

Belsey Mark IV Repair

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The Belsey Mark IV repair or antireflux fundoplication is a classic procedure that has proven to be a successful and durable antireflux operation. Over a 15-year period, Ronald Belsey performed clinical trials to develop and refine the operation, culminating in 4 iterations, with the fourth or Mark IV being the final and most successful. Dr Belsey referred to each version as Mark as a nod to the British Jaguar brand automobile makers for naming their sequential iterations of luxury vehicles Mark I, Mark II, etc. The open Belsey Mark IV fundoplication (BMIV) is performed via a left posterolateral thoracotomy. The goal is to return the “high-pressure zone” of the cardia, otherwise known as the lower gastroesophageal sphincter (LES) to its normal anatomical position below the diaphragm. The BMIV reduces 4-5 cm of distal esophagus to an infradiaphragmatic position in the “high-pressure” upper abdomen, restoring a competent gastroesophageal junction (GEJ). In addition to returning the LES to a high-pressure environment, the BMIV provides an incomplete 240° anterior fundal wrap. The incomplete wrap, as opposed to a complete 360° Nissen fundoplication, is especially useful in the esophagus with underlying motility disorder, avoiding gas bloat syndrome.

Orringer et al¹ reported Belsey’s short- and long-term results in 892 patients, with 84% perceiving excellent or good results, and found a 12% 10-year recurrence rate and 14.7% recurrence rate for patients followed up over 10 years. Operative mortality was only 1%. Similar results in other studies have been reported with low operative mortality and success rates up to 90%.²

With the proliferation of minimally invasive surgery, specifically conventional and robotic laparoscopic surgery, the role of the BMIV has diminished. Incomplete fundoplications such as the 180°-200° Dor anterior and the 270° Toupet posterior fundoplications are easily accomplished minimally invasively. Nguyen et al³ reported on their group’s initial experience with a thoracoscopic BMIV, and although their study demonstrated that a thoracoscopic BMIV could be performed with optimal perioperative mortality and morbidity,

the complexity of the procedure warranted the authors to state an “open thoracotomy for Belsey Mark IV should remain the standard operation for gastroesophageal reflux disease with poor esophageal motility when a thoracic approach is desired.” Regarding BMIV, it is best approached via an open left posterolateral thoracotomy, and appropriate patients should be selected who would benefit from an antireflux procedure using a partial wrap and a thoracotomy.^{2,4} Such patients include those with epiphrenic diverticulum,⁵ giant hiatal hernia with potential pleural adhesions and not requiring a gastric lengthening procedure, and esophageal perforation in the setting of esophageal dysmotility such as achalasia or diffuse esophageal spasm.^{6,7} For patients who require an esophageal lengthening procedure, a Collis gastroplasty should be favored over a BMIV.²

Preoperative assessment is determined by the underlying pathology. Flexible endoscopy, contrast esophagography with thin barium, and chest computed tomography are all employed for anatomical definition and surgical planning. Esophageal manometry identifies underlying esophageal dysmotility. In the following sections, we describe the open BMIV, which consists of 3 major steps: (1) narrowing a potentially patulous esophageal hiatus, (2) creating a 240° anterior fundoplication, and (3) securing the fundoplication in an infradiaphragmatic position therefore recreating the high-pressure zone of the LES.

Operative Technique

Thoracic Exploration

The BMIV is approached via the left-sided posterolateral thoracotomy through the sixth intercostal space. This approach provides the best access to both the esophagus and the esophageal diaphragmatic hiatus. Epiphrenic diverticulum listing to the right can be rotated to the left and addressed. Distal esophageal perforations can also be addressed from the left, even if draining to the right hemithorax. Single-lung ventilation with a double-lumen endotracheal tube may improve exposure; however, this is not necessary if the patient is unable to tolerate lung isolation, as the lung usually can be retracted aside. An epidural continuous-infusion pain-control catheter is placed preoperatively to maintain local analgesia (Figs. 1-13).

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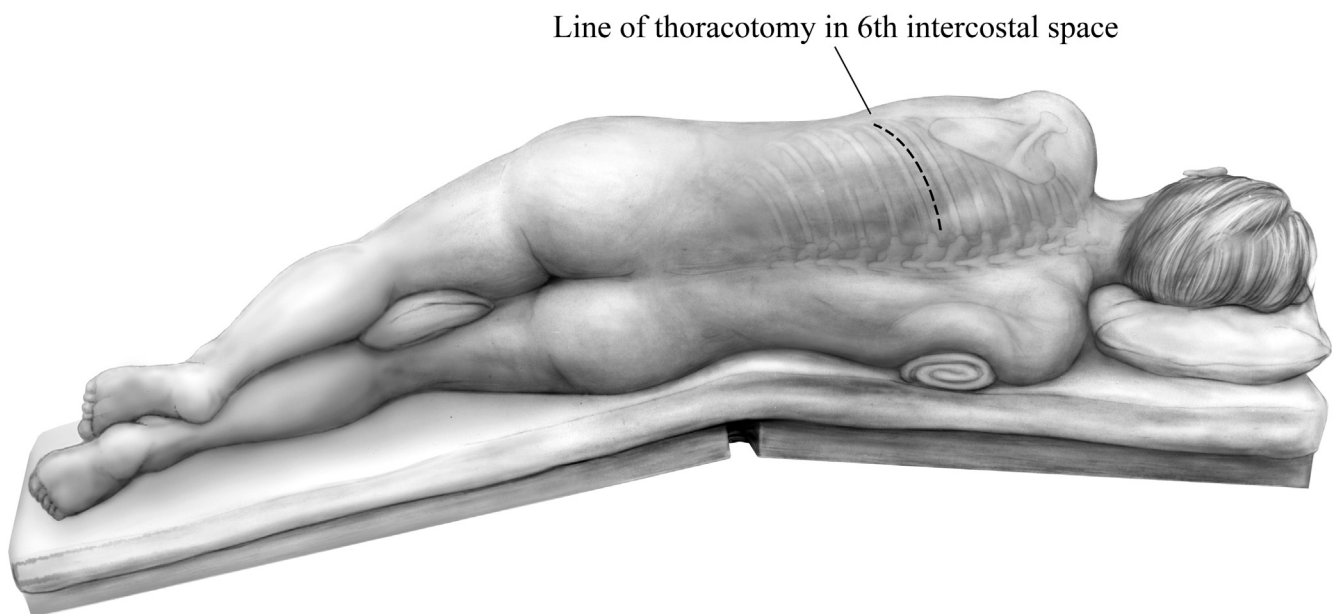


Figure 1 The patient is placed in the right lateral decubitus position, and a “shoulder” roll is placed an arm’s length below the axilla to prevent injury to the brachial plexus. The table is flexed to widen the intercostal spaces and lower the ipsilateral hip out of the way. Reverse Trendelenburg tilting of the table is performed until the axis of the upper spine is parallel to the floor.

