

ORIGINAL ARTICLE

Anesthetic techniques for ureteroscopy in pregnancy and their maternal, fetal, and procedural outcomes: a systematic review and meta-analysis

Fardus Alshangiti^{1*}, Ahmad M. Alridahie², Abdullah M. Alqahtani³,
Lama F. Alqahtani⁴, Abdullah Alsaheed³, Mohammed Khalid Murtada⁵,
Elaf Abdullah Bin Rabah⁶

ABSTRACT

Background: Urolithiasis in pregnancy is challenging due to physiological changes and limited treatment options. Ureteroscopy (URS) is the preferred minimally invasive intervention, but the optimal anesthesia technique remains debated, as general, spinal, and local anesthesia carry distinct maternal and fetal risks. This review synthesized maternal, fetal, and procedural outcomes following URS in pregnancy to guide clinical decision-making.

Methods: This PRISMA-compliant review searched PubMed, Web of Science, and Google Scholar for records published between 2014 and 2025, yielding 26 records after duplicate removal. Eligible studies involved pregnant patients undergoing URS with reported maternal, fetal, or procedural outcomes. Quality was assessed using the Newcastle-Ottawa Scale. Pooled proportions with 95% confidence intervals (CIs) were calculated using a random-effects model with the Freeman-Tukey double arcsine transformation; heterogeneity was quantified using the I^2 statistic.

Results: Five observational studies encompassing 311 URS procedures across 387 pregnant women met the inclusion criteria. Sepsis, Intensive Care Unit admission, and ureteral perforation each occurred in under 1% of cases. Overall maternal complications occurred in 11.0% (95% CI: 0.6%-32.1%), most frequently urinary tract infection. Fetal outcomes were reassuring, with a live birth rate of 99.2% (95% CI: 96.7%-100%), a miscarriage rate of 0.4%, and a procedural success rate of 98.2% (95% CI: 82.7%-100%).

Conclusion: URS in pregnancy appears generally safe and effective, with low major maternal morbidity and high live birth and procedural success rates. A formal comparison of anesthetic techniques was not feasible because of inconsistent outcome reporting, underscoring the need for individualized, multidisciplinary decision-making. Findings warrant cautious interpretation given the observational designs and heterogeneity; prospective, multicenter studies with standardized, anesthesia-specific outcome reporting are needed.

Keywords: Pregnancy, ureteroscopy, urolithiasis, URS.

Introduction

Urolithiasis during pregnancy presents a complex clinical challenge, requiring a balance between maternal efficacy and fetal safety [1,2]. Physiological changes associated with pregnancy, such as urinary stasis and calcium metabolism disturbances, increase the risk of stone formation while simultaneously limiting diagnostic and treatment options due to concerns about fetal drug exposure and potential maternal complications. Among available treatment options, ureteroscopy (URS) has

Correspondence to: Fardus Alshangiti

*College of Medicine, Taibah University, Medina, Saudi Arabia.

Email: drfardusalshangiti@gmail.com

Full list of author information is available at the end of the article.

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become the preferred minimally invasive surgical intervention for symptomatic ureteral stones in pregnant women, demonstrating high success rates with relatively low complication risks [1,2].

However, the choice of anesthesia technique remains an important and under-explored aspect of URS in this patient population. General anesthesia, spinal anesthesia (spinal or epidural), and local anesthesia with mild sedation are used in clinical practice, each with its own potential benefits and risks. While general anesthesia may provide ideal conditions for the procedure, it raises concerns regarding airway management and fetal exposure to medication [3]. In contrast, spinal anesthesia techniques may reduce the systemic side effects of medication and improve maternal hemodynamic stability, while local anesthesia with sedation may reduce the risks associated with the procedure but may affect maternal comfort and success rates [3,4].

Despite the increasing use of URS in pregnant women, there is still a lack of consensus on the best, safest, and most effective anesthesia technique. Available studies show mixed results regarding maternal, fetal, and operative outcomes, often limited by small sample sizes and varying study designs [4,5]. Consequently, clinicians still face challenges in selecting the most appropriate anesthesia technique for this sensitive patient population.

Therefore, this systematic review and meta-analysis aims to systematically synthesize maternal, fetal, and procedural outcomes following URS in pregnancy and to descriptively characterize the anesthesia techniques reported across studies. By compiling the existing evidence, this study seeks to provide clearer guidance for clinical decision-making and to identify the evidence gaps - including the current inability to formally compare anesthetic approaches - that future prospective research should address.

Methods

Eligibility criteria

Studies were eligible for inclusion if they met the following criteria: pregnant patients undergoing URS (diagnostic or therapeutic) for suspected or confirmed stone disease; studies reporting anesthesia modality in extractable categories (either general anesthesia, neuraxial anesthesia, or local anesthesia/light sedation) were eligible even without a comparison group. Comparative studies (RCTs, cohort studies, and case-control studies) were prioritized. Non-comparative cohort studies, case series, or studies with limited outcome reporting were eligible for inclusion in the proportion meta-analysis where sufficient data were extractable. Studies reporting at least one maternal, fetal, or procedural outcome relevant to the review and full-text articles in English were included.

