The Nissen Fundoplication

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Introduction

The "Nissen fundoplication" was first published in 1956 by Rudolf Nissen, a surgeon from Basel, Switzerland [1]. He created the first mechanical effective plication of the gastric fundus around the distal esophagus, which proved to be a true antireflux procedure in the subsequent years with its augmentation effect on the lower esophageal sphincter (LES). With increasing understanding of gastroesophageal reflux disease (GERD) as a distinct entity, this paralleled the development of surgery as a treatment option [2–5]. The history of antireflux surgery in the twentieth century is initially characterized by a reconstruction of the anatomical alterations after the development of a hiatal hernia [1–7]. Especially Allison initiated and propagated the first step in antireflux surgery with an anatomical reconstruction of the hiatus and a gastric fixation by a pexy [2, 3]. However, over the 1950s and 1960s, it became quite evident from clinical experience that only an anatomical reconstruction was not sufficient enough to effectively treat pathologic reflux [4–7]. Allison himself published at the end of his career a summary of his experience with the pexy technique showing a recurrence rate of around 50% [5]. As a consequence, it could be concluded from this era that the technical strategy of an isolated anatomical reconstruction and fixation is probably not sufficient enough to stop reflux for good, especially not in patients with advanced disease [5–7].

The Nissen fundoplication became a successful antireflux procedure during the 1960s and 1970s; however, the published side effects were substantial especially

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dysphagia [4, 7]. This led to searching for a better "fundoplication" and several other procedures like various forms of partial fundoplications such as the Belsey Mark IV procedure or the Lind operation [4, 7, 8]. Very few comparative studies were performed at that time, showing quite superior antireflux effect of the full 360° Nissen fundoplication [6].

In Chicago, a group of surgeons Donahoe, Bombeck, and DeMeester modified the technique to create the short floppy Nissen fundoplication [6, 9, 10]. This version of the Nissen fundoplication with documented fewer side effects as the original version became the most successful Nissen technique in the 1980s and 1990s. DeMeester et al. documented that by using a shorter wrap and a larger bougie during calibration and shaping of the wrap, one can reduce postoperative dysphagia and side effects substantially [10].

With the advent of minimal invasive surgery, the laparoscopic Nissen fundoplication became a "boom operation" [11]. Again, during the learning curve of laparoscopic Nissen fundoplication, the incidence of postoperative dysphagia was high, indicating the need for a very meticulous technique to shape and to suture the fundus around the weak LES [12–16]. Surgeons looking for an alternative with less side effects picked up the posterior hemifundoplication technique published by Toupet in the early 1960s [17]. In subsequent years, the laparoscopic Nissen fundoplication and the laparoscopic Toupet hemifundoplication became the most frequently used minimal invasive techniques [18–21].

Among surgeons, the discussion and the choice for one or the other technique, Nissen or Toupet, have continued with persisting engagement. A number of randomized trials have been performed to compare full and partial fundoplication techniques [18, 19, 22–33]. Several meta-analyses are available to judge over the two versions of fundoplication [34–39]. Based on the evidence in literature, the Toupet fundoplication bears less risk for postoperative dysphagia and side effects, as well as the Toupet has a lower rate of necessary reoperations for dysphagia [34–39]. The level of reoperations for Nissen in these randomized trials and meta-analysis is around 10–15% [22–39].

These results are in severe contrast to results from experienced centers with large case series with Nissen fundoplications, which show a much lower dysphagia rate and reoperation rate at the level of 5% [12–16, 37]. Many discussions have been performed also in several guideline committees about these controversies [40–42]. In addition, it has been discussed whether a partial Toupet fundoplication may have less durability than the Nissen fundoplication, where the posterior fundus is sutured to the anterior fundus wall and additionally to the esophagus, thus creating a possibly more dependable connection of tissue, compared to the fixation of the fundic wall only on the esophageal wall in the Toupet fundoplication [43, 44]. A consensus based on these controversial data was impossible. The guideline commissions have decided to suggest that the surgeons should make this decision based on their experience and their choice of procedure, Nissen or Toupet [40–42].

The Principle of Action of a Nissen Fundoplication

The major pathophysiologic background of GERD is the failure of the natural antireflux barrier and especially the mechanical and functional weakness of the LES as well as the anatomical alteration in that the sphincter is not anymore exposed to the abdominal pressure environment due to the development of a hiatal hernia [45]. As a consequence, these two major components have to be corrected by an effective antireflux procedure [10, 12, 45].

