Global Survey of Esophageal Injury in Atrial Fibrillation Ablation: Characteristics and Outcomes of Esophageal Perforation and Fistula

Chirag R. Barbhaiya, MD
Saurabh Kumar, BSc [Med]/ MBBS, PhD*
Yu Guo, MA[τ]
Judy Zhong, PhD[τ]
Roy M. John, MD, PhD*
Usha B. Tedrow, MD, MSc*
Bruce A. Koplan, MD, MPH*
Laurence M. Epstein, MD
William G. Stevenson, MD*
Gregory F. Michaud, MD*

Leon H. Charney Division of Cardiology. New York University Langone Medical Center. New York, NY, USA
Division of Biostatistics, Department of Population Health, NYU School of Medicine. New York, NY, USA[τ]
Cardiovascular Division, Brigham and Women's Hospital. Boston, MA, USA*

Brief title: Esophageal Perforation and Fistula in AF Ablation

Address for Correspondence:
Dr. Chirag Barbhaiya
Leon H. Charney Division of Cardiology
New York University School of Medicine
550 1st Avenue
New York, NY 10016, USA
Phone: 212-263-5555
Fax: 212-263-8685
E-mail address: chirag.barbhaiya@nyumc.org

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Structured Abstract

Background

Esophageal injury is a feared complication of atrial fibrillation (AF) ablation.

Objectives

To assess the incidence, operator demographics, clinical characteristics, procedural factors, and prognosis of esophageal perforation and fistula after AF ablation.

Methods

An internet-based global survey soliciting anonymous information regarding esophageal perforation and fistula was emailed to 3,080 physicians. Detailed information regarding physician, patient, and procedural characteristics related to esophageal perforation with or without fistula were collected.

Results

The survey was completed by 405 of 3,080 physicians (13%). Responding physicians performed 191,215 AF ablations and esophageal perforation with or without fistula occurred in 31 patients (0.016%) with multiple ablation catheter types despite monitoring of esophageal position or temperature during ablation in 90% of patients. Among patients who present with esophageal perforation, death or severe neurologic injury occurred more frequently in patients with greater body mass index (30.9 ± 6.8 kg/m^2 vs. 25.8 ± 3.3 kg/m^2, p=0.03), and lower left ventricular ejection fraction (55.1 ± 9.1 % vs. 61.7 ± 5.4 %, p=0.04). Among analyzed patients, Atrial–esophageal fistula was seen in 72%, pericardial-esophageal fistula in 14%, and esophageal perforation without fistula in 14%. Mortality was 79% with atrial-esophageal fistula and 13% in esophageal perforation without atrial-esophageal fistula.

Conclusions

Esophageal perforation is rare but continues to occur with multiple catheter types despite esophageal monitoring during ablation. The prognosis of esophageal perforation is substantially improved if diagnosed and treated prior to development of atrial-esophageal fistula. An early surgical approach to esophageal perforation should be strongly considered regardless of evidence of fistula.

Key Words: atrial fibrillation, catheter ablation, esophageal perforation, atrial-esophageal fistula

Condensed Abstract

A global survey regarding esophageal perforation and fistula was completed by 405 physicians who have performed 191,215 AF ablations. Esophageal perforation with or without fistula occurred in 31 patients (0.016%). Among patients with esophageal perforation, increased BMI and decreased left ventricular ejection fraction may be associated with unfavorable outcomes. Mortality was 79% with atrial-esophageal fistula and 13% without atrial-esophageal fistula. All surviving atrial-esophageal fistula patients underwent thoracic surgery. Diagnosis and treatment of esophageal perforation prior prior to development of atrial-esophageal fistula may improve prognosis. An early surgical approach to esophageal perforation should be strongly considered regardless of evidence of fistula.

Abbreviations:
AF – atrial fibrillation
AEF – atrial-esophageal fistula
LA – left atrium
RF – radiofrequency
PVI – pulmonary vein isolation
POD – post-operative day
PPI – proton pump inhibitor

Introduction

Catheter ablation of atrial fibrillation (AF) may be complicated by injury to extracardiac structures. Ablation of the left atrial (LA) posterior wall may result in esophageal injury ranging from mild erythema to ulceration(1), and in rare, but devastating cases, esophageal perforation with(2) or without(3) fistula formation. There are limited data regarding the prevalence, circumstances, and outcomes of these complications(4-8). The aim of this study was to assess real-world prevalence and outcomes of these complications, and to assess in detail physician, patient, and procedural characteristics related to esophageal perforation with or without fistula. We have previously reported data regarding time-course of presentation and outcomes related to various degrees of gastric and esophageal injury from the present survey(9).

Methods

The online survey was circulated to the 3,080 registered physician members of the Heart Rhythm Society in 2013 and all physicians who perform AF ablation were invited to participate in the survey. Survey responses were collected between November 1, 2013 and June 1, 2014. The survey was designed to be brief in order to improve response rates while collecting detailed data regarding esophageal perforation (text of survey is available in appendix). The following data were collected anonymously without identifying physician or patient data:

1. Operator characteristics: procedure volume, practice setting, geographic location, and incidence of AF ablation related esophageal injury. Operators reporting incident complications were invited to provide additional data regarding complications.
2. Esophageal perforation:

a. Patient characteristics including age, gender, height, weight, LA size, left ventricular ejection fraction, comorbidities, paroxysmal or persistent atrial fibrillation, and number of prior LA ablations.
b. Catheter ablation procedure characteristics including type of ablation catheter, posterior LA wall radiofrequency (RF) power settings and lesion duration, esophageal monitoring utilized, pre-procedure imaging, lesion set, and use of prophylactic proton pump inhibitor (PPI).
c. Clinical presentation details including post-operative date and nature of initial symptoms, post-operative date and nature of symptoms at time of admission, specialty of physician performing initial evaluation, and diagnostic studies obtained.
d. Final diagnosis: "atrial esophageal fistula" (AEF) if there was imaging or clinical evidence of communication between LA and esophagus; "esophageal-pericardial fistula" if there was imaging or clinical evidence of communication between the LA and pericardium; and "esophageal perforation without fistula" if there was imaging or clinical evidence of esophageal perforation but no evidence of communication between esophageal lumen and pericardium or LA.
e. Intervention performed, if any, and clinical outcomes.

Statistical Methods

Continuous variables are expressed as the mean value ± SD and categorical variables as percentages. Analysis was performed using Prism (version 6.0d, GraphPad Software, Inc, La Jolla, CA). Continuous variables were analyzed using the Mann-Whitney. Categorical variables were analyzed using Fisher's exact test. A 2-sided P value $< .05$ was considered statistically

significant.

Data collection and analysis was according to protocols approved by the Partners Human Subject Protection Committee.

