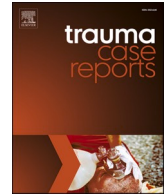




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Case Report

Endoluminal wound VAC therapy for the management of esophageal trauma: A case series

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ARTICLE INFO

Keywords:

Esophagus
Esophageal leak
Esophageal trauma
Endoluminal wound VAC

ABSTRACT

Esophageal trauma is rare and associated with high morbidity and mortality. Management can be challenging. Operative intervention involves exposure of the esophageal injury followed by primary two-layer repair with or without a buttressing muscle flap and wide local drainage. Repair can be complicated by post-operative leak and esophagocutaneous fistula. Endoluminal wound VAC therapy in the management of non-traumatic and iatrogenic esophageal perforations has shown efficacy. Presented here is a case series of four patients who sustained penetrating trauma to the esophagus and were managed successfully with endoluminal wound VAC therapy following primary repair. Therefore, endoscopic placement of an endoluminal wound VAC over the site of esophageal injury can serve as a safe and effective adjunct to primary repair of penetrating esophageal trauma. This procedure allows for frequent direct visualization of the injury as it heals, controls leakage of luminal contents, and promotes granulation for local wound healing.

Introduction

Less than 0.02 % of trauma cases are attributed to esophageal injury according to the National Trauma Database [1]. Despite their rarity, understanding the management of these injuries is necessary due to relatively high morbidity and mortality, approximately 53 % and 70 % respectively [2]. The most severe consequence of esophageal injury results from leakage of intraluminal contents, leading to deep space infection, mediastinitis, and septic shock. Additionally, the esophagus is susceptible to poor wound healing due to the limited blood supply and lack of a serosal layer. Finally, because the esophagus is protected by major surrounding structures—the trachea anteriorly and the aorta and spine posteriorly—esophageal trauma can be associated with concurrent injury to these structures, as well as a high injury severity score.

Management of esophageal trauma can be challenging. Depending on the location, severity, and concern for concomitant injury, esophageal injury can be managed operatively or endoscopically with esophageal stent placement. The operative approach begins with exposure of the esophagus followed by debridement of the muscularis layer to healthy tissue. The mucosal layer is evaluated to determine the full extent of injury. If extensive tissue requires debridement, the distal esophagus can be mobilized for a tension free closure, taking care to preserve the limited blood supply to the esophagus. Primary two-layer repair is then performed with absorbable suture to reapproximate the mucosa and permanent suture along the muscularis. The sternocleidomastoid or an intercostal muscle flap can be used to buttress the injury. Finally, drains are placed to prevent local infection and monitor for post-operative leak. Devastating

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<https://doi.org/10.1016/j.tcr.2022.100748>

Accepted 28 December 2022

Available online 31 December 2022

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or devitalizing injuries or persistent esophageal leak following primary repair may require the creation of an esophagostomy or esophagectomy with reconstruction [3].

Recently, the use of endoluminal wound VAC therapy in non-traumatic and iatrogenic esophageal leaks has shown positive outcomes [4]. However, endoluminal wound VAC therapy specifically in esophageal trauma has not been studied. Presented here is a case series of four patients who sustained penetrating esophageal trauma by either gunshot wound or stabbing with varying degrees of severity. They were subsequently managed with primary repair and endoluminal wound VAC therapy over the site of repair. Initial wound VAC exchanges occurred in the ICU under sedation while the patients remained intubated. For the patients who were successfully extubated, they tolerated frequent returns to the OR for exchanges under general anesthesia. Informed consent was obtained prior to each endoluminal wound VAC placement and exchange from all four patients.