Studies were excluded if they involved non-pregnant populations; drainage-only interventions (e.g., stent or nephrostomy) without a separate URS subgroup; did not provide anesthesia-specific data or had unextractable anesthesia data; were case reports or ultra-small series (below the predefined threshold of <10 URS cases); were

reviews, editorials, or letters without original data; or were conference abstracts without sufficient extractable data.

Search strategy and information sources

A comprehensive literature search was conducted across the following databases: PubMed, Google Scholar, and Web of Science, covering the period from January 2014 to 2025. The search strategy combined controlled vocabulary (MeSH terms, including “Pregnancy,” “Ureteroscopy,” and “Anesthesia”) and free-text keywords using Boolean operators, structured around three concept blocks: (i) anesthesia [“anesthesia” OR “anaesthesia” OR “general anesthesia” OR “spinal anesthesia” OR “regional anesthesia” OR “local anesthesia” OR “sedation”], (ii) procedure [“ureteroscopy” OR “URS” OR “endoscopic stone management”], and (iii) population [“pregnancy” OR “pregnant” OR “gravid”]. The three blocks were combined with the AND operator. Searches were performed independently by two reviewers, most recently updated on 7 April 2026, and duplicate records were removed using Rayyan’s automated duplicate-detection function followed by manual verification. The complete, verbatim search string used for each database is provided in Supplementary Table S1. The review protocol was registered with PROSPERO (International Prospective Register of Systematic Reviews; registration number: CRD420261360708). Only studies published in English were included; no unpublished or gray literature was sought. Following the database searches, a total of 26 records were retrieved (12 from PubMed, 11 from Google Scholar, and 9 from Web of Science).

Study selection

All records identified through database searching were imported into a reference management system (Rayyan; Rayyan Systems Inc., Cambridge, MA, USA). Four reviewers independently screened titles and abstracts for relevance; 20 records were excluded at this stage, leaving 6 reports sought for full-text retrieval (all 6 were successfully retrieved). Following full-text review against the predetermined inclusion and exclusion criteria, 1 report was excluded, and 5 studies met all criteria for inclusion. A PRISMA flow diagram summarizing the number of included and excluded studies was generated (Figure 1).

Data collection process

The data collection process was performed independently by two reviewers. The included studies used a standardized data extraction form. The extracted data included study characteristics (author, year of publication, country, etc.), participant demographics, intervention details, and outcomes of interest. Any discrepancies were resolved by consensus or by involving a third reviewer.

Risk-of-bias assessment

The methodological quality of the included cohort studies was assessed using the Newcastle-Ottawa Scale (NOS), which evaluates three domains: selection (maximum 4

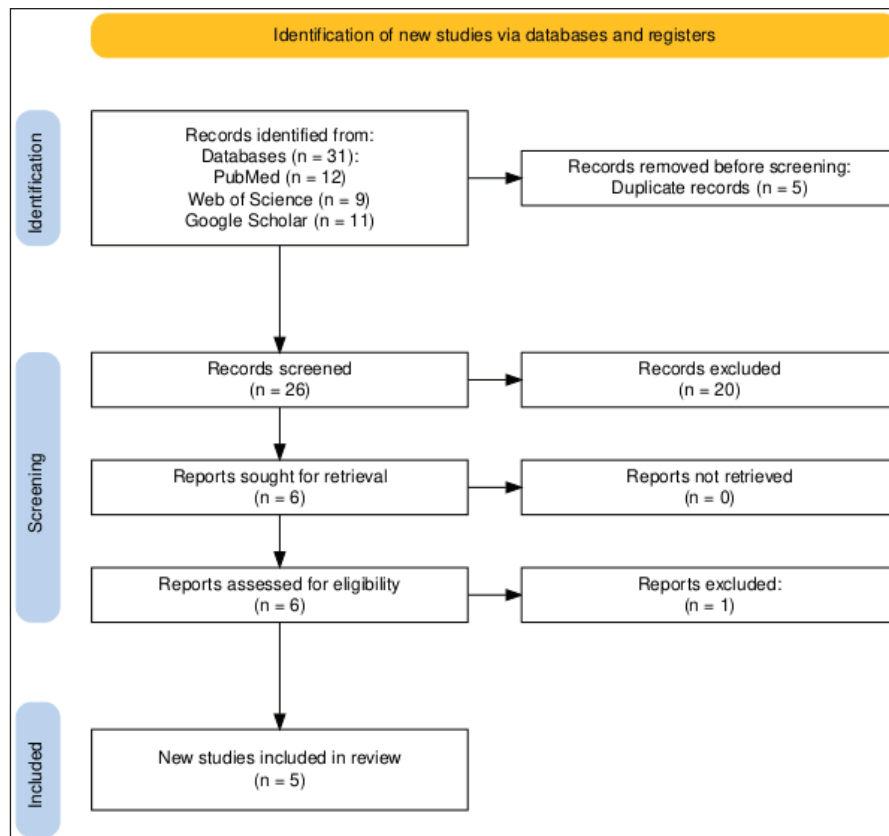


Figure 1. PRISMA flow diagram of the study selection process.

stars), comparability (maximum 2 stars), and outcome (maximum 3 stars). Two reviewers independently assigned scores, with disagreements resolved by consensus. The comparability domain awards stars for adjustment for important confounders through study design or analysis; consequently, single-arm case-series and non-comparative cohorts that did not include a comparison group could not, by definition, score in this domain and were assigned zero stars for comparability rather than being penalized for poor reporting.