Results

Physician Characteristics

Among the 3,080 physicians who received the survey, 405 responded (13%), of whom 404 were cardiac electrophysiologists, and one was a cardiothoracic surgeon. Among responding physicians, 231 (57%) were affiliated with an academic institution, 174 (43%) were in private practice. In aggregate, 191,215 AF ablations were performed by responding physicians, and esophageal perforation with or without fistula was reported in 31 (0.016%) patients by 30 (7%) responding physicians. Characteristics of responding physicians stratified by incidence of esophageal perforation are presented in Table 1. Of note, physicians reporting esophageal perforation had performed on average a significantly greater number of AF ablations (835 ± 675 vs. 472 ± 676, $p<0.001$) and were significantly more likely to have been performing AF ablation with more years of experience ($p=0.01$). The incidence of esophageal perforation among 199 operators with above median procedural experience (>250 AF ablations performed) and among 130 physicians in practice for >10 years, however, was not greater than the overall incidence of esophageal perforation among all responding physicians (0.015% and 0.014%, respectively). No physicians reporting esophageal perforation had been in practice for less than four years, and incidence of esophageal perforation was similar in all geographic areas.

Esophageal Perforation and Fistula

Responding physicians provided full survey details for 28 of 31 patients in whom esophageal perforation or fistula formation was reported. Of these 28 patients, 16 (57%) died, 1 (4%) survived with severe neurologic injury, 2 (7%) survived with mild neurologic injury, and 9 (32%) survived and were neurologically intact. Patient characteristics, procedural data, and information regarding patient presentation and outcomes are presented for the entire cohort (n=31), and stratified by clinical outcome: death or severe neurologic injury vs. mild or no neurologic injury with p-value for difference between these sub-groups (Table 2).

Patient Characteristics

Patients presenting with esophageal perforation had a mean age of 58.7 ± 9.9 years and were 81% male. Compared with patients who survived esophageal perforation with no or mild neurologic injury, patients with esophageal perforation that resulted in death or severe neurologic injury were shorter (67.2 ± 4.3 inches vs. 70.4 ± 3.2, p=0.04), had greater body mass index (30.9 ± 6.8 kg/m^2 vs. 25.8 ± 3.3 kg/m^2, p=0.03), and lower left ventricular ejection fraction (55.1 ± 9.1 % vs. 61.7 ± 5.4 %, p=0.04). All esophageal perforation patients with left ventricular ejection fraction less than 55% (n = 4) died. There is a trend of greater prevalence of diabetes, hypertension, and obstructive sleep apnea in patients with esophageal perforation resulting in death or severe neurologic injury, however these differences did not reach statistical significance. Gastroesophageal reflux disease was reported in 23% (n = 6) of esophageal perforation patients, and hiatal hernia was reported in 10% (n = 3) of esophageal perforation patients. Of patients who developed esophageal perforation, 48% (n = 13) underwent catheter ablation of persistent atrial fibrillation and 55% (n = 15) had undergone at least one prior left atrial ablation for atrial fibrillation.

Procedural Characteristics

An externally irrigated radiofrequency (RF) ablation catheter was utilized in 21 (76%) esophageal perforation cases, of which 50% survived without severe neurologic injury. A second generation Cryoballoon was used in two esophageal perforation cases (7%) and a non-irrigated RF catheter was used in two (7%) esophageal perforation cases, all four of which died from esophageal perforation related injury. Posterior wall RF ablation was performed with a power of 29.2 ± 7.7 W (range 20 - 40 W) and lesion duration of 30.6 ± 16.4 seconds (range 15 – 60s). Esophageal perforation occurred despite esophageal monitoring in 90% (n = 25) of patients and pre-procedure CT scan or MRI in 94% (n = 26) of patients. The most common RF ablation lesion set was ipsilateral pair-wise pulmonary vein isolation (PVI, 86%), and 14% (n = 4) of esophageal perforation patients had additional posterior wall RF ablation in conjunction with PVI. There was no difference in ablation catheters used between patients with esophageal perforation who survived without severe neurologic injury and patients who died or had severe neurologic injury (, p=0.60, table 2).

Patient Presentation and Outcomes

The post-operative day (POD) of reported symptom onset in esophageal perforation patients was 19.3 ± 12.6 days (range 1 – 59 days), and the POD of admission was 22.5 ± 11.1 days (range 7 – 59 days). Admission on the day of symptom onset occurred in 54% of esophageal perforation patients, of whom 46% survived without severe neurologic injury. The 13 esophageal perforation patients who were not readmitted on the day of symptom onset were readmitted 5.8 ± 4.8 days (range 1 – 18 days) after report of initial symptoms with significantly increased incidence of fever (92% vs. 38%, p = 0.003) and neurologic symptoms (69% vs. 15%, p =0.02, Figure 1). Of 15 esophageal perforation or fistula patients with neurologic symptoms at time of

readmission, 10 died, 1 survived with severe neurologic injury, 2 survived with mild neurologic injury, and 2 survived without neurologic injury.

The specialty of the physician who first evaluated esophageal perforation or fistula patients was most frequently emergency medicine (63%). An electrophysiologist performed the initial evaluation for 14% of patients and 3 out of 4 (75%) of these patients survived without severe neurologic injury. Patients who survived without severe neurologic injury tended to be more likely to have had a CT with IV contrast during initial evaluation, but the trend did not reach statistical significance (91% vs. 59%, p = 0.09). Esophageal endoscopy was performed in 6 esophageal perforation patients. Three patients who were ultimately diagnosed with atrial-esophageal fistulas (AEF) underwent esophageal endoscopy and all three of these patients died. Three patients ultimately diagnosed with esophageal perforation without fistula formation underwent esophageal endoscopy, of whom one died of severe sepsis and two survived without severe neurologic injury.

Of the 28 patients with esophageal perforation for whom detailed information was provided, 20 (71%) were diagnosed with AEF, 4 (14%) were diagnosed with pericardial-esophageal fistula, and 4 (14%) were diagnosed with esophageal perforation without fistula formation. The final diagnosis of patients who died or had severe neurologic injury and was significantly different that of patients who survived without severe neurologic injury (p=0.002, table 3). Among esophageal perforation patients, a significantly greater proportion of patients who died or had severe neurologic injury were ultimately diagnosed with an AEF (94% vs. 36%). Of the 20 patients with AEF, 16 died or had severe neurologic injury, 2 had mild neurologic injury, and 2 survived without neurologic injury at time of discharge. All patients with AEF who survived without severe neurologic injury underwent thoracic surgery (Figure 2a). Three patients with

esophageal perforation without fistula underwent esophageal stenting and survived without neurologic injury, and one patient with esophageal perforation without fistula underwent thoracic surgery and later died from sepsis (Figure 2b). All four patients with pericardial-esophageal fistulas survived following thoracic surgery and were neurologically intact at discharge (Figure 2c).

Esophageal stenting was performed in six total patients. All three patients who were ultimately found to have AEF who underwent esophageal stenting died or had severe neurologic injury, whereas all three patients with esophageal perforation without fistula who underwent esophageal stenting survived without neurologic injury. One patient who was found on surgical exploration to have an esophageal perforation without fistula subsequently underwent percutaneous endoscopic gastrostomy tube insertion and esophageal rest and survived without neurologic injury. Of the 11 esophageal perforation with or without fistula patients who survived to hospital discharge without severe neurologic injury, 10 patients remained well with a mean follow-up time of 26 ± 16 months post discharge. One patient who underwent surgical repair of a pericardial-esophageal fistula and was discharged without neurologic injury was readmitted one week after discharge and died of a stroke related to an AEF at the surgical repair site.

