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Glasgow Coma Scale Motor Score Predicts Need for Tracheostomy After Decompressive Craniectomy for Traumatic Brain Injury

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Objective: Many patients with severe traumatic brain injury (TBI) require a tracheostomy after decompressive craniectomy. Determining which patients will require tracheostomy is often challenging. The existing methods for predicting which patients will require tracheostomy are more applicable to stroke and spontaneous intracranial hemorrhage. The aim of this study was to investigate whether the Glasgow Coma Scale (GCS) motor score can be used as a screening method for predicting which patients who undergo decompressive craniectomy for severe TBI are likely to require tracheostomy.
Methods: The neurosurgery census at the University of Kansas Medical Center was retrospectively reviewed to identify adult patients aged over 18 years who underwent decompressive craniectomy for TBI. Eighty patients met the inclusion criteria for the study. There were no exclusion criteria. The primary outcome of interest was the need for tracheostomy. The secondary outcome was the comparison of the total length of stay (LOS) and intensive care unit LOS between the early and late tracheostomy patient groups.
Results: All patients (100%) with a GCS motor score of 4 or less on post operative (POD) 5 required tracheostomy. Setting the threshold at GCS motor score of 5 on POD 5 for recommending tracheostomy resulted in 86.7% sensitivity, 91.7% specificity, and 90.5% positive predictive value, with an area under the receiver operator curve of 0.9101.
Conclusion: GCS motor score of 5 or less on POD 5 of decompressive craniectomy is a useful screening threshold for selecting patients who may benefit from tracheostomy, or may be potential candidates for extubation.

Keywords: Traumatic brain injury; Decompressive craniectomy; Tracheostomy

INTRODUCTION

Traumatic brain injury (TBI) is a common neurosurgical problem. Severe TBI is estimated to affect over 5 million people each year worldwide and is a major cause of morbidity and mortality.[11,13,17,19,20,25] Decompressive craniectomies are performed for a variety of indications in severe TBI such as alleviating elevated intracranial pressure (ICP) secondary to intracranial hemorrhages (ICH) and in cases of diffuse TBI with medically refractory elevated ICP without a mass lesion.[8,14,16,21] Unfortunately, many patients with severe TBI who have undergone decompressive craniectomy ultimately have poor functional outcomes with up to 62% of patients requiring a tracheostomy prior to discharge.[21] The need for mechanical ventilatory support via an endotracheal tube holds patients in an elevated level of care such as an intensive care unit (ICU) while waiting for successful extubation or tracheostomy for definitive airway management which increases healthcare cost and resource utilization. There have been several studies that show benefits of early tracheostomy in patients with neurologic injury such as TBI, stroke, and spontaneous ICH. The benefits of early tracheostomy include decreased ICU stay, decreased hospital length of stay (LOS), reduced healthcare cost, reduction in sedation needs, fewer days of mechanical ventilation, and decreased rates of ventilator associated pneumonia (VAP).[4,6,10,28,29] Ultimately, the decision to proceed with tracheostomy comes as a result of discussions between the patient's family or surrogate medical decision maker, critical care physicians, neurosurgeons, and other care teams. For many patients, the need for tracheostomy is a major factor in deciding between continuing aggressive care versus pursuing comfort measures or organ donation. It is often difficult for the patient's family or decision maker to make the ultimate decision to proceed with tracheostomy due to inability to prognosticate the need for tracheostomy as well as difficulty predicting the long-term neurologic recovery. It would be beneficial to have an accurate prediction of the need for tracheostomy in this patient population to aid in counseling families and guide clinical decision making. There have been several publications which have proposed prediction tools for identifying patients with neurologic insult who are more likely to be successfully extubated versus which patients will require tracheostomy.[1,31,35] However, these prediction tools are limited by the fact that they were not developed specifically for TBI patients, especially patients who are post-decompressive craniectomy. Additionally, the existing scoring systems tend to be based on neurologic function at the time of admission, imaging findings, and co-morbidities. Therefore, these scoring tools tend to be complex and do not account for early improvement which can be seen following surgical decompression. The ideal prediction tool would be derived from the target patient population, simple, easy to use, and accurate (high sensitivity and specificity). The prediction tool should also be applied with appropriate timing to account for early neurologic recovery, but still early enough to allow for early tracheostomy. The aim of this study was to investigate whether the Glasgow Coma Scale (GCS) motor score can be used as a screening method for predicting which patients who undergo decompressive craniectomy for severe TBI are likely to need tracheostomy.

