05 was considered significant.

Results

From January 1994 through May 2000 961 neurologically injured patients were identified from the trauma database. Of these 961 patients 246 (26%) met the study criteria. Excluded from the study were 285 patients (30%) who did not require ventilatory support; 129 patients (13%) who died early; and 301 patients (31%) who did not have TBI, who presented to our hospital with a TR in place, or whose medical records were unavailable for review (Fig. 1). The 246 patients had multiple injuries with a mean ISS of 22.1 ± 9.9 and a presenting GCS of 8.7 ± 4.3 . There were 199 males and 47 females with an average age of 34.4 ± 20.9 years. Of the 246 patients 126 (51.2%) required operations. There were 84 craniotomies, 21 face and neck operations, one thoracic operation, five abdominal operations, and 33 extremity operations. TR was performed on 35 of the 246 patients (14%). Twenty-two (62.8%) of the patients with TR required operations (13 craniotomies, two face surgeries, three abdominal surgeries, and eight extremity surgeries). The timing of conversion to TR varied and ranged from Day one to Day 30. The mean time to TR was 13.3 ± 7.0 days and the mean time from TR to removal from ventilatory support was 6.9 ± 8.4 days.

Data from the 35 patients who required TR were compared with data from the 211 patients without TR (Table 1). No study patient was removed from ventilatory support on Day 1. By Day 7 149 of 211 patients without TR (71%) were extubated. Between Day 1 and Day 7, seven patients with TR (20% of TRs) were converted to TR. The remaining 28 patients were

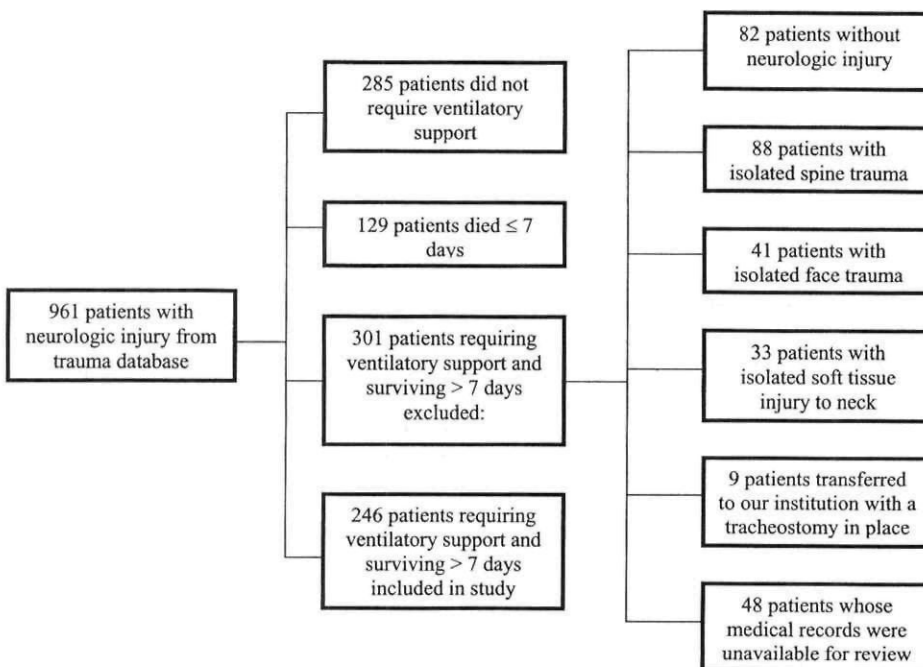


FIG. 1. Distribution of 961 patients evaluated of study population.

TABLE 1. Demographic, Presenting, and Outcome Data for Study Population*

	With TR, n = 35	Without TR, n = 211	P Value
Age	37.4 ± 18.5	33.9 ± 21.3	0.37
Presenting GCS	6.5 ± 4.0	9.7 ± 4.3	0.001
ISS	30.5 ± 8.6	20.8 ± 9.5	0.003
Male:Female	26 (74%):9 (26%)	173 (82%):38 (18%)	0.37
Ventilator days	20.1 ± 9.8	5.4 ± 5.7	<0.001
ICU days	23.5 ± 9.3	8.5 ± 7.1	<0.001
Hospital days	37.2 ± 17.4	14.9 ± 9.6	<0.001
Pneumonia rate	32 (91.4%)	66 (31.3%)	<0.001

* Data are presented as means ± standard deviation or as number (%).

converted to TR after Day 7. The patients with TR were more severely injured ($P = 0.003$) and had a lower GCS on presentation ($P = 0.001$). Patients with TR also had significantly longer mechanical ventilation times, more ICU days, and longer hospital stays ($P < 0.001$). There was a higher incidence of pneumonia in the patients with TR ($P < 0.001$) with 30 of the 35 patients (86%) diagnosed with pneumonia before TR.