Ethical consideration

This systematic review included published data; therefore, ethics approval was not required.

Statistical analysis

A quantitative synthesis was performed for outcomes reported by at least two included studies. For each maternal, fetal, and procedural outcome, event counts and total sample sizes were extracted, and pooled proportions with corresponding 95% CIs were calculated. Because the included studies were clinically and methodologically diverse and were expected to estimate different underlying true effects, a random-effects model was selected a priori in preference to a fixed-effect model. To stabilize variances and accommodate proportions close to 0 or 1, the Freeman-Tukey double arcsine transformation was applied before pooling, and pooled estimates were back-transformed for presentation. Statistical heterogeneity was assessed

using the I^2 statistic, with higher values indicating greater between-study variability. For outcomes included in the meta-analysis, leave-one-out sensitivity analyses were performed by sequentially excluding one study at a time to evaluate the robustness of pooled estimates and to identify studies contributing to heterogeneity. Small-study effects and potential publication bias were assessed using Doi plots and quantified by the Luis Furuya-Kanamori (LFK) asymmetry index. All analyses were performed in R (version 4.5.2; R Foundation for Statistical Computing, Vienna, Austria) using the “meta” package (version 7.x).

Results

Study selection

A systematic literature search was conducted across Google Scholar, PubMed, and Web of Science databases. The initial search yielded a total of 31 records, with contributions from Google Scholar ($n = 11$), PubMed ($n = 12$), and Web of Science ($n = 9$). After removing five duplicate records, 26 articles remained for screening. Based on the title and abstract review, 20 records were excluded due to irrelevance or failure to meet predefined eligibility criteria, leaving 6 reports sought for full-text retrieval (all 6 were successfully retrieved). Of these six full-text articles, one study was excluded at the eligibility stage. Ultimately, five studies met all inclusion criteria and were included in the systematic review and meta-analysis. The entire selection process is outlined in Figure 1, which adheres to the PRISMA reporting framework.

Characteristics of studies

The included evidence consisted of five observational studies published between 2014 and 2025, comprising retrospective cohort studies, multicenter cohort data, and case-series-type designs. Studies were conducted in the United States, Turkey, Norway, and an international European Association of Urology (EAU) multicenter cohort involving 12 tertiary centers [6]. Study periods ranged from 1984 to 2023, reflecting both contemporary practice and longer-term institutional experience. Across the included studies, 387 pregnant patients were reported in the source cohorts, and 311 URS procedures were performed. The number of URS procedures per study ranged from 11 to 146. Inclusion criteria generally involved pregnant patients with confirmed or suspected ureteral stone disease, renal colic, hydronephrosis, obstruction, or imaging-supported evidence requiring procedural management. Most studies excluded patients managed non-operatively or those without adequate follow-up or sufficient clinical data. Reported outcomes focused on the safety and efficacy of URS during pregnancy, including anesthesia-related events, stone-free status, operative findings, complications, gestational age at delivery, preterm birth, fluoroscopy exposure, need for decompression, and fetal outcomes. Where reported, the mean or median maternal age was approximately 28 years, and URS was most frequently performed during the second or third trimester. Preoperative decompression was variably reported; in the largest international cohort, 10.3% had preoperative ureteral stenting, 26.0% had percutaneous nephrostomy (PCN), and 63.7% underwent URS without prior decompression. Detailed characteristics are shown in Tables 1 and 2.

Quality assessment

Methodological quality was assessed using the NOS. Overall, three studies were rated as good quality, and two studies were rated as fair quality. The highest-quality study was Ho et al. [8], which achieved a total score of 9 out of 9, with full scores across selection, comparability, and outcome domains. Juliebø-Jones et al. [1,2] and Rivera et al. [7] were also rated as good quality, scoring 8 and 7 out of 9, respectively. Bozkurt et al. [9] 2013 and the 2025 international Juliebø-Jones et al. [6] cohort were rated as fair quality, each scoring 6 out of 9. Both of these studies scored zero stars in the comparability domain because they were non-comparative, single-arm designs lacking a control group or statistical adjustment for confounders; this reflects their study design rather than a deficiency in conduct or reporting, and such designs are inherently unable to earn comparability stars on the NOS. Across studies, selection and outcome assessment domains were generally adequate, with most studies clearly defining exposure and outcome assessment and providing sufficient follow-up duration. The main limitation was reduced comparability, particularly in non-comparative case-series designs or studies without adjustment for important confounding factors. Despite these limitations, the overall quality of evidence was acceptable for observational surgical literature in pregnancy, with most studies providing clinically relevant maternal, fetal, and procedural outcome data (Table 3).

