

Management of urolithiasis in pregnancy

Kimberley Chan^{a,*}, Taner Shakir^a, Omar El-Taji^a, Amit Patel^b, John Bycroft^a, Chou Phay Lim^c, Nikhil Vasdev^{a,d}

^aUrology Department, Lister Hospital, East and North Hertfordshire NHS Trust, Stevenage, UK; ^bRadiology Department, Lister Hospital, East and North Hertfordshire NHS Trust, Stevenage, UK; ^cGynaecology Department, Lister Hospital, East and North Hertfordshire NHS Trust, Stevenage, UK; ^dSchool of Life and Medical Sciences, University of Hertfordshire, Hatfield, UK

Abstract

Urolithiasis is the most common cause of nonobstetric abdominal pain, resulting in 1.7 admissions per 1000 deliveries. Urolithiasis most commonly occurs in the second and third trimesters, with an incidence between 1:125 and 1:2000. Acute urinary system obstructions are challenging to manage in obstetric patients because they contribute to physiological and anatomical changes that result in pathological outcomes. The restricted use of computed tomography in diagnosing and managing urolithiasis is particularly challenging. In addition, a prompt diagnosis is required because the presence of renal calculi during pregnancy increases the risk of fulminating sepsis and preterm delivery. Affected pregnancies are conservatively managed; however, 1 in 4 requires surgical intervention. Indications for surgical interventions are complex and range from nephrostomy insertion to empirical stent placement or ureteroscopy. Therefore, a multi-disciplinary approach is required to optimize patient care.

The diagnosis and management of urolithiasis in pregnancy are complex. We reviewed the role, safety, advantages and disadvantages of diagnostic tests and treatment used to manage acute urinary obstructions in pregnancy.

Keywords: Urolithiasis; Renal colic; Pregnancy; Acutely obstructed kidney; Hydronephrosis; Gestation

1. Introduction

Urolithiasis is a debilitating condition that affects the well-being of the mother and the fetus. It presents challenges and undue stress to the management team considering the potential side effects of radiation exposure with imaging, anaesthesia and invasive procedures to the mother and foetus. Urolithiasis is the most common etiologic cause for nonobstetric abdominal pain and accounts for 1.7 admissions per 1000 deliveries.^[1] In addition, urolithiasis most commonly occurs in the second and third trimesters. The reported incidence of urolithiasis ranges from 1:125 to 1:2000.^[2-4] An 11-year study showed that urolithiasis had a higher incidence in multiparous patients (66%) and the second or third trimesters (99%).^[5] Common complications of renal tract obstruction during pregnancy are pyonephrosis, preterm labor, and delivery.^[1] The incidence of urolithiasis correlates with increased risks for recurrent urinary tract infections and systemic risks to the mother.^[6] Other complications of urolithiasis include recurrent miscarriages and unexpected cesarean deliveries.^[6]

Although studies without significant differences in perinatal outcomes (e.g. low birth rate, Apgar score and perinatal mortality) were identified, one study reported a higher prevalence of low-birth-weight neonates.^[1,6,7] Data suggest that the risk of premature rupture of membranes has inconsistent incidences.^[2,6]

The risk of urolithiasis in the mother and fetus indicates the need for prompt diagnosis to optimize care. However, diagnosing urolithiasis in pregnancy is difficult because of the prevalence of non-specific symptoms, such as abdominal or back pain, nausea, and vomiting, which are typical complaints of pregnancy and surgical conditions such as appendicitis and diverticulitis. Therefore, imaging studies are often required to verify diagnoses.

2. Materials and methods

A comprehensive electronic literature search of peer-reviewed journal articles was conducted in this review. The PubMed database was queried with the following search terms: “pregnancy,” “obstruction,” “hydronephrosis,” “urolithiasis,” and “kidney stone”; the terms “fetal” and “postnatal” were excluded. The identified articles were further screened and assessed for eligibility. Selected articles were manually searched to generate additional eligible citations. International guidelines from the American College of Obstetricians and Gynecologists,^[8] Society of Interventional Radiology Safety and Health Committee,^[9] Cardiovascular and Interventional Society of Europe Standards of Practice Committee,^[9] and the European Association of Urology^[10] were consulted.

