

Single-port transumbilical pediatric cholecystectomy: any benefits for the patient?

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ABSTRACT

Objective. To compare the perioperative results of single-port laparoscopic cholecystectomy (SPLC) with those of laparoscopic cholecystectomy (LC), and to analyze whether there were any differences between both techniques in our patients.

Materials and methods. A retrospective, observational analysis was carried out in non-homogeneous groups of patients under 15 years of age undergoing LC and SPLC over a 6-year period. LC was conducted using four ports, while SPLC was performed through an umbilical incision using a wound retractor to which a surgical glove was coupled for the insertion of 3 ports and instruments curved as required. 15 clinical, surgical, and economic variables were compared by means of a univariate and bivariate analysis.

Results. 11 patients underwent surgery – 5 through SPLC and 6 through LC. No significant differences were found in terms of mean operating time (SPLC: 144 minutes vs. LC: 139, $P=0.855$) or hospital stay, but a slight increase in hospital cost was noted (SPLC: 1,160 € vs. LC: 1,177 €). The cost of LC was 1,322 € vs. 1,367 € for SPLC, with a premium of 44.30 € owing to the use of the wound retractor. None of the patients had perioperative complications, and all of them felt the cosmetic result was excellent.

Conclusions. In our limited experience, the differences between SPLC and LC do not clearly support one or the other. SPLC could provide patients with a better cosmetic result and allow surgeons to improve their skills. However, we believe cholecystectomy is not the most adequate procedure to start a career in single-port laparoscopy because potential complications may be severe.

KEY WORDS: Cholecystectomy; Minimally invasive surgery; Cholelithiasis; Pediatrics.

COLECISTECTOMÍA PEDIÁTRICA POR PUERTO ÚNICO TRANSUMBILICAL: ¿APORTA ALGO AL PACIENTE?

RESUMEN

Objetivo. Comparar los resultados perioperatorios de la colecistectomía laparoscópica por puerto único (CLPU) respecto a la colecistectomía laparoscópica (CL) y analizar si, en nuestra casuística, existen diferencias entre estas técnicas.

Material y métodos. Análisis retrospectivo y observacional en grupos no homogéneos de pacientes menores de 15 años sometidos a CL y CLPU durante un periodo de 6 años. La CL se realizó con cuatro puertos y la CLPU mediante una incisión umbilical y colocación de un retractor de heridas al que se acopló un guante quirúrgico, a través del cual se insertaron 3 trócares para el instrumental convenientemente curvado. Se compararon 15 variables clínicas, quirúrgicas y económicas mediante análisis univariado y bivariado.

Resultados. Fueron intervenidos 11 pacientes, cinco mediante CLPU y 6 por CL. No hubo diferencias significativas en el tiempo operatorio medio (CLPU: 144 minutos vs. CL: 139, $P=0,855$) ni en estancia hospitalaria, aunque sí un ligero aumento del coste hospitalario (CLPU: 1.160 €, CL: 1.177 €). El coste de la CL fue de 1.322 € frente a 1.367 de la CLPU, con un sobreprecio de +44,30 € debido al uso del retractor de heridas. Ningún paciente presentó complicaciones perioperatorias y todos percibían un resultado cos-mético excelente.

Conclusiones. Las diferencias entre CLPU y CL, en nuestra reducida experiencia, no justifican decidirse claramente por una u otra técnica. La CLPU podría aportar al paciente un mejor resultado cosmético y al cirujano una mejora de sus habilidades, aunque creemos que la colecistectomía no es la intervención adecuada para iniciarse en laparoscopia por puerto único debido a la gravedad de las posibles complicaciones.

PALABRAS CLAVE: Colecistectomía; Cirugía mínimamente invasiva; Colelitiasis; Pediatría.

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INTRODUCTION

The multi-port laparoscopic approach is currently the technique of choice in pediatric cholecystectomy. However, the natural progression of minimally invasive surgery (MIS) is leading to increasingly fewer scars, or even no

scars at all, which has brought about huge advances in minimally invasive techniques. In addition, the advent of new technologies and the constant search for techniques causing less surgical trauma and providing better results have allowed for new accesses to the abdominal cavity⁽¹⁾. In this respect, single-port laparoscopic cholecystectomy (SPLC) stands as an alternative vs. multi-port laparoscopic cholecystectomy, which is more common in pediatrics^(2,3). This novel approach was first described in 1997 in the adult population⁽⁴⁾. Although it has taken some time to be used in pediatric surgery – primarily as a result of the lack of specific instruments and the limited space of the abdominal cavity in this age group –, this technique has progressively gained traction as an alternative to multi-port laparoscopic and hybrid techniques⁽⁵⁾. The surgical principle of SPLC lies in the fact the umbilicus is the embryological means of access to the abdominal cavity⁽⁶⁾. Nevertheless, in spite of such an advantage, there are concerns the use of a single port may reduce operative safety and increase costs and operating times. Even though some international series have compared both surgical approaches, there are currently no cohorts with similar characteristics in our environment^(3,5). This study compares the perioperative results and safety of SPLC vs. standard 4-port LC in our experience.

