11 The Failed Laparoscopic Hiatal Hernia Repair: "Making it Better" at Redo Operation

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Introduction

Despite over 85 years of experience in its surgical management [1], hiatal hernia remains a tremendous challenge to the gastro-intestinal surgeon. The difficulty in effectively managing this disorder is evident in the large amount of literature devoted to the topic and the myriad of surgical options that are described, including open transabdominal and transthoracic and, more recently, laparoscopic and thoracoscopic approaches. The enthusiasm for laparoscopy and its many potential benefits has made it the standard of care for antireflux surgery [2–4], and there is compelling evidence to suggest that redo surgery is also feasible [5–7]. This enthusiasm has naturally carried over to the surgical management of hiatal hernia, which frequently co-exists with reflux. Laparoscopic hiatal hernia surgery, however, is not yet well established, and concern has been voiced that it may not be a suitable approach for those patients with large hiatal hernia, and for those with recurrent hernia after a primary laparoscopic repair [8].

Concern with laparoscopic hiatal hernia repair stems from outcome studies that suggest high recurrence rates. Although some investigators have found the recurrence rates for laparoscopic repair to be comparable to open approaches [8], the highest quoted recurrence for laparoscopy (42%) [9] by Hashemi and colleagues compared unfavourably to their recurrence with open techniques (15%). Other investigators, using mainly transthoracic techniques, have quoted anatomical recurrence rates as low as 2% [10]. These excellent results from open surgery are attributed to extensive mobilization and surgical lengthening of the shortened esophagus (interestingly these maneuvers can also be achieved with laparoscopy) [11]. Given the potentially high recurrence rates with laparoscopic techniques, the laparoscopic surgeon who is confronted with a recurrent hiatal hernia in a patient who has undergone primary laparoscopic repair is faced with a dilemma: should the redo operation be performed laparoscopically, or should the surgeon abandon this approach in favour of an open operation?

Technically speaking, the components of hiatal hernia repair are essentially the same whether done laparoscopically or through an open incision. The difference is the tools that one uses, and the way those tools are used. Laparoscopy can be seen as an addition to the surgeon's armamentarium, albeit one that requires considerable technical skill; success is dependent on the facility of the surgeon and the limitations of the technology. As laparoscopic technology is continuously improving, based on necessity and capability, the limitations are reduced. In 1965, Gordon Moore, co-founder of Intel Corporation, observed that the number of transistors per square inch of an integrated circuit had doubled yearly since the integrated circuit was invented [12]. Since then, progress has slowed from Moore's prediction; however, this technology continues to double in capacity every 18 months. Technophiles are fond of applying this law to other aspects of technological development. If this is true for laparoscopy, then in time minimal access techniques will accomplish

feats not possible by open surgery. Hints of this eventuality are already emerging in the fields of robotic and translumenal surgery.

Proponents of laparoscopic surgery feel that every aspect of hiatal hernia surgery that can be performed through an open approach can be accomplished using laparoscopic and/or thoracoscopic techniques. Therefore, it is possible through attention to specific details of the operative technique to use laparoscopic tools to effect a secure hiatal hernia repair. This article briefly reviews the classification of hiatal hernia and the nature of its recurrence, discusses the factors that may lead to recurrence after laparoscopic hiatal hernia repair, and proposes strategies that should be employed during the laparoscopic procedure to prevent recurrence.

Classification of Hiatal Hernia and the Nature of Recurrence

Hiatal hernia is composed of a widening of the esophageal hiatus large enough to allow intra-abdominal components of the GI tract to enter into the thoracic cavity. Hernias are classified into three primary types [13], and a fourth type is described for classification purposes [14, 15]. The most common is type 1 (sliding hernia), which generally involves a small hiatal defect with intrathoracic herniation of the gastro-esophageal junction (GEJ) and proximal stomach. These make up 90–95% of all hiatal hernia, and can either be aymptomatic or manifest with gastro-esophageal reflux symptoms. Type 2 (para-esophageal) hernia comprises a larger defect with normal infrahiatal placement of the GEJ but significant herniation of the gastric fundus. These patients are at risk of gastric ulceration with hemorrhage, and gastric volvulus with necrosis and perforation. Prior to these life-threatening sequelae, the hernia may be asymptomatic and many surgeons consider an incidental finding to indicate operative repair. Others believe in a more selective approach [16] in patients who are at poor surgical risk. Type-3 (mixed) hernia exhibits components of both type 1 and 2, and clinically behaves as a paraesophageal hernia. A type-3 herniation that also involves other viscera such as colon, small bowel and liver is referred to as a type 4.

