Postoperative Color Doppler Sonography of the Ureteral Jets to Detect Ureteral Patency in Laparoscopic Hysterectomy

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Objective: *To assess the accuracy of color Doppler sonography of the ureteral jets in detecting ureteral injury for gynecologic patient who had undergone laparoscopic hysterectomy.*
Material and Method: *A prospective study was performed on 170 patients scheduled for laparoscopic hysterectomy. The operations were performed for benign gynecologic disease. All patients had pre-and post-operative color Doppler sonography of the ureteral jets to determine ureteral patency. Transabdominal color Doppler sonography was used to evaluate the presence or absence of the ureteral jets from both ureteric orifices. The time for detection of the first jet and the number of jets in five minutes were recorded separately for each side. Preoperative assessment was used as control. Statistical analysis was performed by using Wilcoxon signed ranks test, considering $p < 0.05$ as significant. If there was absence of the ureteral jet on one or both sides, the patient was sent to repeat color Doppler sonography on the next day. Intravenous pyelography was performed to confirm ureteral injuries when the repeat examination was still found abnormal.*
Results: *Bilateral ureteral jets were demonstrated by color Doppler sonography in 168 of the 170 patients. In two patients, postoperative examination demonstrated the absence of the ureteral jet on the left side. Intravenous pyelography was performed and confirmed left ureteral obstruction. They underwent left ureteroneocystostomy. In 168 patients, bilateral ureteral jets were demonstrated in either preoperative or postoperative examination. The time for detection of the first jet was not significantly different between preoperative and postoperative examination of either the right side ($p = 0.189$) or the left side ($p = 0.694$). The number of jets in five minutes was not significantly different between preoperative and postoperative examination of either the right side ($p = 0.854$) or the left side ($p = 0.675$).*
Conclusion: *Color Doppler sonography is a simple and reliable technique that may be used to evaluate ureteral jets into the bladder in patients who underwent laparoscopic hysterectomy. The time for detection of the first jet and the number of jets in five minutes are not affected by the postoperative status. The presented test may be a good screening test to detect ureteral injuries following laparoscopic hysterectomy.*

Keywords: *Ureteral patency, Ureteral jets, Color Doppler sonography, Pelvic surgery*

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Iatrogenic ureteral injuries can occasionally occur after gynecologic surgeries. These are mainly due to anatomic proximity of the reproductive and lower urinary tracts. Iatrogenic injury of the ureter is one of the most serious complications of pelvic surgery. Clinical symptoms may include fever, chills, flank pain, urinary tract infection or urinoma. The absence of immediate postoperative symptoms does not exclude ureteral injuries, some may be asymptomatic and thus undiagnosed. The method of diagnosis of such damage is intravenous pyelography. This test is frequently unpleasant for the patient and is not without risk. Ultrasonographic assessment of intravesical ureteral jets was described by Dubbins et al[1]. They have shown that with the use of ultrasound, it is possible to demonstrate urine entering the bladder and called it ureteral jet phenomenon. Since then, literature on the subject has accumulated[2,3]. Kremer et al[4] suggested that ureteral jets visualization was secondary to the difference in specific gravity of the injected urine and the urine within the bladder. The introduction of color

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Doppler flow imaging was employed to simplify demonstration of ureteral jets[5-10].

As operative laparoscopy is increasingly performed to manage gynecologic procedures, the potential for surgically induced trauma to the ureter also increases. Gynecologic procedure that may incur ureteral injury includes laparoscopic hysterectomy[12-18]. The purpose of the present study was to evaluate the accuracy of color Doppler sonography for the detection of ureteral jets. The authors hypothesized that color Doppler sonography of the ureteral jets in postoperative laparoscopic hysterectomy may serve as a tool for the evaluation of ureteral patency.

Material and Method

The present study obtained approval from Charoenkrung Pracharak Hospital's ethics committee for research of Bangkok Metropolitan Administration. Between November 2006 and October 2008, 170 consecutive gynecologic patients undergoing laparoscopic hysterectomy in the Department of Obstetrics and Gynecology, Charoenkrung Pracharak Hospital were recruited in the present study. The procedure was explained and consent form was approved prior to the present study. All of the approached women agreed to participate. Women with a history of urological disease or previous urological surgery were excluded from participation. Demographic data were collected. All patients underwent preoperative transabdominal color Doppler ultrasonographic assessment of ureteral jets. A G E logiq 3 ultrasound machine with a 3.5 MHz probe was used for the evaluation. The urinary bladder was scanned by using a transabdominal suprapubic approach with a transverse section, angled caudally. A wide sample gate color Doppler was applied to cover the ureteral jets. A low-pulse repetitive frequency, moderate receiver gain were used to optimize visualization. Prior to the examination, the patients were asked not to empty their bladders in order to create a window for visualization of the ureteral jets. Fifteen minutes before the ultrasound examination was performed, approximately 600-1,000 ml of water was administered orally. The scanning was placed in an angle to view both ureteral orifices simultaneously. All patients underwent scanning for at least five minutes. The entire examination was recorded by DVD for further analysis. The presence or absence of the right and left ureteral jets were observed. The time for detection of the first jet and the number of jets in five minutes on each side were recorded. Two days after laparoscopic hysterectomy, the patients underwent postoperative color Doppler ultrasonographic assessment of ureteral jets again. The examination was recorded by DVD for at least five minutes.

