Acute renal colic during pregnancy: management and predictive factors

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Introduction: *The aim of this study was to identify predictive factors of urolithiasis etiology for acute renal colic (ARC) during pregnancy.*

Materials and methods: *We performed a retrospective review of all pregnant women hospitalized for an ARC between January 2007 and October 2012 in the department of Obstetrics and Gynecology of a University Hospital. Univariate and multivariate regression models were used to assess potential predictive factors of urolithiasis etiology.*

Results: *We included 82 patients. A urolithiasis was identified in 24 (29.3%) patients. In univariate analysis, we identified the following predictive factors for a urolithiasis etiology: primiparity (p = 0.017), leukocyturia (p = 0.021), left hydronephrosis > 10 mm and > 15 mm (p = 0.009; p = 0.02) and right hydronephrosis > 15 mm (p = 0.019). In multivariate analysis, only left hydronephrosis > 10 mm remained predictive for a urolithiasis etiology (p = 0.036; HR 7.45). A ureteral stenting was necessary for 23 patients (28.0%). Three patients (3.7%) had a premature membrane rupture and two patients (2.4%) delivered prematurely. After delivery, 10 patients (12.2%) required surgical treatment.*

Conclusion: *Left hydronephrosis was related to urolithiasic etiology for ARC. Obstetrical consequences of ARC were minor.*

Key Words: pregnancy, renal colic, urolithiasis, echography, hydronephrosis, obstetric

Introduction

Acute renal colic (ARC) is a common cause of non-obstetric abdominal pain during pregnancy. ARC affects 0.026% to 0.5% of pregnant women and occurs in 80% to 90% of the cases in the second and the third trimester of pregnancy.[1,2] ARC is defined by an isolated and acute abdominal and lumbar pain with anterior and descending irradiation. Its etiologies are an obstruction by a urolithiasis, a tumoral parietal obstacle or an external compression.[3] During pregnancy, a progressive distension of the urinary upper tract collecting system occurs in 60% to 95% of women.[4] This hydronephrosis is explained firstly by a mechanical compression of the ureter by the gravid uterus and secondly by modifications in hormonal impregnation. Indeed, progesterone and prostaglandin increase during pregnancy and lead to decreased ureter smooth muscle contractility. Its role is to maintain pregnancy but it is also to decrease the upper urinary tract peristalsis and leads to urinary stasis.[4] Moreover, a physiological hypercalciuria occurs during pregnancy which increases the risk of urolithiasis.[5] Finally, during pregnancy, it is difficult to distinguish physiological upper urinary tract distension from a pathological distension due to an obstruction by a stone. Moreover, because of the fetal irradiation risks, contraindications to abdominal x-ray and computed tomography (CT) contribute to the difficulties for establishing a diagnosis. In addition, management of ARC during pregnancy is challenging because of the contraindication of nonsteroidal anti-inflammatory drugs.[6] The aim of this study was to identify predictive factors of urolithiasis etiologies of acute renal colic during pregnancy and to evaluate the management and outcomes.

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TABLE 1. **Patient characteristics**

	Number of patients (n = 82)
Pregnancy term	
1st trimester	3 (3.7%)
2nd trimester	38 (46.3%)
3rd trimester	41 (50.0%)
Primipara, n (%)	38 (46.3%)
Twin pregnancy, n (%)	3 (3.7%)
Hydramniosis, n (%)	2 (2.4%)
Fetal macrosomy, n (%)	2 (2.4%)
Medical history	
Diabetes	3 (3.7%)
Renal colic	27 (32.9%)
Lithiasis disease	9 (11.0%)
Chronic urinary infections	18 (21.9%)
Hypothyroïdism	1 (1.2%)
Mean body mass index (SD)	22.3 +/- 0.5

Materials and methods

We performed a retrospective review of all pregnant women hospitalized for an acute renal colic between January 2007 and October 2012 in the department of Obstetrics and Gynecology of the Angers University Hospital.

After approval from the institutional review board, the Institutional Department of Computer Sciences identified patients for inclusion. The main diagnosis "renal colic" was used as criteria for searching in the institutional database. We considered the ARC diagnosis as defined by an acute lumbar-abdominal pain syndrome. All women admitted with lumbar spasms or sciatic pain were excluded from the study. A written consent to participate in the study was not required for this retrospective observational study.