Surgeons may embark on a hiatal hernia repair as a component of an antireflux operation, or for the specific goal of correcting a type-2 or -3 defect. Either way, a fundoplication should be a component of the repair [17–19]. Extensive hiatal and para-esophageal dissection during antireflux surgery can disrupt the integrity of the hiatus and ligamentous fixation of the esophagus, creating a defect that predisposes to herniation. The most common failure pattern for laparoscopic antireflux surgery and hiatal hernia repair is intrathoracic wrap migration (84% of failures) [20, 21], which results from crural repair breakdown [22]. These patients present with dysphagia and/or recurrent reflux. Interestingly, this is not the case for open antireflux surgery, which has a wrap herniation rate of about 22% [20].

Factors Promoting Hiatal Hernia Recurrence

Recurrence of hiatal hernia can be traced back to a number of factors that may have contributed to the failure of the initial operation. These factors are related to the experience of the surgeon, the anatomy and nature of the disease, the comorbidities of the patient and the consequences of a laparoscopic approach. Understanding these factors gives insight into strategies the surgeon can use to maximize success of primary and redo laparoscopic hiatal hernia repair.

The Surgeon

The surgeon who tackles hiatal hernia repair must have considerable experience in esophagogastric surgery in order to expect optimal results. As such, repair of these defects should be performed at specialist centers where critical volumes can be accrued and adequate expertise is present, particularly with laparoscopy. Reviewing the Austrian experience with redo fundoplication, Wykpiel and colleagues [22] demonstrated an inverse relationship between complication rate and experience with fundoplication procedures.

The ability to perform a successful open hiatal hernia repair does not necessarily implicate immediate success when changing to a laparoscopic approach. Laparoscopy requires an entirely novel set of psychomotor skills, and it is commonplace to acquire additional training in advanced laparoscopic surgery through established fellowships or “mini-residencies” [23]. The surgeon who is newly adopting laparoscopy cannot rely on his open surgical skills as a foundation for his learning, and must often “unlearn” or replace his open skills in order to gain laparoscopic facility. Although dissection is essentially the same in laparoscopic and open approaches, the principles of exposure and the techniques of suturing are very different.

Steep learning curves have been demonstrated for a range of minimal access procedures [24–26]. Soper and Dunnegan [27] found that laparoscopic fundoplication failure was significantly higher early in their learning curve, with a rate of 19% in the first 53 patients as compared to 4% in the subsequent 237 patients. Also of note, these surgeons did not routinely mobilize the fundus and repair the crura in the early patients, but subsequently felt this to be an important factor. It can be expected that the learning curve plays a similar, if not greater role, in the success and failure of the technically more difficult laparoscopic hiatal hernia repair. Ferri and colleagues [8] found their recurrence rate after laparoscopic para-esophageal hernia repair to be higher in their first 15 patients (5 recurrences, 33%) as compared to their subsequent 20 patients (2 recurrences, 10%). Overall, the recurrence rate at their institution for open repair was higher (44%) than for laparoscopic repair (23%).

The Disease

A number of anatomical features of hiatal hernia predispose to recurrence after repair. These issues must be acknowledged and addressed by the operating surgeon at the primary repair, and again at redo operation. All hiatal hernias have an accompanying hernia sac extending into the mediastinum. Because the sac is composed of peritoneum, attempting crural repair with the sac intact results in poor healing between the two peritoneal surfaces, leaving a path for recurrence [5]. The sac acts to tether the stomach and esophagus in the mediastinum, impeding reduction into the abdomen and, furthermore, an intact sac can progress to a mediastinal retention cyst which is at risk of infection and mass effect [16].

A second important feature is the size of the hiatal defect. Smaller defects (usually type 1) can be re-approximated with little or no tension. Type-2 and -3 defects tend to be larger, and significant tension is placed on the tissues with primary suture repair [28]. As we have learned from groin hernia surgery, tension in the repair can lead to recurrence. A further complicating factor is that the tissues at the edge of the defect may be attenuated or friable, and sutures may easily tear through.

