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Normal Variations of Abdominal and Pelvic Anatomy Evaluated at Laparoscopy

CEANA H. NEZHAT, MD, FARR NEZHAT, MD, ANDREW I. BRILL, MD, AND CAMRAN NEZHAT, MD

Objective: To describe certain anatomic relationships in the pelvis and abdominal wall at laparoscopy and the effect of body mass index (BMI) on those parameters.

Methods: In 103 patients we determined the following: distances from the midline to each medial umbilical ligament and the respective inferior epigastric vessels; distances between each ureter and the ipsilateral uterosacral and the infundibulopelvic ligament; relative visibility of the ureters, umbilical and uterosacral ligaments, and the sacral promontory; and the presence and location of congenital bowel attachments to the pelvic walls.

Results: The right ureter ran significantly closer to the infundibulopelvic and uterosacral ligaments than the left ureter. The right inferior epigastric vessels and umbilical ligament coursed more laterally than did those on the left. Both sets of inferior epigastric vessels, and the left umbilical ligament and ureter were significantly more difficult to identify in overweight women. In 69% of the subjects, the uterosacral ligaments were found to be thick or moderately thick. In two thirds, the sacral promontory was more than 75% visualized. Congenital bowel attachments were observed in 74.8% of subjects on the left pelvic sidewall, and 48.5% on the right.

Conclusion: Left and right pelvic anatomy are not necessarily mirror images laparoscopically. The course of the inferior epigastric vessels can be more difficult to identify in overweight patients. Despite marked obesity or congenital bowel attachments to the pelvic side walls, both ureters can usually be identified. The proximity of the ureter to the uterosacral and infundibulopelvic ligaments reaffirms the need to identify them before dissection. (Obstet Gynecol 1999;94:238–42. © 1999 by The American College of Obstetricians and Gynecologists.)

As laparoscopy is used increasingly for abdominal and pelvic operations, its limitations and potential complications must be understood. The insertion of trocars with diameters up to 20 mm exposes abdominal walls and large abdominal blood vessels to risk for injury.[1,2] In obese patients, this risk is amplified by the technical challenge of a large panniculus and the common difficulty in identifying the lower epigastric vessels. Trocar insertion in such cases becomes practically a blind procedure without an ideal measure of control.

The risk for surgical complications is inextricably linked to the surgeon's fundamental knowledge of instrumentation, surgical technique, applicable biophysics, and relevant anatomy. Pelvic anatomy at laparoscopy, compared with conventional surgery, has a different appearance because of the electronically rendered two-dimensional view and the optical element of magnification, and it can differ physically because of the effects of the pneumoperitoneum, steep Trendelenburg position, or the use of uterine manipulators. Studies of ureteral injuries after laparoscopy, particularly during adnexal surgery and hysterectomy,[3–7] might be partly attributable to these alterations.

Although knowledge of "laparoscopic anatomy" is essential to prevent injury to vital structures, normative literature on this topic is limited. One report describes the relationship between the umbilicus and the aorta,[8] and another examined the position of relevant anterior abdominal wall vessels.[2] In the present study we evaluated the visibility and the relative symmetry of several elements of normal pelvic anatomy and the abdominal wall landmarks for identifying the inferior epigastric vessels, in 103 women who had diagnostic or operative laparoscopy for different gynecologic conditions.

Materials and Methods

The study population included 103 middle-class women, aged 16 to 64 years (mean 32 years) with a gravidity between 0 and 6 (mean 1.1 ± 1.7) and parity 0 and 8 (mean 0.6 ± 1.2). Weight ranged from 41 to 104 kg (mean 62 kg), body mass index (BMI) ranged

From the Departments of Gynecology and Obstetrics and Surgery, Stanford University School of Medicine, Palo Alto, California; and the Center for Special Pelvic Surgery, Atlanta, Georgia; and the Department of Obstetrics and Gynecology, University of Illinois at Chicago, Chicago, Illinois.