Therefore, a prerequisite for an optimal working action for a Nissen fundoplication is the mobilization of the esophagus out of the mediastinum in order to gain a sufficient intra-abdominal length of the sphincter. This anatomical reconstruction of the position of the cardia below the hiatus is important to regain the physiologic position of the sphincter within the abdominal pressure system [10, 12, 45]. Then the intra-abdominal pressure system can support the remaining sphincter pressure to close off the intra-abdominal segment of the LES, especially when intra-abdominal pressure or intragastric pressure rises. Figure 8.1 demonstrates the principle of action of a fundoplication. The symmetric wrap around the weakened LES after its correct positioning in the abdomen augments the cardia.

Prior to surgery, an increased intra-abdominal and/or an intragastric pressure will easily cause reflux through a mechanically weak LES because there is no resistance. After performing a technically correct fundoplication, an increased intragastric pressure will cause also a pressure increase within the fundic wrap. The wrap will

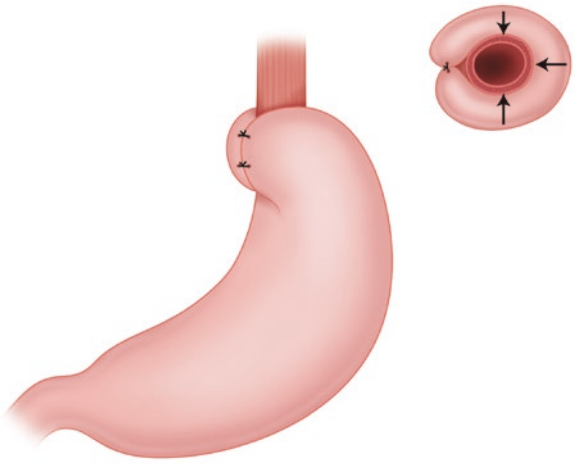

Fig. 8.1 Principle of action of the Nissen fundoplication: After anatomical reconstruction of the hiatus, the fundoplication remains in the abdominal pressure environment. The symmetric shape of the wrap will cause a mechanical augmentation of the weakened cardia. In addition, a rise in intragastric pressure will also cause a rise of the pressure inside the fundoplication, which will cause additional closure of the cardia. The latter will prevent excessive reflux, if the position of the wrap is secured intra-abdominally

have the ability to compress the distal esophagus helping to fulfill the task of an antireflux barrier. In addition, an increased intra-abdominal pressure will create the similar effect. Therefore, an important technical prerequisite for a good result after a Nissen procedure is the anatomical reconstruction to ensure an intra-abdominal position of the sphincter as well as the fundoplication.

Operative Technique

The Nissen fundoplication should consist of a few very important basic technical steps to have the highest probability for a successful operation besides a correct indication for surgery.

The first step is the dissection of the hiatus and the cardia. The second step is a sufficient mobilization of the esophagus in the mediastinum to position the LES in the abdominal pressure environment. The third step is the narrowing of the hiatus to an adequate width around the esophagus. The fourth important step is the shaping of the wrap. Each step is important in creating a functional good result with a long-lasting durability.

We have followed the "DeMeester School" in creating a short floppy Nissen fundoplication in the sandwich technique (Fig. 8.2) [10, 12]. The patient is placed in a French position and in a 30° anti-Trendelenburg situation. Five trocars are used for the laparoscopic fundoplication. Initially, the left liver lobe is retracted toward the right side of the patient to have an optimal exposure of the hiatal region. Especially

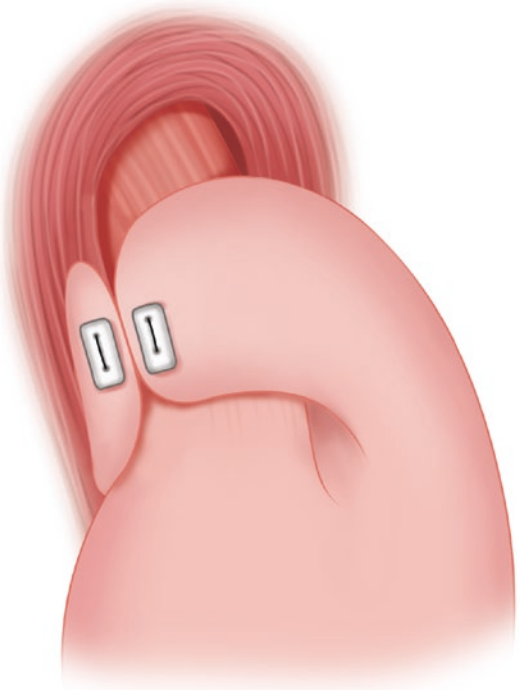

Fig. 8.2 Scheme of a short, floppy total fundoplication in the Nissen-DeMeester-sandwich technique [10]