Discussion

The present survey is the largest series of systematically collected data regarding esophageal injury in AF ablation to date. No physicians with less than 4 years experience reported esophageal perforation, while esophageal perforation was reported most frequently by physicians with greater than 10 years experience. Factors contributing to this difference may include greater awareness of esophageal injury among more recently trained physicians, more experienced operators performing procedures on higher risk patients, a greater willingness of

experienced physicians to report complications, and greater opportunity for low frequency events among physicians with greater experience.

While cases of esophageal perforation without fistula, and pericardial-esophageal fistula have been previously reported(3), we are not aware of prior estimates of their relative incidence in comparison to AEF in the literature. Our data suggests that 28% of esophageal perforation patients present without fistula or with pericardial-esophageal fistula, and the prognosis of these patients is significantly better than that of patients presenting with AEF. It is unclear if improved vigilance will allow a greater proportion of patients to be diagnosed and treated prior to the development of AEF.

In patients presenting with esophageal perforation, lower left ventricular ejection fraction and increased body mass index were associated with death or severe neurologic injury. The increased prevalence of comorbidities such as diabetes, hypertension, obstructive sleep apnea, and GERD in patients with death or neurologic injury related to esophageal perforation was not statistically significant, but given the small sample size and retrospective nature of the data collected, it is unclear if these comorbidities may be associated with increased risk of esophageal perforation or with unfavorable outcome in patients that develop esophageal perforation.

Incident esophageal perforation was noted with all types of ablation catheters and despite all methods of esophageal monitoring. While externally irrigated RF was the most commonly utilized ablation catheter in esophageal perforation patients, it is unclear if this was disproportionately so, and nearly all of the esophageal perforation patients who survived without severe neurologic injury underwent RF ablation with externally irrigated RF catheters.

Esophageal monitoring of some form was performed in 90% of esophageal perforation patients, and no individual form of esophageal monitoring was associated with improved survival. These

data suggest that use of esophageal monitoring alone is insufficient for esophageal perforation prevention and that additional efforts such as intensified esophageal monitoring and empiric reduction in RF power / duration on the LA posterior wall should be considered in combination with prescription of a proton pump inhibitor in the post-operative period.

Our data reinforce the importance of close post-operative follow-up and a low threshold for immediate evaluation of patients with symptoms concerning for esophageal perforation, such as fever, odynophagia, neurologic symptoms, and chest pain. Incidence of fever and neurologic injury was significantly greater on admission in patients with delay between initial symptom report and admission, and although the sample size was small, patients who initially presented to their electrophysiologist appeared to have a favorable prognosis. In addition, given poor outcomes associated with AEF without surgical correction, as well as poor outcomes when endoscopy or esophageal stenting is performed and the patient is ultimately found to have an AEF, we believe that an early, surgical approach to esophageal perforation should be strongly considered. Finally, the reported successful surgical repair of esophageal-pericardial fistula followed by subsequent development of AEF and death weeks after discharge demonstrates the importance of close follow-up in the post-operative period following successful surgical repair of esophageal perforation.

Limitations

Our study has several limitations common to surveys. All data were reported retrospectively by responding physicians, and inaccurate responses due to poor recall cannot be excluded. Reported 0.016% incidence of esophageal perforation in the present analysis is lower than the 0.03% - 0.04% incidence previously reported.(4,10), which might indicate low response rate or self-selection bias, which are limitations of survey-based data. The population of physicians

who respond to online surveys may not be representative of all physicians who perform AF ablation. In addition, the survey solicited responses by email from physicians who performed AF ablation with the subject, "Response Requested: Esophageal Injury in AFib Ablation," thus the overall 13% response rate may be enriched relative to the overall survey population in incidence of esophageal injury. Despite this, the distribution of responding physicians provides a diverse sample of physicians who perform AF ablation with regards to geographic distribution, experience, and practice setting. Lastly, given the anonymous nature of the survey, it is impossible to obtain additional details regarding patients in the survey.

The analysis is descriptive in nature. Small sample size is expected due to low prevalence of esophageal injury in atrial fibrillation ablation, especially severe esophageal injury. Due to the small sample size, the comparisons are considered exploratory and hypothesis-generating.

Conclusions

Esophageal perforation following AF ablation continues to occur with multiple catheter types and despite multiple modalities of esophageal monitoring during ablation and post-procedure PPI. Among patients who present with esophageal perforation, increased BMI and decreased left ventricular ejection fraction may be associated with unfavorable outcomes. Because the window between symptom onset, diagnosis and neurologic injury is often short, and the prognosis of esophageal perforation substantially improved if diagnosed prior to development of atrial-esophageal fistula, it is extremely important to maintain vigilance for this rare complication in the first two months after AF ablation, as well as in the post-operative period following surgical repair of esophageal perforation.

Perspectives

Competency in Medical Knowledge 1: Approximately 70% of esophageal perforation following catheter ablation of atrial fibrillation results in atrial esophageal fistula. The prognosis for survival without severe neurologic injury for esophageal perforation without fistula and pericardial-esophageal fistula is more favorable than that of atrial esophageal-fistula.

Competency in Medical Knowledge 2: The window between symptom onset and neurologic injury is often short in patients with esophageal perforation following atrial fibrillation ablation. It is extremely important to maintain vigilance for this rare complication in the first two months after AF ablation, as well as in the post-operative period following surgical repair of esophageal perforation.

Competency in systems-based-practice: Patients present with symptoms of esophageal perforation to physicians of varied specialties, and prompt diagnosis and treatment requires a coordinated, mutli-disciplinary approach. Following catheter ablation of atrial fibrillation close follow-up by operating physicians may facilitate early diagnosis and coordination of care.

Competency in interpersonal & communication skills: It is important to discuss symptoms suggestive of severe esophageal injury with patients following catheter ablation of atrial fibrillation to facilitate timely physician evaluation.

Translational Outlook: Esophageal perforation remains a rare but devastating complication of atrial fibrillation ablation despite utilization of various esophageal monitoring techniques. Additional research is required to develop ablation techniques with reduced risk of esophageal injury and imaging techniques that allow earlier detection.

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Table 1. Characteristics of Responding Physicians

	Physicians without incidence of Esophageal Perforation(n = 375)	Physicians reporting incidence of Esophageal Perforation (n = 30)	P value
Private Practice	43%	47%	0.71
University Based	57%	53%	0.71
AF Ablations Performed	250[110-500]	550[400-1,000]	<0.001
Years Performing AF Ablation			0.01
1 to 3 Years	20%	0%	
4 to 6 Years	19%	20%	
7 to 9 Years	29%	30%	
≥ 10 Years	32%	50%	
Practice Region			0.44
North America	76%	80%	
South America	4%	0%	
Europe	10%	17%	
Asia	6%	0%	
Australia	4%	3%	

AF = atrial fibrillation

Table 2. Patient and Procedural Characteristics for Esophageal Perforation Patients

	Esophageal Perforation With or Without Fistula – All (N = 31)	Esophageal Perforation With or Without Fistula – Death or Severe Neurologic Injury (N = 17)	Esophageal Perforation With or Without Fistula – Mild or No Neurologic Injury (N = 11)	P value
Age (yrs)	58[50-67]	60[54-67]	55[46-66]	0.29
Male	81%	77%	82%	1.0
Height (inches)	70[66-72]	69[65-72]	71[68-72]	0.04
Weight (pounds)	182.5[160-210]	185[160-220]	170[160-201]	0.32
Body Mass Index (kg/m^2)	26.8[24.4-31.8]	28.5[25.1-35.5]	24.4[23.3-27.0]	0.03
Left Atrial diameter (cm)	4[4-4.65]	4.2[4-5]	4[4-4.2]	0.67
Left Ventricular				0.04

