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Pathogenesis and Outcomes of Traumatic Injuries of the Esophagus

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Abstract

Background—Traumatic injury of the esophagus is extremely uncommon. The aims of this study were to use the Pennsylvania Trauma Outcome Study (PTOS) database to identify clinical factors predictive of esophageal trauma, and to report the morbidity and mortality of this injury.

Methods—A cross-sectional review of patients presenting to twenty Level I trauma centers in Pennsylvania from 2004 to 2010 was performed. We compared clinical and demographic variables between patients with and without esophageal trauma both prior to, and after arrival in the ER. Primary mechanism of injury and clinical outcomes were analyzed.

Results—There were 231,694 patients and 327 (0.14%) had esophageal trauma. Patients with esophageal trauma were considerably younger than those without this injury. The risk of esophageal trauma was markedly increased in males [OR= 2.62 (CI 1.98–3.47)]. The risk was also increased in African Americans [OR = 4.61 (CI 3.65–5.82)]. Most cases were from penetrating gunshot and stab wounds. Only 34 (10.4%) of esophageal trauma patients underwent an upper endoscopy; diagnosis was usually made by CT, surgery, or autopsy. Esophageal trauma patients were more likely to require surgery (35.8% vs. 12.5%; $p < 0.001$). Patients with esophageal trauma had a substantially higher mortality than those without the injury (20.5% vs. 1.4%; $p < 0.005$). In logistic regression modeling, traumatic injury of the esophagus [OR=3.43 9 2.50–4.71] and male gender [OR=1.52 (1.46–1.59)] were independently associated with mortality. For those patients with esophageal trauma, there was an association between trauma severity and mortality [OR = 1.10 (1.07–1.12)] but not for undergoing surgery within the first 24 hours of hospitalization (OR = 0.84; 0.39–1.83).

Conclusions—Our study on traumatic injury of the esophagus is in concordance with previous studies demonstrating that this injury is rare but carries considerable morbidity (~46%) and mortality (~20%). The injury has a higher morbidity and mortality when the thoracic esophagus is involved compared to the cervical esophagus alone. The injury most commonly occurs in younger, Black males suffering gunshot wounds. Efforts to control gun violence in Pennsylvania are of paramount importance.

Keywords

endoscopy; esophageal injury; gunshot; Pennsylvania Trauma Outcome Study

Introduction

Traumatic injury of the esophagus (TIE) is associated with a high morbidity and a mortality that exceeds 20%. (1, 2) If perforation occurs mortality can exceed 50% due to mediastinal and pleural infection leading to sepsis and multi-organ failure. (3–5) This is due in part to the characteristics of the esophageal wall. The thin wall, lack of supporting adventitia, and relatively poor blood supply make the esophagus exceedingly susceptible to perforation. (6) Furthermore, the loose areolar connective tissue and lack of serosa make it unable to prevent the spread of infection and inflammation. (7) This unique anatomical configuration also allows bacteria and digestive enzymes easy access to the mediastinum, leading to mediastinitis, empyema, sepsis and multi-organ failure. (8)

Non-invasive identification of TIE from a penetrating injury can be problematic. Even in busy urban trauma centers, TIE is exceedingly rare and therefore clinical experience tends to be limited and recognition of presenting signs and symptoms can be challenging. (7) In one of the largest single center series reported to date, there were only 77 TIE cases over a period of 22 yrs. (9) In another study of 77 patients with penetrating neck injuries presenting to a single hospital, only one patient was found to have perforation related to TIE. (10) Although there is a lack of evidence-based recommendations concerning management of TIE, some centers have developed clinical algorithms to guide decision making surrounding surgical versus nonsurgical management. (5, 11–13)

