Use of Inverted Fluoroscope's C-arm During Endoscopic Treatment of Urinary Tract Obstruction in Pregnancy: A Practicable Solution to Cut Radiation

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OBJECTIVES To describe the use of pulsed fluoroscopic guidance, to perform endoscopic procedures in pregnant women, by inverting the fluoroscope's c-arm using a lead thyroid collar to shield the fetus from the direct X-ray beam. The use of radiation during treatment of pregnant patients with urolithiasis remains a recurring dilemma.

METHODS Between May 2006 and December 2008, endoscopic treatment due to ureteral stones was attempted in 8 pregnant women. In all cases, we use an inverted fluoroscope's c-arm during endoscopic treatment associated with 2 lead neck thyroid collars to shield the uterus, protecting the fetus from direct radiation. Indication for treatment was symptomatic ureteral stones unresponsive to medical treatment in 7 and persistent fever in 1.

RESULTS Mean ureteral stone size was 8.1 ± 4.8 mm, located in the left ureter in 5 (62.5%) cases. Three (37.5%) patients had stone located in the upper ureter, 2 (25%) in the middle ureter, and 3 (37.5) in the distal ureter. In 6 cases, ureteral stones were treated using the semi-rigid ureteroscope, whereas in 1 case a flexible ureteroscope was needed. One woman was treated with insertion of a double-J stent due to associated urinary infection. No women has early delivery related to the endoscopic procedure, and all neonates were perfectly normal.

CONCLUSIONS We present a technique for endoscopic procedures in pregnant women inverting the fluoroscope's c-arm and protecting the fetus from the direct X-ray beam. This practical approach should be specially considered when no portable ultrasound and radiologic assistance in available in the operating room. UROLOGY 75: 1505–1508, 2010.

Although the incidence of urolithiasis requiring hospital admission during pregnancy is relatively low, this condition still has an increased risk of premature labor.[1] In most cases, initial treatment should be conservative, as approximately 80% of patients will pass their stones spontaneously.[2] However, in some patients, when surgical intervention is necessary, ureteroscopy with stone retrieval has been considered safe and effective in all stages of pregnancy, provided that the appropriate endourologic expertise and equipment are available.[3,4] In cases where stones are proximal in the collecting system or in those with infected hydronephrosis, insertion of an indwelling ureteral double-J stent, avoiding extreme manipulation of urinary system, is highly recommended.

The advent of real-time ultrasonography guidance provides an alternative, but primary fluoroscopic guidance is still the preferred technique to perform most endoscopic procedures.[5] To our knowledge, the use of inverted fluoroscope's C-arm during endoscopic management of urinary tract obstruction in pregnancy has not been described in the published data. To evaluate the feasibility of this procedure, we describe herein our technique.

MATERIAL AND METHODS

Between May 2006 and December 2008, 33 pregnant women presented with ureteral stones. A total of 25 patients underwent conservative management, as described, and 8 pregnant women underwent endoscopic treatment due to ureteral stones. Relevant demographic data and operative outcomes were abstracted from medical records. All patients were submitted to urinary cultures at admission. In all patients, conservative approach was started with hydration; analgesics and antibiotics were administered only in cases with proven urinary tract infection. The indications for endoscopic treatment were severe renal colic unresponsive to adequate analgesics in 7 and persistent fever

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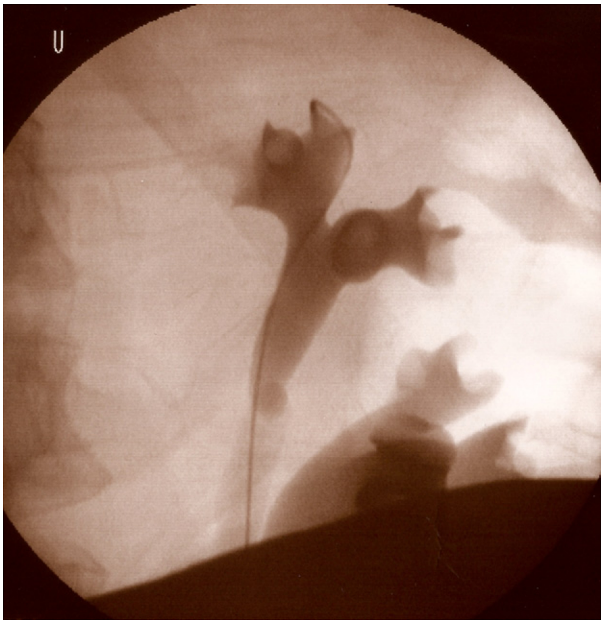

Figure 1. Fluoroscopic picture showing the effect of the shielding. After the retrograde pyelography, a safety hydrophilic guidewire can be visualized in the upper tract.

with marked renal dilatation in 1. No patient needed nephrostomy as urinary diversion, as we could successfully treat all patients endoscopically.

