Comparative outcomes of single incision laparoscopy versus conventional laparoscopy in paediatric population: a meta analysis

Eko Purnomo, PhD[1,2], Bagus Satrio Pambudi, MD[1], Nabilah Anisa Novebri, MD[1]

[1]Pediatric Surgery Division, Department of Surgery, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada-Dr. Sardjito Hospital, Yogyakarta, Indonesia, [2]Pediatric Surgery Division, Academic Hospital, Universitas Gadjah Mada, Yogyakarta, Indonesia

ABSTRACT

Introduction: Single-incision laparoscopic surgery (SILS) and conventional laparoscopic surgery (CLS) are minimally invasive surgical techniques that are widely used as the treatment of appendicitis. While both techniques have demonstrated several advantages over laparotomy, such as reduced postoperative pain and faster recovery, SILS is hypothesized to further enhance clinical outcomes due to its less invasive approach. Hence, systematic comparisons of SILS and CLS are necessary to delineate the most efficient surgery for pediatric surgeons. This study aimed to compare postoperative outcomes between SILS and CLS in pediatric appendicitis, specifically focusing on complication rates, length of hospital stay (LOS), and duration of surgery.

Materials and Methods: A comprehensive search of four databases (PubMed, ProQuest, Scopus, and ScienceDirect) was conducted in October 2024 to identify the eligible studies. Meta-analysis was performed using Comprehensive Meta-Analysis software, applying a random-effects model to calculate pooled effect sizes. Heterogeneity was evaluated using the I^2 and Q statistics to assess consistency across studies.

Results: Six studies, encompassing a total of 838 children who underwent laparoscopic appendectomy, were included. The pooled analysis showed no statistically significant difference in complication rates between SILS and CLS (OR: 1.421, 95% Confidence Interval: 0.609–3.314, p=0.416), nor in length of hospital stay (SMD: -0.003, 95% Confidence Interval: -0.252–0.247, p=0.983).

Conclusion: Both SILS and CLS demonstrate favorable outcomes for pediatric appendicitis surgery, with minimal differences in complication rates and recovery times. These findings suggest that both techniques were feasible choices, allowing for flexibility in choosing the surgical approach based on patient-specific factors and surgical expertise.

KEYWORDS:
Conventional laparoscopic, meta-analysis, single incision laparoscopic

INTRODUCTION

Acute appendicitis remains one of the most common surgical emergencies worldwide. While its exact aetiology is not fully understood, luminal obstruction caused by factors such as fecaliths, hyperplastic lymphoid tissue, foreign bodies, parasitic infections, or tumors is thought to play a significant role.[1] Appendectomy has long been recognized as the standard treatment for this condition, with its first recorded performance by Amyand in 1735 during the repair of an inguinal hernia containing an inflamed appendix. The introduction of the right iliac fossa incision by McBurney in 1894 revolutionized appendectomy, providing the foundation for modern surgical approaches.[2]

The advent of minimally invasive techniques marked a significant milestone in appendectomy. In 1983, the first laparoscopic appendectomy was performed, ushering in a new era of surgical innovation. Laparoscopic appendectomy (LA) has since become the preferred choice for treating suspected appendicitis due to its numerous advantages, including reduced postoperative pain, faster recovery times, fewer complications, and improved cosmetic outcomes.

Furthermore, Single-incision laparoscopic surgery (SILS) represents a further evolution of minimally invasive surgery, aiming to enhance patient recovery and satisfaction by minimizing abdominal wall trauma. SILS reduces the number of incisions to a single-entry point, potentially offering even better cosmetic outcomes and reduced postoperative pain compared to conventional laparoscopic surgery (CLS). Despite these theoretical advantages, SILS has yet to achieve widespread adoption, largely due to technical challenges such as limited instrument maneuverability, ergonomic difficulties, and increased surgeon fatigue.[3]

The current literature on SILS versus CLS is characterized by heterogeneity, with studies reporting varying results and utilizing diverse methodologies. While some studies suggest potential benefits of SILS, others have found no significant differences in outcomes compared to CLS. The absence of consensus highlighted the need for a comprehensive synthesis of the available evidence.