Ejection Fraction	60[55-65]	55[50-60]	62[55-65]	
Diabetes	26%	35%	9%	0.19
Hypertension	65%	77%	45%	0.12
Coronary Artery Disease	10%	6%	9%	1.0
Obstructive sleep apnea	14%	18%	0	0.26
Gastroesophageal Reflux Disease	23%	18%	27%	0.65
Hiatal Hernia	10%	12%	9%	1.0
Persistent AF	48%	53%	36%	0.46
Repeat Ablation	55%	53%	45%	1.0
Ablation Catheters				0.60
RF, non-irrigated	7%	12%	0%	
RF, external irrigation	76%	65%	91%	
RF, internal irrigation	7%	6%	9%	
Cryoballoon-2nd generation	7%	12%	0%	
Other	3%	5%	0%	
Posterior Wall RF Power (Watts)	30[25-30]	30[25-30]	30[25-30]	0.78

Posterior Wall RF Lesion Duration	30[20-30]	30[20-30]	30[20-60]	0.87
Esophageal Mon.				
Intracardiac Echocardiography	26%	18%	45%	0.19
Single Point Temp	65%	59%	73%	0.69
Multipoint Temp	10%	12%	9%	1.0
Fluoroscopy of Probe	3%	18%	36%	0.38
3D Mapping of Esophagus	3%	6%	0%	1.0
None	10%	6%	18%	0.54
Pre-ablation imaging				0.55
MRI	10%	6%	18%	
CT	84%	82%	64%	
None	6%	12%	18%	
RF Lesion Set				
Pair-wise Ipsilateral PVI	88%	94%	82%	0.56
Single Ring PVI	12%	6%	18%	0.56
Roof Line	24%	13%	36%	0.35

Additional Posterior Wall RF	14%	13%	18%	1.0
Proton Pump Inhibitor Post-Ablation	77%	65%	91%	0.19

AF = atrial fibrillation; RF = radiofrequency; MRI = magnetic resonance imaging; CT = computed tomography; PVI = pulmonary vein isolation

p < value indicates significance between Esophageal Perforation With or Without Fistula Death or Severe Neurologic Injury and mild or no neurologic injuries.

Table 3. Patient presentation and Outcome Characteristics for Esophageal Perforation Patients

	Esophageal Perforation With or Without Fistula – All (N = 31)	Esophageal Perforation With or Without Fistula – Death or Severe Neurologic Injury (N = 17)	Esophageal Perforation With or Without Fistula – Mild or No Neurologic Injury (N = 11)	P value
POD of First Symptom Report	20[8-26]	21[10-25]	20[7-30]	0.35
Presenting Symptoms				
Odynophagia	29%	24%	36%	0.67
Fever/Chills	39%	35%	46%	0.70
Pleuritic Chest Pain	37%	24%	55%	0.12
Non-pleuritic Chest Pain	18%	18%	18%	1.0
Neurologic Symptoms	36%	33%	36%	1.0
Hematemesis / Gastrointestinal Bleed	15%	18%	9%	1.0

POD of Admission	20[13-28]	21[13-27]	20[14-30]	0.54
Time from Symptoms to Admission	2.6 ± 4.6	2.7 ± 4.6	2.6 ± 4.1	
Admitted on day of first symptom report	54%	47%	63%	0.46
Specialty of Evaluating				0.58
Emergency Medicine	62%	64%	55%	
Cardiology	14%	18%	9%	
Electrophysiology	14%	6%	27%	
Internal Medicine	7%	6%	9%	
Other	3%	6%	0%	
Symptoms on Admission				
Odynophagia	32%	28%	36%	0.38
Fever/Chills	71%	76%	64%	0.67
Pleuritic Chest Pain	36%	24%	55%	0.12
Non-pleuritic Chest Pain	18%	18%	18%	1.0

Neurologic Symptoms	50%	59%	36%	0.44
Hematemesis / Gastrointestinal Bleed	11%	18%	9%	1.0
Admission Imaging				
Esophageal Endoscopy	21%	24%	18%	1.0
Non-Contrast Only CT	14%	18%	9%	1.0
CT with IV contrast	71%	59%	91%	0.09
CT with Oral Contrast	14%	18%	9%	1.0
Final Diagnosis*				0.002
Atrial-Esophageal Fistula	72%	94%	36%	
Pericardial-Esophageal Fistula	14%	0%	36%	
Esophageal Perforation without Fistula	14%	6%	28%	

Intervention				0.03
Thoracic Surgery	52%	47%	64%	
Esophageal	23%	12%	36%	
Stenting				
None	25%	41%	0%	

POD = post-operative day; CT = computed tomography

p value indicates significance between Esophageal Perforation With or Without Fistula Death or Severe Neurologic Injury and mild or no neurologic injuries.

Figure 1. Symptom Progression Prior to Admission. Reported symptoms of esophageal perforation patients not admitted at time of initial symptom report (n = 13) on initial presentation (red columns) and on admission (blue columns).

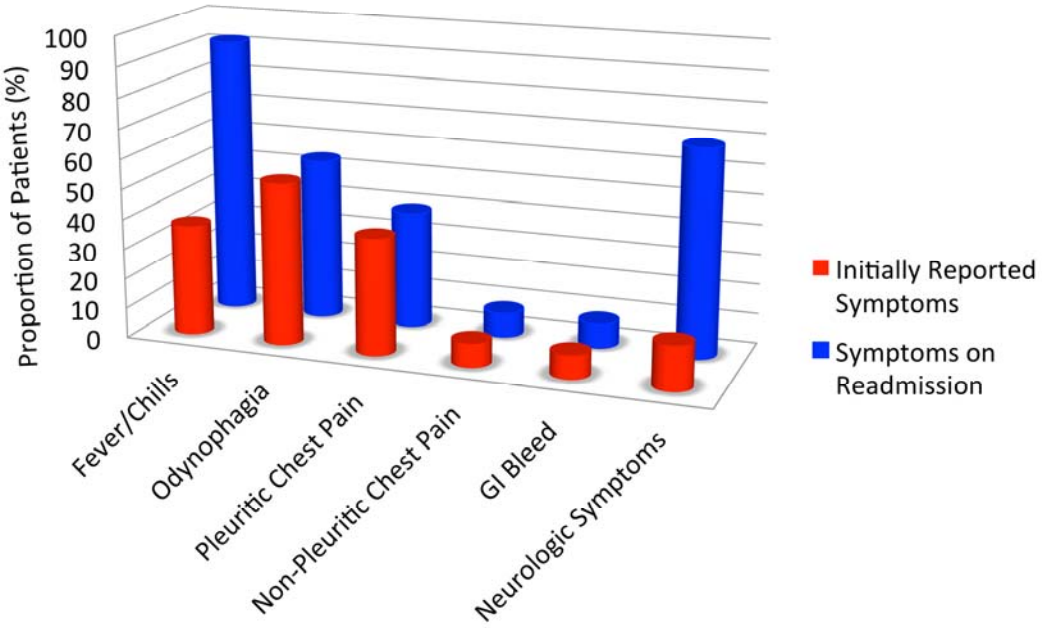


Figure 2a. Atrial-Esophageal Fistula Outcomes Stratified by Intervention.