Demographic and obstetrical characteristics were collected for each patient. Prior history of diabetes, hypothyroïdism, ARC, urolithiasis, chronic urinary infections and pyelonephritis were specifically noted when available. The following clinical data were gathered retrospectively: ARC characteristics at admission (number of previous painful episodes, pain intensity assessed by Visual Analog Scale or VAS, laterality of pain, fever), results of biological exams (blood count, urinary strip, creatinemy, C-reactive protein), hydronephrosis, presence of stone, time of hospitalization, medical and/or surgical treatment and pregnancy evolution.

Univariate and multivariate regression models were used to assess potential predictive factors of a urolithiasis etiology. Only factors that were significant in univariate analysis were considered for multivariate analysis. All tests were done using SPSS, version 10.0.

Results

Patient characteristics

We included 82 patients with a mean age of 26.4 +/-0.5 years between January 2007 and October 2012. During this period, the obstetrics and gynecology department performed 20,500 deliveries. Patients were in their first, second and third trimester of pregnancy in 3 (3.7%), 38 (46.3%) and 41 (50.0%) cases, respectively. In all cases the patient had low back pain radiating to the iliac fossa.

Pain was lateralized on the left side, on the right side or was bilateral in 53 (64.6%), 26 (31.7%) and 3 (3.7%) cases, respectively. Patients' characteristics are reported in Table 1.

Management in emergency

Urine test strips revealed hematuria and/or leukocyturia in 58 (70.7%) and 38 (46.3%) cases, respectively. Cytobacteriological urinary analysis was positive for 7 (8.5%) patients. An abdominal ultrasonography (US), an abdominal x-ray and a CT were performed in 73 (89.0%), 2 (2.4%) and 1 (1.2%) cases, respectively. An obstructive urolithiasis origin was confirmed by imaging in 24 (29.3%) patients. Stones localizations were: the pyelocaliceal cavities, the upper ureter, the mid ureter and the lower ureter in respectively 12 (50.0%), 2 (8.3%), 2 (8.3%) and 8 (33.3%) cases. In one case, CT detected a stone that had not been seen in US. It was

TABLE 2. **Indications for urinary derivation**

Indications for urinary derivation	**Number of patients (n = 24)**
Stone size > 7 mm	7 (29.2 %)
Urolithiasis complicated with urinary infection	7 (29.2 %)
Failed medical pain management	7 (29.2 %)
Severe hydronephrosis	3 (12.4%)

a 34-year-old patient admitted for lumbar pain during her third trimester of pregnancy. She had ARC and urolithiasis histories. She had leukocyturia, hematuria and no urinary infection. Ultrasound identified right hydronephrosis of 40 mm without identifying any stone. Eventually CT revealed a right lumbar ureteral stone.

Patients were treated with paracetamol, antispasmodics (phloroglucinol), non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, nalbuphine and morphine in 80 (97.6%), 79 (96.3%), 3 (3.7%), 1 (1.2%), 49 (59.8%) and 8 (9.8%) cases, respectively. A ureteral stenting was necessary for 24 (29.3%) patients. The indications of urinary derivation are reported in Table 2. The patients' management is reported in Table 3 and Figure 1.

TABLE 3. **Patient management data**

	Patients (n = 82)	**%**	**Mean (+/-SD)**
Pain laterality			
Right	53	64.6%	
Left		26	31.7%
Bilateral	3	3.7%	
Mean VAS (+/-SD)			8.59 +/- 0.3
Imaging examinations			
US	73	89.0%	
Abdominal x-ray	13	15.9%	
CT	14	17.1%	
Mean right hydronephrosis (US) cm			13.9 +/- 1.58
Mean left hydronephrosis (US) cm			5.7 +/- 1.24
Stone showed by imaging	24	29.3%	
US	21	25.6%	
Abdominal x-ray	7	8.5%	
CT	8	9.8%	
CT only	1	1.2%	
Stone localization (n = 24)			
Pyelocaliceal cavities	12	50.0%	
Up ureter	2	8.3%	
Mid ureter	2	8.3%	
Low ureter	8	33.3%	
Urinary test strip	74	90.2%	
Hematuria	58	70.7%	
Leucocyturia	38	46.3%	
Positive cytobacteriological urinary analysis	7	8.5%	
Biological results	74	90.2%	
C-reactive protein > 6 mg/L	26	31.7%	
Mean renal function (mL/min)			149.8 +/-5
Medical treatment			
Paracetamol	80	97.6%	
NSAIDs	3	3.7%	
Corticosteroids	1	1.2%	
Phloroglucinol	79	96.3%	
Nalbuphine	49	59.8%	
Morphine	8	9.8%	
Endoureteral prosthesis	24	29.3%	
Mean hospitalization time (min-max) (days)		3 (1-20)	