MATERIALS AND METHODS

Study description

Adult patients (age greater than or equal to 18) who underwent decompressive craniectomy for severe TBI at University of Kansas Medical Center between November 2007 and November 2020 were included in this study. This study had Institutional Review Board (IRB) approval (STUDY00144361) by the University of Kansas Medical Center. The need to obtain informed patient consent was waived by the IRB. Severe TBI was defined as GCS 3–8 according to the Brain Trauma Foundation guidelines.[5] There was no exclusion criteria for patients meeting the stated inclusion criteria. Therefore, patients with multiple organ systems trauma were included in this study. The study included all types of TBI including both blunt and penetrating trauma. A HIPAA compatible neurosurgery database is maintained for all patients and data was mined using ICD-10 & CPT codes. These cases were then individually verified to make sure they met the inclusion criteria to be complete and include all appropriate patients during the time period of the study. The relevant clinical data was collected from the electronic medical record by the first two authors. The patient data was de-identified and stored in a password protected spreadsheet on an encrypted hard drive. The patients were divided in four categories by outcome including tracheostomy, successful extubation, in-hospital death, and discharge to hospice. **Supplementary Tables 1** and **2** provide the definition of the GCS and Glasgow Outcome Scale (GOS).[18,36] Patients who underwent tracheostomy and those who were successfully extubated were compared to determine predictive factors for need for tracheostomy. There is wide variation in the literature regarding what is considered an early tracheostomy. The timing in most articles varies from 7–14 days.[1,4,10,35] For the purposes of this study, early tracheostomy was defined as tracheostomies performed 10 days or less following the decompressive craniectomy, which is the same criteria used in two studies evaluating early versus late tracheostomy for patients status post decompressive craniectomy.[6,28] The primary outcome of interest was tracheostomy. Secondary outcomes were comparing the total LOS and ICU LOS between early and late tracheostomy patient groups.

Surgical procedures

The decompressive craniectomy technique was either bifrontal decompression or unilateral frontotemporalparietal decompression. The technique was selected by the surgeon based on the patient's pathology and surgeon preference.

The standard bifrontal decompression is commonly known as a Kjellborg craniectomy. The procedure at our institution was performed similar to the procedure described by Kjellborg and Prieto.[22] A bicoronal incision was made. Then, burr holes were placed at the keyhole and adjacent to the frontal sinus to allow for turning a large bone flap to decompress the frontal lobes. The craniectomy could be extended to the root of the zygoma to decompress the middle cranial fossa, if necessary. In some cases, it was determined to be unsafe to remove the strip overlying the superior sagittal sinus. In those cases, a small strip was left in place overlying the sagittal sinus. The dura was then opened widely to allow for brain decompression and evacuation of hematoma if present. When adequate decompression and hemostasis had been achieved, attention was turned to closure.

The typical frontotemporalparietal craniectomy was performed with the patient in the supine position with the head turned toward the contralateral side. A large question mark or reverse question mark incision was planned with the inferior portion extending to the level of the zygoma. Burr holes were made at the root of the zygoma, the keyhole, and additional burr holes as needed to plan a large craniotomy. A craniotome was used to connect the burr holes and remove the bone flap. When possible, the cranial opening was made at least 12×15 cm in accordance with the Brain Trauma Foundation Guidelines.[5] The dura was opened in a stellate fashion to allow for brain decompression and evacuation of hematoma if present. When adequate decompression and hemostasis had been achieved, attention was turned to closure. At our institution, bone flaps are either stored in a subcutaneous pocket on the patient's abdomen or stored in a freezer. Storage method selection is at the discretion of the surgeon.

