CASE REPORT JSLS

Ureteral Injury Due to a Harmonic Scalpel During Laparoscopic Salpingo-oophorectomy

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ABSTRACT

We present an unusual complication of a ureteral injury occurring during a bilateral laparoscopic salpingo-oophorectomy with the Harmonic scalpel (HS). The case illustrates in the same patient the versatility of the HS as a laparoscopic surgical instrument and energy source while at the same time demonstrating the potential for adverse, unexpected complications.

Key Words: Laparoscopy, Harmonic scalpel, Ureteral injury.

INTRODUCTION

Laparoscopic surgery has many advantages over traditional abdominal methods, including smaller incisions, less postoperative pain, less blood loss, lower infection rates, shorter hospital stays, faster recovery time, and faster return to work. Increasing use of laparoscopic surgery has led to reports of increasing numbers of urinary tract complications after such procedures. Most important among these injuries are those involving the ureter. With the increasing use of laparoscopic surgery, particularly laparoscopic hysterectomies, a concomitant increase has occurred in ureteral injuries reported to happen during this procedure.[1] However, laparoscopic salpingo-oophorectomy is a procedure that also places the ureter at risk and is performed much more frequently than laparoscopic hysterectomy. The case detailed below is an example of such an occurrence. Interestingly, it is only the second case of this type of injury occurring specifying use of the Harmonic scalpel that could be found after an English literature review utilizing PubMed and Ovid databases from 1995 through 2008. This particular case also illustrates the advantages and potential disadvantages of the use of this instrument and energy source in gynecologic endoscopic surgery.

CASE REPORT

The patient is a 49-year-old, G0P0, perimenopausal female with a last menstrual period (LMP) of 9/19/07 who was admitted in October of 2007 for an enlarging, complex right adnexal mass measuring 4cm in size. For the year prior to the LMP, the patient had been having infrequent menses and hot flashes. Serial ultrasounds and CT scans of the abdomen and pelvis over a 6-month period demonstrated enlargement of the mass with no evidence of ascites or pelvic adenopathy. The patient's past history was significant for 1 laparotomy and 2 laparoscopies for resection of extensive pelvic endometriosis and lysis of adhesions. In addition, myomectomies were performed during one of the laparoscopies. Subsequent to the prior procedures, the patient underwent 2 inguinal herniorrhaphies with endometriosis resected from the inguinal canal on both occasions. The gynecologic history was also significant for 3 hysteroscopies for Asherman's syndrome

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and 10 failed IVF attempts. The patient's only other past medical history was significant for hypothyroidism for which she was taking levothyroxine. The patient was then admitted for probable laparoscopic bilateral salpingo-oophorectomy, possible hysterectomy. Preoperative laboratory data were all within normal limits including a CA 125 antigen of 5 (normal <21).

Physical examination on admission revealed a thin female in no apparent distress. The general and breast examinations were unremarkable. The abdomen was flat and demonstrated multiple well-healed scars from previous surgical procedures. It was soft and nontender. The liver and spleen were not palpably enlarged. No mass or evidence of ascites was apparent on examination. Pelvic examination revealed a normal vulva, vagina, and cervix. The uterus was retroverted, irregular, and 8cm to 10cm in size.

The right adnexum contained a 4-cm, nontender, mobile mass. The left adnexum was not palpable. Recto-vaginal examination confirmed the pelvic findings, no intrinsic rectal mass was palpable, and the stool was guiac-negative.

Intraoperative findings revealed a 4-cm to 5-cm probable endometrioma of the right ovary that was remarkably free of adhesions and small subserosal uterine myomas. There were dense adhesions of cul de sac peritoneum to the posterior lower uterine segment. The left tube and ovary were densely adherent to the pelvic sidewall just above the ureter, to the posterior broad ligament and to the upper half of the left side of the uterus. The tube was wrapped around the fibrotic remnant of ovary. The appendix was unremarkable. There were several powder burn lesions of endometriosis on the pelvic peritoneum. Visualized portions of stomach, diaphragm, liver, small and large bowel were unremarkable. No unusual amount of pelvic fluid was present, and no implants were noted on any of the parietal or visceral peritoneal surfaces.