Statistical analysis

The demographic data were presented as numbers, percentages, means with standard deviation (SD), or medians with range. The preoperative and postoperative tests were time for detection of the first jet and the number of jets in five minutes. These data were compared using Wilcoxon signed ranks test with $p < 0.05$ to be significant.

Results

The mean age of the women in the present study was 43.6 ± 5.8 years (range 28-58 years) and the mean body mass index (BMI) was 24.8 ± 4.0 kg/m^2. Their demographic data are presented in Table 1.

Table 1. Demographic and intraoperative data (n = 170)

Characteristics	Mean ± SD	Median (range)	Number (%)
Age (years)	43.6 ± 5.8	-	-
Body mass index (kg/m^2)	24.8 ± 4.0	-	-
Parity	-	2 (0-6)	-
Previous pelvic surgery*	-	-	54 (31.8%)
Uterine weight (gm)	307.5 ± 179.1	-	-
Operative time (min)	198.6 ± 61.6	-	-
Estimated blood loss (ml)	506.9 ± 403.8	-	-
Patients transfused	-	-	37 (21.8%)

* Previous pelvic surgery included cesarean section, adnexal surgery, and myomectomy (excluding tubal ligation)

Table 2. Indication for laparoscopic hysterectomy (n = 170)

Indication	Number of patients (%)
Myomas	119 (70)
Adenomyosis	21 (12.4)
Cervical intraepithelial neoplasia	12 (7)
Endometrial hyperplasia	7 (4.1)
Ovarian cyst	5 (2.9)
Endometriosis	4 (2.4)
Abnormal uterine bleeding	1 (0.6)
Pelvic pain	1 (0.6)

In 170 patients, 149 patients had received laparoscopic-assisted vaginal hysterectomy and 21 patients had received total laparoscopic hysterectomy. The indications for laparoscopic hysterectomy are presented in Table 2.

Bilateral ureteral jets could be demonstrated in both preoperative and postoperative examinations in 168 of 170 patients. In two patients, postoperative examinations demonstrated the absence of ureteral jet on the left side. Preoperative examinations of both patients were reviewed and demonstrated bilateral ureteral jets. Intravenous pyelography were performed and confirmed distal obstruction of the left ureter in both patients. In the first patient, ureteral injury occurred in laparoscopic-assisted vaginal hysterectomy and bilateral salpingo-oophorectomy. After diagnosis, the patient was corrected by left ureteroneocystostomy and double-J stent placement. Left distal ureteral injury was found to be caused by bipolar electrocoagulation. The complication of the second patient was followed by total laparoscopic hysterectomy. The left distal ureteral obstruction was found to be caused by suturing at the vaginal stump. Left ureteroneocystostomy with double-J stent insertion was performed on the fourth postoperative day.

The result of 168 patients that had bilateral ureteral jets demonstrated in either preoperative or postoperative examinations is presented in Table 3. The median time for detection of the first jet on the right side was 19.0 (1-240) seconds, and on the left side was 21.5 (1-266) seconds in preoperative examination. In the postoperative examination, the median time for detection of the first jet on the right side was 19.0 (2-270) seconds, and on the left side was 20.0 (2-240) seconds. There was no statistically significant difference in the time for detection of the first jet on the right side ($p = 0.189$) and the left side ($p = 0.694$) between preoperative and postoperative examinations. The median number of ureteral jets in five minutes was 10.0 (3-35) on the right side and 11.0 (3-38) on the left side for preoperative examination. In the postoperative examination, the median number of the ureteral jets in five minutes was 10.0 (1-40) on the right side and 11.0 (2-35) on the left side. There was no statistically significant difference in the number of jets in five minutes on the right side ($p = 0.854$) and the left side ($p = 0.675$) between preoperative and postoperative examinations.

