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Predictors of dysphagia in critically injured patients with neck trauma

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ABSTRACT

Purpose: Trauma patients admitted to the intensive care unit (ICU) are at heightened risk for oropharyngeal dysphagia and pulmonary aspiration. Timely and appropriate referrals for dysphagia may reduce mortality rates and hospital readmissions. This study sought to identify predictors of dysphagia in a large cohort of patients with multiple traumatic injuries.

Methods: The Trauma Registry Database was queried for admissions at a level 1 trauma center from 2012 to 2016 who underwent instrumental swallowing evaluations. Relevant demographics, injuries, and interventions known to be associated with dysphagia were collected. The Dysphagia Outcome and Severity Scale (DOSS) was utilized to define severity of dysphagia. Regression analyses were performed to identify predictors of dysphagia.

Results: Two hundred and sixty two patients met criteria. Multivariate analyses found injury severity ($p < 0.01$), tracheostomy ($p < 0.05$), TBI ($p < 0.05$), and cervical spinal bracing ($p < 0.001$) to be predictors of dysphagia development. Furthermore, length of ICU stay ($p < 0.01$) and cervical spinal bracing ($p < 0.01$) were associated with a greater severity of dysphagia.

Conclusions: Oropharyngeal dysphagia is a common complication in trauma patients. Our results propose a set of predictors that should be considered when identifying critically injured patients at risk for dysphagia.

1. Background

Oropharyngeal dysphagia is a well-established complication in trauma patients admitted to the intensive care unit (ICU) [1]. These patients are at heightened risk for pulmonary aspiration, which is a leading cause of pneumonia [2], and can prolong hospitalization, increase mortality rates, and result in readmission [3,4]. Identifying predictors of dysphagia facilitates appropriate and timely swallowing evaluations, ultimately improving patient outcomes in this medically fragile population.

Patients often present with multiple traumatic injuries that pose significant risk of dysphagia during their acute hospitalization. Common injuries and interventions, such as traumatic brain injury [5], endotracheal intubation [6,7], spinal cord injury [8], and anterior cervical discectomy and fusion (ACDF) [9] are known risk factors that can result in both transient and chronic dysphagia. There is a high prevalence of dysphagia in patients with cervical spine trauma; however, it is unclear whether the presence of cervical spine trauma in addition to other traumatic injuries leads to an increased risk for dysphagia [10]. Given the inherent heterogeneous nature of this patient population, it is important to consider the impact of multiple injuries and interventions when determining predictors of dysphagia to guide management and treatment.

Dysphagia exists across a continuum of severity, with many clinical manifestations. Specific physiologic swallowing impairments, such as aspiration and pharyngeal residue, have been shown to be predictive of enteral feeding dependency in acute stroke patients [11]. Investigations to date have not considered severity of dysphagia when evaluating predictors of dysphagia in polytrauma patients [12]. Studies in which outcomes were limited to a bedside evaluation or the presence of a feeding tube fail to account for physiologic parameters of the swallowing mechanism that can only be evaluated by direct imaging.

The aim of the current study was to determine predictors of dysphagia in critically-injured patients with traumatic neck injuries. We

Abbreviations: TBI, traumatic brain injury; DOSS, Dysphagia Outcome and Severity Scale; VFSS, videofluoroscopic swallow study; SLIC, Subaxial Cervical Spine Injury Classification System; FISS, Facial Injury Severity Scale; PAS, penetration-aspiration scale.

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hypothesized that injuries related to the patient's overall medical acuity would be significant predictors of dysphagia development and severity, including overall injury severity, spinal cord injury, tracheostomy, and length of ICU admission.

2. Methods

2.1. Study population

The Trauma Registry Database at a level 1 trauma center was utilized after approval from the Institutional Review Board. The database was queried for patients sustaining trauma from January 2012 to December 2016 with the following characteristics: 18 years of age and older, blunt or penetrating trauma, and an Abbreviated Injury Scale (AIS) score between 2 and 6. Specific injuries that were included using ICD-9 codes included blunt and penetrating neck trauma, cervical spine fractures, esophageal injuries, laryngotracheal injuries, first and second rib fractures, and blunt cerebrovascular injury. The Trauma Registry Database includes all injured patients whose injury is severe enough to result in trauma activation, hospital admission, or death. Individual medical records were examined to determine if the patient met inclusion and exclusion criteria. To meet inclusionary criteria, patients were required to have had an instrumental swallowing evaluation, specifically a videofluoroscopic swallow study (VFSS), performed during their acute hospital admission. Patients with a history of prior trauma, oropharyngeal or esophageal dysphagia, prior stroke or neurodegenerative disorder, and history of head and neck cancer, chemoradiation, or laryngeal surgery were excluded.

