

# Hybrid Single-Port Cholecystectomy Vs Four-Port Cholecystectomy in Children

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## ABSTRACT

**Background and Objectives:** Evidence is increasing that single-port or single-incision laparoscopic cholecystectomy is a safe and feasible alternative for cholecystectomy in children. In this study, we sought to compare the single-port hybrid technique, which we originally reported in 2012, with the conventional 4-port approach, in regards of complications, outcome, operative time and cost.

**Methods:** A retrospective, single-center comparison of hybrid single-port versus conventional 4-port laparoscopic cholecystectomy was performed in 98 consecutive pediatric patients between January 2010 and October 2014. Patient characteristics, intra- and postoperative outcomes, operative costs, and total hospitalization costs were compared between the 2 approaches using univariate and multivariate analyses.

**Results:** The single-port technique was utilized in 56 (57%) pediatric patients who underwent laparoscopic cholecystectomy. The operative time for single-port procedures was shorter than that of the conventional technique (median, 85 minutes vs 114 minutes;  $P = .003$ ). Patients with single-port procedures were less likely to have a cholangiogram compared to patients who underwent 4-port cholecystectomy. (9% vs 40%;  $P < .001$ ). No statistically significant differences between the 2 cohorts were observed for intra- or postoperative outcomes. Although the 2 groups shared nearly the same median duration of hospitalization (22 hours vs 21 hours;  $P = .70$ ), the single-port group demonstrated a lower total cost of hospitalization (median cost, \$7438 vs \$8783;  $P = .030$ )

and lower operative cost (median, \$3918 vs \$4647;  $P < .001$ ).

**Conclusion:** Hybrid single-port laparoscopic cholecystectomy in children with uncomplicated gallbladder disease is feasible and equally safe, with similar intra- and postoperative outcomes compared with the conventional 4-port approach. It can contribute to global cost reduction because of lower operative and total hospitalization costs.

**Key Words:** Cholecystectomy, Conventional multiport, Pediatric patient, Single-incision, Single-port.

## INTRODUCTION

Conventional multiport or 4-port laparoscopic cholecystectomy remains the first choice of surgical therapy for patients with symptomatic gallbladder disease. With recent advances in laparoscopy, single-port or single-incision laparoscopy has emerged as a safe and feasible alternative technique in children. Multiple studies have shown this technique to be comparable to traditional 4-port laparoscopic cholecystectomy in patient safety and outcomes.<sup>1-4,6</sup> However, most of these techniques use a large multichannel port or multiple small ports through a single incision. These techniques inherently require a larger skin incision and are relatively equivalent in operative and equipment cost when compared to traditional 4-port laparoscopic cholecystectomy.

In 2012, we reported a safe and effective hybrid single-port laparoscopic cholecystectomy technique that uses a conventional 0-degree scope with inbuilt working channel in combination with 2 portless percutaneous graspers<sup>4</sup> (**Figure 1**). This technique obviates the need for a multichannel port or multiple small ports. However, our reported study population was small, and no comparisons with traditional 4-port laparoscopic cholecystectomy were performed. In this study, we wanted to evaluate the outcomes of single-incision laparoscopic cholecystectomy with our hybrid technique in a larger study population and compare the outcomes and cost of this technique against those of the traditional 4-port technique. We hypothesized that there were no differences in patient

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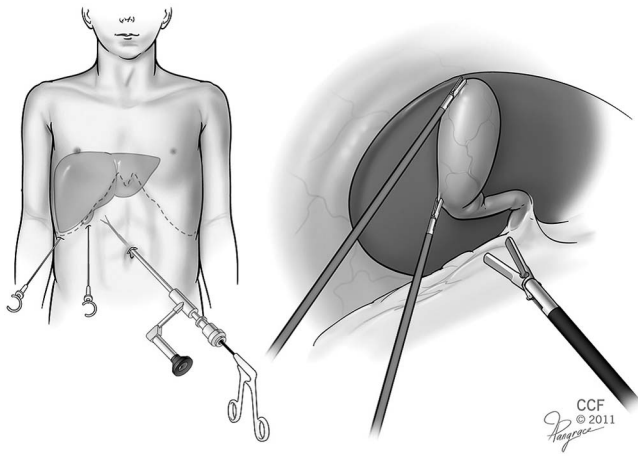
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**Figure 1.** Hybrid single-port cholecystectomy.

outcome between the 2 approaches but that our hybrid technique was associated with overall lower patient care costs.