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Table 1. Patient Characteristics

Characteristic	Mean ± standard deviation	Range
Age (y)	32 ± 9	16–64
Gestation	1.1 ± 1.7	0–6
Parity	0.6 ± 1.2	0–8
Height (cm)	164 ± 7	150–183
Weight (kg)	62 ± 11	41–104
Body mass index (kg/m^2)	23 ± 4	16–36

from 16 to 36 kg/m^2 (mean 23 kg/m^2), and height ranged from 150 to 183 cm (mean 164 cm). The ethnic distribution included 76 (73.8%) white women, eight (7.8%) black, three (2.9%) Jewish, one (0.9%) Asian, and 15 (14.6%) Hispanic or other. All subjects had elective diagnostic or operative laparoscopy between May 1993 and April 1995 (Table 1). Patients with significant distortion of the lower abdominal wall from prior laparotomy or whose pathologic characteristics obscured pertinent pelvic anatomy, such as severe adhesions or endometriosis, posterior cul-de-sac obliteration, large uterine or adnexal mass, as well as those with prior retroperitoneal dissection were excluded from the study. The hospital investigational review board determined that the standard surgical consent form was adequate. All of the evaluations were done in one center (Center for Special Pelvic Surgery, Atlanta, Georgia) by two of the authors (CHN and FN).

Surgery was done using general endotracheal anesthesia after an overnight fast, with mechanical bowel preparation and orogastric tube to empty the stomach contents.[9,10]

In each subject, the primary 10-mm trocar was placed at the base of the umbilicus, and two or three ancillary 5-mm trocars were inserted approximately 5 cm cephalad to the pubic symphysis, one in the midline, and the other two lateral to the right and left inferior epigastric vessels and medial to the anterior superior iliac spines, respectively. The patient was placed in a 30- to 45-degree Trendelenburg position. After initial laparoscopic entry and before any further manipulation of the abdominopelvic contents, the visibility of the sacral promontory was recorded as quartile of exposure by the degree to which it was covered by the mesentery of the sigmoid colon.

At the level of the suprapubic ancillary trocar sites, the distances between each medial umbilical ligament and the ipsilateral inferior epigastric vessels were measured. The distance between the midline and each inferior epigastric vessel complex was then calculated by defining the midline as half the distance between the lateral umbilical ligaments.

Bilaterally, at the level of the bifurcation of the common iliac vessels, the distance between the ureter and the ipsilateral infundibulopelvic ligament was assessed. The distance between the ureter and the ipsilateral uterosacral ligaments was recorded at the point where the ureter could no longer be seen coursing through the medial broad ligament. All distances were measured by the operator, who used a ruled suction-irrigator probe while the uterus was being anteflexed with a transcervical intrauterine manipulator.

The relative ease of visualizing and identifying the medial umbilical ligament, inferior epigastric vessels, and each ureter was recorded on a four-point Likert scale. The proportionate thickness of each uterosacral ligament was assessed. The presence of congenital bowel attachments was noted and described.

To compare the measurements obtained from the patients' right and left sides, a two-tailed paired Student t test was done. Relationships between distance measurements and age, height, weight, and BMI were tested by Pearson r correlation coefficients, a two-tailed Student t test, and scatter plots. After dividing patients into three groups based on BMI (thin, average, and overweight) the groups were correlated with mean distance measurements using χ^2 and Fisher exact tests. Probability values of $<.05$ were considered statistically significant in all analyses.

Results

We noted considerable asymmetry in selected elements of pelvic and abdominal wall anatomy. The mean distances between the right sided infundibulopelvic ligament and ureter (2.2 ± 0.7 cm, range 0.5–3.5 cm) and the uterosacral ligament and ureter (1.8 ± 0.90 cm, range 0.5–4.0 cm) were significantly less than the distances measured from the left side (2.6 ± 0.8 cm, range 1.0–4.5 cm and 2.4 ± 0.9 cm, range 1.0–4.0 cm, respectively). The mean distances between the right medial umbilical ligament and inferior epigastric vessels (2.0 ± 1.3 cm, range 0.5–7.5 cm) and the midline and inferior epigastric vessels (5.5 ± 1.4 cm, range 3.5–12.0 cm) were, conversely, significantly greater than comparable measurements of the left side (1.7 ± 1.0 cm, range 0.5–6.0 cm and 5.20 ± 1.0 cm, range 3.0–8.0 cm, respectively) (Table 2).