2.2. Variables

Demographic data, including age, gender, length of time between date of injury and instrumental swallowing evaluation, cause of trauma, type of trauma (blunt or penetrating), and injury severity scale (ISS) were extracted from the Trauma Registry Database at our institution. The following variables were abstracted from individual medical records: Glasgow coma score (GCS), traumatic brain injury (TBI), stroke secondary to trauma, length and number of intubations, mechanical ventilation, tracheostomy, and type of cervical spinal bracing, as well as facial and cervical spinal injuries as outlined below. Types of spinal bracing included cervical collar, cervical-thoracic orthosis (CTO), cervical-thoracic-lumbar-sacral orthosis (CTLSO), thoracic-lumbar-sacral orthosis (TLSO), and halo fixation.

Cervical spine injuries were separated into two variables depending on the location of injury. The Subaxial Cervical Spine Injury Classification System (SLIC) was used to quantify severity of subaxial cervical neck injury; specifically, the morphology, integrity of the disco-ligamentous complex, and neurologic status of the spinal cord injury in injuries affecting C3 to C6 [13]. The SLIC has been shown to be a reliable and valid scale used to comprehensively quantify the severity of subaxial cervical trauma [14]. SLIC scores were derived from relevant medical imaging by a fellowship-trained neuroradiologist with over 9 years of experience in the interpretation of spinal imaging. Since the SLIC only quantifies subaxial trauma (C3–C6), a separate binary variable was created for patients with C1 and C2 spinal fractures or ligamentous injuries.

The Facial Injury Severity Scale (FISS) was used to quantify the severity of facial trauma and was extracted separately from craniomaxillofacial imaging in the medical chart by two authors [15]. The FISS is a severity scale that divides craniomaxillofacial trauma into three quadrants, the mandible, mid-face, and upper face, and assigns a weighted score for each fracture to these structures. The FISS is highly correlated with severity of injury, need for surgical intervention, and hospital length of stay.

Penetration-aspiration scale (PAS) scores [16], subjective binary ratings of swallowing biomechanics, diet recommendations, level of supervision, and clinical impression were documented after each VFSS. In order to quantify dysphagia severity, the Dysphagia Outcome and Severity Scale (DOSS) was used [17]. The DOSS is a 7-point ordinal scale that rates the functional severity of dysphagia, and takes into account both physiologic characteristics, including oral stage transfer, pharyngeal retention, and extent of airway invasion, as well as clinical outcomes including level of independence, nutrition, and diet modifications [17]. A lower DOSS score corresponds to greater severity of dysphagia. DOSS scores were derived from instrumental swallowing evaluations by the first author and a separate, blinded rater.

2.3. Statistical analysis

Data analysis was performed using SAS statistical analysis software (version 9.2, SAS Institute Inc., Cary, NC). In order to assess reliability of DOSS and FISS scores, kappa and intraclass correlation coefficient measures were calculated, respectively. To first analyze predictors of dysphagia, a binary variable of dysphagia was derived from DOSS. Specifically, a DOSS score of 1–5 was defined as dysphagia, whereas a DOSS of 6 and 7 was defined as normal [17]. A univariate logistic regression was performed in order to calculate odds ratios (ORs) and to identify variables for inclusion in multivariate regression model. In a separate analysis, the dependent variable (DOSS) was treated as an ordinal scale to examine variables associated with severe dysphagia. Similar to the prior analysis, a univariate logistic regression was performed to identify variables of interest to include in the multivariate regression model. The relationships between independent variables that were eligible to be included in the multivariable model were evaluated by calculating Pearson correlation coefficients. Variables with all bivariate correlations <0.5 were entered into the multivariate model. Length of time between date of injury and VFSS was included in multivariate regression analyses to control for differences in timing of evaluation between patients. Lower levels of the DOSS scale were modeled so that a positive maximum likelihood estimate indicated that an increase in the independent variable was associated with lower levels of the DOSS. C-indexes were used to explore the potential predictive value of univariate and multivariate analyses to predict dysphagia development and severity. A p value < 0.05 was considered statistically significant.

