Laparoscopic Versus Open Pyeloplasty for Pelvicoureteric Junction Obstruction: A Systematic Review and Meta-Analysis

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Abstract

Objectives To compare outcomes of laparoscopic versus open pyeloplasty for the management of pelvicoureteric junction obstruction (PUJO) using a systematic review and meta-analysis.

In September 2022, electronic database searches were conducted using the Cochrane Library, the Cochrane Central Register of Controlled Trials, EMBASE, MEDLINE, clinical trial registries, and relevant conferences to identify relevant abstracts and presentations.

Methods Prospective randomized controlled trials comparing laparoscopic to open pyeloplasty for PUJO were included in the review. There were no restrictions on date or language. All populations were included. The authors performed data extraction and risk of bias assessment using the risk of bias tool. Meta-analysis was performed using RevMan software.

Results Six prospective randomized controlled trials involving 335 participants were included in the analysis. Six studies included data on the failure rate, with a slight favouring of open pyeloplasty compared to laparoscopic pyeloplasty, although this was not statistically significant (odds ratio [OR], 1.39; 95% confidence interval [CI] 0.50 to 3.83).

Five studies compared operative time, with open pyeloplasty found to have shorter times across all studies (mean difference [MD], 54.97 minutes; 95% CI 47.08 to 62.85).

Based on 5 studies, laparoscopic pyeloplasty has a shorter hospital stay (MD, 4.12 days; 95% CI 3.64 to 4.59).

Two studies compared postoperative analgesia requirements, showing a lower diclofenac requirement in the laparoscopic group (MD, 330.08 mg; 95% CI 298.05 to 362.11 mg).

One study compared blood loss intraoperatively and found no significant difference between the groups (MD, 8.52 mL; 95% CI -2.49 to 19.53).

Based on 4 studies, laparoscopic pyeloplasty may result in slightly higher complication rates postoperatively (OR, 1.49; 95% CI 0.53 to 4.18); however, there was no statistically significant difference.

No subgroup analyses were conducted.

Conclusions Limited, low-quality evidence from small-scale trials suggests that laparoscopic pyeloplasty has improved outcomes in terms of shorter hospital stays and reduced postoperative pain compared to open pyeloplasty. Open pyeloplasty, on the other hand, had a shorter operative time. Failure rate, complication rate, and blood loss were comparable between the 2 approaches.

Key Words

Pyeloplasty, laparoscopy, minimally invasive surgical procedures, open surgery, pelvicoureteric junction obstruction

Competing Interests

None declared.

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Abbreviations
CI confidence interval
LP laparoscopic pyeloplasty
MD main difference
OP open pyeloplasty
PUJO pelvicoureteric junction obstruction
RCT randomized controlled trials
RR risk ratio

Introduction
Pelvicureteric junction obstruction (PUJO) is a common cause of hydronephrosis in children and adults. The prevalence of this condition has risen recently due to the increased efficacy and hence widespread use of antenatal screening. Approximately one in 1000 newborns has PUJO, with a male predominance [1],[2]. PUJO is most frequently caused by a stenotic segment of the ureter at the pelvicureteric junction (PUJ), creating a functional obstruction. Less common causes of pelvicureteric junction obstruction include crossing vessels, fibrosis, anatomical variants, and fibroepithelial polyps [2]. In adults, acquired stenosis of the PUJ can be caused by upper tract infections, stones, trauma (such as instrumentation), or ischemia and can culminate in reactive fibrosis and an annular stricture. Upon presentation, symptoms typically include flank pain and referred pain to the groin, with a delay to renal failure [3],[4].

In approximately 60% to 70% of cases, patients do not require surgical management, with hydronephrosis resolving spontaneously [4]. However, patients who experience significant symptoms or impairment in renal function may require surgical management. Open pyeloplasty (OP) is considered the gold standard of treatment for symptomatic PUJO [5]. However, there has been a trend toward minimally invasive techniques with advancements in technology. Minimally invasive procedures such as robot-assisted laparoscopic pyeloplasty (LP) can theoretically improve efficacy and effectiveness [6]. These may include a reduced risk for significant bleeding, smaller incisions, decreased pain, improved cosmetic outcomes, lower risk for postoperative infections, and shorter hospital stay [7]. A study reported an increase in the use of minimally invasive pyeloplasty from 2.4% to 33.5% of all pyeloplasty procedures conducted between 1998 and 2009 [8].

