GERD surgery in non-neurologic patients: Modified Laparoscopic Hill-Snow Repair is a valid alternative to Nissen fundoplication. Results of a 20 years of follow-up

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Abstract

Nowadays laparoscopic Nissen fundoplication represents the gold standard in surgical treatment of complicated Gastro-Esophageal-Reflux Disease (GERD), above all in cerebral palsy patients. In non-neurological patients without gastrostomy Nissen fundoplication can create some problems (gas bloat syndrome, dysphagia). Laparoscopic Hill-Snow repair is an established surgical alternative, but it is reported only in adult population. We describe our modification of Hill-Snow technique and our experience in a large series of non-neurological children in order to report its effectiveness and applicability in pediatric patients affected by complicated GERD. Between 2000 and 2022, 319 children underwent surgical correction of gastro-esophageal reflux at our Department. All were affected by complicated gastro-esophageal reflux unresponsive to PPI (Proton Pump Inhibitors). 251 underwent laparoscopic Nissen fundoplication; 68 non-neurological patients underwent laparoscopic Hill-Snow repair. Of these 68 children 48 were males (71%) and 20 females (29%); median age was 5years (3 months-11 years). Weight range was 4-37kg.

52 patients (76.5%) presented the following symptoms: retrosternal pain, dysphagia, regurgitation, coughing, failure to thrive, persisting reflux esophagitis. 16 (23.5%) had chronic respiratory problems (aspiration, apneic-spells, dysphagia, coughing, choking, gagging). For 8 (11.8%) symptoms were expression of chronic recurrent gastric volvulus. All underwent modified-laparoscopic-Hill-Snow repair. Contrast study showed sliding hiatal hernia in 55 patients (81%), while endoscopy demonstrated 16 cases of histologically severe esophagitis (23.5%) and 52 of mild esophagitis (76.5%). No intraoperative/postoperative complications were recorded. 60patients had a complete follow-up (range 1-20 years). 60/68 patients were evaluated with barium-swallow-study at 6-12 months; 40/68 patients with upper-gastrointestinal-endoscopy at 12months. No relapse was reported. 50 patients (73.7%) were symptom-free. 18 (26.3%) referred occasional epigastric pain, associated with vomit in 2 cases. 64 (94.1%) referred ability to vomit; 4 temporary difficulty to swallow (average 30 days). All patients reported being able to burp. 3(4.5%) presented episodes of gas-air-bloat during the first 2 months with spontaneous resolution. No case of dumping syndrome was recorded. This technique's modification yields excellent results in term of relapse and side effects at long-term follow-up. We reported the first and largest pediatric series in non-neurological children with encouraging results.

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Introduction

Gastroesophageal Reflux (GER) is common in infants, with the prevalence ranging from 50% in 3-month-old infants to 5% in

10 to 12 months-old patients. Despite it usually resolves within the first year of life, some patients with complicated Gastroesophageal Reflux Disease (GERD) and dependence on Proton-Pump-Inhibitors (PPI) for symptom relief (increasing indication in young patients) or with no-response to PPI therapy may require surgical antireflux therapy.

Detailed and well-structured patient evaluation and investigation allow a careful selection of patients, confirming the presence of abnormal gastroesophageal reflux and assessing its severity. The more appropriate surgical approach and choice of antireflux procedure are determined by the results of this evaluation.[1]

Although Laparoscopic Nissen Fundoplication (LNF) is considered the gold standard surgical treatment for complicated GER,[2] it may cause postoperative dysphagia and gas bloating especially in non-neurological patients.[3]

The Hill gastropexy has been described in 1967 in adult population[4] and, beginning in 1973, it has been partially modified evolving into an operation that has been standardized in 1987. The modification introduced by Snow (1987) consists of distal abdominal oesophagus fixation by suturing the posteromedial wall of the cardia to the body of the crural decussation and tendon (the caudal part of the crus) with two-three stitches.[5] It has been performed laparoscopically since 1991.

Laparoscopic Hill-Snow Repair (LHSR) is a "physiological" surgical antireflux procedure, which allows to restore the physiological anatomy of the Gastro-Esophageal-Junction (GEJ), with less side effects.

In our centre, we performed laparoscopic reflux correction using different methods (according to the patient condition, clinic and severity of esophagitis). In particular to treat GERD we performed Nissen-Rossetti fundoplication or Hill-Snow technique. According to our experience in the management of GERD in pediatric patients, we introduced a modification of the Hill-Snow technique (modified-LHSR) performing it in carefully selected children without neurological impairment with excellent results at follow-up.