Maternal outcomes

Forest plots, leave-one-out sensitivity analyses, and Doi plots for outcomes presented in the main text are provided in Figures 2-4; the corresponding plots for all remaining outcomes are provided in the Supplementary Material (Supplementary Figures S1–S21). Hospitalization for pain was reported in four studies, including 285 cases. The pooled proportion was 0.011 (1.1%), with 4 events among 285 cases, 95% CI: 0.000-0.043. Heterogeneity was low, with $I^2 = 15.9\%$ (Figure 2a). Sensitivity analysis showed stable pooled estimates ranging from 0.007 to 0.018, and heterogeneity was eliminated when Bozkurt et al. [9] was omitted (Figure 2b). Publication bias assessment using the Doi plot showed no asymmetry, with an LFK index of 0.68 (Figure 2c).

Four studies, including 285 cases, reported overall maternal complications after URS during pregnancy. The random-effects pooled proportion of overall complications was 0.110, equivalent to 11.0%, with 37 events among 285 cases, 95% CI: 0.006-0.321. Moderate heterogeneity was observed across studies, with $I^2 = 64.1\%$ (Figure 3a). Leave-one-out sensitivity analysis showed that the pooled estimate remained broadly consistent, ranging from 0.080 to 0.133, although omission of Rivera ME 2014 reduced heterogeneity substantially to $I^2 = 17.7\%$ (Figure 3b). The Doi plot demonstrated major asymmetry, with an LFK index of -2.12, suggesting possible small-study effects or publication bias (Figure 3c).

Regarding detailed complications, Intensive Care Unit (ICU) admission was assessed in two studies, including 242 cases. The pooled proportion was 0.004, with 2 events among 242 cases, 95% CI: 0.000-0.521. Heterogeneity was moderate to high, with $I^2 = 68.6\%$ (Figure 4). Sepsis was reported in two studies, including 178 cases. The random-effects pooled proportion was 0.010, with 2 events among 178 cases, 95% CI: 0.000-0.285. No heterogeneity was detected, with $I^2 = 0.0\%$ (Supplementary Figure S1). Urinary tract infection was reported in two studies, including 178 cases. The pooled proportion was 0.064, with 9 events among 178 cases, 95% CI: 0.000-0.951. Heterogeneity was moderate to high, with $I^2 = 69.0\%$ (Supplementary Figure S2). Ureteral perforation was evaluated in two studies, including 128 cases. The pooled proportion was 0.006, with 1 event among 128 cases, 95% CI: 0.000-0.356. Heterogeneity was negligible, with $I^2 = 0.3\%$ (Supplementary Figure S3).

Fetal outcomes

Live birth was reported in four studies including 276 pregnancies. The pooled live birth proportion was 0.992, with 273 live births among 276 pregnancies, 95% CI: 0.967-1.000. No heterogeneity was observed, with $I^2 = 0.0\%$ (Supplementary Figure S4). Leave-one-out sensitivity analysis confirmed the robustness of this finding, with pooled estimates ranging from 0.989 to 0.996 (Supplementary Figure S5). The Doi plot showed major asymmetry, with an LFK index of 2.18 (Supplementary Figure S6).

Miscarriage was reported in three studies, including 189 pregnancies. The pooled miscarriage proportion was 0.004, with 1 event among 189 pregnancies, 95% CI:

Table 1. Study characteristics.

First Author	Country / Region	No. of centers	Study design	Study period	Total Pts (N)	URS procedures (N)	Inclusion criteria	Exclusion criteria	Primary outcome reported	Secondary outcomes reported
Rivera et al. [7]	USA (Rochester, MN)	1 (Mayo Clinic)	Retrospective Cohort	1997-2012	26	11	Confirmed urolithiasis in pregnancy; underwent surgical intervention; returned for follow-up	No follow-up at institution	Anesthesia events & duration (URS vs. stent)	Stone location, fluoroscopy time, induction of labor, complications
Ho et al. [8]	USA (Cleveland, OH)	1 (Cleveland Clinic, multicenter academic)	Retrospective Cohort	2009-2021	96	26	Pregnant, ≥18 years; symptoms of renal colic; procedural management (stent/PCN/URS); imaging evidence of obstruction	<18 yr; non-operative management; no clinical signs of obstruction; incomplete data; fetal anomalies causing IUFD	Preterm birth (<37 weeks) by anesthesia type	Gestational age at delivery, anesthesia by trimester & procedure type
Bozkurt et al. [9]	Turkey (Diyarbakir)	1 (Dicle University)	Retrospective Cohort / Case Series	April 2005-November 2010	32	32	Pregnant women with hydronephrosis requiring surgical intervention; ureteral calculi or symptomatic hydronephrosis	NR	Efficacy and safety of URS in pregnancy	Anesthesia type, complications, fetal outcomes
Juliebø-Jones et al. [6]	International (12 tertiary centers)	12 (EAU multicenter)	Retrospective Multicenter Cohort	January 2014-December 2023	146	146	Pregnant, ≥18 years; underwent URS for suspected stone disease; tertiary endourology centers	Non-URS management; age <18 years; non-tertiary settings	Safety and outcomes of URS in pregnancy; stone-free rate	Diagnostic imaging performance, complications by trimester, anesthesia distribution
Juliebø-Jones et al. [2]	Norway (Bergen)	1 (Haukeland University Hospital)	Retrospective Cohort (4-decade evolution)	1984-2023	87	96	Pregnant women undergoing URS for suspected kidney stone disease; tertiary center	Sepsis requiring emergency decompression	Operative findings, anesthetic approach, complications over time	Operative time, hospital stay, exit strategy, delivery outcomes

Abbreviations: EAU, European Association of Urology; IUFD, intrauterine fetal death; NR, not reported; PCN, percutaneous nephrostomy.