VAS = Visual Analogic Scale; US = ultrasonography; CT = computer tomography; NSAIDs = non-steroidal anti-inflammatory drug

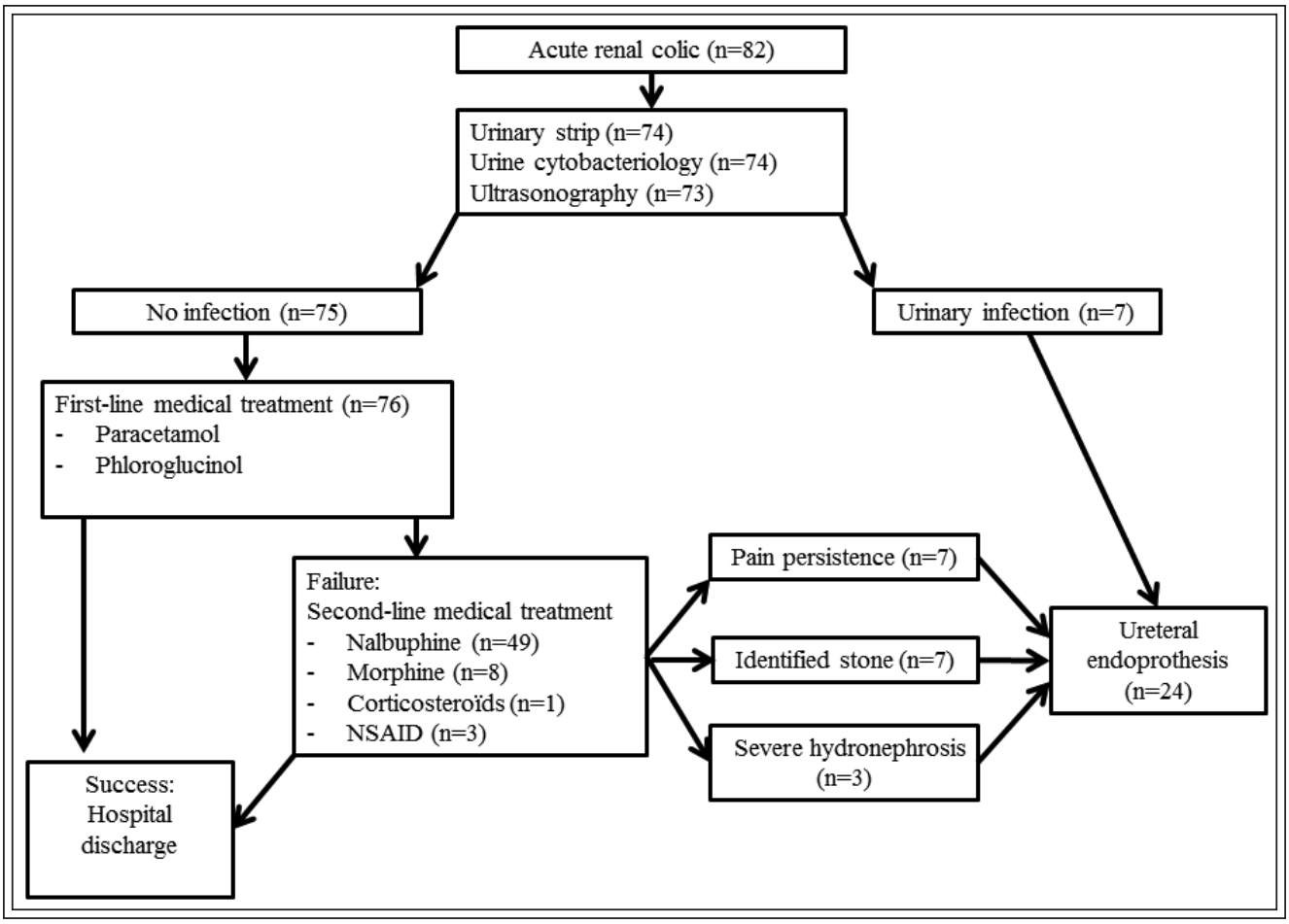

Figure 1. Patient management.