Despite the increasing popularity of laparoscopic approaches, there is a lack of high-quality evidence directly comparing OP to LP. Systematic reviews have been conducted comparing different laparoscopic approaches to pyeloplasty [9], LP versus OP in children [10], or LP versus robotic-assisted LP in infants [11], or have predominantly included retrospective studies [12]. To date, there has not been a systematic review of prospective studies comparing LP to OP. This systematic review aims to identify and analyze randomized controlled trials (RCTs) to assess the use of laparoscopic pyeloplasty in patients of all ages with PUJO.

Methods
Eligibility criteria
We included all prospective RCTs and excluded all other study designs. We evaluated laparoscopic pyeloplasty compared to open pyeloplasty in children and adults with a diagnosis of PULO who had not previously received any surgical management.

Information sources
In July 2022, we conducted electronic searches of the Cochrane Library and the Cochrane Central Register of Controlled Trials, MEDLINE, and EMBASE Ovid (see Online Appendix 1 for search strategy), with no restrictions on date or language. We reviewed trials registries for unpublished studies, including the Australia and New Zealand Clinical Trials Registry, International Clinical Trials Registry (World Health Organization), and Clinicaltrials.gov. Additionally, we reached out to experts in urology to identify critical studies and ongoing research. We searched for abstracts presented at the European Association of Urology (EAU) annual meetings, the British Association of Urological Surgeons (BAUS), and the American Urological Association (AUA) between 2019 and 2021. We conducted a manual search of the reference lists of included studies to identify any additional research.

Selection process
Two authors (B.B. and T.S.) reviewed all identified studies using Rayyan, a software program designed to screen potential studies. All studies identified in the search strategy were screened by title and abstract. Two review authors (B.B. and T.S.) independently conducted a thorough evaluation of the full text of all potentially relevant studies and categorized them as included, excluded, ongoing, or awaiting classification. The authors made a common decision in 98% of the specific cases. In the case of any discrepancies between the authors, a third author (H.N.) was involved to discuss and adjudicate on any differences that remained unresolved.

Criteria assessed:
- Random sequence generation (selection bias)
- Allocation concealment (selection bias)
- Blinding of participants and personnel (performance bias)
- Blinding of outcome assessment (detection bias)
- Incomplete outcome data (attrition bias)
- Selective reporting (reporting bias)
- Other sources of bias

We evaluated selection bias on a trial-by-trial basis by examining the methods of randomization and allocation concealment. Similarly, we assessed performance bias on a trial-by-trial basis by examining the methods used to blind participants and personnel to the intervention received.

For each outcome within each trial, we assessed outcome and reporting bias. We then categorized the outcomes into objective (not susceptible to detection bias) and subjective (susceptible to detection bias).

We planned to perform a primary analysis using only the studies with a low risk of bias and then a sensitivity analysis.

Effect measures and synthesis methods
We reported continuous outcome data measures as mean differences (MDs) with 95% confidence intervals (95% CI) and dichotomous outcome measures as a risk ratio (RR) with 95% CI. Given the difference in population (pediatric and adult populations were synthesized separately).

We summarized the data using a random effects model and interpreted the results by considering the whole distribution of effects in the random-effects meta-analyses. Additionally, our statistical analyses followed the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions. For dichotomous outcomes, we used the Mantel-Haenszel method; for continuous outcomes, we used the inverse variance method. We used Review Manager 5 (RevMan 5) software to perform all the analyses.

Missing data: We had planned to contact the study authors for any missing data and intended to use an intention-to-treat analysis. However, no missing data were reported, and thus no imputation was necessary by the authors.

Statistical heterogeneity: We assessed heterogeneity both graphically, by interpreting forest plots, and statistically using the I2 statistic. A value of 12 over 75% indicated significant heterogeneity between studies.