With the right ureter readily apparent through the patient's thin retroperitoneum and 5-cm to 6-cm below, the right infundibulopelvic ligament was coagulated and divided without difficulty utilizing the Harmonic scalpel at power level 3. The right tube and ovary were then removed also with the Harmonic by coagulating and dividing its remaining attachments to the uterus. No blanching of tissue was noted near the ureter, which was under constant view of the 2 surgeons throughout this process. Because of the dense adhesions of the fibrotic left tube and ovary, the left pelvic sidewall was opened to allow identification of the ureter on that side. It was found to be adherent to the ovarian vessels for several centimeters along the left infundibulopelvic ligament. Using cold scissors and the Harmonic scalpel (HS), we freed the ureter with some difficulty from the vessels so that they could be coagulated and divided with the Harmonic scalpel. The remainder of the dense adhesions to the posterior broad ligament and uterus were carefully lysed in a similar fashion and with some difficulty so that the left tube and ovary were eventually excised completely and removed. Finally, the cul de sac adhesions to the posterior lower uterine segment were lysed. To achieve complete hemostasis, fulguration with a few short bursts from the unipolar cautery was necessary. This fulguration, however, occurred well away from both ureters. Because of the extensive left adnexal dissection and concern for the integrity of the left ureter, indigo carmine dye was given intravenously by the anesthesiologist. No dye was present in the pelvis, which was noted to be draining into the Foley bag. In addition, cystoscopy was performed at the completion of the laparoscopic surgery and blue dye was seen to be effluxing from both ureteral orifices.

When the patient arrived in the recovery room, clear fluid was noted to be draining from the right lower quadrant trocar incision. No blue dye was noted, and the drainage resolved by the next morning. The patient was seen on postoperative day 3 complaining of bloating and abdominal discomfort. She was passing only small amounts of flatus. She did not complain of fever or chills. Examination revealed minimal abdominal distension. The incisions were clean and intact with no drainage. Bowel sounds were normal. The abdomen was soft and nontender. A Ducolax rectal suppository was ordered, and the patient was advised to return in 1 to 2 weeks or sooner if needed. The patient was seen 10 days later. At that time, she complained of nausea relieved by food and was now taking Prilosec. She was having normal bowel movements and denied fever. She also noted that she had been having increased bloating and abdominal discomfort for several days. Physical examination at that time demonstrated a flat, soft, nontender abdomen with healing incisions. Bowel sounds were normal. Pelvic examination revealed that the vulva and vagina were unremarkable. Examination of the cervix revealed that no discharge or cervical motion tenderness was present. The uterus was retroverted, irregular, and 8cm to 10cm in size. The adnexal areas were free of any mass or tenderness. The patient was reassured and asked to return in 2 weeks.

The patient saw her gastroenterologist 10 days later because of abdominal distension. In spite of a relatively "benign" physical examination, he referred her for a CT scan of the abdomen and pelvis without contrast. The CT

demonstrated a large amount of abdominal fluid with normal-appearing liver and kidneys. She was admitted for paracentesis, which was suggestive of urine. Cystoscopy with bilateral retrograde pyelograms demonstrated a surprisingly normal left ureter and normal efflux of clear urine from the right ureteral orifice. The retrograde pyelogram on the right side, however, revealed a ureteral fistula at the level of S-1. A J-stent was placed and the patient was discharged. Approximately 2 months subsequently, the stent was removed and the fistula had healed. A degree of stenosis secondary to scarring was found and dilated. A second J stent was placed and was removed approximately 6 weeks to 8 weeks later with acceptable patency of the ureter at that time.

DISCUSSION

Ureteral injuries have been recognized as a potential complication of gynecologic surgery for more than a century. In spite of various diagnostic and surgical procedures developed with the specific intent of avoiding this complication, ureteral injuries continue to occur. Ureteral injury also carries with it a very high medico-legal risk, and, consequently, is the subject of many lawsuits in the United States today. The most common major gynecologic surgery performed worldwide is hysterectomy. There are approximately 600 000 hysterectomies performed per year in the US.[1,2] There are also approximately 200 000 procedures for prolapse, 135 000 procedures for incontinence, and numerous salpingo-oophorectomies.[3,4,5] Many of the latter procedures are performed laparoscopically for a variety of indications including, most recently, for prophylaxis of ovarian cancer. All of these procedures expose the ureter to significant risk for injury in even the most experienced surgeon's hands.

