Contemporary management of traumatic cervical and thoracic esophageal perforation: The results of an Eastern Association for the Surgery of Trauma multi-institutional study

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BACKGROUND: Traumatic esophageal perforation is rare and associated with significant morbidity and mortality. There is substantial variability in diagnosis and treatment. Esophageal stents have been increasingly used for nontraumatic perforation; however, stenting for traumatic perforation is not yet standard of care. The purpose of this study was to evaluate current management of traumatic esophageal perforation to assess the frequency of and complications associated with esophageal stenting.

METHODS: This was an Eastern Association for the Surgery of Trauma multi-institutional retrospective study from 2011 to 2016 of patients with traumatic cervical or thoracic esophageal injury admitted to one of 11 participating trauma centers. Data were collected and sent to a single institution where it was analyzed. Patient demographics, injury characteristics, initial management, complications, and patient mortality were collected. Primary outcome was mortality; secondary outcomes were initial treatment, esophageal leak, and associated complications.

RESULTS: Fifty-one patients were analyzed. Esophageal injuries were cervical in 69% and thoracic in 31%. Most patients were initially managed with operative primary repair (61%), followed by no intervention (19%), esophageal stenting (10%), and wide local drainage (10%). Compared with patients who underwent operative primary repair, patients managed with esophageal stenting had an increased rate of esophageal leak (22.6% vs. 80.0%, $p = 0.02$). Complication rates were higher in blunt compared with penetrating mechanisms (100% vs. 31.8%, $p = 0.03$) despite similar Injury Severity Score and neck/chest/abdomen Abbreviated Injury Scale. Overall mortality was 9.8% and did not vary based on location of injury, mechanism of injury, or initial management.

CONCLUSION: Most patients with traumatic esophageal injuries still undergo operative primary repair; this is associated with lower rates of postoperative leaks as compared with esophageal stenting. Patients who have traumatic esophageal injury may be best managed by direct repair and not esophageal stenting, although further study is needed. (*J Trauma Acute Care Surg.* 2020;89: 691–697.

LEVEL OF EVIDENCE: Therapeutic, level IV.
KEY WORDS: Traumatic esophageal perforation; traumatic esophageal injury; esophageal stent; esophageal injury; primary repair of esophagus.

Traumatic esophageal perforation is rare with a reported incidence varying from 0.02% to less than 1%.[1–5] Despite its rarity, esophageal injury is associated with high morbidity and mortality, likely because of a combination of esophageal anatomy, spread of mediastinal contamination, severity of associated injuries, and difficulty with/delay in diagnosis.[6] The high mortality rate, ranging from 12% to 44%, has persisted over time despite overall improvements in surgical technique and critical care support, along with an increase in minimally invasive treatment options.[3–6]

Given its relative rarity, only a few retrospective studies have examined contemporary management of traumatic cervical and thoracic esophageal perforation.[2–4] To obtain an adequate sample size, many prior studies have evaluated very different patient populations with esophageal perforation. These studies included patients with various etiologies of perforation (such as Boerhaave syndrome, iatrogenic perforation, foreign-body–associated perforation, traumatic injury, etc.) and underlying pathologies (including malignancy, benign stricture, and esophageal motility disorder).[7–10] The ideal management strategy may vary depending on the etiology of the perforation and extent of the injury. Recent studies have reported good outcomes with esophageal stenting in patients with esophageal perforation; however, the heterogeneous populations included in these studies make it difficult to determine if the results are applicable to all patients or types of esophageal injury.[10–13] Optimal treatment specifically for trauma-related perforation and the role of esophageal stenting has yet to be determined.[6] A recent analysis of the National Trauma Databank (NTDB) revealed that esophageal stenting is being used infrequently within the trauma population; however, a more detailed evaluation is necessary to fully characterize the risks, benefits, and role for esophageal stenting in trauma.

The purpose of this multi-institutional study was to examine current practice and standard management of both cervical and thoracic traumatic esophageal injury. Specifically, we wanted to evaluate the incidence of esophageal stenting in trauma patients with esophageal injury and to assess the associated outcomes and complications. We hypothesized that esophageal stenting for traumatic esophageal injury remains significantly less common than operative intervention and is also associated with worse outcomes, including increased leak rates as well as increased mortality, when compared with open primary repair.