This study aims to address this gap by conducting a systematic review and meta-analysis to compare SILS and

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Corresponding Author: Eko Purnomo
Email: eko.p@ugm.ac.id

CLS in the treatment of appendicitis, especially in children. The primary outcomes evaluated include complication rates and hospital stay. Through this analysis, we seek to provide a clearer understanding of the relative benefits or limitations from these two surgical approaches.

MATERIALS AND METHODS

Search strategy

The protocol for the meta-analysis was developed in alignment with the Cochrane Collaboration guidelines.[4] This study was conducted following the updated of 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses as reporting guidelines.[5]

An extensive search across four databases (PubMed, ProQuest, Scopus, and ScienceDirect) was conducted in October 2024 to identify relevant articles, without restrictions on language or publication year. The search terms were conducted using a combination of Boolean operators and Medical Subject Headings keywords: (laparoscopy OR peritoneoscopy OR surgery, laparoscopic OR laparoscopic surgical procedures) AND (appendicitis) AND (SILS OR CLS OR single OR conventional). The specific search terms and syntaxes used across four databases are outlined in Supplementary 1.

Eligibility criteria

The inclusion criteria for this meta-analysis were studies that reported the effectiveness of SILS versus CLS in treating children with appendicitis, adhering to the diagnostic criteria outlined in the International Classification of Diseases. To maintain consistency throughout the study, we included studies that delineated the effectiveness of SILS vs CLS based on the availability of 2x2 contingency table, using either raw or modified data. Our initial search included all comparative studies, including randomized controlled trials and quasi-experimental studies. While the exclusion criteria for this meta-analysis were applied to studies that failed to meet the following conditions: (1) relevance to the designated topic, (2) adherence to an appropriate study design, (3) classified as non-meta analysis or systematic review, and (4) sufficient raw data.

Data extraction

Articles were screened by two independent reviewers. Initially, duplicated articles were identified and removed, followed by an assessment based on titles and abstracts. Subsequently, a thorough review of the full-text articles was performed on the basis of predetermined inclusion and exclusion criteria. Any discrepancies between the reviewers were addressed through discussion for resolution. To ensure accuracy and relevance, a post hoc exploration of the reference lists from relevant previous systematic reviews and meta-analyses was also been carried out. Finally, after completing the screening and reviewing process, the following data were extracted from each included study: (1) author names, country, and study design; (2) sample size; (3) demographic characteristics (e.g., age, gender distribution, weight, height, and comorbid if data were available); and (4) effectiveness of SILS versus CLS.

Data synthesis and analysis

The pooled effect size of SILS versus CLS effectiveness was evaluated using a random effects model in CMA version 3. I2 and Cochran's Q tests were assessed to determine the heterogeneity within the included studies, with an I2 value exceeding 30%, a small Q value, and a p value of <0.1 indicating a significant heterogeneity. Study outcomes were presented as odds ratio (OR) and standardized mean difference (SMD) with corresponding 95% confidence intervals (95% CIs). In the presence of heterogeneity, meta-regression analyses were conducted to identify potential moderators such as age, weight, height, and child's gender. A p-value of <0.05 was considered as significant moderator variable.

Sensitivity analysis based on study weight was not carried out because of the small number in our included studies. However, to maintain the consistency and study robustness, we conducted the identification of publication bias using visual inspection of a funnel plot and analyzes using Peters' regression test.[6] Alteration in the funnel plot and p-value of Peters' regression test ≤0.10 suggested the potential presence of publication bias. In cases where publication bias was identified, a trim-and-fill procedure will be implemented to correct the bias.

RESULTS

Overview of included studies

A comprehensive search across the four databases yielded a total of 732 relevant studies. After excluding 122 duplicates, the remaining 610 studies underwent initial screening based on titles and abstracts. Subsequently, 593 studies were excluded due to irrelevant topic, design, or a non-research nature. This process led to the identification of 17 eligible studies for full-text examination. Out of these, 11 studies were excluded for not meeting our inclusion criteria, leaving 6 studies that fulfilled the specified criteria and were included in the analysis (Figure 1).