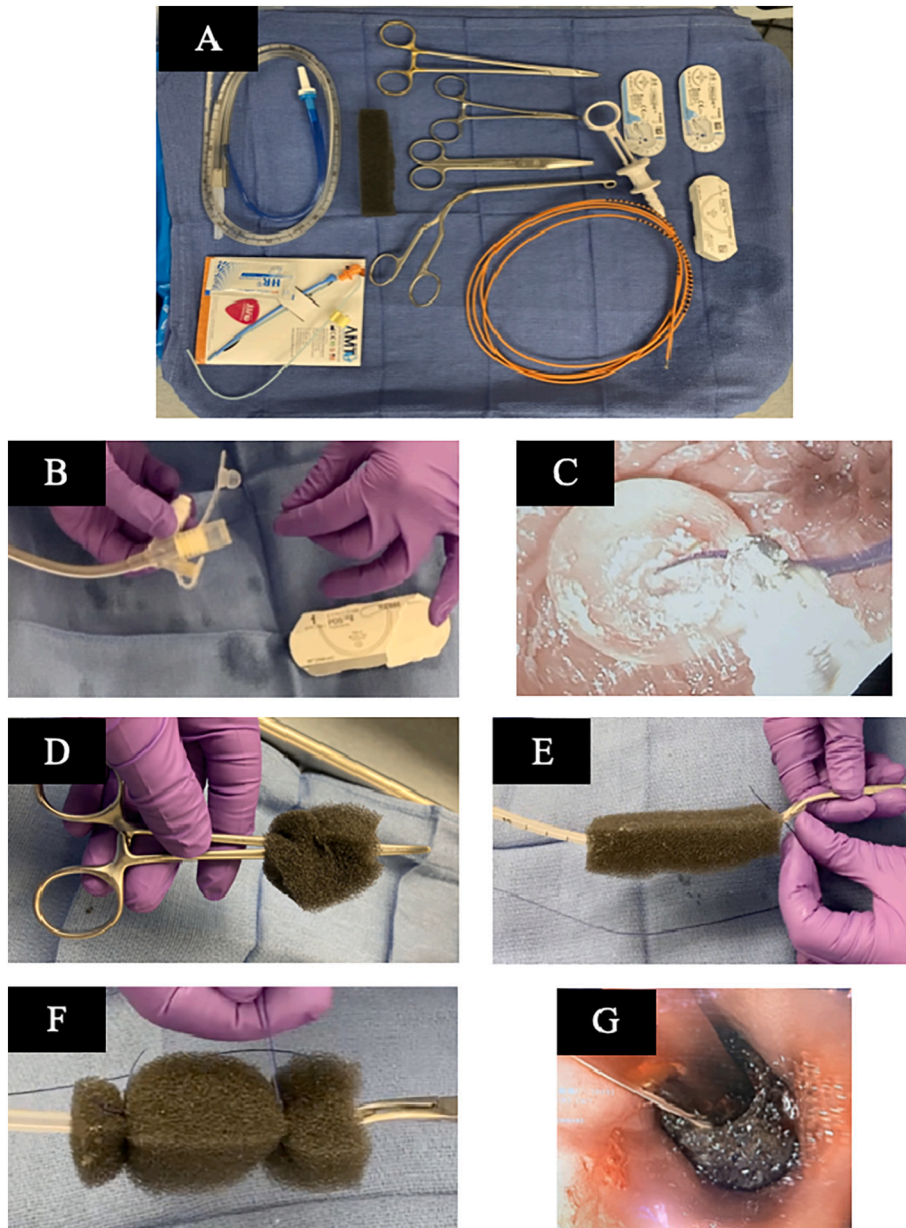


Image 1. A) Supplies needed to perform endoluminal wound VAC placement and exchange. B) PDS suture threaded through the gastrostomy tube. C) Endoscopic snare clasps around the PDS suture. D) Hemostat tunneled through VAC sponge. E) VAC sponge tunneled over the NGT. NGT and PDS suture extending out from oral cavity. PDS suture tied to the end of the NGT. F) VAC sponge secured on both ends to the NGT with prolene. H) Endoluminal wound VAC covering the site of injury.

