Single-port laparoscopic-assisted pyloromyotomy: a 6-year experience

Mirko Bertozzi, Niccolò Nardi and Antonino Appignani

Objective **The aim of this paper is to present the results of a 6-year experience with a laparoscopic-assisted approach to infantile hypertrophic pyloric stenosis (IHPS): the single-port, laparoscopic-assisted pyloromyotomy (SPLAP).**

Summary background data **Ramstedt pyloromyotomy is the procedure of choice for IHPS; however, the best way to approach the pylorus is still debated. The recent literature reports many comparisons between various open and laparoscopic approaches. Here, we report our long-term result with a laparoscopic-assisted technique for IHPS.**

Materials and methods **Thirty-eight infants underwent SPLAP. The approach to the abdominal cavity is performed through a right circumbilical incision and then a 10 mm trocar is inserted. After the pneumoperitoneum is established, an operative telescope is introduced. Once the telescope is inserted, the pylorus is easily located and then grasped and exteriorized by the umbilical incision. At this point, conventional Ramstedt pyloromyotomy is performed. Once the pylorus is reintroduced into the abdomen, a new pneumoperitoneum is created to control mucosal integrity and hemostasis.**

Results **In all 38 cases, adequate pyloromyotomy was performed in a good operative time, without any major intraoperative or postoperative complications, achieving excellent cosmetic results.**

Conclusion **The feasibility of SPLAP found over these 6 years suggests that this procedure is an excellent alternative to open or laparoscopic pyloromyotomy. *Ann Pediatr Surg* 11:203–206 © 2015 Annals of Pediatric Surgery.**

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Introduction

Infantile hypertrophic pyloric stenosis (IHPS) is a common surgical condition of early infancy, with an incidence of approximately one to three per 1000 live births [1].

Ramstedt pyloromyotomy was initially described in 1912 and remains the 'gold standard' technique for IHPS [2]. Several significant modifications to gain access to the pylorus have been introduced since the original publication. We describe the results of our 6-year experience in performing Ramstedt's pyloromyotomy with the single-port, laparoscopic-assisted pyloromyotomy technique (SPLAP) [3], a slight modification of the Tan and Bianchi procedure [4].

Materials and methods

From November 2008 to October 2014, 38 children were subjected to SPLAP.

The procedure is performed under general anesthesia and endotracheal intubation. Optimum patient position is achieved by positioning a mild roll under the baby's back to expose the high quadrants of the abdomen. The infant is placed in the anti-Trendelenburg position. The surgeon is positioned on the right of the operating table, the assistant on the left, and the scrub nurse at the bottom end. The screen is just behind the patient's head.

A right circumbilical incision is performed and a 10 mm trocar with pneumostatic anchorage is inserted using Hasson's technique. After establishing a pneumoperitoneum (6 mmHg–flow 0.5 l/min), a 10 mm operative telescope, 23 cm in length, is introduced (Fig. 1). With a 5 mm atraumatic grasp inserted through the 6 mm operative channel of the telescope, the pylorus is spotted, then the stomach is gently grasped laparoscopically proximal to the pyloric tumor and moved just under the trocar's site. After removing the trocar, ensuring that the grip is maintained, the tumor is easily exteriorized through the right umbilical incision (Fig. 2a–c). A traditional open Ramstedt's pyloromyotomy is then performed. Once a conventional intervention is performed, the pylorus is reintroduced into the abdomen and a new pneumoperitoneum is created. After the individuation of the pyloromyotomy, a minimal irrigation with a cannula 14 CH introduced into the operative channel of the telescope is performed and an air test by insufflating 50–100 ml of air through a previously placed nasogastric tube is performed to exclude any mucosal leakage (Fig. 3). If no perforation is detected, after careful control of the hemostasis, the trocar is removed. The wound is then closed meticulously with an absorbable interrupted suture and skin suture is performed using cyanoacrylate glue [5,6].

