World J Surg (2011) 35:1436–1441
DOI 10.1007/s00268-011-1029-3

World Journal of Surgery

Evolution and Development of Surgery for Large Paraesophageal Hiatus Hernia

David I. Watson

Published online: 5 March 2011

Abstract Laparoscopic repair is the standard surgical approach to the problem of large paraesophageal hiatus hernia. It is associated with low risks of morbidity and mortality, although there is a small risk (less than 5%) of a clinically significant recurrent hernia. Various techniques have been proposed to minimise this risk, including esophageal lengthening procedures and mesh reinforcement of the hiatus. Both remain controversial. Radiological outcomes from randomised trials suggest that a reduction in hernia recurrence rates can be achieved with the use of mesh repair, although these trials have not demonstrated any clinically significant benefits for mesh repair. The risk of complications following mesh placement at the esophageal hiatus or an esophageal lengthening procedure needs to be balanced against potential benefits. More work is required to define the optimal approach to repair of large paraesophageal hiatus hernias.

Introduction

In the early 1990s, soon after the introduction of laparoscopic approaches to antireflux surgery, surgeons began to report experience with laparoscopic repair of large hiatus hernias [1]. These approaches have now become the techniques of choice for the repair of large hiatus hernia, and low morbidity and mortality rates are now reported, even in older patients [2, 3]. More recent reports, however, have also consistently described a significant risk of recurrent, although frequently asymptomatic, hiatus hernia at medium-term follow-up [4, 5]. Partly for this reason, there is still no consensus amongst surgeons about what is the optimal technique for laparoscopic repair of a large hiatus hernia.

Large hiatus hernias occur predominantly in late-middle-aged and older individuals. As the populations of many countries age, this is becoming an increasingly common problem, and over the last decade there has been a significant increase in the number of patients presenting for surgery [6]. This trend is in part driven by the perception that the development of reliable laparoscopic techniques has led to a reduction in the morbidity and risk that was previously perceived to be associated with open surgical repair. In Australia, for example, the proportion of patients who undergo laparoscopic antireflux surgery and who have a very large hiatus hernia has increased from less than 10% of the caseload 15 years ago to 25-30% of current caseload [6]. Hence, large paraesophageal hiatus hernia is becoming an increasingly important component of the workload of many specialist upper gastrointestinal surgeons. When considering whether to recommend surgery to an individual patient, various issues should be considered. These include the safety, morbidity and mortality associated with surgical repair versus the safety, morbidity, and mortality associated with nonoperative management.

Clinical presentation

The main indications for surgical repair of a large paraesophageal hiatus hernia are either "mechanical" problems or gastroesophageal reflux. More rarely, a small proportion of otherwise asymptomatic patients present with anaemia due to chronic gastrointestinal blood loss from the large hernia [7]. "Mechanical" problems associated with a large

D. I. Watson (✉)
Flinders University Department of Surgery,
Flinders Medical Centre, Bedford Park, SA 5042, Australia
e-mail: david.watson@flinders.edu.au

paraesophageal hiatus hernia occur when the stomach rotates and twists within the hernia sac [8]. If the twisting obstructs the gastroesophageal junction, the outcome is acute dysphagia. When this occurs patients often experience intermittent episodes of complete esophageal obstruction. Obstruction of the distal stomach can lead to gastric distension that presents as vomiting and/or chest pain which often radiates to the upper back. These "mechanical" problems usually manifest intermittently, with episodes often lasting for several hours. When the gastric obstruction fails to resolve, the result is acute gastric volvulus, and this can progress to strangulation, gastric ischemia, and rarely gastric rupture. For this reason, "mechanical" symptoms may herald a potentially life-threatening problem. This underpins the current recommendation for surgical repair in many patients.

In patients presenting with acute gastric volvulus, management initially entails urgent nasogastric tube decompression of the stomach. If successful, semiurgent laparoscopic repair can then be undertaken within the next few days. Urgent operative repair is required rarely and only in patients in whom gastric decompression has not been successful, or if the problem has already progressed to gastric ischemia or gastric rupture.