Study characteristics

All studies included in this meta-analysis were published from 2011 to 2019 and were conducted in diverse countries, including United States (n=3), Poland (n=1), China (n=1), and Japan (n=1). All of the studies were designed using randomized controlled trial and comprised of 838 children diagnosed with appendicitis. The majority of participants in the included studies were male (52.9%) with the mean age at 9.9 years. Average weight of the participant was 36.21 kg. In the SILS group, observed complications included wound seroma (1 case), abdominal collection (1 case), postoperative wound infection (10 cases), and intra-abdominal abscess (1 case). In comparison, the CLS group reported postoperative wound infection (7 cases) and intra-abdominal abscess (2 cases). Notably, no severe complications such as postoperative ileus requiring reoperation via laparotomy were reported in either group (Table I).

Result of the meta-analysis

Our meta-analysis showed no significant difference between the measured variables when comparing SILS to CLS (Figure 2,3 and 4). The effect size for complication rates between SILS

Table I: Characteristics of the included studies

No	Author(s) (year)	Study design, country	Sample size	Demographic characteristic, n (%) or mean±SD	n-event (%) or mean±SD
1	Peter et al, (2011)[10]	Randomized controlled trial, United States	360	Type of appendicitis: Acute and chronic Age: 11.10±3.50 Gender, male 191 (53.05) female 169 (46.94)	Complication rate SILS: 6/180 (3.33) CLS: 4/180 (2.22) LOS duration SILS: 0.94±0.26 CLS: 0.92±0.28
2	Knott et al, (2012)1[1]	Randomized controlled trial, United States	274	Weight: 42.70±18.50 Type of appendicitis: Acute Age: 11.00±3.50 Gender, male 143 (52.19) female 131 (47.81) Weight: 38.30±14.50	Surgery duration SILS: 35.2±14.5 CLS: 29.8±11.6 Complication rate SILS: 2/135 (1.48) CLS: 3/139 (2.16) LOS duration SILS: 0.92±0.24 CLS: 0.94±0.30 Surgery duration SILS: 34.0±13.6 CLS: 29.6±13.6
3	Perez et al, (2012)[12]	Randomized controlled trial, United States	50	Type of appendicitis: Acute Age: 8.70±0.60 Gender, male: 25 (50) female: 25 (50) Weight: 36.25±NA	Complication rate SILS: 1/25 (4.00) CLS: 0/25 (0.00) LOS duration SILS: 1.70±NA CLS: 1.50±NA Surgery duration SILS: 46.8±3.7 CLS: 34.8±2.5
4	Wu et al, (2014)[13]	Randomized controlled trial, China	60	Type of appendicitis: Acute Age: 8.90±1.80 Gender, male 37 (61.67) female 23 (38.33) Weight: 27.6±3.8	Complication rate SILS: 1/30 (3.33) CLS: 1/30 (3.33) LOS duration SILS: 4.00±0.84 CLS: 4.50±1.17 Surgery duration SILS: 64.3±3.1 CLS: 53.0±2.8
5	Moriguchi et al, (2018)[14]	Randomized controlled trial, Japan	44	Type of appendicitis: NA Age: 8.70±2.40 Gender, male 26 (59.09) female 18 (40.90)	Complication rate SILS: 1/20 (3.33) CLS: 0/24 (2.22) LOS duration SILS: 9.20±5.90 CLS: 10.00±7.90 Surgery duration SILS: 85.1±36.2 CLS: 78.5±30.3
6	Golebiewski et al, (2019)[15]	Randomized controlled trial, Poland	50	Type of appendicitis: Acute Age: 11±3 Gender, male 21 (42) female 29 (58)	Complication rate SILS: 2/25 (8.00) CLS: 1/25 (4.00) LOS duration SILS: 6.00±4.00 CLS: 4.00±2.00 Surgery duration SILS: 68.0±15.0 CLS: 58.0±15.0