MATERIALS AND METHODS

A retrospective, observational analysis of the cholecystectomies performed in a second-level pediatric surgery institution was carried out. Patients under 15 years of age undergoing LC and SPLC from January 2014 to January 2020 as a result of symptomatic cholelithiasis, vesicular polyps, choledocholithiasis, or anemia of falciform cells were included. All procedures were conducted or supervised by pediatric surgeons with over 5 years' experience.

Exclusion criteria included open cholecystectomy and incomplete medical records. The electronic medical records of patients meeting inclusion criteria were reviewed following the signature of an informed consent form and the Ethics Committee's approval. Demographic (age, sex), clinical (diagnosis, weight, size, body mass index [BMI]), surgical (approach, conversion, perioperative complications, operating time, hospital stay, pain control), and economic (operative cost, hospital cost, total cost) variables were studied. Operating time was expressed in minutes from the first incision to the cutaneous closure of all wounds. All patients received analgesia with paracetamol (15 mg/kg dose every 6 hours [h]) and metamizole (40 mg/kg dose every 6 h), and morphine hydrochloride only in case of persistent pain (0.1 mg/kg dose). The analytical estimation of costs was conducted using a price list established by the financial department of our institution. Prices were as follows: surgical retractor: 39.93 €; removal bag: 21.87 €; 5x100mm AnchorPort® port: 95.99 €; port

with 5mm balloon: 107.79 €; port with 12mm balloon: 49.91 €; monopolar hook: 62 €; and laparoscopic grasping forceps: 114.37 €.

Variables were collected and anonymized using a Microsoft® Excel (v. 16.59) database, and subsequently underwent a descriptive statistical analysis through absolute frequency, relative frequency, central tendency measures, and dispersion measures using the SPSS® (IBM, v. 27.9) statistical software. The bivariate analysis was conducted by means of a Student's t-test for quantitative variables, and a chi-squared test for the nominal or ordinal scale.

SPLC surgical technique

All procedures were conducted under general anesthesia, orotracheal intubation, and a preoperative dose of amoxicillin/clavulanic acid. A 2cm semilunar incision was performed at the lower umbilical fold until the abdominal cavity was reached. A wound retractor (Alexis®; Applied Medical, Rancho Santa Margarita, CA, USA) was subsequently placed, and a sterile surgical glove was coupled to it. Through its fingers, 3 ports (AnchorPort® 5mm, CONMED CORPORATION, New York, USA) were inserted and held for the 5mm, 30° scope (HOPKINS®, KARL STORZ SE & Co. KG, Tuttlingen, Germany) and the disposable conventional instruments (grasping forceps and 5mm monopolar hook, Covidien®, Inc.), manually curved approximately 30° to improve the angle of dissection and increase triangulation capacity. In 2 out of the 5 cases, traction was exerted on the gallbladder fundus using Kirschner wires modelled within the cavity. They were held by an assistant or fixated to the sterile operating fields using a Kocher forceps. The procedure was carried out according to the standard surgical technique and to Strasberg's critical view principle⁽⁷⁾ (Figs. 1 and 2). Contrarily to LC, no bag was used to remove the specimen, since the incision allowed the gallbladder to be taken out and held in one of the glove's fingers until the device was removed.

LC surgical technique

A 2 cm semilunar incision was performed at the lower umbilical fold until the abdominal cavity was accessed. A 12 mm port was subsequently placed for the 5 mm, 30° scope, and under direct vision, three accessory 5 mm ports (Applied Medical, Rancho Santa Margarita, CA, USA) were placed underneath the right rib cage. The procedure was completed according to the standard surgical technique.

RESULTS

A total of 11 patients –7 girls and 4 boys– underwent surgery. The data of the population studied is featured in Table 1. 5 patients were treated through SPLC, and the remaining 6 through LC. In the SPLC group, there were



Figure 1. Incision at the lower umbilical fold (A) and placement of the surgical retractor (B) to couple the sterile glove (C). The conventional laparoscopic instruments are curved as required (D).