In general, elective repair is usually appropriate in all otherwise fit patients with a large hiatus hernia who present with "mechanical" symptoms, irrespective of the individual's age. A proportion of patients, however, have no symptoms. In these, the risk of surgery must be balanced against the risk of developing a life-threatening problem at a later stage. The risk of progressing to a life-threatening situation is less in older patients but probably greater in younger, fitter patients because of their longer life expectancy. A study reported by Stylopoulos et al. [9] pooled outcome data from 20 published studies and then constructed a Monte Carlo probabilistic model to evaluate the risks versus benefits of elective repair of asymptomatic large paraesophageal hiatus hernia. They estimated the annual risk of developing acute symptoms and having to undergo emergency surgery to be 1.1%, the risk of morbidity of elective surgery to be 5.4%, and the mortality of elective surgery to be 1.4%. Using these assumptions, they determined that the risk of elective repair exceeded any benefits in otherwise asymptomatic patients aged over 65 years.

In patients for whom the primary problem is symptomatic gastroesophageal reflux, the presentation and workup is the same as for any other patient with symptomatic reflux who is being considered for laparoscopic antireflux surgery. In the small group of patients in whom the indication for surgery is chronic blood loss and anaemia, it is important to confirm that anaemia is due to gastrointestinal bleeding and also to adequately exclude other sources of gastrointestinal bleeding by fully investigating the full length of the gastrointestinal tract.

Older techniques for surgical repair

The original methods of surgical repair for large paraesophageal hiatus hernias entailed an open transthoracic approach, usually via a left posterior-lateral thoracotomy incision [5, 10]. However, it is well understood that the surgical access required for this approach is associated with significant morbidity [11] and mortality risks and a prolonged convalescence compared to current laparoscopic approaches, especially in elderly patients. During the early 1990s, as laparoscopic techniques were being developed and refined, it was claimed that the open thoracic approach provided better access to the esophagus via the left chest and allowed esophageal length to be better assessed, with a view to using the Collis procedure to "lengthen" the esophagus [5]. Subsequent experience with the laparoscopic approach has meant that patients now expect a minimal access approach, and it is now very unusual for a left thoracotomy to be performed for primary repair of a paraesophageal hernia.

The progression to open transabdominal approaches for antireflux surgery in the 1970s was also followed by the development of open abdominal approaches to repair paraesophageal hernias [12]. This was probably associated with less incision-related morbidity than the open transthoracic approach, although there is no high level of evidence to support this statement. What is clear is that both open approaches, abdominal and transthoracic, are associated with significant postoperative pain, which drives perioperative morbidity. Randomised controlled trials of laparoscopic versus open Nissen fundoplication have clearly shown better short-term outcomes following laparoscopic approaches [13]. This is now well recognised by referring medical practitioners, who are now much more likely to refer these patients, especially the elderly, for surgical assessment.

Laparoscopic techniques for surgical repair

Laparoscopic approaches to the repair of large paraesophageal hiatus hernia were described in 1992, soon after the development of laparoscopic techniques for antireflux surgery [1]. Early repairs paid little attention to the actual hernia sac and aimed to fully reduce the stomach laparoscopically, followed by dissection of the esophagus from within the actual hernia sac. This strategy was unreliable, especially when more than 30-40% of the stomach was located within the hiatus hernia; conversion rates to open

surgery initially approximated 40-50% [14, 15]. What many surgeons failed to recognise was that the posterior wall of the hernia sac in a large paraesophageal hiatus hernia and the proximal stomach are actually the same structure, a situation not dissimilar to a sliding inguinal hernia containing colon. Hence, with hindsight it is perhaps not surprising that the early attempts at laparoscopic repair were associated with such high rates of conversion to open surgery. In the late 1990s we [14], as well as Edye et al. [15], reported studies that demonstrated that when the laparoscopic approach initially focused on dissection and reduction of the sac from the mediastinum before dissecting the esophagus, then the completion rate for laparoscopic repairs improved to more than 90%. More recent experience suggests that when surgery is undertaken by experienced surgeons, conversion to open surgery is now very uncommon [16]. Hence, the standard technique for repair of large paraesophageal hiatus hernias is now laparoscopic, with initial dissection of the hernia sac from the chest. The esophagus is then easily seen and mobilized above the sac. The decline in laparoscopic-to-open conversion rates has been associated with reduced perioperative morbidity, and mortality rates are now less than 0.5%, even though many operations are undertaken in elderly patients with significant comorbidities [2].