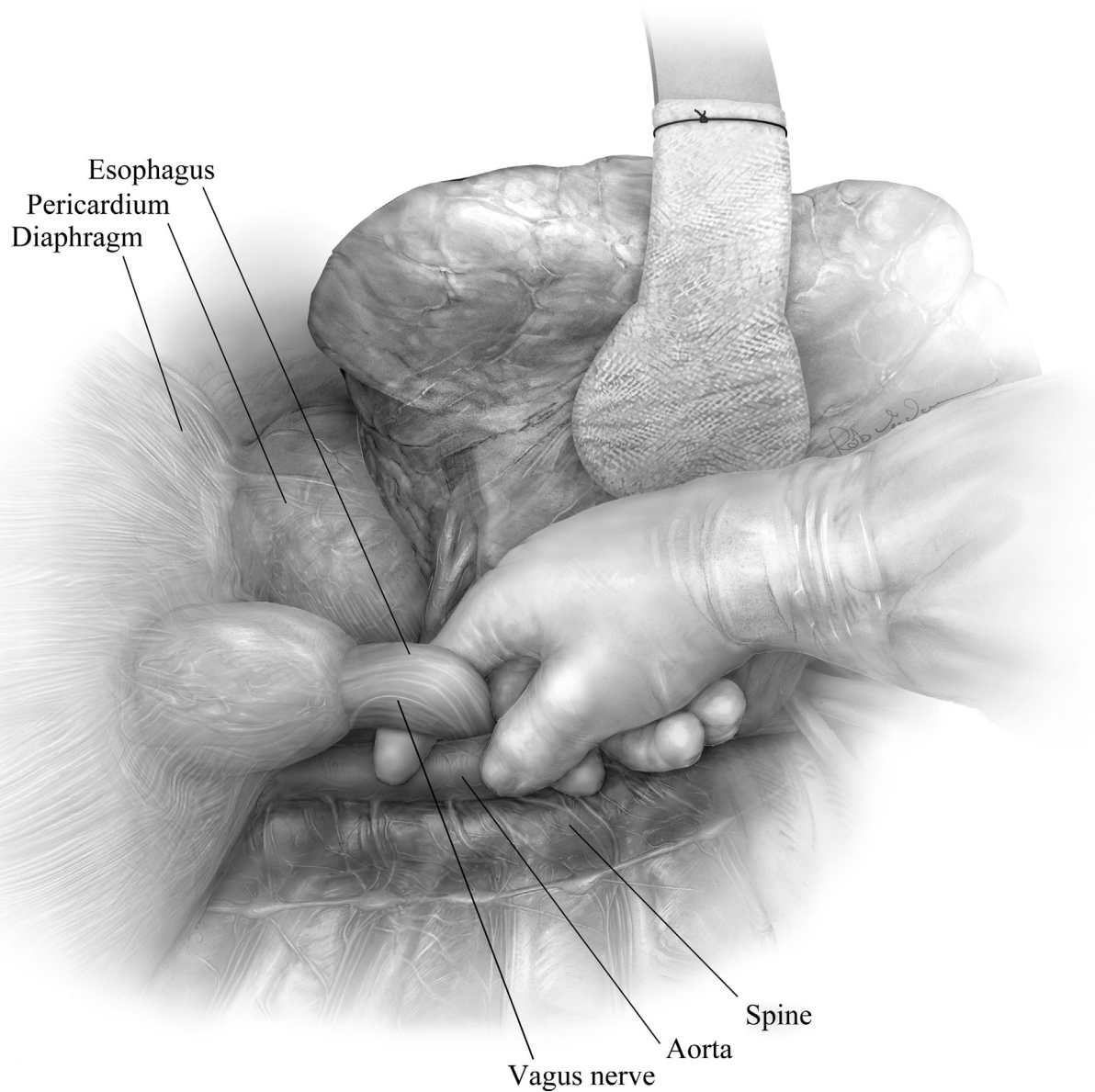


Figure 2 Once the chest is entered, the lung is retracted medially with a cloth-covered retractor. The mediastinal pleura overlying the esophagus is incised beginning at the esophageal hiatus and extending up to the arch of the aorta. The inferior pulmonary ligament is divided with cauterly to the level of the inferior pulmonary vein. The lower esophagus and vagus nerves are mobilized with a finger. The left and right vagus nerves are identified, but care is taken not to separate the nerves from the body of the esophagus. The vagus nerves are not individually isolated, for example, with suture or umbilical tape, as dissecting them from the body of the esophagus risks injury.