Prompt evaluation is vital as mortality rates exceed 90% in cases of unrecognized perforation. (12) CT scan is the most accurate method for illustrating para-esophageal manifestations of TIE including mediastinal collections, abscesses, and effusions. (11, 14, 15) Emergent flexible endoscopy has been used for the assessment of TIE in patients with penetrating injury to the thorax or neck (16, 17). Evaluation for TIE may also include chest and/or lateral neck radiograph, water-soluble contrast esophograms, and flexible pharyngoscopy/laryngoscopy. (12) Two papers concluded that endoscopy was safe and accurate in identifying esophageal perforation in cases of TIE. The results reported a sensitivity of 100% and specificity of 92.4%. (16, 17) These papers had methodological flaws including no “gold standard” to assess accuracy and failure to account for patients who underwent emergent surgery prior to receiving endoscopy. Also, the prevalence of any injury to the esophagus, including perforation, was less than 3%. Therefore, the number needed to scope to find one esophageal injury was substantial. This is problematic because patients usually require endotracheal intubation and deep sedation to complete an endoscopy.

The aims of this study were threefold. First, we aimed to identify clinical factors predictive of TIE. Second, we aimed to report the pattern of diagnostic testing used for TIE. Finally, we aimed to report the morbidity and mortality of TIE managed at Level I trauma centers.

Methods

Study Design

We performed an analysis of patients who presented to twenty Level I trauma centers in Pennsylvania. Trauma data was obtained with permission of the Pennsylvania Trauma Outcome Study (PTOS) for the complete years 2004–2010 after IRB approval. Patients with traumatic injury of the esophagus (TIE) were identified by ICD-9 code (862.22-injury to thoracic esophagus without open wound, 862.32- injury to thoracic esophagus with open wound, 874.4- injury to pharynx and cervical esophagus without open wound 874.5- injury to pharynx and cervical esophagus with open wound). We compared clinical and demographic variables between patients diagnosed with and without TIE. Management prior to and after arrival to the emergency room (ER) was analyzed. We identified the mechanism of injury (E-code) leading to TIE. (Table 1). Diagnostic procedure codes (ICD-9 42.21–42.25) were used to determine which patients with TIE underwent esophagoscopy, although specific results are not provided. Utilization (but not results) of imaging procedures such as body CT, plain films of the chest and abdomen, and MRI studies was determined. We recorded the modality by which the final diagnosis of TIE was made including surgery, autopsy, or through imaging. Complications at or after admission were recorded.

Data Analysis

After an exploratory data analysis we compared continuous variables using Student's t-test, and for categorical data the Pearson chi-square test. In comparing length of stay and mortality we adjusted for injury severity using the Injury Severity Score (ISS) found on the trauma.org website (<http://www.trauma.org/archive/scores/iss.html>). All analyses were performed using IBM SPSS Statistics v. 19 (Armonk, New York). All tests of significance were 2-tailed with statistical significance set at $p = 0.05$.

Results

Of the 231,694 trauma patients recorded in the PTOS database from 2004 to 2010, there were 327 (0.14%) patients found to have TIE (Table 2). Trend analysis did not demonstrate a significant difference in rates over time ($P = 0.23$). The incidence of TIE for all 79 counties in Pennsylvania ranged from 0–0.7% and was 0.3% in Philadelphia. Patients with TIE were younger than those without TIE; 29.7 ± 20.5 v. 44.9 ± 25.9 years ($P < 0.001$). The risk of TIE was markedly increased in males; OR = 2.62 (CI 1.98–3.47). Similarly, the risk was increased when comparing African Americans to Caucasians; OR = 4.61 (CI 3.65–5.82). Approximately 60% of all TIE injuries were due to penetrating injuries from a gunshot or stab wound. By final anatomical diagnosis there were 190 (58.1%) injuries to the cervical esophagus, 123 (37.6%) to the thoracic esophagus, and 14 (4.3%) injuries at both locations. For both blunt (60.9%) and penetrating (58.8%) mechanisms of injury, the cervical esophagus was the primary site of involvement.

