# Laparoscopic Appraisal of the Anatomic Relationship of the Umbilicus to the Aortic Bifurcation

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## Abstract

**Study Objective.** To determine the cephalocaudal relationship among the umbilicus, aortic bifurcation, and iliac vessels by direct measurement during laparoscopy.

**Design.** Prospective, consecutive study (Canadian Task Force classification II-1).

**Setting.** Tertiary referral center.

**Patients.** Ninety-seven women undergoing operative laparoscopy.

**Interventions.** The distance from the aortic bifurcation relative to the umbilicus was measured in both the supine and Trendelenburg positions with a marked suction-irrigator probe. Patients were stratified into three groups based on body mass index (kg/m$^2$). The anatomic location of the common iliac vessels and course of the left common iliac vein were identified in 68 women.

**Measurements and Main Results.** The position of the aortic bifurcation ranged from 5 cm cephalad to 3 cm caudal to the umbilicus in the supine position, and from 3 cm cephalad to 3 cm caudal in the Trendelenburg position. In the supine position, the aortic bifurcation was located caudal to the umbilicus in only 11% of patients compared with 33% in the Trendelenburg position. This difference was statistically significant for the total study population ($p < 0.0001$) and for the nonoverweight group ($p < 0.01$). In both positions no significant correlation was found between the distance from the aortic bifurcation to the umbilicus and body mass index. Mean ± SD distance of the aortic bifurcation from the umbilicus in the supine position was 0.1 ± 1.2 cm for the nonoverweight group, 0.7 ± 1.5 cm for the overweight group, and 1.2 ± 1.5 cm for the very overweight group. Respective values in Trendelenburg position were 1.0 ± 1.1, -0.4 ± 1.2, and -0.2 ± 1.3 cm. The common iliac artery was caudal to the umbilicus in four women. The space between common iliac arteries was always at least partly occupied by the left common iliac vein, and was completely filled in 19 women (28%).

**Conclusions.** The cephalocaudal relationship between the aortic bifurcation and umbilicus varies widely and is not related to body mass index in anesthetized patients. Regardless of body mass index, the aortic bifurcation is more likely to be located caudal to the umbilicus in the Trendelenburg compared with the supine position. Its

*presumed location can be misleading during Veress needle or primary cannula insertion, and a more reliable guide is necessary for this procedure to avoid major retroperitoneal vascular injury.*

As laparoscopy is performed increasingly for abdominal and pelvic surgery, its limitations and potential for complications must be clearly understood. Blind entry into the peritoneal cavity through an infraumbilical incision with either the Veress needle or sharp cannula presents several challenges;· the propensity for preperitoneal insufflation and injury to the underlying structures must be minimized. Albeit rare, potentially catastrophic injury to the major retroperitoneal vessels does arise from this technique.[1–5] Risk of vascular injury is minimized by using a technique that ensures controlled entry and is predicated on underlying anatomic relationships. Invasion of the retroperitoneum can be related to use of excessive force, failing to follow the midline axis, and using an incorrect angle relative to the abdominal wall to insert the Veress needle or cannula downward into the peritoneal cavity.

Based on presumptions that the aorta and inferior vena cava bifurcate before entering the pelvis and that the umbilicus is located caudally, it was traditionally recommended to insert the cannula at a 45-degree angle into the midline of the pelvis.[3] However, if the distance from the abdominal wall to the vessels is carefully judged, a 90-degree angle can be safe.[6–8] Whereas the main benefit of perpendicular entry is to minimize the chance of preperitoneal insufflation, some recommended this method only in obese women, in whom preperitoneal insufflation is more likely to occur.[9, 10]

As the rapid evolution and reporting of laparoscopic surgery continues to be procedure based, only one study examined the anatomic association between the umbilicus and underlying retroperitoneal vessels, based on information extracted from randomly selected radiographic images of unanesthetized women.[11] To define these critical relationships further, and to gauge the wisdom of conventional teaching, we evaluated the cephalocaudal position of the aortic bifurcation relative to the umbilicus in women undergoing operative laparoscopy, in both the supine and Trendelenburg positions, correlated with body mass index (BMI). Whenever possible, positions of iliac vessels as they coursed between aortic bifurcation and sacral promontory were also recorded.

## Materials and Methods

The distance between the aortic bifurcation and umbilicus was measured in 97 consecutive women (age 15–65 yrs, mean 35.3 yrs) who underwent operative laparoscopy at the Center for Special Pelvic Surgery. Subjects were divided into three groups according to BMI. The nonoverweight group consisted of 69 women whose BMI was below 25 kg/m$^2$, the overweight group 16 women with BMI between 25 and 30 kg/m$^2$, and the very overweight group 12 women whose BMI was more than 30 kg/m$^2$. Mean ± SD age of the women in the three groups was 32 ± 9.2, 38.1 ± 9.4 and 34.3 ± 9.0 years, respectively.

The institutional review board was informed of the study, and each patient received detailed preoperative counseling.

All measurements were performed by the same author (FN). Women whose abdominal wall was deformed from earlier surgery were excluded from the study, as were those with significant adhesions or other pathology that obstructed the view of the aortic bifurcation. Whenever possible, locations of common iliac vessels were recorded, including the path of the left common iliac vein between the aortic bifurcation and sacral promontory.