The standard tracheostomy procedure was performed in a percutaneous manner with a modified Seldinger technique using a percutaneous tracheostomy set and a bronchoscope for direct visualization. A cuffed tracheostomy tube was inserted and secured with suture.

Statistical analysis

Microsoft Excel and Matlab R2022a were used for statistical analysis. Wilcoxon rank-sum test was used to compare continuous variables. The Wilcoxon rank-sum test was selected because it

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is appropriate for comparing two continuous variables and does not require the assumption of a normal distribution. This is in contrast to the student's *t*-test which does require assumption of a normal distribution. Fisher's exact test was used to compare categorical variables. Fisher's exact test was selected because it is valid for binary data with small sample sizes and is more accurate than the χ^2 test for all sample sizes. Fisher's exact test can be computationally inefficient for large samples, however, this was not an issue for our study with small sample sizes.[26] The *p*-value less than or equal to 0.05 was considered statistically significant.

RESULTS

Eighty patients underwent decompressive craniectomy for severe TBI during the defined time period and met the inclusion criteria for the study. 85% of the decompressive craniectomies were performed within the first 24 hours after presentation. The other 15% were performed following a clinical decline or radiographic progression of hemorrhage and/or edema. The demographics of the study sample are summarized in **TABLE 1**. The demographics for patients who underwent tracheostomy and extubation are listed separately with the *p*-value comparing these two groups. There were no statistically significant differences in the demographics between patients who were extubated and who underwent tracheostomy. The injury mechanism and the primary lesion requiring decompression are listed. **FIGURE 1** summarizes the distribution of patients in each treatment group. Twenty-two patients (27.5%) underwent tracheostomy. A 72.7 percent of the tracheostomies were performed on post-operative day 10 or less, therefore meeting the criteria for early tracheostomy. The mean number of days to tracheostomy after craniectomy was 8.6±3.8 standard deviation (SD) with a range of 0 to 20 days. One patient who underwent tracheostomy later died of respiratory failure. Twenty-four patients (30.0%) were successfully extubated. The mean number of days to

TABLE 1. Patient demographics

Characteristics	All patients	Tracheostomies	Successful extubations	*p*-value
Total patients	80	22	24	
Tracheostomies	22 (27.5)			
Average days to tracheostomy	8.6±3.8			
Number of early tracheostomies	16 (72.7)			
Patients successfully extubated	24 (30.0)			
Average days to successful extubation	6.4±3.4			
Average age	44±18	41±14	45±21	0.7429
Male	61 (76.3)	20 (76.3)	16 (66.7)	0.0740
Median GCS on presentation	5	6	7	0.3115
Average days from presentation to decompression	0.73	0.50	1.42	0.3115
Inpatient deaths	31 (38.8)	1 (4.5)	0	0.4783
Patients discharged to hospice	4 (5.0)	0	0	
Blunt trauma	70 (87.5)	16 (72.7)	21 (87.5)	0.2757
Penetrating trauma	8 (10)	4 (18.2)	3 (12.5)	0.6943
Cerebrovascular injury	2 (2.5)	2 (9.1)	0	0.2232
Subdural hematoma	44 (55.0)	8 (36.4)	14 (58.3)	0.1547
Epidural hematoma	4 (5.0)	1 (4.5)	1 (4.2)	1.0000
Intraparenchymal hematoma	14 (17.5)	9 (40.9)	5 (20.8)	0.2022
Cerebral edema	18 (22.5)	4 (18.2)	4 (16.7)	1.0000
Bifrontal craniectomies	13 (16.3)	4 (18.2)	4 (16.7)	1.0000
Frontotemporoparietal craniectomies	67 (83.8)	18 (81.8)	20 (83.3)	1.0000
Left side craniectomies	29 (43.3)	9 (50)	8 (40.0)	0.7525
Right side craniectomies	38 (56.7)	9 (50.0)	12 (60.0)	0.7525

Data are shown as mean±standard deviation or number (%).
GCS: Glasgow Coma Scale.