Pre-ER and ER Management

Prior to ER arrival, patients with TIE presented with a significantly lower mean pulse rate (76.1 ± 45.9 vs. 90.2 ± 23.0 BPM; $P < 0.001$), systolic blood pressure (86.6 ± 59.0 vs. 132.9

± 33.5 mmHg; $P < 0.001$), respiratory rate (15.2 ± 11.1 vs. 18.8 ± 5.3 per min; $P < 0.001$), and Glasgow Coma Score (10.3 ± 5.5 vs. 13.5 ± 3.3 ; $P < 0.001$) than patients without TIE. TIE patients required a greater volume of crystalloid infusion and more frequently required intubation at the scene of arrival (10.0% vs. 1.2%, $p < 0.001$). Similarly, in the ER, TIE patients had a lower pulse rate, mean systolic blood pressure, and Glasgow Coma Score, and a higher need for mechanical intubation. Only 34 (10.4%) TIE patients underwent a diagnostic upper endoscopy.

Post-ER Disposition and Management

After initial evaluation, 117 (35.8 %) of TIE patients required surgery either for esophageal repair or another injury related to trauma. Surgery was far more common in those who suffered injuries to the thoracic vs. the cervical esophagus (39.0% vs. 14.4%; $P=0.010$). The surgery rate for TIE patients was far higher than for those presenting without TIE (12.5%); $P < 0.001$. Both TIE and non-TIE patients had a similar frequency of ICU assignment (25.7% vs. 27.1%). Non-TIE patients were more likely to be sent to the hospital ward (42.7% vs. 11.3%; $p < 0.001$). The remaining patients in both groups either died or were managed in a step down unit. Final anatomical diagnosis of TIE was made by one or more of the following; CT/MRI (63.6%), surgery (61.8%), and/or autopsy (23.9%).

Morbidity

There were a total of 152 complications in 72 patients with TIE. The most common complications included pneumonia ($n=18$), UTI ($n=11$) and DVT ($n=10$). No complications were reported in 255 TIE patients.

Mortality and Length of Stay

The mortality rate for those with TIE was 29.1%. Those patients with TIE who died had a significantly higher ISS score compared to those who survived (45.5 ± 21.5 vs. 18.4 ± 12.9 ; $P < 0.01$). Patients with TIE involving the thoracic esophagus were far more likely to die compared to those with cervical injuries (44.7% vs. 17.9%; $P < 0.001$). Those with injuries at both sites had a very high mortality similar to those with isolated thoracic esophagus injuries (42.9%). TIE patients had a longer mean length of stay in the ICU than non-TIE patients (3.9 ± 7.8 for TIE patients vs. 1.8 ± 5.8 days for non-TIE patients; $P < 0.001$). However, after adjustment for the Injury Severity Score (ISS) there was no relationship between TIE and ICU length of stay ($P=0.14$). TIE patients had a substantially higher mortality than those trauma patients without TIE (20.5% vs. 1.4%; $p < 0.005$). In logistic regression modeling, after adjustment for age and injury severity score (ISS), TIE (OR=3.43; 2.50–4.71) and male gender (OR=1.52; 1.46–1.59) were independently associated with mortality. After adjustment for age, gender, and ISS there was no association between undergoing surgery within the first 24 hours of hospitalization (OR = 0.84; 0.39–1.83) and mortality in those patients with TIE.

Discussion

Traumatic injury of the esophagus results in substantial rates of morbidity and mortality (18). Our review of the Pennsylvania Trauma Outcome Study (PTOS) database from 2004–

2010 identified 327 cases, representing 0.14% of all trauma cases seen at Level I trauma centers throughout Pennsylvania. Our study confirms that TIE is a rare disorder likely owing to the small size of the esophagus, its relative protected position anatomically, and the odds of fatal concurrent cardiovascular, tracheal, or spinal cord injury. (6, 19, 20–22) The primary mechanism of injury was penetrating injury due to a gunshot wound (47.7%). These findings are in line with the results of Cornwell et al. who reported an incidence of intrathoracic esophageal injuries in 0.7% of 1,961 patients with gunshot wounds to the chest. (23) Yearly prevalence over the study period varied (0.10–0.19%) but there was no significant trend. This finding is in concordance with data reported by the US Bureau of Justice Statistics in which the number of crimes committed with firearms has remained stabilized since 2000 (<http://www.bjs.gov/index.cfm?ty=daa>). We found the risk of TIE to be nearly 3-fold increased in males and 5-fold increased in African Americans which is also in agreement with a previous publication. (24)

