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Single-incision laparoscopic pyloromyotomy: initial experience

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Abstract
Background Laparoscopic pyloromyotomy has become the standard treatment for hypertrophic pyloric stenosis. Single-incision laparoscopic surgery is an emerging operative approach that utilizes the umbilical scar to hide the surgical incision.
Objective To describe our initial experience with single-incision laparoscopic pyloromyotomy in 15 infants.
Materials and methods Laparoscopic pyloromyotomy was performed through a single skin incision in the umbilicus, using a 4-mm 30° endoscope and a 5-mm trocar. The 3-mm working instruments were inserted directly into the abdomen via separate lateral fascial stab incisions. All patients were prospectively evaluated.
Results The procedure was performed in 15 infants (13 male) with mean age of 45 ± 16 days and mean weight of 4.04 ± 0.5 kg. All procedures were completed laparoscopically, and one case was converted to a conventional triangulated laparoscopic work configuration after a mucosal perforation was noted. The perforation was repaired laparoscopically. On average, operating time was 29.8 ± 13.6 min, and postoperative length of stay was 1.5 ± 0.8 days. All patients were discharged home on full feeds. Follow-up was scheduled 2–3 weeks after discharge, and no postoperative complications were noted in any of the patients.
Conclusions Single-incision laparoscopic pyloromyotomy is a safe and feasible procedure with good postoperative results and excellent cosmesis. The main challenge is the spatial orientation of the instruments and endoscope in a small working space. This can be overcome by a more longitudinally oriented working axis than used in the conventional angulated laparoscopic configuration.

Keywords Pyloromyotomy · Single incision · Laparoscopy · Infant

Single-incision laparoscopic surgery (SILS) is increasingly used for urologic procedures [1, 2], appendectomy [3], and cholecystectomy [4] in adults. By taking advantage of the umbilicus as the sole access site, it leaves almost no visible postoperative scar. In the pediatric age group, SILS has been reported for varicocele ligation in adolescents [5].

Laparoscopic pyloromyotomy was introduced in 1991 by Alain and Grousseau [6]. Since then, studies have shown better cosmesis [7] and similar complication rates [8, 9] compared with open pyloromyotomy.

Single-incision laparoscopic pyloromyotomy was first performed in our institution in March 2009. In this report we describe the technique, challenges, and outcomes of our first 15 procedures.

Materials and methods

Institutional review board approval was obtained. Infants with clinical and sonographic diagnosis of hypertrophic pyloric stenosis were admitted, intravenously hydrated, and scheduled for operation as soon as electrolytes and acid–base status were normal.

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Surgical technique

After supine positioning and sterile preparation of the abdomen, a 5-mm transverse incision was made in the lower umbilical skin fold. The abdomen was entered through the fascia, and a 5-mm STEP trocar (Covidien, Mansfield, MA) was introduced. The capnoperitoneum was insufflated using a pressure of 8 mmHg and a flow of 1 l/min. A 4-mm 30° angled endoscope was used to visualize the abdominal cavity. In order to expose the pyloric region, the liver was suspended by a transabdominal epigastric 0-PDS U-stitch around the falciform ligament (Fig. 1). The umbilical skin incision was then stretched towards the 10 o'clock position in reference to the midline trocar and a stab incision was made in the fascia in this position, introducing a 3-mm bowel grasper directly into the abdomen. A second fascial stab incision was then made in the 2 o'clock position to introduce a single-use retractable arthrotomy knife into the abdomen (Fig. 2). The duodenopyloric junction was grasped with the bowel grasper in the left hand and gently retracted inferiorly, angulating the pylorus upward towards the patient's left. The blade of the arthrotomy knife was deployed 2 mm, and a serosal incision was made longitudinally over the entire length of the pylorus (Fig. 3). The blade was then retracted, and the blunt arthrotomy tool was used to separate the muscle fibers down to the submucosa in the center of the incision. The arthrotomy knife was exchanged for a second bowel grasper, the two jaws of which were introduced into the muscular defect. The rest of the muscle fibers were subsequently separated along the entire length of the pylorus by slowly opening the jaws (Fig. 4). The mucosa was inspected to rule out any perforation. If none was found, the capnoperitoneum was desufflated, all endoscopic equipment was removed, and the wound was closed in two layers: The three fascial incisions were all included into one 3-0 polydioxanone figure-of-eight suture, and the skin was closed with subcuticular 5-0 polyglecaprone. Postoperatively, the patients were fed milk or formula ad libitum and discharged once they were tolerating full feeds. Follow-up was scheduled 2–3 weeks later (Fig. 5).