We found no significant linear or nonlinear relationships between height, weight, age, gravity, parity, or ethnic group and the distances between selected anatomic structures, except for height and the distance between the left uterosacral ligament and the left ureter. The subjects' BMI was not correlated significantly with any measured distance (Table 2). However, higher BMI resulted in significantly poorer visualization of both inferior epigastric vessel complexes, left medial umbilical ligament, and the left ureter (Table 3). Regardless of

Table 2. Mean Distances Between Selected Anatomic Structures

Body mass index	Medial umbilical ligament to inferior epigastric vessels		Midline to inferior epigastric vessels		Infundibulopelvic ligament to ureter		Ipsilateral uterosacral ligament to ureter	
	Right	Left	Right	Left	Right	Left	Right	Left
≤20 kg/m² (n = 25)	2.3 ± 1.8	1.6 ± 0.8	5.9 ± 1.9	5.1 ± 0.8	2.3 ± 0.7	2.6 ± 0.8	2.1† ± 0.8	2.5 ± 0.7
21–25 kg/m² (n = 55)	1.9 ± 0.9	1.7 ± 1.0	5.1 ± 1.5	5.0 ± 1.4	2.2 ± 0.6	2.7 ± 0.6	1.7 ± 0.8	2.4 ± 0.8
≥26 kg/m² (n = 23)	1.7 ± 0.8	1.6 ± 0.7	4.4 ± 1.5	4.2 ± 1.7	2.3 ± 0.7	2.60 ± 0.59	1.6 ± 1.1	2.5 ± 0.8
Total (n = 103)	2.0 ± 1.3*	1.7 ± 1.0	5.5 ± 2.25*	5.1 ± 2.0	2.2 ± 0.7†	2.6 ± 0.8	1.8 ± 0.9†	2.4 ± 0.9

All distances are rounded to nearest 0.1 cm and are given as mean ± standard deviation.
* Mean distances between the structures on the right side were significantly greater than the left.
† Mean distances between the structures on the right side were significantly less than the left.

BMI, however, some portion of the ureters could be seen in most women. At laparoscopic entry, a significant portion of the sacral promontory was visualized in most women (0–25% in 12, 26–50% in 17, 51–75% in eight, and 76–100% in 66 women). In 69% of the women, the uterosacral ligaments appeared thick or moderately thick (Table 4).

Pelvic congenital bowel attachments were noted on the left in 74.8% of women and in 48.5% on the right. One woman had attachments between the rectosigmoid colon and left ovarian fossa. Otherwise, all left attachments could be described in terms of their relation to the infundibulopelvic ligaments or the common iliac vessels (Table 5). The attachments were more ventral on the right side, and 84% of them extended to the anterior abdominal wall. Right lateral sidewall attachments were found in 16% of women.

Discussion

During laparoscopic surgery, the operator must rely on two elements for proper treatment and avoiding injury to the intraperitoneal and retroperitoneal structures—their normal, presumed anatomic location and their visibility and appearance on the video monitor. Compared with the laparotomic view, certain anatomic structures in the abdominal and pelvic cavity can appear differently during laparoscopic procedures because of the effects from pneumoperitoneal pressure, Trendelenburg positioning, and the use of an intrauterine manipulator. However, the magnification should enhance the recognizability of those structures. In this study, we evaluated the degree of visibility of certain anatomic landmarks and their distances to neighboring structures that are commonly reported to be injured during laparoscopic surgery. We acknowledge that the small sample sizes for each BMI category precludes the elimination of possible type 2 errors and might have significantly biased our data.