The patients' cohort presented a mean age of 29.6 ± 4.8 years with 29.2 ± 3.7 weeks of gestation. The mean stone size treated was 8.1 ± 4.8 mm, located in the left ureter in 5 (62.5%) cases. Three (37.5%) patients had stone located in the upper ureter, 2 (25%) in the middle ureter, and 3 (37.5%) in the distal ureter.

Surgical Procedure

All procedures were carried out with patients under spinal anesthesia. All women were placed on the operating table in an oblique position, with the left side down to decrease the pressure of the pregnant uterus on the inferior vena cava. Ultrasonography was available throughout the procedures for constant fetal evaluation. Briefly, after the retrograde pyelography, a safety hydrophilic guidewire was positioned smoothly in the upper tract (Fig. 1). In all cases, we use an inverted fluoroscope's c-arm during endoscopic treatment associated with 2 lead neck thyroid collars to shield the uterus, protecting the fetus from direct radiation, as show in Fig. 2. Limited pulsed fluoroscopy was used to visualize the guidewire in the upper tract. We used a commercially available Philips BV Pulsera C-Arm, (Philips Healthcare, Best, The Netherlands), with an exposure rate of 71 kV and 2.4 mA. Fluoroscopy times varied from 8 to 14 seconds (time necessary to view the passage of ureteral guidewire and correct positioning of ureteral stent).

Ureteral stones were treated using a 6.9F semi-rigid ureteroscope (Wolf 8702.402) or a flexible ureteroscope (7.5F Karl Storz Flex-X). Basket retrieval of stones was performed carefully under direct ureteroscopic visualization. Stone fragmentation was performed using the holmium laser, when needed. Our preferred laser settings (Medilas H, Wave Light Laser Technology, Germany) was 1 Joule at 8 Hz, with a total power of 8 W using a 200 μm (Dornier LightGuide Super 200) core sized

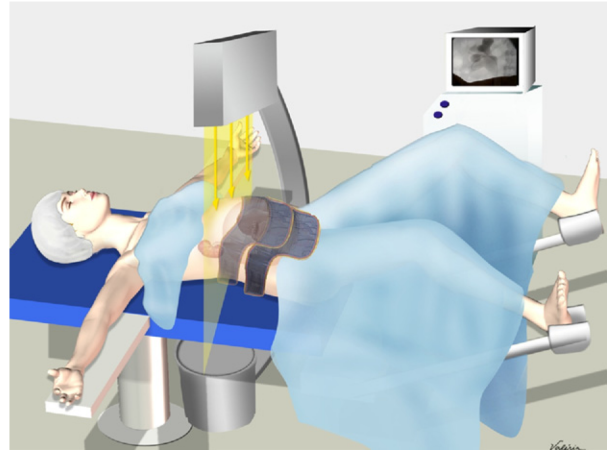

Figure 2. A safety guide can be visualized in the upper tract using an inverted fluoroscope's c-arm. The x-ray tube is located above the table emitting radiation through the patient, and 2 lead thyroid collars is used to shield the uterus protecting the fetus from direct x-ray beam.

fiber. After the ureteral stone was adequately treated, a double-J stent was placed with pulsed fluoroscopy assistance to check adequate renal pelvic position. Stents attached with pull-strings were used when stones were completely fragmented or retrieved. In these cases, stent removal was performed 1 week later on an outpatient basis.

RESULTS

Of 8 women, 7 underwent ureteroscopic treatment that was performed without dilation of the ureteral orifice. In 6 cases, ureteral stones were treated using the semi-rigid ureteroscope, including 1 in the upper ureter. In these cases, ureteral calculi were extracted without fragmentation, with a stone basket under direct vision in 4. Two stones required fragmentation with laser before extraction.

In 1 case, the stone was located near to ureteropelvic junction, thus a flexible ureteroscope was needed to achieve an adequate view of the stone. The instrument was introduced without an access sheath through its placement over a guidewire under pulsed fluoroscopic guidance, also using the pelvic lead rubber protection of radiation. The stone was fragmented until very small pieces (<2 mm) remained, obviating the need of basket stone retrieval.

