Esophageal perforation carries with it a high morbidity and mortality if not treated appropriately and aggressively. Three approaches are available for the treatment of esophageal perforation: conservative, endotherapy, and surgery. The location viz. cervical, thoracic, or abdominal portions of the esophagus and size of the perforation influence treatment choice. Cervical perforations are usually small and can be treated conservatively as the perforation or leak is also contained within the triangle of Killian in the neck. Most cervical perforations have a good outcome with conservative treatment with intravenous antibiotics and nil by mouth. Treatment of thoracic perforations depends very much on the size of the perforation. Small perforations due to sclerotherapy injection, for example, can be treated conservatively. Endotherapy can help avoid surgery in other cases: small tears from endoscopic insertion can be clipped and esophageal fistulae can be injected with fibrin glue. Larger perforations can be treated with stent placement if the dehiscence of the lumen circumference does not exceed 70%. Stent placement with self-expandable fully-covered plastic and metallic stents or partially-covered metallic stents has been used with fairly good success. One of the problems with stent placement is the migration of these stents. Perforation of the intra-abdominal portion of the esophagus often results in a very rapid development of peritonitis and sepsis and surgery is usually recommended. Surgery is mandatory in any part of the esophagus when the perforation is large or when patients do not improve with conservative or endoscopic treatment. In very ill patients, esophageal exclusion surgery can be carried out until the patient’s general condition stabilizes. In cases of a diseased esophagus such as corrosive injury related perforations or cancer of the esophagus, esophageal replacement surgery should be contemplated with total esophagectomy and gastric pull-up surgery or creation of a neoesophagus with colonic interposition.
The most common symptom of esophageal perforation is chest pain, which is present in 70–80% of cases. However, the clinical presentation of esophageal perforation depends on the location of the perforation.

Cervical perforations can present with neck pain, dysphonia, hoarseness, and cervical dysphagia. Subcutaneous cervical emphysema has been observed, in 30% of cases. Thoracic perforations present with acute chest pain, and in 30% of cases, back pain or radiation to the back. Perforations at the gastroesophageal junction can manifest as acute abdominal pain, with signs of peritonitis and rarely gastrointestinal bleeding. Pain can be experienced at the back or epigastric area, which may be referred to the shoulder, as a result of diaphragmatic irritation. Vomiting and shortness of breath associated with pain can be seen in 25% of cases. Signs of systemic inflammatory response also develop such as tachycardia, tachypnea, and fever. Fever is an invariable finding 50% of the time, but is considered as a late sign.

Diagnostic imaging

Imaging modalities that are useful in the diagnosis and work up of esophageal perforation include a plain chest radiograph, Gastrografin upper gastrointestinal study, chest and upper abdomen CT scan, and endoscopy. The most common finding in a chest radiograph is pneumomediastinum, occurring in 42% of cases, followed by pneumothorax and pneumoperitoneum (Fig. 1). Radiographically evident subcutaneous emphysema is seen in 95% of cervical perforations. However, the extent and location of the perforation is difficult to assess in a plain chest radiograph. A water-soluble contrast swallow or Gastrografin study can localize the site and extent of perforation as seen by extravasation of contrast (Fig. 2). A negative study, however, does not exclude the presence of a perforation and a repeat study can be done after 4–6 hours. Chest and upper abdomen CT scan with oral contrast can better visualize the site and degree of containment of the perforation (Fig. 3). Endoscopic evaluation provides direct visualization of the defect (Fig. 4). However, the use of endoscopy in the evaluation of
esophageal perforation remains controversial as air insufflation can result in pneumomediastinum and cervical emphysema, which may further aggravate the condition. Although several studies have utilized carbon dioxide for insufflation during esophageal submucosal dissection to minimize mediastinal emphysema, its utility in esophageal perforation has yet to be determined.12,13

**Treatment**

Over the years, despite development of novel techniques and recommendations to treat esophageal perforation, the goals of treatment remain the same: to treat infection, minimize and prevent further septic contamination; to provide nutritional support; and to restore the continuity of the digestive tract.9,14

**Location of the perforation**

Cervical perforations are often iatrogenic, such as during intubation with a gastroscope. Cervical tears can usually be treated conservatively as the perforation or leak is contained within the triangle of Killian in the neck. Endoscopic therapy with clipping is possible but visualization of the area may be difficult and endoscopic stent placement may not be feasible. Most cervical perforations have a good outcome with conservative treatment with intravenous antibiotics and nil by mouth.

