# Does type of anesthesia during procedural management of suspected renal colic during pregnancy have an impact on preterm birth?

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## ABSTRACT

**Introduction:** Anesthesia choice during the procedural management of suspected renal colic during pregnancy may vary based on available resources and patient or provider preferences, as there are no specific recommendations. Our objective was to evaluate whether preterm birth (<37 weeks) was associated with anesthesia type, anesthesia timing by trimester, or procedure type.

**Methods:** We retrospectively identified pregnant patients who required procedural management with ureteral stent, percutaneous nephrostomy (PCN), or ureteroscopy (URS) for suspected renal colic based on laboratory and imaging findings from 2009–2021 at our center. Analyzed data included anesthesia type (local analgesia only, monitored anesthesia care [MAC], spinal anesthesia, or general anesthesia), trimester of procedure, procedure type, and obstetric outcomes including preterm birth.

**KEY MESSAGES**

- Anesthesia type for procedural management of renal colic was not associated with preterm birth.
- Trimester of anesthetic exposure was not associated with preterm birth.
- Percutaneous nephrostomy tube was associated with the use of less invasive analgesia or anesthesia.
- Ureteroscopy and ureteral stent were associated with lower rates of preterm birth and longer gestational age at delivery compared to percutaneous nephrostomy tube.

**Results:** The study cohort included 96 patients who underwent 231 total procedures, including primary URS, PCN, stent, as well as PCN and stent change. The median gestational age was 38.7 (37.1–39.5) weeks, and preterm birth rate was 15.8%. The most common anesthetic used across all procedures and trimesters was MAC. PCN was associated with the use of less invasive analgesia or anesthesia, whereas endoscopic procedures were more commonly performed with spinal or general anesthesia. Using multivariable logistic regression, procedure type was associated with preterm birth, but not anesthesia type or timing by trimester.
**Conclusions:** Anesthesia type and timing were not associated with preterm birth, and selection may be influenced by resources, clinical scenario, or patient and provider preferences.

## INTRODUCTION

Kidney stones are common in the general population with an increasing prevalence worldwide.[1] The incidence of stones has been shown to be equal in pregnant and non-pregnant women of childbearing age, with the actual incidence of stones in pregnancy estimated to be 0.49-0.8%, or up to one case for every 125 pregnancies.[2,3] However, the diagnosis and management of urinary calculi in pregnant women are challenging, and the associated risks of serious complications are concerning.[4] There is significant morbidity associated with stone episodes, similar to non-pregnant patients, including uncontrolled pain, acute renal injury, urinary tract infection, and recurrent emergency room visits and hospital admissions. Pregnancies affected by symptomatic urolithiasis have an increased risk of adverse maternal outcomes including pre-eclampsia/eclampsia, hypertension, gestational diabetes mellitus, pyelonephritis, and venous thromboembolism as well as an increased risk of adverse neonatal outcomes such as low birth weight, preterm birth, and congenital anomalies.[2,5,6]

If the diagnosis of obstructing urolithiasis is suspected based on clinical and/or radiographical findings, current American Urological Association guidelines recommend conservative management as the first line option in clinically stable pregnant patients in an effort to mitigate anesthetic and radiation exposure associated with interventions.[7] However, medical expulsive therapy options are more limited compared to the non-pregnant patient; use of tamsulosin (Food and Drug Administration category B) is considered off-label, nonsteroidal anti-inflammatories are contraindicated during pregnancy, codeine is contraindicated in the first trimester due to teratogenic effects, and while narcotics are generally considered safe, they can be associated with neonatal abstinence syndrome.[8] The overall spontaneous stone passage rate in pregnant women has been reported to be 64.3-84%, but for stones in certain locations, for example the ureteropelvic junction, it may as low as 27.3%.[9]

Conservative management is not always successful, with an estimated 5-26% of pregnant women with suspected stones ultimately requiring procedural intervention, including percutaneous nephrostomy tube (PCN), ureteral stent, or primary ureteroscopy, with the potential

for multiple subsequent procedures.[4,10] These procedures all have accompanying anesthetic risks, whether local, sedation, regional, or general anesthesia is used. For procedural management of urolithiasis during pregnancy, anesthesia choice may vary based on available resources and patient or physician preferences, as there are no specific recommendations.

In the present study, our objective was to evaluate whether preterm birth (<37 weeks), was associated with anesthesia type, anesthesia timing by trimester, or procedure type.