Materials and Methods

At the Pediatric Surgery Department of San Bortolo Hospital of Vicenza, Italy, from 2000 to 2022 319 children affected by complicated gastro-esophageal-reflux unresponsive to PPI underwent surgical correction. 251 underwent laparoscopic Nissen fundoplication; 68 non-neurological patients underwent Laparoscopic Hill-Snow repair.

We performed a retrospective review of preoperative and postoperative demographic and clinical data of 68 non-neurologically impaired patients with at least 18 months follow-up who underwent modified-LHSR at our Pediatric Surgery Department. Surgical technique, preoperative and postoperative endoscopic findings, imaging studies (barium swallow), and clinical symptoms were carefully assessed. We excluded one patient lost to follow-up.

Among these patients, 48 were males (71%) and 20 females (29%). Average age was 5 years (3 months-11 years). Weight range at surgery was 4-37 kg.

Demographic data included: sex, age, weight at surgery and comorbidities. Preoperative data included the presence of symptoms, the need of PPI, the endoscopic and esophagogram findings.

52 patients (76.5%) presented with retrosternal pain, dysphagia, regurgitation, coughing, failure to thrive and persisting reflux esophagitis; 16 (23.5%) presented predominantly chronic respiratory symptoms instead, such as aspiration, apneic-spells, dysphagia, coughing, choking and gagging. In 8 patients (11.8%) symptoms were typical of chronic recurrent gastric volvulus. Gastroesophageal reflux was documented in all patients. All patients have been treated with Proton Pump Inhibitors (PPI) but resulted unresponsive.

The main indication for surgical treatment was complicated GER unmanageable with conservative treatment.

Overall, all patients were preoperatively studied with barium swallow and Esophagogastroduodenoscopy (EGDS) with biopsies, using a flexible video-gastroscope (Olympus video-gastroscope 5mm or 8mm).

The radiologic criteria for reflux diagnosis were visible reflux during the fluoroscopy associated or not with herniation of the stomach above the diaphragm (hiatal hernia). The endoscopic criteria were histologically defined esophagitis, and the modification of the His angle according to the Hill classification.[6] The Gastroesophageal Valve (GEV) was classified according to the Hill grading system from Grade I (normal valve) to Grade IV (no definable mucosal fold, open esophagus, hiatal hernia is invariably present). Esophagitis was histologically graded as none, mild, moderate, or severe.

Results

Preoperative upper gastrointestinal contrast study showed a sliding hiatal hernia in 55 patients (81%) and gastroesophageal reflux without hiatal hernia in 13 (19%). In 16 patients (23.5%) esophagitis was described histologically as severe. In the other 52 patients a mild esophagitis was reported. GEV was described of Grade IV in 14 patients (20.7%) with hiatal hernia; Grade III in 12 children (17.6%); Grade II in 42 (61.7%).

Medical therapy was started and routinely consisted of a combination of dietary modifications, positional therapy, prokinetic agents, H2-blockers or proton pump inhibitors. Failure of medical management, defined by persistence of symptoms, lead to surgery.

All patients underwent modified-LHSR. Neither significant intraoperative nor postoperative complications were recorded. 60 out of 68 patients (88.2%) had a complete follow-up (range 1-20 years). They were evaluated with clinical examinations, barium swallow study at 6 and 12 months and upper gastrointestinal endoscopy at 12 months follow-up in 40 patients (58.8%). No relapse was reported. Postoperative presence of symptoms was assessed during the routinely clinical evaluation, including dysphagia, regurgitation/vomit, chest pain, respiratory symptoms, the use of medications and the need of other surgical procedures. 50 out of 68 patients (73.7%) are symptoms-free and 18 (26.3%) referred occasional epigastric pain, associated with vomit in 2 cases. 64 (94.1%) experienced ability to vomit and 2 (2.9%) occasional difficulty to swallow. 3 (4.5%) presented episodes of gas-air-bloat during the first 2 months with spontaneous resolution. No dumping syndrome was recorded.

Operative technique

We performed in all patients a modification of the Hill-Snow procedure, which was first described by Hill in 1967 in the adult population and then partially modified by Snow in 1987. This technique has been performed laparoscopically since 1991.