3. Methods of obstruction

3.1. Anatomical and physiological changes

Obstetric patients are potentially challenging to manage because of changes in their anatomical and physiological compositions. Increases in cardiac output correlate with simultaneous decreases in systemic vascular resistance. The increased circulating volume raises renal blood flow by 30% and doubles the glomerular filtration rate.^[11] This results in a dilutional effect on serum urea and creatinine. Therefore, clinicians must be vigilant as the doubling creatinine may still be within the reference range. Physiological hydronephrosis and

*Corresponding Author: Kimberley Chan, Urology Department, Coreys Mill Lane, Lister Hospital, East and North Hertfordshire NHS Trust, Stevenage, SG1 4AB, UK. E-mail address: Kimberley.chan@nhs.net (K. Chan).

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hydronephrosis become apparent in the second trimester and peak between 24 and 28 weeks.^[12] In the United Kingdom, the Royal College of Obstetricians and Gynecologists (RCOG) defines the “second trimester” as the period between 13 and 26 weeks.^[13] The second trimester is governed by progesterone-mediated muscle relaxation. The enlarging uterus compresses the ureters at the level of the iliac crossing, and a combination of factors leads to the prominent dilatation of the right upper urinary tract. The sigmoid colon and dextrorotation of the uterus has a relatively protective effect on the left ureter from extrinsic compression. In addition, the right ureter crosses the iliac artery at the level of the pelvic brim, as opposed to the left ureter, which crosses more proximally and is less liable to compression.^[14] Another mechanism leading to the increased propensity of the right system for obstruction is the increased likelihood of pregnancy-associated constipation. Constipation increases the volume of the sigmoid colon and causes dextrorotation of the gravid uterus and the subsequent compression of the right system.

Consequently, the dilated system may contain an extra 300 mL of urine; urinary stasis predisposes the patient to infections. Therefore, the risk of pyelonephritis in obstetric patients is increased by 40%.^[15] Serial ultrasonographic evaluations show resolution of these changes within 4 to 6 weeks of the postpartum period.^[15]

3.2. Calculi

Despite the increased risk of upper tract infections and urinary stasis, the incidence of renal calculi is not significantly increased in obstetric patients. A 7-year single-center observational study reported a 1:1600 incident rate for upper tract infections and urinary stasis.^[16] Nonetheless, renal colic is the most prevalent non-obstetric-related cause of admissions in obstetric patients.

Several factors predispose women to calculus formation during pregnancy. Physiological changes include increased glomerular filtration rate, resulting in additional urinary excretion of sodium, calcium, and urate. Parathyroid hormone–dependent system negative feedback mechanisms and the placental production of hydroxylated vitamin D result in hypercalcemia. The combination of urinary alkalinization and hypercalciuria produces calcium phosphate calculi in pregnancy.^[17] A reported 74% of obstetric patients with renal calculi have calcium phosphate stones. In contrast, calcium oxalate stones predominate in the general population.^[18]

4. Diagnostic evaluation

4.1. History and examination

A focused history and examination should be taken from patients with symptoms suggestive of urolithiasis. Flank pain is the most common presenting complaint in obstetric patients with confirmed calculi. An 11-year retrospective study reported that flank pain was the presenting complaint in 89% of obstetric patients. In the same study, non-visible hematuria and visible hematuria occurred in 95% and 20% of patients, respectively.^[6] Up to 20% to 25% of these patients had a history of renal calculi,^[6,19] and nonspecific symptoms of renal calculi included nausea, vomiting, dysuria, and urinary frequency.

The initial workup for obstetric patients with renal calculi should include urinalysis, complete blood count, inflammatory markers, basic metabolic profiling, and imaging. Computed tomography (CT) scans are the criterion standard for radiation-based imaging; however, this imaging modality may harm the developing fetus. As such, a comparative analysis of the risks versus the benefits should be discussed with the patient to enable informed consent.