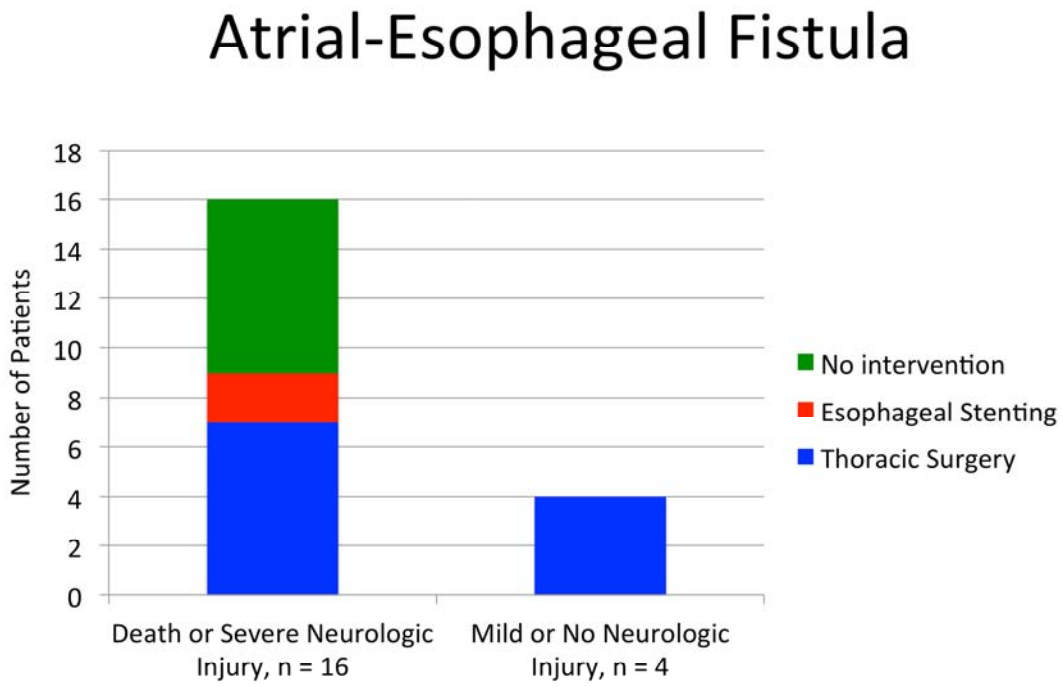


Figure 2b. Esophageal Perforation without Fistula Formation Outcomes Stratified by Intervention