in obese patients, the anti-Trendelenburg position will facilitate a sufficient exposure of the cardia, since gravity will pull fatty omentum and bowel downward. Initially, the size of the hiatal hernia and the width of the hiatus are evaluated to get an impression about the possibility of a short esophagus and the mobility of the esophagus.

For dissection, the stomach and especially the fundus are pulled downward, and the gastrosplenic ligament is exposed. With an energy instrument, the short gastric vessels are separated starting at the upper pole of the spleen in order to free the fundus. It is important to mobilize all tissue connections of the posterior fundus with the retroperitoneum, with the spleen, and with left hiatal crus. In addition, the left crus is completely dissected as an important landmark for later approximation with the right crus. Later, the posterior fundus will be pulled over to the right side of the patient. It is important that the fundus has space to move around in this area especially when the fundus will be filled with food and will need space for fundic accommodation. At the left crus, the hernia sac can be grasped and pulled downward in order to get in the tissue layer between the left crus and the hernia sac into the mediastinum. This is a very important step. It should be executed with caution. If this is done accurately in the correct tissue layer, the hernia sac can be dissected completely out of the mediastinum rather easily. An incision is carried out around the hiatal arch toward the right side of the patient, constantly pulling the hernia sac downward.

On the right side of the hiatus, the most upper part of pars flaccida is opened to visualize the right crus. This opening is kept limited in size to keep only a rather small window for the posterior flap of fundus. Many surgeons open the pars flaccida completely and divide all vagal branches toward the liver. We try to preserve these branches for their functional task and also to keep the opening small to have an abutment for the posterior fundic flap. A complete dissection of the smaller curvature would allow for an easy sliding of the fundoplication downward on the stomach, which would facilitate slipping. This can be prevented by keeping this opening small.

Once the hernia sac is completely mobilized out of the mediastinum, the aorta and the esophagus become nicely visible on the aorta (Fig. 8.3). If one has dissected these layers carefully with minimal bleeding, it is usually easy to identify the two vagal trunks around the esophagus. During further blunt dissection and mobilization

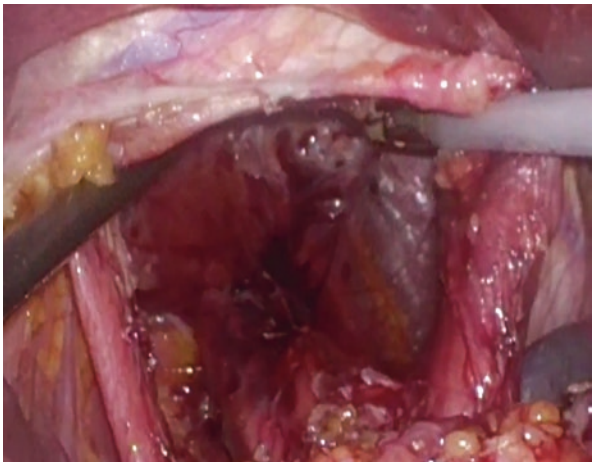

Fig. 8.3 View in the mediastinum after mobilization and resection of the hernia sac. Only these preparations will allow a sufficient anatomical assessment of the esophagus in the mediastinum and a full mobilization

of the esophagus in the mediastinum, it is advisable to keep those two trunks together with the esophagus as a package to avoid any lesions. The next step is the complete resection of the hernia sac and all fatty tissue around the esophagus, especially around the esophagogastric junction. The step requires extreme caution not to harm the vagal trunks. Care should be taken to avoid thermal damage to the vagus by energy devices. On the other hand, it is important to clean the cardia from any of this superfluous tissue. This will allow for a scar tissue development between the esophagus and the fundus. If fatty tissue remains around the cardia and/or this tissue is interposed between the muscle of the cardia and the stomach wall, it will create an easy sliding area for future recurrence of hiatal hernia.

