Peddireddy Nithin (Orcid ID: 0000-0001-5902-0047)

Anterior Spinal Hardware Erosion of the Pharyngoesophagus: A Difficult Reconstructive Challenge—Our Experience in 9 patients

Running Title: Spinal Hardware Erosion Reconstruction

Nithin S. Peddireddy, MD[1] ORCID: 0000-0001-5902-0047, Pratyusha Yalamanchi, MD, MBA[1] ORCID: 0000-0003-0776-3759, Osama Kashlan, MD, MPH[2], Paul Park, MD[2] ORCID: 0000-0002-0375-396X, Rishindra M. Reddy MD[3] ORCID: 0000-0002-4337-5051, Steven B. Chinn MD[1] ORCID: 0000-0003-4282-0640, Keith A. Casper MD[1] ORCID: 0000-0003-2878-3863, Kelly M. Malloy MD[1] ORCID: 0000-0002-0337-9293, Chaz L. Stucken MD[1], Mark E.P. Prince MD[1], Andrew J. Rosko, MD[1] ORCID: 0000-0001-6432-5451, Matthew E. Spector, MD[1] ORCID: 0000-0001-7646-6075

[1]Department of Otolaryngology-Head and Neck Surgery, University of Michigan, Ann Arbor, MI, USA
[2]Department of Neurosurgery, University of Michigan, Ann Arbor, MI, USA
[3]Section of Thoracic Surgery, Department of Surgery, University of Michigan, Ann Arbor, MI, USA

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Corresponding Author:

Nithin S. Peddireddy, MD
Department of Otolaryngology-Head & Neck Surgery Michigan Medicine
1500 East Medical Center Drive
Ann Arbor, MI 48109, United States of America
Phone: 734-936-8051
nithins@med.umich.edu

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Data Availability:

The data that was used is presented in the article. For any specific questions, the corresponding author can be contacted.

Key Points:

- Pharyngoesophageal perforation secondary to anterior spinal hardware erosion is a difficult dilemma with many reconstructive options available
- Multidisciplinary approach with thoracic surgery and neurosurgery is critical and can lead to excellent post-operative swallowing outcomes
- Patients who have a history of radiation to the head and neck benefit from the use of tissue flaps
- Culture-directed antibiotic use is important to ensure surgical healing and given the risk of salivary fistula

- After reconstruction, there may be need for further, less invasive interventions such as diverticulectomy or esophageal dilation.

1. Introduction:

Pharyngoesophageal perforation (PEP) can be spontaneous, secondary to instrumentation/resection, or as a sequela of interventions such as anterior cervical discectomy and fusion (ACDF). After ACDF, PEP can either be due to intraoperative injury or hardware failure/chronic erosion [1]. The rate of injury has been variable in multiple studies, ranging from 0.02% to 1.62% [2,3]. Though incidence of PEP is rare, complications including spinal abscesses, sepsis, mediastinitis, and osteomyelitis are devastating with reported mortality rates approaching 20-50% [4,5].

Reconstruction of these defects is challenging given the intrinsic qualities of the esophagus as well as extrinsic patient factors such as a history of local radiation, nutritional status, and other comorbidities that predispose the patient to poor wound healing. Prior studies have evaluated multiple reconstructive options, including conservative management, primary closure, and a variety of different flaps (both local and free-tissue transfer). However, there are limited reports of functional outcomes after surgery. Therefore, our objective is to report our experience of the variety of reconstructive options available for PEP after an ACDF, report the need for revision surgery in many of these complex cases, and to present patients' post-operative swallowing outcomes.

2. Methods:

2.1 Ethical Considerations:

This study was approved by The University of Michigan Institutional Review Board (HUM00050982).

2.2 Study Design, Setting, and Participants

The STROBE reporting guideline was followed.

We performed a retrospective review of nine patients from 2013 to 2019 who developed PEP secondary to spinal hardware erosion confirmed on imaging or endoscopy that necessitated reconstruction at a single academic medical center. Long-term swallowing outcomes up to four years were collected.