Treatment of thoracic perforations depends on the size of the perforation. Small perforations (e.g., due to sclerotherapy injection) can be treated conservatively. Small tears from endoscopic insertion can be clipped. However, successful closures of spontaneous perforations by endoscopic clipping have been reported in recent years.15,16 Esophageal fistulas can be injected with fibrin glue.17 Stent placement with self-expandable fully covered plastic and metallic stents or partially covered metallic stents has been used with fairly good success (Fig. 5).18 Migration is a particular problem with fully covered stents where it has been reported in up to 25% of cases.19 With conservative or endotherapy, simultaneous drainage of any mediastinal or pleural collection of fluid or pus should be carried out and patients put on intravenous antibiotics.

Perforation of the intra-abdominal portion of the esophagus often results in a very rapid development of peritonitis and sepsis and surgery is usually recommended. Small leaks or perforation, such as a small tear from balloon dilatation or from sclerotherapy, can be treated with stent placement across the cardio-esophageal junction. Larger tears, such as in Boerhaave’s syndrome or spontaneous barotraumatic rupture of the esophagus, will require surgery.

**Conservative treatment**

Early recognition of iatrogenic perforations, within 6 hours or less than 24 hours, correlates with better prognosis and can be managed conservatively.9,9 Conservative management includes nil by mouth, intravenous fluids and antibiotics, total parenteral nutrition, nasogastric tube, and chest drainage. In a 10-year retrospective study by Hasan et al, conservative management of esophageal perforation had a survival of 84.6%, mortality rate of 15%, with chest infections as the most common complication in 46% of cases.8 Their study also revealed that perforations had favorable outcomes when diagnosed within 6 hours. In another retrospective review, successful nonoperative therapy resulted in shorter hospitalizations, fewer complications, and lower mortality rates compared to operative treatment.5 However, conservative management should be limited to patients who have a localized contrast extravasation on imaging.5,8 Other indications for conservative treatment are the absence of infective syndrome, cervical or thoracic perforations, intramural perforation, and nontumoral perforation.9

Conservative management of perforations can be considered in small perforations and with the following features: diagnosis made early and perforation contained within the neck and mediastinum; drainage into the esophageal lumen shown by contrast imaging; injury does not occur in neoplastic tissue or corrosive injury; in the abdomen or proximal to an obstruction; and absence of systemic sepsis and availability of interventional radiological and surgical expertise. In all cases managed conservatively, nutritional support and the use of broad spectrum antibiotics as well as appropriate radiologically guided drainage of localized collections of fluid and pus should be carried out at the same time.8,20,21 Total parenteral nutrition, broad-spectrum antibiotics, and proton pump inhibitors should be given for a period of 14–21 days.9 Patients are maintained nil by mouth for an average of 7 days until check contrast swallows are performed to document healing and facilitate diet progression to oral fluids.8,9 Successful esophageal healing with conservative treatment has been reported to be as high as 96%, with an overall mortality of 4.2%.22

**Endoscopic therapy**

Endoscopic therapy of esophageal perforations aims to restore continuity of the esophagus for early feeding, prevent contamination of the mediastinum, and facilitate re-epithelialization of the mucosal defect. This can be achieved by using hemoclips and stents to seal the mucosal defect. Endoscopic hemoclipping has been
shown to be successful for defects 3–25 mm in size and less than 25% of the esophageal circumference and a median healing time of 18 days.\(^\text{23,24}\) A novel over-the-scope clip has been recently developed to successfully close perforations up to 30 mm in diameter.\(^\text{25,26}\) Larger perforations can be treated with stent placement if the dehiscence of the lumen circumference does not exceed 70%.\(^\text{27}\)