## METHODS

### Patient population

After obtaining internal review board approval, we completed a retrospective review of pregnant patients who required procedural management with ureteral stent, PCN, or primary ureteroscopy for clinically suspected symptomatic urolithiasis from January 1, 2009 to Dec 31, 2021 at our large multi-center academic tertiary care center.

### Inclusion criteria

Patients were included if they were pregnant when they presented with symptoms of renal colic (e.g. flank pain, nausea or vomiting) and required procedural management during the pregnancy. Renal colic was suspected if imaging showed hydronephrosis and at least one of the following additional criteria; microscopic or gross hematuria, stone crystals on urinalysis, pyuria, absent ureteral jets, resistive indices consistent with obstruction, or stone(s) clearly noted on imaging. Patients were excluded from analysis if they were under 18 years of age at the time of the procedure, renal colic was managed non-operatively, there were no clinical signs of obstructing nephrolithiasis (see criteria above), or there was incomplete data in the electronic medical record. Stent removal under anesthesia was not included as an anesthetic event as this only occurred in 4 patients. Two births with underlying fetal anomalies (one due to genetic abnormalities, and one due to the umbilical cord being wrapped around the baby's foot) resulting in intrauterine fetal demise were also excluded.

### Data collection

Individual medical records were abstracted for demographic information, previous medical and obstetric history, presenting symptomatology, and urological interventions. The indications for procedural management were the same as is typical for non-pregnant stone patients including intractable symptoms, acute kidney injury, or concern for infection. The type of procedure was urologist-dependent after discussion with the patient. The type of anesthesia was agreed upon by the entire team including the anesthesiologist, obstetrician (or maternal-fetal medicine specialist), and urologist after discussion with the patient.

The primary outcome was preterm birth, with a secondary interest of gestational age at birth. In addition, we aimed to understand the range of anesthesia used by trimester for each procedure type.

**Statistical methods**

Categorical factors were summarized with frequencies and percentages. Normality of continuous and ordinal measures was assessed. Only age appeared to be normally distributed, so it was summarized with mean and standard deviation. Other continuous and ordered measures were summarized with medians and quartiles. Births were classified as preterm (<37 weeks) vs. term (≥ 37 weeks). Overall summaries and a patient level plot, ordered by gestational age at birth, were generated. To evaluate whether preterm birth was associated with anesthesia type or timing of anesthesia by trimester, a univariable and multivariable logistic regression model with generalized estimating equations (GEE) to account for multiple procedures for the same patient were performed. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. As a sensitivity analysis, a linear regression with GEE was also fit using continuous gestational age. Analysis was performed using R software (version 4.3; Vienna, Austria), with $p<0.05$ considered to be statistically significant.

**RESULTS**

The study cohort included 96 pregnant patients who underwent 231 total procedures including primary ureteroscopy, PCN, stent, as well as PCN and stent change. The mean maternal age at time of initial presentation for renal colic was 27.8 ± 5.2 years, and the median maternal body mass index was 27.3 (23.6-33.1) kg/m$^2$. Median gravidity was 2 (1-3) and parity was 1 (0-2). The anesthesia types used were local analgesia at the skin site or intraurethral lidocaine gel only, conscious sedation with monitored anesthesia care (MAC), spinal anesthesia, or general anesthesia.

Figure 1 is a patient level plot of anesthesia and procedure type by timing. There was notable variability in the management of patients, and most patients required multiple procedures. This data is summarized in Table 1, which shows the anesthesia type used for stent placement/exchange, PCN placement/exchange, and ureteroscopy for each trimester.

There were only 10 (4.3%) procedures in the first trimester, with 129 (55.8%) of the procedures performed in the third trimester. The most common anesthetic used across all procedures in all trimesters was MAC for 35.5% (82) of the procedures. General anesthesia was given for 19% (44), spinal for 19.9% (46), and local for 25.5% (59) of the procedures. There were three patients who underwent primary ureteroscopy in the first trimester, each receiving a different type of anesthetic. For ureteroscopy in the second trimester, general and spinal anesthesia were used equally. In women undergoing ureteroscopy in the third trimester, spinal anesthesia was more commonly used than general anesthesia (71.4% and 28.6%, respectively). Similarly, spinal anesthesia was the most-commonly used anesthetic for stent placement in the later trimesters (37.9% and 53.1%, for trimesters 2 and 3 respectively). Conversely, PCN insertion or exchange was completed more often under local anesthesia only or MAC during the second trimester (44.7% and 36.2%, respectively), as well the third trimester (40% and 44.4%, respectively).