Logistic regression analysis was used to identify factors that would predict the progression to TR. This analysis identified presenting GCS ≤ 8 , ISS ≥ 25 , and ventilator days greater than 7 as predictors of TR (Table 2). Applying these three criteria to the 246 patients identified 48 patients including 21 of the 35 patients with TR (60%) and 27 patients without TR (Table 3). Of the 27 patients without TR 18 patients (67%) were successfully weaned from mechanical ventilation and extubated whereas nine patients (33%) died on the ventilator without TR. For the 21 patients with TR the mean time to TR was 13.7 ± 6.4 days with a mean time from TR to removal of ventilatory support of 7.8 ± 10.2 days. A sensitivity of 60 per cent, a specificity of 87 per cent, a positive predictive value of 44 per cent, and a negative predictive value of 93 per cent were calculated for these three predictors of TR. The demographic, presenting, and outcome data for the 48 patients identified by logistic regression criteria are presented in Table 3. The data of the nine patients who died on the ventilator without TR are presented for comparison but are not included in the statistical analysis. When patients with TR were compared with patients successfully weaned without TR ISS and pneumonia rates were not different. However, venti-

lator days ($P < 0.001$), ICU days ($P = 0.02$), and length of hospital stay ($P = 0.03$) were significantly longer and presenting GCS was significantly lower ($P = 0.006$) in patients with TR.

To further examine these 48 patients identified by logistic regression criteria the daily m-GCS scores for each group were compared (Table 4). The patients without TR on average reached neurologic recovery (GCS ≥ 9) by Day 7 as compared with the patients with TR who had neurologic recovery at day 14. There was a significant difference in the m-GCS on Days 10 to 14 for these two groups. The patients who died on the ventilator without TR showed a steady decline in their m-GCS over Days one to 14.

Calculating the average change in m-GCS from Day one to the day of extubation, TR, or death identified three distinct patterns in these 48 patients. For the patients undergoing TR the average m-GCS on the day of TR was 9.0 ± 2.5 with an average change in m-GCS from Day one to day of TR of $+2.2 \pm 4.0$. In contrast the patients without TR had a significantly higher average m-GCS on the day of extubation of 12.8 ± 2.2 with a significantly higher average change in m-GCS from Day one to extubation of $+4.7 \pm 2.3$. The patients who died on the ventilator without TR had an average m-GCS on the day of death of 4.1 ± 3.2 with an average change in m-GCS from Day one to death of -3.3 ± 3.7 (Fig. 2).

Discussion

The incidence of conversion to TR was 14 per cent in this study of patients with TBI and is similar to the incidence of 14 to 18 per cent reported by Gordon et al.¹⁰ in a series of 1132 head injury patients. Most surgeons would convert to TR when there is a need for prolonged mechanical ventilation (greater than 21 days), a high cervical spinal cord injury, or extensive facial trauma. In fact five of our seven early TRs (≤ 7 days) were performed for concurrent facial or cervical spine injury.

The concept of early TR in brain-injured trauma patients remains controversial. Two retrospective

TABLE 2. Logistic Regression Analysis Results for Predictors of TR

Clinical Predictor	Odds Ratio	95% Confidence Interval	P Value
Presenting GCS ≤ 8	3.4	1.5-7.9	0.004
ISS ≥ 25	7.2	2.9-18.1	<0.001
Ventilator days >7	21.45	7.3-63.5	<0.001

TABLE 3. Demographic, Presenting, and Outcome Data for 48 Patients with Presenting GCS ≤ 8 and ISS ≥ 25 and Requiring Ventilator Support Greater than 7 Days

	With TR n = 21	Without TR n = 18	No TR/No EX* n = 9	P Value†
Age	33.1 \pm 16.0	33.1 \pm 23.1	42.1 \pm 23.0	0.75
Presenting GCS	4.4 \pm 1.4	5.8 \pm 1.5	4.7 \pm 1.9	0.006
ISS	34.3 \pm 7.2	31.4 \pm 8.2	28.2 \pm 4.4	0.08
Male:Female	16 (76%):5 (24%)	14 (78%):4 (22%)	7 (78%):2 (22%)	0.99
Ventilator days	21.4 \pm 9.9	12.9 \pm 2.5	15.9 \pm 10.4	<0.001
ICU days	24.6 \pm 9.5	18.4 \pm 7.6	15.9 \pm 10.4	0.02
Hospital days	40.2 \pm 19.0	29.1 \pm 7.8	15.9 \pm 10.4	0.03
Pneumonia rate	20 (95.2%)	14 (77.8%)	5 (55.6%)	0.16

Data are presented as mean \pm standard deviations or as number (%).

* Patients who died on the ventilator without TR.

† P values are comparing the patients with TR with those without TR.