Recurrence following surgical repair

Whilst good clinical outcomes are reported in approximately 90% of patients who underwent the standard laparoscopic approach to repair of large paraesophageal hernias, which entails hiatal repair with sutures and a fundoplication, studies that have used objective outcome measures report apparently different outcomes [4, 5, 17]. Studies evaluating repair using routine barium meal radiology at medium-term follow-up have consistently shown that suture repair alone is associated with a "radiological" recurrence rate of 20-30% [4, 5, 17]. However, most "radiological" recurrences are relatively small and are not associated with recurrent mechanical symptoms. The number of patients who develop a larger recurrent hernia that is symptomatic and requires surgical revision appears to be less than 5% [4, 17]. Contrast radiology almost certainly overestimates the extent of any clinical problem associated with recurrence, as a small fixed hernia is unlikely to progress to gastric volvulus or strangulation. Nevertheless, there has been much recent focus on techniques that might be used to prevent recurrence, and in the context of clinical trials, all studies focus on radiological recurrence rather than symptoms or revision surgery rates [18–20]. The two strategies that have been advocated to prevent recurrence are the Collis gastroplasty and the use of mesh.

Short esophagus and esophageal lengthening

The Collis procedure entails "lengthening" the esophagus by creating a tube of stomach around which the gastric fundus is subsequently wrapped. In the late 1990s a number of publications reported techniques and outcomes for laparoscopic approaches, with application rates for the Collis gastroplasty of 4-5% described [21, 22]. However, clinical outcome studies reported mixed results [23, 24]. Furthermore, the increased complexity and risks associated with performing the Collis procedure and the sometimes poor functional result that can be associated with creating a tube of amotile stomach with a fundoplication below it have probably led many surgeons to avoid this approach.

Even the concept of the short esophagus is controversial, with some surgeons claiming that this problem is present in a significant proportion of patients who undergo repair of large paraesophageal hiatus hernias, whereas others (including this author) claim that it is now a rare problem. In the era of open surgery, however, most surgeons did agree that the short esophagus was a true entity, although since the introduction of proton pump inhibitor medication for gastroesophageal reflux, fewer patients have reflux-related esophageal mucosal damage, and it is likely that this entity is now much less common [25].

If a short esophagus is encountered during laparoscopic repair of a large paraesophageal hernia (and this is uncommon), then the treatment options are to either (1) repair only the hiatus hernia and accept that there might be a risk of hernia recurrence or (2) add an esophageal lengthening procedure. These different philosophies explain why the lengthening procedures vary from 0% in some series to more than 50% in others [26]. What is known is that the Collis procedure is associated with a small but significant risk of gastrointestinal leakage, and this is associated with morbidity and mortality [24]. This needs to be balanced against the risk of an adverse outcome from a recurrent hernia.

Not all recurrent hiatus hernias are a problem. Before surgery the risks and symptoms associated with a large paraesophageal hiatus hernia are directly associated with the ability of the stomach to rotate and twist. This occurs because free movement of the stomach is possible within the large hernia sac. For this to occur, herniation of approximately 50% or more of the stomach is probably required.

Small recurrent hernias, which are identified only by contrast radiology, are usually asymptomatic and often entail only a relatively small slippage of the gastroesophageal junction above the level of the diaphragm. If these patients undergo revision surgery, substantial adhesions are

usually encountered in the vicinity of the diaphragmatic hiatus as well as between the upper stomach and the undersurface of the left lobe of the liver [27]. In this scenario, it is hard to see how the stomach can rotate and twist within the recurrent hernia, and perhaps the problem that is more likely to occur is recurrent gastroesophageal reflux. Hence, the extent of the clinical problem of hernia recurrence probably better matches the surgical revision rate which is less than 5% [4, 17], not the higher recurrence rate suggested by radiological outcome studies [4, 5, 17]. This means that the risks associated with liberally applying a Collis procedure should be less than the risk of a symptomatic hernia recurrence in patients who undergo repair without a lengthening procedure if such a strategy is to make sense. A similar balancing of risks versus benefits also needs to be considered when evaluating the use of mesh reinforcement of the hiatal repair.

Mesh reinforcement

An alternative approach advocated to minimise the risk of hernia recurrence is the technically easier reinforcement of the hiatal repair with prosthetic mesh [18]. This adapts the principles of inguinal hernia repair, i.e., tension-free repair with prosthetic reinforcement. However, mesh repair has not been universally supported because any advantages might be offset by a risk of complications associated with the use of mesh. These include mesh erosion into the esophageal lumen, stenosis at the hiatus, and esophageal obstruction [28]. Mesh erosion into the esophagus can be disastrous. The risk of this problem might be specifically associated with the use of "harder" mesh types, in particular, the placement of mesh so that it encircles the esophagus and places a "sharp" edge of mesh against the esophageal wall.