A final, and critical, anatomical concern is the esophageal length. A number of investigators have identified shortened esophagus as a source of crural repair breakdown [10, 20, 29–31]. Patients with hiatal hernia frequently have severe reflux disease which results in inflammation, fibrosis and consequent shortening of the esophagus. Hernias of types 1 and 3 are most likely to have a shortened esophagus, with the GEJ situated in the mediastinum. A hiatal repair under these conditions experiences tension when the fundoplicated esophagus attempts to re-establish its intrathoracic position, and the repair eventually breaks down, resulting in intrathoracic wrap herniation.

The Patient

The surgeon must recognize pre-operatively the patient-specific factors that can compromise success of hiatal hernia repair. Patients with respiratory disease may have chronic cough which can place great stress on a crural repair through repetitive violent contractions of the diaphragm and severe transient increases in intra-abdominal pressure. Patients with chronic obstructive pulmonary disease or asthma may be on steroid medications which can compromise tissue integrity and healing, further detrimenting the success of a hiatal repair. Furthermore, patients with large paraesophageal hernias are often elderly with poor nutrition and healing ability.

Patients who retch or vomit are also at risk for recurrence, and prone to acute postoperative wrap herniation [5]. These patients can often be identified pre-operatively, and the degree of their retching can increase postoperatively, leading to considerable tension on the repair. Pediatric surgeons are very familiar with this problem in their neurologically impaired patients, many of whom retch and gag as a consequence of poor gastric motility, promoting a higher recurrence rate [32].

The Laparoscopic Approach

Some benefits of the laparoscopic approach can also be a detriment. Laparoscopy results in fewer adhesions than open approaches, and this allows for redo laparoscopic fundoplication. However, the Achilles' heel [20] of laparoscopic fundoplication, intrathoracic wrap herniation, is thought to be due to relatively reduced adhesions posterior to the esophagus where most of these herniations occur [20]. At redo fundoplication, it is common to find multiple adhesions of the liver to the wrap, but much reduced adhesions posteriorly at the crural repair. Laparoscopists must pay particular attention to this area in order to decrease the rate of crural breakdown.

Performing an Effective Laparoscopic Redo Hiatal Hernia Repair

When confronted with a recurrent hiatal hernia following primary laparoscopic repair, addressing the issues outlined above and paying attention to key technical details can help to prevent recurrence and effect a secure redo operation. The surgeon can derive clues from the pre-operative work-up about the technical source of the failure. For example, intrathoracic wrap migration where the GEJ has also relocated above the hiatus most likely represents inadequate esophageal length in addition to crural repair breakdown. Alternatively, if the GEJ is still intra-abdominal but there is herniated fundus, then the culprit is the hiatal repair alone. Adherence to the following principles may help to prevent recurrence after primary laparoscopic repair, or effectively treat it at re-operation.

Traversing the Learning Curve

Laparoscopic repair of large hiatal hernia is clearly an advanced procedure that requires considerable skill and comfort with minimal access surgery. Surgeons should not attempt such a procedure early in their learning curve. Learning laparoscopic surgery should not be viewed as mastery of a successive series of operations, but instead a gradual accumulation and refinement of a repertoire of skills. Eventually, the surgeon masters enough of these skills such that they can be applied to virtually any operation. This comfort level is indicated by a change in the way the surgeon approaches a surgical problem – they begin to think "laparoscopically".

Although the literature discusses specific numbers of cases that must be done of a particular operation before being considered competent, experience with laparoscopic training shows that this can be highly variable. Some surgeons can learn in two operations what it might take another surgeon ten operations to learn. A surgeon well advanced in his repertoire of skills may be quite facile at a novel laparoscopic procedure despite never having performed it before.

Surgeons interested in performing laparoscopic hiatal hernia repair should first make an assessment of their skill level. Skills are best accumulated by first performing operations of lesser technical difficulty such as cholecystectomy and appendectomy. Once working in a laparoscopic environment becomes comfortable, surgeons should accumulate experience with uncomplicated fundoplications, where less difficult intracorporeal suturing can be performed. It may also be useful to use inanimate video box trainers and computer-based virtual reality platforms for purposes of practice [33]. Working with a preceptor who is advanced in the learning curve can also accelerate learning [34]. Laparoscopic hiatal hernia repair should only be performed once a solid foundation is developed in the skills of laparoscopic dissection (blunt, sharp, and thermal), stapling, and suturing.