The procedure requires: i) general anaesthesia; ii) supine position; iii) legs adducted or abducted depending on the patient's age and mobility; iv) reverse Trendelenburg (not mandatory); v) nasogastric tube; vi) urinary catheter (not mandatory).

The surgeon stands between the patient's legs. The two assistants stand on the right and left of the patient. The scrub nurse

stands on the surgeon's left. The monitor is positioned at the head of the patient.

The procedure is performed with 4-5 trocars: i) one 10/5mm trocar for the laparoscope through the umbilicus; ii) one 3/5mm operative trocar on the right flank; iii) one 3/5mm operative trocar on the left flank/left hypochondrium; iv) one 3/5mm trocar for liver retractor on the epigastrium; v) one 3/5mm trocar on left iliac fossa for gastric traction (accessory).

We use 3-5 mm trocars and a 5-10 mm trocar for the 30° laparoscope according the patient's age. An important principle is to place ports according to triangulation methods and to prevent the instruments from interfering with each other.

The laparoscopic Hill gastropexy aims to restore both normal anatomy and physiological anti-reflux mechanisms.

The basic steps of the procedure are: i) freeing of the abdominal esophagus; ii) pulling down the esophagus slipped in thorax (hiatal hernia reduction); iii) retroesophageal cruroplasty (hernia closure); iv) posterior gastropexy down to the origin of the crura; v) recreation of the angle of His with a gastro-esophagus suture; vi) fundus gastropexy to the diaphragm.

The gastrohepatic ligament is divided up and down to the gastrohepatic pedicle. The dissection is continued across the attenuated phrenoesophageal ligament near its origin in the diaphragm, and then posteriorly over the right crus, exposing the esophagus completely along with the right crus, the left crus and the esophagocrural grooves. The hiatal hernia is reduced. Anterior and posterior vagus nerve, as well as the anterior and posterior phrenoesophageal bundles, are identified.

The esophagus and the stomach are retracted anteriorly, exposing both crura and the crural tendon, just proximal to its insertion into the median arcuate ligament.

The right and left pillar are bluntly dissected until the crural muscle decussation. Sometimes the arcuate ligament is visualized during this operative step. The esophagus is pulled down and the hiatus is then closed posteriorly using interrupted sutures. The stomach is then rotated to expose the anterior and posterior phrenoesophageal bundles.

In the original Hill procedure 4-5 non-absorbable sutures are placed sequentially through the anterior and posterior phrenoesophageal bundles and then through the pre-aortic fascia which has been exposed. The pre-aortic fascia usually begins where the muscular right and left pillars of the hiatus fuse posteriorly (crus) and is incorporated into the muscular tissue that overrides the aorta. It continues inferiorly to the point where the celiac axis originates from the aorta, where it forms the median arcuate ligament. These sutures are placed low on the fascia, but not so low as to risk injury to the celiac trunk (Figure 1a).[4]

According to the modification introduced by Snow (1987), the Hill-Snow procedure, the distal abdominal oesophagus is fixed by suturing the posteromedial wall of the cardia to the body of the crural decussation and tendon (the caudal part of the crus) with two-three stitches (Figure 1b).[5]

For both techniques, the GEV is re-established by suturing the fundus of the stomach to the entire length of the abdominal esophagus and to the diaphragm with running or single 2/0 or 3/0 sutures.

As last step, the final stitches anchor the fundus to the diaphragm reinforcing and protecting the previous suture (which included the stomach, crura, phrenoesophageal ligament and proximal end of the abdominal esophagus). The phrenoesophageal ligament is then sutured to the proximal abdominal oesophagus with interrupted stitches.

The sutures are placed so as not to create tension or injure the vagus nerves. The entire abdominal esophagus is now secured within the abdominal cavity, restoring both the LES (Lower Esophageal Sphincter) and the GEV. In both procedures the closure of the esophageal hiatus is performed passing a calibration bougie inside the esophagus.