Before ancillary trocar insertion, the inferior epigastric vessels often can be identified laparoscopically along the abdominal wall below the posterior rectus sheath as they travel between the exit of the medial umbilical ligament and the round ligament. In nonobese patients, our data confirmed that they usually can be visualized. However, identifying their precise location can be impaired by a large abdominal panniculus, prior abdominal incision, or normal anatomic variation. The distance between the inferior epigastric vessels and the midline was 5 to 6 cm at a level 5 cm above the symphysis pubis. This finding concurs with measurements based on computed tomography (CT) that also demonstrated that, running cephalad, these vessels are located more medially.[2] However, averaging bilateral data provides no information regarding symmetry. In very obese women, our data indicated that the risk of

Table 3. Visualization of Selected Structures and Body Mass Index

Structure	≤20 kg/m² (n = 25)		21–25 kg/m² (n = 55)		≥26 kg/m² (n = 23)	
	Poor	Good	Poor	Good	Poor	Good
Left ureter	8	92	13	87	30	70*
Right ureter	4	96	11	89	17	83
Left medial umbilical ligament	8	92	14	86	26	74*
Right medial umbilical ligament	8	92	27	73	13	87
Left inferior epigastric vessel	16	84	27	73	43	57*
Right inferior epigastric vessel	16	84	35	65	43	57*

Statistical comparison of high and low body mass index. All data are given as percentages.
* $P < .05$.

Table 4. Relative Thickness of Uterosacral Ligaments

Ligament	No. (%) of women			
	Underdeveloped	Thin	Moderate	Thick
Left	8 (7.8)	31 (30.1)	35 (34)	29 (28.2)
Right	6 (5.8)	18 (17.5)	37 (35.9)	42 (40.8)

Table 5. Locations of Congenital Bowel Attachments

Location	Total women	Dorsal to vessels	To anterior wall	Ventral to vessels	To lateral wall	Both dorsal and ventral	At the vessels
Left side							
Free of attachments	26 (25.2%)						
Ovarian fossa	1 (1.0%)						
Infundibulopelvic ligament	56 (54.4%)	25 (44.6%)		10 (17.9%)		5 (8.9%)	16 (28.6%)
Iliac vessels	20 (19.4%)	10 (50.0%)		4 (20.0%)		0 (0%)	6 (30.0%)
Total	103 (100%)	35 (34.0%)		14 (13.6%)		5 (4.9%)	22 (21.4%)
Right side							
No. with attachments	50 (48.5%)		42 (84.0%)		8 (16.0%)		

accidentally lacerating the inferior epigastric vessels during accessory trocar insertion can be reduced by anticipating these structures to be somewhat closer to the lateral umbilical ligament on the right side.

The distances from the ureter to the ipsilateral uterosacral and infundibulopelvic ligaments were slightly, but significantly, longer on the left side. Most published data do not include information on symmetry. Hofmeister and Wolfgram,[11] who used cinefluorography and postoperative radiography to measure relationships between the ureter and vaginal hysterectomy ligatures, found distances between the ureter and the uterosacral ligament of 1 to 3 cm. In Gray's Anatomy,[12] it is stated that the ureter is situated "commonly about 2 cm lateral to the supravaginal portion of the cervix of the uterus," varying from 1 to 4 cm. Both reports are consistent with our data, except for the minimum within the range, which we found to be as close as 0.5 cm. Contrary to our findings, the anatomists Freund and Joseph[13] demonstrated that, in cadavers, compared with the left ureter, the right ureter ran farther from the cervix. Several authors[14–16] reference the classic study of Sampson, who in 1904 asserted that manipulating the uterus can affect the relative distance of either ureter. At laparoscopy we used an intrauterine manipulation device to anteflect the uterus, which could explain this seeming contradiction.

Contrary to our expectations, there was no significant correlation between BMI and any measured distance. Similarly, Hurd et al[2] found no significant correlations between BMI and the location of the inferior epigastric vessels and the medial umbilical ligaments, although a trend was noted. In obese women, it is reasonable to presume that the inferior epigastric vessels are farther from the midline than in thinner patients, but these vessels are actually the same distance from the midline. However, BMI did affect the visibility of the inferior epigastric vessels, left medial umbilical ligament, and left ureter. As expected from their comparative anatomic prominence, this relationship was less pronounced with the umbilical ligaments.

In two thirds of the subjects, when placed in the Trendelenburg position with a pneumoperitoneum, the sacral promontory was more than 75% free of the mesocolon. Retroperitoneal entry at this site for presacral neurectomy and paraaortic node dissection is not difficult and requires little, if any, adhesiolysis. Congenital bowel attachments are common, particularly on the left side of the pelvis. These attachments often are near major blood vessels, the ureters, or fallopian tube and ovary. They are not pathologic and should be incised only when surgically indicated, to expose the infundibulopelvic ligament or the ureter at the pelvic brim and to treat otherwise inaccessible abnormalities.