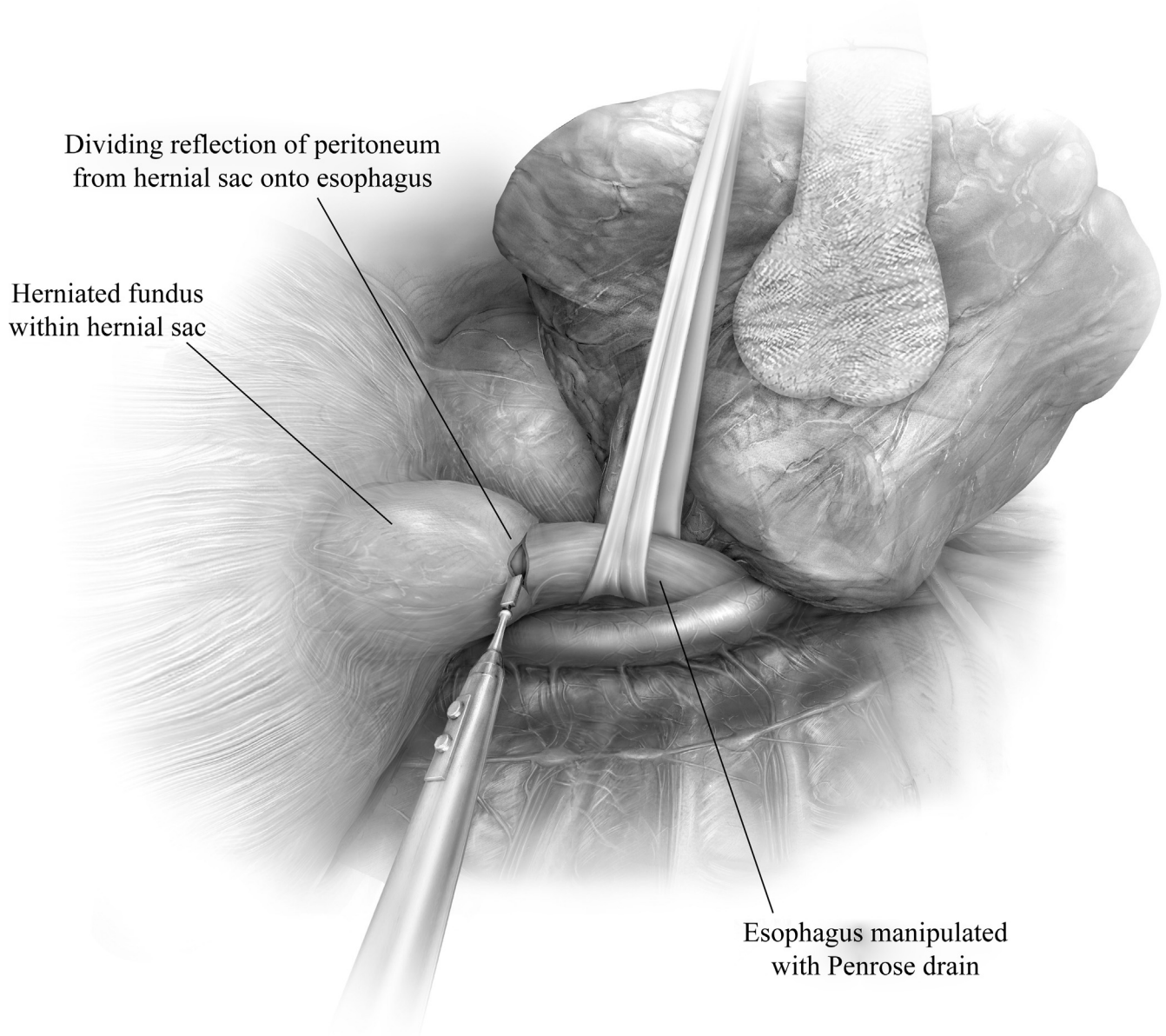


Figure 3 The esophagus is encircled with a Penrose drain for easy manipulation. In the case of a hiatal hernia, the phrenoesophageal membrane is attenuated as a large herniation of peritoneum. Anterolateral to the cardia, the herniated peritoneum is opened with cautery and the peritoneal cavity is entered. The attenuated peritoneum is circumferentially incised laterally toward the short gastric arteries and medially toward the pericardium. The herniated peritoneum can be removed, and if adherent, bluntly dissected off the esophagus with a Kitner or “peanut,” avoiding sharp injury to the vagus nerves. Through the patulous hiatus, the lesser sac and the caudate lobe of the liver are identified.

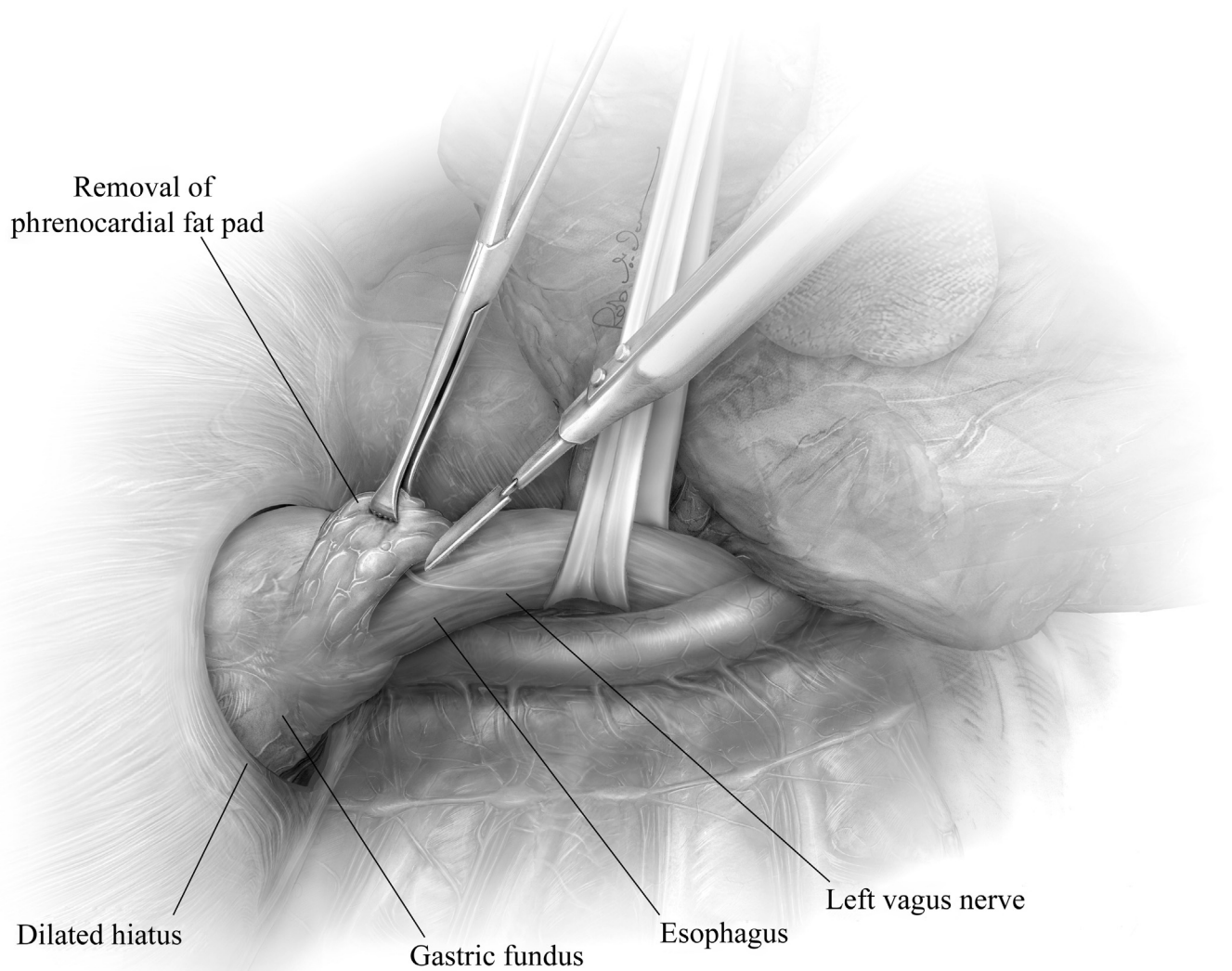
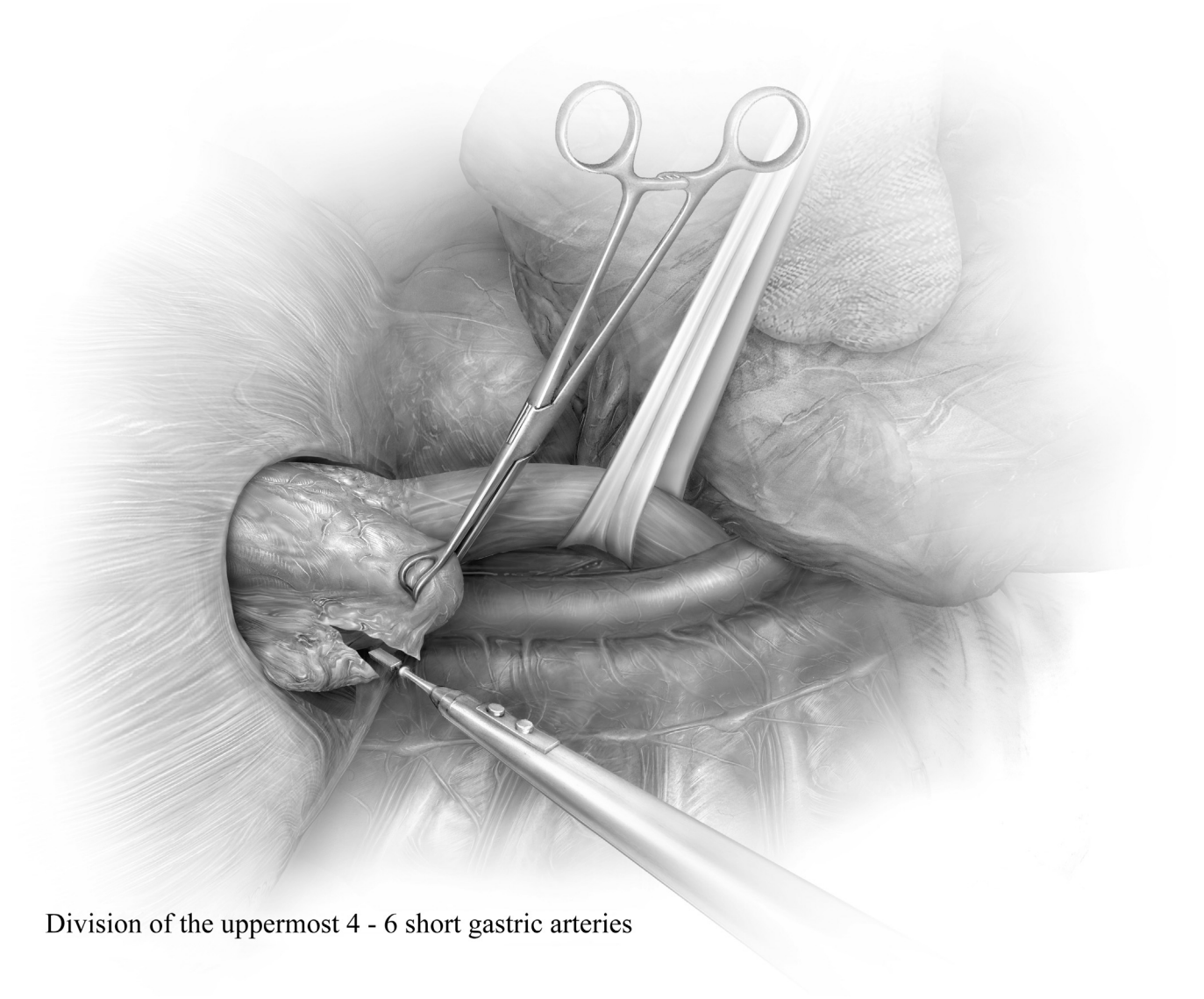