Two randomised trials have examined mesh repair of large hiatus hernias. Frantzides et al. [18] enrolled 72 patients in a trial of repair with sutures versus nonabsorbable polytetrafluoroethylene mesh. Mesh encircled the esophagus. Radiological hernia recurrence at a median of 2.5 years of follow-up was reduced from 22 to 0%. However, this study enrolled a relatively small number of patients and the outcomes reported for each procedure do not match the majority of studies that report outcomes from uncontrolled case series [4, 5, 15, 17]. Oeschlager et al. [19] reported 6-month outcomes from a multicentre trial of 108 patients who underwent repair with sutures versus reinforcement with an absorbable mesh (Surgisis). Recurrent hernia, determined by contrast radiology, was reduced from 24 to 9% following mesh reinforcement. Unfortunately, neither trial reports later follow-up, and all outcome differences were radiological rather than clinical.

In addition to these two trials, Granderath et al. [20] reported a randomised trial in which 100 patients who underwent laparoscopic Nissen fundoplication primarily for gastroesophageal reflux had hiatal repair with sutures with or without reinforcement with an onlay of a 3-cm × 1-cm piece polypropylene mesh. The use of mesh was also associated with a reduced radiological incidence (26 vs. 8%) of intrathoracic migration of the fundoplication at 12 months follow-up. Unfortunately, in this study the 26% incidence of fundoplication migration in the control group was much more common than usual. In an earlier randomised trial reported from my department, the incidence of barium meal X-ray-detected migration of the fundoplication 6 months after a Nissen fundoplication undertaken for reflux, and that incorporated a sutured hiatal repair (no mesh) was a much lower 6% [29]. Granderath's trial [20] enrolled some patients who presented primarily with reflux and others with a large hiatus hernia, the number of which was not stated. Hence, it is difficult to extrapolate these data to either patients with a large hiatus hernia or those presenting primarily with reflux. Nevertheless, the trial does lend support to the use of mesh reinforcement of the hiatal repair.

For now, however, the issue of how best to repair a large hiatus hernia remains unclear. This is because the randomised trials were powered to only evaluate the surrogate marker of contrast radiology outcomes, and significant clinical outcome differences have not been demonstrated. Furthermore, this area remains confused by the plethora of competing mesh types and repair techniques. Any benefits from a possible reduction in the rate of hernia recurrence also need to be balanced against the risk of complications that can follow mesh placement. Hence, further studies are needed to determine whether mesh has a role in the repair of large paraesophageal hiatus hernia, to fully evaluate mesh complications versus recurrence risk, and to determine the optimal technique for placement.

Gastroesophageal reflux

Whilst many patients present with predominantly mechanical problems associated with a large paraesophageal hiatus hernia, and this article has concentrated primarily on this issue, gastroesophageal reflux is also common in these patients [30, 31]. For this reason most surgeons add a fundoplication to the repair of large paraesophageal hernias. This serves several purposes. It provides a degree of reflux control, and the suturing of the fundoplication and its construction can also add a gastropexy to hold the stomach within the abdomen, thereby minimising the risk of hernia recurrence. There is some disagreement among surgeons about the use of a partial

versus Nissen fundoplication [32]. In general, the author's view is that if reflux symptoms dominate the clinical presentation, then the fundoplication becomes the major focus of the surgery and the pros and cons of Nissen versus partial fundoplication should be considered. On the other hand, if reflux is a minor issue, then the risk of side effects following a Nissen fundoplication may outweigh the risk of developing reflux after a partial fundoplication [33]. In this situation the author's preference is to perform a partial fundoplication as a gastropexy and accept an increased risk of at some stage developing gastroesophageal reflux with the knowledge that in most instances reflux symptoms will be controllable with medication [33].