Chiarenza's modification technique (Vicenza's technique/modification)

Dissection starts at the hiatus to identify the esophagus and the presence of a hiatal hernia. Blunt dissection is then carried out, exposing both Laimer's fascia and diaphragmatic pillars. Once the peritoneal sac is identified, the hernia is reduced and the sac is excised. Afterward, our routine practice is to pass the calibration bougie (size according age varies from 10 to 28 Ch) and then

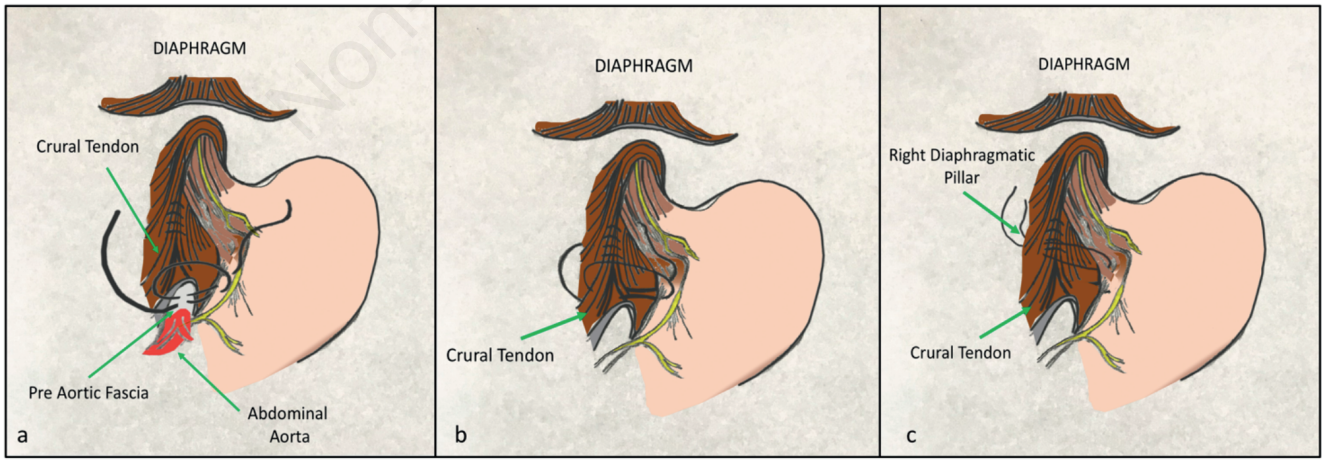

Figure 1. a) Hill posterior gastropexy: after dissection of the pre-aortic-fascia inferiorly to the point where the celiac axis originates from the aorta, where it forms the median arcuate ligament, sutures are placed low on the fascia, but not so low as to risk injury to the celiac trunk; b) Hill-Snow gastropexy: the distal abdominal oesophagus is fixed by suturing the posteromedial wall of the cardia to the body of the crural decussation and tendon (the caudal part of the crus) with two-three stitches; c) Chiarenza (Vicenza) technique: the postero-medial wall of the gastro-oesophageal junction and of the abdominal oesophagus is anchored down to the right pillar with 1-3 stitches (according to the age of the patient), just near the confluence with the left one, to secure the maintaining of the cardia avoiding the manipulation of periaortic tissues.

approximate the diaphragmatic crura with two-three non-absorbable stitches to close the hiatal defect.

Our modification of Hill-Snow technique involves anchoring the postero-medial wall of the gastro-esophageal junction of the abdominal oesophagus down to the right pillar with 1-3 stiches (according to the age of the patient) just near the confluence with the left one to secure the maintaining of the cardias avoiding the manipulation of periaortic tissues (Figure 1c).

A stitch is then placed between the apex of the fundus and the diaphragm, proximally to the esophageal hiatus, in order to restore the physiological anatomy of the fundus close to the esophagus (Figure 2). Finally three-four stiches are placed between the esophagus and gastric fundus to consolidate the stomach's position and the His angle (Figure 3). The next steps are then those of the usual LHSR with the suture of the gastric fundus to the esophagus, passing a running suture between the anterior portion of the fundus' seromuscular layer and the lateral wall of the esophagus' seromuscular layer for the entire length of the abdominal esophagus to restore the His angle (Figure 4). To secure the position of the GEJ and to avoid an intrathoracic sliding two stitches are placed between the esophagus and the diaphragm, at the hiatus to the right and left of the anterior vagus nerve (Figure 5a). and three stitches are then placed between the fundus and the diaphragm (Figure 5b).