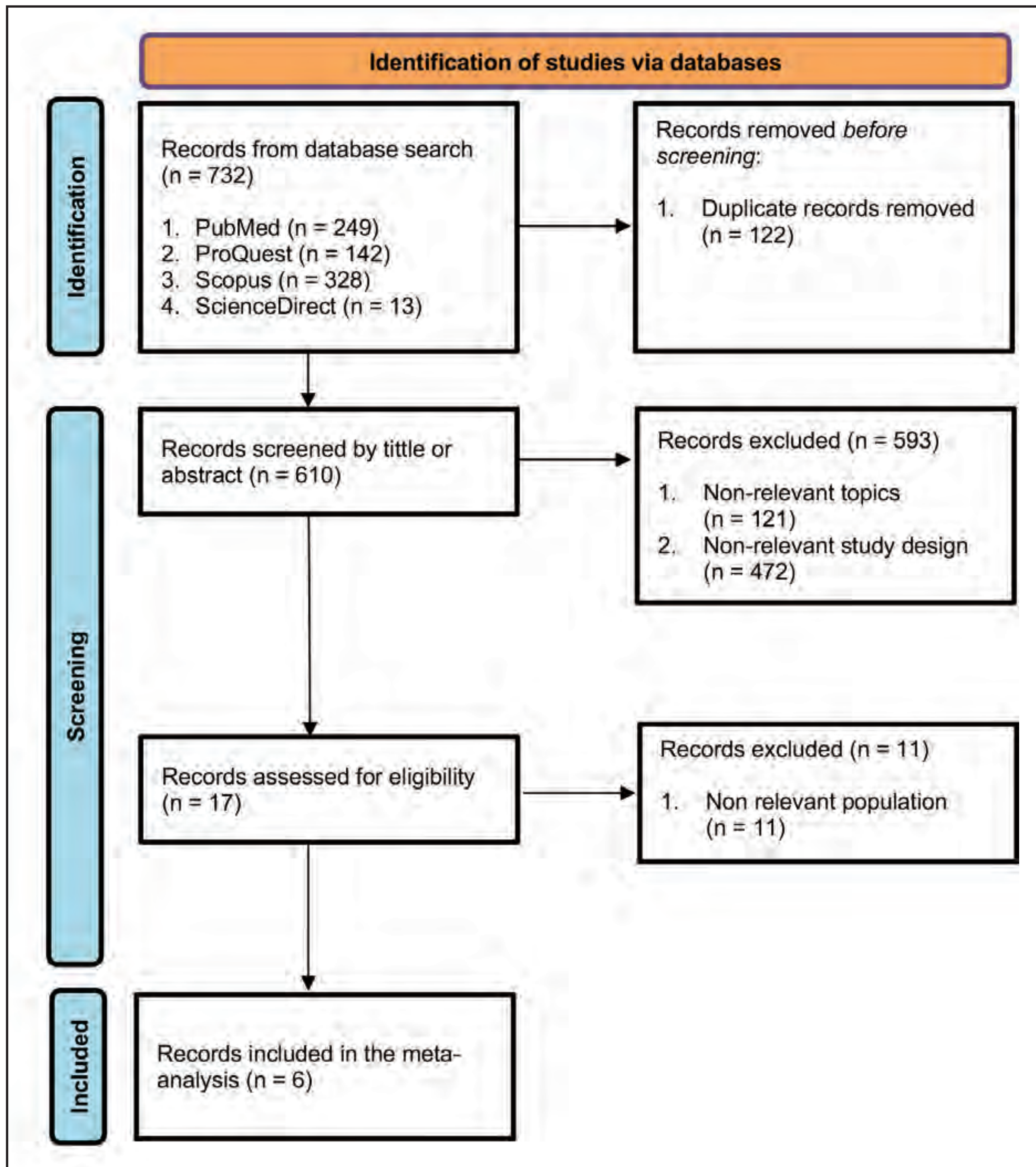

Fig. 1: Prisma flow diagram

and CLS was measured in odds ratio and valued as 1.421 (95% CI: 0.609–3.314, Q=1.370, p=0.416, and I2=0%). Similarly, in terms of hospital stay comparison that was measured in SMD, yielded the value of -0.003 (95% CI: -0.252–0.247, Q=9.271, p = 0.983, and I2 = 56.8%) (Figure 2,3 and 4). Visual examination of publication bias using the funnel plot displayed no apparent asymmetry. This observation was further substantiated by Egger's regression test that yielded p-value of 0.402 and 0.963 (p>0.05) for complication rate and hospital stay respectively, both indicating the absence of publication bias in our meta-analysis (Supplementary 2).