Redo hiatal hernia surgery requires an even greater degree of skill. In a review of the Austrian experience with redo laparoscopic fundoplication, a six times greater conversion rate as compared to primary laparoscopic fundoplication attested to the difficulty of this procedure. This was due mainly to adhesions between the liver and the stomach and wrap, a factor responsible for the more frequent complications of esophageal and gastric perforations [35].

Preparing the Patient for Surgery

A number of steps can be taken in patient preparation that will maximize chances for a successful operation. Patients with COPD, asthma and other conditions that can lead to chronic cough should have their medical therapy optimized. A concerted effort should be made to control symptoms with nonsteroid medications and steroid use should be minimized. Anesthetic reversal and extubation should be performed carefully to prevent violent coughing, and consideration given to prolonged intubation to allow for a slow, easy wean off the ventilator. Patients with a history of retching and vomiting should be agressively treated peri-operatively with anti-emetics. Finally, nutritional maximization should be instituted prior to surgery.

Operative Strategy

To minimize hiatal hernia recurrence, special attention must be paid to a number of key aspects of the laparoscopic procedure that address the disease-specific problems discussed above. These recommendations pertain both to the primary operation and redo procedures.

Hernia Content Reduction, Sac Mobilization, and Sac Resection

After mobilization of the fundal wrap off adjacent structures, it is necessary to reduce the hernia contents. In redo operations, it is important to first dissect

the often dense adhesions between the wrap and the liver. This is best accomplished by following the liver surface, to avoid gastric perforation, and a lighted bougie in the stomach may be helpful. The herniation of the stomach typically occurs posteriorly and, depending on the type of hernia, there may be varying degrees of stomach and other viscera involved. All hernia content must be completely reduced and adhesive attachments to the mediastinum must be released, otherwise there is tension on the reduced structures and a tendency to reherniate. Moving these structures away from the area also greatly helps in exposure when repairing the hernial defect.

The hernia sac should then be completely excised. This is done by incising the sac circumferentially around the edge of the defect. Continuous traction is applied while the sac is reduced from the mediastinum and loose adhesions are transected bluntly or with a thermal energy source. The entire sac should be removed, en bloc if possible, so as not to leave sac remnants.

Assess and Address Esophageal Length

Because the esophagus is a dynamic structure that contracts and extends in relation to the hiatus, it is difficult to estimate its length using endoscopy or esophagogram, and only approximations can be made with these modalities. Patients with severe esophagitis or stricture, Barrett's disease, para-esophageal hernia, and those undergoing redo surgery have a higher likelihood of foreshortened esophagus [36]. More accurate assessment of esophageal length is made intra-operatively with the laparoscope. Specifically, it is important to have more than 2.5 cm [36, 37] of esophagus sitting without tension below the hiatus. This ensures that there will be no upward tension by the fundoplication on the hiatal repair.

Inadequate esophageal length can in most cases be addressed laparoscopically by generous mobilization of the mediastinal esophagus [30, 31, 38]. Care must be taken to not induce pneumothoraces by avoiding violation of the pleura. In severe situations, mediastinal mobilization is insufficient and an esophageal lengthening procedure must be utilized. This has been done both laparoscopically [39] and thoracoscopically [40], and both are technically challenging. Lengthening typically takes the form of a Collis gastroplasty in which a circular stapling device is used to make a defect on the fundus from which a second linear stapler is fired toward the angle of His adjacent to a bougie placed in the esophagus to tubularize the proximal stomach. More recently, surgeons experienced in these procedures have recommended the use of a simpler wedge gastroplasty [41]. This technique is more easily done using conventional roticulating endoscopic staplers, and involves an initial transverse staple fire across the fundus followed by an inferior to superior staple fire parallel to the left side of the esophagus. A wedge of fundus is removed, while tubularizing the proximal stomach. The lengthened portion of the esophagus can then be fundoplicated, and care must be taken to incorporate the superior-most fundoplication sutures into normal esophagus in order to prevent an obstructive effect.

