

Contemporary management of esophageal perforations: A resource-intensive problem



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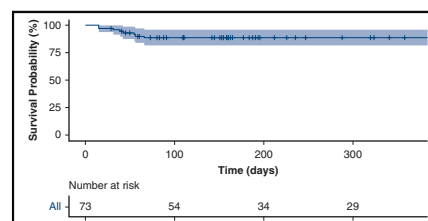
ABSTRACT

Objective: The study objective was to describe the outcomes of the modern management of esophageal perforations in a tertiary-quaternary referral center.

Methods: Retrospective single institution analysis of patients with esophageal perforation from 2017 to 2023. Patient characteristics, mechanism, time to presentation, pretransfer and in-hospital interventions, mortality, and hospital course were analyzed. Perforations were classified by location from incisors. One-year survival and 30- and 90-day mortality rates were calculated.

Results: Seventy-three patients were identified. Sixty-six patients (90%) had delayed (>24 hours) presentation; 62 patients (85%) were transferred from an outside hospital. The median time from injury to transfer or surgical consult was 4 days (interquartile range, 1-11). Pretransfer temporizing measures included antibiotics only (60%, 37/62), thoracostomy tube (15%, 9/62), endoscopic stenting (11%, 7/62), attempted primary repair (3%, 2/62), and thoracoscopic chest washout (11%, 5/62). Definitive treatment was as follows: 49% (36/73) esophageal stenting, 23% (17/73) primary repair, 16% (12/73) washout with feeding tube placement, and 11% (8/73) esophagectomy with diversion. The 30- and 90-day mortality rates were 4% (3/73) and 10% (7/73), respectively. There was no difference in 30-day mortality or length of stay between patients undergoing invasive interventions before transfer versus treatment with antibiotics alone ($P = .547$ and $P = .739$, respectively). Compared with early presentation, patients with delayed presentation underwent more treatment interventions (median: 4 [interquartile range, 4-6] vs 1 [interquartile range, 1-3] interventions respectively, $P = .005$) and had longer intensive care unit stays (mean: 3.7 vs 10.5 days, $P = .005$).

Conclusions: Delayed esophageal perforation is a morbid condition, but high vigilance and multi-modal (surgical, endoscopic, radiologic) interventions improve survival. A conceptual modernization of the management of esophageal perforation includes more interventions and longer hospital stays. (JTCVS Open 2025;27:197-208)



One-year survival probability: 88.7% (95% CI, 81.6-96.4) predicted by the Kaplan-Meier method.

CENTRAL MESSAGE

Surgical vigilance and multi-modal management improve survival after esophageal perforation.

PERSPECTIVE

Esophageal perforations were historically associated with high morbidity and mortality, particularly in the setting of delayed presentation. We found that after referral to a tertiary/quaternary treatment center, frequent interventions, and monitoring conferred lower mortality rates than those reported previously.

See Commentary Discussion on page 209.

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Esophageal perforation is an uncommon, yet serious condition characterized by a rupture or tear in the esophageal wall. Etiologies vary widely, including malignancy, benign ulceration, postemetic or post-traumatic barotrauma, foreign body or caustic ingestions, as well as iatrogenic injury. Iatrogenic injuries may result from a wide array of etiologies, including esophageal endoscopy and interventions, intraoperative injury, spinal hardware erosion, as well as transesophageal

Abbreviations and Acronyms

CT	= computed tomography
ICU	= intensive care unit
IQR	= interquartile range
SOFA	= Sequential Organ Failure Assessment
TQC	= tertiary/quaternary center

echocardiography and other endoscopic diagnostics.¹ Thoracic esophageal injuries are the most common, followed by cervical and distal perforations.²

Although infrequent, the consequences of esophageal perforation are devastating, with contemporary studies citing mortality rates as high as 40%.³⁻⁶ In-hospital complications are frequent, regardless of initial therapeutic intervention. When selecting a treatment modality, variables such as mechanism of injury, time of presentation, location, and size of the defect must all be considered. Traditionally, injuries that are recognized within 24 hours can be repaired primarily, whereas those presenting in a delayed manner are managed with a combination of approaches including drainage and diversion. Delayed presentation of esophageal perforation has historically conferred significantly higher morbidity and mortality than those presenting within 24 hours of injury.⁷⁻¹⁰

With the continued improvement and implementation of endoscopic therapies, patients presenting with delayed esophageal perforations are increasingly managed with endoscopic stent placement, potentially decreasing the need for higher morbidity interventions such as esophagectomy.¹¹⁻¹³ In this single-institution retrospective study, the contemporary management and outcomes of patients presenting with esophageal perforation to a tertiary referral center are described. The hypothesis was that with modern management, the mortality associated with delayed presentation would be

similar to that of early presentation. The objective of this study was to report on the presentation, initial and subsequent management, and outcomes of patients with cervical, thoracic, and distal esophageal perforations.