Table 2. Population characteristics.

Study ID	Mean/Median Age (year)	BMI (kg/m ²)	Gravidity	Parity	First Trimester, n (%)	Second Trimester, n (%)	Third Trimester, n (%)	Gest. Age at Procedure (weeks)	Pre-op Stent (n/%)	Pre-op PCN (n/%)	None (n/%)
Rivera et al. [7]	NR	NR	NR	NR	NR	NR	NR	Median: 29.1	0 (0%)	0 (0%)	11 (100%)
Ho et al. [8]	27.8 ± 5.2	27.3 (IQR 23.6-33.1)	2 (IQR 1-3)	1 (IQR 0-2)	3 (11.5%)	16 (61.5%)	7 (26.9%)	NR	NR	NR	NR
Bozkurt et al. [9]	27.8 (range 20-39)	NR	2.5 (range 1-6)	NR	NR	NR	Minority	24 (range 15-34)	NR	NR	NR
Juliebø-Jones et al. [6]	Median: 28 (IQR 24-32)	NR	NR	NR	18 (12.3%)	85 (58.2%)	43 (29.5%)	NR	15 (10.3%)	38 (26.0%)	93 (63.7%)
Juliebø-Jones et al. [1,2]	NR	NR	NR	NR	7 (7.3%)	31 (32.3%)	58 (60.4%)	NR	NR	NR	NR

Abbreviations: BMI, body mass index; IQR, interquartile range; NR, not reported; PCN, percutaneous nephrostomy.

Table 3. Newcastle-Ottawa Scale quality assessment of included studies.

Author/Year	Representativeness	Non-exposed cohort	Exposure ascertainment	Baseline outcome absent	Comparability factor 1	Comparability factor 2	Outcome assessment	Follow-up duration	Follow-up adequacy	Selection (4)	Comparability (2)	Outcome (3)	Total (9)	Quality
Bozkurt et al. [9]	★	N/A	★	★	—	—	★	★	★	3	0	3	6	Fair
Rivera et al. [7]	★	★	★	★	★	—	★	★	—	4	1	2	7	Good
Juliebø-Jones et al. [1,2]	★	★	★	★	★	—	★	★	★	4	1	3	8	Good
Ho et al. [8]	★	★	★	★	★	★	★	★	★	4	2	3	9	Good
Juliebø-Jones et al. [6]	★	N/A	★	★	—	—	★	★	★	3	0	3	6	Fair

Abbreviations: NOS, Newcastle-Ottawa Scale; N/A, not applicable (non-comparative design; comparability domain not scorable).

★ indicates one point (star) awarded for that Newcastle-Ottawa Scale criterion; — indicates the criterion was not met or not scored; N/A indicates the domain was not applicable because the study used a non-comparative, single-arm design (Bozkurt et al. and the 2025 Juliebø-Jones et al. multicentre cohort lacked a non-exposed comparison group, so the 'Nonexposed cohort' item and the comparability domain could not be scored, as noted in the Risk-of-bias assessment section of the Methods).