We reintroduced feeding 6 h after the intervention following an increasing scheme, and we discharged the patients only 24 h after the first full meal.

The results of our experience were analyzed.

Results

We performed SPLAP in 38 infants (29 males and nine females) with hypertrophic pyloric stenosis, median age 36.7 days (20–53 days), with weight ranging from 2.8 to

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5.3 kg (median 4337 kg). The duration of operation ranged from 16 to 56 min (median 23.5).

In terms of operative complications, no perforation, incomplete pyloromyotomy, or bleeding was encountered. Individuation and exteriorization of the pylorus was quick and an adequate pyloromyotomy was performed safely in all patients, except in one case, where a mild gastric serosal laceration occurred during the pyloric exteriorization.

Time to full feeding was achieved from 18 to 27 h postoperatively (median 21 h).

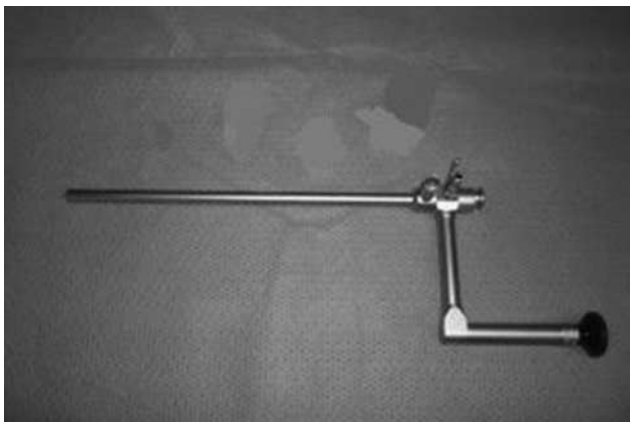
A single episode of postoperative emesis occurred in two patients after the first postoperative meal.

All patients were discharged on the second or the third postoperative day. Postoperative follow-up of the SPLAP group ranged from 6 months to 6 years, and cosmetic results are excellent in all cases (Fig. 4a and b).

Discussion

Since the description of Ramstedt's intervention [2], the treatment of IHPS has remained essentially the same; what has changed, however, is the means of approaching the pylorus.

Fig. 1



The operative telescope adopted for single-port laparoscopic-assisted pyloromyotomy.

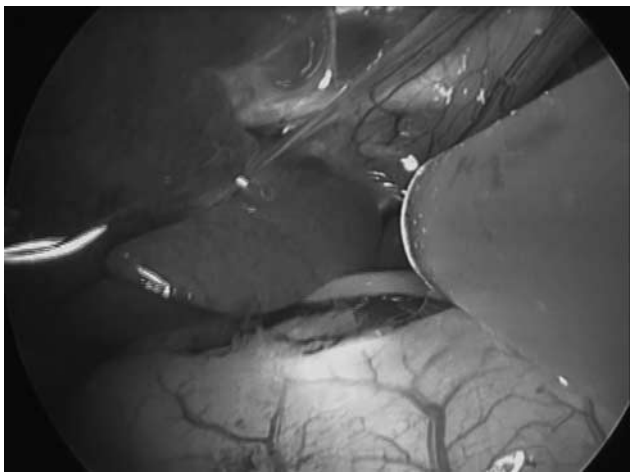
In 1986, Tan and Bianchi [4] described a supraumbilical skin-fold incision to perform the pyloromyotomy, and in 1991, Alain *et al.* [7] introduced the laparoscopic approach.

During the last 15 years, many surgeons have preferred to change the conventional open approach in favor of laparoscopic pyloromyotomy (LP), but the approach to the pylorus to perform pyloromyotomy is still debated, and many authors in recent years have compared the various approaches, considering complications, time to full feeding, postoperative hospital stay, cosmetic results, etc.

Although there are several studies comparing laparoscopic and open pyloromyotomy [8–13], the results are different according to the authors and there is no definitive evidence in favor of LP or the open procedure.