The median gestational age at birth was 38.7(37.1-39.5) weeks, and the rate of preterm birth was 15.8% (15). Neither anesthesia type nor trimester of procedure were associated with preterm birth in univariable or multivariable logistic regression models (Table 2). In the sensitivity analysis looking at continuous gestational age, anesthesia type and timing of procedure were again not associated with gestational age at birth (Table 3).

However, on multivariable analysis, procedure type was associated with preterm birth. Patients who underwent ureteroscopy were less likely to have a preterm birth (OR = 0.26; 95% CI: 0.08-0.82; $p$= .022) and had a gestational age at delivery that was 16 (95% CI: 6.3-26; $p$=0.001) days longer as compared to those who were managed with PCN. Similarly, patients who were managed with a stent insertion or exchange were also less likely to have a preterm birth (OR=0.29; 95% CI: 0.10-0.85; $p$=0.024), and delivered 12 (95% CI: 5.7, 18; $p$<.001) days later than patients managed with PCN insertion or exchange.

## DISCUSSION

Nephrolithiasis during pregnancy has been associated with preterm birth, with a large meta-analysis reporting an OR of 1.46 (95% CI: 1.30-1.64; $p$<.01).[2] In addition, women undergoing any type of non-obstetric surgery during pregnancy have a further increased risk of preterm birth (OR=2.1; 95% CI: 2.0-2.1) compared to women without surgery,[11] with a meta-analysis estimating a prematurity rate of 8.2%.[12] In our cohort of pregnant women requiring procedural management for suspected renal colic, there was a 15.8% rate of preterm birth. This is consistent with the published rates in a large retrospective series, which reported that preterm delivery rates increased from a baseline of 7.0% for pregnancies unaffected by stones, to 9.1% for patients with stones managed conservatively, 11.2% for those undergoing a urologic intervention, and 19.6% for patients who had PCN placement.[13]

Alterations in maternal anatomy and physiology induced by pregnancy have clinical anesthetic implications and present potential hazards while undergoing anesthesia for non-obstetric surgery during pregnancy, with different challenges during each of the three trimesters.[14] In general, neuraxial anesthesia is often favored over general anesthesia in obstetric patients given that the physiologic changes of pregnancy increase the incidence of aspiration and difficult airway management as well as present challenges in maintaining hemodynamic stability, utero-placental perfusion, and uterine relaxation. This is particularly important for patients in the third trimester, as anesthesia-induced hemodynamic changes can heighten the likelihood of premature uterine contractions. Additionally, neuraxial anesthesia limits the amount of fetal exposure to anesthetic agents and medications.[15] In this study, the type of anesthesia used for management was not associated with preterm birth.

In pregnant women, symptomatic urolithiasis most commonly occurs in the second and third trimesters.[16] In addition, initial attempts at observation are made in an effort to delay anesthesia to later trimesters. Our patient population reflects this trend, with most procedures taking place in the later trimesters. While the second trimester is traditionally preferred for non-obstetric surgery as organogenesis is completed, thus minimizing the risk of potential teratogenic

effects of anesthetic drugs,[17] the trimester of anesthetic exposure was not associated with preterm birth within our cohort. Furthermore, per American College of Obstetricians and Gynecologists (ACOG) guidelines, it is not recommended to delay medically necessary surgery, regardless of the trimester, as this can negatively impact both the mother and the fetus.[18]

Ureteral stents and PCN drainage are considered equally safe and effective in pregnancy, although higher rates of radiation exposure have been noted with PCN vs. stent.[19] Temporizing treatment with ureteral stent or PCN has the benefit of being less invasive and faster than primary ureteroscopy and can potentially be performed under local anesthesia.[20] In our cohort, ureteral stent and PCN were observed to be more commonly offered than primary ureteroscopy. However, stenting had lower odds of preterm birth compared to PCN, which is consistent with the aforementioned retrospective series by Drescher et al, where PCN had a greater risk of preterm delivery compared to endoscopic interventions. Furthermore, a propensity score-matched analysis in almost 3000 pregnant women reported that ureteral stent versus PCN placement was associated with a lower incidence of hospital admissions, emergency department visits, exchange procedures, and new urinary tract infections or pyelonephritis, although there was no difference in rates of adverse pregnancy events.[21]