Discussion

Ureteral injury remains a serious complication in gynecologic surgery. This type of injury is associated

Table 3. Ureteral jets findings in preoperative and postoperative examination (n = 168)

	Time for the first jet (second)		
	Preoperative examination	Postoperative examination	p-value
Right side (median with range)	19.0 (1-240)	19.0 (2-270)	0.189
Left side (median with range)	21.5 (1-266)	20.0 (2-240)	0.694
	Number of jets in 5 minutes		
	Preoperative examination	Postoperative examination	p-value
Right side (median with range)	10.0 (3-35)	10.0 (1-40)	0.854
Left side (median with range)	11.0 (3-38)	11.0 (2-35)	0.675

p-value by Wilcoxon signed ranks test

with high morbidity, ureterovaginal fistulas and the potential loss of kidney function. The incidence of ureteral injury after laparoscopic hysterectomy was reported at about 1%[12,17]. Most injuries took place during laparoscopic parts of the hysterectomy and may be caused by electrocoaggulation, sharp dissection, suture ligation or endoscopic linear stapler[13,14]. It had been shown that around two thirds of ureteral injuries were not recognized intraoperatively[17]. The gold standard method for diagnosis such damage is intravenous pyelography. This test frequently causes unpleasantness to the patient, and may pose some risks. Generally, IVP is reserved for complicated or symptomatic cases. It is impractical to perform IVP in all patients because of the potential risks. Several published reports have shown that with the use of ultrasound, it is possible to demonstrate urine entering the bladder[1-3]. The ureteral jet phenomenon has been attributed to the presence of acoustic interfaces between fluids of different specific gravity[4]. Sonographic detection of ureteral jets depends on the specific gravity difference between urine in the bladder and that in the ureter. Testing should be undertaken with a bladder that contains urine, of higher specific gravity. The urine that has been excreted prior ingestion of water. After ingestion of water to enhance new urine formation, the specific gravity drops. The echogenic stream created by the urine jet also produces a Doppler shift that can be detected by color Doppler ultrasound. Small density differences can be detected by color Doppler ultrasound because of its high sensitivity. The introduction of color Doppler ultrasound has enabled non-invasive evaluation of ureteric function. Burg et al[7] showed that color Doppler ultrasound could enable the diagnosis of complete or partial obstruction due to ureteric calculi. Tal and co-workers[19] reported the use of color Doppler ultrasound and intravenous pyelography in 25 patients, whose postoperative ureteric obstructions were suspected. They concluded that color Doppler ultrasound may be a good screening test for ureteric occlusion following pelvic surgery. Since then, several articles have described the use of postoperative color Doppler ultrasonographic assessment of ureteral patency in gynecologic surgery[20-23].

In the present study, all 170 patients underwent laparoscopic hysterectomy either with or without salpingo-oophorectomy. Bilateral ureteral jets were seen in both preoperative and postoperative examinations in 168 patients. Only two patients demonstrated the absence of ureteral jet on the left side and their obstructions were confirmed by intravenous pyelography. The first case was a 46-year-old patient indicated for laparoscopic-assisted vaginal hysterectomy and bilateral salpingo-oophorectomy. The diagnosis was myoma uteri with 640 gram uterine weight. The uterus was rather bulky. After IVP, she received exploratory laparotomy and found that the left distal ureter was injured by bipolar electrocoagulation. An ureteroneocystostomy was performed on the fourteenth postoperative day. The second case was a 36-year-old patient indicated for total laparoscopic hysterectomy. The diagnosis was adenomyosis with uterine weight 220 gram. An ureteroneocystostomy was performed on the fourth postoperative day. In both patients, a double-J stent was placed for three months and they were recovered after stent removal.

One hundred sixty eight patients demonstrated bilateral ureteral jets in both pre-operative and postoperative examinations. The time for detection of the first jet did not differ significantly in either the right side ($p = 0.189$) or the left side ($p = 0.694$) between preoperative and postoperative examinations. There was no statistically significant difference in the number of jets in five minutes on the right side ($p = 0.854$) and the left side ($p = 0.675$) between preoperative and postoperative examinations. This may be due to minimal ureteral manipulation in the presented study group. In the present study, there are some limitations because the authors could not perform intravenous pyelography for all patient. The authors limited IVP for the patients detected with absence of ureteral jet during ultrasonography. Some limitation are caused by the small number of true positive cases. The result is based on a small sample size that should be confirmed in a larger study group.

Conclusion

The presented study has demonstrated that postoperative color Doppler sonography is a simple, reliable, and non-invasive method for early detection of ureteral injuries after laparoscopic hysterectomy. Nowadays, the authors routinely use this method in all patients who have laparoscopic hysterectomy. The advantage include safety, convenience, low cost, and simplicity.

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Potential conflicts of interest

None.