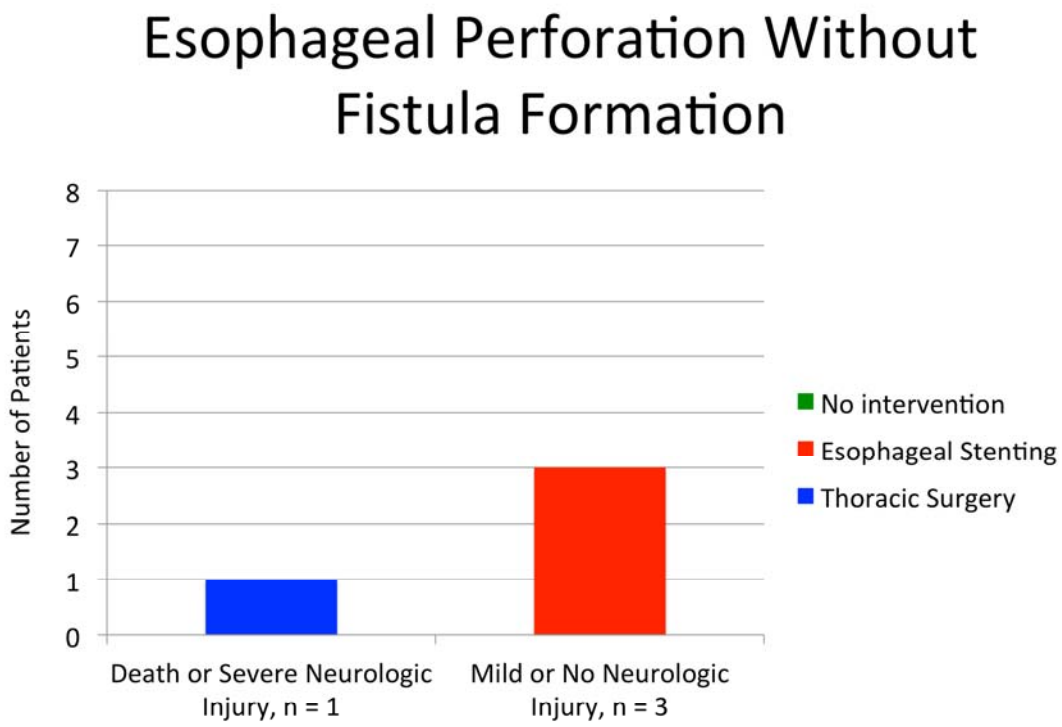
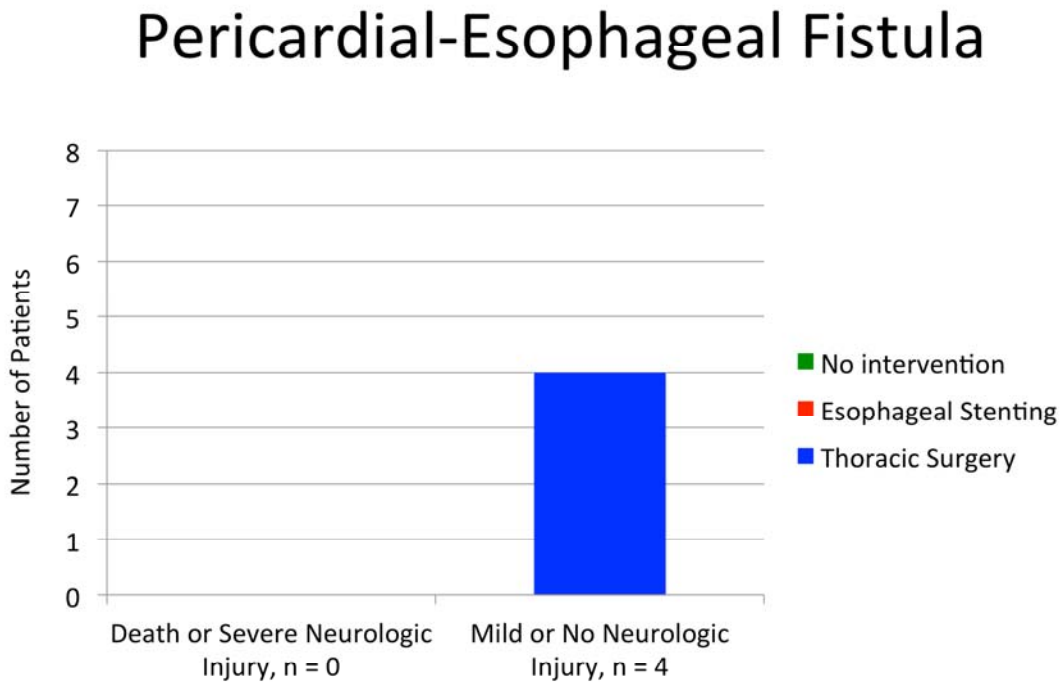
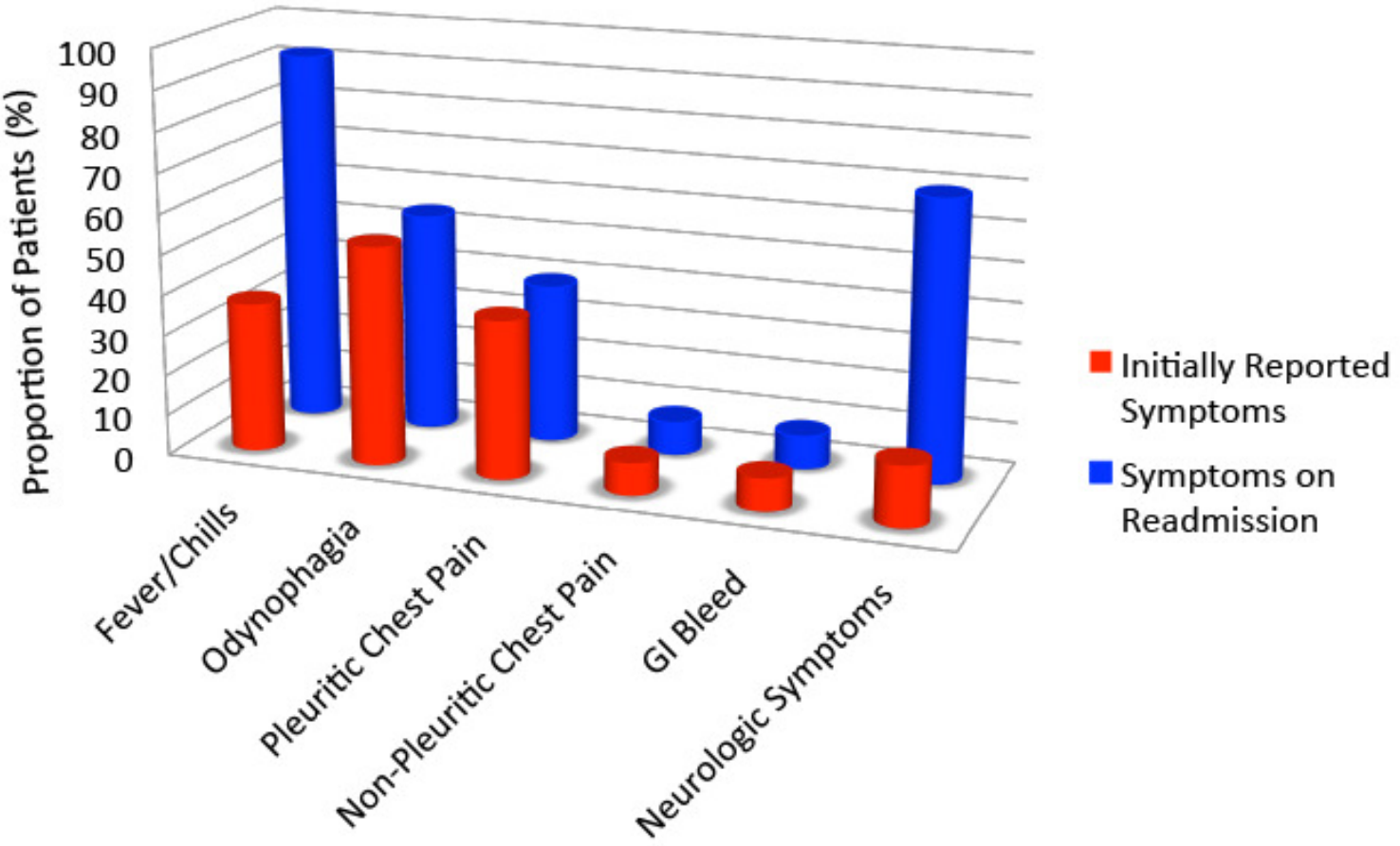
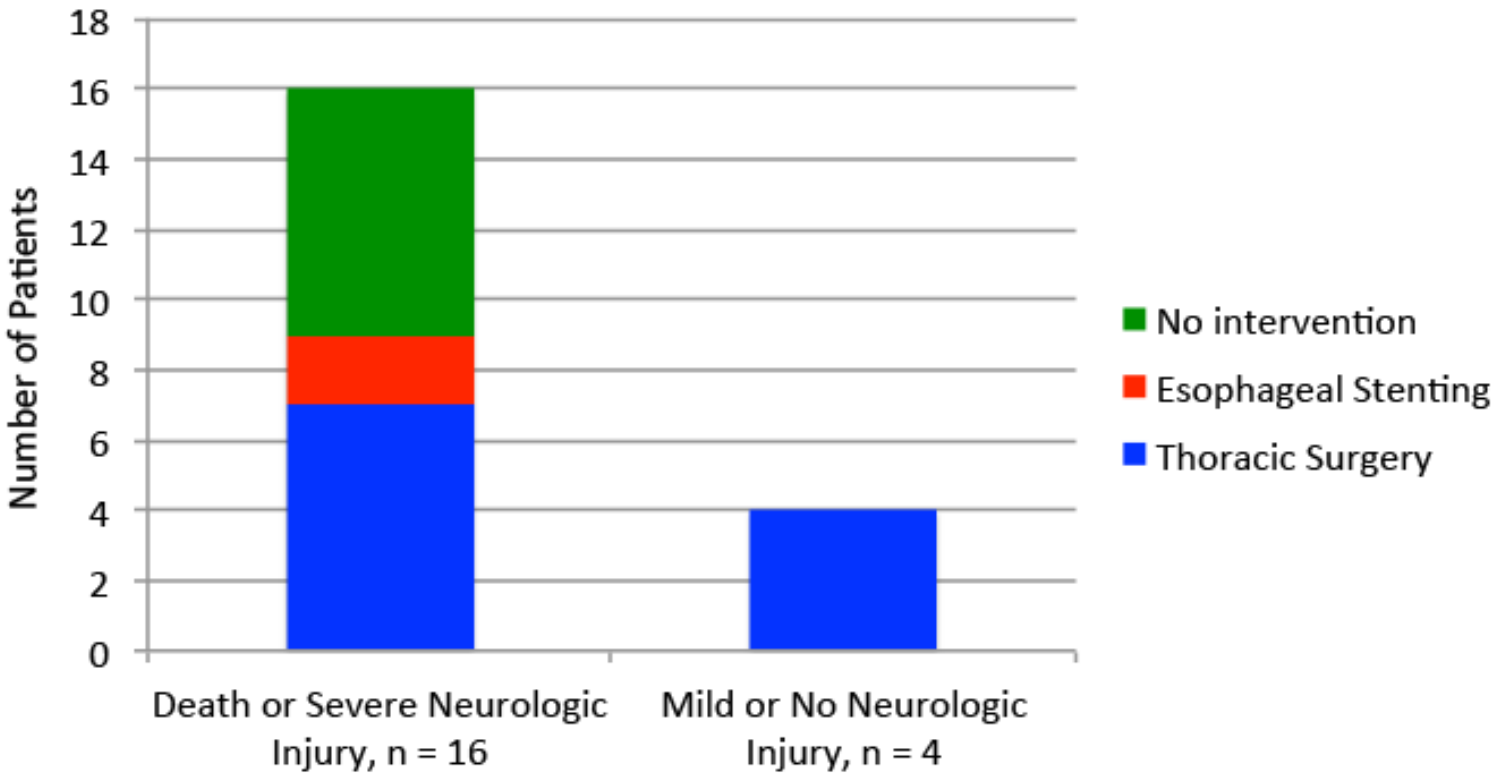


Figure 2c. Pericardial-Esophageal Fistula Outcomes Stratified by Intervention.