4.2. Ultrasound

Ultrasound (US) of the renal tract remains the first-line investigation for diagnosing renal tract obstruction during pregnancy. This is a safe, noninvasive method of visualizing the urinary tract, especially the renal pelvis, to identify hydronephrosis. However, operator variability limits the effective elucidation of renal tract obstruction during pregnancy. The sensitivity of diagnosing calculus ranges from 38% to 95%.^[20] Transvaginal US (TVUS) is an alternative imaging modality. Transvaginal US effectively visualizes distal ureteric calculi and enables the operator to ascertain the level of hydronephrosis; dilatation to the pelvic brim indicates physiological hydronephrosis of pregnancy.^[21] A retrospective study supported the utility of TVUS in evaluating distal stones, with 94% of distal stones detected with TVUS compared with the 29% detected transabdominally.^[22] In cases of uncertainty, adjunct measurements, such as ureteral jets, improve US imaging characteristics. Physiologically, ureteral jets are seen as periodic effluxes of urine from the distal ureter to the bladder, which are detected by color Doppler studies of the base of the bladder and trigone. The absence of ureteral jets on the side of renal obstruction has a sensitivity of 100% and a specificity of 91% for diagnosing distal stones.^[23] However, a study on obstetric patients showed that ureteral jets might be absent in 13% of these patients without obstruction, particularly during the third trimester. Such false-positive results may be minimized by imaging obstetric patients in the contralateral decubitus position.^[24] Another adjunct measurement to renal color Doppler US is the renal resistance index. Resistance index indirectly measures resistance in the intrarenal vasculature^[25] and pressures within the collecting system. Resistance index increased in cases of acute ureteral obstruction, with a value greater than 0.70 considered significant.^[26] However, patient factors such as age and systemic conditions such as diabetes and hypertension increase resistance index without renal obstruction. Therefore, clinical correlations of patients' symptoms are essential to determine the best treatment modality.

4.3. Computed tomography

Noncontrast CT of the kidneys, ureters, and bladder (CTKUB) is the criterion standard investigation in nonpregnant patients. The sensitivity and specificity of this procedure are greater than 98%.^[27] Radiation exposure with CT and nuclear medicine scans tend to be lower than the doses needed to harm the fetus. The American College of Obstetricians and Gynecologists recommends that the use of CTKUB, in addition to ultrasonography or magnetic resonance imaging, should not be withheld from obstetric patients if these techniques are required to make the final diagnosis.^[8] However, these imaging modalities are generally reserved for life-threatening conditions such as acute bowel obstruction and pulmonary embolism.

The International Commission on Radiological Protection, in addition to a joint guideline by cardiologists and interventional radiologists, states that radiation exposure during pregnancy should not exceed 1 mGy.^[9,28] This translates to a dose of 2 mSv on the surface of the obstetric patient.^[29] It is essential to limit radiation exposure during pregnancy, especially during the first trimester, as the gestational age of the fetus at the time of radiation exposure determines the teratogenicity risk. The radiation threshold leading to teratogenesis is lower in the first trimester than in the third trimester. Traditional noncontrast CTKUB scans use a dose of 4.5 to 5 mSv. A systematic review showed that newer techniques of low-dose (LD) and ultra-LD CT utilize doses of less than 3.5 and less than 1.9 mSv, respectively. Using standard-dose CTKUB as a reference, the sensitivity and specificity of LD CT were 90% to 98% and 88% to 100%, respectively, with a diagnostic accuracy of 94.3%. Ultra-LD CT had a similar sensitivity, specificity, and

diagnostic accuracy of 72% to 99%, 86% to 100%, and 95.5%, respectively. The review showed that despite a significant reduction in the radiation dose, these imaging modalities retained high diagnostic accuracies, specificities, and sensitivities.^[30] However, they are not as effective in patients with high body mass indexes greater than 30 kg/m² or in detecting calculi of less than 3 mm.^[31] Although ultra-LD CTKUB may be safely used in pregnancy, this technology may not be generalizable.

4.4. Magnetic resonance urography

Because magnetic resonance urography (MRU) does not include the use of ionizing radiation, this is a suitable alternative for obstetric patients. In addition, studies have shown that infants exposed to serial magnetic resonance imaging scans after 20 weeks in utero do not have abnormalities at 9 months of age.^[32] However, data on the safe use of MRUs during the first trimester are limited.