Now, a Penrose drain is slung around the cardia, and the esophagus is pulled downward. It must be double-checked whether the length of the intra-abdominal segment of the LES is sufficient. If this is not the case, more mediastinal dissection is necessary to get a tension-free segment of the LES into the abdominal pressure environment. The resected hernia sac is removed through the largest trocar.

Now, the approximation of the crura is performed by crural hiatoplasty (Fig. 8.4). The esophagus is pulled toward the left side of the abdomen, and this allows for a sufficient view from the right side on the aorta and the hiatus. A figure-of-8 stitch is performed at the lower and posterior part of the crura above the arcuate ligament. Usually, a second figure-of-8 stitch with non-resorbable material size 0 is needed to achieve sufficient narrowing of the hiatus. If the hiatal opening is large and two sutures still leave a gap, more stitches may be needed. There is a danger in creating a posterior obstruction of the esophagus when placing too many posterior crural sutures because the esophagus may be indented by the crura. Such a situation must be avoided. A third suture or more can always be quite easily added in the anterior position of the hiatus ventral to the esophagus. These combined posterior and anterior hiatoplasty should be performed, adequately downsizing the hiatal opening [46]. If the hiatal narrowing cannot be performed sufficiently because the hiatus is

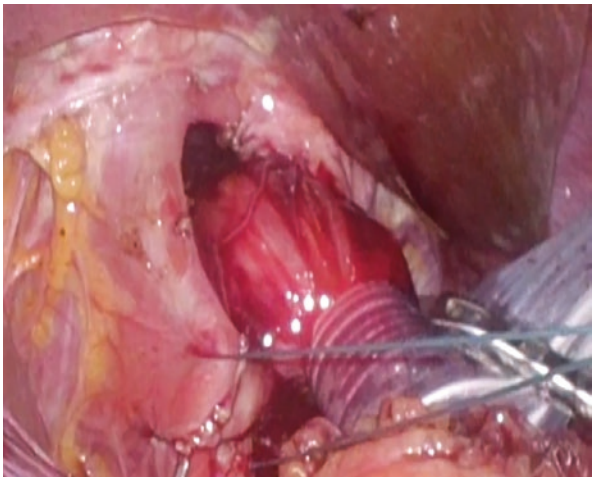

Fig. 8.4 Posterior hiatoplasty with figure-of-8 stitches. Often, only two stitches are sufficient. Otherwise, this can be completed with anterior hiatoplasty stitches

too wide and/or the crural material is too weak to carry a sufficient number of sutures and/or the tension is too large, the surgeon must consider the use of a mesh to complete the hiatal narrowing (see also Chap. 10). If the esophageal mobilization cannot be performed sufficiently because the esophagus is too short, an esophageal lengthening procedure must be added at this point (see Chap. 12).

After narrowing of the hiatus, attention is focused on the shaping and creation of the fundoplication. The mechanical effect of the fundoplication must prevent pathologic reflux in the future, and at the same time, passage of fluids and food must occur without dysphagia. As a consequence, time and care must be invested for this important step of the procedure. In addition, the shape of the wrap must leave enough volume and mobility of the fundus to allow for a postprandial enlargement and fundic accommodation without subsequent early satiety, postprandial epigastric pain, and other unpleasant postprandial symptoms.

To achieve this functional status for the shape of the wrap, an adequate part of the posterior fundic flap must be identified and grasped from the left side of the esophagus and pushed behind the esophagus toward the right side where it is taken over by another grasper to ensure its position. At the same time, the anterior fundic flap is also grasped at the future connection point and pulled over across the anterior aspect of the cardia toward the right side of the esophagus. In doing so, great care is taken to shape the wrap in symmetrical portions around the esophagus (Fig. 8.5). If this is done in the correct fashion, the greater curvature remains on the left side of the esophagus and allows for a sufficient postprandial fundic enlargement and fundic accommodation (Fig. 8.6).

These are very important steps of the procedure, and unfortunately, it is very often done incorrectly as can be seen in many revisional surgeries. An incorrect shaping of the wrap will result in unhappy patients with troublesome and annoying postprandial symptoms after the procedure. Therefore, it is worthwhile to spend time and attention for these maneuvers.