3. Results

3.1. Patient characteristics

Two hundred and sixty-two patients met criteria and were included in the study group. Patients were predominantly young (58% under 65) and male (68%), with an average GCS of 12 ($SD = 4.19$) and ISS of 24 ($SD = 12.28$). Common mechanisms of injury included motor vehicle accidents (61.1%) and falls (33.2%), while penetrating trauma occurred in a small subset of patients (3.4%). The most frequent injuries included cervical spine injury (50.7%), TBI (38.9%), facial fractures (20.2%) and SCI (9.5%). Stroke secondary to trauma was a rare complication (1.5%). Interventions included mechanical ventilation (75.5%), tracheostomy (22.5%) and ACDF (6.8%). The majority of patients were evaluated with a type of cervical orthosis in place (51.8%). Patients required nearly five days of mechanical ventilation on average (115.54 h) and spent an average of six and a half days in the ICU. The average length of time between injury date and VFSS was approximately 11 days. Dysphagia was identified in 86% of patients. Of the 172 patients who aspirated, 43% did not demonstrate a reflexive, overt cough in response to airway invasion.

Nine patients with penetrating neck trauma involving a range of severity and depth of injury are described (Table 1). Six patients developed dysphagia, three of which required enteral tube feeding due to the severity of dysphagia. Common complications included vocal fold paralysis, supraglottic edema, cranial nerve injury, and paralysis due to spinal cord injury. Physiologic impairments included prolonged

Table 1
Description of penetrating neck trauma.

Age	Nature of injury	Swallowing history	DOSS
24	Stabbing with laceration of right neck. Patient underwent neck and carotid artery exploration and closure.	Functional swallow.	6
35	Stabbing with laceration of left neck and subsequent tracheal injury with penetration through thyroid cartilage, facial vein injury, and sternocleidomastoid transection. Patient underwent neck exploration and closure.	Sensate aspiration of honey-thick liquid, with significant supraglottic edema, absent hyolaryngeal elevation, limited UES opening. Resolved 15 days after admission.	1
40	Stabbing with laceration of right posterior neck with exposed thyroid cartilage. Patient underwent exploration and transection of right sternocleidomastoid and strapezius muscles. Course complicated by hypomobile right vocal fold, requiring injection.	Sensate aspiration of thin liquid. Placed on a soft diet with nectar-thick liquids. Resolved 42 days after admission.	4
27	Self-inflicted left neck laceration, as well as self-reported consumption of anti-freeze. Patient underwent neck exploration with closure.	Functional swallow.	6
32	Self-inflicted neck laceration through anterior pharyngeal wall with complete transection of epiglottis, laceration of posterior pharyngeal wall, and anterior esophagus. Patient underwent neck exploration, closure of posterior pharyngeal wall laceration and right pyriform sinus mucosa, reapproximation of base and distal portion of epiglottis, as well as anterior neck laceration repair with reapproximation of multiple muscle and fascial layers.	Sensate aspiration of all consistencies. Persistent sensate aspiration of thin liquids 29 days later. Resolved 50 days after admission.	1
50	Self-inflicted bilateral neck laceration. Patient underwent bilateral exploration and repair of left internal jugular vein. Course complicated by vocal fold paralysis.	Functional swallow.	6
21	Sustained gunshot wound to right anterior neck, with subsequent subclavian artery injury and clavicle, scapula, humeral head, and rib fractures.	Silent aspiration of nectar-thick liquids. Resolved 14 days after admission.	3
23	Sustained gunshot wound to left lower neck with associated fractures of C6 vertebral body, bilateral lamina, spinous process, right articular facets, and right pedicle at this level, as well as subsequent paralysis due to spinal cord injury.	Silent aspiration of nectar-thick liquids. Resolved 28 days after admission.	2
52	Sustained two gunshot wounds to chin and anterior neck, as well as C4 burst fracture, mandible parasymphyseal and left body fracture, and extensive soft tissue injury to tongue and submandibular muscles.	Silent aspiration of thin and nectar-thick liquids. Discharged and lost to follow-up.	1

pharyngeal transit time, decreased hyolaryngeal displacement and upper esophageal sphincter opening, pharyngeal residue, and silent aspiration. Dysphagia was documented as fully resolved between fourteen and fifty days after admission. Physiological characteristics of the swallowing mechanism in neck injuries, and in the total patient population are shown in Fig. 1 and Table 2, respectively.