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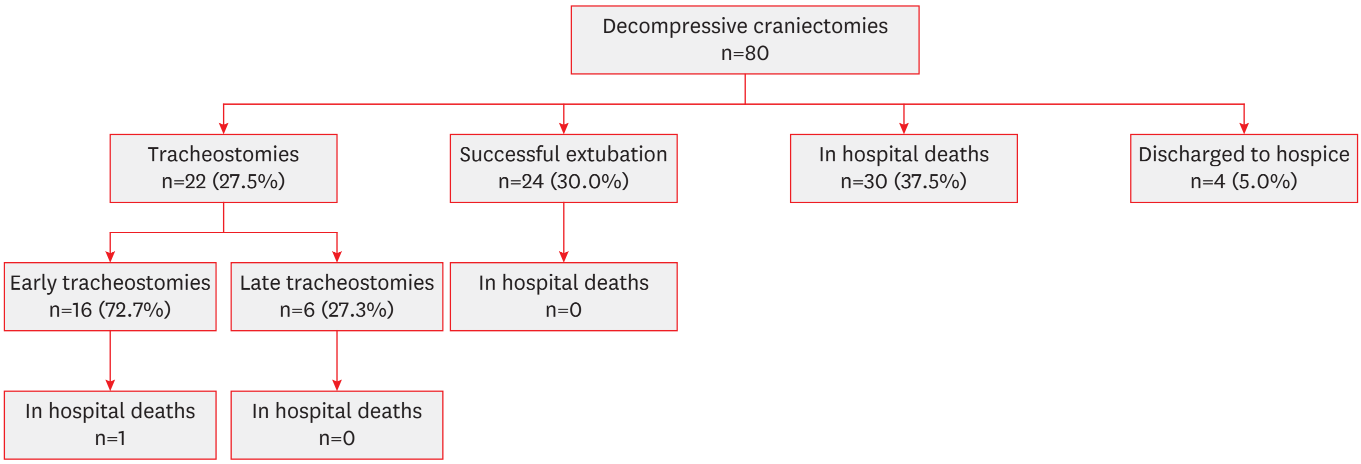

FIGURE 1. Distribution of patient treatment groups.

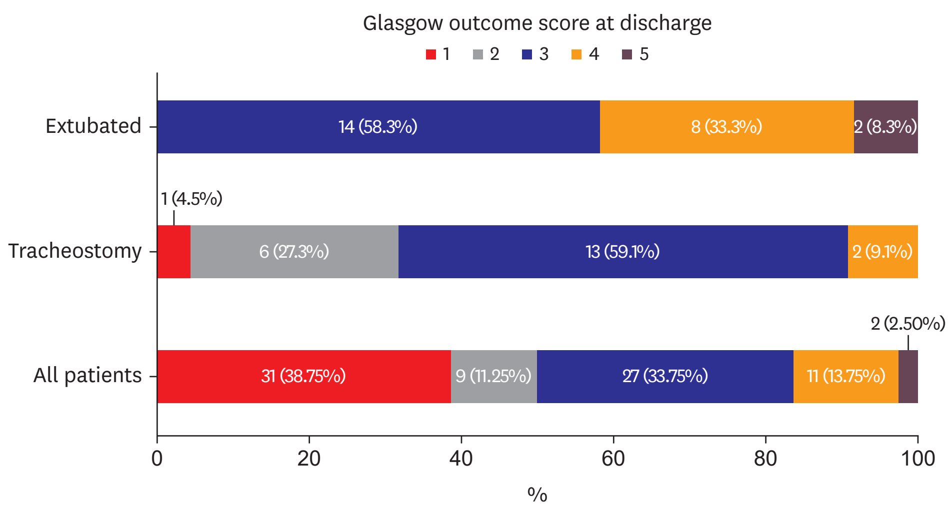

FIGURE 2. Distribution of patient outcomes by Glasgow Outcome Scale at time of discharge.