On the other hand, ureteroscopic stone removal can offer definitive clearance of the stone burden, compared to ureteral stent or PCN, which also require regular exchanges due to the high propensity for encrustation during pregnancy.[19] Although ureteroscopy typically requires spinal or general anesthesia, a small study of 26 patients reported no difference between the number of anesthetic events and cumulative anesthetic time between stenting and ureteroscopy.[22] Notably, in our study, while anesthesia type or timing was not associated with preterm birth, intervention with ureteroscopy had lower odds of preterm birth and longer gestational age at delivery compared to PCN. Despite the potential for ureteral perforation and sepsis during ureteroscopy, obstetric complications at time of ureteroscopy are rare (<5%).[23] Pathways for management of urolithiasis in pregnancy have been proposed by large centers, and one multidisciplinary panel suggested primary ureteroscopy should be offered as first-line treatment in non-complex scenarios, with neuraxial anesthesia preferred.[24] However, there is a concern that ureteroscopy may be more technically challenging later in gestation due to anatomical changes in the bladder secondary to compression by the gravid uterus.[25]

Although not commonly offered, percutaneous nephrolithotomy (PCNL) may be another feasible treatment option for symptomatic patients.[26] There were no cases of PCNL in our patient cohort. A meta-analysis of limited case series in the literature with a total of 16 patients reported no maternal or fetal complications after PCNL during pregnancy. Notably, most cases were done exclusively using ultrasound guidance.

Similar to other studies on the pregnant patient population, this study is limited by its retrospective nature and small sample size. We focused primarily on patients with suspected renal colic. In our cohort, most patients were evaluated exclusively with ultrasound, which has a poor sensitivity for urolithiasis and cannot reliably distinguish urolithiasis from gestational

hydronephrosis. However, we tried to mitigate this by incorporating several inclusion criteria consistent with renal colic. Also, patients were not able to be stratified by stone size and location due to the limited imaging. Furthermore, while most patients continued the initial procedure type, some changed over the course of pregnancy. The choice of anesthetic type was also influenced by practice patterns and preferences of providers at our institution and may not necessarily reflect practices at other institutions. We used a multivariable model to account for patients with multiple procedures and anesthetic types, but the relative effect of each may not have been completely captured in the analysis.

While the inherent limitations of a retrospective design make it challenging to draw definitive conclusions, the results of this study suggest in the pregnant stone forming patient, type and timing of anesthesia during a stone intervention is not associated with preterm birth. Ultimately, consensus guidelines recommend a multidisciplinary team approach involving anesthesiologists, obstetricians, urologists, pediatricians, and nurses for the optimal safety of both the mother and the fetus. Other considerations include providing appropriate perioperative prophylaxis for the increased risk of venous thromboembolism risk in pregnancy and considering corticosteroid administration in patients with viable premature fetuses.[18]

## CONCLUSIONS

PCN was more commonly performed with less invasive analgesia or anesthesia, whereas endoscopic procedures were associated with spinal or general anesthesia. Anesthesia type and timing were not associated with preterm birth, and selection may be influenced by resources, clinical scenario, or patient and provider preferences. However, procedure type was correlated with preterm birth, with stent and ureteroscopy being associated with lower rates of preterm birth compared to PCN. Ultimately, a multidisciplinary approach involving urologists, obstetricians, radiologists, and anesthesiologists is fundamental for optimizing safe management of suspected kidney stone disease in the pregnant patient.