Despite the volume of literature about procedural aspects of operative laparoscopic surgery, little attention has been given to fundamental anatomic considerations. Knowledge of anatomy is essential for adequate treatment and minimization of complications and untoward injuries. Our results shed light on some aspects and interrelationships between critical abdominal wall and pelvic structures for the laparoscopic surgeon. Based on our analysis, anatomic variation and asymmetry should be expected whenever the anatomy is visualized thoroughly during laparoscopic surgery.

References

1. Hurd WW, Pearl ML, DeLancey JO, Quint EH, Garnett B, Bude RO. Laparoscopic injury of the abdominal wall blood vessels: A report of three cases. Obstet Gynecol 1993;82:673–6.
2. Hurd WW, Bude RO, DeLancey JOL, Newman JS. The location of abdominal wall blood vessels in relationship to abdominal landmarks apparent at laparoscopy. Am J Obstet Gynecol 1994;171: 642–6.
3. Grainger DA, Soderstrom RM, Schiff SF, Glickman MG, DeCherney AH, Diamond MP. Ureteral injuries at laparoscopy: Insights into diagnosis, management and prevalence. Obstet Gynecol 1990; 75:839–43.
4. Daly JW, Higgins KA. Injury to the ureter during gynecologic surgical procedures. Surg Gynecol Obstet 1988;167:19–22.
5. Dawling RA, Corrierre JN Jr, Sandler CM. Iatrogenic ureteral injury. J Urol 1986;133:912–5.
6. Nezhat C, Nezhat F. Laparoscopic repair of ureter resected during operative laparoscopy. Obstet Gynecol 1992;80:543–4.

7. Assimos DG, Patterson LC, Taylor CL. Changing incidence and etiology of iatrogenic ureteral injuries. J Urol 1994;152:2240–6.
8. Hurd WW, Bude RO, DeLancey JOL, Pearl ML. The relationship of the umbilicus to the aortic bifurcation: Implications for laparoscopic technique. Obstet Gynecol 1992;80:48–51.
9. Nezhat CR, Nezhat FR, Luciano AA, Siegler AM, Metzger DA, Nezhat CH. Operative gynecologic laparoscopy: Principles and techniques. New York: McGraw-Hill, Inc., 1995.
10. Nezhat C, Nezhat F, Nezhat C. Operative laparoscopy: Videolaparoscopy and videolaseroscopy. Ann N Y Acad Sci 1994;734:433–44.
11. Hofmeister FJ, Wolfgram RC. Methods of demonstrating measurement relationships between vaginal hysterectomy ligatures and the ureters. Am J Obstet Gynecol 1962;83:938–48.
12. Williams PL, Warwick R, eds. Gray's anatomy. 36th ed. Philadelphia: WB Saunders, 1980:1402.
13. Freund WA, Joseph L. Ueber die Harnleiter—Gebarmutter—=Fistel nebst neuen Unntersnchungen uber das normale Verhalten der Harnleiter im Wiblichen Becken. Berlin Klin Wochenschrift 1869;6:504. Cited in Mattingly RF, Thompson JD, eds. TeLinde's operative gynecology. 7th ed. Philadelphia, Pennsylvania: Lippincott, 1990.
14. Nichols D. Reoperative gynecologic surgery. St. Louis, Missouri: Mosby-Year Book, Inc, 1991.
15. Mattingly RF, Thompson JD, eds. TeLinde's operative gynecology. 7th ed. Philadelphia, Pennsylvania: Lippincott, 1990.
16. Sabiston DC Jr, ed. Textbook of surgery: The biological basis of modern surgical practice. Philadelphia, Pennsylvania: WB Saunders, 1991.

Address reprint requests to:
Camran Nezhat, MD
Stanford Endoscopy Center for Training and Technology
900 Welch Road, Suite 403
Palo Alto, CA 94304
E-mail: info@nezhat.com

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