MATERIAL AND METHODS**Patient Population and Exposure**

A retrospective study of all consecutive adult patients presenting with esophageal perforation to a tertiary referral center from 2017 to 2023 was conducted, including those transferred from an outside hospital with or without prior interventions. Patients with tracheoesophageal fistula, postoperative anastomotic leaks, or perforations that had resolved on endoscopic examination after transfer from an outside hospital were excluded. Patients were grouped and compared by time of presentation, defined as immediate (≤ 24 hours of injury) or delayed (> 24 hours after injury), ascertained by chart review (Figure 1).

Covariates, Management, and Outcomes

Patient age, sex, and sociodemographics were recorded. Comorbidities were collected according to the Charlson Comorbidity index.^{14,15} A history of gastroesophageal reflux disease and most recent body mass index were also recorded.

Perforations were diagnosed preoperatively with contrast esophagography or computed tomography (CT) scan and confirmed endoscopically or intraoperatively (Figure 2). The location of perforation was classified as cervical (< 18 cm from the incisors), thoracic (18–32 cm from the incisors), and distal (> 32 cm from the incisors) based on the National Cancer Institute anatomic guidelines.¹⁶ Etiologies of perforations were classified as iatrogenic, post-metric, foreign body impaction, malignant, and infectious. We recorded whether patients presented at the hospital of definitive management or were transferred from an outside hospital. Pretransfer interventions and temporizing measures were recorded. The acuity of presentation at the time of arrival at the hospital or time of surgical consult was assessed by vital signs, creatinine, lactate, and hemoglobin. Sepsis at time of presentation was defined as a modified Sequential Organ Failure Assessment (SOFA) score 2 or greater above the individual patient's baseline, per the *Third International Consensus Definitions for Sepsis and Septic Shock*.¹⁷

Definitive treatment center interventions were classified as esophageal stenting, primary repair with muscle flap buttress, thoracoscopic or cervical washout with feeding tube placement, and esophagectomy with diversion. Combinations of these aforementioned treatment interventions were also

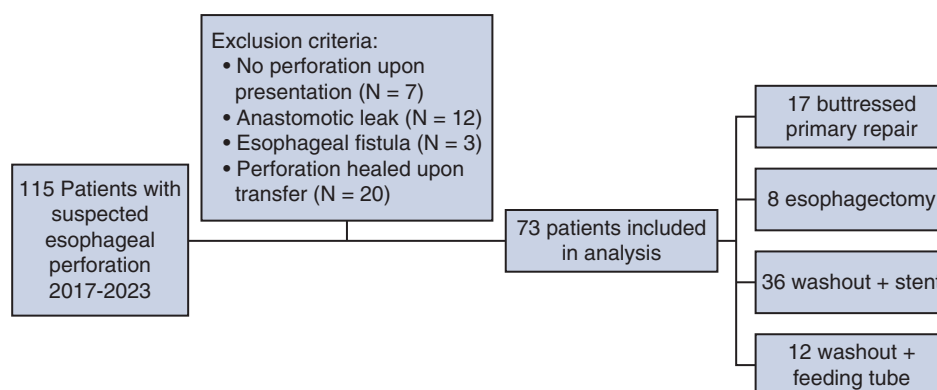


FIGURE 1. Flow diagram of patients included in study. There were 115 patients who presented to the TQC with suspected esophageal perforations. Patients were excluded if no perforation was identified on diagnostic evaluation, the perforation had healed sufficiently by the time of endoscopic evaluation, or the alternative pathologies were identified (anastomotic leak, esophageal fistula). A total of 73 patients met inclusion criteria and definitive treatments were categorized as primary buttressed repair, esophagectomy, esophageal stenting, and feeding tube with or without thoracoscopic washout.

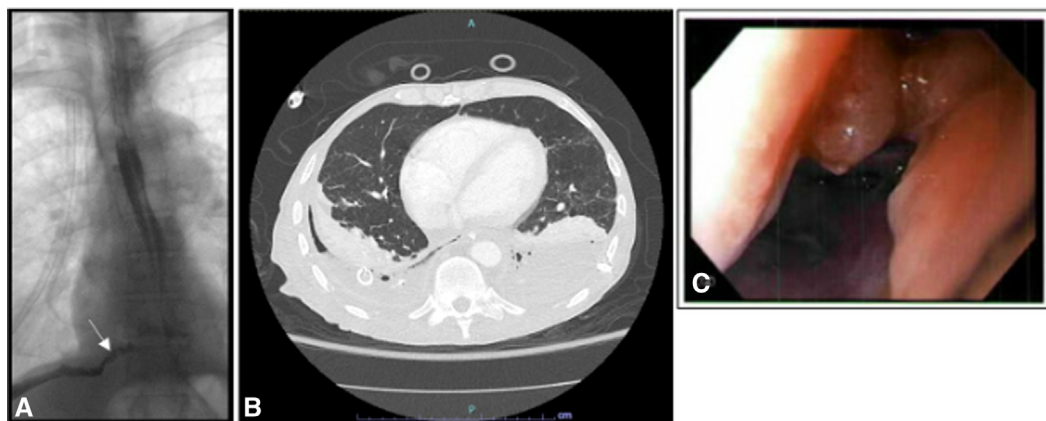


FIGURE 2. Diagnosis of esophageal perforation. Diagnosis of esophageal perforation with (A) contrast esophagography, (B) CT scan, and (C) confirmed with esophagogastroduodenoscopy. Arrow denotes contrast extravasation at the site of esophageal perforation.

used and recorded. Mortality and follow-up were determined by review of institutional records including the perioperative hospitalizations and postoperative inpatient and outpatient visits. The primary outcomes were 30- and 90-day mortality and overall survival, calculated from the date of consult or arrival at our tertiary/quaternary center (TQC). Secondary outcomes included number of intensive care unit (ICU) days, hospital length of stay, postoperative length of stay, number of procedures, feeding tube placement, and disposition after discharge. Death was determined from chart review and follow-up phone communication from clinic.