Discussion

The first pathogenetic theories of GERD stated that the causes of the disease were of anatomic and mechanical nature. This led to the hiatal hernia repair as the main focus of the surgical procedures. In fact, the first description of surgical hiatal hernia repair was by Soresi in 1919[7] and many years later Sweet published a transthoracic technique in which the hernia was reduced, the phrenic nerve was crushed, the hernia sac was plicated and the hiatus was narrowed.[8] However, the evolution of knowledge led to a shifting of the pathogenetic hypotheses from the anatomic and mechanical to a functional and physiologic nature and consequently the surgical approaches evolved as well. In early fifties Allison achieved the hiatal reduction, through a transthoracic operative technique, by incising and resuturing the phrenoesophageal ligament and peritoneum to the abdominal aspect of the diaphragm approximating the diaphragmatic crura behind the esophagus.[9] In 1955 Nissen performed the first fundoplication for reflux esophagitis making a 360-degree fundoplication around the lowest 6 cm of the esophagus. Four or five sutures were used, one or more of which were also fixed to the esophagus.[10] This innovative technique was an inspiration for numerous surgeons who made some effective modifications. In 1962 Dor reported an anterior 180-degree fundoplication in which the wrap covers the anterior aspect of the distal esophagus and is fixed to the edges of the diaphragm.[11] In 1963 Toupet described a 270-degree posterior fundoplication in which the esophagus and the posterior gastric wall are mobilized, then the left and right sides of the wrap are fixed to the anterior wall of the distal esophagus and the edges of the hiatus.[12] In 1967 Hill performed posterior gastropexy for an anti-reflux procedure after analysing manometry and pH recordings along with cadaver studies, concluding that, in order to restore the angle of His, the phrenoesophageal bundles should be reapproximated and anchored to the median arcuate ligament.[4] Since then, only a few modifications of these surgical techniques have been described and only the advent of minimally invasive surgery has changed the postoperative course of patients treated for GERD. Surgical correction is still considered the definitive therapy for GERD refractory to medical management.

In literature, the clinical results of anti-reflux surgery in the adult population have been more carefully evaluated than in children. Several studies have reported excellent results of Hill's repair for the treatment of both complicated and uncomplicated GERD.[13-14] Some have also reported the successful use of combined techniques (Hill-Nissen) for the treatment of uncomplicated reflux.[15]

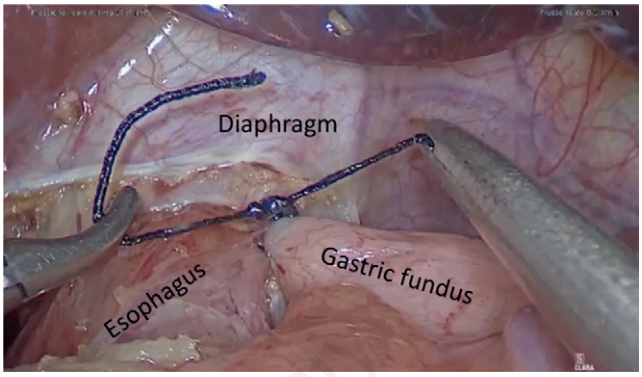

Figure 2. A stitch between the apex of the fundus with the diaphragm proximal to the esophageal hiatus is then placed in order to restore the physiological anatomy of the fundus close to the esophagus.

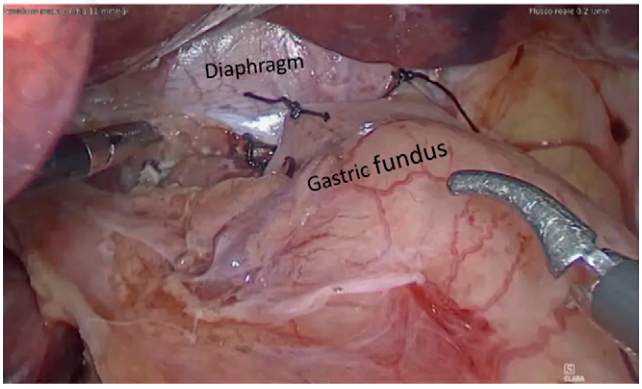

Figure 3. Three-four stitches are placed between the esophagus and gastric fundus to consolidate their position and the His angle.

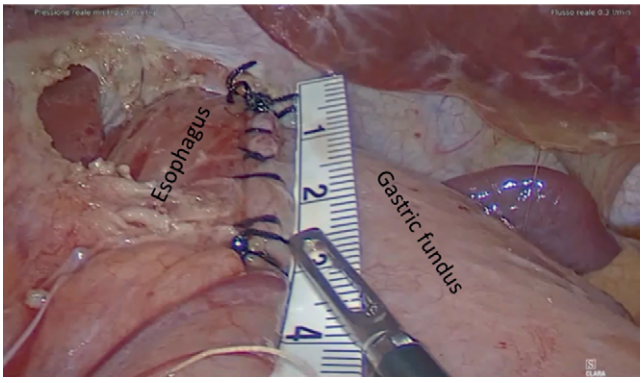

Figure 4. Re-creation of His angle by a running silk suture between distal esophagus and gastric fundus.