Various stents are commercially available for stenting esophageal perforations; these include Ultraflex stent (Boston Scientific, Natick, MA, USA), Niti-S stent (TaeWoong Medical, Gyeonggi-do, Korea), Polyflex stent (Boston Scientific), and Flamingo Wallstent (Boston Scientific). In a systematic review by van Boeckel et al, stenting of esophageal perforations with fully covered self-expandable metal stents (FSEMS), partially covered self-expandable metal stents (PSEMS), and self-expanding plastic stents (SEPS) had an overall clinical success rate of 85%.\(^\text{19}\) Surgical interventions were only done in 13% of the cases. However, stent migration was noted to be highest in SEPS followed by fully-covered metallic stents and PSEMS with migration rates of 31%, 26%, and 12%, respectively.\(^\text{19}\) Stent migration is a common problem, particularly for covered stents because there is nothing to hold the stents in place and deployment of the largest diameter stents is recommended.\(^\text{19}\) In a retrospective study by Swinnen et al, closure of leak after PSEMS removal was 77.6%.\(^\text{28}\) In several instances tissue overgrowth and hyperplasia render the stent adherent to the esophagus limiting its retrieval. A second stent is then inserted through the initial stent to induce pressure necrosis of the hyperplastic tissue in-growth and stent retrieval can be attempted after 2 weeks.\(^\text{28}\) In an observational study, Fischer et al were able to demonstrate that early stent placement, average time delay of 45 minutes, resulted in successful healing of esophageal perforation and shorter duration of hospital stay.\(^\text{29}\) A novel biodegradable stent has recently been developed to eliminate the problems of stent retrieval. These stents are covered with biodegradable polydioxanone monofilament with a polyurethane skeleton. In a series by Černá et al, covered biodegradable stents (SX Ella-BD; ELLA-CS, Hradec Králové, Czech Republic) were used to treat anastomotic esophageal leaks and perforation and technical success was 100%, while clinical success was achieved in 80% of the cases.\(^\text{30}\) The stent was fixed into position by balloon dilatation. The follow-up protocol described in the series include esophagography after 2 days, radiograph of the stent every 4 weeks until complete degradation was observed and endoscopy after 12 weeks of stent implantation. Stent degradation was seen at around 11–12 weeks and was dependent on pH, therefore stents placed at the distal esophagus near the cardioesophageal junction were degraded earlier. A randomized study comparing SEPS with biodegradable stents in the treatment of refractory esophageal strictures showed that stent-related complications resulting in dysphagia were higher after biodegradable stent placement compared to SEPS, but stent migration rates were similar.\(^\text{31}\) The main benefit of biodegradable stents is that stent removal is not required after completion of therapy, minimizing the number of reinterventions.

The optimal time of stent placement ranges from 4 weeks to 6 weeks to avoid secondary perforation, hemorrhage, or impaction of the stent\(^\text{9}\) (Fig. 6). Stent retrieval complications, such as bleeding, stent fractures, and impaction, were noted to be more common for stents extracted beyond 6 weeks.\(^\text{32}\) However, larger defects may require more than 6 weeks to heal and the initial stent should be replaced within 6 weeks to prevent stent embedding.\(^\text{32}\)

**Surgery**

The surgical approach for the treatment of esophageal perforations is influenced by the location and size of the perforation, viability of the esophageal mucosa, degree of local sepsis,
and underlying pathology. Surgery is mandatory in any part of the esophagus when the perforation is large or when patients do not improve with conservative or endoscopic treatment. The latter usually happens when diagnosis of the perforation is delayed and if the perforation is noncontained resulting in mediastinal or peritoneal contamination and systemic sepsis. Primary repair with suture of perforation with reinforcement flaps is the main surgical treatment and has a favorable outcome especially if done within 24 hours of diagnosis. However, in the presence of empyema, debridement and pleural decortication are indicated to obtain full lung expansion and facilitate sealing of the defect. In very ill patients, esophageal exclusion surgery can be carried out until the patient’s general condition stabilizes. The aim of surgery is to achieve primary repair of the perforation but identification of the perforation may not be easy. Appropriate cleaning and debridement of surrounding necrotic tissue with placement of drains close to the site of perforation are important; T-tube drainage has successfully provided a preferential flow of inflammatory debris to facilitate wound healing. Repair of perforation can be reinforced with muscle or pleural flaps. A laparoscopic or thoracoscopic approach is increasingly used for such repairs. In cases of a diseased esophagus such as corrosive injury related perforations or cancer of the esophagus, esophageal replacement surgery should be contemplated with total esophagectomy and gastric pull-up surgery or creation of a neoesophagus with colonic interposition.

**Conclusion**

Esophageal perforation is a life-threatening condition that must be recognized and addressed aggressively. The treatment of esophageal perforation is dependent on various clinical factors, technology, and level of expertise available. Conservative management is possible for small and contained defects in the absence of sepsis and aggravating underlying comorbid illnesses. Minimally invasive treatment or endotherapy is a viable option for most esophageal perforations especially with the development of newer biodegradable stents. Surgical treatment is indicated for larger defects and in overt sepsis requiring drainage and in perforations involving diseased esophagus. The different treatment modalities of esophageal perforation are not exclusive of each other but may be used altogether in the management of the condition. Further studies and technology may aim to improve the currently available endoscopic treatment modalities, and to develop novel techniques in the treatment of esophageal perforation.

**Conflicts of interest**

We declare that we have no conflict of interest with regards to this paper.

**References**

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**Fig 7** Summarizes the treatment approach to esophageal perforations.