PATIENTS AND METHODS

The Eastern Association for the Surgery of Trauma Multicenter Trial Committee sponsored a multi-institutional retrospective study for a 6-year period (2011–2016) evaluating

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This study was presented at the 33rd EAST Annual Scientific Assembly, January 16, 2020, in Orlando, Florida.

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management of traumatic cervical and thoracic esophageal injuries. The trial proposal was submitted in 2017, and the study was selected for sponsorship by the Multicenter Trial Committee in 2018. Subsequently, 11 trauma centers were enrolled in the study.

The trial proposal, detailing the purpose of the study along with inclusion and exclusion criteria, was sent to participants at each institution. In addition, participants were sent a data collection tool and data dictionary; data were entered into excel, which was then sent to the primary investigator. Institutional review board permission was obtained at each institution. In addition, a data use agreement was obtained between all participating institutions and the University of North Carolina at Chapel Hill, where all data were sent for analysis.

The main inclusion criterion was diagnosis of traumatic perforation of the cervical or thoracic esophagus from any mechanism; we excluded perforation of the abdominal esophagus because of the rarity of this injury and the fact that these injuries are generally managed with open repair. We also excluded pregnant females, prisoners, and patients who died in the trauma bay. Our primary outcome of interest was patient mortality; secondary outcomes included initial treatment modality, presence of postprocedure esophageal leak, thoracic infectious complications (mediastinitis, pneumonia, empyema, sepsis), thoracic drainage procedures, hospital length of stay (LOS), intensive care unit (ICU) LOS and ICU-free days, endoscopic intervention or reintervention, or surgery after endoscopic intervention. Mediastinitis, pneumonia, empyema, and sepsis were all diagnosed by the presence of clinical signs and symptoms as well as radiographic findings consistent with the diagnosis. Esophageal leak was diagnosed with radiographic evidence of contrast extravasation.

Data collected included patient demographics, mechanism of injury (blunt or penetrating), location of esophageal injury (cervical or thoracic), any additional injuries, and preexisting medical comorbidities. Admission through discharge characteristics were collected including Injury Severity Score (ISS), pH, lactic acid, base deficit on arrival, initial management of the esophageal perforation, presence of esophageal leak after initial intervention, number and type of additional interventions, and associated complications. Data on antifungals and/or antibiotic use, index hospitalization mortality, and disposition on hospital discharge were collected as well. Statistical analysis was performed using Kruskal-Wallis test/Wilcoxon rank sum test for continuous variables and Fisher's exact test for categorical variables where appropriate.

RESULTS

From 11 centers, a total of 51 patients met the inclusion criteria. The mean age for the cohort was 39.8 years (SD, 19.8 years), and 80.4% were male. Mechanism of injury was penetrating in 86.3% of patients with the remaining patients having blunt injuries. The majority of injuries were in the cervical (68.6%) as opposed to the thoracic esophagus. Of the entire patient group, primary repair of the esophagus was the management of choice for the majority of patients (60.8%), followed by no intervention (19.6%), esophageal stent (9.8%), or wide local drainage (9.8%) (Table 1). The overall esophageal leak rate was 27.5%. All patients who had a leak underwent a subsequent intervention. The mortality rate for the entire cohort was 9.8%.

TABLE 1. Demographic, Injury, and Clinical Characteristics Among All Traumatic Injuries of the Esophagus