## METHODS

### Study Population and Data Collection

This was an institutional review board (IRB)–approved, single-center, retrospective, cohort study of pediatric patients who underwent laparoscopic cholecystectomy at the Cleveland Clinic Foundation healthcare system from January 2010 through October 2014 (IRB No. 15/252). The inclusion criteria included any patient who underwent surgery in the Children’s Hospital and included pediatric patients between 2 and 18 years of age who underwent a laparoscopic cholecystectomy performed by 1 of 6 pediatric surgeons. Type of technique and decision in favor of or against intraoperative cholangiogram was not randomized, but was solely based on the surgeon’s preference. Exclusion criteria included patients with choledocholithiasis and patients who underwent an incidental cholecystectomy or another operative procedure in addition to cholecystectomy during the same anesthesia.

The electronic medical records for patients meeting the above criteria were interrogated. Demographic data collected included age at time of surgery and gender. Physiologic data collected included weight, height, body mass index (BMI), and diagnosis. Operative data included technique of laparoscopic cholecystectomy and deviations from the defined single-port laparoscopic or traditional 4-port laparoscopic cholecystectomy techniques, such as conversion from the single-port to 4-port method, use of

additional ports, and conversion to open cholecystectomy. Additional operative details collected included performance of intraoperative cholangiogram, estimated blood loss, operative time, intraoperative complications, and operative cost. Hospitalization data collected included length of hospital stay, incidence of wound infection, and total cost of hospitalization.

### Operative Technique

Our hybrid single-port laparoscopic cholecystectomy technique has been reported in the medical literature.<sup>5</sup> This single-port technique uses a 10-mm 0-degree scope with inbuilt 6-mm working channel (Karl Storz, Southbridge, Massachusetts, USA) introduced via a transumbilical 11-mm laparoscopic port (Step; Medtronic, Minneapolis, Minnesota, USA) and 2 portless Clutch graspers (Stryker, Kalamazoo, Michigan, USA) placed in the right upper quadrant for gallbladder retraction. Dissection of the infundibulum, cystic duct, and cystic artery are performed with 43-cm long, 5-mm diameter laparoscopic instruments. Dissection of the gallbladder off the liver bed is achieved by hook electrocautery. The traditional 4-port laparoscopic cholecystectomy technique uses a Hasson technique entry at the umbilicus with placement of a 10-mm laparoscopic port (Step; Covidien). An additional three 5-mm laparoscopic ports (Step; Covidien) are placed in the right subcostal space for gallbladder retraction and working instruments. We do not routinely perform a cholangiogram in all cholecystectomies, but we use this tool as clinically indicated on a case-by-case basis. When performed for either cholecystectomy approach, the technique involves the application of a laparoscopic Kumar Clamp (Nashville Surgical Instruments, Springfield, Tennessee, USA). The Kumar Clamp is placed across the neck of the gallbladder and a Kumar Catheter is introduced in to the clamp channel. The 19-gauge needle at the end is used to puncture the infundibulum, and bile is aspirated to confirm biliary access. Contrast is subsequently injected for the cholangiography. If a cholangiogram is not performed or after its completion, the cystic duct and cystic artery are controlled with laparoscopic titanium clips (Covidien) in the multiport procedure or Weck clips (Teleflex, Wayne, Pennsylvania, USA) when the single-port technique is applied. During the multiport technique, the transected specimen is placed in an Endo-Catch bag (Covidien) and subsequently removed through the umbilical port. In the single-port procedure, the gallbladder is removed via the umbilical incision without the use of a retrieval bag. The umbilical port fascia is closed with a figure-of-8 polyglactin suture followed by interrupted 5-0

poliglecaprone stitches. The additional laparoscopic port sites are closed with buried interrupted subcuticular interrupted 4-0 polyglactin sutures.

### Statistical Analysis

Data were described using medians and ranges for continuous variables and counts and percentages for categorical variables. Procedure types were compared on demographics, clinical characteristics, and outcomes, using Chi-square, Fisher's exact, and Wilcoxon rank sum tests. Linear regression models were built to assess the association between procedure type and outcomes, adjusting for BMI-for-age percentile. Sample sizes for individual variables reflect missing data. All analyses were performed on a completed-case basis. All tests were 2-tailed and performed at a significance level of 0.05. SAS 9.4 software (SAS Institute, Cary, NC) was used for all analyses.