Subgroup analysis: No subgroup analysis was planned.

Certaination assessment:
The employed the GRADE approach to assess the quality of evidence generated by this systematic review. The GRADE Guideline Development Tool was used to make the summary of findings table.

Results
The initial search strategy identified 1561 records from electronic databases, with an additional 8 records identified from conference abstracts and 22 from citation searching of other sources (Figure 1). After removing duplicates, we screened 1168 records, excluding 1010 based on the title and abstract screening. We screened 158 full articles for suitability. Of these, 119 were excluded due to incorrect study type and 34 were excluded due to wrong intervention. We included 5 studies based on eligibility criteria and identified an additional study (Garg 2014[4]) through other searching methods.

Study characteristics
The baseline characteristics and demographics of participants are included in Table 1.

Risk of bias assessment
Please refer to Figures 2, and 5, as well as the study characteristics and evidence for Risk of Bias tool can be found in Online Appendix 1.
In one study (Gatti 2017 [16]), the operating surgeon completed all follow-up, leading to high risk of bias.

Incomplete outcome data
No studies reported incomplete data, indicating low risk of bias for all 6 studies.

Selective reporting
No studies included a published protocol. All outcomes appeared to be reported appropriately and logically as RCTs. Given that there was no protocol to compare, all 6 studies were judged as unclear risk of bias.

Other potential bias
No studies included any disclaimer or declaration regarding conflicts of interest or funding.

Publication bias
No publication bias was observed. A funnel plot was not feasible due to the low number of included studies.

Results of synthesis

Primary outcome—Failure rate
All 6 studies included data on the failure rate of pyeloplasty (total, 304; LP, 148; OP, 156) (Figure 4). However, there were no events in Srinivas [17], making the risk ratio not estimable.

In the adult population, LP likely results in no greater risk for failure compared to OP (RR, 1.23; 95% CI 0.32 to 4.72). There was no statistical heterogeneity (I²=0%) among the included studies.

Similar results were seen in the paediatric population (RR, 1.44; 95% CI 0.25 to 8.24).

Secondary outcomes

Operative time: Five studies included data on operative time (total, 304; LP, 148; OP, 156) (Figure 5). In adults,
TABLE 1. Baseline characteristics

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<td>Indications for surgery</td>
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<td>Cardiopulmonary compromise</td>
<td>Refusal of randomization</td>
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<td>Demographics (LP vs OP)</td>
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<td>Median age in years – 27.27 vs 23.47</td>
<td>Median age in years – 6.8 vs 7.6</td>
<td>Mean BMI (kg/m^2) 28.4 ± 3.25 vs 30.4 ± 3.5</td>
<td>Mean age in years - 31.64 vs 29.58</td>
<td>Mean BMI (kg/m^2) 28.4 ± 3.25 vs 30.4 ± 3.5</td>
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<td>Male sex (%) – 60.7% vs 58.8%</td>
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<td>Left-sided operation (%) – 42.9% vs 47.1%</td>
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LP: laparoscopic pyeloplasty, OP: open pyeloplasty.
LP likely results in a longer operative time of 66 minutes compared to OP (MD, 66.48 minutes; 95% CI 19.54 to 113.41). There is significant statistical heterogeneity (I²= 96%). There was a smaller difference in the paediatric population of 17 minutes (MD, 17.00 minutes; 95% CI 3.04 to 30.96).

Length of stay: Five studies included data on length of stay (total, 304: LP, 148; OP, 156) (Figure 6). LP likely reduces hospital stay by 3 days in adults (MD, -3.55 days; 95% CI -1.52 to -5.58). There is substantial statistical heterogeneity (I²= 92%). There was no difference in the paediatric group (MD, 0.10 days; 95% CI -4.58 to 4.37).

Complications: Four studies included data on complications (total, 269: LP, 123; OP, 126) (Figure 7). LP likely results in no difference in complication rates in adults (RR, 1.24; 95% CI 0.48 to 3.23). There is no significant statistical heterogeneity (I²= 0%). Similar results were seen in children (RR, 2.88; 95% CI 0.12 to 69.07).