Predictive factors for a urolithiasis etiology

In univariate analysis, primigravidia (p = 0.017), leukocyturia (p = 0.021), left hydronephrosis > 10 mm and > 15 mm (p = 0.009; p = 0.02) and right hydronephrosis > 15 mm (p = 0.019) were predictive factors for a urolithiasis etiology. In multivariate analysis, only left hydronephrosis > 10 mm remained predictive for a urolithiasis etiology (p = 0.036; HR 7.45), Table 4.

Obstetrical follow up after acute renal colic

The median term of pregnancy was 39 weeks of gestation (range 33-42). Two patients (2.4%) had a preterm delivery (< 37 weeks of gestation) and 3 (3.7%) had a preterm rupture of membranes.

Urological follow up

After an initial treatment by double-J stenting, the stent were changed every 2 months and the median time that this stent were kept in situ was 2 months (0-4). Five patients (25%) needed a replacement of the double-J before delivery, 6 patients (30%) had calcification of the double-J, 5 (25%) had double-J related chronic pain and 6 (30%) had a urinary infection. After delivery, 10 patients (12%) required surgical treatment. Six patients (30%) had an extracorporeal shockwave lithotripsy, 2 (8.3%) had a retrograde intrarenal surgery and 2 (8.3%) had a percutaneous lithotripsy. Stones were analyzed in 2 cases (8.3%) and spectrophotometric analysis showed a calcium phosphate stone and a calcium oxalate stone.

Discussion

Pregnancy induces upper urinary tract modifications with an increased risk of lumbar pain.[7] It is although difficult to determine with certainty the cause of this ARC because of the low specificity of ultrasonography and the limited use of CT because of teratogenic risks. However, the incidence of urolithiasis in pregnant women is equivalent to that of non-pregnant women,[7] hence the necessity of predictive factors for urolithiasis etiology. In this study, we reviewed all pregnant women

TABLE 4. **Uni and multivariate analysis of predicting factors of a urolithiasis etiology in case of acute renal colic during pregnancy**

Predictive factors	Univariate	Multivariate		
	p value	p value	HR	IC
History of lithiasis disease	0.112			
History of renal colic	0.305			
Body mass index > 25	0.227			
Pregnancy trimester				
1st trimester	0.485			
2nd trimester	0.464			
3rd trimester	0.33			
Primipara	0.017	0.051	4.4	0.99-19.3
Hematuria on urinary strip	0.562			
Leucocyturia on urinary strip	0.021	0.095	3.1	0.82-11.6
Leucocytosis > 15000/mm^3	0.224			
C-reactive protein > 6 mg/L	0.601			
Left hydronephrosis				
> 10 cm	0.009	0.036	7.45	1.1-48.7
> 15 cm	0.02	0.157	1.27	0.13-12.2
Right hydronephrosis				
> 10 cm	0.176			
> 15 cm	0.019	0.157	2.808	0.67-11.7

hospitalized in the obstetric department for acute lumbar pain during 5 years. We identified a urolithiasis etiology for 29.3% of the ARC during pregnancy. Establishing the diagnosis of ARC and excluding any obstetrical related pain are probably the first and the most important steps in the management of an acute lumbar pain during pregnancy. We identified promising predictive factors of urolithiasis etiology: in univariate analysis, primiparity, leukocyturia, left hydronephrosis > 10 and > 15 mm, and right hydronephrosis > 15 mm were predictive factors for a urolithiasis etiology. In multivariate analysis, only a left hydronephrosis > 10 mm remained a predictive factor for a urolithiasis etiology. These outcomes made sense because of the physiological right hydronephrosis due to the pregnancy.[2] Eventually the threshold for hydronephrosis was higher for the right than the left kidney. Similarly, the fact that only the left hydronephrosis remained predictive in multivariate analysis was not a surprise for the same reason. In our study, the primigravidia status was associated with a urolithiasis etiology whereas multiparity was not. A few studies reported on the contrary an increased risk of urolithiasis for multiparous women when compared to primigravidia, however, the incidence in multiparous women was no longer higher when adjusted for age.[2]