## RESULTS

A total of 98 patients were included in the study. Demographic, physiologic, operative, and total hospitalization data for the study population are presented in **Table 1**. Most patients underwent a single-port laparoscopic cholecystectomy ( $n = 56$ ; 57%). There were no significant differences in age or gender between the 2 cohorts. Patients treated with the single-port procedure were less likely to be overweight compared to patients who underwent 4-port cholecystectomy. (48% vs 74%;  $P = .011$ ), with lower weight (58.3 kg vs 83.3 kg;  $P < .001$ ), BMI (22.9 vs 31.7;  $P < .001$ ), and BMI-for-age percentile (83% vs 97%;  $P < .001$ ). Although cholelithiasis was the most common indication for cholecystectomy in both groups, biliary dyskinesia was the second most common indication in the single-port group (21%), whereas cholecystitis was the second most common indication in the conventional group (24%). Biliary dyskinesia was defined as gallbladder ejection fraction  $<35\%$ , pain, or both, with cholecystokinin [CCK] on cholescintigraphy, in the absence of gallstones or cholecystitis on ultrasound.

The operative time for single-port procedures was shorter than that of the conventional technique (median, 85 minutes vs 114 minutes;  $P = .003$ ). Patients who had single-port surgery were less likely to have a cholangiogram (9% vs 40%;  $P < .001$ ). There was 1 intraoperative complication (enterotomy) in the entire study population, 1 case that required conversion from a laparoscopic to an open approach, and 2 wound infections, all of which occurred in patients treated with the conventional technique. Despite these events, no statistically significant differences

between the 2 groups were observed for intraoperative complications or need for conversion to open. In addition, no differences were observed in estimated blood loss or incidence of wound infection. Although the 2 groups shared nearly the same median duration of hospitalization (22 h vs 21 h;  $P = .70$ ), the single-port group demonstrated lower total cost of hospitalization (median \$7438 vs \$8783;  $P = .028$ ) and lower operative cost (median \$3918 vs \$4647;  $P \leq 0.001$ ).

To further elucidate the impact of a cholangiogram, the study population was stratified according to whether a cholangiogram was performed. A total of 76 patients underwent laparoscopic cholecystectomy without a cholangiogram. Fifty-one (67%) patients in this subgroup were treated with the single-port procedure. Compared to patients who received a 4-port technique without cholangiogram, those treated with the single-port procedure and no cholangiogram had significantly lower body weight (median, 57.6 kg vs 84 kg;  $P < .001$ ), lower BMI (median, 22.7 vs 31.7;  $P = .002$ ), and lower BMI-for-age percentile (83% vs 98%;  $P = .002$ ). There were no significant differences in the remaining variables between the single-port and conventional group that did not have a cholangiogram, including total hospitalization cost (median, \$7339 vs \$8078;  $P = .39$ ) and operative cost (median, \$3933 vs \$4177;  $P = .20$ ).

A total of 22 patients underwent laparoscopic cholecystectomy with cholangiogram. Five (23%) patients in this subgroup were treated with the single-port procedure. Although cholelithiasis was again the predominant indication for cholecystectomy in both groups, only the conventional group contained patients with a diagnosis of cholecystitis. There were no differences in weight, BMI, or BMI-for-age percentile between the single-port and conventional groups in patients who underwent laparoscopic cholecystectomy with intraoperative cholangiogram. Operative (median \$3585 vs \$4978;  $P = .002$ ), and total cost (median \$7657 vs \$9462;  $P = .70$ ) were lower in the single-port group.

## DISCUSSION

The continued evolution of laparoscopy has facilitated the growing use of single-port or single-incision approaches for laparoscopic cholecystectomy in the pediatric population. There are several published studies demonstrating the safety and efficacy of a single-incision laparoscopic approach. Unfortunately, sample sizes in most of these studies are small, with limited comparative data. Furthermore, most have employed techniques that use relatively large single incisions to accommodate either a single large