Although Ostlie *et al.* [14] reported an absence of complications in a large series of LP, other authors have reported that this technique may expose patients to a higher risk of inadequate pyloromyotomy and duodenal perforation because of a longer learning curve [8,10,15]. Leclair *et al.* [16], in a double-blinded, randomized, controlled trial, compared LP and circumbilical approaches,

Fig. 3

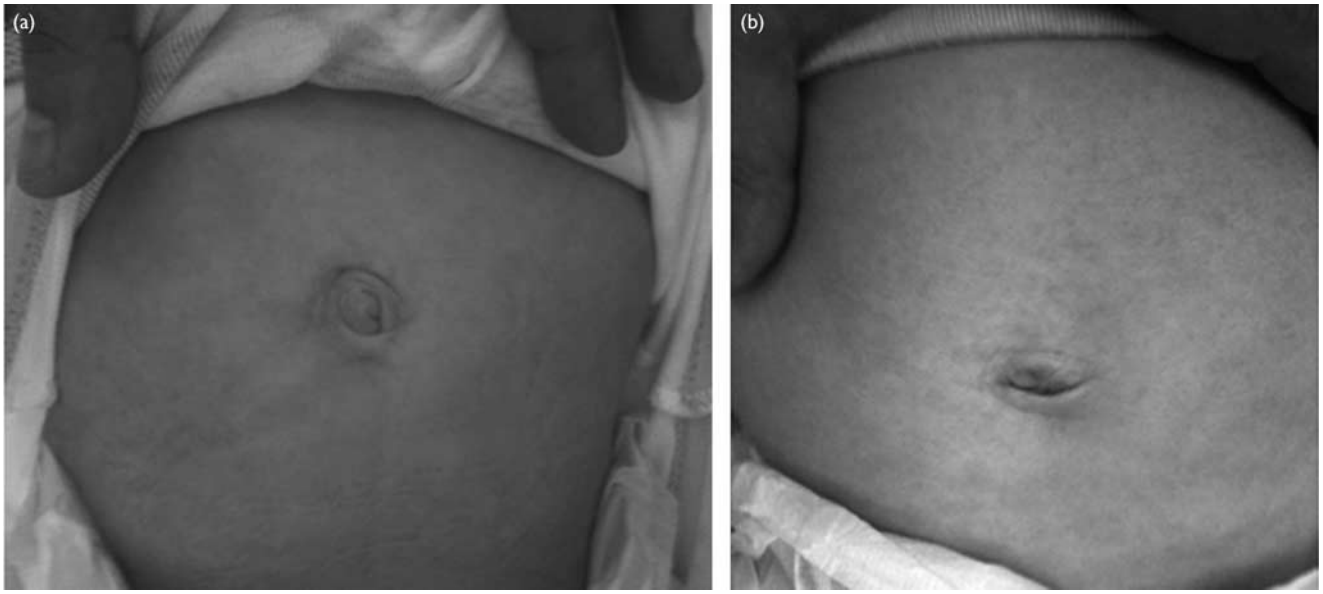


Laparoscopic image showing the air test during single-port laparoscopic-assisted pyloromyotomy.

Fig. 2

(a–c) The pylorus is laparoscopically spotted. (b) The stomach is gently grasped with an atraumatic grasper proximal to the pyloric tumor. (c) Image showing the exteriorization through the right umbilical incision.

Fig. 4



(a, b) Early cosmetic results after single-port laparoscopic-assisted pyloromyotomy.

concluding that the open approach is their first choice for pyloromyotomy. Hall *et al.* [17] carried out a meta-analysis of studies comparing open and LP and concluded that the open approach is associated with fewer complications and higher efficacy, but highlight the significantly shorter recovery time after LP.

Siddiqui *et al.* [18] compared the LP with open pyloromyotomy performed with the traditional right upper quadrant incision and concluded that there was no difference in operating time, hospital stay, or refeeding patterns between open and LP. In this randomized-controlled trial, the complication rates were similar between the two methods, but long-term cosmetic results were significantly superior in the laparoscopic group.