DISCUSSION

The results of this meta-analysis indicate that there was no significant difference in complication rates or hospital stay between SILS and CLS when treating children with appendicitis. Our findings align with those studies conducted by Aly et al (2016) and Deng et al (2017), who compared complication rates between SILS and CLS for adult appendicitis, both studies also reported no significant difference in complication rates following appendicitis surgery. However, our findings differ from study that conducted by Ding et al (2013) in term of hospital stay, who reported a better outcome in SILS surgeries. This discrepancy might be attributed to the differences in the characteristics of

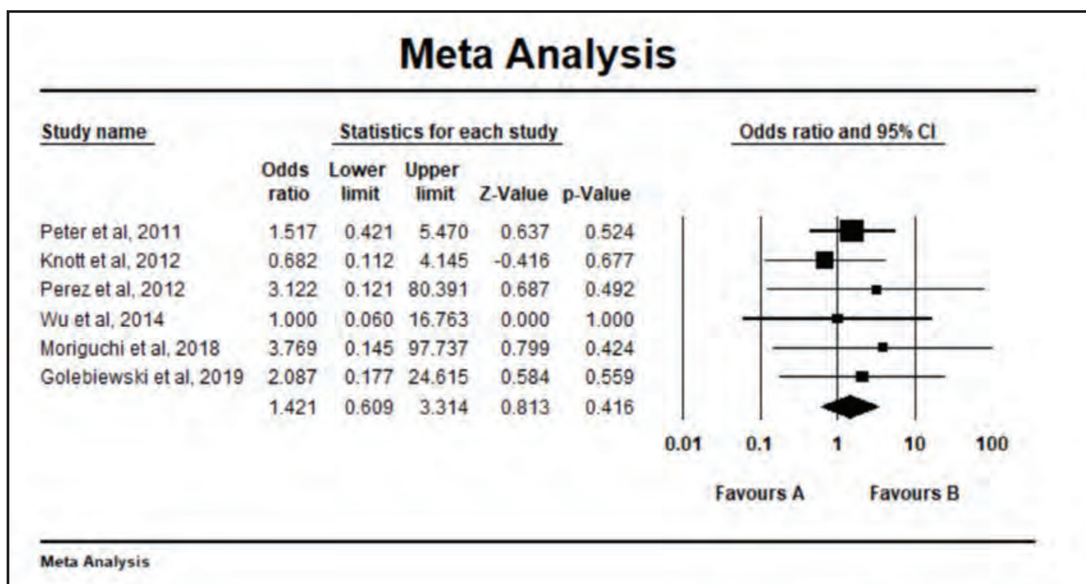

Fig. 2: Forest plot of post-operative complication comparison

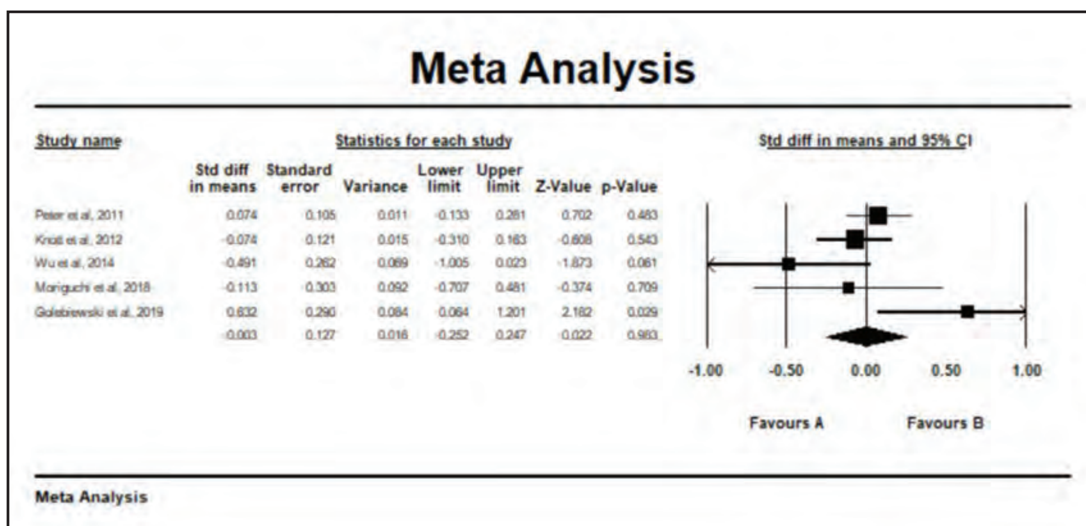

Fig. 3: Forest plot of length of stay comparison

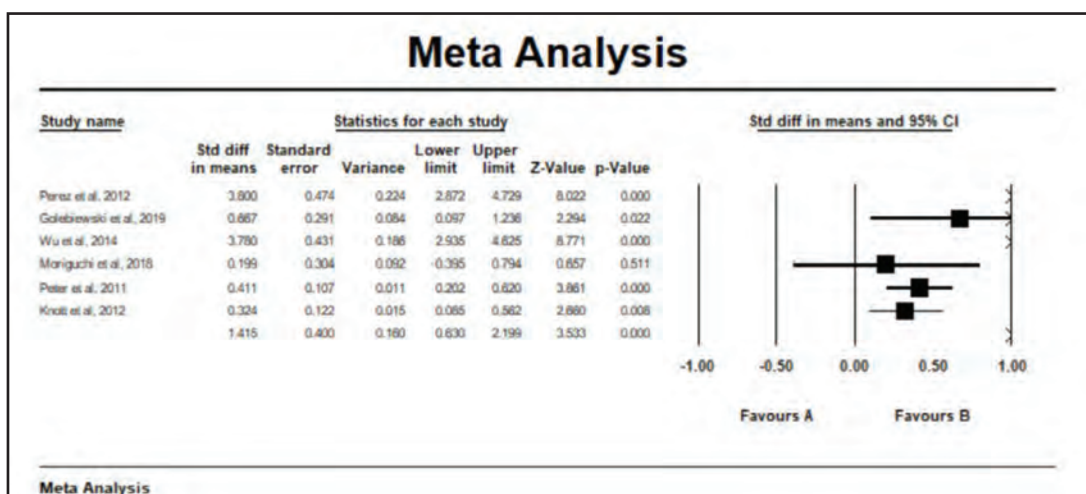

Fig. 4: Forest plot of surgery duration comparison

the study populations. While it has been demonstrated that SILS results in lesser wounds, which could hypothetically accelerate recovery, the actual healing process in children might be influenced by the immaturity of their immune system. This factor could potentially negate any differences in hospital stay between the two surgical techniques.[7,8,9]

Notably, this study holds several strengths. Firstly, to the best of our knowledge, this study was the first meta-analysis that comprehensively evaluated the global comparison between SILS and CLS in the treatment of child appendicitis. Secondly, we conducted an extensive search across four databases without implementing any limitations such as publication date, region, or language restrictions. Finally, we followed a clear and detailed methodological procedure for data extraction using the Cochrane guidelines.

However, this study is not without its limitations. Firstly, we identified a moderate level of heterogeneity in one of our analyzed variables, which could alter the generalizability of our findings. Secondly, we were unable to perform further analysis regarding these findings due to the lack of measured other variables within the included studies, such as anthropometric factors, which might pose as potential moderators. Therefore, future research incorporating larger data pool and additional analyses, such as meta-regression, is essential to address these limitations.

CONCLUSION

Both SILS and CLS demonstrate favorable outcomes for pediatric appendicitis surgery, with minimal differences in complication rates and recovery times. These findings suggest that both techniques are feasible choices, allowing for flexibility in choosing the surgical approach based on patient-specific factors and surgical expertise.

CONFLICT OF INTEREST

The authors confirm that they have no conflict of interest to declare.