The Large Hiatal Defect – Mesh or No Mesh?

Some investigators define a large hiatal defect as those greater than 4–5 cm in diameter [16], and others consider 8 cm [42] as the cutoff. In general, a large defect is one that cannot be closed primarily without excessive tension. This latter definition, although subjective, accounts for the quality of the tissues that are being re-approximated. The problem with tension is that sutures ultimately tear through, particularly with diaphragmatic contraction, and friable tissues are more prone to this. Poor tissue integrity is seen in the elderly, malnourished, and those on corticosteroids. It is important also to note that the magnified view provided by the laparoscope may lead the surgeon to get insufficient crural purchase during suturing of the hiatus, and that bigger bites should be taken to compensate for this. Magnification may also lead the surgeon to overestimate the size of a defect, and so more objective means of measurement should be employed.

When conditions exist that are not ideal for primary closure, the surgeon must consider alternate forms of tension-free repair such as with mesh. Many surgeons choose to avoid mesh due to concerns over erosion, infection and stricture; however, when a large hiatal defect recurs, mesh repair should be seriously considered at redo operation. In addition to reducing tension, the mesh most likely perpetuates robust adhesions posterior to the esophagus that are otherwise lacking with a laparoscopic approach. These adhesions bolster the hiatal closure and secure the wrap in the abdomen.

Mesh can be used in two ways. One approach is to suture the mesh patch to the edges of the defect without re-approximating the crura [14]. This is the purest form of tension-free repair of the hiatal defect. The concern, however, is that the mesh cannot be anchored to the esophagus at its anterior border, thereby leaving a po-

tential defect. To avoid this, the mesh must abut the esophagus in order to minimize the defect. The esophagus is a dynamic structure that moves in a vertical plane relative to the crura, and the resultant chronic abrasion can result in mesh erosion into the esophagus.

As a remedy to this situation, a more popular approach is to re-approximate the crura primarily with suture, then place a mesh onlay that is anchored to both crura [43]. Although some authors describe creating a horseshoe- or ovoid-shaped [16] mesh that encircles the esophagus, there are concerns over mesh shrinkage and consequent esophageal stricture [44], hence a rectangular mesh situated posterior to and away from the esophagus may be a better option. The mesh onlay distributes tension more evenly, hopefully reducing the chance of tissue tear at any one place. Once again, the mesh must not abut the esophagus to avoid erosion, and some surgeons recommend placing it such that it abuts the fundal wrap [45]. Some authors advocate an A-shaped mesh as optimal, based on studies of crural mechanics [14, 46].

There has been excellent success reported with mesh cruruplasty using both polypropylene and expandable polytetrafluorethylyne (ePTFE; DualMesh, Gore-Tex; W.L. Gore & Associates, Flagstaff, AR). Granderath and colleagues [45] recently reported their experience in 100 consecutive fundoplication patients that were randomized to crural closure with and without polypropylene mesh overlay. A rectangular piece of mesh was secured with suture to both crura after primary suture closure. Postoperative intrathoracic wrap migration on fluoroscopy was significantly lower in the mesh group than the non-mesh group (8 versus 26%). In an earlier study, Frantzides and colleagues randomized a total of 72 hiatal hernia/reflux patients to ePTFE mesh onlay or no mesh. An ovoid piece of mesh with a "keyhole" was situated around the esophagus and secured with tacks. In a follow-up ranging from 6 months to 6 years, there were 8 (22%) recurrences in the non-mesh group versus none in the mesh group [43].

A distinction must be made between polytetrafluoroethylene (PTFE) and expanded polytetrafluoroethylene (ePTFE). There is a tendency in the surgical literature to incorrectly refer to ePTFE as PTFE. Strictly speaking, PTFE, also known as Teflon (Dupont, Wilmington, Delaware), is frequently the material of which pledgets are made and it has also been used as a mesh onlay in the past. In distinction, ePTFE (expanded polytetrafluoroethylene) is a processed form of PTFE that is microporous and has unique mechanical properties.