	Esophageal Injury (n = 51)
Demographics	
Mean age, y	39.8 (19.8)
Male, n (%)	80.4
Mechanism (%)	
Blunt	13.7
Penetrating	86.3
ISS, median (SD)	27.6
Injury	
Location of injury, %	
Cervical	68.6
Thoracic	31.4
Admission lactate, median (SD), mg/dL	3.9 (3.0)
Admission base deficit, median (SD), mEq/L	−2.5 (7.1)
Admission pH, median (SD)	7.29 (0.12)
Initial intervention	
Intervention performed, n (%)	
Primary repair	31 (60.8)
Esophageal stent	5 (9.8)
Wide local drainage	5 (9.8)
None	10 (19.6)
Esophageal leak following initial intervention, n (%)	14 (27.5)
Uncontained leak, n (%)	5 (35.7)
Additional procedures for any leak, n (%)	14 (100.0)
Persistent leak following additional procedures, n (%)	3 (21.4)
Clinical	
Hospital stay, median (SD), d	21.1 (16.0)
ICU LOS, median (SD), d	10.7 (11.7)
Ventilator days, median (SD)	7.4 (9.2)
In-house mortality, n (%)	5 (9.8)
Within 24 h, n (%)	2 (40)
Complications,* n (%)	18 (35.3)

*Complications limited to infectious complications and esophageal fistula.

Injury burden and clinical outcomes were compared between patients with cervical esophageal injury and thoracic esophageal injury (Table 2). Injury Severity Score was significantly higher in the thoracic group compared with the cervical group (36.5 vs. 25, $p < 0.01$); however, infectious complications (mediastinitis, pneumonia, sepsis) and rates of esophageal fistula formation were equal between groups (37.1% vs. 25%, $p = 0.53$). Mortality, hospital days, ICU-free days, and ventilator-free days were not different among these two groups. Likewise, leak rates were not different following interventions between all cervical versus thoracic esophageal injuries. When all blunt esophageal injuries (both cervical and thoracic) were compared with all penetrating esophageal injuries, infectious complications and esophageal fistulae were noted to be significantly higher within the blunt group (100% vs. 22.7%, $p < 0.001$) despite equal ISS and Abbreviated Injury Scale (AIS) between these two groups. Median hospital LOS was also significantly longer for patients with blunt esophageal injury

TABLE 2. Demographic, Injury, and Clinical Characteristics Among Traumatic Injuries of the Cervical Versus Thoracic Esophagus

	Cervical Injury (n = 35)	Thoracic Injury (n = 16)	p*
Demographics			
Mean age, median (IQR), y	35 (23–49)	32.5 (21–52.5)	0.74
Male, %	77.1	87.5	0.47
Mechanism, %			0.66
Blunt	11.4	18.7	
Penetrating	88.6	81.3	
ISS (IQR)	25 (17–30)	36.5 (21.3–48)	<0.01
AIS neck (IQR)	4 (1–4)	0 (0–2.8)	<0.01
AIS chest (IQR)	2 (0–3)	4 (2.3–4.8)	<0.01
AIS abdomen (IQR)	0 (0–0)	0 (0–4.8)	0.19
Injury			
Admission lactate, median (IQR), mg/dL	3.1 (1.8–4.5)	2.5 (1.8–4.6)	0.70
Admission base deficit, median (IQR), mEq/L	−1.25 (−4.9 to 2.2)	−3.7 (−9.7 to −2.0)	0.11
Admission pH, median (IQR)	7.3 (7.2–7.4)	7.3 (7.3–7.4)	0.25
Intervention performed, %			
Primary repair	65.7	50.0	0.16
Esophageal stent	2.9	25.0	1.00
Wide local drainage	11.4	6.3	0.58
None	20.0	18.8	1.00
Esophageal leak following initial intervention, n (%)	10 (28.6)	4 (25.0)	1.00
Uncontained leak, n (%)	5 (50.0)	3 (75.0)	
Additional procedures for leak, n (%)	10 (100.0)	4 (100.0)	
Persistent leak following additional procedures, n (%)	2 (20.0)	1 (25.0)	
Clinical			
Hospital stay, median (IQR), d	12 (8–23)	25.5 (14.3–39)	0.07
ICU-free days, median (IQR)	7 (4–17)	12 (1.25–16.8)	0.60
Ventilator-free days, median (IQR)	9 (6–19)	14 (1.3–22)	0.43
In-house mortality, n (%)	3 (8.6)	2 (12.5)	0.64
within 24 h, n (%)	0 (0.0)	2 (100)	0.10
Complications** %	37.1	25.0	0.53

*p Values based on Fisher's exact and Wilcoxon rank sums test for categorical and continuous variables, respectively.
**Complications limited to infectious complications and esophageal fistula.