Despite this, there are few reports regarding the use of Hill's technique in the pediatric population and currently laparoscopic Nissen fundoplication represents the most widely used technique of surgical repair and it is considered the gold standard for surgical treatment of severe GERD.2 In our Centre, according to the NASPGHAN (North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition) and ESPGHAN (European Society for Pediatric Gastroenterology, Hepatology, and Nutrition) guidelines, only patients with objectively verified GERD are operated on. We decided to treat with modified Hill-Snow procedure only non-neurological patients because of the high risk of relapse in cerebral-palsy children and above all because some rare cases of gas bloat syndrome or dysphagia are difficult to manage in non-neurological patients. This study revealed that all patients had an objectively verified GERD, severe in some cases, with a heavy impact on the health-related quality of life. In this group of patients, we have chosen the modified Hill-Snow procedure for the purpose for which it was described. This technique is often erroneously described as partial fundoplication or a wrap. It is important to underline that the Hill's repair is not a fundoplication; in fact the stomach is not wrapped around the lower esophagus, but rather a careful calibration of the antireflux barrier and restoration of the physiologic anatomy is performed, recreating the GEV and fixing posteriorly the GEJ to restore esophageal peristalsis and clearance.

Hill's procedure leads to an augmentation of the intrinsic pressure and its special features. By placing tension on the collars ling musculature, the technique automatically restores the GEV which has been shown to be important in the prevention of reflux. The Hill's procedure anchors the GEJ posteriorly, in our technique to the right pillar (its normal primary attachment was the pre-aortic fascia), while Nissen repair is allowed to float freely and the GEJ is not anchored. The unanchored esophagus has no fulcrum and usually can develop a dysmotility since the esophagus cannot generate propulsive waves. In our Centre however, we fixed also the wrap to the diaphragm (Nissen-Rossetti) to avoid a wrap sliding. Moreover, the Nissen repair causes an indirect increased extrinsic pressure of the wrap around the lower esophagus. This leads to higher risks of postoperative complications such as gas-bloat syndrome, early satiety/pain, dysphagia, retching, dumping syndrome, worsening aspiration risk from esophageal stasis, and wrap slipping/unwrapping resulting in the need for reoperation.[16] Even in floppy Nissen dysphagia is very common shortly after the operation with a reported incidence in pediatric population of 24%.[17] Usually most of the symptoms occur in the first 6 weeks after surgery and usually subside within few weeks. Temporary dysphagia could be attributable to esophageal oedema, stretching or temporary hypomotility. Persistent and severe postoperative dysphagia is mainly related with anatomical problems including tight, twisted or slipped fundoplication, paraesophageal herniation and hiatal stenosis.[18,19] Another usual side effect of antireflux surgery, in particular of fundoplication, is related to the reduced ability to vent gas from the stomach into the esophagus (gas-bloat syndrome). Many of the symptoms related to gas-bloat syndrome are associated with delayed gastric emptying, a condition which has been reported to be common in GERD patients.

In our series of modified-laparoscopic-Hill-Snow technique, 73.7% of patients rated their results as excellent as they were symptom-free and referred the ability to vomit at a median follow up of 120 months. Less than 30% only referred occasionally epigastric pain (for about 40 days), rarely associated with vomit. Only 2.9% reported occasionally difficulty to swallow (for 30 days) and all patients are able to burp. 3 patients (4.5%) presented episodes of gas-air-bloat during the first 2 months with spontaneous resolution. These symptoms were successfully treated with conservative management. None of the patients required a second surgical procedure. The Hill-Snow repair represents in fact a physiologic correction of reflux restoring the normal anatomy and so the normal physiology. The goal of surgery is to increase LES pressure, therefore preventing acid reflux, and to repair any present hiatal hernia. It is important to adequately evaluate patients before surgery, because an inappropriately performed operation can have disastrous effects[20] especially in non-neurologically impaired children. Anti-reflux surgery and above all Nissen fundoplication in chil-