Description of endoluminal wound vac placement

An endoscope is passed through the oral cavity, beyond the site of esophageal injury, into the stomach. A gastrostomy tube is placed percutaneously. A snare is passed through the endoscope port, while a 0-looped PDS suture with the needle removed, is threaded through the gastrostomy tube. Under endoscopic visualization, the snare clasps around the suture, and the entire scope, snare, and suture end are retracted out of the mouth. A 16 French nasogastric tube (NGT) is inserted through the nasopharynx. Using a pair of McGill forceps, the nasogastric tube is pulled out of the oral cavity. A tunnel is made through a 1 cm × 1 cm × 5 cm piece of black wound VAC sponge. The NGT is passed through the tunnel and positioned at the end of the tube so that all holes in the tube are covered. The NGT is sutured to the VAC sponge with a non-absorbable suture on each end, ensuring that the needle passes through the tube. The PDS suture which was pulled from the gastrostomy tube out of the mouth is tied to the distal end of the nasogastric tube. From the gastrostomy tube, the PDS suture is pulled while the sponge secured to the NGT is directed into the mouth and down the esophagus. The endoscope is passed again into the esophagus and held just proximal to the site of injury. The nasogastric tube is retracted until the wound VAC sponge is covering the esophageal injury in its entirety (*Image 1*). The NGT is placed to wall suction at –100 mmHg prior to removing the endoscope from the esophagus. The nasogastric tube is bridled to the naris. The PDS suture is cut at the gastrostomy tube, allowing it to retract into the stomach. The wound VAC is changed in the same fashion every 2–3 days until the wound is healed, confirmed visually by endoscopy followed by esophagram, using water-soluble gastrograffin followed by barium contrast.

Case 1

A man with multiple gun-shot wounds to the neck, chest, abdomen, and bilateral lower extremities was transferred from a referring facility after cardiac arrest with return of spontaneous circulation after a single dose of epinephrine, bilateral finger thoracostomies, and blood product resuscitation. Upon initial evaluation, the patient had been intubated with bilateral chest tubes, palpable central pulses, and a Glasgow coma score (GCS) of 3 while intubated and sedated. He was brought emergently to the operating room. A damage control operation was performed with exploratory laparotomy, aortic cross-clamping, segmental colectomy and ileocecectomy. He was left in discontinuity with a temporary abdominal closure for later reoperation and end ileostomy. A left neck exploration was additionally performed following aggressive resuscitation for severe acidosis, hypothermia, and coagulopathy. A 40 % circumference destructive injury to the cervical esophagus and a 20 % destructive injury to the trachea at the third tracheal ring were identified. After debridement of the devitalized muscular edges of the esophageal injury, a double layer closure of the esophageal mucosa and muscularis was performed with wide drainage. Additionally, the trachea was repaired with a single layer and the superior thyroid, inferior thyroid, and anterior jugular veins were ligated due to injury. In the first 24 h of this patient's hospitalization he received a total of 13 units of packed red blood cells, 13 units of fresh frozen plasma, 1 unit of platelets and 1 unit of cryoprecipitate.

On hospital day 10, an open tracheostomy was performed for ventilator dependence. During this operation an esophageal leak from the previous repair was encountered. Initially this was managed with wide local drainage. On hospital day 20, in the setting of persistent leak, salivary fistula, and sepsis, the decision was made to place an endoluminal wound VAC over the site of injury to seal the esophageal leak and promote wound healing. This patient underwent 11 subsequent endoluminal wound VAC exchanges every two to three days over the course of 1 month, until the esophageal wound healed (*Image 2*). This was confirmed with direct visualization by endoscopy and a negative methylene blue test intra-operatively. At 8 month follow-up in outpatient trauma clinic, the patient was noted to be tolerating oral intake without signs of infection or stricture.