Table 1. Summary of the main variables analyzed.

Variable	SPLC (n=5)	LC (n=6)	P value
Sex	F=2. M=3	F=5. M=1	0.391
Age (mean)	10.4 ± 4.6 years	12.1 ± 3.1 years	0.582
BMI (median, IQR)	19.2 (16 - 25.8)	24.4 (18.6 - 29)	0.361
Conversion (n, %)	1, 20%*	0, 0%	0.924
Operating time (minutes)	144 ± 65.4	139 ± 46.4	0.855
Intravenous morphine hydrochloride (doses)	1	0	0.273
Perioperative complications (n)	0	0	-
Mean hospital stay (h)	42 ± 2.8	42.6 ± 18	0.778

F = Female; M = Male; * = Conversion to LC

2 girls and 3 boys (mean age: 10.4 ± 4.6 years) vs. 5 girls and 1 boy in the LC group (mean age: 12.1 ± 3.1 years), with no statistical differences in terms of sex or age.

Median BMI was 19.2 (interquartile range [IQR]: 16-25.8; SPLC) vs. 24.4 (IQR: 18.6-29; LC), with no statistical differences ($P = 0.361$). Mean operating time was

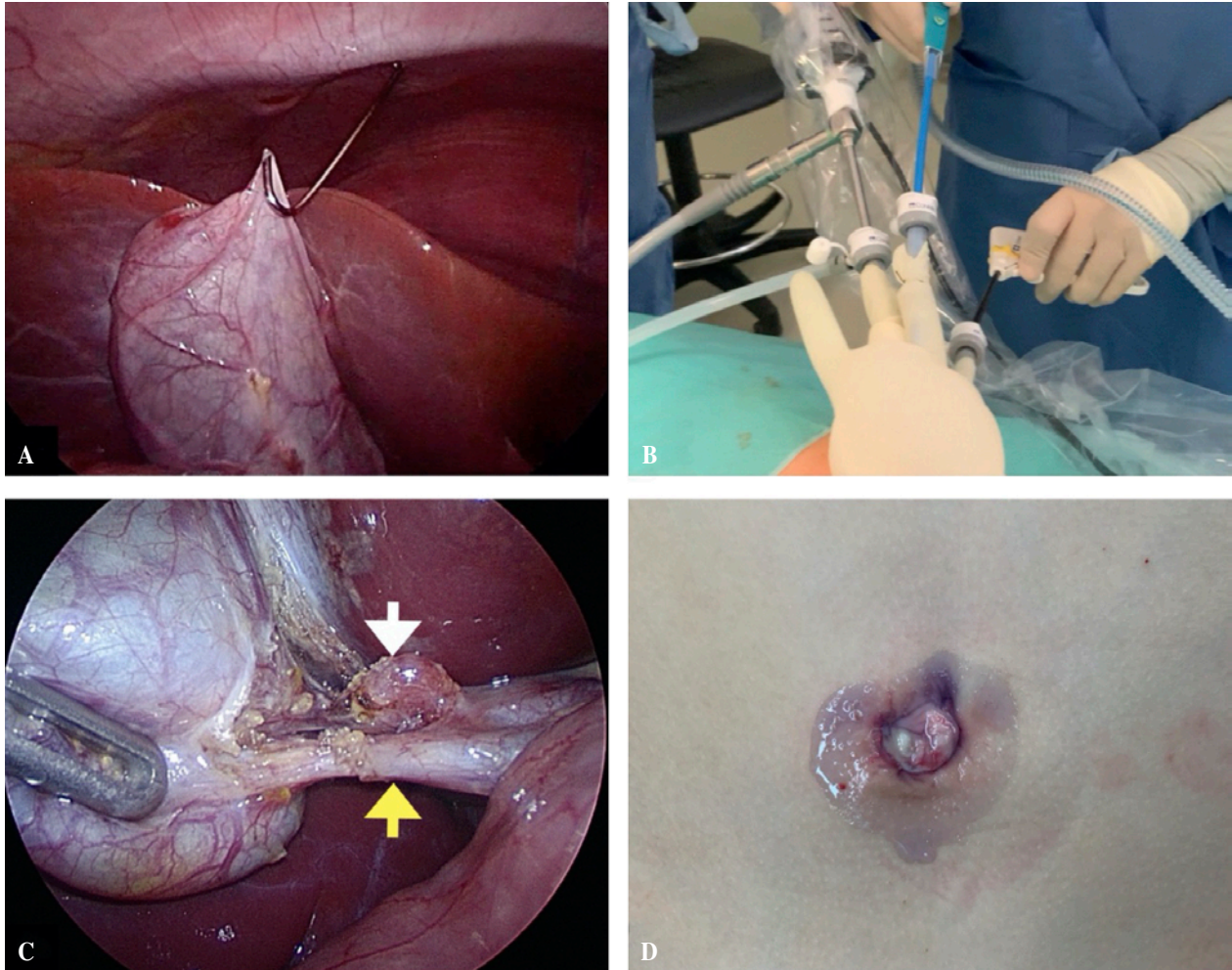


Figure 2. Traction can be optionally exerted on the gallbladder fundus using a percutaneous Kirschner wire to improve exposure of the operating field (A). The 5mm material is introduced through the glove's fingers (B) to conduct the procedure according to the standard technique and to Strasberg's critical view principles (C, cystic duct [yellow arrow] and cystic arteries [white arrow]). Appearance of the single umbilical incision (D).

144 ± 65.4 minutes (SPLC) vs. 139 ± 46.4 minutes (LC), with no differences between groups ($P = 0.855$). In the first SPLC, operating time was 145 minutes, and in the last two, 95 and 85 minutes, which is likely to be related to the learning curve. However, such reduction in operating times was not noted in the LC, with the first procedure lasting for 113 minutes and the last for 124.

Conversion rate from SPLC to LC was 20% (n=1), which was not significant. The primary reason for conversion was an important dilatation of the colon and the small bowel, with an insufficient pneumoperitoneum, which impaired progression using a single port. None of the LCs required conversion to open surgery. Mean hospital stay was 42 h (range: 40-46 h) in the SPLC group, and 42.6 h (range: 24-72 h) in the LC group. The longest stay (72 h) occurred in the LC group as a result of little oral tolerance. This had no implications in terms of clinical or statistical differences, but it did cause a slight increase in