One woman presented at 34 weeks of gestation with proximal ureteral stone associated with severe renal pelvic dilatation and acute upper urinary tract infection was treated with insertion of a double-J stent, avoiding manipulation of urinary system. Although she complained of dysuria due to the catheter, the double-J was removed 2 weeks after the delivery, when she underwent an ureteroscopic procedure definitive treatment of the stone.

The medium operating time was 41 minutes (range, 35-50 minutes), and mean postoperative hospital stay was 2 days (range, 1-3 days).

No women has early delivery related to the endoscopic procedure, and all neonates were perfectly normal. At ultrasound examination, approximately 2 months after delivery, all women were stone free and without dilatation of the renal pelvis.

COMMENT

When urolithiasis requires treatment during pregnancy, it is imperative that a multidisciplinary team make the patient aware of all alternative therapies with potential risks to the mother as well as the fetus.[1] Most symptomatic ureteral stones in pregnancy pass spontaneously with conservative therapy. However, 15%-30% of pregnant patients will require active intervention, which include uncontrolled pain, sepsis, obstruction of a solitary kidney, obstetric complications, and poor access to urology care. In this setting, ureteroscopy is now considered as the procedure of choice because of its safety and effectiveness in all stages of pregnancy, with stone-free rates of 70%-100%. Besides, it is associated with a significant decrease in hospital stay, and has the advantage over ureteral stents and nephrostomy because it does not involve additional procedures, such as stents or nephrostomy replacement, during pregnancy.[6]

Regarding radiological work-up for urinary lithiasis diagnosis during pregnancy, the low-dose computed tomography (CT) is accepted as second-line in the radiologic evaluation of urinary stones during pregnancy. Ultrasonography is the procedure of choice because it does not involve ionizing radiation; however, ultrasound sensitivity may be as low as 50%. The main advantage of low-dose CT is the high sensitivity (95%) with acceptable radiation doses (average exposure radiation of 705 Mrad = 0.7 rad = 0.007 Gy or 7 mGy).[7]

The use of double-J stent to bypass urinary obstruction in pregnant women has been documented in several series.[8,9] However, ureteroscopy with basket stone extraction allows for definitive treatment, thus avoiding stent changes and the complications associated with internal stents, including irritative lower urinary tract symptoms, an increased risk of ascending infections. Stents have to be replaced every 6-8 weeks (independently to pregnancy trimester) to avoid encrustation and recurrent infections, resulting in further inconvenience and potential risks for the patient. Some investigators suggested that the preferred technique for urinary diversion should be percutaneous nephrostomy before 22-week gestation and ureteral stent in later pregnancy.[6-9] However, in our service, we find ureteral stenting safer than placing a nephrostomy (even with the drawback of multiple changes, if used in early pregnancy). Nephrostomies carry the additional risk of bleeding during the procedure, with the obvious possibility of maternofetal stress. The use of stents attached with pull-strings after ureteroscopic procedures, that we systematically removed 1 week later, avoids this inconvenience of repeated ureteral stents changes.

Limitations on the use of ionizing radiation are one of the factors that contribute to treatment challenges during pregnancy. Although fetal exposures of $<$50 mGy have not been associated with an increase in fetal anomalies, the risk–benefit ratio must be always carefully weighed.[10] Concern regarding radiation exposure during stent placement has led some authors to propose that endoscopic placement of ureteral stents should be guided by real-time ultrasound, as an alternative approach. Although ultrasound-guided stent placement is an effective and safe method, this procedure needs a radiologic assistance as well as a portable ultrasound accessible in the operating room, which are not yet always available in every hospital.[8] Furthermore, with ultrasonic guidance in a few cases, stents needed to be replaced. This results from the technical difficulties inherent to ultrasound imaging, and we find it easier to place urinary catheters fluoroscopically (easier to see and accompany the ascension).[8]

The effects of radiation exposure can be classified as deterministic and stochastic. The deterministic occur principally above a threshold dose and are manifested as clinical damage, primarily because of cell killing, although damage to individual cells will take place at lower doses. The stochastic effects occur some time after exposure and consist of damage to nuclear material in the cell, which can be transmitted to descendants of exposed individuals. Information on radiation-induced cancer is available from many epidemiologic studies.[11]