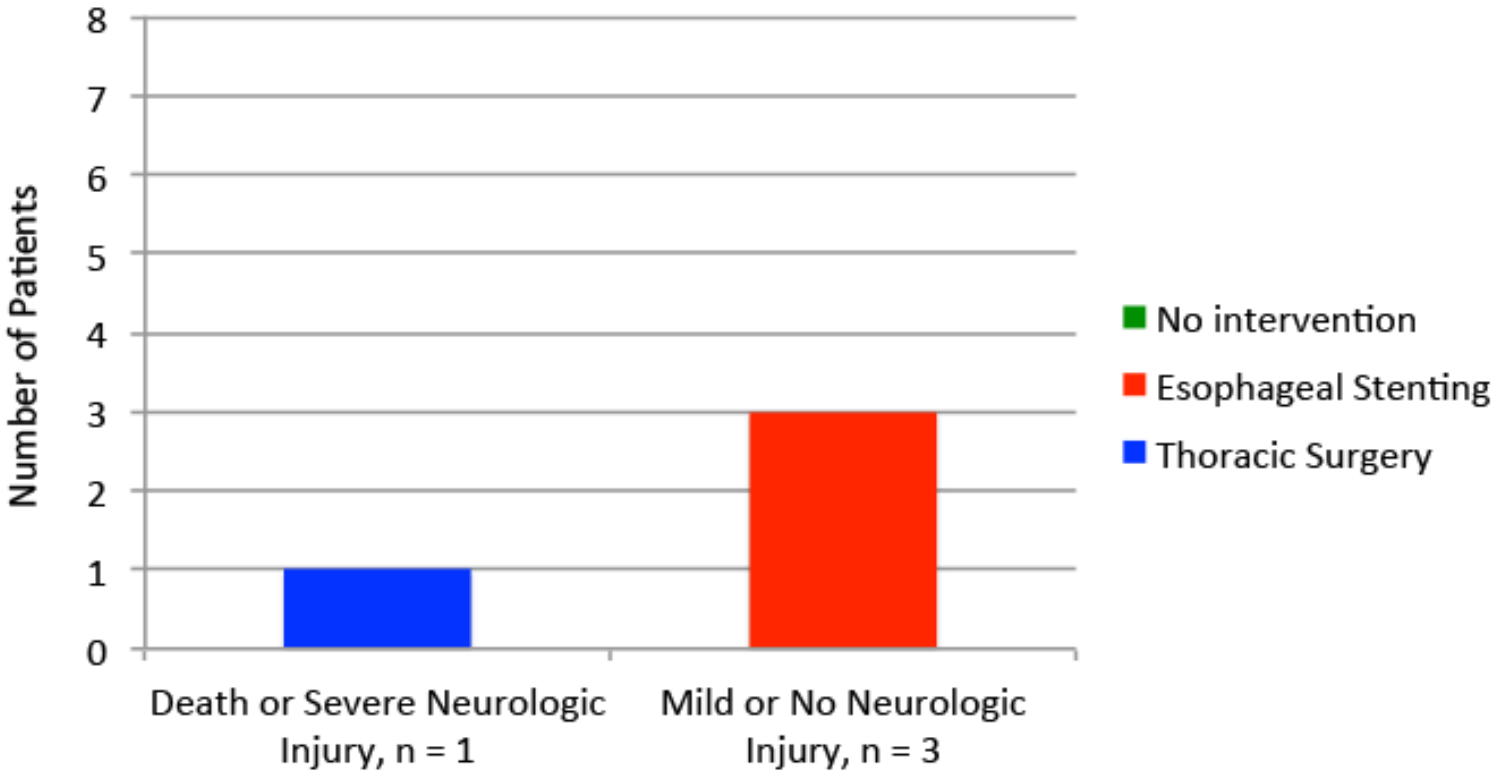



Proportion of Patients (%)
100
90
80
70
60
50
40
30
20
10
0
Fever/Chills
Odynophagia
Pleuritic Chest Pain
Non-Pleuritic Chest Pain
GI Bleed
Neurologic Symptoms
Initially Reported Symptoms
Symptoms on Readmission