the cost of hospital stay (SPLC: 1,160 € vs. LC: 1,177 €). In both groups, pain was adequately controlled with paracetamol and metamizole, and only 1 patient from the SPLC group required one dose of morphine hydrochloride ($P=0.273$). None of the patients had perioperative complications or surgery-related symptoms (pain in the incision area, unspecific abdominal pain, pain at the right upper quadrant) over the mandatory 3-month follow-up period, and they all felt the cosmetic result was excellent. However, this variable was entirely subjective, since it was dependent upon the patient and their family's perception. The total cost of LC in our institution was 1,322.74 € vs. 1,367.04 for SPLC, with the latter involving a premium of + 44,30 €/procedure owing to the use of the surgical glove, the wound retractor, and the Kirschner wire – the remaining instruments were common to both groups, except for the removal bag, which was not used in the SPLC group (Table 2).

Table 2. Analysis of costs according to the surgical approach.

Cost per procedure (€)	SPLC	LC
Disposable laparoscopic instruments	1,312.7	1,281.3
Amortization of the laparoscopic tower	36.11	36.11
Amortization of lenses and scopes	3.73	3.73
Amortization of other instruments	14.5	1.6
Procedure cost	1,367.04	1,322.74
Premium per procedure	+ 44.30 €	0
Mean hospital stay (663.15 €/day)	1,160.51	1,177.09
Total cost	2,527.55	2,499.83

DISCUSSION

The progress made in minimally invasive techniques in pediatrics has allowed for a decreasingly aggressive approach of gallbladder pathologies through techniques such as conventional or single incision laparoscopy. The current literature features a number of series with a large amount of patients, which demonstrates the safety and effectiveness of single-port cholecystectomy^(1,2). However, in nearly all cases, an incision of a sufficiently large diameter is used in order to be able to place a single port with multiple working channels, which typically have a diameter greater than that of a conventional port, or multiple ports positioned through the same cutaneous incisions and various aponeurotic incisions⁽³⁾. In this respect, our technique slightly differs from others described in the literature, which use previously manufactured multi-port devices. In our case, all instruments are introduced through a single artisanal port created by a surgical retractor and a sterile glove, without any multi-port device or percutaneous grasping forceps being required. The use of the surgical retractor allows for incisions of a size similar to that required for the placement of specialized multi-port devices. However, the surgical retractor exerts constant pressure on the soft tissues of the abdominal wall, which slightly increases the diameter of the umbilical wound, allows all instruments to be introduced through it, and could improve maneuverability during the procedure.