The use of the HS in endoscopic surgery has been extensive due to its ability to coagulate and dissect effectively in close association to vital structures without the risk of electrical injuries. In addition, its use is usually associated with less heat production than that produced by most electrical surgical instruments with the possible exception of the LigaSure coagulator. Consequently, less heat production should reduce the incidence of collateral thermal injury, including ureteral injuries. However, animal studies have shown that heat production is dependent on several factors, most important of which are power settings and application times. The experimental literature concerning peak heat production and the ability of the Harmonic scalpel to produce thermal injuries has been mixed and study conclusions somewhat conflicting. Some of the confusion probably is due to variations in experimental design including differences in use of the instrument, heat measurements, tissues used, and methods of assessing collateral damage.

In an instructional video produced by the manufacturer, the Harmonic scalpel is described as achieving its surgical effects by producing tissue temperatures of under 100°C. The surgeon using the LCS Ace instrument is advised that vessels up to 5 mL may be sealed in 4 seconds to 6 seconds utilizing power level 3. The surgeon is cautioned, however, not to fire the shears with the blades closed when no or a small amount of tissue is present. This technique known as "abuse mode" will result in generation of high blade temperatures and, consequently, in longer cooling times. Under such conditions, the risk of adjacent tissue injury is potentially greater. (Harmonic. DVD-ROM, DSL# 06–0820; 2006: Ethicon Endo-Surgery, Inc.)

Seven experimental animal studies were reviewed for this paper.[6–12] All attempt to describe the potential for thermal injury utilizing various energy sources. Of these 7 studies, 4 failed to report any activation times, and one study (Kadesky et al[6]) gave a time estimate for only some procedures preformed and did not specify the power level used.[6,7,11,12] Significantly, in this study, dissection adjacent to the ureter (power settings, application times, and distance not specified) produced no visible damage. Histologic studies, however, revealed transmural ureteral damage similar to that found with electrocautery.[6] Only 3 studies attempted to measure temperatures in adjacent tissues, 2 with infrared cameras and 1 with direct tissue thermocouples.[8,10,12]

Using both in vitro and in vivo studies on various porcine tissues, Koch et al[8] utilized thermocouples to measure tissue temperatures generated at various distances by the Harmonic scalpel and histologic analysis to assess collateral damage. They demonstrated temperatures of >40°C at 1 mm from the blades and ≤ 6 degrees at 2 mm or more in vivo. No coagulation necrosis was noted more than 2 mm from the blades, when level 3 was used for <10 seconds or level 5 for <5 seconds. Since denaturation of tissue proteins leading to thermal damage occurs at temperatures exceeding 40°C, they concluded that the Harmonic scalpel could be used safely beyond 3mm of vital structures.

Using anesthetized pigs and temperature mapping with infrared cameras, Emam et al[10] clearly showed the relationship between temperature, power settings, and application times with the Harmonic scalpel. Power settings of

3 for 10 seconds generated blade temperatures of approximately 70°C to 75°C and temperatures of approximately 50°C at a distance of 10mm. At level 5 for 5 seconds, blade temperatures measured 124°C with a temperature of approximately 90°C at 10 mm. Blade temperatures were ≥200 degrees at power level 5 for 10 seconds. Under these conditions, tissue temperatures 10mm from the blade ranged between 130° to 145°. It is noteworthy that the temperatures recorded in this study with the infrared camera were higher than those recorded in the study by Koch et al[8] utilizing tissue thermocouples.

Kim et al[11] also used infrared technology to compare heating and cooling temperatures generated in a porcine model between the ACE Harmonic scalpel, LigaSure, and the Gyrus plasmakinetic bipolar device. The Harmonic was used at power level 3, but no application times were specified. The highest temperatures were achieved by the Harmonic scalpel (234°C) and demonstrated a temperature surge at the onset of the cooling phase. The ACE also had the longest cooling times (>40 s to decrease to 60°C).[11]

Finally, the animal studies of Landman et al[9] and Diamantis et al[12] measured histologic damage at various distances from several different energy sources without measuring tissue temperatures and with the HS and LigaSure achieving the least thermal damage.

The only other reported ureteral injury that specified the use of the Harmonic scalpel during gynecologic laparoscopic surgery was reported by Seman et al.[13] In this study, 4 ureteral injuries occurred in a series of 436 consecutive laparoscopic hysterectomies.