The mortality rate found in this study (29.1%) is substantially higher than reported from a large multicenter North American study (19%). (25) In regression analysis, which controlled for the severity of trauma, those patients with TIE were far more likely (OR=3.43; 2.50–4.71) to expire. For those surviving, prolonged ICU care was common, and complications developed in 152 patients (46.4%).

After TIE complicated by perforation occurs, a systemic inflammatory response develops rapidly within 24–48 hrs. Frequently this leads to bacterial mediastinitis that can cause multi-organ failure. (26) Therefore we were surprised to find that surgery within 24 hours was not an independent predictor of survival. Historically, repair of an esophageal perforation greater than 24 hours following a delay in diagnosis has been associated with an increased mortality. In fact, one study showed that mortality doubled if the diagnosis and treatment were delayed over 24 hours. (27) In the large AAST study, delay of surgery beyond a cutoff of approximately 13 hours was associated with a higher frequency of complications such as empyema. (25) Our findings agree with those from a smaller study by Muir et al. (28) They reviewed 75 patients with non-traumatic esophageal injuries and found that the only independent predictor of mortality was time to diagnosis of perforation, not the time to definitive management.

Our results are consistent with previous studies by demonstrating quite clearly that injuries to the thoracic esophagus are associated with a far higher mortality than injuries of the cervical esophagus. (8, 29 – 34) Muir et al also noted a lower mortality rate for cervical perforation, although this was not statistically significant. (28) Perforation of the thoracic esophagus with spillage of gastrointestinal contents into the pleural space had a higher (22% vs 11%) mortality than when the spillage was confined to the mediastinum. (28) Another study by Parsons et al. mentioned that residence in the thoracic cavity makes the transmural pressure gradient greater than the intraluminal pressure, potentially exacerbating partial perforations in this location. (35) While a complete perforation of the cervical esophagus would cause spillage of contents into the retro-esophageal space, lateral spread is limited by areas of attachment of the esophagus to the prevertebral fascia. (36) Moreover, the blood supply to the thoracic esophagus derives from branches directly off the thoracic aorta,

bronchial arterial system, left gastric and inferior phrenic arteries whereas the cervical esophagus has a blood supply from branches of the thyroid arteries. (37)

The diagnosis of TIE relies on clinical history, physical exam, and diagnostic testing. Chest pain is regarded as the cardinal symptom is present in more than 70% of patients. Other clues include the triad of vomiting, chest pain and subcutaneous emphysema known as the Mackler Triad. Other signs and symptoms of esophageal perforation vary widely and are not specific contributing to a miss rate of up to 17% in some case series.(18) We also found that relative hypotension, bradycardia, and hypoxemia were associated with TIE with or without perforation.

Across Pennsylvania flexible endoscopy was used diagnostically in only 10.4 % of confirmed cases of TIE. Our hospital utilizes endoscopy to rule out TIE in cases of penetrating neck and chest trauma when radiographic workup with CT scan reveals air concerning for an aerodigestive tract injury. This is based on two small, retrospective studies performed nearly 20 years ago. (16, 17) Additional single-institution studies have reported on the role of flexible endoscopy. For example, Goudy, et al reviewed the charts of 19 patients admitted with cervical crepitance or emphysema secondary to trauma. Only one patient was found to have an esophageal perforation which was identified by both endoscopy and Gastrografin swallow. (12) Another study from Brazil evaluated flexible endoscopy in 143 patients suspected of TIE, primarily after gunshot wounds. (24) Patients were referred for endoscopy based on clinical suspicion from radiology, mechanism of injury, or clinical exam. Overall 120 (83.9%) exams were normal, although one false-negative exam occurred. In 14 (9.8%) patients a perforation was identified. An additional nine patients were found to have esophageal contusions which were treated non-operatively. A paper by Ahmed et al emphasized that endoscopy performed emergently by the trauma surgery team can more rapidly identify cervical and thoracic TIE than water soluble contrast studies in patients “suspicious” for TIE.(38) A recent study by Demetriades and others referred 22 patients for endoscopy based on the proximity of the injury or suspicious clinical signs. (19) All examinations were normal and they concluded that routine evaluation by contrast radiographic studies and/or endoscopy had low yield at a significant cost. (19)