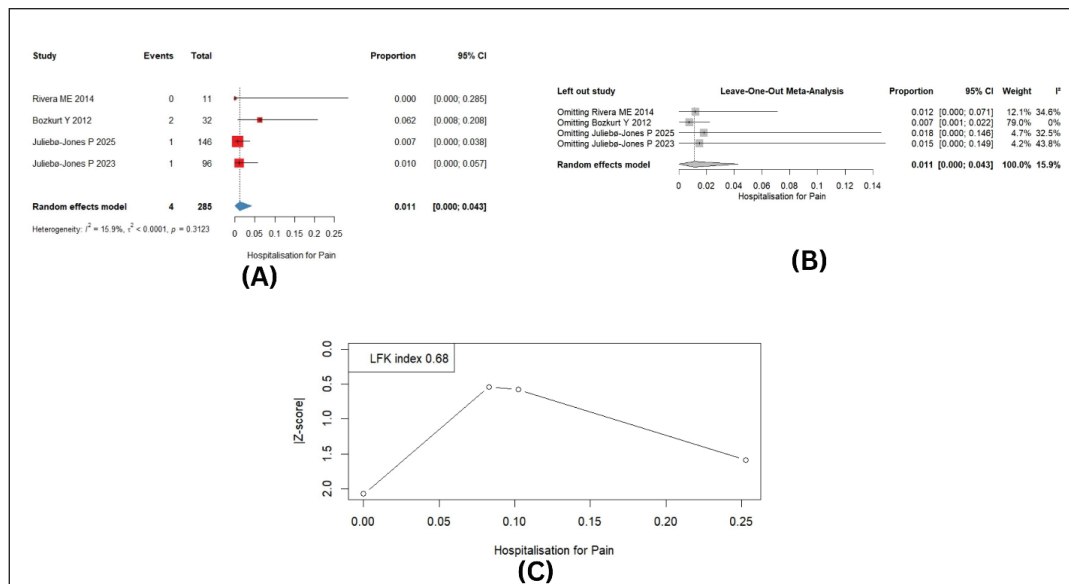


Figure 2. Hospitalization for pain after ureteroscopy during pregnancy. (a) Forest plot of the pooled proportion. (b) Leave-one-out sensitivity analysis. (c) Doi plot for publication-bias assessment.

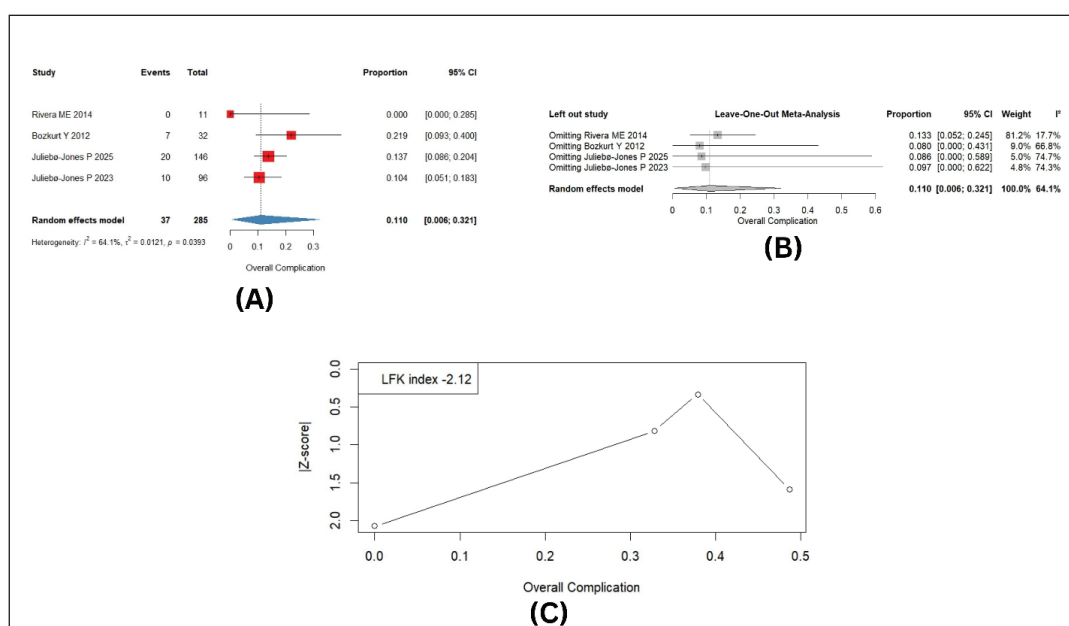


Figure 3. Overall maternal complications after ureteroscopy during pregnancy. (a) Forest plot of the pooled proportion. (b) Leave-one-out sensitivity analysis. (c) Doi plot for publication-bias assessment.

0.000-0.029. No heterogeneity was detected, with $I^2 = 0.0\%$ (Supplementary Figure S7). Sensitivity analysis showed that the pooled estimate remained very low when Rivera ME 2014 or Bozkurt et al. [9] was omitted but became 0.000 when Juliebo-Jones et al. [6] was excluded, indicating that the pooled estimate was driven by a single reported event (Supplementary Figure S8). The Doi plot demonstrated major asymmetry, with an LFK index of -5.88 (Supplementary Figure S9).

Preterm birth was reported in four studies, including 340 pregnancies. The pooled proportion was 0.019, with 16 events among 340 pregnancies, 95% CI: 0.000-0.190. Considerable heterogeneity was present, with $I^2 = 92.5\%$ (Supplementary Figure S10). Leave-one-out analysis

showed that omission of Ho et al. [8] reduced the pooled estimate to 0.002, 95% CI: 0.000-0.041, and reduced heterogeneity to $I^2 = 22.6\%$, indicating that this study was the main contributor to between-study heterogeneity (Supplementary Figure S11). The Doi plot did not show asymmetry, with an LFK index of -0.54 (Supplementary Figure S12).