Other clinical data as urolithiasis history, laterality of the pain or trimester of pregnancy were not predictive for a urolithiasis etiology. For Isen et al, most of patient did not have a prior history of urolithiasis and stones were equally frequent in both sides.[8,9] Moreover, urine test strips were not helpful with establishing a diagnosis. We found a microscopic hematuria in 58 (70.7%) patients and contrary to the study of Andreoiu et al, it was not predictive of a urolithiasis origin.[10] However, even if microscopic hematuria is frequent (70%-79%), it is not pathognomonic and has variable causes; even though, it remains a useful argument.[11-13] In this context, imaging investigations are fundamental and were performed in 73 (89%) patients. Fetal exposure to radiation is known to be responsible of fetal mortality, congenital foetopathy, mental retardation and neoplasia and thus should be minimal.[14] Because of the fetal irradiation risk associated with CT, US was the preferred first-line imaging modality during pregnancy.[4,15] Ultrasonography is able to detect the presence of pyelocaliceal cavities distension and might detect the presence of a stone. However, US alone had a sensitivity of 34% to 86% for detecting urolithiasis during pregnancy.[9] The positive predictive value of US according to White and al was 77%.[16] To improve the

sensitivity of US for detecting stones during pregnancy, it is advised to use an endovaginal US to improve distal ureteral stone detection.[17] Indirect signs of obstruction like unilateral absence of ureteral urinary flow or renal resistive index could also be helpful.[18] For instance, renal resistive index was not modified by the physiological hydronephrosis of pregnancy but was higher in case of ureteral obstruction.[19] In this study, pyelo-caliceal dilatation was the main indirect predictive factor for a urolithiasis origin of the pain. The dilatation was more important for the upper right urinary collecting system. In univariate analysis, we found a threshold of 10 mm on the left and 15 mm on the right as indirect signs of urolithiasis obstruction. In cases where a diagnosis could not be made by US and after confronting benefits and risks, a low-dose CT could be considered as an alternative.[9] White et al have reported a positive predictive value of 96% for CT low-dose.[16] Concerning fetal radiation, a dose < 50 mGy has not been associated with an increase in fetal abnormalities or pregnancy loss.[14] In our series, no MRI was performed. White et al have reported a positive predictive value of 80% for MRI.[16] In our series, one patient had a low-dose CT after US and an abdominal x-ray which did not provide any diagnosis. Retrospectively, we think that a urinary derivation could have been offered without performing any CT, only by considering the pain intensity, the pyelocaliceal distension (40 mm) and the history of urolithiasis disease.

In this study, all patients were hospitalized until the pain was resolved. Every patient had an analgesic medical treatment consisting of an intravenous injection of antispasmodic drugs and paracetamol. In case of persistent pain, an injection of nalbuphine was prescribed.[20] Prednisone could be another therapeutic option. Guichard et al reported a 71% success rate of prednisone on ARC pain control during pregnancy.[21] In our study, one patient received prednisone with a clinical improvement. Overall, medical treatment without urinary derivation was efficient for 71.1% of the patients. This rate is close the literature with a success rate for medical treatment during pregnancy between 70% and 80%.[22,23] Nevertheless, Burgess et al found that only 48% of the patients spontaneously passed the stone. Their explanation might be that 23% of pregnant women diagnosed with urolithiasis were diagnosed inaccurately which might have led to the misconception that most stones pass with conservative management during pregnancy.[13]

In case of failure of the medical treatment, a double-J stent was used in 23 (28.0%) patients. All of the cases were performed under local anesthesia with minimal radioscopic control. Double-J stents were associated with postoperative complications. In fact, 6 (30%) patients had calcifications of the stent, 5 (25%) patients had a chronic pain related to the stent and 6 (30%) patients had a urinary infection. Moreover, the double-J stents needed frequent changes especially in case of ARC occurring at the beginning of the pregnancy because of the early calcifications of the stent. This was probably linked to the hypercalciuria and the urinary stasis related with pregnancy. Similar results were reported by Wang et al: double-J stenting induced UTI (21%), bladder irritation (63%), incrustation (16%), hematuria (37%), and stent replacement was needed in 21% of the cases.[11] In these situations, nephrostomy could have been used.[24] However, inconveniences exist: catheter obstructions, bleeding and the need of a collector bag.