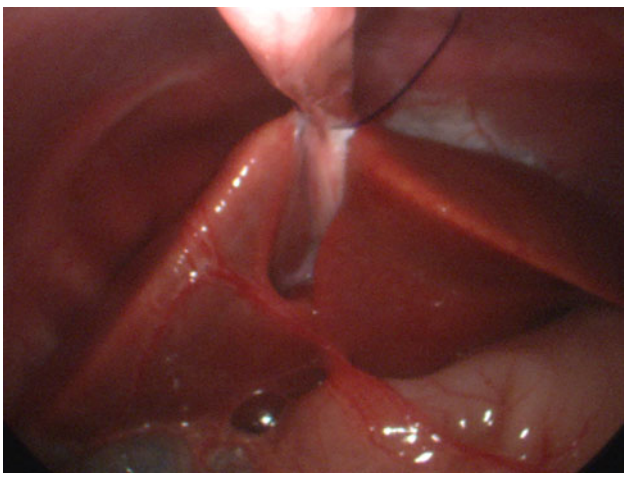

Fig. 1 Exposure of the pylorus, lifting the liver by using a U-stitch through the falciform ligament

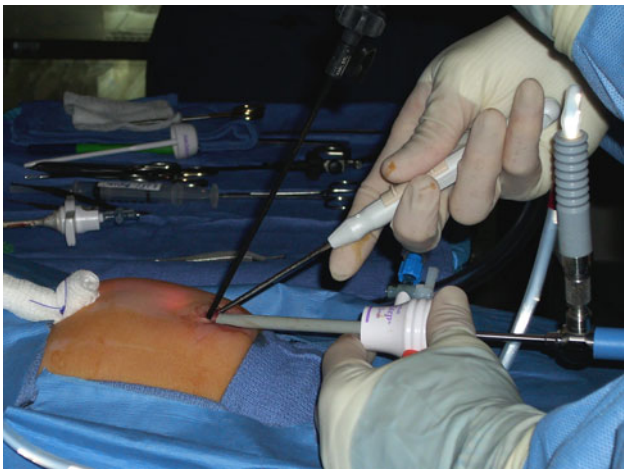

Fig. 2 Outside configuration of the instruments and camera. Using instruments of different length aids with spatial separation of the surgeon's hands

Fig. 3 The serosal incision is performed by lining up the pylorus more obliquely than in the standard laparoscopic configuration. The cut is made upward toward the left upper quadrant of the patient

Data acquisition

All data were collected in a prospective manner and entered in an electronic Excel spreadsheet (Microsoft Corporation, Redmond, WA). The first patient was operated on March 14th, 2009. The last patient entered in this report was operated on July 18th, 2009.

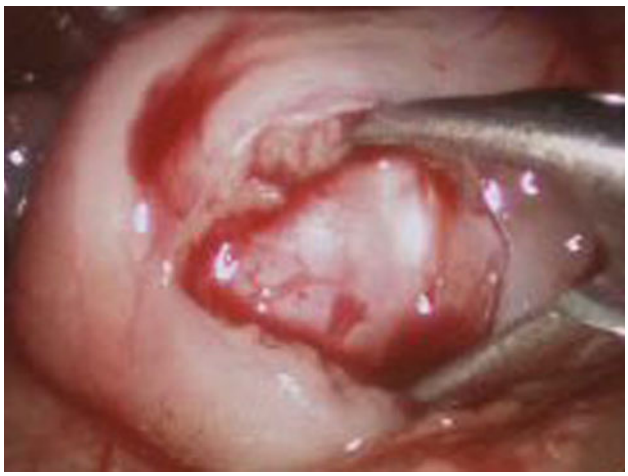

Fig. 4 The muscles are bluntly separated in the same way as during the standard laparoscopic procedure

Fig. 5 Two weeks postoperatively, there is virtually no discernible scar

Results

From March through July 2009, a total of 15 infants underwent single-incision laparoscopic pyloromyotomy. Table 1 presents the demographic data of the patients.

All procedures were completed laparoscopically, and 14 out of 15 were completed using the single-incision technique. There was one conversion to the standard laparoscopic configuration. Average operating time was 29.8 ± 13.6 min (range 18–68 min, median 25 min), average postoperative length of stay was 1.47 ± 0.8 days (range 1–3 days), and all patients were discharged home on full feeds. Follow-up was scheduled 2 weeks after discharge, and no postoperative complications were noted in any of the patients.

In one patient, mucosal perforation at the duodenal end of the pyloromyotomy was noticed intraoperatively. The operation was converted to the standard laparoscopic setup, with two stab incisions in the left and right upper quadrants, to triangulate the working instruments. The defect was repaired transversely by two 4-0 polyglactin sutures using intracorporeal knot-tying. The closure was reinforced by fibrin glue, and an omental patch was loosely laid on top of the pyloromyotomy. The patient tolerated this procedure well, advanced to full feeds over the course of the next 24 h, and was discharged home in good condition on the first postoperative day. Two weeks later, on follow-up, he was taking formula without emesis and demonstrating good weight gain.