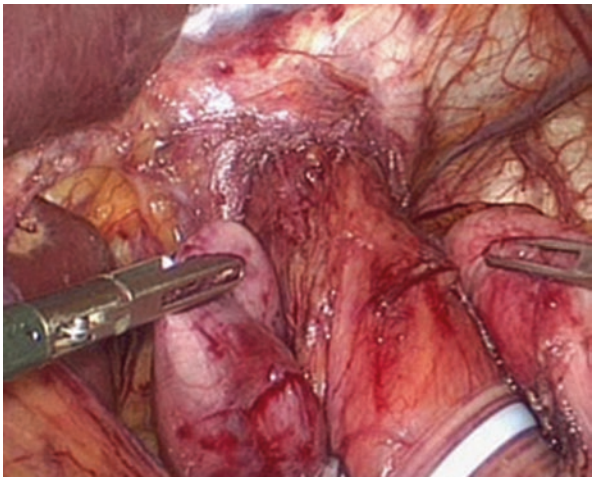

Fig. 8.5 The correct shaping of the Nissen fundoplication is very important for the postoperative long-term function. Care should be invested to shape the wrap short, symmetrical, and floppy to avoid side effects

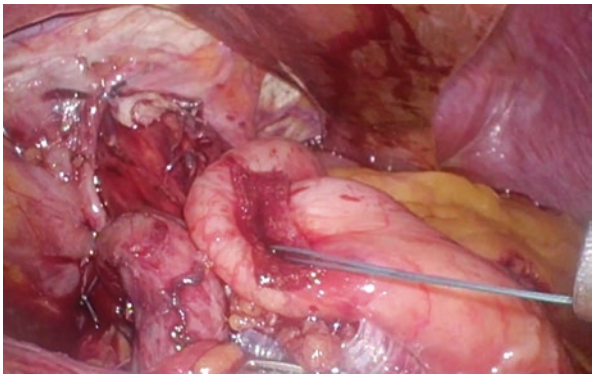

Fig. 8.6 The completed Nissen fundoplication with a short, floppy, and symmetrical-shaped fundic flaps, sutured together with only one U-shaped suture, enforced with pledgets and positioned at the right lateral aspect of the esophagus

To make sure that the wrap is not too tight, a 54 French bougie is placed through the esophagus in the antrum for calibrating the cardia to an optimal size. The advancement of the bougie is observed with great attention by both the anesthesiologist (or whoever person advances the bougie) and the surgeon to make sure that the advancement of the bougie corresponds with the expected intra-abdominal observations. For this procedure, a good communication between the anesthesiologist and the surgeon is very important. If the anesthesiologist pushes the bougie further down the esophagus into the stomach, and at the same time the surgeon cannot see this bougie advancement in the esophagus, there may have been already a perforation in the upper mediastinum or throat. Therefore, to avoid this catastrophe, the communication between these two therapists is essential for the safety of the patients. When the bougie is in its correct antral position, the shape of the wrap is rechecked. Usually, the size of the bougie (54 French) creates an additional tension on the wrap, and it may need some reshaping. This is very important because the fundoplication should be still floppy with the bougie in place [10, 47]. If the tension is too big on the previously shaped fundic flaps after the bougie is placed, the surgeon has to take everything down and reshape the fundic flaps again in order to create a less tight wrap.

When shape and position of the wrap is again double-checked and confirmed to be correct, the wrap is completed and fixed with the typical "DeMeester-sandwich-suture technique" using one U-shaped suture. The suture material (size 0 non-resorbable) is armed with pledgets (Ethisorb™ size 4 × 10 mm). The U-stitch includes the anterior flap of the fundus and then the right lateral aspect of the esophageal wall (on the right side to the anterior vagus) and the posterior fundus followed by another set of pledgets. Then the needle is driven back through the same layers to complete the U-stitch (Fig. 8.6). The suture is tied and the position is secured. The fundoplication is secured by two additional sutures on the fundic flaps. These sutures should not enlarge the fundoplication but just create more suture safety.

After the procedure, the patients may drink fluids in the afternoon after surgery. Since there is quite some edema due to the manipulation and the suturing at the wrap, all patients will have dysphagia directly postoperatively. This is not worrisome. In order to provide time for the edema to resolve on the first postoperative

day, only fluids may be given to prevent dysphagia, choking, and vomiting, which may endanger the operative result. On the second postoperative day, usually the edema is reduced, and the patients can have more fluids and semisolid food. Usually, they have very little epigastric pain. On the third postoperative day, the patients eat semisolid food.