Another therapeutic option was to treat the stone during pregnancy. Several studies assessed the use ureteroscopy in this situation. Semins et al reported in a meta-analysis including 108 patients no significant difference in the rates of urinary tract infection (UTI) and ureteral injury between pregnant and non-pregnant women undergoing ureteroscopy ($p = 0.191$ and 0.597 respectively).[25] However, Johnson et al reported in a series of 46 patients a 4.3% rate of obstetric complications after ureteroscopy during pregnancy.[26] Hoscan et al reported in a series of 29 ureteroscopies only one case of postoperative uterine contraction but no serious obstetric or urologic complications.[27] Yan et al compared ureteroscopy and double-J stenting during pregnancy and reported significantly more complications with double-J (respectively 14% versus 53%, $p = 0.039$).[12] Lately, White and al reported a series of 51 pregnant patients who underwent ureteroscopy. There were no stones found in 14% of the case, and 23% of patients treated after US alone had no stone found.[28] Consequently, when conservative treatment fails, ureteroscopy might be an option, if a proper imaging such as low-dose CT is performed and after a multidisciplinary discussion. However, morbidity of anesthesia during pregnancy are higher because of soluble gases from anesthetic agents passing through the hematoplacental barrier, the intubation difficulty, the aortocaval compression by the gravid uterus, and the full stomach phenomenon from 12 to 24 amenorrhea weeks. All these risks (teratogenic, preterm delivery, miscarriage) explain why local anesthesia is preferred for pregnant women undergoing surgery and could also favor the postponement of surgery.[28]

Patients left the hospital after maternal and fetal clinical surveillance with a weekly urinary strip test and a monthly cytobacteriological urinary analysis. From an obstetrical point of view, our study found a poor rate of preterm delivery (2.4%). This was in

accordance with Guichard et al which reported no patients who prematurely delivered after ARC.[10,21]

The limits of our study were its retrospective approach and the number of participants. We probably failed to validate predictive factors because of the lack of statistical power. Moreover, in regard to the poor sensibility of the echography to detect urolithiasis during pregnancy, we probably underestimated the prevalence of urolithiasis in our population. However, the follow up of those patients did not reveal other complications related to ARC.

Conclusion

We identified a urolithiasis etiology for one third of the acute renal colic during pregnancy. In univariate analysis, primiparity, leukocyturia, left hydronephrosis > 10 mm and > 15 mm, and right hydronephrosis > 15 mm were predictive factors for a urolithiasis etiology. In multivariate analysis, left hydronephrosis > 10 mm remained a predictive factor for a urolithiasis etiology. Obstetric consequences of renal colic were rare and minor. □