Magnetic resonance urography has a sensitivity of 82% and a specificity of 98%.^[33] This relatively low sensitivity arises from the fact that calculi are not directly visible but are indirectly apparent as signal voids. Magnetic resonance urography also enables the detection of physiological hydronephrosis, as ureteral dilatation occurs at a predictable site—the pelvic brim. However, the availability of this imaging modality, especially for hours outside of the typical business day, in addition to high costs, hinders its use. Even so, this imaging modality should be used cautiously in patients with claustrophobia and metallic implants.

Which option to choose?

Ultrasound of the urinary tract should be the first-line imaging modality for detecting renal calculi in obstetric patients. Even so, in cases of equivocal US, further management includes a choice between further imaging or proceeding to operative intervention. For example, a multicenter retrospective analysis of 51 patients reported a negative ureteroscopy (URS) rate of 14%.^[34] In these cases, preoperative imaging utilized either renal US alone, renal US plus MRU, or renal US plus LD CT. The positive predictive values for these imaging modalities were 77%, 80%, and 95.8%, respectively.^[34] Therefore, LD CT should be considered for equivocal cases. However, this imaging modality may be performed only after the patient provides informed consent, in which they acknowledge that they understand the risks associated with exposure to ionizing radiation in pregnancy. A more practical and potentially safer alternative may be to offer MRU as a second-line investigation and LD CT as the third-line option according to recommendations made by the European Association of Urology guidelines published in 2022.^[10]

5. Management

Managing renal calculi in obstetric patients requires a multidisciplinary approach involving a urologist, obstetrician, radiologist, and potentially a neonatologist. Immediate treatment will aim to relieve renal system obstruction. Treatment options include conservative management, double-J stent insertion, laser URS, and percutaneous nephrostomy. Extracorporeal shockwave lithotripsy is contraindicated because of limited data on the short- and long-term fetal safety profile and the need to assume the prone positioning.

The gestational age of the pregnancy is a relevant factor to consider in managing renal calculi. Gestations above 37 weeks in singleton pregnancies are generally considered term. Consequently, induction of labor or cesarean section should be considered to relieve the pressure of the gravid uterus on the renal system. The current practice in the United Kingdom remains that the mother's care is the priority,

with no right assigned to the unborn fetus. Even so, gestations of more than 22 weeks are often considered viable.^[35] Therefore, discussions with the neonatologist regarding the location of care are needed (depending on the immediate availability of neonatal resuscitation service) to prepare for unplanned preterm delivery. In gestations of extreme prematurity, between 22 and 26 weeks, specialist discussions should be held with the patient to discuss the development issues that may occur after delivery and to ascertain the patient's stance on whether a resuscitation attempt should be made.

5.1. Conservative

A trial of the conservative passage should be considered. This trial consists of analgesia, hydration, antiemetics, α -blockers, and antibiotics if features of sepsis are exhibited. The British National Formulary^[36] and RCOG support the use of paracetamol throughout pregnancy and nonsteroidal anti-inflammatory drugs in the first and second trimesters (Table 1). However, some nonsteroidal anti-inflammatory drugs should be avoided in the third trimester because of the increased risk of fetal ductus arteriosus closure and persistent fetal pulmonary hypertension. In addition to the withdrawal effects, opiates may also cause neonatal respiratory depression.

The RCOG guides the management of nausea and vomiting during pregnancy.^[37] Antihistamine-based medications (eg, cyclizine) are recommended for first-line use (Table 1). Metoclopramide and ondansetron are relatively safe and effective, although data on this are limited in the literature.^[37] However, metoclopramide may precipitate an oculogyric crisis in addition to extrapyramidal effects and should be used with caution. α -Blockers are useful as a form of expulsive medical therapy. However, α -blockers are contraindicated in pregnancy and may have little effect on an already physiologically dilated ureter.