extubation was 6.3±3.4 SD with a range of 1 to 13 days. Thirty-one patients (38.8%) died while in-hospital either with endotracheal tube in place or following terminal extubation. Four patients (5.0%) were extubated and discharged to hospice care. **FIGURE 2** summarizes the distribution of patient outcomes according to the GOS at the time of discharge. Patients who underwent tracheostomy showed higher rates of poor outcomes compared to patients who were extubated (p=0.0007). However, the poorer outcomes are unlikely to be caused by undergoing the tracheostomy. Instead, the association likely reflects the fact that the poor neurologic outcome is the reason most patients required a tracheostomy, although causation cannot be proven with this retrospective study.

The 46 patients who were either successfully extubated or underwent tracheostomy were further analyzed to identify neurologic factors which predict the need for tracheostomy. The GCS motor score on post craniectomy day 5 was investigated to determine whether it would be useful for predicting which patients would require tracheostomy. All patients who had a GCS motor score of 4 or less underwent tracheostomy during the hospital admission. An 80% of patients with GCS motor score of 5 underwent tracheostomy with the rest being successfully extubated.

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Only 12.5% of patients with GCS motor score of 6 on post craniectomy day 5 underwent tracheostomy. **TABLE 2** summarizes the sensitivity, specificity, and positive predictive value (PPV) for need for tracheotomy for each GCS motor score. Using GCS of 4 for the threshold is 100% specific and has 100% PPV for need for tracheostomy but is only 50.0% sensitive. Increasing the threshold to GCS motor score of 5 results in 86.4% sensitivity, specificity of 91.7% and PPV 90.5% for undergoing tracheostomy. The receiver operator curve (ROC) for GCS motor score on post-craniectomy day 5 is shown in **FIGURE 3**. The area under the ROC (AUROC) is 0.9101. **TABLE 3** summarizes the difference in hospital and ICU LOS between groups who underwent early and late tracheostomy. The ICU LOS was statistically significantly shorter for patients who underwent early tracheostomy compared to late. The mean ICU LOS was 20±8.6 SD days for patients who underwent early tracheostomy compared to 29±8.6 SD days for patients who underwent late tracheostomy with a p-value of 0.0138. There was no statistically significant difference in the total hospital LOS between early and late tracheostomy groups p=0.5798.

TABLE 2. Sensitivity, specificity, and positive predictive value of need for tracheostomy by GCS motor score on POD 5

GCS motor score POD 5	Sensitivity	Specificity	PPV
1	0	1	-
2	0.1818	1	1
3	0.3182	1	1
4	0.5000	1	1
5	0.8636	0.9167	0.9048
6	1	0	0.4783

GCS: Glasgow Coma Scale, POD: postoperative day, PPV: positive predictive value.