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การตรวจคลื่นเสียงความถี่สูงดอปเลอร์ เพื่อวินิจฉัยการบาดเจ็บของท่อไตในผู้ป่วยที่ได้รับการผ่าตัดมดลูกโดยใช้กล้องส่องช่องท้อง

สงวน โล่ห์จินดารัตน์, สาวิตรี สุวิกรม, สุภลาภ พวงสอาด

วัตถุประสงค์: *เพื่อศึกษาการใช้คลื่นเสียงความถี่สูงดอปเลอร์ในการตรวจหาการบาดเจ็บของท่อไตในผู้ป่วยที่ได้รับการผ่าตัดมดลูกโดยใช้กล้องส่องช่องท้อง*

วัสดุและวิธีการ: *ทำการศึกษาในผู้ป่วย 170 ราย ที่ได้รับการวินิจฉัยว่ามีพยาธิสภาพทางนรีเวชและมีข้อบ่งชี้ในการผ่าตัดมดลูกโดยใช้กล้องส่องช่องท้อง โดยใช้คลื่นเสียงความถี่สูงดอปเลอร์ ประเมินการทำงานของท่อไตทั้งสองข้างทั้งก่อนผ่าตัดและหลังผ่าตัด ทำการตรวจด้วยคลื่นเสียงความถี่สูงดอปเลอร์ทางหน้าท้อง เพื่อตรวจหาลำปัสสาวะจากรูเปิดท่อไตทั้งสองข้าง จับเวลาตั้งแต่เริ่มตรวจจนเริ่มเห็นลำปัสสาวะจากรูเปิดท่อไตครั้งแรก และนับจำนวนครั้งของลำปัสสาวะจากรูเปิดท่อไตแต่ละข้างในระยะเวลา 5 นาที วิเคราะห์ข้อมูลเปรียบเทียบผลการตรวจก่อนผ่าตัด และหลังผ่าตัดโดยใช้วิธีทางสถิติคือ Wilcoxon signed ranks test ถ้าผลการตรวจหลังผ่าตัดไม่เห็นลำปัสสาวะจากรูเปิดท่อไตข้างใดข้างหนึ่งหรือทั้งสองข้าง ผู้ป่วยจะได้รับการตรวจด้วยคลื่นเสียงความถี่สูงดอปเลอร์อีกครั้ง ในวันต่อมา ถ้าผลการตรวจซ้ำยังพบความผิดปกติ ผู้ป่วยจะได้รับการตรวจยืนยันโดยการทำ intravenous pyelography*

ผลการศึกษา: *สามารถตรวจพบลำปัสสาวะจากรูเปิดท่อไตทั้งสองข้างในผู้ป่วย 168 ราย จากผู้ป่วยทั้งหมด 170 ราย ผู้ป่วยสองรายที่ผลการตรวจคลื่นเสียงความถี่สูงดอปเลอร์หลังการผ่าตัด ไม่เห็นลำปัสสาวะจากรูเปิดท่อไตข้างซ้ายได้รับการตรวจยืนยันการบาดเจ็บของท่อไตข้างซ้ายโดยการทำ intravenous pyelography ผู้ป่วยทั้งสองรายได้รับการผ่าตัด ureteroneocystostomy เพื่อแก้ไขความผิดปกติ ในผู้ป่วย 168 ราย ที่ตรวจพบลำปัสสาวะจากรูเปิดท่อไตทั้งสองข้าง ทั้งก่อนผ่าตัดและหลังผ่าตัด ระยะเวลาตั้งแต่เริ่มตรวจจนเห็นลำปัสสาวะจากรูเปิดท่อไตครั้งแรกเปรียบเทียบก่อนผ่าตัดกับหลังผ่าตัด พบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติทั้งท่อไตข้างขวา ($p = 0.189$) และท่อไตข้างซ้าย ($p = 0.694$) การนับจำนวนครั้งของลำปัสสาวะจากรูเปิดท่อไตแต่ละข้างในระยะเวลา 5 นาที เปรียบเทียบก่อนผ่าตัดกับหลังผ่าตัด พบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติทั้งท่อไตข้างขวา ($p = 0.854$) และท่อไตข้างซ้าย ($p = 0.675$)*

สรุป: *การตรวจคลื่นเสียงความถี่สูงดอปเลอร์เพื่อตรวจลำปัสสาวะจากรูเปิดท่อไตในกระเพาะปัสสาวะ เป็นวิธีการตรวจที่ทำได้ง่ายและสามารถใช้ตรวจในผู้ป่วยที่ได้รับการผ่าตัดมดลูกโดยใช้กล้องส่องช่องท้องเพื่อตรวจหาการบาดเจ็บของท่อไต จากการศึกษาพบว่า การทำงานของท่อไตโดยวัดจากระยะเวลาที่ตรวจพบลำปัสสาวะจากรูเปิดท่อไตครั้งแรกและจำนวนครั้งของลำปัสสาวะจากรูเปิดท่อไตในระยะเวลา 5 นาที ไม่ได้รับผลกระทบจากการผ่าตัดมดลูกโดยใช้กล้องส่องช่องท้อง*