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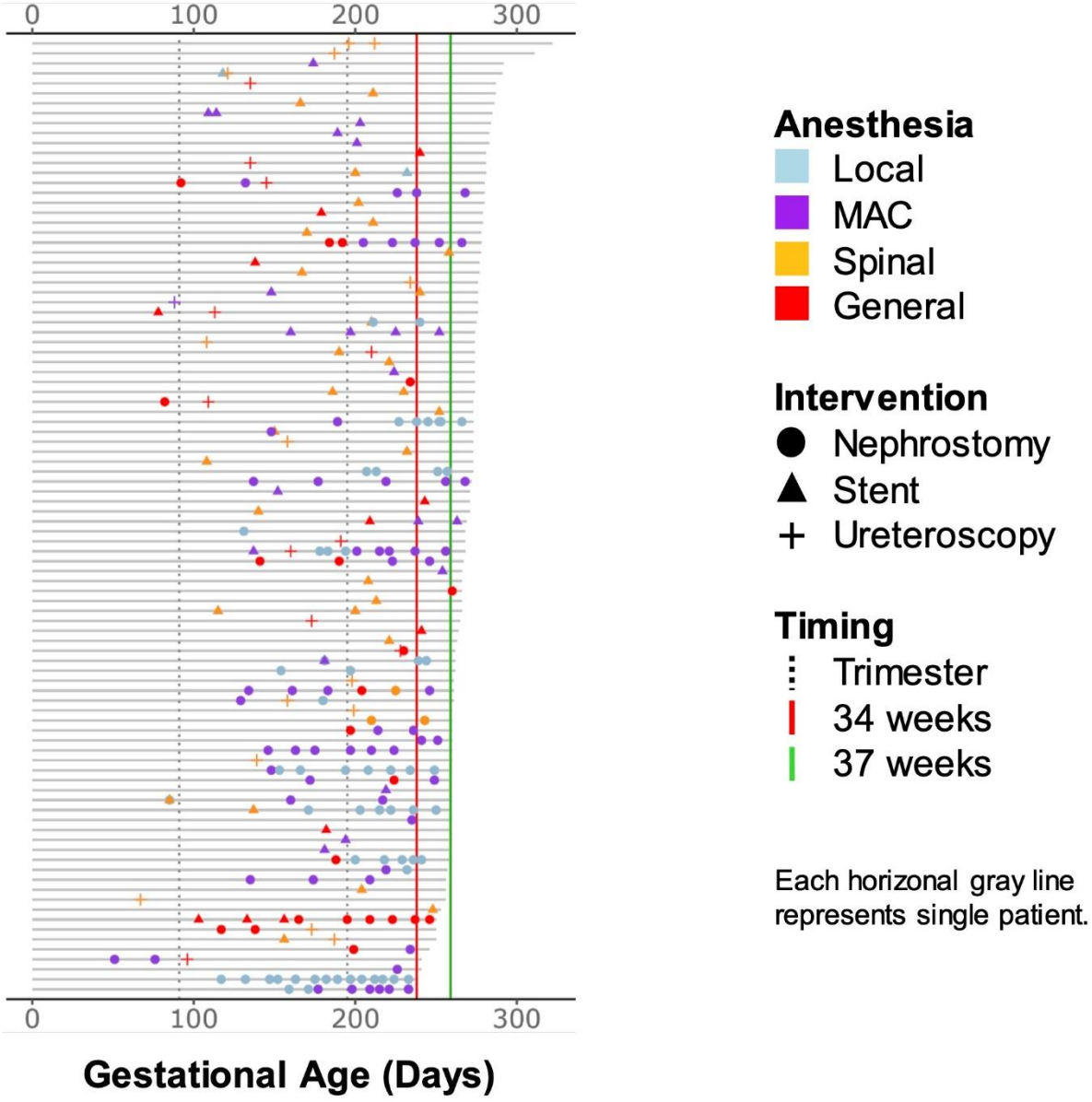
## FIGURES AND TABLES

**Figure 1.** Patient plot of anesthesia and procedure type by timing. Each horizontal gray line represents a single patient, ordered from longest gestational age at birth at the top to the shortest gestational age at birth at the bottom. Dashed vertical lines separate trimesters. Red vertical line indicates 34 weeks gestational age. Green vertical line indicates 37 weeks gestational age. Anesthesia type is denoted by marker color. Procedure type is denoted by the marker shape.



| **Table 1. Anesthesia type by procedure and trimester** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Procedure** | **Trimester 1** | | | | **Trimester 2** | | | | **Trimester 3** | | | | **Total** |
| | **Local** | **MAC** | **Spinal** | **General** | **Local** | **MAC** | **Spinal** | **General** | **Local** | **MAC** | **Spinal** | **General** | |
| Nephrostomy | 1 (20) | 2 (40) | 0 | 2 (40) | 21 (44.7) | 17 (36.2) | 0 | 9 (19.1) | 36 (40) | 40 (44.4) | 3 (3.3) | 11 (12.2) | 142 |
| Stent | 0 | 0 | 1 (50) | 1(50) | 1 (3.4) | 11 (37.9) | 11 (37.9) | 6 (20.7) | 0 | 11 (34.4) | 17 (53.1) | 4 (12.5) | 63 |
| Ureteroscopy | 0 | 1 (33.3) | 1 (33.3) | 1 (33.3) | 0 | 0 | 8 (50) | 8 (50) | 0 | 0 | 5 (71.4) | 2 (28.6) | 26 |
| **Total** | 1(10) | 3 (30) | 2 (20) | 4 (40) | 22 (23.9) | 28 (30.4) | 19 (20.7) | 23 (25) | 36 (27.9) | 51 (39.5) | 25 (19.4) | 17 (13.2) | 231 |

n, row % by trimester. MAC: monitored anesthesia care.