TABLE 4. m-GCS Day One to 14 for Population with Presenting GCS ≤ 8 and ISS ≥ 25 and Requiring Ventilator Support Greater than 7 Days

	With TR n = 21	Without TR n = 18	No TR/No EX* n = 9	P Value‡
Day 1	6.84 \pm 3.40	8.07 \pm 2.33	7.44 \pm 3.44	0.204
Day 2	7.36 \pm 3.15	8.09 \pm 2.49	8.12 \pm 3.32	0.430
Day 3	7.07 \pm 2.44	8.59 \pm 1.31	7.93 \pm 3.95	0.020
Day 4	7.27 \pm 2.94	8.37 \pm 2.30	7.58 \pm 4.09	0.226
Day 5	7.51 \pm 2.71	8.89 \pm 3.28	5.38 \pm 2.76	0.163
Day 6	7.83 \pm 2.74	8.88 \pm 3.18	4.86 \pm 3.26	0.291
Day 7	7.16 \pm 3.10	9.24 \pm 3.11	4.36 \pm 2.41	0.060
Day 8	7.80 \pm 2.86	9.65 \pm 3.66	4.19 \pm 2.48	0.109
Day 9	8.15 \pm 3.10	10.43 \pm 4.01	3.14 \pm 1.57	0.088
Day 10	8.47 \pm 2.33	11.74 \pm 3.27	3.93 \pm 2.09	0.004
Day 11	8.73 \pm 3.22	11.96 \pm 2.68	4.58 \pm 2.36	0.009
Day 12	8.48 \pm 3.01	12.17 \pm 3.23	3.80 \pm 2.36	0.010
Day 13	8.74 \pm 3.02	13.37 \pm 1.07	3.80 \pm 2.36	0.001
Day 14	10.02 \pm 2.30	12.68 \pm 1.93	4.19 \pm 2.72	0.025

Data are presented as mean \pm standard deviations.

* Patients who died on the ventilator without TR.

† P values are comparing the patients with TR with those without TR.

studies and one prospective analysis suggest that pneumonia rate, mechanical ventilator support, ICU days, and hospital days are less with early TR. However, the TR must be performed by Day 7 for the patient to experience these benefits. Lesnik et al.³ performed early TR (≤ 4 days) in multitrauma patients with significant reduction in ventilator days and pneumonia rates. All of the patients undergoing early TR were liberated from the ventilator by 7 days. D'Amelio et al.¹ found reductions in ventilator, ICU, and hospital days for head-injured patients undergoing TR ≤ 7 days. Similar results were achieved in a prospective study of trauma patients by Rodriguez et al.² In our series with the time to TR conversion at 13.3 ± 7.0 days these potential benefits were not realized. Our patients did not have reduced pneumonia rates or ventilator, ICU, or hospital days. Our findings are similar to those of a series of patients with infratentorial lesions reported by Qureshi et al.¹¹ who found that TR

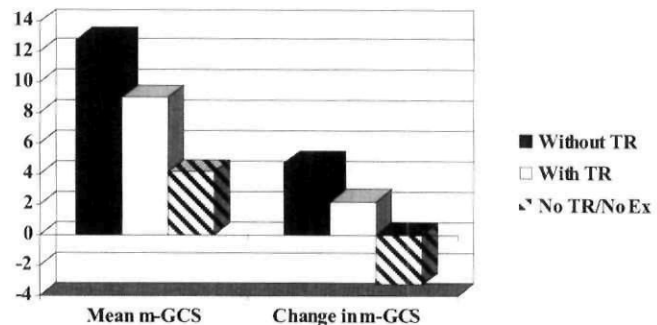


FIG. 2. Mean m-GCS on day of extubation, TR, or death and change in m-GCS from Day one to day of extubation, TR, or death.

at Day 10 resulted in more ventilator, ICU, and hospital days.

To realize the benefits of early TR one must identify those patients who will most likely progress to TR. The GCS serves as a guide to the severity of brain injury, correlates to outcome, and has been used as an indicator of the need for TR.^{10, 12, 13} Patients with a GCS from 13 to 15 have a minor brain injury, good neurologic recovery, and a low mortality rate.¹² Intubation with mechanical ventilation is not required for their brain injury but may be used because of associated injuries. Patients with a GCS ≤ 8 have severe brain injury and a mortality rate of 24 per cent. These patients require intubation and ventilation for their brain injury. However, even in this patient population there is a 55 per cent good neurologic recovery rate, a 14.5 per cent severe disability rate, and a 6.5 per cent vegetative rate.¹⁰ Koh et al.¹⁴ found that a GCS < 8 at Day 7 in head-injury patients was a good indicator of progression to TR. There was a reintubation rate of 22 per cent in patients with GCS < 8 , which was thought to be secondary to airway laxity and tracheal secretions. In surgical intensive care patients Johnson et al.¹³ concluded that a GCS ≤ 9 at Day 2 was a predictor of mechanical ventilation greater than 14 days with a positive predictive value of 91 per cent and a negative predictive value of 96 per cent. These results

correspond with our findings that the patients progressing to extubation showed neurologic recovery earlier (Day 7 *versus* Day 14) than those requiring TR.