Figure 4 With upward traction on the Penrose drain circling the distal esophagus, any additional phrenoesophageal attachments and peritoneum surrounding the cardia including the phrenocardial fat pad (shown) are divided and removed using cautery.



Division of the uppermost 4 - 6 short gastric arteries

Figure 5 The fundus is grasped with a Babcock tissue clamp, and 4-6 high short gastric vessels are divided with 2-0 silk ligatures or using an energy sealant device.

Pre-placement of sutures for
re-approximation of the hiatus

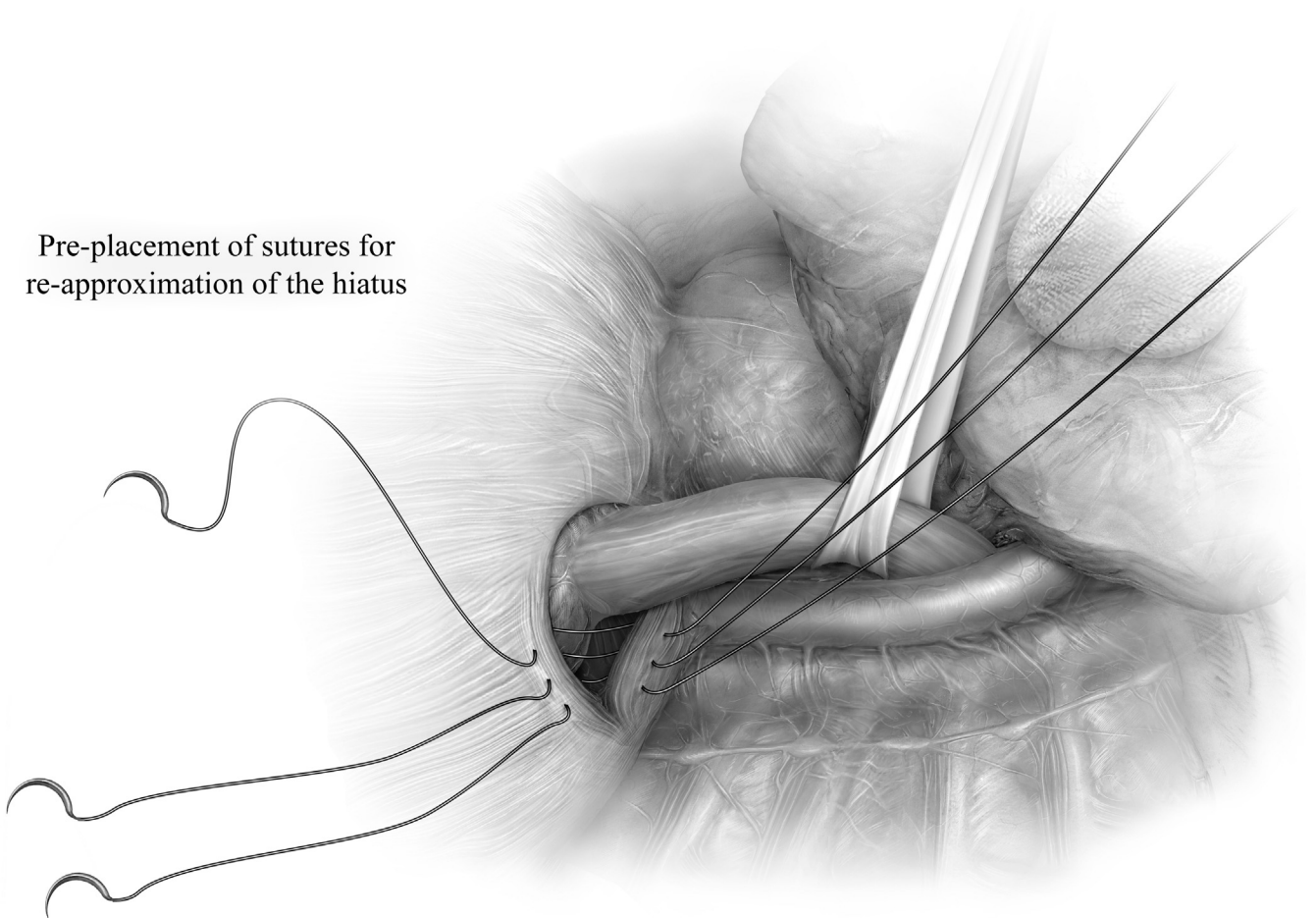


Figure 6 *Step 1:* After complete mobilization of the cardia and the superior fundus, the fundus is reduced back into the abdomen. Three interrupted no. 1 silk sutures are placed posterior to the esophagus from the medial to lateral crus of the diaphragm approximately 1 cm apart to permit subsequent narrowing of the esophageal hiatus after completion of the fundoplication. The sutures are left untied until the end of the procedure.