(34 days vs. 13.55 days), although ICU LOS was not different (Table 3).

Analysis of the initial management strategy for all injuries demonstrated that there were four general treatment categories: open primary repair, endoscopic stenting, wide local drainage, and no intervention (Table 4). Of the five patients that were stented, four were in the thoracic location and one was in the cervical location (Table 4). Only patients with penetrating mechanism of injury were stented; no patient with blunt esophageal perforation was stented (Table 4). When comparing stenting to open repair, there were significantly higher total leak rates among the stented group (80.0% vs. 22.6%, $p = 0.03$). Uncontained leak rate, overall mortality rate, and percentage of patients with infectious complications/development of esophageal fistulae were not significantly different between the treatment groups. Hospital LOS, however, was significantly longer for patients who were stented ($p = 0.02$), despite there being no patients with blunt esophageal injury receiving stents.

DISCUSSION

Traumatic esophageal perforation is an uncommon injury and is associated with significant morbidity and mortality, particularly if not recognized and treated early.[3,5,7,14] There is substantial variability in the way that these injuries are managed, ranging from a complete nonoperative approach to endoscopic stenting to operative primary repair, esophagectomy with anastomosis, or esophageal diversion. Treatment is often dictated by multiple factors, including location of perforation, duration of perforation, severity and extent of tissue injury, contained versus uncontained perforation, presence of esophageal malignancy or other underlying pathology, and the systemic condition or clinical stability of the patient.[9] Therefore, previous studies evaluating patient outcomes and management have been somewhat limited.[8] Many studies have also been performed over relatively long periods, sometimes up to 14 years or more, during which time clinical management and specifically ICU care have changed dramatically.[9] Thus, this multi-institutional study was designed to enroll a significant number of patients from a variety of institutions over a shorter, 6-year period to better evaluate the current, contemporary management of traumatic cervical and thoracic esophageal perforation, particularly the complications and outcomes associated with esophageal stenting within the trauma population.

Previously, a multi-institutional American Association for the Surgery of Trauma study was published in 2001 that focused on penetrating esophageal injury and sought to define the time-period after which delays in treatment led to increasing morbidity and mortality. A total of 405 patients were evaluated for a 10.5-year period (1988–1998). The overall mortality rate was 19%. All patients were managed with surgical intervention. Primary repair was most frequently performed (82%) followed by drainage alone (11%), esophageal resection and diversion (4%), and esophageal resection and anastomosis (3%). Esophageal stenting was not performed for traumatic esophageal perforation during this period.[5]

More recently, Patel et al.[4] queried the NTDB for penetrating esophageal trauma to determine risk factors associated with morbidity and overall mortality. This study evaluated 227 patients from 108 centers for a 2-year period (2007–2008). Overall mortality was high at 44%; 92% of all deaths occurred within 24 hours of presentation. In patients who were admitted longer than 24 hours, 62% underwent primary repair, 13% drainage alone, 4% esophageal resection, and 1% esophageal diversion, and in 20%, procedure data were not recorded. Age and abdominal/pelvic AIS score of ≥ 3 were the only factors associated with esophageal-related complications. Esophageal-related complications did not ultimately contribute significantly to patient mortality; ISS was the only statistically significant predictor of mortality.[4]

Similarly, Aiolfi et al.[3] queried the NTDB for traumatic cervical and thoracic esophageal perforation for a 7-year period (2007–2014); 944 patients were ultimately analyzed. A total of 345 patients (36.5%) underwent operative exploration, and

TABLE 3. Demographic, Injury, and Clinical Characteristics Among Penetrating Versus Blunt Injury of the Esophagus