Analgesia requirements: Two studies included data on this analgesia requirements (total, 122: LP, 58; OP, 64) (Figure 8). LP is likely to have a lower analgesia postoperative requirement (MD, -364.66 mg; 95% CI -776.90 to 47.58). There is significant statistical heterogeneity (I²= 99%).

Blood loss: One study included data on blood loss (total, 66: LP, 30; OP, 30) (Figure 9). LP likely results in little to no difference in blood loss (in millilitres) (MD, 8.52 mL; 95% CI -2.49 to 19.53). There was no data on blood loss for the paediatric population.

Cosmetic outcome: No studies included data on cosmetic outcome.

No subgroup analysis or sensitivity analysis was performed.

Summary of findings is shown in Table 2.

Discussion

Key findings

The review is based on 6 randomized controlled trials, all of which had relatively small sample sizes and events rates. Additionally, most studies had a relatively short follow-up period of 3 months, which limits the data to short-term outcomes. Long-term outcomes are important for choosing a surgical approach in all populations, however.

A key finding of this systematic review is the lack of high-quality studies endorsing the use of laparoscopic pyeloplasty over open pyeloplasty.

LP likely results in little to no difference in failure rate, complication rate, intraoperative blood loss, or short-term pain in both adult and paediatric populations. The laparoscopic approach likely has shorter hospital stays, decreased analgesic requirements, and improved pain at 7 days postoperatively. LP likely has longer operative times compared to OP.

The results of this systematic review highlight that the key clinical benefits of using a laparoscopic technique are a shorter length of stay and improved pain compared to OP. However, there is no significant difference in failure rates or complications between the 2 techniques. As such, patients can be counselled that LP may slightly
improve recovery times and postoperative pain, but there is no significant difference in outcomes of either failure rates or complications. LP and OP are equivalent in these outcomes in both populations.

**Comparison with existing knowledge**

Previous systematic reviews comparing laparoscopic to open pyeloplasty have included only retrospective studies,[12] focused on specific populations such as children,[10] or compared other approaches such as robotic-assisted or retroperitoneal approaches.[9,11] Mei et al. had similar results in the paediatric population, with LP having shorter hospital stays without an increased risk for complications or failure of the pyeloplasty.[10] Huang et al. reported a shorter hospital stay and lower complication rate with LP compared to OP in children.[18]

**Strengths and limitations**

This study only included randomized controlled trials, the gold-standard study type for an intervention such as LP compared to OP.

The quality of evidence was consistently downgraded for all studies included in this review due to the studies’ intrinsic limitations. Given the surgical nature of the intervention, these studies are prone to selection bias from poor allocation concealment and lack of blinding.[19] Overall, all studies included in this review are at high risk of bias, and the results should be interpreted with caution.

An ongoing challenge in assessing new or evolving surgical techniques is accounting for user experience and the surgical learning curve.[20] Surgical outcomes are dependent on the experience of the surgeon, the number of procedures performed, and the centre’s experience. Other specific factors that may affect outcomes for pyeloplasty include stent and drain placement, which were not assessed. Thus, this review cannot account for any of these factors, which may influence outcomes.

**Implication for practice**

This systematic review highlights the minor benefits offered by laparoscopic pyeloplasty. In practice, these minor benefits are unlikely to outweigh the surgeon’s preference of approach based on their training, experience, and available resources. However, it emphasizes the importance of urologists in training to learn the laparoscopic approach for pyeloplasty.

**Implication for research**

Overall, this review has shown that LP may have some minor advantages over OP, but the evidence is of low quality. Further research could focus on larger sample sizes, with longer-term follow-up of participants. With the introduction of robotically assisted pyeloplasty, this approach could also be investigated with large RCTs.

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**References**


4. Chen YS, Liu YH, Lin GL, Liu JQ, Chao KC, Chen CJ. Minor advantages over OP, but the evidence is of low quality. Further research could focus on larger sample sizes, with longer-term follow-up of participants. With the introduction of robotically assisted pyeloplasty, this approach could also be investigated with large RCTs.