3.2. Predictors of dysphagia development

DOSS ($\kappa = 0.82$) and FISS (ICC = 0.89) measures were found to have high inter-rater reliability. An initial univariate analysis found ISS ($p < 0.01$, OR = 1.05), SLIC ($p = 0.04$, OR = 0.86), TBI ($p < 0.01$, OR = 3.69), tracheostomy ($p = 0.03$, OR = 3.62), and cervical spinal bracing

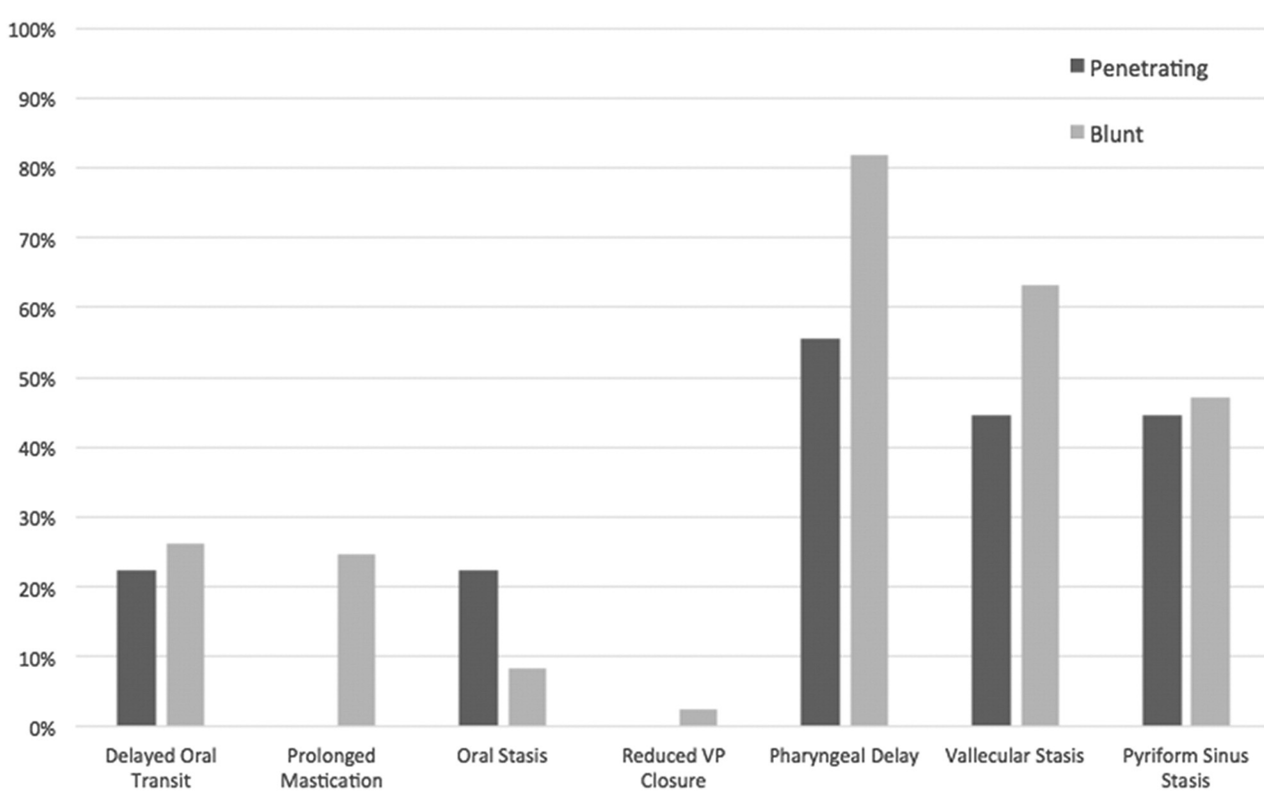

Fig. 1. Percentage of physiologic characteristics of dysphagia in blunt and penetrating neck injuries. *VP = velopharyngeal*

Table 2
Patient demographics.