Analysis

Patient comorbidities, management, and postoperative outcomes were compared between patients with immediate and delayed presentation using the Fisher exact test for categorical variables and Student *t* test for continuous variables. All statistical analyses were conducted using R version 4.2.1 (www.r-project.com). This study was approved by the University of Southern California Institutional Review Board with exempt status on August 25, 2023 (HS-23-00517) with a waiver of consent.

RESULTS

Patient Characteristics and Presentation

There were 73 patients who met inclusion criteria (Figure 1). Baseline sociodemographics are presented in Table 1. Delayed presentation occurred in 90% (66/73), whereas 10% (7/73) presented within 24 hours of perforation. The majority of patients were transferred from an outside hospital to the TQC (85% [62/73]). The mechanisms of injury included iatrogenic 44% (32/73), postoperative 30% (22/73), foreign body or food impaction 12% (9/73), extrinsic compression injury by mediastinal mass or hardware 7% (5/73); malignant perforation 4% (3/73), and infectious 3% (2/73). The median time from injury to transfer or surgical consult was 4 days (interquartile range [IQR], 1-11). Of the patients who were transferred, initial temporizing measures included antibiotics without further intervention 60% (37/62); antibiotics with thoracentesis or thoracostomy tube placement 15% (9/62); antibiotics and endoscopic stenting 11% (7/62); thoracoscopic chest washout 11% (5/62); attempted primary repair 3% (2/62); and neck washout with drainage 3% (2/62).

Fifty-nine percent (43/73) of patients were septic on admission or consult per SOFA criteria. There was no association between presentation time and laboratory values or vitals. However, patients who presented delayed were more likely to have significant regional contamination compared with those who presented early ($P = .037$). There were no statistically significant differences in size of defect or circumferential disruption, although there was a trend to larger defects in the delayed perforation cohort (Table 1). There was a significant association between anatomic site and definitive management. Thoracic and distal perforations were more likely to be treated with stenting, whereas cervical perforations were more likely to be treated with primary repair or feeding tube only (Table E1). When looking at the mechanism of perforation, there were no differences in the SOFA scores at presentation to the TQC (Table E2).

Interventions, Hospital Course, and Mortality

Primary intervention was as follows: A total of 49% (36/73) underwent esophageal stenting with or without thoracoscopic washout; 23% (17/73) received primary buttressed repair; 16% (12/73) received washout with feeding tube placement; and 11% (8/73) received esophagectomy with diversion (Table 2). Two patients were initially temporized at the TQC with a stent for source control and later required definitive esophagectomy and diversion. Hospital length of stay was significantly longer among patients with delayed presentation (27.1 ± 19.7 days vs 14.0 ± 12.1 days; $P = .029$). Patients with delayed presentation also spent more time in the ICU compared with those who presented early (10.5 ± 13.2 days vs 3.7 ± 3.9 days, $P = .005$) and had a greater number of interventions during primary admission (4 [IQR, 4-6] vs 1 [IQR, 1-3] interventions, respectively, $P = .005$) (Figure 3). Surgical feeding tubes were more common in delayed presentations (85% vs 43%; $P = .002$, Table 2). Of those who did not receive surgical feeding tubes ($N = 14$), half had temporary