One injury occurred with a stapling device, 2 with bipolar cautery, and one while a Harmonic scalpel was being used in addition to "a small amount of bipolar cautery." Unlike injury in the present case, these injuries were all at the level of the uterine arteries. The authors speculated that their nonstaple injuries were either due to devascularization or thermal injury to the ureter. They also mentioned that an additional factor might have been failure to skeletonize the uterine vessels that may have allowed for thermal spread along the peritoneum.

The present case is an example of how effective an instrument the HS can be for safely dissecting and coagulating around vital structures, including the ureter. Although much of the difficult dissection of the left adnexum was accomplished with cold scissors, the HS was used at times very close to the ureter. Brief bursts at level 5 were used for dissection, and level 3 was used for coagulation and division of the dissected left ovarian vessels that at this time were <1 cm to 2 cm from the ipsilateral ureter. And this was accomplished without any injury to the ureter.

In contrast, removal of the uninvolved right adnexum was accomplished with the HS at level 3. This resulted in an injury to the right ureter that was at least 5cm to 6cm below the point of coagulation and division of the ovarian vessels. The mechanism of this injury is difficult to determine. Certainly, it was not likely due to a malfunction of the instrument because the right adnexum was removed before the left and no change in instruments was necessary.

One possible mechanism is that the injury was due to devascularization of a segment of ureter. Coagulation of the ovarian vessels probably results in interruption of the ureteral arterial contribution from that ovarian artery. If the anastomosis along the ureteral adventitia were to be congenitally underdeveloped in that area, a zone of ischemia leading to focal necrosis and subsequent fistula could occur.

Another possibility is that the injury was secondary to a thermal injury from the HS. One of 2 possible scenarios could have taken place that might produce conditions for such an accident to occur. Although the dissection and vessel coagulation on that side seemed to proceed smoothly and uneventfully, it is not standard protocol to time every firing of the HS during surgery. A situation could have occurred whereby a thin strip of peritoneum covering the infundibulopelvic ligament may have extended into the proximal 25% of the HS blade length. This portion of the blade generates the least heat and requires a longer time to divide, unless the surgeon simultaneously elevates the blades to place the tissue on tension. Because one does not generally place vascular pedicles on tension to avoid premature separation and incomplete vessel sealing, it is conceivable that the vascular tissue separated while a thin piece of peritoneum remained between the proximal segment of the blades. This would result in the distal, hotter three-fourths of the blades coming in contact with each other (ie, abuse mode) while an additional 5 seconds to 10 seconds of firing might have been necessary to allow for complete division of the peritoneum. Under these conditions, a rapid rise in blade temperature with significant spread of heat for a greater distance than usual would be expected. Such a scenario would agree with the findings of Kim et al[11] who recorded the highest tissue temperatures when applying the HS to peritoneum. The authors believe that the avascular peritoneum became

hotter due to the lack of a heat pump effect created by a rich blood supply in other tissues. However, the authors do not mention whether they simultaneously placed the peritoneum on tension while activating the HS, as would typically be used during surgery when rapidly dividing thin, avascular tissues with minimal tissue heating. Even given this scenario in the present case, it is difficult to imagine that activating the HS for an additional 5, 10, or even 5 seconds in the abuse mode could generate enough heat to cause a thermal injury to a ureter at least 5cm to 6cm away. A second and more plausible scenario could occur under the above conditions whereby excessive heating of the HS blades could cause superheating of the water vapor created by the cavitational effect. The vapor dissects tissue planes rapidly and could have conceivably traveled down the infundibulopelvic ligament with enough heat to result in a thermal ureteral injury.

CONCLUSION

The Harmonic scalpel has proven itself to be an effective, versatile, and safe instrument for the performance of complex laparoscopic surgery, and, therefore, is favored by many gynecologic surgeons. However, like most energy sources, unusual circumstances can occur that may result in unexpected injuries. This case raises issues that should caution surgeons who utilize this instrument to pay particular attention to application times during dissection. This is particularly true of dissection of peritoneum at high power settings (level 4 and 5) during which tissue may fail to divide at the proximal portion of the blades while allowing contact between the distal blade ends. The rapid rise in temperature that would occur under those conditions could result in unexpected thermal injury in adjacent structures.

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