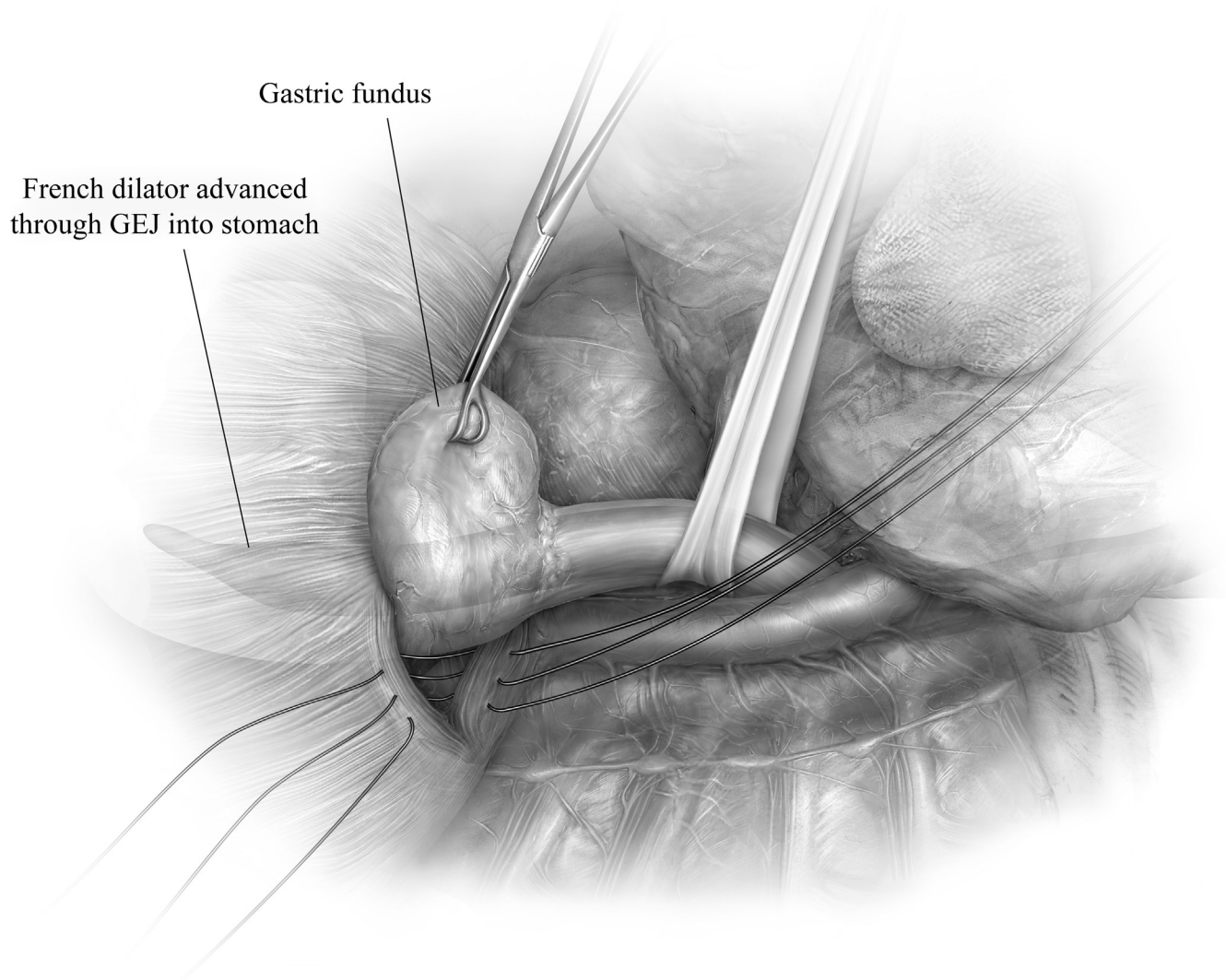


Figure 7 A Maloney dilator of 50-56 Fr is placed orally by the anesthesiologist and guided by the surgeon across the GEJ into the stomach. GEJ = gastroesophageal junction.

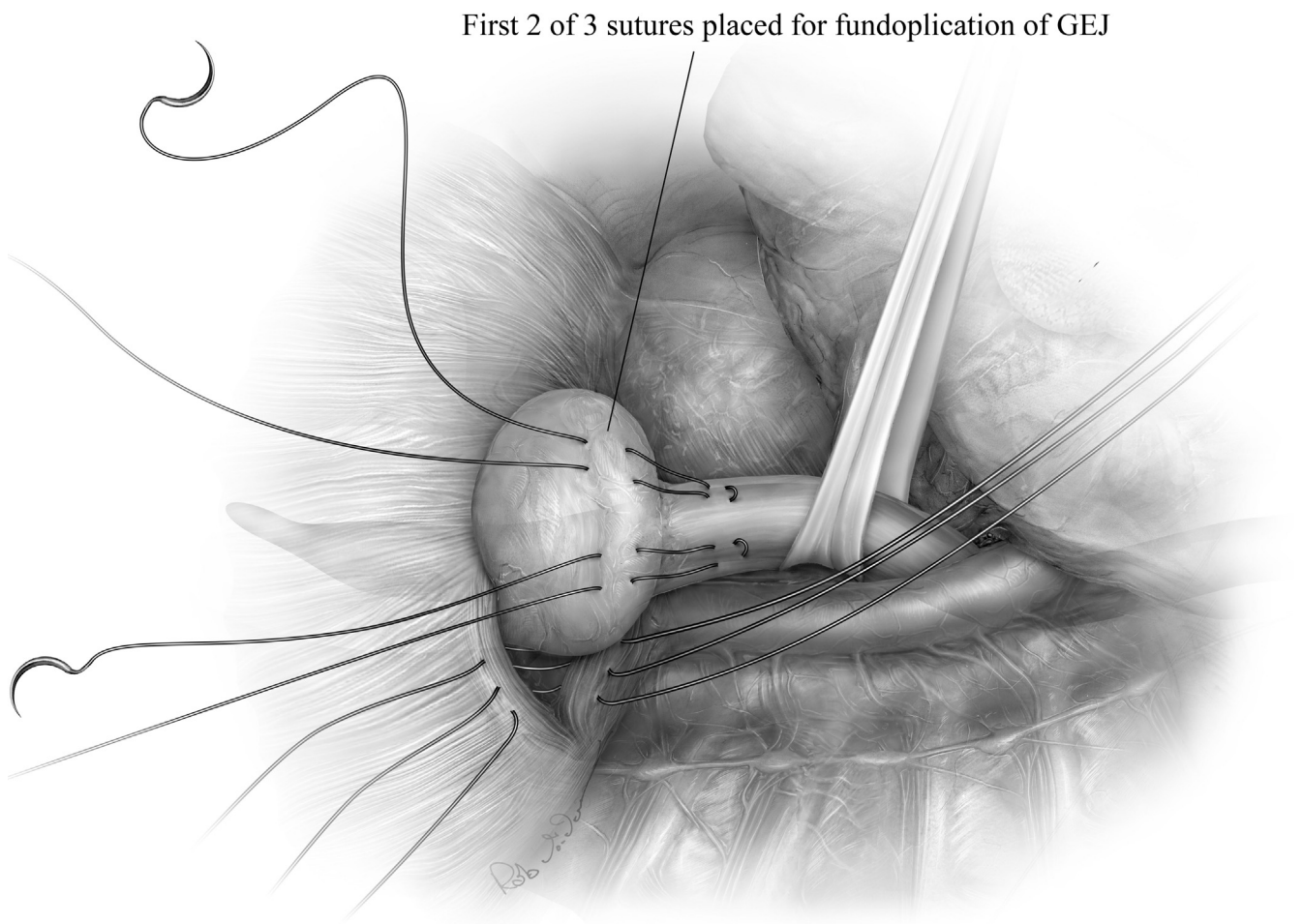


Figure 8 Step 2: The fundoplication is performed by placing 2 mattress interrupted 2-0 silk sutures, placed 1-cm apart, each stitch starting 2 cm below the GEJ, passing from gastric fundus (seromuscular layer) through esophageal muscle 2 cm above the GEJ and then reverse mattressed to the gastric fundus again. GEJ = gastroesophageal junction.