References

1. Drago JR, Rohner TJ. Management of urinary calculi in pregnancy. *Urology* 1982;20(6):578-581.
2. Biyani CS, Joyce AD. Urolithiasis in pregnancy. I: pathophysiology, fetal considerations and diagnosis. *BJU Int* 2002;89(8):811-818.
3. El Khebir M, Fougeras O, Le Gall C et al. Update of the 8th Consensus Development Conference of the Francophone Society of Medical Emergencies of 1999. The treatment of adult renal colic by the emergency services and in emergency rooms. *Prog Urol* 2009;19(7):462-473.
4. Saussine C, Lechevallier E, Traxer O. Urolithiasis and pregnancy. *Prog Urol* 2008;18(12):1000-1004.
5. Traxer O, Lechevallier E, Saussine C, Daudon M, Haymann JP. Metabolic syndrome and urolithiasis. A new concept for the urologist. *Prog Urol* 2008;18(12):828-831.
6. Semins MJ, Matlaga BR. Kidney stones and pregnancy. *Adv Chronic Kidney Dis* 2013;20(3):260-264.
7. Biyani CS, Joyce AD. Urolithiasis in pregnancy. II: management. *BJU Int* 2002;89(8):819-823.
8. Isen K, Hatipoglu NK, Dedeoglu S, Atilgan I, Caca FN, Hatipoglu N. Experience with the diagnosis and management of symptomatic ureteric stones during pregnancy. *Urology* 2013;79(3):508-512.
9. Wang PI, Chong ST, Kielar AZ et al. Imaging of pregnant and lactating patients: part 1, evidence-based review and recommendations. *AJR Am J Roentgenol* 2012;198(4):778-784.
10. Andreoiu M, MacMahon R. Renal colic in pregnancy: lithiasis or physiological hydronephrosis? *Urology* 2009;74(4):757-761.
11. Wang Z, Xu L, Su Z, Yao C, Chen Z. Invasive management of proximal ureteral calculi during pregnancy. *Urology* 2013;83(4): 745-749.
12. Song Y, Fei X. Diagnosis and operative intervention for problematic ureteral calculi during pregnancy. *Int J Gynaecol Obstet* 2013;121(2):115-118.
13. Burgess KL, Gettman MT, Rangel LJ, Krambeck AE. Diagnosis of urolithiasis and rate of spontaneous passage during pregnancy. *J Urol* 2011;186(6):2280-2284.
14. Cordoliani YS, Ait-Ameur A, Lahutte M, Dion AM. Risk from prenatal exposure to ionizing radiation. *J Radiol* 2005;86 (5 Pt 2):607-608.
15. Chaliha C, Stanton SL. Urological problems in pregnancy. *BJU Int* 2002;89(5):469-476.
16. White WM, Johnson EB, Zite NB et al. Predictive value of current imaging modalities for the detection of urolithiasis during pregnancy: a multicenter, longitudinal study. *J Urol* 2013; 189(3):931-934.
17. Laing FC, Benson CB, DiSalvo DN, Brown DL, Frates MC, Loughlin KR. Distal ureteral calculi: detection with vaginal US. *Radiology* 1994;192(2):545-548.
18. Masselli G, Derme M, Laghi F et al. Imaging of stone disease in pregnancy. *Abdom Imaging* 2013;38(6):1409-1414.
19. Shokeir AA, Mahran MR, Abdulmaaboud M. Renal colic in pregnant women: role of renal resistive index. *Urology* 2000;55: 344-347.
20. ACOG Committee Opinion No. 376. Nalbuphine hydrochloride use for intrapartum analgesia. *Obstet Gynecol* 2007;110(2 Pt 1):449.
21. Guichard G, Fromajoux C, Cellarier D et al. Management of renal colic in pregnant women, based on a series of 48 cases. *Prog Urol* 2008;18(1):29-34.
22. Lewis DF, Robichaux AG, 3rd, Jaekle RK, Marcum NG, Stedman CM. Urolithiasis in pregnancy. Diagnosis, management and pregnancy outcome. *J Reprod Med* 2003;48(1):28-32.
23. Loughlin KR, Ker LA. The current management of urolithiasis during pregnancy. *Urol Clin North Am* 2002;29(3):701-704.
24. Song Y, Fei X. Diagnosis and operative intervention for problematic ureteral calculi during pregnancy. *Int J Gynaecol Obstet* 2013;121(2):115-118.
25. Semins MJ, Trock BJ, Matlaga BR. The safety of ureteroscopy during pregnancy: a systematic review and meta-analysis. *J Urol* 2009;181(1):139-143.
26. Johnson EB, Krambeck AE, White WM et al. Obstetric complications of ureteroscopy during pregnancy. *J Urol* 2012;188(1):151-154.
27. Hoscan MB, Ekinci M, Tunckiran A, Oksay T, Ozorak A, Ozkardes H. Management of symptomatic ureteral calculi complicating pregnancy. *Urology* 2012;80(5):1011-1014.
28. Practice guidelines for obstetric anesthesia: an updated report by the American Society of Anesthesiologists Task Force on Obstetric Anesthesia. *Anesthesiology* 2007;106(4):843-863.