Concern with mesh repair as a potential source for fistulization and esophageal erosion arises from reports of polypropylene mesh erosion into the esophagus [47, 48] and PTFE into the stomach [49] after para-esophageal hernia repair. There is one report in the literature of Teflon pledgets used in hiatal hernia repair fistulizing to the esophagus [50]. In addition, I recently operated on a 12-year-old neurologically impaired patient who had had mesh repair of a hiatal hernia as a 3-year-old using a PTFE (Teflon) patch. The mesh had almost completely eroded into the esophagus, causing obstruction, and was successfully removed using a laparoscopic transgastric approach (narrowly avoiding a much more involved operation such as esophagogastric resection) [53].

Although ePTFE is safely used for other diaphragmatic defects such as Bochdalek and Morgagni hernias, the hiatus represents a unique situation where the esophagus may be exposed to chronic abrasion against the mesh. Since PTFE (in Teflon mesh form) clearly can erode into the esophagus, ePTFE (Gore DualMesh) should also be held in suspicion for erosion as an eventuality. Nevertheless, when the surgeon is left with no choice but to use mesh for the hiatal repair, ePTFE is most likely the best compromise [37].

Hopefully future development of biological meshes, such as those derived from porcine intestinal submucosa [48, 51], will obviate the need for prosthetic materials and eliminate the concern over erosion.

Conclusion

Although there are few randomized prospective data to make definitive conclusions, proponents of minimal access esophagogastric surgery assert that proper use of laparoscopic tools and approach can result in effective repair of hiatal hernia with minimal recurrence [52]. These success rates are subject to the experience of the surgeon, the nature of the disease and the comorbidities of these complex patients. Attention to these issues, with specific modifications in peri-operative care and technical approach, should minimize their negative effects. Recurrence rates can be further expected to decline with introduction of improved laparoscopic technologies and less troublesome biologically derived prostheses. Patients with hiatal hernia, particularly the fragile elderly, greatly benefit from a minimal access approach. For this reason alone, surgeons should focus their efforts on maximizing the success of laparoscopic hiatal hernia repair rather than abandoning it.

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Discussion

Read: *I would like to point out that you mentioned chronic cough and maybe you mentioned smoking. But smoking not only causes chronic cough, but is chronic and a big comorbidity. For decades, because I have been around for decades, I have heard hernia surgeons or general surgeons talking about chronic cough. In other words, it is a mechanical problem. The cough and the increased abdominal pressure blow the repair apart. I have heard that for so long, that now, when you present this work again, with that slide, you need to give not only chronic cough but smoking as comorbidity.*

Dutta: *Thank you for the kind comments. I agree with you that there are two aspects to smoking as a causal factor, the chronic cough and the systemic effect on tissue integrity.*

Franzidis: *I would like to congratulate you on this excellent presentation. I would agree with you, when you have finished with the challenge of the redo, there are so many factors that play a role, the adhesions with the left lobe of the liver and so on. I wonder sometimes if you are clear on the anatomy, because many times no matter how many positions you have done, the anatomy is not clear. What we have used is a light and bougie. I know that it is controversial to introduce anything, especially if the device is introduced by an anesthesiologist. But if you have someone who can do this, he can clearly find the anatomy in the gastro-oesophageal junction, so that it is clear where you have mobilization of the oesophagus. Also, when you are dealing with a young child, obviously there is going to be a growth of tissue and the oesophagus is going to become larger; do you account for that when you place the mesh? I feel a little bit uncomfortable with the idea of placing a mesh on a child.*

Dutta: *I like the idea of the bougie. I have not talked about that, because my approach is just to stick onto the liver. Liver bleeding always stops on its own or with some pressure. With reference to your second question, I do worry about that, but once again, it is a compromise, and a judgment. With congenital diaphragm hernia we sometimes use Gore-Tex mesh to close, sometimes we use a muscle flap. When we use a mesh we see later on in life that these children have an indentation of the rib cage on the left side, where we*

typically have the mesh. So yes, there is some issue with growth.

LeBlanc: *Do you have any comment on or experience with the incision in the diaphragm and putting a mesh there and taking the tension of?*

Dutta: *No, but I have read about it. There is something intuitively that I worry about by making a hole somewhere, where there was no hole. But I understand the concept, that it is a relaxing incision that has been done for hernia surgery and groin hernia surgery. My answer is, personally I would say that I would not do that, because of making another hole where I didn't have one before.*

LeBlanc: *It is just an option.*