A combination of these factors may contribute to the formation of a successful management option. A 12-year retrospective analysis of 112 pregnant patients with urolithiasis managed 76% of these patients conservatively. Forty-eight percent of these patients spontaneously passed calculi.^[38] The size and position of the calculi play a role in its passage. A 2-center retrospective analysis of 300 individuals reported that 55% of calculi with a size less than 4 mm, 42% with calculi sized between 4 and 8 mm, and 0% of calculi greater than 8 mm passed spontaneously.^[20] The same study noted that distal ureteric and renal pelvic calculi had a passage rate of 42% to 44% with conservative management. Even so, only 27% of proximal ureteric calculi were passed spontaneously. These factors should be considered when determining further management of the patient.

5.2. Intervention

The overarching principle of intervention during pregnancy is to balance the benefits with the risks. Surgical intervention should be offered only if benefits outweigh the risk. For example, the risk of preterm delivery may be higher if intervention is not performed in cases of fulminating sepsis compared with invasive procedures used to relieve obstruction. In obstetric patients, surgical intervention should be reserved for patients exhibiting signs of sepsis, intractable pain, or severe kidney injury and patients with single kidneys. In general, intervention in the first and third trimesters should be avoided, because of the high risk of miscarriage and induction of preterm labor, respectively. The second trimester is preferred for nonobstetric surgery because of its safety profile and as the reduced onset of complications to the fetus and mother.^[39] Management options include double-J stent insertion, percutaneous nephrostomy, and primary treatment via URS.

5.3. Stent

Historically, temporizing measures such as ureteral stenting and percutaneous nephrostomy drainage were considered criterion standard

Table 1**Medications recommended by RCOG for pain control and nausea and vomiting in pregnancy.**

Medication	Comments
Nausea and vomiting	
Histamine H1 receptor antagonist, eg, promethazine, cyclizine, cinnarizine, doxylamine, and dimenhydrinate	Recommended as first-line antiemetics therapy by RCOG. Safe in pregnancy
Phenothiazines including prochlorperazine, chlorpromazine, and perphenazine	Recommended as first-line antiemetic therapy during pregnancy by RCOG. Caution: Drug-induced extrapyramidal symptoms and oculogyric crises can occur
Dopamine antagonists including metoclopramide and domperidone	Recommended as second-line antiemetic therapy during pregnancy by RCOG. Caution: Drug-induced extrapyramidal symptoms and oculogyric crises can occur. Short-term use only with maximum duration of 5 d
Ondansetron	Should be used only if aforementioned antiemetics fail due to limited evidence on safety. Should be avoided in first trimester
Pain	
Paracetamol	Safe during pregnancy in all trimesters
Nonsteroidal anti-inflammatory drugs	Should be used only in first and second trimesters if clinically indicated and when other analgesics fail. Should be avoided after 30-wk gestation as it is associated with neonatal pulmonary issues and premature closure of the ductus arteriosus
Opioids	Licensed for use in the first 30-wk gestation but should be avoided after 30 wk because it can lead to neonatal respiratory depression

RCOG = Royal College of Obstetricians and Gynecologists.

surgical treatment options after failed conservative management in pregnancies,^[17] especially in the first trimester. A multi-institutional analysis reported that there were no significant differences associated with percutaneous nephrostomy and the rates of adverse pregnancy events. However, ureteric stenting in pregnancy is associated with a lower incidence of urinary tract infection, hospitalization duration, emergency department visits, and frequency of exchange procedures.^[40] Ureteric stent insertion can be performed using a retrograde approach via cystoscopy, or an antegrade approach after percutaneous renal puncture, with the location of the stent confirmed using US. Performing this procedure under sedation or local anesthesia in some instances is preferable in the first trimester, because general anesthesia increases the risk of miscarriage. Ultrasound confirms its position within the renal pelvis and avoids the use of ionizing radiation. The safe use of this procedure during pregnancy was demonstrated in a 9-year retrospective analysis. Of the 39 patients with confirmed renal colic, 14 required intervention, 13 patients received a ureteric stent, and 1 patient required percutaneous nephrostomy. No obstetric complications were reported.^[41]

However, accelerated stent encrustation during pregnancy is a known phenomenon that requires stent replacement every 4 to 6 weeks.^[42] This condition occurs secondary to metabolic changes in urine chemistry in the form of hypercalciuria, hyperuricosuria, and hyperoxaluria.^[43] Other risk factors include prolonged indwelling time, urinary tract infections, stent materials, and individual patient factors, such as chronic renal failure and metabolic abnormalities. Furthermore, stent-related symptoms are particularly troublesome, with reports of early induction of labor to progress with definitive renal calculi treatment.^[44] The safety of anticholinergic and antimuscarinic medications in alleviating these symptoms is ambiguous.