Procedural outcomes

Successful operation was reported in four studies, including 215 cases. The pooled procedural success proportion was 0.982, with 208 successful procedures among 215 cases, 95% CI: 0.827-1.000. Moderate to high heterogeneity was observed, with $I^2 = 69.1\%$

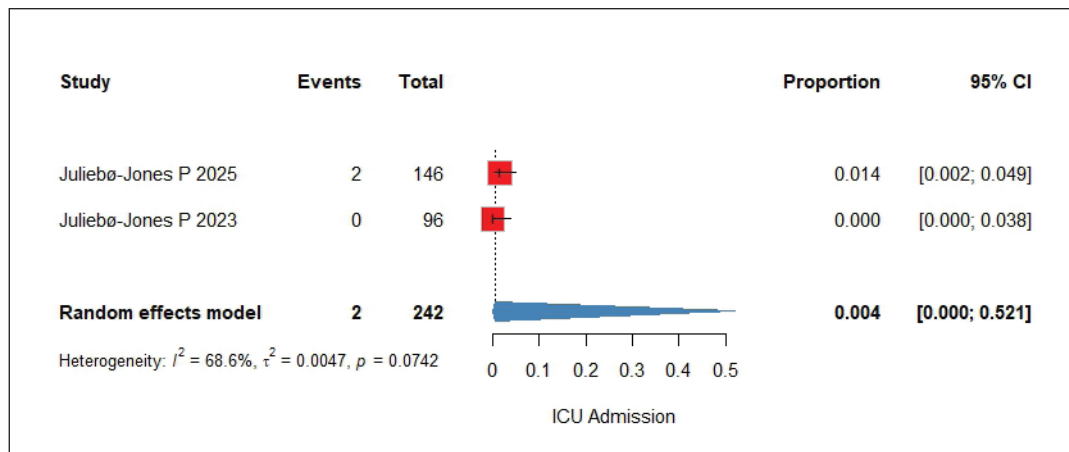


Figure 4. Forest plot of the pooled proportion of ICU admission after ureteroscopy during pregnancy.

(Supplementary Figure S13). Leave-one-out sensitivity analysis showed consistently high pooled success proportions, ranging from 0.966 to 0.993, indicating that the overall result was not dependent on any single study (Supplementary Figure S14). The Doi plot showed no asymmetry, with an LFK index of 0.58 (Supplementary Figure S15).

Stone identification during URS was reported in three studies, including 274 cases. The pooled proportion was 0.628, with 153 stones identified among 274 cases, 95% CI: 0.162-0.976. Substantial heterogeneity was present, with $I^2 = 86.2\%$ (Supplementary Figure S16). Sensitivity analysis showed that omission of Bozkurt et al. [9] reduced the pooled proportion to 0.521 and eliminated heterogeneity, while omission of either Juliebø-Jones [1,2,6] study resulted in wider estimates around 0.687-0.688 with persistent high heterogeneity (Supplementary Figure S17). The Doi plot demonstrated major asymmetry, with an LFK index of 3.06 (Supplementary Figure S18).

Negative URS was reported in three studies, including 274 cases. The pooled proportion was 0.322, with 106 negative ureteroscopies among 274 cases, 95% CI: 0.027-0.746. Considerable heterogeneity was observed, with $I^2 = 87.3\%$ (Supplementary Figure S19). Leave-one-out sensitivity analysis produced pooled estimates ranging from 0.246 to 0.403, with persistently wide CIs and high residual heterogeneity, indicating uncertainty in the pooled estimate (Supplementary Figure S20). The Doi plot showed minor asymmetry, with an LFK index of -1.44 (Supplementary Figure S21).

Discussion

Summary of main findings

This systematic review and meta-analysis, incorporating five observational studies and 311 URS procedures in 387 pregnant patients, represents a comprehensive quantitative synthesis of perioperative outcomes to date [1,2,6–9]. Our findings suggest an acceptable incidence of significant maternal morbidity, with pooled rates for sepsis, ICU hospitalization, and ureteral perforation each remaining below 1%. The overall maternal complication

rate was 11.0% (95% CI: 0.6%-32.1%), primarily driven by minor events. The most frequent complication was urinary tract infection (UTI), while fetal outcomes appeared highly reassuring, with a live birth rate of 99.2% (95% CI: 96.7%-100%) and a procedural success rate of 98.2% (95% CI: 82.7%-100%). However, these conclusions should be interpreted with caution given the statistical heterogeneity and the retrospective nature of the included data.

Maternal outcomes in context

The observed total complication rate of 11.0% aligns with the 4%-14% range previously reported [10]. The prevalence of UTIs over major surgical events is consistent with the known physiological susceptibility of pregnant women to ascending infections [11]. Notably, the moderate-to-high heterogeneity ($I^2 = 64.1\%$) for overall complications may be partly related to the inclusion of the study by Rivera et al. [7]; its exclusion reduced heterogeneity to 17.7%, potentially reflecting its earlier timeframe or specific institutional case-mix. Low rates of pain-related hospitalization (1.1%) could indicate sufficient perioperative analgesia across different anesthetic methods.

Fetal outcomes: reassurance and residual uncertainty

The live birth rates exceeding 99% across four studies ($I^2 = 0.0\%$) may further challenge traditional concerns regarding the fetal risks of non-obstetric surgery during pregnancy [12]. Evidence suggests that the risks associated with untreated obstructive urolithiasis - such as uterine irritability and sepsis - may outweigh the risks of carefully managed surgical intervention [11]. While preterm birth showed high heterogeneity ($I^2 = 92.5\%$), this appeared to be largely driven by the study by Ho et al. [8]. The reduction to 22.6% upon its exclusion suggests that such heterogeneity might arise from differences in result ascertainment rather than inherent procedural risk.