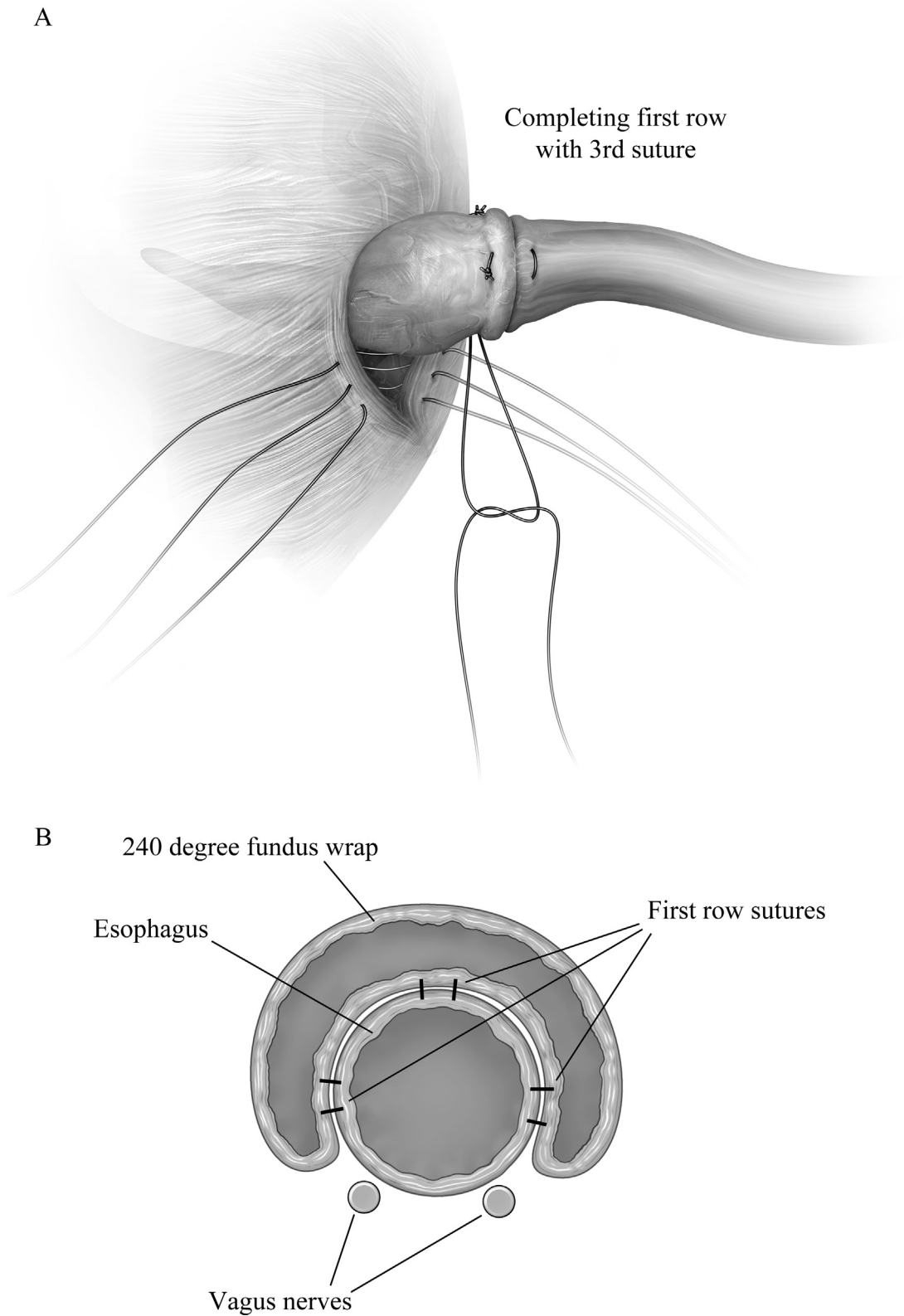


Figure 9 The fundoplication sutures are tied. The 3 sutures are placed in a semicircumferential manner to form a 240°, incomplete anterior wrap. For a modified BMIV performed after an esophageal long myotomy, the middle suture is omitted to avoid the myotomy.

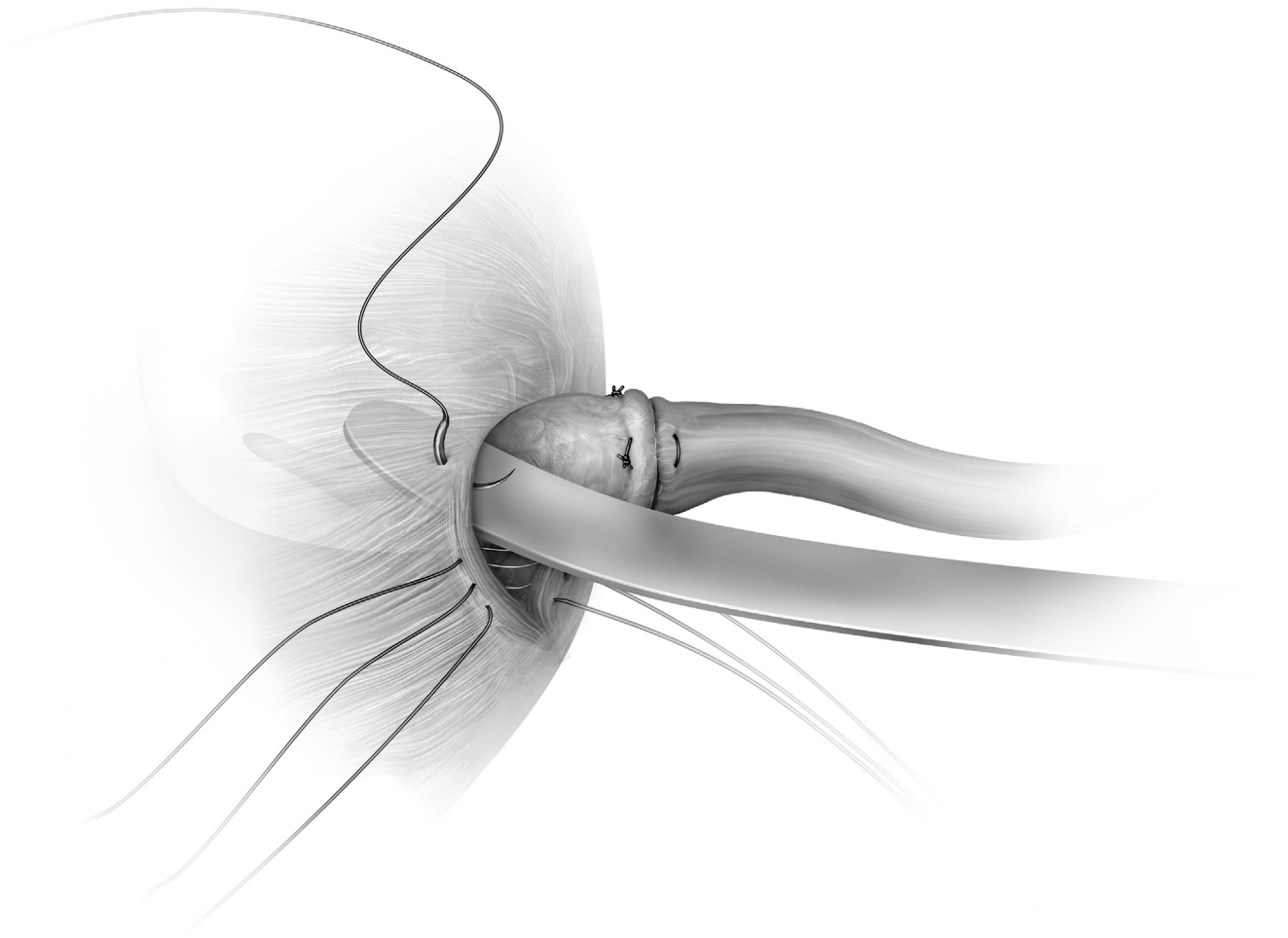


Figure 10 Step 3: A second row of 3 2-0 silk fundoplication sutures is performed. The suture is first passed through the diaphragm where the central tendon transitions to the muscular ring of the hiatus. A narrow malleable retractor is used to protect the abdominal viscera as the needle is passed through the diaphragm. Incorporating the diaphragm would secure the finished wrap to the diaphragm's peritoneal surface.