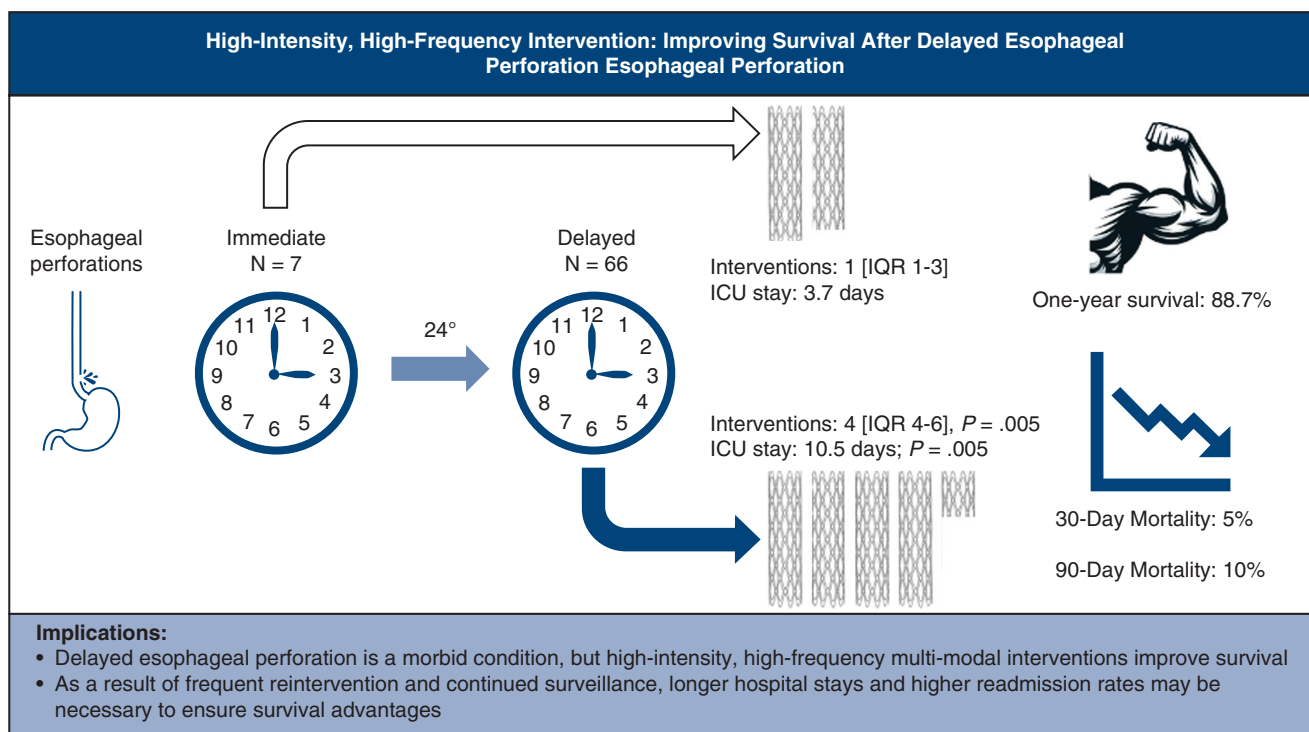


FIGURE 3. High-frequency intervention and monitoring associated with improved mortality in esophageal perforation. A total of 73 patients with esophageal perforations were identified and met inclusion criteria; 7 presented immediately (within 24 hours of perforation, and 66 presented delayed (>24 hours after perforation). Patients with delayed presentation had a greater number of interventions compared with those with immediate presentation (4 [IQR, 4-6] vs 1 [IQR, 1-3] interventions respectively, $P = .005$) and spent significantly more time in the ICU (10.5 ± 13.2 days vs 3.7 ± 3.9 days, $P = .005$). The overall 1-year survival was 88.7%; 30-day mortality 5% and 90-day mortality 10%. ICU, Intensive care unit; TQC, tertiary/quaternary center.

Dobhoff tube placements due to expectant fast recovery, 3 (21%) resumed oral intake within 7 days of intervention, and thus no enteral access was obtained, and 4 (29%) were maintained on TPN until resuming oral intake. Patients with delayed presentations also tended to have an increased rate of tracheostomy, but this did not reach statistical significance (15% vs 0%; $P = .58$).

The 30-day mortality was 4% (3/73), all of whom had a delayed presentation; 2 underwent esophagectomy, and 1 underwent cervical neck exploration and washout. The 90-day mortality was 10% (7/68) (Table 3). The median length of follow-up was 155 days (IQR, 67-409). There was no difference in 30-day mortality or length of stay between patients who had invasive interventions before transfer versus patients treated with antibiotics alone ($P = .547$ and $P = .739$, respectively). The 1-year survival probability was 88.7% (95% CI, 81.6-96.4) predicted by the Kaplan–Meier method (Figure 4).

Among patients alive at 30 days, the unplanned 30-day readmission rate was 27% (20/70), of whom 10% (2/20) underwent immediate intervention and 90% (18/20) were delayed ($P > .999$) (Table 3). Upon readmission, 55% (11/20) required endoscopic intervention, including stent

replacement, removal, or simple evaluation; 20% (4/20) required surgical washout and drain placement; 10% (2/20) required interventional radiology replacement of a feeding tube; 5% (1/20) underwent esophagectomy with diversion; and 10% (2/20) were readmitted for medical comorbidity exacerbations. All readmissions for endoscopic intervention were due to high-risk features found during endoscopy, including large persistent leaks, feeding tube mispositioning, and those requiring inpatient video esophagram, which requires overnight admission due to availability in our institution. Among patients readmitted within 30 days, all were alive within 90 days of initial intervention.

The most common disposition after hospital course was home with home health (40%, 27/68), followed by discharge to a long-term acute care facility (20%, 13/68) (Table 3).