	Blunt (n = 7)	Penetrating (n = 44)	p*
Demographics			
Mean age, median (IQR), y	45 (25–73)	34.5 (22–49)	0.47
Male, n (%)	6 (85.7)	35 (79.5)	1.00
Location of injury, n (%)			
Cervical	4 (57.1)	31 (70.4)	0.66
Thoracic	3 (42.9)	13 (29.6)	
ISS (IQR)	27 (20–2)	25.5 (17.5–37)	0.80
AIS neck (IQR)	1 (0–3)	3 (0–4)	0.29
AIS chest (IQR)	4 (2–4)	2 (0–4)	0.35
AIS abdomen (IQR)	0 (0–0)	0 (0–0)	0.78
Injury			
Admission lactate, median (IQR), mg/dL	4 (2–4.5)	2.8 (1.8–4.5)	0.49
Admission base deficit, median (IQR), mEq/L	−6.5 (−10 to −2)	−1.8 (−4.6 to 1.8)	0.12
Admission pH, median (IQR)	7.3 (7.2–7.3)	7.3 (7.2–7.4)	0.50
Initial intervention			
Intervention performed, n (%)			
Primary repair	2 (28.6)	29 (65.9)	
Esophageal stent	0 (0.0)	5 (11.4)	
Wide local drainage	1 (14.3)	4 (9.1)	
None	4 (57.1)	6 (13.6)	
Esophageal leak following initial intervention, n (%)	2 (28.6)	12 (27.3)	1.00
Uncontained leak, n (%)	1 (50.0)	4 (33.3)	0.51
Additional procedures for leak, n (%)	2 (100.0)	12 (100.0)	1.00
Persistent leak following additional procedures, n (%)	0 (0.0)	3 (25.0)	1.00
Clinical			
Hospital stay, median (IQR), d	34 (19–42)	13.55 (8.0–26.8)	0.02
ICU-free days, median (IQR)	14 (0–21)	8 (4.3–16.3)	0.87
Ventilator-free days, median (IQR)	6 (0–26)	10.5 (6–22)	0.45
In-house mortality, n (%)	1 (14.3)	4 (9.1)	0.54
Within 24 h, n (%)	0 (0.0)	2 (50.0)	1.00
Complications, n (%)	7 (100)	10 (22.7)	<0.001

*p Values based on Fisher's exact and Wilcoxon rank sums test for categorical and continuous variables, respectively.
**Complications limited to infectious complications and esophageal fistula.

425 patients either underwent nonoperative management or the management was not specified. Of the 345 operative patients, 91.9% underwent primary suture repair, 16.9% underwent surgical drainage, 4.3% underwent esophagectomy, 3.7% underwent esophageal diversion, and only 1.2% (11 patients) underwent esophageal stenting. Seven patients with thoracic esophageal injury were stented, and four patients with cervical esophageal injury were stented. Two of 11 stented patients had an esophageal Organ Injury Scale (OIS) score of 1 and 2, corresponding to a partial thickness laceration or laceration of <50% circumference, respectively; 9 of 11 had an OIS score of 3, corresponding to a laceration of >50% circumference. No patients with esophageal OIS score of 4 and 5, or segmental loss/devascularization of either <2 or >2 cm, respectively, were managed with esophageal stenting.[15] Overall mortality was lower than the prior NTDB study at 12%.[3] The results of this study, when compared with the earlier two, show the increasing use of esophageal stenting for traumatic perforation in highly selected patients over time.

Esophageal stents first became commercially available in the 1990s, and clinicians began reporting increasing experience using stents to treat acute esophageal perforations and anastomotic leaks in the early 2000s. Despite variable success early on, as experience grew and stent technology improved, the indications for esophageal stenting expanded over time. Currently, there are relatively few absolute contraindications to esophageal stenting, and many practitioners will place stents as first-line therapy for a variety of conditions. Long segment perforations (>6 cm), complete dehiscence or necrosis of an esophageal anastomosis, or patients who require an open operation for other reasons are generally treated with operative intervention. Proximal cervical and abdominal/gastroesophageal junction perforations have also previously been considered to be relative contraindications for stenting because of patient discomfort and/or stent migration, although some authors do report experience and good outcomes stenting select patients with perforations in these locations.[10,11]