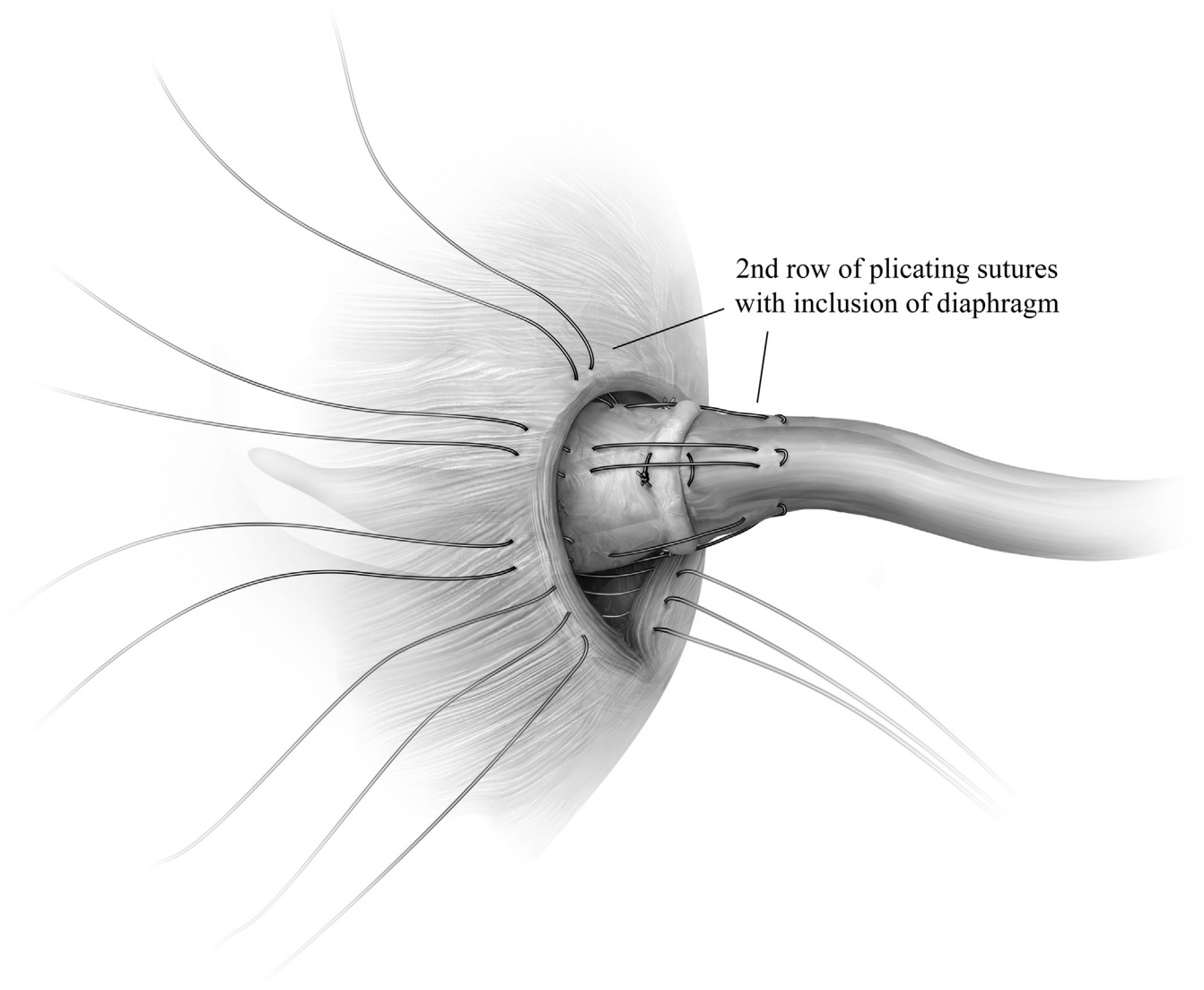


Figure 11 The second mattress row is placed seromuscular through the stomach, 2 cm below the first row, and through the esophagus 2 cm above the first row, reversed mattressed, and finally through the diaphragm using the thin malleable retractor to protect the abdominal viscera. The sutures are tied to complete the 240° plication. As mentioned earlier, for a modified BMIV performed after an esophageal long myotomy, the middle suture is omitted to avoid the myotomy.

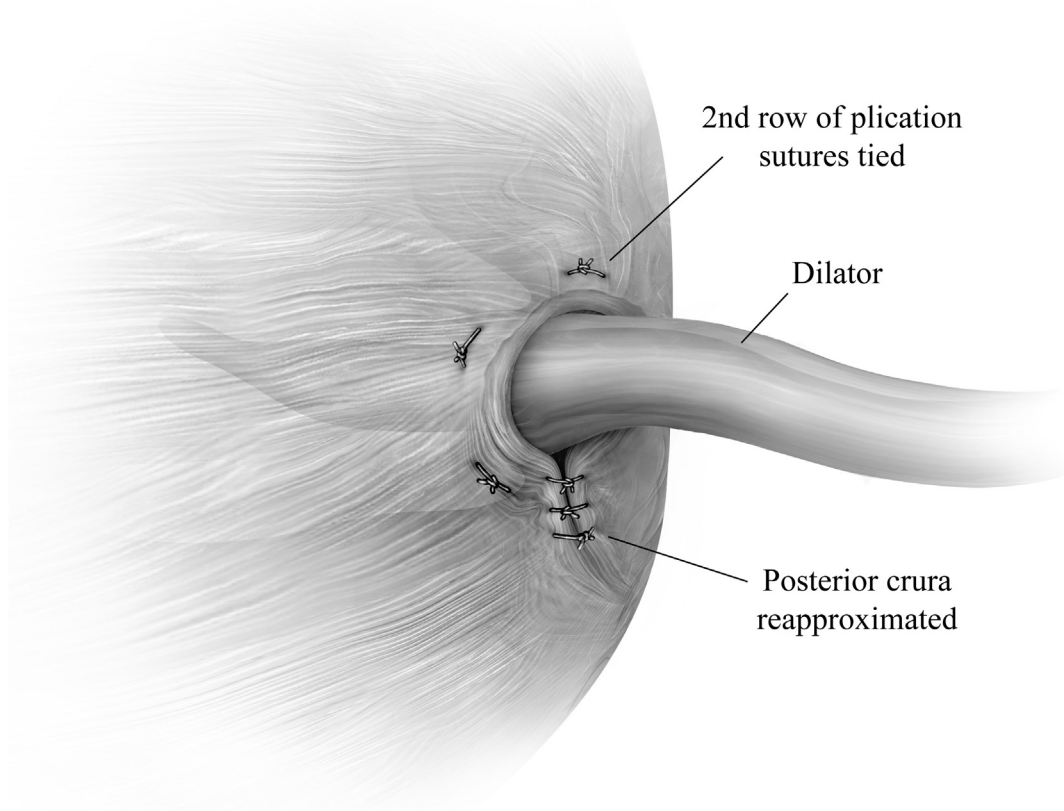


Figure 12 The 3 posterior crural sutures are tied. The resulting narrowed hiatus should allow the passage of an index finger alongside the esophagus into the peritoneal cavity. The dilator is removed, and a nasogastric tube is passed by the anesthesiologist and guided by the surgeon into the stomach.