Any alteration from this general pathway such as heavy pain should create special attention from the surgeon and nursing staff because that would be unusual and could mean problems may be developing. Patients after primary fundoplications do rarely have severe pain after the first postoperative day. They usually improve their general condition within the first 48 hours remarkably, and any deviation from that should draw attention to it. Some authors start giving patients very early solid food, which is of course also a possibility. Our experience showed that this may be often tolerated. However, with the risk of dysphagia, choking, and vomiting, the latter could be a reason for a high pressure and strain on the sutures and the tissue, followed by an early weakening of the suture situation and also the risk for early migration. Therefore, we decided to stay for 2 days with fluids and liquid nutrition in the early phase.

Special Issues

Vagal lesions can occur during antireflux surgery because their location at the distal esophagus bears the risk of damage during dissection [48–50]. As a consequence, patients should be informed about this possibility for forensic reasons. There are quite some controversial opinions about actions to avoid such lesions. Some authors are convinced that it is not necessary to identify the vagal trunks at the distal esophagus when performing an antireflux surgery. We are convinced that it is of importance to dissect carefully the hiatus and focus during that section rather on the hiatus and then on the esophagus because after a clean dissection of the hiatus, the esophagus and the vagal trunks will remain unharmed in the middle between the crura and the hiatal arch. Afterward, the vagal trunks can be rather easily identified. In the subsequent maneuvers, damage can be prevented by leaving them on the esophageal package.

Vagal damage can result in some functional problems such as chronic diarrhea or increased dumping. However, it can also develop in a complete gastroparesis. The latter can emerge into a catastrophe for the patient because quality of life can be bad. Therefore, this complication should be prevented by all means. There are only few studies investigating the role of vagal lesions after antireflux surgery [50]. These studies show that it is important that the vagal branches should be identified and damage should be avoided [48, 50].

Patients with a large hiatal hernias may run the risk that their hiatus is too large to achieve a sufficient hiatal narrowing. This may require certain surgical steps such as an implantation of the mesh [51–57]. As shown and discussed in a special chapter, the implantation of a mesh can cause severe problems and complications and therefore should be considered carefully for its indication [58–61]. As has been

shown in the past 10–15 years, surgeons entertain a controversial discussion about this subject [62–64]. While most surgeons favor only hiatal mesh implantation in selective cases, where an effective narrowing of the hiatus may not be possible with simple sutures, other surgeons like to implant a mesh as hiatal enforcement in every case.

The latter position is not supported by evidence from the last 5 years; however, especially in Europe, hiatal mesh enforcement during laparoscopic antireflux surgery is widespread. The problem is that this can cause severe side effects and complications leading repetitively to resections during the second or third reoperation [60–64] (see Chap. 10).

The term "short esophagus" is used for those cases, in which the esophagus cannot be sufficiently mobilized during an antireflux procedure to achieve a tension-free position of the LES 2–3 cm into the abdominal pressure environment. The incidence of this finding varies in literature remarkably between 1% and 20% [65–67]. A possible surgical solution is the esophageal lengthening procedures such as the Collis cardioplasty (see Chap. 12).

Results of Laparoscopic Nissen Fundoplication

The success rate of laparoscopic Nissen fundoplication has been around 90% good results in experienced esophageal centers in studies with a follow-up time of around 5 years [12–16]. Table 8.1 shows an overview of a selection of publications focusing on laparoscopic Nissen fundoplication. There are some studies available with long-term results of 10 years with a remaining success rate of 80–85% [12, 20, 21, 68–75]. It must be emphasized that at least half of the success for an antireflux surgery is created by an optimal selection of the right patients for surgery and the other half is created by the correct operative technique [41, 42]. As a consequence, only this combination of selection of patients based on extensive diagnostic preparation and well-experienced technique will create good results.

Since laparoscopic antireflux surgery is performed worldwide not only in esophageal centers but also in general surgery services, it may not be surprising that in some overviews, results may be less optimal than in those from esophageal centers. The morbidity of laparoscopic antireflux surgery can be assessed from the results of several randomized trials and large case-control series, which are also demonstrated in Table 8.1 [12, 20, 21, 68–75]. Complication rates may be elevated in the learning phase. Therefore, teaching these laparoscopic procedures is essential for quality and patient care [76–79]. The possible surgical complications can be esophageal and gastric perforations, bleeding, spleen lacerations, and infections as well as early signs of vagal lesions [50]. These complications occur in only 2–3%, while general complications (pneumonia, urinary infections) can be as high as 5–6%. There is evidence that in experienced centers with high caseload, morbidity is below 5% and the mortality below 0.2% [12, 20, 21, 68–75]. Several meta-analyses show a good success rate for laparoscopic antireflux surgery both for a Nissen fundoplication and a Toupet hemifundoplication (Table 8.2). In these studies, the morbidity is