Case 2

A man presented with self-inflicted stab wounds to zone 2 of the left anterior neck and the left forearm. His airway was intact with normal initial blood pressure. He was found to have a large left-sided pneumothorax on secondary survey. Therefore, a chest tube was placed emergently. He was subsequently brought to the operating room for neck exploration, where a 2 cm laceration to the anterior esophagus was identified. Following debridement, the esophageal injury was primarily repaired in two layers and buttressed with a left

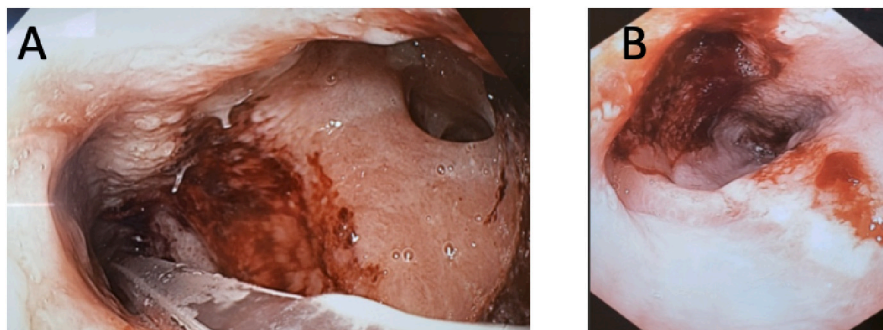


Image 2. A) Esophageal injury at initial EGD prior to endoluminal wound VAC placement. B) Esophageal injury on EGD prior to final wound VAC placement.

sternocleidomastoid muscle flap. A Jackson-Pratt drain was placed around and inferior to the site of repair.

On post-operative day 3, drainage from the JP drain had increased significantly and was associated with worsening edema and erythema surrounding the neck incision. A CT scan showed evidence of mediastinitis, concerning for persistent esophageal leak and esophagocutaneous fistula. The patient was brought back to the operating room for left neck incision and drainage, bilateral video-assisted thoracoscopy with drainage of the mediastinum, bilateral chest tube placement, and endoluminal esophageal wound VAC placement. This patient underwent 7 subsequent endoluminal wound VAC exchanges every 2–3 days until the esophageal injury healed. This was confirmed with direct observation via endoscopy and esophagram showing no leak. This patient did not present to his scheduled follow-up appointments. However, upon readmission for opioid overdose 11 months following discharge from the trauma service, he was tolerating a regular diet.

Case 3

A man with a single cervicothoracic GSW was transferred from a referring facility. Upon arrival, he was intubated, breathing, with a normal BP. His GCS was 3 while intubated and sedated, reportedly insensate and no motor function from the level of the midchest down. Advanced imaging was obtained showing a left pulmonary contusion with a small pneumothorax and left sided effusion, mediastinal hematoma, T2-T3 vertebral body fractures, and a suspicion for esophageal injury. Due to the location of the injury, the optimal point of access was difficult to determine. An esophagoscopy was performed for better localization ([Image 3](#)). This was followed by PEG tube placement and a left neck dissection with manubrial transection for better exposure of the esophageal injury. A blast injury to the cervicothoracic esophagus was identified at the level of the sternal notch with approximately 20 % mucosal injury and devitalized surrounding muscularis. Following debridement, the mucosa was repaired in a single layer, as there was insufficient tissue for a second layer closure. The repair was buttressed with a sternocleidomastoid muscle flap and a penrose drain was placed near the repair. An endoluminal wound VAC was inserted over the site of injury. Finally, a left-sided VATS, washout, and chest tube placement was then performed.

On post-operative day 3, the patient was persistently febrile to 39 degrees Celsius with worsening leukocytosis and hypotension secondary to presumed septic shock. A CT scan of the chest showed persistent esophageal leak and mediastinitis along with a right sided pneumothorax and pleural effusion. He returned to the operating room for right posterolateral thoracotomy, complete decortication of the right lung with parietal pleurectomy, incision and drainage of the mediastinum. The previous esophageal repair had opened slightly. The leak was buttressed with a pedicled intercostal muscle flap. Two chest tubes and two mediastinal drains were left in place. The endoluminal wound VAC was exchanged. This patient underwent 14 subsequent endoluminal wound VAC exchanges over the course of 6 weeks. An esophagram following wound VAC removal showed no evidence of esophageal leak. At approximately 6 months from his final wound VAC exchange, he presented with an esophageal stricture requiring endoscopic dilation. It is unclear if this patient initially failed therapy due to the location of the injury in the cervicothoracic region, which was more difficult to access surgically and ultimately required a dual cervical and thoracic approach.