2.3 Surgical Approach

For each patient, multidisciplinary coordination with neurosurgery and thoracic surgery was performed. If the spine was deemed unstable after removal of anterior implants and/or instrumentation, posterior fusion by neurosurgery was performed the day prior to reconstructive surgery. For reconstruction of these pharyngoesophageal defects, we used either free tissue transfer (radial forearm (RFF), anterolateral thigh (ALT), parascapular (PS)), rotational flaps (sternocleidomastoid flap (SCM)), or primary closure. All patients with free tissue flaps underwent post-operative monitoring using a standardized protocol consisting of doppler, color, turgor, and capillary refill with hourly monitoring for 48 hours, then every 2 hours for 48 hours, then every 4 hours for the remainder of the hospitalization.

2.4 Data Collection

Variables that were collected included age, gender, prior trach dependence, history of radiation exposure, location of hardware at time of presentation, length of hospital stay, type of drain (passive vs suction), antibiotic duration, fistula occurrence, re-operation/re-exploration during admission, need for further procedural intervention after discharge and timing of such intervention, total follow-up time, and swallowing outcomes. Given the case numbers and the goal of this study being experiential in nature, statistical analysis was not performed.

3. Results:

3.1 Indications and Operative Interventions

There were nine patients included in our study population. **Table 1** reports each patient's indications for ACDF, spinal surgical history, and operative neurosurgical and reconstructive intervention. Indications for ACDF ranged from prophylaxis in the setting of cervical chondrosarcoma that was resected and required post-operative radiation to cervical trauma/myelopathy. Cervical trauma was the most common indication. At presentation, six patients had both anterior and posterior hardware in place, three had only anterior hardware, and two patients had interbody cages in place that were not removed as the surrounding bone had fused. All patients had their anterior hardware removed by neurosurgery during reconstructive surgery. Two patients had an unstable spine and required posterior fixation the day prior to reconstructive surgery Reconstruction was performed with primary closure with 3 RFF, 2 ALT, and 1 PS free flap overlay; 2 primary closures without free flap overlay, and 1 SCM flap for carotid coverage for a patient who had a difficult intubation resulting in more significant pharyngotomy that was stented with a nasogastric tube rather than primary repair. A reconstructive algorithm for these patients is shown in Figure 1 and representative pictures are seen in Figure 2.

3.2 Demographic and Hospitalization Data

Table 2 reports demographic and post-operative details. Patients on average were 61.9(±14.8) years old. 4/9 were male, 5/9 were former smokers, and 3/9 had previous exposure to head and neck radiation. The post-operative length of stay was 13.4(±4.6) days. Culture-directed antibiotics were used for an average of 8.1(±8) days. Suction drains were used in 7/9 patients, while 2 patients had solely passive drain placement. For those with suction drains, there was a

requirement of subsequent red rubber catheter drain placement for wound irrigation due to a salivary leak in 6/7 that was found by having the patient take in water dyed blue and evaluating the suction drain for blue liquid. There was a low threshold to place these passive drains to minimize the need for operative intervention, and doing so resulted in only 3 patients requiring operative takeback for management of infection/dehiscence, with no development of recurrent fistulae

3.3 Follow-up, Swallowing Outcomes, Additional Interventions:

The average follow-up time was 2.3(±1.8) years. Eight patients were able to take all nutrition orally on average 57.6 (±30.9) days after their reconstructive surgery, while one patient with a history of radiation for treatment of larynx cancer used a G tube for nutrition with some oral trial. There were no restrictions to their diet, though some patients did have trouble with dry food and preferred liquids. The decision to advance to an oral diet was made in a multidisciplinary fashion utilizing speech language pathology, patient preference, physical examination, and/or swallow studies. Each patient was examined in clinic prior to this decision, and 6/8 patients were seen in conjunction with a head and neck trained speech language pathologist. It was found that four patients had post-operative diverticula on average 179 days after reconstruction; three required endoscopic diverticulectomy. Three patients also required esophageal dilation. One patient required a tracheostomy and was subsequently decannulated

4. Discussion:

4.1 Key Findings

Management of pharyngoesophageal erosion secondary to anterior spinal hardware remains challenging. While a number of reconstructive approaches have been described, there is limited data on postoperative functional/swallowing outcomes. Here, our study demonstrates that a

customized, multidisciplinary approach to reconstruction and follow-up is key and can promote excellent wound healing and swallowing outcomes. Patients can have multiple complications including diverticulectomy, salivary leaks requiring additional intervention, and need esophageal dilation, and it is important to counsel them on these possibilities. However, an oral diet is possible, and all but one of our patients demonstrated complete oral nutrition without supplementation regardless of reconstructive option.