Risk Factors for Mortality

The 90-day mortality was 10% (7/73). On a univariate analysis of risk factors for 90-day mortality, only sepsis on presentation ($P = .008$) and increasing age ($P = .010$) were associated with 90-day mortality. Patients who died

TABLE 1. Comparison of comorbidities, presenting condition, and disposition by time of presentation

Variable	Overall N = 73 Mean (SD) or N (%)	Immediate N = 7	Delayed N = 66	P value
Age, y	59.4 (16.3)	60.0 (15.2)	59.3 (16.5)	.910
Female gender	26 (36%)	5 (71%)	21 (32%)	.089
Race				.031
Asian	2 (3%)	0	2 (3%)	
Black or African American	6 (8%)	3 (43%)	3 (5%)	
White	31 (42%)	1 (14%)	30 (45%)	
Multiple	5 (7%)	1 (14%)	4 (6%)	
Other	28 (38%)	2 (29%)	26 (39%)	
Refused	1 (1%)	0	1 (2%)	
Ethnicity				.037
Hispanic or Latino	17 (23%)	0	17 (26%)	
Non-Hispanic or Latino	55 (75%)	6 (86%)	49 (74%)	
Refused	1 (1%)	1 (14%)	0	
Transfer	62 (85%)	2 (29%)	60 (91%)	<.001
HLOS	25.9 (19.4)	14.0 (12.1)	27.1 (19.7)	.029
Mechanism				.566
Iatrogenic	37 (41%)	6 (86%)	31 (47%)	
Postemetic	22 (30%)	1 (14%)	21 (32%)	
Impaction	9 (12%)	0	9 (14%)	
Malignant/tumor	3 (4%)	0	3 (5%)	
Infection	2 (3%)	0	2 (3%)	
Location				>.999
Cervical	21 (29%)	2 (29%)	19 (29%)	
Thoracic	9 (12%)	1 (14%)	8 (12%)	
Distal	43 (59%)	4 (57%)	39 (59%)	
Sepsis (adj. SOFA >2)	43 (59%)	3 (43%)	40 (61%)	.436
Intubated	17 (23%)	2 (29%)	15 (23%)	.661
Vitals at treatment center				
Temperature	36.9 (0.8)	37.0 (0.8)	36.9 (0.8)	.885
Heart rate	96 (22)	91.4 (24.6)	96.8 (21.3)	.596
Systolic blood pressure	126 (23)	127 (19)	126 (24)	.907
Respiratory rate	22 (6)	22 (5)	22 (6)	.782
Labs at treatment center				
White blood cell count	12.0 (5.3)	10.4 (5.7)	12.1 (5.3)	.483
Creatinine	1.00 (0.64)	1.05 (0.47)	0.99 (0.65)	.782
Hemoglobin	11.0 (2.4)	11.0 (1.9)	11.0 (2.4)	.988
Lactate	2.13 (1.64)	2.2 (1.6)	2.1 (1.7)	.952
Platelets	260 (128)	300 (172)	256 (124)	.566
Bilirubin	0.9 (0.7)	1.0 (0.3)	0.9 (0.7)	.449
Comorbidities				
BMI	27.9 (8.0)	29.3 (12.0)	27.8 (7.6)	.751
Polysubstance use	9 (12%)	0	9 (14%)	.586
Hypertension	36 (49%)	2 (29%)	34 (52%)	.430
Diabetes mellitus	11 (15%)	1 (14%)	10 (15%)	>.999
GERD/PUD	24 (33%)	2 (29%)	22 (33%)	>.999
PVD	4 (5%)	2 (29%)	2 (3%)	.044
Cancer	11 (15%)	2 (29%)	9 (14%)	.283
Rheumatologic disorder	8 (11%)	1 (14%)	7 (11%)	.573
Congestive heart failure	10 (14%)	2 (29%)	8 (12%)	.243
Valvular disorder	10 (14%)	2 (29%)	8 (12%)	.243

(Continued)

TABLE 1. Continued

Variable	Overall N = 73 Mean (SD) or N (%)	Immediate N = 7	Delayed N = 66	P value
Prior MI/NSTEMI	2 (3%)	0	2 (3%)	>.999
Prior CVA/TIA	2 (3%)	0	2 (3%)	>.999
Arrhythmia	15 (21%)	0	15 (23%)	.332
Coronary artery disease	7 (10%)	2 (29%)	5 (8%)	.132
Aortic disease	3 (4%)	0	3 (5%)	>.999
Chronic kidney disease	8 (11%)	0	8 (12%)	>.999
Dementia	3 (4%)	1 (14%)	2 (3%)	.264
Cirrhosis	3 (4%)	1 (14%)	2 (3%)	.264
COPD	9 (12%)	1 (14%)	8 (12%)	>.999
Charlson Comorbidity Index				.693
0-1	22 (30%)	1 (14%)	21 (32%)	
2-3	24 (33%)	3 (43%)	21 (32%)	
4+	27 (37%)	3 (43%)	24 (36%)	
Charlson Comorbidity Index	3 [1-4]	3 [2.5-5.5]	3 [1-4]	.354
Regional contamination	57 (78%)	3 (43%)	54 (82%)	.037
Largest defect dimension (cm)	1.5 [1.0-3.0]	1 [1-1.5]	2 [1-3]	.117
Circumferential defect				.334
<33%	52 (71%)	7 (100%)	45 (69%)	
33%-67%	14 (19%)	0	14 (21%)	
>67%	7 (10%)	0	7 (11%)	