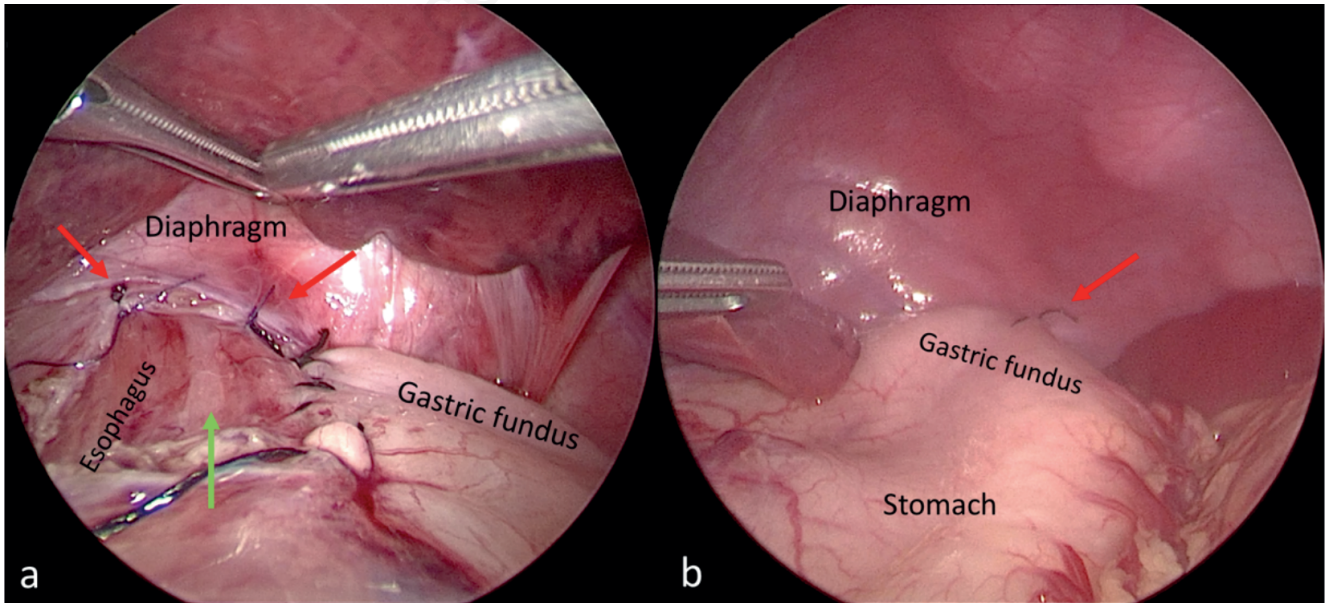

Figure 5. To secure the position of the GEJ and to avoid an intrathoracic sliding: a) two stitches (red arrows) are placed between the esophagus and the diaphragm at the hiatus to the right and left of the anterior vagus nerve (green arrow); b) three stitches are placed between the fundus and the diaphragm (red arrow).

dren with significant associated disorders is often focused on prevention of life-threatening or disabling complications rather than to attenuate uncomfortable symptoms. However, this concept should not be applied for non-neurologically impaired patients. For this reason, we adopted since the beginning of our experience (2000s) and prefer the Hill-Snow repair with our modification as it is a more physiological technique with less side effects in selected non neurologically impaired infants and children affected by complicated GERD.

Acid suppression only addresses one factor in a multifactorial disease. In severe disease, there is a significant failure rate of long-term standard dose medical therapy and progression of disease is often noted.[21,22] Laparoscopic Hill repair shows excellent long-term durability and quality of life similar to the open Hill repair, with 85% good to excellent results at a median follow-up of 19 years and a reoperation rate under 10%. It is surmised that Hill suture fixation of the gastroesophageal junction to the pre-aortic fascia may confer unique structural integrity compared to other repairs.[13] In our experience in pediatric patients we obtained similar results avoiding the fixation to the pre-aortic fascia, with less surgical intraoperative risks, fixing the GEJ to the right pillar near the crura confluence.

Conclusions

In summary, the Hill-Snow procedure includes reconstruction of the normal gastroesophageal junction and restoration of the gastroesophageal valve. This restores the esophagus to its normal point of attachment allowing it to generate effective peristaltic waves to propel food ab-orally into the stomach, reinstating in this way the esophageal motility. The sphincter is calibrated creating a range of pressure that is high enough to prevent reflux but not so high as to create or to cause persistent dysphagia. With careful selection of patients and performance of the procedure, we obtained good results over the long term also in children with isolated GERD.

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