4.2 Comparison to Prior Studies

There is no single "ideal" flap, either free tissue or local, for reconstruction after PEP secondary to anterior spinal hardware. In our study, those patients who had a previous history of head and neck radiation were reconstructed with tissue flaps. The local effects of radiation are known to be detrimental to rapid dividing tissues such as mucosa, leading to poor wound healing, higher infection risks, and increased risks of complications [6]. However, free flap reconstruction has been shown to be effective and have high success rates in previously irradiated areas in the head and neck [7] with comparable anastomotic failure rates as compared to non-irradiated fields [8]. It is therefore a reasonable option to reconstruct with tissue flaps in these patients with a history of radiation as the increased bulk of tissue and coverage can have a high chance of reconstructive success while also providing redundant tissue to help reduce the chance of a leak. Though there have been studies suggesting that gastro-omental flaps lead to earlier return of feeding or resolution of leak on esophagram [9], these authors did not use these flaps due to the need to enter the abdomen and the subsequent potential increase in infection risk.

Conclusion:

A variety of reconstructive options can be used for fistula closure due to anterior spinal hardware erosion with excellent swallowing outcomes. A customized, multidisciplinary approach must be

used based on indication for ACDF, stability of the spine with hardware removal, patient's previous exposure to radiation, and their extent of pharyngoesophageal erosion.

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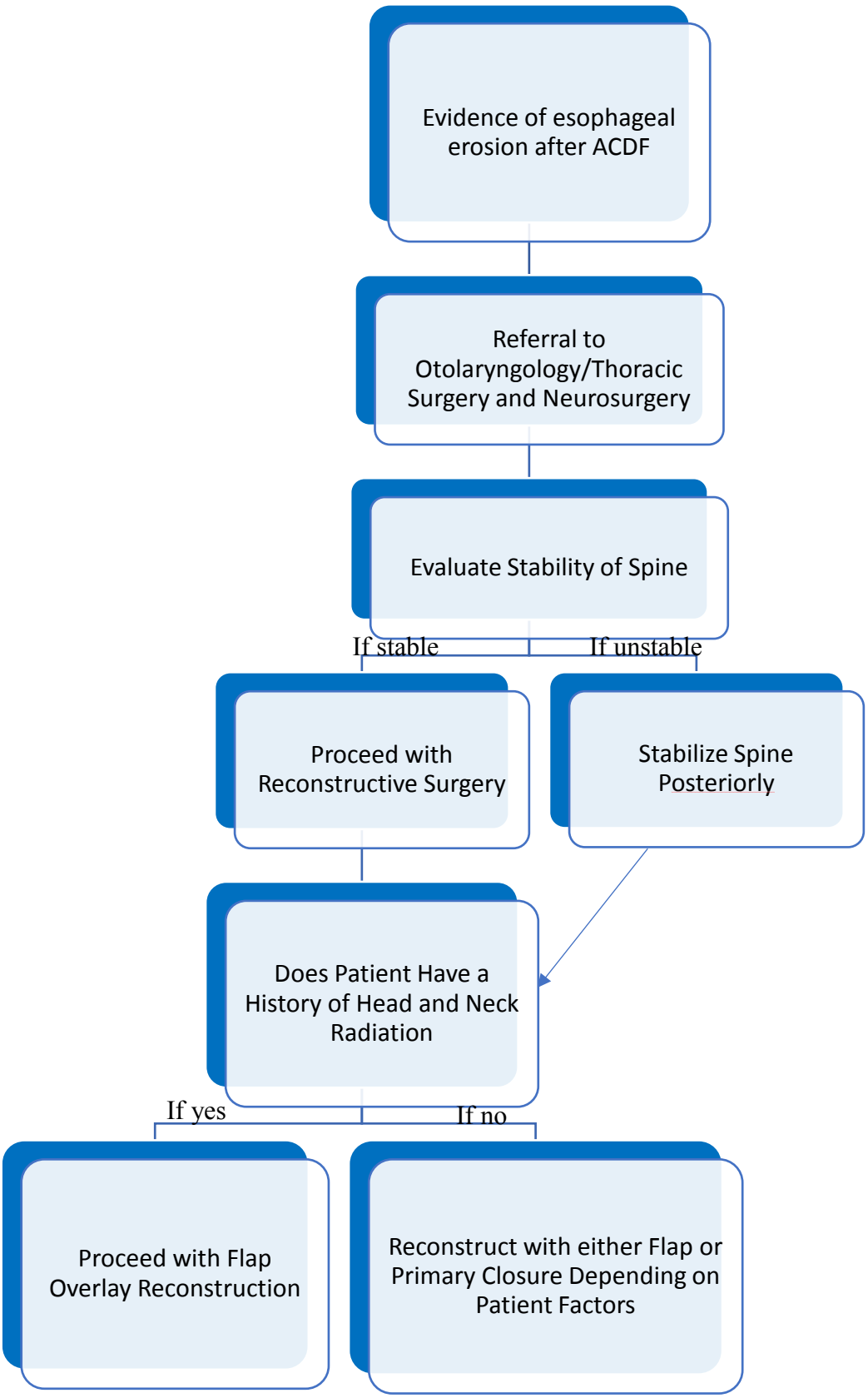