BMI, Body mass index; COPD, chronic obstructive pulmonary disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; GERD/PUD, gastroesophageal reflux disease/peptic ulcer disease; HLOS, hospital length of stay; MI/NSTEMI, myocardial infarction/non-ST elevation myocardial infarction; PVD, peripheral vascular disease.

within 90 days were more likely to have a higher Charlson Comorbidity Index than those who survived ($P = .034$, Table E3). The low number of deaths within 90 days precluded a multivariable analysis that, if performed, would result in inaccurate estimates.¹⁸ Descriptively, among patients who died with 90 days of surgery, all presented delayed (100%, 7/7); 42% (3/7) underwent recent cardiothoracic surgery with iatrogenic injury or complication of aortic surgery, 29% (2/7) had Boerhaave syndrome after noncardiothoracic surgeries, and 29% (2/7) had iatrogenic injury from endoscopic therapies. All patients survived the initial hospitalization, and deaths occurred at an average of 37 ± 17 days after first intervention.

DISCUSSION

In this study, we demonstrate that the contemporary management of esophageal perforation necessitates repeated interventions with continued interval follow-up and monitoring. Patients with delayed presentation had significantly longer ICU stays and a greater number of in-hospital interventions, tracheostomies, and feeding tube placements. However, with a 30-day mortality rate of 5% among delayed presentations, it is possible that improvements in endoscopic techniques coupled with close monitoring and reintervention may be responsible for this reduction in mortality compared with historic rates. Additionally, modern management of esophageal perforation also includes improvements in critical

care, including better antimicrobial use, nutritional support, and minimally invasive interventions such as radiographically guided abscess drainages. In our cohort, patients presenting in a delayed fashion spent on average approximately 10 days in the ICU, with a relatively low mortality rate compared with those recorded historically.

Increasing age was associated with worse overall survival, consistent with prior analyses.^{4,8,19} The most common disposition after hospital course was discharge to home with home health services, followed by discharge to a long-term acute care facility. Although the 30-day readmission rate was relatively high at 27%, none of these patients died on readmission or within 90 days of date of injury, and the majority underwent endoscopic assessment or reintervention on readmission. Many others, who were not captured in the 30-day readmissions, underwent planned endoscopic reintervention on an outpatient basis. We propose that frequent follow-up and monitoring are key in preventing late complications of perforation and may improve overall survival.

The potential morbidity and mortality of esophageal perforation underscore the importance of maintaining vigilance and a low threshold for recurrent interventions. In our institution, patients presenting with perforation are initially evaluated with a CT esophagram. If the CT esophagram is negative or the index of suspicion is low, we observe expectantly with nil per os, fluids, and antibiotics. If the CT

TABLE 2. Tertiary/quaternary center definitive management and interventions by time of presentation

Variable	Overall N = 73	Immediate N = 7	Delayed N = 66	P value
Definitive management				.442
Buttressed primary repair	17 (23%)	3 (43%)	14 (21%)	
Esophagectomy	8 (11%)	0	8 (12%)	
Washout				
+ stent	36 (49%)	4 (57%)	32 (48%)	
+ feeding tube	12 (16%)	0	12 (18%)	
Interventions† (per patient)	4 [2-5]	1 [1-3]	4 [2-6]	.005
IR procedures*,† (per patient)	0 [0-1]	0 [0-0.5]	0 [0-1]	.708
Tracheostomy	10 (14%)	0	10 (15%)	.583
Surgical feeding tube	59 (81%)	3 (43%)	56 (85%)	.002

IR, Interventional radiology. *IR procedures included gastrojejunostomy tube conversions, J tube, and pigtail placements. †Median; [first quartile – third quartile]; and Wilcoxon rank-sum test reported.

esophagram is negative or equivocal but our index of suspicion is high, we then obtain a video esophagram. Most perforations are then evaluated endoscopically, with stent placement if amenable, and assessment for enteral feeding access. If the perforation is small and expected to heal quickly, a Dobhoff tube may be placed rather than a surgical feeding tube. Defects less than 50% of the circumference are typically amenable to stenting. Video-assisted thoracoscopic surgery washout is considered based on our subjective composite assessment of pleural soilage, nature of the chest tube effluent, and the CT findings. Those who underwent video-assisted thoracoscopic surgery in this study were thought to have considerable pleural soilage. Primary repair is considered if patients present early with healthy surrounding tissue, and more consideration is given to primary repair of cervical perforations that are not amenable to stenting. Because of the chronicity of most of the cases in our institution, most perforations were not amenable to primary repair unless presenting close to the 24-hour mark. After primary intervention, frequent reinterventions may result from unplanned complications or planned procedures such as stent exchange. Feeding tubes are placed for the majority of patients; however, it is up to the surgeon's discretion, and sometimes these are placed later in the treatment course, with the decision ultimately based on the clinical status of the patient, their overall health, and the size and extent of the perforation. Patients with perforations managed with endoscopic stenting who are suitable for discharge are subsequently followed weekly or biweekly in the clinic until the perforation is fully healed, and further interventions with interval imaging are pursued as needed. For the patients treated without an esophageal defunctionalization, we continue to follow in the acute and subacute period until they have resumed the diet they were on before their injury, and offer long-term follow-up at 6 to 12 months from return to their prior diet. In patients treated with esophageal defunctionalization,

we follow them closely until they are reconstituted, and at least until 1 year after reconstitution. In the time period of this study, endoscopic vacuum therapy was not performed. However, this negative pressure therapy has been recognized to be a valuable adjunct in select situations such as with chronic leaks into the pleural space and now is being considered more frequently in other circumstances.