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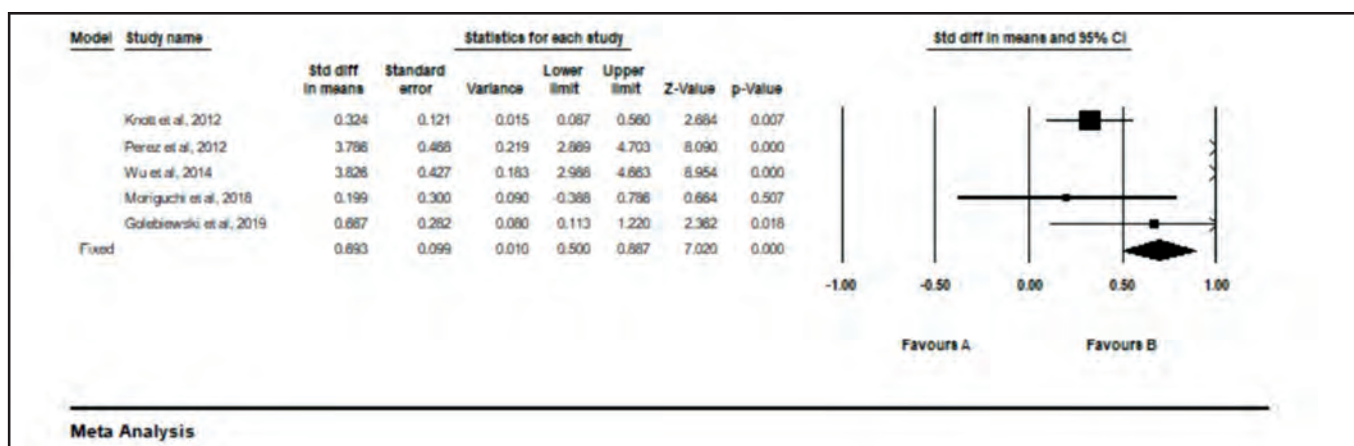
Supplementary 1
Syntaxes Used in the PubMed, ProQuest, Cochrane, Scopus, and Sage

PubMed	
"Laparoscopy"[Mesh] OR "Peritoneoscopy"[tw] OR "Surgery, Laparoscopic"[tw] OR "Laparoscopic Surgical Procedures"[tw]	123,959
"Appendicitis"[Mesh]	21.799
"SIL"[Title] OR "CL"[Title] OR "single"[Title] OR "conventional"[Title]	391,486
(("Laparoscopy"[Mesh] OR "Peritoneoscopy"[tw] OR "Surgery, Laparoscopic"[tw] OR "Laparoscopic Surgical Procedures"[tw]) AND ("Appendicitis"[Mesh])) AND ("SIL"[Title] OR "CL"[Title] OR "single"[Title] OR "conventional"[Title])	249
ProQuest	
"Laparoscopy" OR "Peritoneoscopy" OR "Surgery, Laparoscopic" OR "Laparoscopic Surgical Procedures"	75,270
“Appendicitis”	25,051
title ("SIL" OR "CL" OR "single" OR "conventional")	4,124,754
("Laparoscopy" OR "Peritoneoscopy" OR "Surgery, Laparoscopic" OR "Laparoscopic Surgical Procedures") AND "Appendicitis" AND title("SIL" OR "CL" OR "single" OR "conventional")	142
Scopus	
ALL("Laparoscopy" OR "Peritoneoscopy" OR "Surgery, Laparoscopic" OR "Laparoscopic Surgical Procedures")	162,562
TITLE-ABS(“Appendicitis”)	27,805
TITLE (“SIL" OR "CL" OR "single" OR "conventional”)	911,885
(ALL("Laparoscopy" OR "Peritoneoscopy" OR "Surgery, Laparoscopic" OR "Laparoscopic Surgical Procedures") AND TITLE-ABS("Appendicitis") AND TITLE("SIL" OR "CL" OR "single" OR "conventional"))	328
ScienceDirect	
("Laparoscopy" OR "Peritoneoscopy" OR "Surgery, Laparoscopic" OR "Laparoscopic Surgical Procedures")	83,810
("Appendicitis")	39,884
("SIL" OR "CL" OR "single" OR "conventional")	+1,000,000,000
((("Laparoscopy" OR "Peritoneoscopy" OR "Surgery, Laparoscopic" OR "Laparoscopic Surgical Procedures") AND ("Appendicitis"))) AND ("SIL" OR "CL" OR "single" OR "conventional")	13