Sola *et al.* [19] published a systematic review and meta-analysis of six previously published studies on comparisons between open versus LP and concluded that the study favors the laparoscopic approach, with a significantly reduced rate of total complications, which is mostly because of a lower wound complication rate.

The reporting of a higher complication rate in LP reported in some published data may be justified by the learning curve as much as if the operation is performed by a general surgery resident [20,21].

Even if LP may be a good way for the entire surgical team to receive training in neonatal laparoscopic surgery because it is quite frequent, an adequate learning curve is necessary; Oomen *et al.* [22] reported that the learning curve for LP involved 35 procedures.

The same author in a recent publication [23] confirmed that the debate on whether LP is superior to open pyloromyotomy is not over as long as it is not clear whether the minimally invasive operation is beyond the initial or tail of the learning curve.

Perger *et al.* [24] reported that if the skill and experience for replication of good outcomes of laparoscopy are not available, open pyloromyotomy is a safer technique. They also report that if the umbilical approach is performed by experienced surgeons, it yields results comparable to those of LP and may be the preferred technique.

Video-assisted surgery often offers the benefits of endoscopic exploration and mini-invasive surgery as much as the advantages of conventional surgery, and many others have applied this combined technique for the treatment of various pathologies even in children [25–28].

Traditionally, a right upper quadrant incision was used by our department to approach the IHPS; then, in 2007, we decided to use the Tan and Bianchi approach [4]. In the first cases, we had some difficulties in detecting the pylorus in those patients who had a distended bowel. This problem was probably because of the learning curve; therefore, the idea of using a hybrid technique to approach the IHPS emerged, and in 2008, a slight modification of the Tan and Bianchi technique using an operative laparoscope enabled quick detection of the pylorus even in this condition.

Considering our 38 patients treated over 6 years, the learning curve for the LP appeared to be too long for our catchment area. Our high level of confidence and experience with laparoscopic-assisted procedures [26,29] led us to prefer a laparoscopic-assisted approach instead of the laparoscopic one.

In our 38 cases treated, we performed the SPLAP with a right semicircular incision, which provides an almost invisible unique scar and a cosmetic outcome with a very high overall satisfaction [30] (Fig. 3).

The exteriorization of the pylorus may be difficult through the circumbilical incision and some authors

prefer to perform an extended incision [31,32], performing an intra-abdominal pyloromyotomy [33,34] or modifying the original technique [8]. In our series, using the right semicircular umbilical approach, we found difficulties in extracting the pylorus only in one case and a mild serosal injury occurred without other major complications. This complication could have been because of the fact that from our preliminary reported experience, we have reduced the trocar's size from 12 to 10 mm.

During the SPLAP, we perform an open Ramstedt's procedure to avoid an inadequate pyloromyotomy, which is easy to perform even by our residents of pediatric surgery. Through the air test, the integrity check of the mucosa may be performed outside and inside the abdominal cavity as well as the bleeding control, avoiding any unrecognized perforation or bleeding, which can expose patients to a possible second emergent intervention or a risk of systemic sepsis [13].

During SPLAP, we use the pneumoperitoneum only for the identification of the pylorus and for the final mucosal and bleeding check; in this manner, we avoid all the disadvantages of a prolonged pneumoperitoneum in infants. Finally, we wish to highlight that thanks to the trocar with pneumostatic anchorage, which allows abdominal wall traction by the assistant surgeon, we performed the operation with a very low carboperitoneum pressure (6 mmHg). With the same device, we can perform an incision larger than 10 mm without loss of pneumoperitoneum, making the exteriorization of the pyloric tumor easier. A further advantage of the SPLAP is the exploration of the abdominal cavity, which can show other possible associated anomalies.

Conclusion

Ramstedt's pyloromyotomy remains the procedure of choice for IHPS. Our further experience with SPLAP confirms the preliminary experience already reported with a further decrease in the operative time and hospital stay. For these reasons, SPLAP remains our procedure of choice for IHPS.