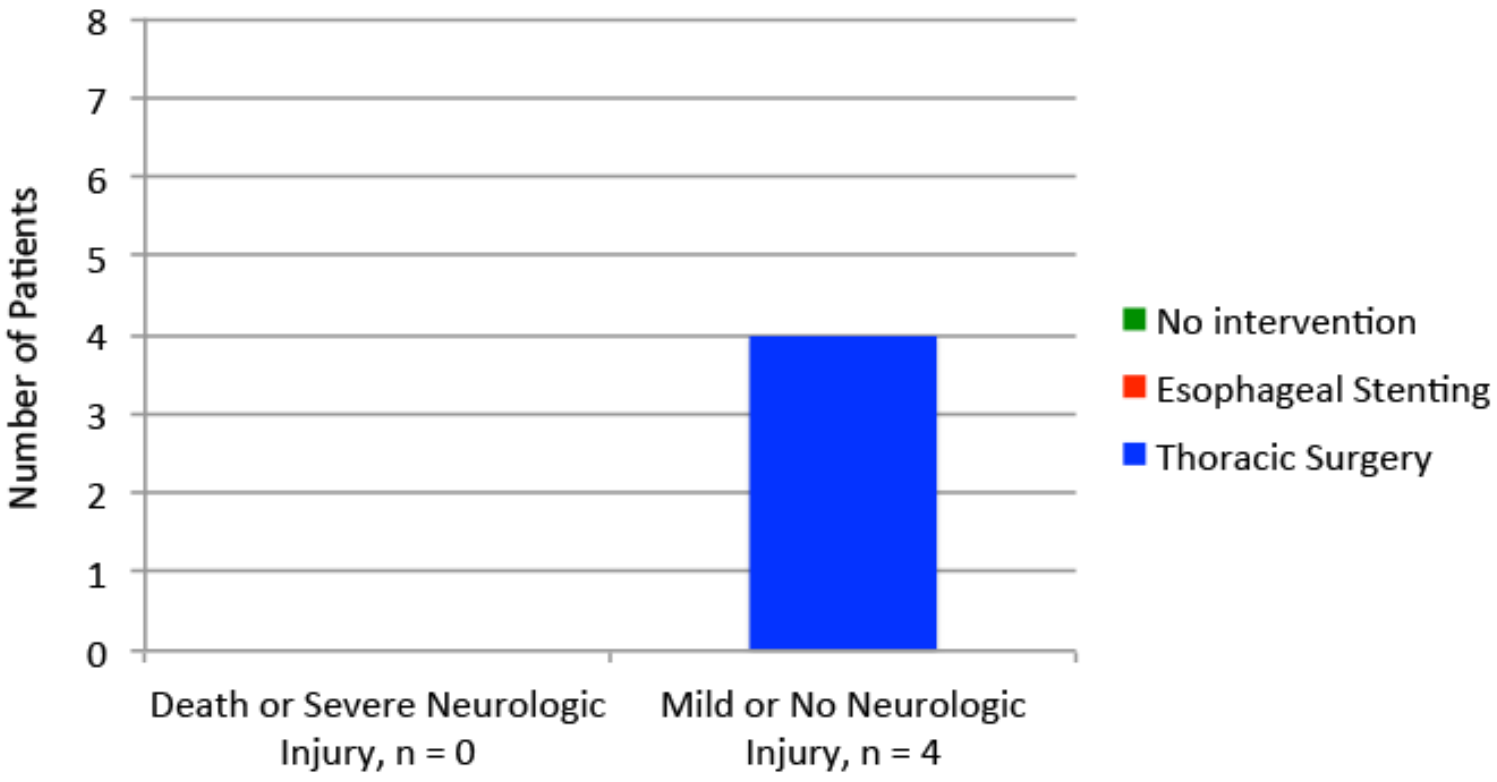
Atrial-Esophageal Fistula



Esophageal Perforation Without Fistula Formation



Pericardial-Esophageal Fistula



Esophageal Injury in AF Ablation Survey

Gregory F. Michaud, MD
Chirag Barbhaiya, MD
Harvard Medical School
Brigham and Women's Hospital

Operator Data

1. Cardiac Surgeon/Electrophysiologist
2. University based/Private practice
3. Years performing AF ablation
    a. 1-3
    b. 4-6
    c. 7-9
    d. ≥10
4. Total number of AF ablations performed
    a. 1-50
    b. 51-100
    c. 100-200
    d. 200-500
    e. ≥500 (Provide estimate)

5. Any incidence of esophageal injury (symptomatic confirmed esophageal ulcer, gastroparesis, esophageal perforation, esophageal fistula) following AF ablation procedure in which you were primary operator.
    a. Yes
    b. No (If no, end of survey)

6. Number of patients with symptomatic esophageal injury with documented ulcer
    a. For each case of symptomatic esophageal ulcer:

Patient	POD# of Dx	Diagnostic modality	Complete resolution?
#1			
#2			

7. Number of patients with Gastroparesis
    a. For each case of Gastroparesis:

Patient	POD# of Dx	Complete resolution?
#1		
#2		

8. Number of patients with atrial esophageal perforation, with or without fistula formation:

One of each subsequent field would be filled out for each case esophageal perforation, with or without fistula

Patient Data

1. Age
2. Gender
3. Height
4. Weight
5. LA size
6. Comorbidities (check all that apply)
    a. Diabetes
    b. Hypertension
    c. Coronary artery disease
    d. Obstructive sleep apnea
    e. Chronic renal insufficiency
    f. Dialysis
7. Gastrointestinal/Esophageal Comorbidities (check all that apply)
    a. GERD
    b. Hiatal hernia
    c. Achalasia
    d. Esophageal stricture
    e. Other (specify)
8. Persistent/Paroxysmal
9. Number of prior ablation procedures
    a. 1
    b. 2
    c. 3
    d. ≥4

Procedure Data

1. Type of ablation
    a. Cryoablation
    b. RF, non-irrigated
    c. RF, internally irrigated
    d. RF, externally irrigated
2. Posterior wall ablation settings if RF
    a. Power (Watts)
    b. Intended lesion duration (seconds)
3. Catheter used
4. Method of esophageal monitoring (check all)
    a. ICE
    b. Temperature
    c. Fluoroscopy of esophageal temperature probe
    d. Barium Swallow

e Other (specify)

5 Pre-ablation imaging
   a Cardiac MRI
   b Cardiac CT
   c ICE 3D Map
   d Fast Anatomical Map
   e None
   f Other (specify)

6 Lesion Set (check all)
   a Pair-wise left and right sided PVI
   b Single ring PVI
   c Roof Line
   d Posterior Wall ablation independent of PVI
   e Other (specify)

7 PPI or H2 Blocker prescribed at time of discharge
   a Yes
   b No

Presentation Data

1 Onset of symptoms (Number of days post-procedure)

2 Initial symptoms (check all)
   a Odynophagia
   b Pleuritic chest pain
   c Non-pleuritic chest pain
   d Neurologic symptoms (specify)
   e Hematemesis/GI bleed
   f Other (Specify)

3 Day of presentation to hospital (Number of days post-procedure)

4 Specialization of physician performing initial evaluation
   a Emergency Medicine
   b Internal Medicine
   c Family Medicine
   d Cardiovascular Medicine
   e Electrophysiology
   f Gastroenterology

5 Symptoms upon presentation (check all that apply)
   a Odynophagia
   b Fever/Chills
   c Pleuritic chest pain
   d Non-pleuritic chest pain
   e Neurologic symptoms (specify)
   f Hematemesis/GI bleed
   g Other (Specify)

6 Imaging studies obtained (check all, write-in main findings)
   a CXR
   b EGD

c CT non-contrast
d CT with oral contrast
e CT with IV contrast
f Barium Swallow
g Other (specify)

7 Diagnosis
a Esophageal perforation without fistula formation
b Pericardial-Esophageal fistula
c Atrial-esophageal fistula

8 Intervention performed
a None
b Esophageal stenting (Procedural outcome)
c Thoracic surgery (Procedural outcome)
d Other (specify)

9 Neurologic outcome
a Neurologically intact
b Mild neurologic impairment
c Severe neurologic impairment
d Death

10 Non-neurologic adverse events during admission
a ICU admission
b Mechanical ventilatory support
c Blood transfusion
d Atrial fibrillation
e Vasopressor support

11 Discharge
a Home
b Skilled Nursing Facility
c Death

12 Duration of follow-up since presentation with atrial esophageal fistula

13 Additional complications since Hospital Discharge

14 I am interested in contributing radiologic imaging for analysis of imaging findings related to esophageal fistula. Images will be uploaded via an anonymous website and will not contain operator or patient identifiers
a yes, please provide email for further information:_____
b No

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Authors	Chirag Barbhaiya, Saurabh Kumar, Roy John, Usha Tedrow, Bruce Koplan, Laurence Epstein, William Stevenson, and Gregory Michaud
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Article entitled: Global Survey of Esophageal Injury in Atrial Fibrillation Ablation: Characteristics and Outcomes of Esophageal Perforation and Fistula

Manuscript number: JEP072715-0251

Corresponding Author: Dr. Barbhaiya

Corresponding author's printed name: Chirag Barbhaiya

First author's printed name: Chirag Barbhaiya

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Corresponding Author: Dr. Barbhaiya

Corresponding author's printed name: bruce koplan

First author's printed name: chrag barbaya

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Author/s:
Barbhaiya, CR; Kumar, S; Guo, Y; Zhong, J; John, RM; Tedrow, UB; Koplan, BA; Epstein, LM; Stevenson, WG; Michaud, GF

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