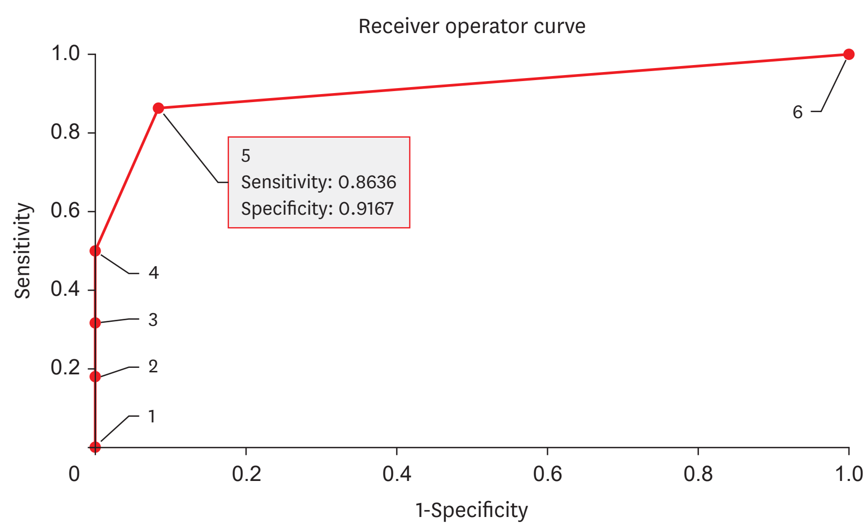

FIGURE 3. ROC for tracheostomy by Glasgow Coma Scale motor score on post-operative day 5. Area under ROC is 0.9101.
ROC: receiver operator curve.

TABLE 3. Total and ICU LOS for early and late tracheostomy groups

LOS	Early tracheostomy	Late tracheostomy	p-value
Total LOS in days	33±14.0	37±16.4	0.5798
ICU LOS in days	20±8.6	29±8.6	0.0132*

Data are shown as mean±standard deviation.
ICU: intensive care unit, LOS: length of stay.
*Indicates statistical significance.

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DISCUSSION

Predicting the need for tracheostomy in patients with neurologic injury is often challenging. There is disagreement in the literature regarding the neurologic function that is required to consider extubation. Some protocols state the patient should be awake and cooperative, while some authors have advocated for considering extubation in patients with GCS <8.[3,9,37,38] Many studies have demonstrated benefits to early tracheostomy including fewer days of mechanical ventilation, shorter ICU LOS, shorter hospital LOS, and lower incidence of pneumonia.[2,6,10,28] In patients with severe neurologic injury, poor neurologic function is commonly the primary indication for ongoing mechanical ventilation and eventually tracheostomy.[3,38] It is helpful to have objective criteria to aid the decision-making process for selecting which patients should receive a tracheostomy. The currently existing screening tools for predicting the need for tracheostomy in patients with neurologic injury include the SET score and TRACH score. However, these scoring systems were developed for patients with ischemic stroke and spontaneous intracranial hemorrhage. Many of the components of those systems are not applicable to TBI patients which limits their utility in this population. The aim of this project was to develop a predictive tool that is simple, easy to implement, and accurate for selecting which patients are likely to require a tracheostomy and which patients are likely to be candidates for extubation following decompressive craniectomy for severe TBI based on the neurologic exam. The purpose of the predictive tool is to assist clinical decision making as well as guide discussions with the patient's family or medical decision makers to facilitate early tracheostomy when appropriate. Similar to the SET score and TRACH score, this screening tool is not intended to be a comprehensive ventilator weaning algorithm or extubation protocol.

Our screening tool is based on the GCS motor score on POD 5. The GCS score was selected for our screening tool because it a standardized neurologic assessment with high interobserver repeatability that can be used to evaluate patients with all degrees of neurologic deficit. It can be easily evaluated in patients with severe TBI who are intubated and mechanically ventilated. A meta-analysis showed that GCS score prior to extubation was the strongest predictor of successful extubation compared to many other factors including comorbid disease, vital signs, and respiratory function.[38] We focused on the motor portion of the GCS score because as a single parameter it contains all the pertinent information about neurologic status that the total GCS score is able to assess. The GCS motor score is able to assess neurologic function ranging from high level cortical function such as language and motor control to brainstem dysfunction. Several studies have advocated for the use of using the motor score alone for neurologic assessment and prognostication in TBI patients.[15,24,30,34] Additionally, in the specific patient population for this study, all have endotracheal tubes at the time of evaluation. Therefore, the verbal score is 1T for all patients. Also, the eye-opening portion of the GCS score is unreliable in these patients. Many of the patients are sedated for a variety of reasons including but not limited to agitation, ICP control, facilitating mechanical ventilation, and pain control. Adequately assessing eye opening would require pausing sedation for a long enough period to time to assess for spontaneous eye opening. This is not always possible and could be highly variable among examiners depending on how long the sedation was paused prior to examination. Additionally, these patients who are status post decompressive craniectomy for severe TBI frequently have periorbital swelling secondary to facial injuries or post-operative swelling which limits the ability to assess eye opening.