In the majority of TIE cases in our series CT of the chest (63.6%) or surgery (61.8%) documented the injury. Roughly 1 in 4 patients with TIE were found to have this injury on autopsy. In one study, CT esophagography was recommended as the best diagnostic tool for the evaluation of suspected TIE. (7) It demonstrated a significantly higher sensitivity than plain film water-soluble contrast esophograms. CT provides additional information about the level, size, and extent of TIE.(5) Characteristic changes on CT scans include extraluminal air, periesophageal fluid, wall thickening, intramural hematoma, and extraluminal contrast. (5, 39, 40) It is our opinion that after stabilization, all patients suspected of TIE should undergo a CT scan of the chest and abdomen. Those with obvious perforation should receive emergent surgery. Those without these findings in which the clinical suspicion remains high should undergo additional testing. If flexible endoscopy is readily then this should be performed. Otherwise, if there will be a delay, a water-soluble contrast exam is indicated.

There are several weaknesses of our study. Our retrospective use of an administrative database limits the exploration of several important details. For example, we were not able to determine whether patients underwent surgery or died principally because of their esophageal injury. In addition, we are unable to determine whether immediate or long term morbidity resulted from esophageal injury. The diagnostic accuracy of imaging and endoscopic procedures was not available, information which could assist in determining an evidence-based diagnostic algorithm. Misclassification due to unrecognized injuries or erroneous coding could potentially have occurred. Nevertheless, our study does provide important information on the mechanism of injury and independent prognostic importance of cervical and thoracic esophageal injury in the trauma patient.

Conclusion

In conclusion, our study of 327 cases of traumatic injuries of the esophagus found that young males sustaining a gunshot wound were the most likely to experience this injury. In the field and the ER they have relative hypotension, bradycardia, slowed respirations, and lowered Glasgow Coma Score. Traumatic injury of the esophagus is usually diagnosed by CT scan or in the OR, with the remainder at autopsy. The mortality rate is approximately 29%, and morbidity is at least 47%. Injuries to the thoracic esophagus are associated with higher morbidity, need for surgery and mortality as compared to injuries to the cervical esophagus alone. Early prompt recognition of this potentially fatal injury in combination with the clinical factors and results discussed in this study should allow more prompt management of these patients. In addition, efforts to control the rate of gun violence especially among inner city minorities are essential in impacting this devastating injury.

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Table 1

Ten most frequent mechanisms of Injury (E-Code)

Mechanism of Injury (E-Code)	Frequency	Percent
965: Assault by firearms and explosives	126	38.5
966: Assault by cutting and piercing instrument	26	8.0
921: Accident caused by explosion of pressure vessel	18	5.5
812: Other motor vehicle traffic accident involving collision with motor vehicle	15	4.6
888: Other and unspecified fall	15	4.6
955: Suicide and self-inflicted injury by firearms, air guns and explosives	14	4.3
815: Other motor vehicle traffic accident involving collision on the highway	13	4.0
956: Suicide and self-inflicted injury by cutting and piercing instrument	11	3.4
922: Accident caused by firearm, and air gun missile	9	2.8
918: Caught accidentally in or between objects	8	2.4
821: Nontraffic accident involving other off-road motor vehicle	7	2.1

Table 2

Characteristics of trauma patients with and without traumatic injuries to the esophagus from the PTOS database, 2004–2010.