Technical issues

The instrumentation required for repair of large paraesophageal hernias is relatively simple. A Nathanson liver retractor (Cook Medical Technology, Queensland, Australia) provides excellent and stable visualisation of the operative site. Precise dissection is achieved using a diathermy hook, and ultrasonic shears or similar technology is not usually necessary. When commencing surgery, it is not necessary to initially reduce the hernia contents, as the operation should focus first on dissection of the hernia sac. The dissection of the hernia sac starts by dividing the attenuated phrenoesophageal ligament near where it attaches to the hiatal rim. Two layers need to be divided to enter the correct plane. Dissection should be maintained 0.5-1 cm inside the hiatal rim to avoid excising the fascial coverings which protect the muscle fibres at the hiatal rim. These coverings are important as they anchor the hiatal repair sutures. The cut edge of the sac is pulled into the abdomen and dissection progresses. This allows the hernia contents to passively reduce into the abdomen and the esophagus is then seen above the sac. If dissection is in the correct plane, separation of the sac from the mediastinum is usually bloodless. Any posterior sac should be identified and dissected as well. During posterior dissection, the posterior vagus nerve is at risk and should be preserved by pushing it posteriorly, away from the esophagus. The hiatus is next repaired with posteriorly placed sutures, and its size is reduced to a diameter of approximately 30 mm. If the repair appears to be under excessive tension, additional sutures can be added to the anterior hiatus, or mesh reinforcement can be considered. If the fascial coverings over the left and right hiatal pillars are preserved, then a satisfactory primary repair with sutures can usually be achieved. At this stage a fundoplication should be added, according to surgeon preference.

Conclusions

Laparoscopic repair is now the standard approach to the surgical treatment of symptomatic large paraesophageal hiatus hernias. This approach is followed by a short period of convalescence, and it is associated with low risks of morbidity and mortality. For these reasons surgery has become more acceptable and the threshold for surgery has been lowered, with more elderly patients now presenting for repair. Inherent in all laparoscopic repair techniques, however, is a small risk (less than 5%) of a clinically significant recurrent hernia. Various techniques have been proposed to minimise this risk. The use of an esophageal lengthening procedure remains controversial, and arguments about the prevalence of the "short" esophagus and the role of esophageal lengthening are likely to continue for the foreseeable future. However, presently there is little enthusiasm from most surgeons to expand the use of procedures such as the Collis gastroplasty; this would suggest that many surgeons believe that the risks of esophageal lengthening in their hands are greater than the risk of symptomatic hernia recurrence. Radiological outcome studies suggest that a reduction in hernia recurrence can be achieved by routine use of mesh repair of large hiatus hernia, although randomised trials are yet to demonstrate any clinically significant benefits with mesh repair. The risk of complications following mesh placement at the esophageal hiatus need to be balanced against any potential benefits. For this reason, more work is required to define the role of mesh repair, to determine the ideal placement technique, and to determine the optimal mesh type for repair of large paraesophageal hiatus hernia.

References

1. Cuschieri A, Shimi S, Nathanson LK (1992) Laparoscopic reduction, crural repair, and fundoplication of large hiatal hernia. Am J Surg 163:425–430
2. Grotenhuis BA, Wijnhoven BP, Bessell JR et al (2008) Laparoscopic antireflux surgery in the elderly. Surg Endosc 22: 1807–1812
3. Oelschlager BK, Pellegrini CA (2001) Paraesophageal hernias: open or laparoscopic or thoracic repair? Chest Surg Clin N Am 11:589–603
4. Aly A, Munt J, Jamieson GG et al (2005) Large hiatal hernia: recurrence after laparoscopic repair. Br J Surg 92:648–653
5. Hashemi M, Peters JH, DeMeester TR et al (2000) Laparoscopic repair of large type III hiatal hernia: objective follow up reveals high recurrence rate. J Am Coll Surg 190:533–560
6. Jay AP, Watson DI (2010) Changing work patterns for benign upper gastrointestinal and biliary disease: 1994–2007. ANZ J Surg 80:519–525
7. Hayden JD, Jamieson GG (2005) Effect on iron deficiency anemia of laparoscopic repair of large paraesophageal hernias. Dis Esophagus 18:329–331