	Total population	Dysphagia	WFL
	n = 262	n = 226	n = 36
Gender			
Male	179 (68.3%)	154 (68.1%)	25 (69.4%)
Female	83 (31.7%)	72 (31.9%)	11 (30.6%)
Age			
Young (<65)	152 (58.0%)	130 (57.5%)	22 (61.1%)
Old (≥65)	110 (42.0%)	96 (42.5%)	14 (38.9%)
Time (days)	M = 11.2	M = 10.7	M = 14.3
Intubation length (hours)	M = 81.5	M = 84.3	M = 64.2
ISS	M = 23.9	M = 24.8	M = 18.8
GCS	M = 12.2	M = 12.0	M = 13.2
Biomechanics			
Delayed oral transit	68 (25.9%)	66 (29%)	2 (5.5%)
Prolonged mastication	62 (23.6%)	59 (26.1%)	3 (8.3%)
Oral stasis	23 (8.7%)	22 (9.7%)	1 (2.7%)
Reduced VP closure	6 (2.2%)	6 (2.6%)	0 (0%)
Pharyngeal delay	212 (80.9%)	192 (84.9%)	20 (55.5%)
Vallecular stasis	164 (62.6%)	147 (65.0%)	17 (47.2%)
Pyriform sinus stasis	123 (46.9%)	115 (50.8%)	8 (22.2%)
DOSS			
1 (Severe - NPO)	53 (20.2%)		
2 (Moderate-to-severe)	21 (8.0%)		
3 (Moderate)	21 (8.0%)		
4 (Mild-to-moderate)	76 (29.0%)		
5 (Mild)	55 (20.9%)		
6 (WFL with strategies)	28 (10.6%)		
7 (WFL)	8 (3.0%)		
Spinal bracing			
Cervical collar	113 (43.1%)	104 (46.0%)	9 (25.0%)
CTO	8 (3.0%)	7 (3.0%)	1 (2.7%)
CTLSO	15 (5.7%)	14 (6.1%)	1 (2.7%)
TLSO/halo	5 (1.9%)	4 (1.7%)	1 (2.7%)
None	121 (46.1%)	97 (42.9%)	24 (66.6%)

VP = velopharyngeal, DOSS = dysphagia outcome and severity scale, NPO = nil per os, WFL = within functional limits, CTO = cervical-thoracic orthosis.
CTLSO = cervical-thoracic-lumbar-sacral orthosis, TLSO = thoracic-lumbar-sacral orthosis.

($p < 0.01$, OR = 2.66) to be significant predictors of dysphagia development (Table 3). When accounting for multiple factors in the multivariate logistic regression model, all variables remained significant (Table 4). Specifically, a one-point increase in injury severity score was associated with an additional 5% increased risk of the development of dysphagia. Patients with TBI were three times more likely to develop dysphagia than patients without TBI, and patients with a tracheostomy were eight times more likely than those without a tracheostomy to develop dysphagia. Additionally, patients with higher SLIC scores indicative of C3-C6 trauma were 20% less likely to develop dysphagia, whereas patients with cervical spinal bracing were at more than four times greater risk. Univariate c-indexes ranged from 0.41–0.65. C-index for the multivariate model was 0.79, indicating a strong model to predict dysphagia development.

3.3. Predictors of dysphagia severity

An initial univariate analysis found length of ICU stay ($p = 0.01$, OR = 1.03), tracheostomy ($p = 0.03$, OR = 1.76), and cervical spinal bracing ($p < 0.01$, OR = 1.90) to be significantly associated with severe dysphagia (Table 3). In the multivariate model, length of ICU admission ($p < 0.01$, OR = 1.05) and cervical spinal bracing ($p < 0.01$, OR = 2.09) remained associated with greater severity of dysphagia. Patients requiring cervical spinal bracing were more than twice as likely to develop severe dysphagia, and each day spent in the ICU was associated with a 5% increased risk of severe dysphagia (Table 4). Univariate c-indexes ranged from 0.41–0.62. C-index for the multivariate model was 0.62, indicating a fair model to predict dysphagia severity.

4. Discussion

The aim of this study was to identify predictors of oropharyngeal dysphagia in a large cohort of critically-injured patients with traumatic neck injuries. Results suggest that overall injury severity, TBI, tracheostomy, and cervical spinal bracing are significant predictors of dysphagia development in the acute care setting and should be considered when determining appropriateness for referral to speech pathologists specializing in the evaluation and treatment of oropharyngeal dysphagia. Silent aspiration was documented in nearly a third of patients, emphasizing the importance of direct visualization with an instrumental swallowing evaluation when assessing patients with multiple traumatic injuries.

Table 3
Results of univariate regression analysis.