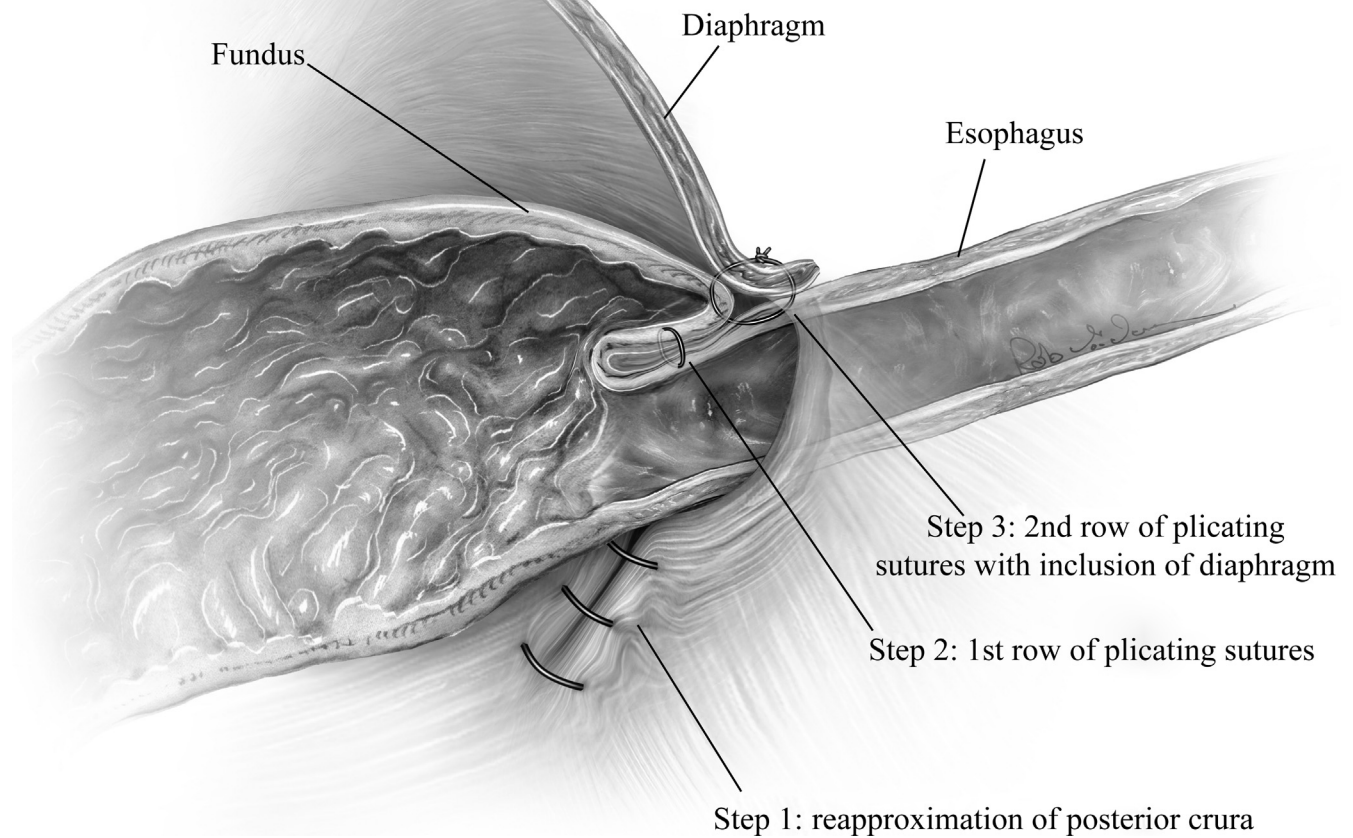


Figure 13 A final sagittal view of the Belsey Mark IV demonstrates the 3 steps of the repair: step 1—narrowing of the esophageal hiatus; step 2—first mattress row of the 240° fundoplication; and step 3—second mattress row of sutures that incorporate the diaphragm, securing the 240° plication to the diaphragm’s peritoneal surface and maintaining the gastroesophageal junction (GEJ) in the abdomen.

The mediastinum and chest are thoroughly irrigated and a straight 28-Fr chest tube is placed along the posterior thorax toward the apex. If the BMIV is being performed for esophageal perforation, then an angled 28-Fr chest tube or a flexible Blake drain is positioned over the diaphragm and near the repair.

Postoperative Care

For indications other than esophageal perforation, the nasogastric tube is left to low wall suction and then removed on postoperative day (POD) 1. Moreover, on POD1, a thin barium esophagram is performed. If this demonstrates no leak, the patient is started on a sips-of-clears diet, and advanced over a period of 24-48 hours to a final soft mechanical diet. The epidural catheter is generally removed on POD3. The chest tubes are removed once total pleural output is $< 300 \text{ cm}^3/24$ hours. For BMIV in the setting of esophageal perforation, patients are started on a sips-of-clears diet on POD3 and advanced daily to clears, and then full liquids. A thin barium swallow study is obtained on POD7, and if the result is negative, the patient's diet is advanced to mechanical soft solid food. The angled chest tube or Blake drain placed along the primary repair is removed after a favorable esophagram.

Postoperative Complications

Postoperative complications include those germane to a thoracotomy, including atelectasis and hospital-acquired pneumonia. Aggressive postoperative pulmonary physiotherapy and early ambulation is important to avoiding pulmonary complications. Other complications include bleeding from improper hemostatic control of short gastric vessels or unidentified full-thickness injury to the cardia during gastric mobilization. Long-term complications include gas bloat syndrome secondary to a more than 240° wrap, or injury to the bilateral vagus nerves. This may require takedown and redo fundoplication.

Summary

In certain clinical situations such as epiphrenic diverticulum, esophageal perforation in the setting of underlying esophageal

dysmotility and giant esophageal hernia with suspected chronic pleural-based adhesions,⁴⁻⁷ a thoracotomy with BMIV may be a valuable and effective technique. When an esophageal lengthening procedure is required, a Collis gastroplasty should be favored. The incomplete 240° wrap makes the BMIV an effective antireflux procedure in patients with underlying esophageal dysmotility, such as achalasia or diffuse esophageal spasm, and avoids gas bloat syndrome.⁸ Though declining in the era of minimally invasive surgery, the BMIV remains a valuable surgical technique in tailored settings and should remain in the highly skilled esophageal surgeon's armamentarium.

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