2. Edger regression for length of stay (LOS)'s funnel plot analysis

Egger's regression intercept	
Intercept	-0.09205
Standard error	1.85050
95% lower limit (2-tailed)	-5.98118
95% upper limit (2-tailed)	5.79708
t-value	0.04974
df	3.00000
P-value (1-tailed)	0.48173
P-value (2-tailed)	0.96345

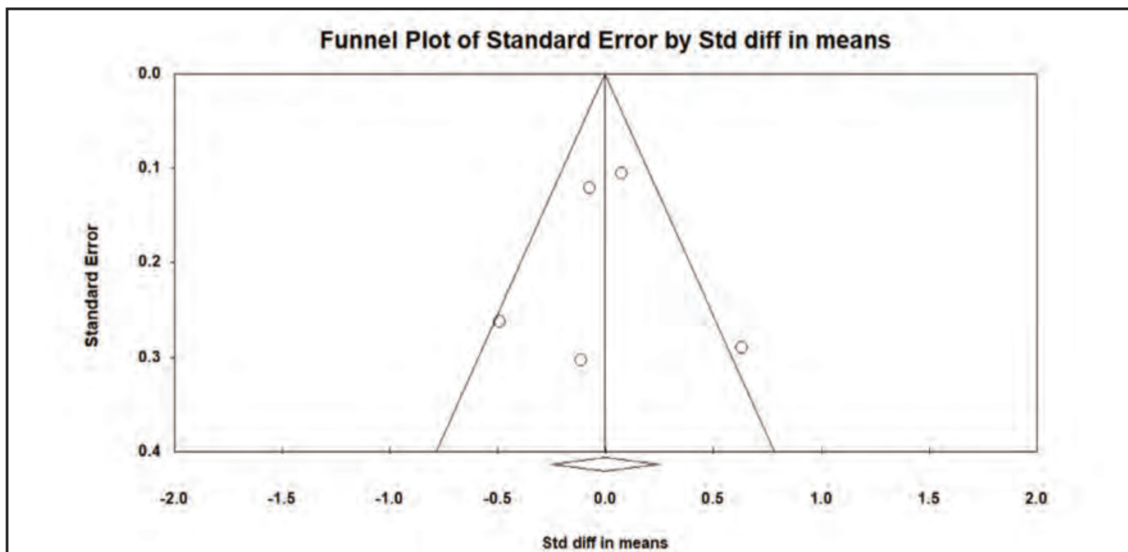
3. Forest plot of surgery duration SILS vs CL comparison



Model	Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Knott et al, 2012	0.324	0.121	0.015	0.087	0.560	2.684	0.007
	Perez et al, 2012	3.786	0.466	0.219	2.869	4.703	8.090	0.000
	Wu et al, 2014	3.826	0.427	0.183	2.986	4.663	8.954	0.000
	Moriguchi et al, 2018	0.199	0.300	0.090	-0.388	0.786	0.664	0.507
	Golebiewski et al, 2019	0.667	0.282	0.080	0.113	1.220	2.362	0.018
Fixed		0.693	0.099	0.010	0.500	0.887	7.020	0.000

Model	Effect size and 95% confidence interval						Test of null (2-Tail)		Heterogeneity				Tau-squared			
Model	Number Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed	5	0.004	0.071	0.005	-0.136	0.144	0.055	0.956	9.271	4	0.055	56.853	0.041	0.057	0.003	0.203
Random	5	-0.003	0.127	0.016	-0.252	0.247	-0.022	0.983								

Funnel plot of surgery duration SILS vs CL comparison



Egger's regression intercept

Intercept	7.40100
Standard error	3.36864
95% lower limit (2-tailed)	-3.31951
95% upper limit (2-tailed)	18.12152
t-value	2.19703
df	3.00000
P-value (1-tailed)	0.05775
P-value (2-tailed)	0.11549