The previously mentioned SET score and TRACH score evaluations were designed to be completed within the first 24–48 hours after admission. Post operative day 5 was selected

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as the time for neurologic assessment for our screening method for several reasons. Early predictive tools such as the SET score and TRACH score include several neurologic and radiographic parameters which must be scored. The radiographic parameters are important for these early prognostication tools to estimate the severity of neurologic insult and help prognosticate neurologic improvement and therefore need for tracheostomy. By focusing our screening tool on the GCS motor exam and delaying the evaluation until POD 5, we obviate the need to predict neurologic recovery based on radiographic data. We expect that evaluating the patient's actual neurologic function at a delayed time point when the patient's neurologic exam is expected to be stable or improving will be more accurate than predicting based on radiographic data. There are several reasons why delaying the neurologic evaluation is advantageous. It provides ample time for resuscitation and stabilization of additional injuries in polytrauma patients. By delaying the evaluation, it allows for assessment of neurologic improvement following the decompressive surgery. Importantly, by performing the evaluation on POD 5 most patients will have already experienced peak cerebral edema.[32,39,40] Hematoma expansion is also known to occur in the first several days following severe TBI. By POD5, most ICH will have stabilized in size.[7,12,27] Although delayed edema, hematoma expansion, or other complications can arise; most patients should have stable or improving neurologic status by POD 5. Importantly, POD 5 is early enough to allow for planning early tracheostomy by POD 10. Additionally, one of the primary intended uses for this tool is to aid discussions with patients' family and/or medical decision makers. Using a simple tool such as GCS motor score, which is easily understood by laypersons, facilitates understanding the degree of neurologic injury and therefore discussions regarding further goals of care. Also, few families are prepared to discuss the need for tracheostomy within 48 hours of admission. Delaying the application of the selection tool to POD 5 compared to within 24–48 hours admission is beneficial for family members to gain understanding of the nature of the patient's condition, observe the trajectory of neurologic improvement, begin to emotionally process the severity of the injury, and consider the patient's wishes for this type of care. Understanding the need for tracheostomy during these discussions with family is critical as it is commonly a major factor in the decision to continue with aggressive care, transition to comfort measures, or consider organ donation.[23,33]

The results of this study demonstrate that the GCS motor score on POD 5 is predictive of the need for tracheostomy with high sensitivity and specificity. The AUROC of GCS motor score on POD 5 is 0.9101, which indicates that it is a good test for determining the need for tracheostomy. The threshold for screening for the need for tracheostomy was determined by reviewing the ROC. The goal was to select the optimum point to balance sensitivity and specificity. We do not want to miss opportunities to perform early tracheostomy, but we also do not want to perform unnecessary tracheostomies. A 100% of the patients in this study with GCS motor score of 4 or less underwent a tracheostomy. However, using motor score of 4 or less as the criteria for recommending tracheostomy would only result in 50% sensitivity. Using GCS motor score of 5 or less for recommending tracheostomy results in 86.7% sensitivity, 91.7% specificity, and 90.5% PPV. This provides the best balance of sensitivity and specificity as shown in **TABLE 2** and **FIGURE 3**. These results meet or exceed the predictive capability of existing scoring systems for the need for tracheostomy in patients with spontaneous ICH and cerebrovascular events. The TRACH score has an AUROC=0.92, sensitivity of 94%, and PPV of 83% for patients with spontaneous intracerebral hemorrhage (ICH).[35] The SET score predicts the need for tracheostomy in patients with severe stroke, spontaneous ICH, and subarachnoid hemorrhage with a sensitivity of 65.4%, specificity of 73.5%, and AUROC=0.741.[2,31]

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Performing the tracheostomy in the early postoperative time period was associated with decreased ICU LOS by an average of 9 days in our study. However, there was no statistically significant difference in total LOS. This study was not sufficiently powered to evaluate differences in adverse events such as VAP between the early and late tracheostomy groups.