Procedural efficacy and the challenge of intraoperative stone identification

A procedural success rate of nearly 98% indicates that pregnancy is not a technical barrier to successful endoscopic therapy. However, the negative URS rate of 32.2% warrants consideration. This figure likely reflects diagnostic challenges, where physiological hydronephrosis can mimic obstructive pathology on ultrasound [13,14]. These findings support the consideration of magnetic resonance urography when ultrasound results are equivocal [12].

Anesthetic considerations in the gravid patient

A formal comparison between general and regional anesthesia was not feasible due to inconsistent data reporting. Given the physiological alterations in pregnancy, a coordinated multidisciplinary approach is necessary [12,15]. While regional anesthesia is often preferred to limit fetal exposure, the low adverse event rates across various techniques may suggest that institutional expertise and patient-specific factors play a significant role in outcomes [12,15]. These findings are broadly consistent with current AUA and EAU guideline recommendations supporting surgical intervention for symptomatic, obstructing urinary stones when conservative management is inappropriate or has failed [16,17].

Strengths of the current study

The present analysis has some methodological strengths compared to previous narrative reviews on this topic [10,11]. This study is the first to incorporate a formal meta-analytic framework, using random-effects modeling, to synthesize maternal and fetal outcomes following URS in pregnancy, providing pooled estimates with CIs that allow for more rigorous clinical inference than narrative synthesis alone. Second, the use of leave-one-out sensitivity analyses for all quantitative outcomes enabled rigorous examination of the robustness of each pooled estimate and identification of particular studies contributing disproportionately to between-study heterogeneity. Third, for outcomes with a limited number of contributing studies, the evaluation of small-study effects and publication bias by Doi plots and the LFK index is methodologically sound, as asymmetry tests using funnel plots have poor statistical power. Fourth, the inclusion of geographically and institutionally diverse cohorts, including single-center academic institutions in the United States, Turkey, and Norway, and a 12-center international EAU collaboration, allows for the external applicability of findings across diverse healthcare settings [1,2,6–9]. Fifth, the quality assessment was standardized using the NOS, identifying three studies of good quality and two of acceptable quality and providing a transparent and reproducible review of the methodological rigor of the included evidence.

Limitations

Limitations of this research include the retrospective observational study methodology, the total procedural

sample of only 311 patients, and the varied reporting of complications across the studies. There was a high degree of heterogeneity, especially for preterm delivery and stone detection. Because only a small number of studies contributed to each outcome, the sources of this heterogeneity could not be formally explored through subgroup analysis or meta-regression (e.g., by anesthesia type, trimester, or study quality); they were instead examined descriptively through leave-one-out sensitivity analyses. The pooled estimates for these outcomes should therefore be interpreted with caution. In addition, our search was restricted to PubMed, Web of Science, and Google Scholar and to English-language publications, without seeking unpublished or grey literature; relevant studies indexed elsewhere or published in other languages may therefore have been missed. In particular, the planned comparison between anesthetic techniques was not feasible because anesthesia-specific outcome data were inconsistently reported across the included studies. Most studies had no non-operative control arm, so it cannot be determined whether the observed outcomes were attributable to the procedure itself rather than to the underlying condition. Finally, Doi plot asymmetry for total complications and live birth indicated possible publication bias that should be taken into account when evaluating these results.

Conclusion

The high procedural success and favorable safety profile observed support URS as a viable intervention for stone disease during pregnancy in selected patients, in line with current clinical guidelines for the surgical management of urinary stone disease. Future prospective, multicenter registries are needed to standardize outcome reporting, including anesthesia-specific data, and to refine evidence-based therapeutic strategies for this population.

List of Abbreviations

ACOG	American College of Obstetricians and Gynecologists
AUA	American Urological Association
BMI	Body mass index
CI	Confidence interval
EAU	European Association of Urology
ICU	Intensive Care Unit
IQR	Interquartile Range
IUFD	Intrauterine Fetal Death
LFK	Luis Furuya-Kanamori (asymmetry index)
NOS	Newcastle-Ottawa Scale
NR	Not Reported
PCN	Percutaneous Nephrostomy
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
URS	Ureteroscopy
UTI	Urinary tract infection

Conflicts of interest

The authors declare no conflicts of interest.

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Consent to participate

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Ethical approval

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Author details

Fardus Alshangiti¹, Ahmad M. Alridahie², Abdullah M. Alqahtani³, Lama F. Alqahtani⁴, Abdullah Alsaee⁵, Mohammed Khalid Murtada⁵, Elaf Abdullah Bin Rabah⁶

1. College of Medicine, Taibah University, Medina, Saudi Arabia
2. College of Medicine, Qassim University, Qassim, Saudi Arabia
3. College of Medicine, King Faisal University, Alahsaa, Saudi Arabia
4. College of Applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia
5. College of Medicine in King Abdulaziz University, Jeddah, Saudi Arabia
6. College of Health and Rehabilitation Sciences, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia

Supplementary content (if any) is available online.

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