Figure 1: Reconstructive Algorithm

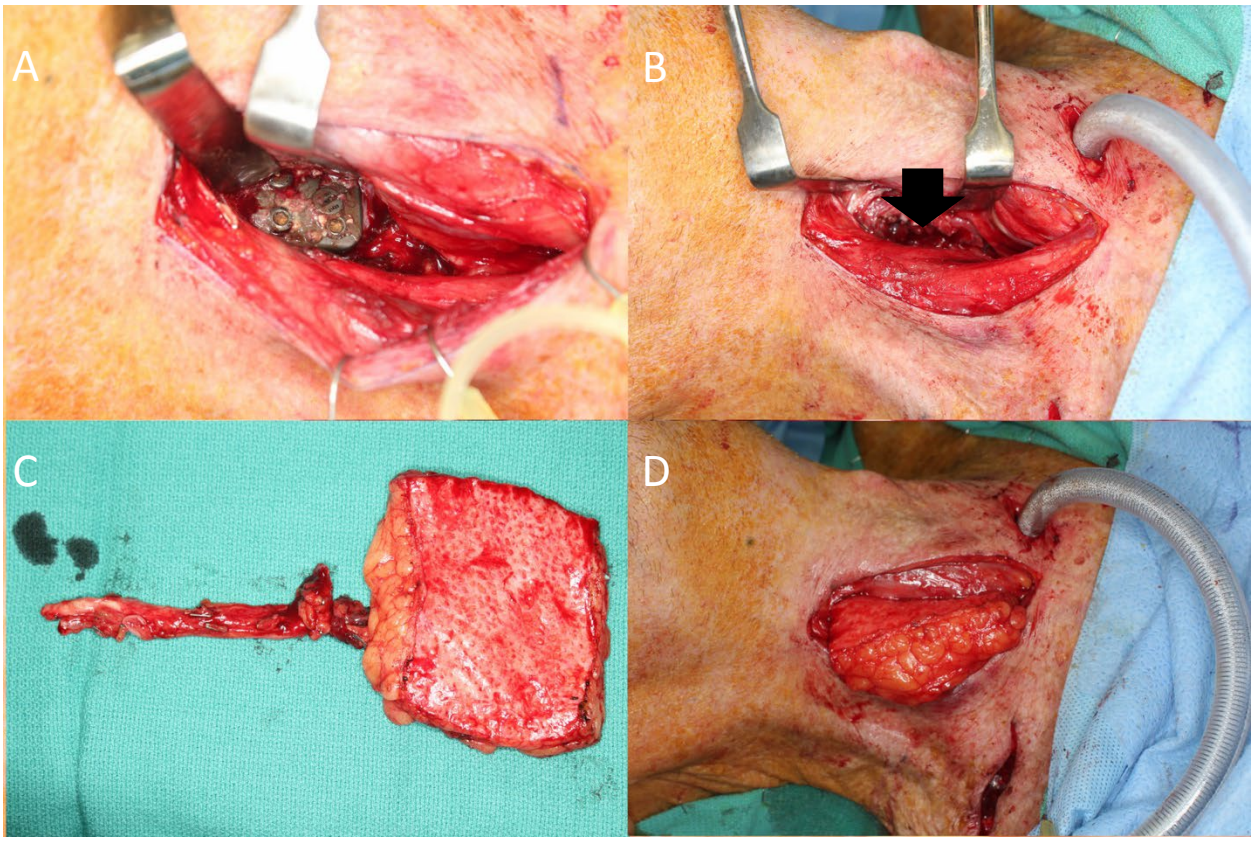

Figure 2: Intraoperative Reconstructive Approach

A: Exposure of plate

B: Primary repair of PEP (arrow to repair)

C. Deepitethialized anterolateral thigh flap for overlay of repair

D. Flap sutured in place over repair

Patient	Indication for ACDF	Levels of Spine Originally Intervened Upon	Neurosurgical Intervention	Reconstruction Type
1	Cervical Trauma	C3-C6	Debridement of infection in corpectomy site	Primary Repair with ALT Overlay
2	Cervical Disc Herniation	C4-T1	Removal of anterior plate and screws from C-4 to T- 1	Primary Repair without tissue overlay
3	Cervical Trauma; Prior attempt at repair with SCM rotational Flap	C5-C7	Removal of corpectomy graft, revision anterior fusion with placement of interbody cage	Primary Repair with RFFF Overlay
4	Lower extremity weakness and unstable spine in the setting of larynx radiation	C5-T1	Removal of anterior plate and screws	Primary Repair with ALT Overlay
5	Osteomyelitis	C2-T1	Anterior hardware Removed	Primary Repair without tissue overlay
6	Cervical Myelopathy	C4-T1	Day prior to reconstruction- posterior Fusion C4-C7; day of reconstruction-removal of anterior plate and screws. Two interbody cages left in place	Primary Repair with Parascapular Overlay
7	Cervical Trauma	C5-C7	Removal of anterior plate and screws; one interbody cage left in place	Primary Repair with RFFF Overlay