8. Krähenbühl L, Schäfer M, Farhadi J et al (1998) Laparoscopic treatment of large paraesophageal hernia with totally intrathoracic stomach. J Am Coll Surg 187:231–237
9. Stylopoulos N, Gazelle GS, Rattner DW (2002) Paraesophageal hernias: operation or observation? Ann Surg 236:492–501
10. Allen MS (1998) Open repair of hiatus hernia: thoracic approach. Chest Surg Clin N Am 8:431–440
11. Martin TR, Ferguson MK, Naunheim KS (1997) Management of giant paraesophageal hernia. Dis Esophagus 10:47–50
12. Treacy PJ, Jamieson GG (1987) An approach to the management of paraoesophageal hiatus hernias. Aust NZ J Surg 57:813–817
13. Peters MJ, Mukhtar A, Yunus RM et al (2009) Meta-analysis of randomized clinical trials comparing open and laparoscopic antireflux surgery. Am J Gastroenterol 104:1548–1561
14. Watson DI, Davies N, Devitt PG et al (1999) Importance of dissection of the hernial sac in laparoscopic surgery for large hiatal hernias. Arch Surg 134:1069–1073
15. Edye M, Salky B, Posner A et al (1998) Sac excision is essential to adequate repair of paraesophageal hernia. Surg Endosc 12:1259–1263
16. Mitiek MO, Andrade RS (2010) Giant hiatal hernia. Ann Thorac Surg 89:S2168–S2173
17. Smith GS, Isaacson JR, Draganic BD et al (2004) Symptomatic and radiological follow-up after para-esophageal hernia repair. Dis Esophagus 17:279–284
18. Frantzides CT, Madan AK, Carlson MA et al (2002) A prospective randomised trial of laparoscopic polytetrafluroethylene (PTFE) patch repair vs simple cruroplasty for large hiatal hernia. Arch Surg 137:649–652
19. Oelschlager BK, Pellegrini CA, Hunter J et al (2006) Biologic prosthesis reduces recurrence after laparoscopic paraesophageal hernia repair: a multicenter, prospective, randomized trial. Ann Surg 244:481–490
20. Granderath FA, Schweiger UM, Kamolz T et al (2005) Laparoscopic Nissen fundoplication with prosthetic hiatal closure reduces postoperative intrathoracic wrap herniation. Arch Surg 140:40–48
21. Johnson AB, Oddsdottir M, Hunter JG (1998) Laparoscopic Collis gastroplasty and Nissen fundoplication. A new technique for the management of esophageal foreshortening. Surg Endosc 12:1055–1060
22. Swanstrom LL, Marcus DR, Galloway GQ (1996) Laparoscopic Collis gastroplasty is the treatment of choice for the shortened esophagus. Am J Surg 171:477–481
23. Youssef YK, Shekar N, Lutfi R et al (2006) Long-term evaluation of patient satisfaction and reflux symptoms after laparoscopic fundoplication with Collis gastroplasty. Surg Endosc 20: 1702–1705
24. Orringer MB, Sloan H (1977) Complications and failings of the combined Collis-Belsey operation. J Thorac Cardiovasc Surg 74:726–735
25. Herbella FA, Patti MG, Del Grande JC (2009) When did the esophagus start shrinking? The history of the short esophagus. Dis Esophagus 22:550–558
26. Luketich JD, Nason KS, Christie NA et al (2010) Outcomes after a decade of laparoscopic giant paraesophageal hernia repair. J Thorac Cardiovasc Surg 139:395–404
27. Watson DI, Jamieson GG, Game PA et al (1999) Laparoscopic reoperation following failed antireflux surgery. Br J Surg 86: 98–101
28. Stadlhuber RJ, Sherif AE, Mittal SK et al (2009) Mesh complications after prosthetic reinforcement of hiatal closure: a 28-case series. Surg Endosc 23:1219–1226
29. Watson DI, Pike GK, Baigrie RJ et al (1997) Prospective double blind randomized trial of laparoscopic Nissen fundoplication with division and without division of short gastric vessels. Ann Surg 226:642–652
30. Avidan B, Sonnenberg A, Schnell TG et al (2002) Hiatal hernia and acid reflux frequency predict presence and length of Barrett's esophagus. Dig Dis Sci 47:256–264
31. Braghetto I, Korn O, Csendes A et al (2010) Postoperative results after laparoscopic approach for treatment of large hiatal hernias: is mesh always needed? Is the addition of an antireflux procedure necessary? Int Surg 95:80–87
32. Cai W, Watson DI, Lally CJ et al (2008) Ten-year clinical outcome of a prospective randomized clinical trial of laparoscopic Nissen versus anterior 180° partial fundoplication. Br J Surg 95:1501–1505
33. Shukri MJ, Watson DI, Lally CJ et al (2008) Laparoscopic anterior 90 degree fundoplication for reflux or large hiatus hernia. ANZ J Surg 78:123–127