Table 1 Patient demographics ($n = 15$)

Age (days)	45 ± 16
Weight (kg)	4.04 ± 0.5
Gender (M/F)	13/2
Sonographic dimensions (mm)	
Length	20.3 ± 4.3
Width	4.8 ± 0.6

One patient was seen in the emergency department of our hospital 10 days after the operation for fever without clinical signs of wound infection or gastrointestinal symptoms. Workup including blood count, blood cultures, and lumbar puncture was performed, which yielded negative results. The patient was well at his 2-week follow-up in our ambulatory clinic.

Discussion

Ramstedt described the original pyloromyotomy for hypertrophic pyloric stenosis in 1912 through a right upper quadrant incision. Although the principle of the operation of splitting the hypertrophied muscle fibers bluntly and leaving the mucosa intact has not changed, the approach to the pylorus has undergone a great deal of evolution [10]. In order to make the scar less conspicuous, Tan and Bianchi first proposed a circumbilical incision [11]. Laparoscopic pyloromyotomy is generally performed via three access sites, leaving small yet noticeable scars on the abdomen. In most pediatric surgical centers, laparoscopic pyloromyotomy has become the standard procedure.

After acquiring experience with single-incision laparoscopic appendectomy and cholecystectomy in a total of 24 patients, we successfully performed SILS pyloromyotomy in this series of infants. As far as we know, this is the first report of this procedure in the literature.

SILS poses a number of challenges for the surgical team. For one, the lack of separation of the camera and instruments leads to limited maneuverability. This handicap is further exaggerated when operating on small infants

because of the limited overall dimensions of the workspace. Furthermore, having the camera inline with the instruments can compromise intracorporeal visualization of the operating field. However, it is important to realize that the single-incision approach is merely a variation of the standard laparoscopic technique, and not a new operation. While it may require the surgeon to adapt some particular skills in dealing with the instrument configuration, the same equipment and trocars are used without producing additional costs.

These disadvantages can be minimized by using instruments of differing lengths, providing longitudinal separation of the hands. Likewise, using an endoscope longer than the other instruments takes the assistant's hands out of the working space of the surgeon, and angulation of the optical axis of at least 30° provides an offset rather than inline view of the pylorus. In order to avoid collision of the instruments, it is useful to adapt a more vertical working direction than with conventional laparoscopy, where maneuvers are performed in a more horizontal fashion. For example, we found it helpful to orient the pylorus in an 8 to 2 o'clock axis rather than horizontal to perform the serosal incision. If this cannot be accomplished by traction from the duodenal side alone, a transabdominal antral suspension suture, similar to the one around the falciform ligament, may prove useful in future cases.

A suboptimal view and working angle, combined with several attempts at separation of the muscle fibers with the blunt arthrotomy knife, may have led to the solitary mucosal perforation in our series. It is essential to have a low threshold for conversion to the standard laparoscopic configuration if the operation becomes more difficult than expected, if visualization is poor, or if the pylorus and the instruments do not line up well.

The advantages of the SILS technique include an essentially scarless operation, because the incision is hidden in the umbilicus. In our limited series, patients do not seem to do worse than after standard laparoscopic surgery. The fact that there was one perforation in the series may be due to a learning curve that accompanies a new technique, or coincidental in a limited number of patients. To assess the true complication rate of SILS pyloromyotomy, more experience and larger numbers are required. The SILS operating times were similar to the mean conventional laparoscopic operating times of 20–31 min reported in recent studies [8, 9, 12]. The technique may be impracticable in infants with intraabdominal adhesions from previous operations, intestinal malrotation, or other unusual anatomy.

When performed in the proposed fashion, no special equipment is needed for SILS pyloromyotomy, and the expenses are equal to those of standard laparoscopy. Special SILS trocars are available for adult-sized patients [13, 14], but are impractical for use in infants. Perhaps smaller instruments with flexible tips will help overcome some of the drawbacks of the SILS approach in the future.

A scarless, purely endoscopic pyloromyotomy has been described [15]. Although promising in the first ten patients, no follow-up or further reports of this method have been published. In contrast to all other surgical approaches, the endoscopic pyloromyotomy violates Ramstedt's principle of leaving the mucosa intact and only incising the musculature and serosa.

In summary, single-incision laparoscopic pyloromyotomy can be safely performed and yields good results with excellent cosmesis and virtually no visible scar. In order to evaluate objectively the risks and benefits of the procedure compared with conventional laparoscopy, a randomized controlled trial is the next appropriate step.

Disclosures

Oliver J. Muensterer, Obinna O. Adibe, Carrol M. Harmon, Albert Chong, Erik N. Hansen, Donna Bartle, and Keith E. Georgeson have no conflicts of interest or financial ties to disclose

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