SPLAP for IHPS is safe and is an alternative approach to LP or open pyloromyotomy. Furthermore, we believed that this technique might be preparatory also for pure LP for surgeons who want start this last technique.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Grant GA, McAleer JJ. Incidence of infantile hypertrophic pyloric stenosis. *Lancet* 1984; **1**:1177.
2 Ramstedt C. Zur operation der angeborenen pylorus stenose. *Med Klinic* 1912; **8**:1702–1705.
3 Bertozzi M, Prestipino M, Nardi N, Appignani A. Preliminary experience with a new approach for infantile hypertrophic pyloric stenosis: the single-port, laparoscopic-assisted pyloromyotomy. *Surg Endosc* 2011; **25**:2039–2043.
4 Tan KC, Bianchi A. Circumbilical incision for pyloromyotomy. *Br J Surg* 1986; **73**:399.
5 Prestipino M, Bertozzi M, Nardi N, Appignani A. Outpatient department repair of urethrocutaneous fistulae using N-butyl-cyanoacrylate (NBCA): a single-centre experience. *BJU Int* 2011; **108**:1514–1517.
6 Bertozzi M, Appignani A. Applications of cyanoacrylate glue in pediatric urology. *N Am J Med Sci* 2012; **4**:323–324.
7 Alain JL, Grousseau D, Terrier G. Extramucosal pyloromyotomy by laparoscopy. *Surg Endosc* 1991; **5**:174–175.
8 Sitsen E, Bax NM, van der Zee DC. Is laparoscopic pyloromyotomy superior to open surgery? *Surg Endosc* 1998; **12**:813–815.
9 Fujimoto T, Lane GJ, Segawa O, Esaki S, Miyano T. Laparoscopic extramucosal pyloromyotomy versus open pyloromyotomy for infantile hypertrophic pyloric stenosis: which is better? *J Pediatr Surg* 1999; **34**:370–372.
10 Campbell BT, McLean K, Barnhart DC, Drongowski RA, Hirschl RB. A comparison of laparoscopic and open pyloromyotomy at a teaching hospital. *J Pediatr Surg* 2002; **37**:1068–1071.
11 Yagmurlu A, Barnhart DC, Vernon A, Georgeson KE, Harmon CM. Comparison of the incidence of complications in open and laparoscopic pyloromyotomy: a concurrent single institution series. *J Pediatr Surg* 2004; **39**:292–296. discussion 292–296.
12 St Peter SD, Holcomb GW 3rd, Calkins CM, Murphy JP, Andrews WS, Sharp RJ, *et al*. Open versus laparoscopic pyloromyotomy for pyloric stenosis: a prospective, randomized trial. *Ann Surg* 2006; **244**:363–370.
13 Taqi E, Boutros J, Emil S, Dubé S, Puligandla P, Flageole H, Laberge JM. Evaluation of surgical approaches to pyloromyotomy: a single-center experience. *J Pediatr Surg* 2007; **42**:865–868.
14 Ostlie DJ, Woodall CE, Wade KR, Snyder CL, Gittes GK, Sharp RJ, *et al*. An effective pyloromyotomy length in infants undergoing laparoscopic pyloromyotomy. *Surgery* 2004; **136**:827–832.
15 Ford WD, Crameri JA, Holland AJ. The learning curve for laparoscopic pyloromyotomy. *J Pediatr Surg* 1997; **32**:552–554.
16 Leclair MD, Plattner V, Mirallie E, Lejus C, Nguyen JM, Podevin G, Heloury Y. Laparoscopic pyloromyotomy for hypertrophic pyloric stenosis: a prospective, randomized controlled trial. *J Pediatr Surg* 2007; **42**:692–698.
17 Hall NJ, van Der Zee J, Tan HL, Pierro A. Meta-analysis of laparoscopic versus open pyloromyotomy. *Ann Surg* 2004; **240**:774–778.