A reasonable way to implement the results of the study in clinical practice could be to evaluate the GCS motor score on POD 5. A patient with GCS motor score of 4 or less should be recommended for early tracheostomy on POD 10 or earlier. The patient should then be evaluated by the surgeon who performs tracheostomies to determine whether the patient is an appropriate surgical candidate for tracheostomy. Patients with GCS motor scores of 5 should also be evaluated for early tracheostomy. However, these patients should continue to be evaluated daily for signs of neurologic improvement which would obviate the need for tracheostomy while waiting for the tracheostomy to be performed. Patients with GCS motor score of 6 have a high probability of successful extubation and should continue to be evaluated using standard ventilator weaning and extubation protocols. Any patient specific factors such as additional traumatic injuries, medical or surgical comorbidities, or other post-op operative complications should be considered, and the recommended airway management strategy adjusted accordingly.

The limitations of this study include the retrospective nature and the relatively small sample size of patients from a single institution. Additionally, the severe TBI patient population is heterogenous due to the variety of types of traumatic hemorrhage, diffuse brain injuries, and the possibility of additional organ system injuries which may result in respiratory failure or airway compromise such as face/neck injuries, burns (especially to the face or airway), or pulmonary injuries. This study included polytrauma patients in the analysis. TBI patients are also at risk for complications such as infection, venous thromboembolism, or delayed neurologic decline which may impact the ability to extubate the patient. Patients with significant injuries or complications involving the chest or airway, such as the ones listed, will likely need individualized plans for airway management which cannot be easily accounted for in a screening tool which is meant for broad application in all TBI patients. Additionally, institutional and/or individual physician practices regarding approaches to selecting patients for decompressive craniectomy and weaning ventilator support versus pursuing early tracheostomy in TBI patients may significantly affect the generalizability of these results. This study set out to test the hypothesis that the GCS motor score would be useful for screening for the need for tracheostomy, which the results confirmed. Therefore, the validity of this study may be impacted by confirmation bias. We attempted to mitigate the susceptibility to confirmation bias by using standard statistical techniques used for evaluating screening tests such as ROC analysis. A reasonable next step would be to test the validity of the screening method and generalizability of the results using patient populations from multiple additional centers.

CONCLUSION

The GCS motor score on post-operative day 5 is a useful screening tool for selecting which patients may benefit from early tracheostomy and which patients are likely to be candidates for extubation in patients with severe TBI following decompressive craniectomy. Undergoing early tracheostomy 10 days or less from time of decompression was associated with shorter ICU LOS. Shortening the ICU LOS reduces healthcare costs and resource utilization and may reduce the risk of some adverse events. The simplicity of this tool makes it easily applicable to clinical practice. The GCS motor score is able to predict tracheostomy versus extubation with high accuracy due to the fact that it evaluates multiple aspects of neurologic function in a single parameter. Waiting until POD 5 has several advantages compared to earlier prognostication, especially obviating the need for scoring of complex radiographic data. This scoring system can be easily implemented by clinicians and used for discussions with patients' family members to aid making care decisions such as proceeding with tracheostomy versus considering comfort measures or organ donation.

SUPPLEMENTARY MATERIALS

SUPPLEMENTARY TABLE 1

Glasgow Coma Scale adapted from Teasdale and Jennett.[36)]

Click here to view

SUPPLEMENTARY TABLE 2

Glasgow Outcome Scale adapted from Jennett and Bond.[18)]

Click here to view

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