**Table 1.**  
Cholecystectomy Cohort by Procedure Type

<b>Factor</b>	<b>Total (N = 98)</b>	<b>Single Port (n = 56)</b>	<b>Conventional (n = 42)</b>	<b>P</b>
Surgeon, n (%)				<b>&lt;0.001<sup>c</sup></b>
1	3 (3)	0 (0)	3 (7)	
2	8 (8)	0 (0)	8 (19)	
3	31 (32)	25 (45)	6 (14)	
4	40 (41)	29 (52)	11 (26)	
5	4 (4)	1 (2)	3 (7)	
6	12 (12)	1 (2)	11 (26)	
Sex, n (%)				0.99 <sup>b</sup>
Male	21 (21)	12 (21)	9 (21)	
Female	77 (79)	44 (79)	33 (79)	
Age, yr, median (min, max), n (%)				0.27 <sup>a</sup>
<5 yr	16 (2, 18)	16 (2, 18)	16 (9, 18)	0.99 <sup>c</sup>
> = 5 yr	97 (99)	55 (98)	42 (100)	
<5 yr	1 (1)	1 (2)	0 (0)	
Weight, kg, median (min, max)	66.6 (11.9, 138.0)	58.3 (11.9, 95.5)	83.3 (22.4, 138.0)	<b>&lt;0.001<sup>a</sup></b>
Height (m), median (min, max)	1.61 (0.94, 1.87)	1.60 (0.94, 1.87)	1.63 (1.27, 1.82)	0.092 <sup>a</sup>
BMI, median (min, max)	25.0 (13.5, 53.2)	22.9 (13.5, 42.2)	31.7 (13.9, 53.2)	<b>&lt;0.001<sup>a</sup></b>
BMI-for-age percentile, median (min, max)	88 (0, 100)	83 (0, 100)	97 (4, 100)	<b>&lt;0.001<sup>a</sup></b>
BMI group, n (%)				<b>0.011<sup>b</sup></b>
Normal weight	40 (41)	29 (52)	11 (26)	
Overweight	58 (59)	27 (48)	31 (74)	
Diagnosis, n (%)				<b>0.005<sup>c</sup></b>
Cholelithiasis	59 (60)	34 (61)	25 (60)	
Cholecystitis	14 (14)	4 (7)	10 (24)	
Biliary dyskinesia	14 (14)	12 (21)	2 (5)	
Chronic abdominal pain, unknown	8 (8)	6 (11)	2 (5)	
Cholecystolithiasis	3 (3)	0 (0)	3 (7)	
Cholangiogram, n (%)				<b>&lt;0.001<sup>b</sup></b>
No	76 (78)	51 (91)	25 (60)	
Yes	22 (22)	5 (9)	17 (40)	
Intraoperative complications, n (%) <sup>*</sup>				0.42 <sup>c</sup>
None	95 (99)	56 (100)	39 (98)	
Enterotomy	1 (1)	0 (0)	1 (3)	
Conversion to open, n (%)				0.43 <sup>c</sup>
No	97 (99)	56 (100)	41 (98)	
Yes	1 (1)	0 (0)	1 (2)	
Estimated blood loss, median mL (min, max) <sup>*</sup>	0 (0, 30)	0 (0, 20)	0 (0, 30)	0.79 <sup>a</sup>

**Table 1.**  
Continued

<b>Factor</b>	<b>Total (N = 98)</b>	<b>Single Port (n = 56)</b>	<b>Conventional (n = 42)</b>	<b>P</b>
Wound infection, n (%) <sup>*</sup>				0.19 <sup>c</sup>
No	83 (98)	48 (100)	35 (95)	
Yes	2 (2)	0 (0)	2 (5)	
Operative time, minutes, median (min, max)	96 (45, 228)	85 (45, 194)	114 (50, 228)	<b>0.003<sup>a</sup></b>
Duration hospitalization, hours, median (min, max)	22 (0, 142)	22 (0, 142)	21 (0, 119)	0.70 <sup>a</sup>
Total cost (\$), median (min, max)	8015 (5,141, 37,987)	7438 (5,141, 37,987)	8783 (5,180, 21,625)	<b>0.028<sup>a</sup></b>
Operative cost (\$), median (min, max)	4158 (2,111, 7,439)	3918 (2,111, 6,949)	4647 (2,880, 7,439)	<b>&lt;0.001<sup>a</sup></b>

<sup>\*</sup>Data not available for all subjects. Missing values: intraoperative complications, n = 2; estimated blood loss(mL), n = 5; and wound infection, n = 13.

<sup>a</sup> Wilcoxon rank sum test; <sup>b</sup> Pearson's Chi-square test; <sup>c</sup> Fisher's exact test.

multichannel port or multiple ports placed through a single incision.