Case 4

A man sustained multiple gunshot wounds to the left neck, shoulder and right flank. He was hemodynamically normal on arrival with airway, breathing and circulation intact. His GCS was 15. He was taken for advanced imaging where a CT angiography of the neck and CT of the chest, abdomen and pelvis demonstrated a comminuted left clavicle fracture, a bullet tract tracing posterior to the trachea without overt injury to the trachea or esophagus. There was a bullet fragment in the spinal canal of L1 with associated L1 vertebral fractures and pneumoperitoneum present. The patient was taken emergently to the operating room. Given the CT findings and the trajectory of the bullet, a left neck exploration was performed. The carotid artery and vagus nerve were identified and inspected for injury, none was identified. There was a destructive injury to the esophagus, measuring 1 cm in length, involving 75 % of

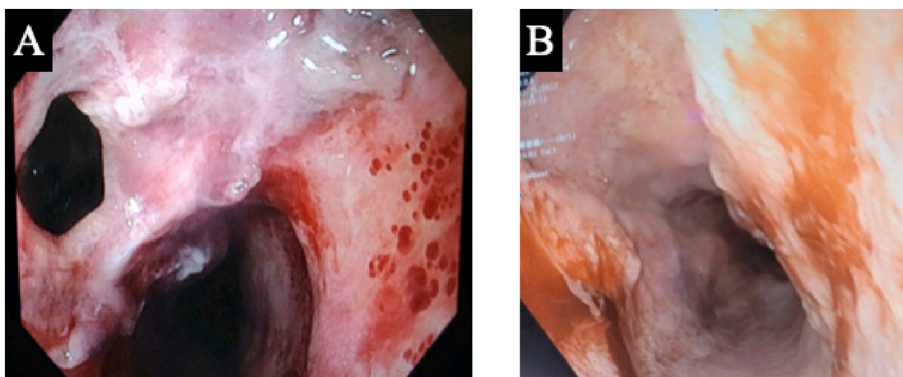


Image 3. Case 3: A) Esophageal injury at initial EGD prior to endoluminal wound VAC placement. B) Esophageal injury on EGD prior to final wound VAC placement.

the circumference. This was debrided back to healthy, viable tissue. The distal esophagus was mobilized. The esophagus was primarily repaired in two layers, approximating the mucosa and muscular layers. A rotational sternocleidomastoid flap was buttressed over the area of esophageal repair.

A midline laparotomy was then performed given the findings of pneumoperitoneum. There was a full thickness destructive injury to the cecum. A right hemicolectomy with ileocolonic anastomosis was performed. Prior to closure of the abdomen, a Stamm gastrostomy tube was placed. An endoluminal wound vac was inserted into the esophagus over the area of esophageal injury. The patient underwent 2 endoluminal wound VAC exchanges every two days over the course of one week. After wound VAC removal an esophagram demonstrated a persistent leak. Therefore, therapy was continued for an additional three weeks, exchanged 11 times every two to three days. The esophageal wound healed, which was confirmed with direct visualization on endoscopy and an esophagram. He is now tolerating a regular diet.

Discussion

The first reported study of endoluminal wound VAC therapy in the management of esophageal leaks was presented in 2010 [5]. This study followed 10 patient over three years, who each presented with esophageal anastomotic leaks, iatrogenic perforation, Boerhaave syndrome, or spontaneous perforation from cancer or ischemia. In this study, one patient died from fulminant pseudo-membranous colitis. The remaining nine were managed successfully with no reported dysphagia at follow-up.