| **Table 2. Logistic regression model** | | |
|---|---|---|
| **(A) Univariable predictors of preterm birth (GEE model [patients: 96])** | | |
| **Characteristic** | **OR (95% CI)** | **p** |
| Anesthesia | | |
| Local | 1.24 (0.17, 9.17) | 0.83 |
| MAC | 0.57 (0.11, 3.00) | 0.51 |
| Spinal | 0.32 (0.06, 1.65) | 0.17 |
| General | Reference | |
| Procedure | | |
| Nephrostomy | Reference | |
| Stent | 0.29 (0.09, 0.96) | **0.042** |
| Ureteroscopy | 0.37 (0.10, 1.40) | 0.14 |

| | | |
|---|---|---|
| Trimester | | |
| Trimester 1 | Reference | |
| Trimester 2 | 0.59 (0.08, 4.28) | 0.60 |
| Trimester 3 | 0.44 (0.06, 3.14) | 0.41 |
| **(B) Multivariable predictors of preterm birth (GEE model [procedures: 231; patients: 96])** | | |
| **Characteristic** | **OR (95% CI)** | **p** |
| Anesthesia | | |
| Local | 0.84 (0.10, 7.14) | 0.87 |
| MAC | 0.48 (0.08, 2.92) | 0.42 |
| Spinal | 0.63 (0.10, 3.84) | 0.62 |
| General | Reference | |
| Procedure | | |
| Nephrostomy | Reference | |
| Stent | 0.29 (0.10, 0.85) | ***0.024*** |
| Ureteroscopy | 0.26 (0.08, 0.82) | ***0.022*** |
| Trimester | | |
| Trimester 1 | Reference | |
| Trimester 2 | 0.56 (0.06, 5.34) | 0.61 |
| Trimester 3 | 0.34 (0.04, 3.22) | 0.35 |

CI: confidence interval; MAC: monitored anesthesia care; OR: odds ratio.

| **Table 3. Sensitivity analysis** | | |
|---|---|---|
| **(A) Univariable predictors of gestational age at birth (GEE model [patients: 96])** | | |
| **Characteristic** | **Beta (95% CI)** | **p** |
| Anesthesia | | |
| Local | -6.2 (-18, 5.6) | 0.30 |
| MAC | -0.01 (-8.4, 8.4) | >0.99 |
| Spinal | 7.6 (-1.1, 16) | 0.086 |
| General | Reference | |
| Procedure | | |
| Nephrostomy | Reference | |
| Stent | 12 (5.7, 18) | ***<0.001*** |
| Ureteroscopy | 14 (3.8, 25) | ***0.008*** |
| Trimester | | |
| Trimester 1 | Reference | |
| Trimester 2 | 3.8 (-10, 18) | 0.59 |
| Trimester 3 | 4.5 (-9.3, 18) | 0.52 |
| **(B) Multivariable predictors of gestational age at birth (GEE model [procedures: 231; patients: 96])** | | |
| **Characteristic** | **Beta (95% CI)**[1] | **p** |
| Anesthesia | | |
| Local | -0.78 (-12, 11) | 0.89 |
| MAC | 2.7 (-4.9, 10) | 0.49 |
| Spinal | 1.6 (-6.1, 9.2) | 0.69 |
| General | Reference | |
| Procedure | | |
| Nephrostomy | Reference | |
| Stent | 12 (5.7, 18) | **<0.001** |

| | | |
|---|---|---|
| Ureteroscopy | 16 (6.3, 26) | ***0.001*** |
| Trimester | | |
| Trimester 1 | Reference | |
| Trimester 2 | 4.5 (-8.8, 18) | 0.50 |
| Trimester 3 | 7.7 (-5.8, 21) | 0.26 |

CI: confidence interval; MAC: monitored anesthesia care.