Our time to conversion to TR (13.3 days) is very conservative and is clearly considered to be in the category of late TR. Our bias has been to give patients a chance for extubation and if extubation is unsuccessful a TR is performed. Based on the literature and our data it appears that the patients with GCS ≤ 8 and ISS ≥ 25 may benefit from early TR. Examination of the patients presented in Table 4 shows that if we performed TR at 48 hours on patients with GCS ≤ 8 some patients who had later deterioration of brain function would have received TR. However, if the decision to convert to TR was delayed to Day 5, 6, or 7 a clear delineation of patients with deteriorating brain function *versus* improving neurologic status would have been made.

Conclusions

Patients with TBI presenting with a GCS ≤ 8 , an ISS ≥ 25 , and need for ventilator support for longer than 7 days are more likely to require a TR. Lack of neurologic recovery by Day 7 can also aid in the decision to perform a TR. Performing TR late (Day 13) does not reduce ventilator, ICU, or hospital days nor does it reduce pneumonia rates. Early identification of the at-risk population could lead to earlier TR in an attempt to decrease morbidity and length of stay.

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DISCUSSION

DR. ROXIE M. ALBRECHT (Albuquerque, NM): This is a very timely paper in this day of limited hospital beds, ICU beds, and nurses to take care of our ICU patients. The authors have really searched for predictors and indicators to identify patients that would benefit them from early tracheostomy and decrease these ICU stays and hospital stays. Dr. Gurkin and her colleagues have found that GCS of less than 8 and an ICS of greater than 25 as well as ventilator days of over 7 are significant predictors of tracheotomy. I would really like to see if we could decrease those days even further before the patients get their first episode of pneumonia. As you have shown a number of those patients develop pneumonia and that seemed to delay their tracheotomy until their first pneumonia episode was over.

I do have a couple questions. Regarding the eight patients who underwent early tracheotomy before Day 7 did they

have a reason other than the traumatic brain injury that required the tracheostomy? Did these patients have less hospital stay days and less ICU days and did they have less incidence of pneumonia? I know it's a small number, but I think it's important to know that.

What type of sedation do you usually use in your ICU and did that have any influence on the recovery of their Glasgow Coma Scale over that period of time?

Did you look at any components of the ISS, such as the Abbreviated Injury Score (AIS) of the head or the AIS of the cerebrum as a potential determinant for the need for the tracheotomy?

DR. J. WAYNE MEREDITH (Winston-Salem, NC): Are you making a specific recommendation as to who should get a tracheostomy in the first 5 days? Everybody with Glasgow Coma Scale of less than 7? Everybody with an ISS greater than 25? And if so what do you do with those patients who are going to be extubatable and you can't get

them into a nursing home because now they have a trach and that requires a skilled facility and they are not available and all of that?

DR. SCHOLTEN (Moderator): Did you identify the phenomenon of what is termed by the neurosurgeons as the "wake-up trach?" That is, after tracheostomy is done within a day or two the patient comes off the ventilator with an improved mental status?

DR. MYSTAN A. GURKIN (Closing Discussion): As for Dr. Albrecht's questions we had seven patients that underwent tracheostomy before or on day seven. Five of those patients had concomitant high cervical spine injuries and/or facial fractures which provided a more concrete indication for early airway control.

Those patients that underwent early tracheostomy did have lower ventilator, ICU, and hospital days as well as lower pneumonia rates, but due to the small numbers these results would not reach any statistical significance.

As to sedation in our neurosurgical ICU, the neurosurgeons are very strict. We do not give any sedation except codeine and an occasional small dose of Versed for any procedures. As to the ISS breakdown we did not look at the

individual components of the ISS but will do this in follow-up studies. We did evaluate which patients underwent operations. Fifty per cent of the total population required operations. There were 144 operations performed in 126 patients.

As to the questions about specific recommendations, as noted in our presentation the three criteria are very good negative predictors and they reliably eliminate patients that will eventually progress to extubation. Of the 211 patients that did not require tracheostomy, 70 per cent were extubated by Day 7. Those patients that did not require tracheostomy tended to rapidly progress toward extubation.

So yes, if you did use these as absolute recommendations, there would be 18—well, 27—patients that included the nine that died later on that would have a tracheostomy that eventually required extubation. However, the number of vent days for those patients was also on the longer side.

As to the wake-up tracheostomy our average number of days from tracheostomy to liberation from the ventilator was 7 days. I don't have the range on me here, but for the most part, our patients that needed tracheostomy did need it at that time.

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