	Traumatic Esophageal Injury N=327	No Esophageal Injury N=231,367	P
Demographics			
Male (%)	81.7	62.9	<0.001
Age, mean (SD)	29.7 (20.5)	44.9 (25.9)	<0.001
Race (%)			<0.001
White	45.9	75.9	
Black	41.3	14.8	
Hispanic/Latino	7.5	5.0	
Asian	1.2	0.9	
Other	4.1	3.4	
County of Trauma, n (%)			< 0.001
Philadelphia	121 (38.9)	39,091 (18.3)	
Pittsburgh	37 (11.9)	22,656 (10.6)	
Other	169 (49.2)	169,620 (71.1)	
Underlying GI Disorders (%)			0.44
Peptic Ulcer Disease	0.3	0.6	
Esophagogastric Varices	0.0	0.2	
Pancreatitis	0.3	0.2	
IBD	0.0	0.4	
Gastric Bypass Surgery	0.0	0.2	
Cirrhosis	0.3	0.6	
Prior to ER Arrival			
Vitals at Scene (mean, SD)			
Pulse (per min)	76.1 (45.9)	90.2 (23.0)	< 0.001
Respiratory Rate (per min)	15.2 (11.1)	18.8 (5.3)	< 0.001
Systolic Blood Pressure (mmHg)	86.6 (59.0)	132.9 (33.5)	< 0.001
Glasgow Score	10.3 (5.5)	13.5 (3.3)	< 0.001
Crystalloid Infused Prior to ER,			<0.001
ml (%)	19.0	27.4	
None	15.6	23.5	
< 500	16.8	13.4	
500–2000	2.4	0.9	
> 2000	46.2	34.8	
Unknown Amount			

	Traumatic Esophageal Injury N=327	No Esophageal Injury N=231,367	P
Mechanism of Injury (%)			< 0.001
Motor Vehicle Accident	14.1	30.8	
Fall	7.6	28.2	
Foreign Body	14.1	2.9	
Penetration/Stabbing	6.1	0.8	
Explosion	47.7	4.5	
Gunshot Wound	17.4	32.8	
Other			
Required Extrication at Scene (%)	4.9	8.6	0.48
Required Intubation at Scene (%)	10.0	1.2	< 0.001
ER Management			
Mean Injury Severity Score **	26.3 ± 20.0	12.3 ± 10.5	< 0.001
Trauma Alert Level (%)			< 0.001
1	70.7	27.0	
2	17.9	35.7	
3	4.9	13.8	
4	6.5	23.6	
Vitals Arrival in ER (mean, SD)			
Pulse (per min)	84.5	91.1	0.02
Respiratory Rate (per min)	16.3	19.0	<0.001
Systolic Blood Pressure (mmHg)	99.8	135.6	<0.001
Glasgow Score	10.4	13.7	<0.001
Intubated on arrival to ER (%)	29.7	7.1	< 0.001
Post-ER Management			
Destination after Arrival (%)			< 0.001
ICU	25.7	27.1	
OR	35.8	12.5	
Hospital Ward	11.3	42.7	
Step Down	3.7	9.1	
Morgue	20.5	1.4	
Other	3.0	7.2	
Surgery (n)			
Abdominal < 24 hours	39		
Abdominal > 24 hours	5		
Thoracic < 24 hours	30		
Thoracic > 24 hours	1		

	Traumatic Esophageal Injury N=327	No Esophageal Injury N=231,367	P
Other Surgery*	42		
No surgery	210		
Days in ICU (%)			< 0.001
None	43.4	62.6	
1-5	35.8	29.6	
>5	20.8	7.8	
Discharged Alive (%)	70.9	94.6	<0.001

* Includes vascular, orthopedic, and neurosurgery.

** Scores range from 1–75, with the higher number indicating more severe injury.