Laukoetter et al. presented a prospective cohort study of 52 patients who received endoluminal wound VAC therapy for the management of anastomotic leak following gastrectomy or esophagectomy, iatrogenic injury, and Boerhaave syndrome [6]. They reported a 94 % successful closure rate, which is consistent with other studies following a smaller population size [7–9]. One patient in this study failed to respond to the VAC therapy, with no granulation tissue or signs of healing in subsequent VAC exchanges, requiring an alternative method for treatment. The remaining two failures resulted from acute uncontrollable hemorrhage, one from a right atrium pseudoaneurysm and the other from the descending aorta attributed to endoluminal wound VAC therapy.

Complications of endoluminal wound VAC therapy include esophageal stenosis and minor bleeding that does not require intervention or transfusion. However, major hemorrhage resulting from VAC erosion into major thoracic vascular structures has been reported [3,5]. Therefore, obtaining a CT scan of the thorax early in the course of endoluminal wound VAC therapy has been recommended to note the proximity of the injury to these major structures and stratify the risk of using endoluminal wound VAC therapy.

Few studies have compared outcomes of endoluminal wound VAC therapy to other treatment modalities for esophageal leak. One single center retrospective study compared wound VAC therapy to non-operative, operative, and stent management of 62 patients with anastomotic leak following esophagectomy [10]. In this study, variations in the studied patients' condition severity were controlled by matching the APACHE II scores at the initiation of each treatment. They reported mortalities of 83 % for patients managed by esophageal stenting, 50 % for surgical management, and 12 % for endoluminal wound VAC therapy. Other retrospective studies showed either no difference or decreased mortality using endoluminal wound VAC in esophageal leak [11–13]. The most common cause of death in these studies was sepsis.

Although the evidence for endoluminal wound VAC therapy is increasing, no current studies describing its use specifically in traumatic esophageal injuries were identified. This case series follows four patients whose traumatic esophageal injuries were successfully managed with endoluminal wound VAC therapy in conjunction with primary repair. The injuries were located in the cervical or cervicothoracic esophagus. These patients received a range of 7–14 endoluminal wound VAC exchanges every 2–3 days over the course of 3–6 weeks (Table 1). Minor bleeding was encountered during exchanges. However, VAC erosion causing major hemorrhage was not observed in these cases. Only one of these patients developed an esophageal stricture within 1 year. The remaining three do not report any signs of dysphagia or stricture.

Conclusion

Endoluminal wound VAC therapy can be a safe and effective adjunct to primary repair in traumatic esophageal injuries. The purpose of this procedure is three-fold. Exchanging the endoluminal wound VAC every 2–3 days allows for frequent direct visualization of the injury as it heals. Additionally, the negative pressure wound VAC controls contamination, preventing leakage of luminal contents and promotes granulation of the damaged tissue. A CT scan of the chest should be obtained in all patients with an esophageal injury to determine its proximity to other major structures. Wide local drainage of the area surrounding the injury should continue until the wound is healed. After the wound appears to be healed on endoscopy, the endoluminal wound VAC can be removed. An esophagram with gastrograffin followed by barium is then performed to ensure resolution of the esophageal injury.

Table 1
Overview of injury details and duration of endoluminal wound VAC therapy.

	Mechanism of injury	Location of injury	Number of VAC exchanges	Duration of therapy
Case 1	GSW	Cervical	11	27 days
Case 2	Stabbing	Cervical	7	23 days
Case 3	GSW	Cervicothoracic	14	45 days
Case 4	GSW	Cervical	14	35 days

Further study

At this point, the evidence for using endoluminal wound VAC therapy in traumatic esophageal injury is anecdotal and extrapolated from studying patients with non-traumatic or iatrogenic leaks. Studies involving a trauma population can be limited by the rarity of esophageal trauma. However, a retrospective study can be performed comparing the outcomes of endoluminal wound VAC therapy to other treatment methods in patients with traumatic esophageal injury after controlling for injury severity. Additionally, an “Endo-sponge” similar to the system developed for endoluminal wound VAC therapy in the treatment of rectal anastomotic leaks could be developed for the esophagus.

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