Whereas most of the existing literature relies on historical data, this study focuses on the contemporary management of perforations over the last 7 years at a single TQC. This study characterizes the number of interventions per patient during index admission to the TQC and demonstrates that patients who presented in a delayed manner required more interventions. Despite the need for repeated interventions, they did not necessarily translate into increased mortality, suggesting the need for both vigilance and persistence. There was also no difference in mortality between patients who received only antibiotics at an outside facility before transfer versus those who underwent an intervention. By using sepsis and intubation rates as clinical indicators of acuity, patients in the immediate and delayed groups performed similarly. However, there was a potential selection bias among transferred patients favoring more clinically stable patients who survived the initial hours or days after perforation, or, at minimum, were stable enough for transfer to another facility. These factors notwithstanding, all patients who transfer from an outside facility to the definitive treatment center should do as expeditiously as possible, because temporizing interventions at an outside facility may not improve patient outcomes, and patients presenting within 24 hours will likely have lower morbidity after intervention than those presenting late, despite possibly similar mortality rates.

Although esophageal perforations remain a surgical emergency, mortality rates may not be as high as historically thought. With the increasing use of endoscopic therapies, patients who would have previously undergone open

TABLE 3. Tertiary/quaternary center outcomes by time to presentation

Variable	Overall N = 73	Immediate N = 7	Delayed N = 66	P value
Mortality				
30 d	3 (4%)	0	3 (5%)	>.999
90 d	7 (10%)	0	7 (11%)	>.999
Hospital length of stay	25.9 (19.4)	14.0 (12.1)	27.1 (19.7)	.029
ICU length of stay	9.8 (12.8)	3.7 (3.9)	10.5 (13.2)	.005
30-d readmission	20 (27%)	2 (29%)	18 (27%)	>.999
Disposition				
Deceased	4 (5%)	0	4 (6%)	
Home	9 (12%)	2 (29%)	7 (11%)	
Home with home health	29 (40%)	4 (57%)	25 (38%)	
Home with hospice	1 (1%)	0	1 (2%)	
Long-term acute care	14 (19%)	1 (14%)	13 (20%)	
Rehab	5 (7%)	0	5 (8%)	
Skilled nursing facility	7 (10%)	0	7 (11%)	
Transfer back to facility	3 (4%)	0	3 (5%)	
Left AMA	1 (1%)	0	1 (2%)	
90-d mortality	7 (10%)	0 (0%)	7 (11%)	>.999
Sex				.089
Male	47 (64%)	2 (29%)	45 (68%)	
Female	26 (36%)	5 (71%)	21 (32%)	
Age (y)	59 (16)	60 (15)	59 (17)	.910
Time to presentation	4 [1-11]	0 [0-0]	5 [2-14]	<.001
Location of perforation				
Cervical	1 (14%)		1 (14%)	
Thoracic	3 (43%)		3 (43%)	
Distal	3 (43%)		3 (43%)	
Interventions before transfer				
Antibiotics only	4 (57%)		4 (57%)	
Nontransfers	2 (29%)		2 (29%)	
Endoscopic stent	1 (14%)		1 (14%)	

AMA, Against medical advice; ICU, intensive care unit.

esophagectomies now are increasingly offered endoscopic stenting combined with minimally invasive thoracoscopic washout, with or without temporary feeding tube access to bypass the injury.¹¹ These patients may require more frequent interventions; however, the tradeoff is avoidance of a highly morbid surgery with severe life-changing consequences. As a result of frequent reintervention and continued surveillance, longer hospital stays and higher re-admission rates may be seen to ensure long-term survival advantages.

Limitations

Limitations of this study include the aforementioned selection bias among patients transferred from another facility, which made up a large proportion of the patients included in this study. We acknowledge that a control group was not included in this study due to the comparison of early and late perforations, and that the results are therefore largely

descriptive. Additionally, the immediate intervention group was of relatively smaller sample size than the delayed group, which decreased the statistical power of the analysis. We acknowledge that this discrepancy in sample size also lends to difficulty in comparing outcomes between the delayed and immediate presentation groups, and notably all patients who died within 90 days of perforation presented in a delayed manner. The details of the cause of death for the 90-day mortality was not available for the majority of patients due to all of them occurring outside of the hospital. Given the nature of a tertiary referral center, inequality in group size based on time to presentation is likely inevitable. It is notable that patients who had iatrogenic perforations, accounting for 86% of the immediate intervention group, may have been nil per os due to planned intervention, which could contribute to improved outcomes. Further study is indicated. This study did not account for the deconditioned state or nutritional status of patients, whether from underlying disease or