	Dysphagia development		CI	C-index	Dysphagia severity		CI	C-index
	p-Value	OR			*p*-Value	OR		
ISS	0.0073**	1.05	1.01–1.08	0.65	0.0971	1.01	1.00–1.09	0.55
SCI	0.3435	0.60	0.21–1.72	0.53	0.8414	1.07	0.50–2.23	0.50
SLIC	0.0409*	0.86	0.74–0.99	0.53	0.8810	1.00	0.90–1.12	0.51
C1-C2 trauma	0.6073	1.27	0.50–3.25	0.52	0.1595	0.67	0.39–1.16	0.53
Age	0.0623	1.01	0.99–1.03	0.58	0.2069	1.00	0.99–1.01	0.53
Gender	0.8760	0.94	0.43–2.00	0.51	0.5171	1.16	0.73–1.84	0.51
Trauma type	0.4584	0.54	0.10–2.72	0.51	0.4504	1.57	0.48–5.14	0.51
Length of ICU	0.2266	1.03	0.97–1.09	0.62	0.0174*	1.03	1.00–1.06	0.57
TBI	0.0052**	3.69	1.47–9.21	0.63	0.1783	1.35	2.10–2.11	0.53
GCS	0.1170	0.92	0.82–1.00	0.59	0.2961	0.97	0.92–1.02	0.52
Spinal surgery	0.2160	0.57	0.24–1.37	0.54	0.3132	0.73	0.40–1.33	0.52
FISS	0.5069	1.04	0.91–1.20	0.52	0.5183	0.97	0.91–1.00	0.52
Intubation length	0.2828	1.00	0.99–1.00	0.58	0.0789	1.00	1.00–1.01	0.58
One intubation	0.1804	1.76	0.76–4.00	0.59	0.1885	1.41	0.84–2.38	0.58
Two intubations	0.9950	1.00	0.33–2.99	0.59	0.2711	1.50	0.72–3.13	0.58
Three intubations	0.4325	0.55	0.12–2.42	0.59	0.7795	0.85	0.27–2.64	0.58
Mechanical vent	0.3584	1.43	0.66–3.11	0.54	0.1952	1.39	0.84–2.29	0.54
Tracheostomy	0.0386*	3.62	1.07–12.0	0.58	0.0310*	1.76	1.05–2.97	0.58
Spinal bracing	0.0097**	2.66	1.26–5.58	0.62	0.0037**	1.90	1.23–2.95	0.62
Stroke	0.5193	0.47	0.04–4.65	0.51	0.4699	0.52	0.09–3.02	0.51
Time	0.1759	0.98	0.99–1.00	0.41	0.2657	0.99	0.97–1.00	0.41

OR = odds ratio, CI = confidence interval, ISS = injury severity scale, SCI = spinal cord injury, SLIC = subaxial cervical spinal injury classification system, ICU = intensive care unit, TBI = traumatic brain injury, GCS - glasgow coma score, FISS = facial injury and severity scale.
* $p < 0.05$.
** $p < 0.01$

Table 4
Results of multivariate regression analysis.

	Dysphagia development		p-Value	Dysphagia severity		p-Value
	OR	95% CI		OR	95% CI	
ISS	1.05	1.01–1.10	0.0087**			
SLIC	0.80	0.68–0.94	0.0086**			
TBI	3.11	1.13–8.57	0.0277*			
Tracheostomy	8.12	1.62–40.63	0.0107*	1.73	0.95–3.17	0.0726
Spinal bracing	4.66	1.97–11.01	0.0004***	2.09	1.33–3.28	0.0012**
Time	0.94	0.9–0.99	0.0275*	0.97	0.95–0.99	0.0331*
Length in ICU				1.05	1.01–1.08	0.0050**

OR = odds ratio, CI = confidence interval, ISS = injury severity scale, SLIC = subaxial cervical spinal injury classification system, TBI = traumatic brain injury, ICU = intensive care unit.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Dysphagia in patients with TBI is multifactorial secondary to both cognitive and biomechanical impairments [5]. Impaired sensorium hinders the patient's ability to fully participate in an evaluation and places them at higher risk for aspiration [18]. Patients often demonstrate poor lingual control, prolonged oral and pharyngeal transit, and pharyngeal residue, as well as a high incidence of silent aspiration [5]. In our cohort, patients with TBI were three times more likely to develop dysphagia than patients without neurologic damage secondary to trauma.

