REVIEW ARTICLE

A comprehensive approach to the management of acute endoscopic perforations (with videos) CME

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The only method to prevent iatrogenic luminal perforation at the time of endoscopy is the avoidance of endoscopic procedures. Luminal perforation is among the most feared adverse events of GI endoscopy, and the rationale for this is multifactorial: (1) it may carry significant morbidity and mortality; (2) perforation may not be remediable without a surgical procedure; (3) management of perforation requires a multidisciplinary approach, often beyond the endoscopist's control; (4) perforation usually requires hospitalization, thus adding to the cost of care; and (5) perforation has medicolegal implications, including liability not only for the endoscopist but other providers involved with the case.[1] In addition, the mere mention of the word *perforation* triggers alarm and panic among faculty and trainees alike, often with the assumption that all perforations require surgical management. In some cases, there may even be disagreement among involved specialties as to the approach toward perforation.

With the development of endoscopic devices and techniques, such as natural orifice transluminal endoscopic surgery (NOTES), luminal perforation is a component of the procedure that can be readily managed endoscopically.[2] On the other hand, surgical exploration and repair are generally required in patients in whom endoscopic measures are unsuccessful or technically not feasible in closing the perforation or in whom recognition of perforation is delayed. The challenge lies in determining which patients can undergo nonsurgical treatment alternatives and knowing when to realize whether the management chosen is successful or not.

Despite the extensive, peer-reviewed literature on endoscopic perforations, data from controlled clinical trials do not exist to provide the clinician with consensus management algorithms regarding the care of the patient with an endoscopically induced perforation. In this review, we outline the general principles regarding the approach to endoscopic perforations, discuss the anatomic peculiarities of perforations throughout the GI tract, and provide a framework for management of luminal endoscopic perforations.

Abbreviations: ESD, endoscopic submucosal dissection; FCSEMS, fully covered self-expandable metal stent; FDA, U.S. Food and Drug Administration; NOTES, natural orifice transluminal endoscopic surgery; OTSC, over-the-scope clip; PCSEMS, partially covered self-expandable metal stent; PEG, percutaneous endoscopic gastrostomy; TTS, through-the-scope.

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GENERAL PRINCIPLES

Table 1 summarizes the general principles related to endoscopic perforation. We consider these the "Ten Commandments of Endoscopic Perforation." An understanding of these basic concepts guides the establishment of proper management strategies.

(1) Prompt recognition of endoscopic perforation is essential to improvement in outcome

Early recognition of perforation, preferably during the procedure, allows prompt intervention that is critical for a successful outcome. Identification of an iatrogenic perforation during the procedure allows one not only to limit the accumulation of extraluminal air by minimizing insufflation but, more importantly, to prevent the egress of luminal contents by rapid closure of the perforation, diversion, or immediate referral for surgery, as appropriate. Delayed identification of perforation typically results in egress of luminal contents that lead to infection and a worse outcome.[3-5]

(2) The presence of extraluminal air does not automatically mean the need for surgery

Extraluminal air is the hallmark of endoscopic perforation and may be incidental (asymptomatic) or symptom-

TABLE 1. The ten commandments of endoscopic perforation

1. Prompt recognition of endoscopic perforation is essential to improvement in outcome.
2. The presence of extraluminal air does not automatically mean the need for surgery.
3. The volume of extraluminal air is not necessarily proportional to the size of the perforation.
4. Extraluminal air per se is not infectious.
5. Extraluminal air under pressure is a medical emergency.
6. Extraluminal air can dissect into distant spaces.
7. Residual extraluminal air may persist without clinical significance.
8. Perforations tend to close after drainage or diversion of luminal contents.
9. Oral, rectal, or injected contrast material extravasation should elicit prompt intervention.
10. Failed endoscopic closure of a perforation generally requires surgical intervention.

atic. For certain procedures, such as percutaneous endoscopic gastrostomy (PEG) tube placement, the presence of extraluminal air is expected and inconsequential.[6] Incidental extraluminal air is generally identified when radiographs, such as abdominal radiographs and CT, are obtained after uncomplicated endoscopy.[7,8] Typically, the patient undergoes a prescheduled imaging study pursuant to the problem already being investigated. In the absence of concerning symptoms or signs, specific treatment is usually not necessary, although serial examination and monitoring are recommended.

A small volume of extraluminal air without any endoscopically visible sign of perforation may occur in some endoscopic submucosal dissection (ESD) procedures associated with large dissections, long procedure times, and after-exposure or minimal damage of the muscularis propria. During gastric ESD, for example, localized extraluminal air close to the gastric wall may be visible on CT but not on plain radiographs, and this has been defined as a transmural air leak.[9,10] In some ERCP procedures, the use of compressed air to maintain luminal patency may result in asymptomatic retroperitoneal air, which does not require surgical intervention.[8,11]. The use of carbon dioxide rather than air for insufflation may minimize the amount of extraluminal air because the former is rapidly absorbed.[12] This may prevent the development of overt symptoms in the presence of a small perforation or transmural air leak or diminish the severity of presentation after a perforation, although data are lacking to support this.

(3) The volume of extraluminal air is not necessarily proportional to the size of the perforation

The volume of extraluminal air present is not determined primarily by the size of the perforation but by the degree of air insufflation after perforation. A very small perforation may be associated with a large volume of free air. Conversely, a large hole that is recognized immediately and followed by prompt removal of the endoscope may not generate any free air at all. The volume of extraluminal air is directly related to the duration of the procedure and degree of insufflation performed after the perforation has occurred[11,13] and whether or not the perforation is contained by surrounding tissues.

(4) Extraluminal air per se is not infectious

Free air in and of itself is not infectious. Extraluminal air will resolve spontaneously as long as the perforation closes, and enteric contents do not egress.[6-8] The spillage of luminal contents outside the GI tract accounts for the inflammatory/infectious response and will cause symptoms due to contamination of the sterile extraluminal spaces by oral and gut flora. Patients with signs or symptoms suggestive of perforation after endoscopy including pain, abdominal distention, fever, and tachycardia should undergo urgent imaging, such as abdominal radiography, CT, and/or a contrast upper GI series. Confirmation of free air, along with the earlier-mentioned signs and symptoms, generally requires surgical intervention.[14,15]

(5) Extraluminal air under pressure is a medical emergency

Although extraluminal air does not directly introduce infectious elements to sterile planes, free air under pressure can result in a medical emergency. Examples include tension pneumothorax, tension pneumomediastinum, tension pneumopericardium, and abdominal compartment syndrome.[16-18] Treatment to decompress the cavity under pressure should be carried out immediately (see the following).

(6) Extraluminal air can dissect into distant spaces

Air can remain trapped in a single compartmental space or localized in a specific soft tissue, but it also can diffuse rapidly through diverse and distant anatomical planes, potentially resulting in a life-threatening complication.[19] Colorectal perforations, for example, can be manifested by subcutaneous emphysema in the neck (Video 1, available online at www.giejournal.org).[16,17] The degree and reach of air dissection are related to ongoing air insufflation and long procedure times.

(7) Residual extraluminal air may persist without clinical significance

Free air can persist and continue to disperse into tissues for a variable amount of time after closure of the perforation (Fig. 1). Postoperative pneumoperitoneum usually resolves within a week[20] but may persist for 10