Despite the disadvantages of frequent stent exchanges and stent-related symptoms, a recently published meta-analysis featuring 25 studies demonstrated pooled occurrence rates for serious complications (Clavien-Dindo III–V) of less than 1% for ureteral stenting, thus supporting the safe use of these procedures in pregnancy.^[45]

5.4. Percutaneous nephrostomy

These techniques offer temporary solutions and may be performed under local anesthesia; therefore, it is another treatment option that may be used during the first trimester. A 5-year study found

that 15 pregnant patients underwent nephrostomy insertion without immediate complications. However, 2 patients had blocked nephrostomies, whereas 2 patients had nephrostomies that fell out.^[46] There was an instance of infection that required oral antibiotics in one of the patients. Similar to ureteric stent, nephrostomy encrustation is an issue. A retrospective 10-year study found that 30.6% of patients had difficult nephrostomy exchanges due to encrustation, with a mean time of 20.5 days between exchanges.^[47] This increased morbidity with external drainage may be troublesome to the patient; therefore, ureteric stenting is the preferred option.

5.5. Ureteroscopy

Ureteroscopy is a definitive method of stone treatment, and it is associated with a high stone clearance rate.^[45] Contraindications to URS include sepsis, a large stone burden, or the presence of multiple stones. Technically, the procedure is altered according to the anatomy of the gravid uterus. This technique abuts the dome of the bladder, and the ureteric orifices are in a higher position. The 2022 European Association of Urology guidelines recommend that URS may be used as a reasonable alternative,^[34] especially in nonurgent cases during the second trimester if access to neonatal and obstetric services is available. A systematic analysis of 23 articles demonstrated pooled occurrence rates for complications and normal fertility outcomes of 1% and 99%, respectively. These results support safe use of URS in pregnancy.^[45] The procedure can be performed under spinal anesthesia, thereby enhancing its safety. While performing URS after the first trimester is preferred to minimize the risks associated with surgery and anesthesia, a retrospective study from a tertiary center demonstrated the absence of intraoperative or postoperative obstetric complications following URS performed in the first trimester.^[48] The same study showed that URS may be performed safely during pregnancy with local anesthesia (2% lidocaine gel) and light sedation, which offers a useful alternative for patients in whom spinal anesthesia cannot be tolerated or is contraindicated and for patients who do not want to undergo general anaesthesia.^[48]

6. Study limitations

Our study has several limitations. First, although we provided an informative and up-to-date review of the management of urolithiasis

in pregnancy, this was a nonsystematic review. Second, our methodology was limited to the PubMed database and manually searched articles. To minimize selection bias with hand-searched articles, expanding our literature search to include EMBASE, MEDLINE, and Cochrane Library could help to generate more relevant articles for inclusion. Finally, a few of our included studies were retrospective, which caused inevitable data bias.

7. Conclusions

Which option to choose?

The management of cases should be individualized, with consideration given to the patient's gestational age and response to initial treatment. If intervention is required, a multidisciplinary approach should be implemented. Therefore, a combined procedure with an interventional radiologist, involving attempted double-J stent insertion under US guidance, is recommended. If this procedure fails, an on-table nephrostomy tube should be inserted. Renal function and sepsis markers should be closely monitored during the postoperative period. Further imaging and definitive management may be deferred until the postpartum period.

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Statement of ethics

Not applicable.

Conflict of interest statement

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KC: Lead in conceptualization, methodology, original drafting, review and editing;

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CPL: Supporting in review, editing and supervision;

NV: Supporting in conceptualization, review, editing and supervision.

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