Though research has demonstrated no causal relationship between tracheostomy and aspiration, patients are at risk for dysphagia as a result of their medical acuity, often requiring sedatives, neuromuscular blocking agents, high oxygen requirements, and prolonged hospitalization resulting in limited mobility and deconditioning [19,20]. In our sample population, patients with a tracheostomy were greater than seven times more likely to develop dysphagia; therefore, it is important to consider these patients for swallowing evaluation. However, the presence of a tracheostomy tube was not associated with severe dysphagia, which suggests that these patients may be appropriate candidates for safe oral intake with a modified diet as determined by a speech pathologist specializing in dysphagia management. Though the prevalence of dysphagia has been well documented in post-extubation patients [21,22], our results did not show a relationship between intubation and dysphagia. This is likely due to the heterogenous injury patterns in our patient population and the large percentage of patients that developed dysphagia as a result of other polytraumatic injuries.

Previous research has suggested an increased prevalence of dysphagia in cervical spine trauma patients without concomitant spinal cord injury [10]. Interestingly, patients with a greater severity of cervical spine trauma involving C3 – C6 were 20% less likely to develop dysphagia in our population, whereas when all patients with cervical spinal bracing were included, they were more than four times as likely to have dysphagia. Thus, it is possible that an underlying factor behind the relationship between cervical spine injuries and dysphagia is cervical spinal bracing and its effects on the swallowing mechanism. Limited research exists examining the effects of cervical spinal bracing on the biomechanics of the swallowing mechanism and patient outcomes. Pharyngeal changes in healthy participants wearing a cervical orthosis have been documented, including prolonged hyoid movement and upper esophageal sphincter opening, which may be the result of reduced activation of the suprahyoid musculature [23]. Compensatory behaviors have also been documented in healthy adults during mastication, specifically increased cervical segmental motion as a result of restricted mandibular opening [24]. Bhattacharya and colleagues [25] examined swallowing outcomes in twenty-two patients with and without a cervical collar in place and found that swallowing outcomes did not differ between conditions. However, direct imaging with an instrumental swallowing evaluation was performed in only a small subset of patients in this study. Future research should seek to examine biomechanical effects of cervical spinal bracing, such as hyoid movement and pharyngeal residue, as well as clinically relevant outcomes in a randomized and controlled manner.

Our results align with prior research demonstrating that dysphagia is associated with the number of comorbid conditions and prolonged ICU length of stay [12]. However, the present study demonstrated that similar factors, such as length of ICU admission and injury severity, are associated with both dysphagia development and a greater severity of dysphagia, which previous investigations have not examined [12].

Patients with penetrating neck injuries are a unique population at risk for dysphagia. However, research has yet to examine the impact of penetrating injuries on swallowing beyond case studies [26-28]. Although penetrating neck injuries in our sample involved a variety of etiologies and structures affected, it appears that both depth and location of injury are related to severity of dysphagia (Table 1). Patients with injuries requiring extensive intervention to structures directly implicated in swallowing, including lingual, submandibular, pharyngeal, and laryngeal structures, appeared to develop more severe dysphagia. Fortunately, our data support that dysphagia in this population is transient with proper management.

This study has several limitations that warrant discussion. Most importantly, the retrospective nature of this investigation limited our ability to control certain variables such as timing of evaluation and standardization of the type and volume of food and liquid presented to the patient. Patients with neurologic changes secondary to spinal cord injury, ACDF, and penetrating neck trauma were underrepresented in our sample population. Thus, despite literature suggesting that these patients are at significant risk [8,9,29,30], our model failed to demonstrate this association possibly due to insufficient subgroup sample size.

In conclusion, our results propose a set of predictors for both the development of dysphagia and severity of dysphagia in a cohort of critically injured patients with multiple traumatic injuries. Management of these patients require an understanding of the numerous risk factors and subsequent sequelae. Specifically, appropriate identification of patients at high risk for dysphagia is crucial to provide appropriate and timely evaluation and treatment to prevent pulmonary complications associated with dysphagia and improve patient outcomes.

Conflict of interest

None of the authors have any conflicts of interest to disclose.

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Authorship contributions

JCB, ST, and ALG designed the study. JCB performed data extraction, coding, and manuscript preparation. JCB and ALG derived FISS scores from medical records. AG extracted SLIC scores from medical imaging. JCB and a blinded rater derived DOSS scores. ST, ALG, and AG edited the manuscript and advised statistical analysis.

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