Reported outcomes associated with esophageal stenting are somewhat conflicting. A large meta-analysis found that stenting for esophageal perforation was associated with a pooled mortality rate of 7.3% compared with pooled mortality rates of 9.5% to 13.8% for patients undergoing primary repair and

TABLE 4. Demographic, Injury, and Clinical Characteristics Among Traumatic Esophageal Injury Management

	None (n = 10)	Repair (n = 31)	Stent (n = 5)	WLD (n = 5)	*p**
Demographics					
Mean age, median (IQR), y	61.5 (35–76)	32 (21–45)	28 (19–52)	44 (26–63)	0.08
Male, n (%)	8 (80)	23 (74.2)	5 (100)	5 (100)	0.67
Location of injury, %					
Cervical	70.0	74.2	20.0	80.0	0.13
Thoracic	30.0	25.8	80.0	20.0	
Mechanism, %					0.05
Blunt	40.0	6.5	0.0	20.0	
Penetrating	60.0	93.5	100.0	80.0	
ISS (IQR)	19 (17–27)	29 (20–41)	34 (25–39)	20 (20–30)	0.05
AIS neck (IQR)	2.5 (0–3.3)	4 (0–4)	3 (1–3.5)	2 (0–3.5)	0.68
AIS chest (IQR)	0.5 (0–3.3)	3 (0–3)	3 (2–4)	2 (0–3)	0.26
AIS abdomen (IQR)	0 (0–0)	0 (0–3)	0 (0–0)	0 (0–0)	0.39
Injury					
Admission lactate, median (IQR), mg/dL	4.3 (1.9–8.6)	2.6 (1.8–4.0)	5.6 (3.3– 8.4)	2.1 (0.9–4.1)	0.10
Admission base deficit, median (IQR), mEq/L	−1.7 (−4.0 to 2.8)	−2.0 (−6.8 to 2.1)	−3.7 (−8.2 to 3.6)	−5.2 (−11.7 to −0.8)	0.80
Admission pH, median (IQR)	7.38 (7.29–7.39)	7.31 (7.19–7.36)	7.32 (7.22–7.32)	7.32 (7.23–7.38)	0.46
Esophageal leak following initial intervention, n (%) (n = 14)	3 (30.0)	7 (22.6)	4 (80.0)	0 (0.0)	0.03
Uncontained leak, n (%)	1 (33.3)	2 (28.6)	1 (100.0)	N/A	0.77
Additional procedures for leak, n (%)	3 (100.0)	7 (100.0)	4 (100.0)	N/A	1.00
Persistent leak following additional procedures, n (%)	2 (33.3)	3 (37.5)	1 (25.0)	N/A	1.00
Clinical					
Hospital stay, median (SD), d	18.5 (9–25)	13 (8–26)	39 (32–69)	9 (4–28)	0.02
ICU-free days, median (SD)	5 (0–19)	8 (5–14)	19 (13–25)	6 (2–12)	0.07
Ventilator-free days, median (SD)	6.5 (0–20)	10 (6–22)	39 (15–69)	9 (2–20)	0.07
In-house mortality, n (%) (n = 5)	2 (20.0)	1 (3.2)	1 (20.0)	1 (20.0)	0.09
Within 24 h, n (%)	1 (50.0)	0 (0.0)	1 (20.0)	0 (0.0)	0.15
Complications,** n (%)	5 (50.0)	9 (29.0)	2 (40.0)	1 (20.0)	0.73

*p Values based on Fisher's exact and Kruskal-Wallis test for categorical and continuous variables, respectively.
**Complications limited to infectious complications and esophageal fistula.
N/A, not available; WLD, wide local drainage.

esophagectomy, respectively.[7] Although these results are likely impacted by bias in patient selection, multiple other studies have confirmed decreased morbidity, leak rates, mortality, hospital LOS, and medical costs in heterogeneous groups of patients with esophageal perforation.[10–13,16] Resuscitation, antibiotics, adequate drainage, reliable enteral access, and monitoring for stent migration are also key components of successful management of these patients.[10] However, Schweigert et al.[17] compared operative primary repair to stenting in patients with Boerhaave syndrome and found that mortality was 3.3 times greater in the stented group with 85% of those patients ultimately requiring operative intervention. Persson et al.[18] evaluated a group of patients with benign esophageal perforations and found a low mortality rate (7.5%) among all patients treated with stenting and an 83% stenting success rate. The only identifiable risk factor associated with stent failure was delay in stent placement. Of the 17% of patients who did fail stenting, however, 85% ultimately underwent esophagectomy with a 43% in-house mortality rate.[18] Clearly, thoughtful patient selection and ongoing critical supportive care with source control, drainage of contamination, and nutritional optimization are necessary for success with esophageal stenting.