In 2011, in a study involving 69 patients, Chandler and Danielson<sup>1</sup> compared conventional 4-port laparoscopic cholecystectomy against the single-incision technique that used either the SILS Port (Medtronic) or the Tri-Port (Olympus; Advanced Surgical Concepts, Wicklow, Ireland) and a transabdominal suture for gallbladder retraction. No differences between the techniques were observed for operative time, length of stay, analgesia requirement, or cost. In contrast to using a dedicated single multichannel port, Emami et al<sup>2</sup> reported their experience in 25 patients who underwent laparoscopic cholecystectomy with multiple small ports placed adjacent to one another through a single umbilical incision and a transabdominal suture for gallbladder retraction. No cost or outcomes comparisons with the conventional 4-port laparoscopic cholecystectomy technique were reported. Leinwald et al<sup>3</sup> reported their experience in 18 patients using a similar technique. Equipment cost comparison demonstrated that their single-incision laparoscopic cholecystectomy technique was 28% cheaper than the traditional 4-port technique.

Our technique differs from those used in the aforementioned studies in several respects. We use a conventional-sized (10 mm) scope with an in-built working channel. Use of these instruments translates into a truly single-port approach that does not require a larger skin incision to accommodate a large multichannel port or multiple adjacently placed ports. The use of a smaller incision carries the putative benefits of improved postoperative pain and

cosmesis. Moreover, our technique avoids the costs of single-use specialized or multiple ports, does not apply costly multifire clip appliers or sealing devices, and involves no retrieval bag, which should translate into reduced costs. In our institution, the cost for the 2 percutaneous graspers does not exceed the expense for 3 additional 5-mm laparoscopic ports. There are potential drawbacks of this technique, including the requirement for longer instruments, which may be challenging in smaller patients. Furthermore, the in-line relationship of the operating channel and the 0-degree optic can create parallax view problems.

In 2012 we reported our early experience with this single-port laparoscopic cholecystectomy technique in 20 patients.<sup>4</sup> This report did not include any cost or outcomes comparisons against the conventional 4-port laparoscopic technique. Karakus et al<sup>5</sup> reported their experience in 27 patients with the same scope without intra- or postoperative complications. Instead of using the portless Clutch graspers, 2 transabdominal sutures were used for gallbladder retraction.

When the single-port and conventional laparoscopic cholecystectomy modalities were compared in our current study population, operative times for the single-port approach were found to be shorter without any significant differences in estimated blood loss, need for conversion to open, and intra- or postoperative complications. We acknowledge a strong selection bias, as more patients in the single-port group were diagnosed with biliary dyskinesia, and therefore presented with favorable anatomy, and consequently, a technically easier procedure. These findings

demonstrate that the single-port laparoscopic cholecystectomy technique, despite its unique instrumentation and associated challenges, is faster than the conventional approach in noncomplicated cases and is equal in safety to the conventional approach. Postoperative analgesic needs and total length of hospitalization were also similar, further demonstrating equivalence in clinical outcomes. Of equal importance, the total hospitalization and operative costs were significantly less with the single-port laparoscopic approach for patients with or without cholangiogram. The cost differential is likely attributable to the shorter operative times and reduced equipment costs. Such cost savings, in the absence of compromising patient safety and clinical outcomes, are substantial when extrapolated across a large patient population and particularly in the current climate where attention is focused on efficiency and healthcare cost reduction.

The single-port cohort was less likely to undergo a cholangiogram. This observation may in part be associated with the finding that more patients with cholecystitis and cholelithiasis were treated by the conventional approach, whereas more patients with no stones and anatomically unremarkable gallbladders (biliary dyskinesia) were treated by the single-port approach. Stratifying by performance of a cholangiogram confirmed the skewed distribution of patients with cholecystitis into the conventional 4-port laparoscopic cohort. Performance of a cholangiogram in the single-port technique is feasible with the Kumar clamp but requires more practice than in the multiport technique. This finding could also have influenced the surgeon's choice to omit the cholangiogram in the single-port cohort. Surgeon's preference may also account for the observed difference in the patients' weight between the groups by electing to treat patients of greater weight with the conventional method rather than applying this newer technique without reported evidence of superiority in overweight or obese patients. This question requires additional investigation and should be addressed by randomization.

Careful consideration of the above-mentioned selection bias is warranted when interpreting our data. The study was not powered to detect differences between the surgical techniques in the diagnostic or weight subgroups. Additional limitations of this study include its retrospective nature, single-center focus, and the varied skills and laparoscopic preferences of the 6 participating surgeons.

## CONCLUSION

Hybrid single-port laparoscopic cholecystectomy in children with uncomplicated gallbladder disease is feasible and equal in safety, with similar intra- and postoperative outcomes as the conventional 4-port approach. In selected patients, it can contribute to global cost reduction by lowering operative and total hospital costs.

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