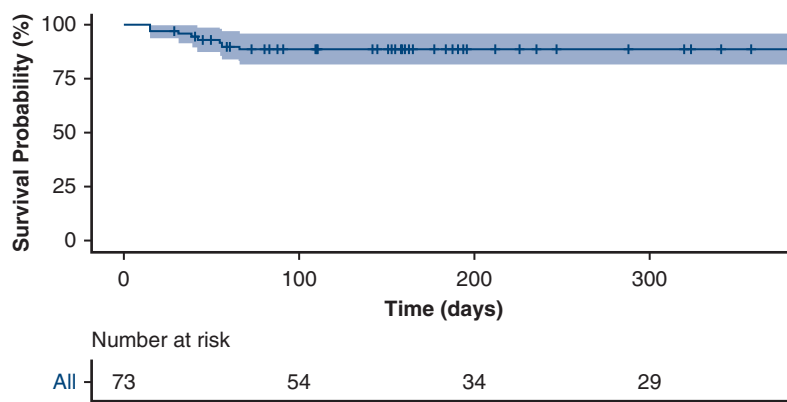


FIGURE 4. One-year survival. The 1-year survival probability was 88.7% (standard error 0.04; 95% CI, 81.6-96.4) as estimated by Kaplan–Meier method.

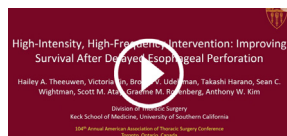
socioeconomic factors, and these factors may have affected outcomes described in the study. Last, because there were only 7 deaths within 90 days, multivariable analysis would result in inaccurate estimates and therefore was not pursued.¹⁸ There may be confounding factors that affect the association of sepsis or age with 90-day mortality. There are situations in which the exact cause of death was not available for patients who died after discharge from their acute episode of care. Details from a mortality can be challenging to acquire because they are reported by family members or nonphysician health-care workers from outside care facilities. In these circumstances, the policies of the managed-care providers policies often preclude a return to our institution for the postoperative management thereby limiting the ability to both deliver care aligned with the institutional goals and gather an accurate assessment of the individual patients' condition.

CONCLUSIONS

Applying the principles of extreme vigilance and reintervention as needed during the acute and subacute states of an esophageal perforation can lead to favorable outcomes that challenge historical data.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: <https://www.aats.org/resources/high-intensity-high-frequency-7317>.



Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or

reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: esophageal perforation, esophageal stent, interventions, length of stay, mortality

TABLE E1. Management by anatomic location

Variable	Overall N = 73	Cervical N = 21	Thoracic/distal N = 52	P value
Definitive management				<.001
Buttressed primary repair [3]	17 (23%)	8 (38%)	9 (17%)	
Esophagectomy [2]	8 (11%)	0	8 (15%)	
Washout				
+ stent [1]	36 (49%)	4 (19%)	32 (62%)	
+ feeding tube [0]	12 (16%)	9 (43%)	3 (6%)	
Interventions† (per patient)	4 [2-5]	3 [2-4]	4 [2-5]	.644
IR procedures*,† (per patient)	0 [0-1]	0 [0-1]	0 [0-1]	.370
Tracheostomy	10 (14%)	3 (14%)	7 (13%)	>.999
Surgical feeding tube	59 (81%)	15 (71%)	34 (65%)	.785

IR, Interventional radiology. *IR procedures included gastrojejunostomy tube conversions, J tube, and pigtail placements. †Median; [first quartile – third quartile]; and Wilcoxon rank-sum test reported.

TABLE E2. Sequential Organ Failure Assessment score by mechanism of perforation

Variable	Overall N = 73	Mechanism					P value
		Iatrogenic N = 37	Postmetabolic N = 22	Impaction N = 9	Malignant/tumor N = 3	Infection N = 2	
Sepsis (SOFA >2)	43 (59%)	22 (59%)	14 (64%)	4 (44%)	1 (33%)	2 (100%)	.615
SOFA score	2 [0-5]	2 [0-4]	3 [0-7]	2 [0-4]	1 [0-2]	4 [3-5]	.627*
Adjusted SOFA score	2 [0-5]	2 [0-3]	3 [0-6]	2 [0-4]	1 [0-2]	4 [3-5]	.587*

SOFA, Sequential organ failure assessment. *Kruskal–Wallis rank-sum test.

TABLE E3. Mortality analysis by comorbidity burden

Variable	Overall	30-d mortality	Alive at 30 d	P value
CCI				>.999
0-1	22 (30%)	1 (33%)	21 (30%)	
2-3	24 (33%)	1 (33%)	23 (33%)	
4+	27 (37%)	1 (33%)	26 (37%)	
CCI continuous	3 [1-4]	3 [2-4]	3 [1-4]	.877
		90-d mortality	Alive at 90 d	
CCI				.208
0-1	21 (30%)	1 (14%)	20 (31%)	
2-3	24 (34%)	1 (14%)	23 (36%)	
4+	26 (37%)	5 (71%)	21 (33%)	
CCI continuous	3 [1-4]	5 [3.5-6]	3 [1-4]	.034

CCI, Charlson comorbidity index.