In our study, overall mortality associated with esophageal injury was 9.8%. There was no significant difference in patient mortality between injury mechanism, location of injury, or initial management strategy. Infectious complications, such as pneumonia, mediastinitis, and empyema, and development of esophageal fistulae were found to be significantly higher in patients with blunt mechanism of injury. In addition, these patients also had significantly longer hospital LOS. However, patients with blunt mechanism of injury had similar ISS and neck/chest/abdomen AIS as compared with patients with penetrating mechanism of injury. The reason behind these findings is unclear but deserves further investigation. Future studies should investigate how injury mechanism relates to time to diagnosis and treatment modality.

The highest esophageal leak rates were associated with esophageal stenting; 80% of stented patients had a post procedural leak as compared with 22.6% of patients who underwent open repair. The uncontained leak rate, however, was no different between these two groups. Interestingly, more patients managed initially with esophageal stenting developed infectious complications and/or esophageal fistula (40%) when compared

with patients managed initially with open repair (22.6%), although these results were not statistically significant. The higher rates of esophageal leak, infectious complications, and esophageal fistula development did not impact patient mortality in our study, although patients who were stented did have a significantly longer hospital LOS. It is possible that, because of small sample size, our study was underpowered to detect several of these expected differences between groups. Future studies should focus on how the initial management strategy relates to time to diagnosis and time to initial treatment. In addition, future studies should also evaluate the esophageal injury grade to determine if the extent of injury (i.e., perforation vs. segmental loss) impacts whether management with a stent will be successful.

Our study has limitations. Despite collecting data from 11 institutions for a 6-year period, we only analyzed 51 patients. Small sample size has been a long-standing limitation of many studies evaluating esophageal perforation and this study was no different. In addition, only 10% of patients in our study underwent esophageal stenting, limiting the ability to draw significant conclusions regarding the viability of stenting within the trauma population. This study is also limited by its retrospective nature. In the future, larger multi-institutional studies could be performed to accrue more trauma patients with esophageal perforation; this could be aided by the use of a national or international registry. In addition, as stenting continues to increase, likely there will be more patients managed with this treatment modality to critically evaluate in the future.

In conclusion, although traumatic esophageal injuries are complicated to diagnose and manage, mortality seems to be improving over time. Most patients with traumatic esophageal injury still undergo operative primary repair, despite the fact that esophageal stenting has substantially increased for nontraumatic esophageal perforation. Esophageal stenting for trauma is still relatively infrequent, although it is likely slowly increasing in incidence as well. Overall, in our study, we found that patients initially managed with esophageal stent had significantly higher leak rates and hospital LOS than those managed with open primary repair. However, the uncontained leak rate, incidence of infectious complications and esophageal fistula formation, and patient mortality were no different. It is possible that our study was underpowered to detect these differences. It is also possible that these data truly reflect the ability to successfully manage these patients and potentially prevent the pain, respiratory complications, and other morbidities associated with an invasive thoracotomy and open esophageal repair. Extensive future study is warranted to determine the exact circumstances under which esophageal stenting should preferentially be used for traumatic esophageal perforation.

AUTHORSHIP

L.A.R. and P.B. contributed in the study design, data collection, data analysis, submission and organization of multi-institutional study, and writing and editing article. R.G.M. contributed in the writing and editing article. E.A.S. and J.J. contributed in the study design, data collection, and analysis. The remainder of authors performed the institutional data collection and preliminary analysis along with the review of the article.

DISCLOSURE

The authors declare no conflicts of interest.

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