Considering single-port cholecystectomy involves fewer incisions, various authors who have studied its potential benefits posit it may be associated with shorter operating times and hospital stays, fewer costs, and better cosmetic results. Seifarth et al. compared a hybrid single-port approach using a single umbilical incision and two transperitoneal traction forceps (n= 56) vs. the 4-port laparoscopic approach (n= 42), finding that single-port patients had shorter operating times, with a median of 85 minutes vs. 114 minutes ($P= 0.003$), respectively⁽²⁾. Other studies have reported similar results, mentioning that SPLC's learning curve may require up to 20 procedures^(3,5,8,9). In

our series, no statistical differences were found in terms of operating time, but the first three SPLCs took clearly longer (145, 145, and 250 minutes) than the last two (95 and 85 minutes), probably as a result of the progression of the learning curve.

Regarding hospital stay, other authors have found no differences between both surgical approaches⁽²⁾, but significant differences have been noted in terms of postoperative pain, which translated into fewer opioids being required in the single-port technique ($P= 0.007$)⁽³⁾. Similarly, our results suggest a slightly shorter –although non-significant– postoperative stay in SPLC, with no differences regarding opioids, since only 1 of our SPLC patients required 1 dose of morphine hydrochloride postoperatively. As for cost reduction, other authors describe that the single-port approach has demonstrated to be less expensive in terms of surgery than conventional laparoscopy (median of 3,918 USD vs. 4,647 USD, respectively, $P < 0.001$), with lower hospitalization costs (7,438 USD vs. 8,783 USD, respectively, $P = 0.030$). In these aspects, our study yields slightly different conclusions, because even though SPLC was a little less expensive in terms of hospitalization, the surgical cost was higher as a result of the use of the standard laparoscopic instruments plus the surgical retractor and the Kirschner wire. However, none of these differences was statistically significant.

Regarding SPLC safety, a systematic review of 218 cholecystectomy patients –54 undergoing multi-port laparoscopic surgery and 164 undergoing SPLC– aged 4 months-23 years old found no differences in the occurrence of perioperative complications, concluding that although the single-port approach is technically more complex and involves a steeper learning curve, it is safe and feasible in pediatric cholecystectomy⁽⁵⁾, which is consistent with our results and attenuates concerns of a potential sample-size-related bias. In addition, it is possible to convert to conventional laparoscopy and to add accessory ports anytime throughout the procedure, if required.

The safety of other minimally invasive techniques, such as the robotic one, has been recently explored in cholecystectomy. Nolan et al. compared LC (n= 30), SPLC (n= 20), multi-port robotic cholecystectomy (n= 11), and single-port robotic cholecystectomy (n= 10). They concluded that even though all techniques were safe and had similar results, single-port robotic cholecystectomy had shorter operating times and hospital stays ($P= 0.04$)⁽¹⁰⁾, similar to Ahn et al.'s findings⁽¹¹⁾. This suggests the single-port technique could prove beneficial for the patient in certain indications and have potential for development in other fields, such as robotics.

It can be inferred that SPLC perioperative results are directly related to surgical complexity, since greater technical difficulty involves longer operating times, greater trauma, greater pain, and longer hospital stays, with an increase in costs. Therefore, if the first contact with single-port surgery cannot be made via other procedures, such

as appendectomy, it is preferable not to start with cholecystectomy. Indeed, apart from the standard issues associated with pediatric laparoscopy, cholecystectomy involves greater surgical difficulty owing to the limited mobility of the instruments, which often collide into one another along the axis as a result of the umbilical area being small. Considering this limitation, the authors of this study have put forward some strategies: (1) instead of conventional ports, use AnchorPort® or similar ports, since they have a smaller head, they can be easily attached to the glove's fingers, and they remain still throughout the procedure; (2) curve the grasping forceps and the dissector to improve the working angle and minimize instrument collision – this allowed us to conclude a procedure which remained stagnant; the other one required conversion to LC; (3) use external traction, for example with percutaneous Kirschner wires, since this may improve the exposure of the operating field and free some space in the umbilical port, which is small; (4) use instruments and ports of different lengths, since this reduces instrument collisions. These strategies emerged as a result of the lack of specific instruments for this technique in our environment. However, the progressive reduction in costs and access to umbilical ports with multiple working channels, as well as to articulated forceps, will allow us to make new advances in the field of MIS. Even though our results are promising, further studies with a larger patient cohort are required, since sample size represents a risk of systematic error in this study.

In our limited experience, the differences between SPLC and LC do not clearly support one or the other. However, the single-port technique could provide patients with better cosmetic results and allow the surgical team to improve their skills, with probably lower costs and shorter hospital stays in the long-term. However, cholecystectomy is not the most adequate procedure to start a career in single-port laparoscopy.

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