Table 8.1 Overview on results of laparoscopic Nissen fundoplication

Author/year	*n*	Techniques	Morbidity (%)	Follow-up (months)	Good results (%)	Reflux recurrence (%)
Champault [68] 1994	940	Nissen Hill	5	4–10	92	2
Fuchs [69] 1997	221	Nissen	14	1–56	92	2.4
Peters [12] 1998	100	Nissen	6	8–60	95	2.1
Dallemagne [70] 1998	550	Nissen Toupet	2.3	16–44	96	2
Zaninotto [71] 2000	513	Nissen	15	1–25	91	8.5
Granderath [72] 2003	668	Nissen Toupet	7.6	3–94	93	7
Dallemagne [20] 2006	100	Nissen Toupet	–	60	89.5	6.7 18.2
Fein [21] 2008	120	Nissen Toupet/Dor	3	60	85	15 30/44
Gee [73] 2008	173	Nissen Toupet	–	60	88	10
Anvari [74] 2011 RCT	51	Nissen	–	36	88	11.8
Maret-Ouda [75] 2017	2655	Total + partial fundoplication	4.1	49	82	17.7

published at 0–13%, while the dysphagia rate (3–100%) is under controversial discussion depending on the definition [34, 36–39].

Gastroenterologists report sometimes on quite negative results [80]. The long-term results of antireflux surgery depend on the criteria used to define a failure. If the criteria are any symptoms and/or the use of PPI, the failure rate may be quite high. The latter is caused by the wide use of PPIs with any abdominal or upper GI symptoms occurring within the years after antireflux surgery [81–83]. As a consequence, this criterion is not very discriminative and should not be used. Better are well-established assessments of quality-of-life or objective measurements of the functional result, necessary to receive an in-depth assessment of antireflux surgery.

In upper GI surgery, the discussion around an optimal antireflux procedure is an ongoing process, since many surgeons are entertaining controversial opinions about the optimal technique such as a Nissen fundoplication or a partial fundoplication [34, 36–39]. New antireflux procedures have entered the market such as the LINX antireflux device or endoscopic antireflux procedures [84, 85]. Until decisive randomized comparative trials are finished, this discussion will go on.

Table 8.2 Overview on results of meta-analyses [34, 36–39]

Author/ year	Comparison	*n*	Morbidity (%)	Dysphagia (%)	Reflux recurrence (%)	Redo surgery (%)
Catarci [34] 2004	Total vs. partial wrap	388 405	9.4 13.1	16.8 10.1	16.5 14.9	9.6 1.6
Davis [36] 2010	Total vs. partial wrap	1302	Major morbid 0–7 total 0–5 partial	17 8	7 9	
Broeders [38] 2010	Total vs. partial wrap	371 261	2.5 4.4	13.5 8.6	22.6 18.2	6.9 3.1
Fein [37] 2010	Total vs. partial wrap	1061	0–8 1–10	2–19 0–8	0.4–19.1 0–15.3	–
Tan [39] 2011	Total vs. partial wrap	478 461	Overall: ns (early compl. partial wrap $P < 0.04$)	16.4 6.9	13.1 13	–

Conclusion

Regarding the choice for a Nissen versus a partial fundoplication, the evidence-based data support a partial fundoplication, since the hemifundoplication provides lower reoperation rates and lower postoperative dysphagia than a Nissen fundoplication [34–39]. However, the rates of postoperative dysphagia and postoperative reoperation rate from these studies are at a level of 10–15% [29, 37–39]. In contrast, the levels of postoperative dysphagia and reoperation rate in large case-controlled series from esophageal centers with Nissen fundoplication are both below 5% [12–16, 20, 21]. As a consequence, despite evidence-based results, these experienced surgeons would not change from their standard Nissen procedure to a partial fundoplication because their results are even better than those in the reported trials. This sort of discussion occurred in several guideline committees, and as a conclusion, it was suggested that the surgeons familiar with Nissen or Toupet fundoplication should perform the technique, with which they have the largest experience [40–42].

The principle of mechanical augmentation of the cardia around the incompetent sphincter in GERD remains the best of concept to reconstruct a weak and deteriorated antireflux barrier. Until new data may emerge in the future, the Nissen fundoplication is the best surgical treatment for patients with advanced progressive GERD.

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