8	Cervical Stenosis; in the setting of oropharyngeal radiation	C4-C7	Day prior to reconstruction- C5-C7 total laminectomies, C3-T2 posterior spinal fusion; day of reconstruction-removal of anterior plate and screws	Primary Repair with RFFF Overlay
9	Prophylactic fusion during resection of cervical chrondrosarcoma in the setting of required post-operative radiation	C2-C7	Removal of anterior plate and screw	SCM Rotational Flap

Table 1: Indications for ACDF and Operative Interventions during Reconstruction

Variable	Overall n (%)
Male, n (%)	4(44)
Age, mean (SD), y	61.9 (15)
Race, n (%)	
White	8(89)
Other	1(11)
Tobacco Use, n (%)	
Current	0 (0)
Former	5 (56)
Never	4(44)
Alcohol Use, n (%)	
Current	2(22)
Former	2(22)
Never	5(56)
Radiation, n (%)	
Yes	3 (33)
No	6 (67)
Length of Stay, mean (SD), d	13.4 (5)
Follow-up, mean (SD), m	27 (21)
Antibiotic duration, mean (SD), d	8.1 (8)
Drain Requirement, n (%)	
Initial Suction	7(78)
Initial Passive	2(22)
Post-Operative Complications, n (%)	
Leak	6(67)
Diverticula	4(44)
Need for Intervention	3(33)
Return to OR for dehiscence/infection	2(22)
Tracheostomy	1(11)
Need for Esophageal Dilation, n (%)	3(33)
Final Nutrition Avenue, n (%)	
All Nutrition Orally	8(89)
G tube with some oral trial	1(11)
Time to oral intake, mean (SD), d	57.6(30.9)

Table 2: Demographic and Post-Operative Results