18 Siddiqui S, Heidel RE, Angel CA, Kennedy AP Jr. Pyloromyotomy: randomized control trial of laparoscopic vs open technique. *J Pediatr Surg* 2012; **47**:93–98.
19 Sola JE, Neville HL. Laparoscopic vs open pyloromyotomy: a systematic review and meta-analysis. *J Pediatr Surg* 2009; **44**:1631–1637.
20 Adibe OO, Nichol PF, Flake AW, Mattei P. Comparison of outcomes after laparoscopic and open pyloromyotomy at a highvolume pediatric teaching hospital. *J Pediatr Surg* 2006; **41**:1676–1678.
21 Haricharan RN, Aprahamian CJ, Celik A, Harmon CM, Georgeson KE, Barnhart DC. Laparoscopic pyloromyotomy: effect of resident training on complications. *J Pediatr Surg* 2008; **43**:97–101.
22 Oomen MW, Hoekstra LT, Bakx R, Heij HA. Learning curves for pediatric laparoscopy: how many operations are enough? The Amsterdam experience with laparoscopic pyloromyotomy. *Surg Endosc* 2010; **24**:1829–1833.
23 Oomen M, Bakx R, Peeters B, Boersma D, Wijnen M, Heij H. Laparoscopic pyloromyotomy, the tail of the learning curve. *Surg Endosc* 2013; **27**: 3705–3709.
24 Perger L, Fuchs JR, Komidar L, Mooney DP. Impact of surgical approach on outcome in 622 consecutive pyloromyotomies at a pediatric teaching institution. *J Pediatr Surg* 2009; **44**:2119–2125.
25 Valla JS, Kimber CP. One port coelioscopy and thoracoscopy: a preliminary report of the modified Valla technique. *Pediatr Endosurg Innov Tech* 2000; **4**:100.
26 Bertozzi M, Nardi N, Prestipino M, Magrini E, Appignani A. Minimally invasive removal of urachal remnants in childhood. *Pediatr Med Chir* 2009; **31**: 265–268.
27 Lima M, Tursini S, Ruggeri G, Gargano T, Libri M, Domini M. One trocar assisted pyeloplasty (OTAP): initial experience and codification of a technique. *Pediatr Med Chir* 2007; **29**:108–111.
28 Lima M, Bertozzi M, Dòmini M, Pession A, Ruggeri G, Libri M, *et al*. Thoracoscopic management of suspected thoraco-pulmonary malignant diseases in pediatric age. *Pediatr Med Chir* 2004; **26**:132–135.
29 Bertozzi M, Verrotti A, Latini ME, Rinaldi VE, di Cara G, Appignani A. Secondary involvement of Meckel's diverticulum by group A β-hemolytic *Streptococcus* in a child with upper airways infection treated by laparoscopic-assisted resection. *Ann Pediatr Surg* 2015; **11**:156–158.
30 Cozzi DA, Ceccanti S, Mele E, Frediani S, Totonelli G, Cozzi F. Circumumbilical pyloromyotomy in the era of minimally invasive surgery. *J Pediatr Surg* 2008; **43**:1802–1806.
31 Khan AR, Al-Bassam AR. Circumumbilical pyloromyotomy: larger pyloric tumours need an extended incision. *Pediatr Surg Int* 2000; **16**:338–341.
32 Karri V, Bouhadiba N, Mathur AB. Pyloromyotomy through circumbilical incision with fascial extension. *Pediatr Surg Int* 2003; **19**:695–696.
33 Gauderer MW. Experience with a nonlaparoscopic, transumbilical, intracavitary pyloromyotomy. *J Pediatr Surg* 2008; **43**:884–888.
34 Takamizawa S, Obatake M, Muraji T, Tsugawa C, Nishijima E, Satoh S. Supraumbilical pyloromyotomy: comparison between intracorporeal and extracorporeal approaches. *Pediatr Surg Int* 2004; **20**:101–104.