Ionizing radiation is a potential teratogen, whose dependent action has not been well defined. During pregnancy, the absorbed fetal dose should be considered. Effects of ionizing radiation depend on gestational age during exposure, besides fetal dose absorbed. There is no evidence either in humans or animals that exposure to diagnostic radiation ($<$0.5 Gy) is associated with an increase in congenital malformations. The risk of anomalies is considered negligible at 5 rad (0.05 Gy) or less, and the risk of malformations is substantially increased only at doses above 15 rad (0.15 Gy). Most diagnostic procedures give a fetal dose $<$0.05 Gy (pelvic and abdominal CT, 0.025 and 0.0088 Gy, respectively). Considering the additional protection of a lead apron over the uterus, there is an obvious decrease in fetal absorbed dose.[11,12]

According to gestational period, radiation-induced teratogenesis effects and estimated threshold doses are as following: (1) before implantation (0-2 weeks after conception)—death of embryo, 50-100 mGy; (2) organogenesis (2-8 week after conception)—congenital abnormalities (skeleton, eyes, and genitals), 200 mGy; (3) fetal period (8-15 weeks)—severe mental retardation, intellectual deficit, and microcephaly, $>$60 mGy; (4) after (16-25 week)—mental retardation, 250-280 mGy.[11,12]

Estimated absorbed fetal dose for CT abdomen or pelvis is approximately 25-30 mGy. According to White et al, low-dose protocols that alter pitch, *z* axis modulation, and mAs diminish this dose to 7 mGy. Regarding abdominal and pelvic anteroposterior radiographs, absorbed fetal doses are estimated to be approximately 1.5-4 mGy. With the addition of lead aprons to protect the fetus during ureteroscopy, ultimately ureteroscopy using radioscopy has become an acceptable procedure during pregnancy.[7]

The endoluminal sonography with a 20-MHz transducer passed endoscopically has also been described to assist with placement of an indwelling ureteral stent in patients who are pregnant. However, this study has not specified the cost of the procedure.[13]

Usually the X-ray tube rests under the patient table, while the fluoroscopic image intensifier is located above the table. As the tube emits the radiation, we inverted fluoroscope's c-arm so as to use the thyroid collars to shield the uterus from the direct X-ray beam.

Fluoroscopically guided procedures use low-energy X-rays that rapidly attenuate as the beam penetrates tissue. Therefore, absorption is most intense at the surface, where the beam enters the patient, and doses decrease with depth of soft tissue.[14] However, scatter and leakage radiations are produced as secondary radiation from fluoroscopy; they usually are $<1\%$ of the incident beam.[5] The dose rate depends on variables, such as beam incidence, source-to-skin distance, field size or pulsed vs continuous fluoroscopy. Pulsed fluoroscopy reduces the dose rate to skin by emitting the X-ray beam as a series of short, strobe-like pulses rather than continuously.[14]

The lack of measuring scatter and leakage radiation doses under the thyroid protector are the drawback of this study. However, we described the use of inverted fluoroscope's C-arm during endoscopic management of urinary tract obstruction in pregnancy. Our technique has the advantages of not limiting the radioscopy arch during the procedure, and also facilitates to move the lead apron during the procedure. With the lead apron under the patient's back, both things would be more difficult. In a previous study regarding absorbed radiation doses at ureteroscopic procedures (rate of 71 kV, 2.4 mA and mean fluoroscopy time of 78 seconds), the surgeon was more affected by scatter radiation, and lower legs were most affected part of the body with 11.6 μGy of absorbed radiation dose (with C-arm at its normal position).[15] With the inverted C-arm, probably legs would be more protected, whereas hands and eyes are more affected by scatter radiation. Regarding surgical personnel, everyone in the surgical room usually uses body and neck protectors (which reduce transmission by 100-fold). Also, since we use fluoroscopy times that are comparatively very small (<15 seconds), radiation exposure is much lower. The ultimate objective is to protect the fetus from radiation; we do believe that surgical personnel are not at risk by the scatter radiation because (1) ureteral procedures are rare in pregnant patients, when we believe that this technique would be worthwhile; (2) lead aprons and shields are used by surgical personnel, with 100-fold reduction of radiation transmission; (3) fluoroscopy times are low due to which we use it only to verify that the guidewire and ureteral stents reached the renal pelvis.

This simple procedure should be validated in larger series and may be a useful tool to assist ureteral stone management in pregnant women who will ultimately require intervention with no additional costs to the conventional equipment necessary endourologic procedures.

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