### Operative Procedure

Surgery was performed under general endotracheal anesthesia after an overnight fast, complete bowel preparation, and orogastric tube emptying of stomach contents. The women were placed in dorsal lithotomy position and surgery was begun in the supine position. After elevating the abdominal wall with two towel clips placed 1 to 2 cm lateral to the umbilicus by the primary surgeon and assistant, a 10-mm cannula was inserted directly through the base of the umbilical fossa and into the peritoneal cavity at a 90-degree angle. Carbon dioxide pneumoperitoneum at 15 mm Hg was established. A 10-mm operative

**TABLE 1. Location of Aortic Bifurcation in Relationship to the Umbilicus in Supine and Trendelenburg Positions**

| BMI (kg/m$^8$) | Weight ± SEM (kg) | Cephalad[a] | | Same Level[b] | | Caudal[c] | |
|---|---|---|---|---|---|---|---|
| | | Supine | Trendelenburg | Supine | Trendelenburg | Supine | Trendelenburg |
| < 25[d] (n = 69) | 58.3 ± 7.5 | 71 | 46 | 19 | 26 | 10 | 28 |
| 25–30 (n = 16) | 75.1 ± 10.1 | 56 | 31 | 31 | 19 | 13 | 50 |
| > 30 (n = 12) | 83.4 ± 9.8 | 75 | 17 | 8 | 41.5 | 17 | 41.5 |
| Totals[e] (N = 97) | 64.0 ± 14.6 | 69 | 40 | 20 | 27 | 11 | 33 |

[a]Greater than 0.5 cm cephalad of the umbilicus.
[b]Less than 0.5 cm cephalad or caudal of the umbilicus.
[c]Greater than 0.5 cm caudal of the umbilicus.
[d]$p < 0.01$ supine vs Trendelenburg.
[e]$p < 0.0001$ supine vs Trendelenburg.

laparoscope was placed through the umbilical cannula sleeve. Two or three 5-mm accessory cannulas were inserted under direct vision approximately 5 to 7 cm suprapubically, including one in the midline, and the other two lateral to the inferior epigastric vessels and medial to the anterior superior iliac spines, respectively.

Initially, a 5-mm laparoscope was passed through the midline suprapubic cannula. A marked suction-irrigator probe was then inserted through the umbilical 10-mm cannula sheath and directed perpendicular to the operating table, down to the level of the aortic bifurcation. Another marked suction-irrigator probe was placed through the midline suprapubic port, and a grasping forceps for bowel retraction through the remaining lateral suprapubic port. The pneumoperitoneum was then partly released to flatten the abdominal wall as much as possible and minimize distortion of the original anatomic position of the umbilicus.

Using centimeter marks on the suction-irrigator probe placed through the midline suprapubic port, the distance from the tip of the probe inserted through the umbilicus to the aortic bifurcation was measured within ±0.5 cm. No force was exerted on the probe. Great care was taken to obtain precise intraabdominal measurements. All measurements were performed first in steep Trendelenburg position (30 degrees) and repeated in the supine position. The location of the common iliac vessels and course and relationship of the left common iliac vein between the aortic bifurcation and sacral promontory were also evaluated at this time.

**Data Analysis**

Measurements were compared for BMI as a continuous variable using the Spearman rank correlation. The $\chi^2$ test and two-tailed nonpaired Student's $t$ test were used for comparisons among groups. Statistical significance was probability at 0.05.

**Results**

The relative position of the aortic bifurcation was quite variable, ranging from 5 cm cephalad to 3 cm caudal to the location of the umbilicus in the supine position, and from 3 cm cephalad to 3 cm caudal in the Trendelenburg position. In the supine position (Table 1), the aortic bifurcation was located caudal to the umbilicus in only 11% of patients, compared with 33% in Trendelenburg. This difference was statistically significant for the total study population ($p < 0.0001$) and for the nonoverweight group ($p < 0.01$).

In both positions, no statistically significant correlation was found between the distance from the aortic bifurcation to the umbilicus and BMI (Figure 1). The mean ± SD distance of the aortic bifurcation from the umbilicus in the supine position was 0.1 ± 1.2 cm for the nonoverweight group, 0.7 ± 1.5 cm for the overweight group, and 1.2 ± 1.5 cm for the very overweight group. Values in the Trendelenburg position were 1.0 ± 1.1, -0.4 ± 1.2, and -0.2 ± 1.3 cm, respectively.

Both the left common iliac vein (as it crossed to the right side) and right common iliac artery were seen in 68 women and were observed most easily in nonoverweight patients. The space between the two common iliac arteries was always occupied to some degree by the left common iliac vein as it crossed to the right. In 19 (28%) patients this space was completely occupied by the left common iliac vein. The course of this vessel toward the sacral promontory varied, as did its visibility, which depended on the amount of overlying retroperitoneal fibrofatty tissue. The left

## Discussion

Based on radiographically determined thickness of the abdominal wall and the distance between the umbilicus and retroperitoneal vessels in unanesthetized women, it was suggested that to minimize both peritoneal placement and retroperitoneal injury, the angle of placement of the Veress needle or primary cannula be chosen according to patient weight, and placed at 45 degrees in nonoverweight, 45 to 90 degrees in overweight, and 90 degrees in the obese women.[11] However, deductions based solely on geometric relationships among umbilicus, abdominal wall thickness, and linear dimensions of the Veress needle or primary cannula do not account for the highly variable dynamic forces required to penetrate the abdominal wall. Most important, observations in this study reveal that the cephalocaudal relationship between the umbilicus and aortic bifurcation is highly variable, and is not necessarily correlated with the patient's body habitus (BMI). Therefore, unless the depth of insertion is tailored to the thickness of intervening tissues of the abdominal wall, there is no particular angle of insertion that by itself will always ensure the safety of underlying retroperitoneal vessels.

Our observations also emphasize the fact that the close proximity of common iliac vessels to the aortic bifurcation positions these structures at similar risk for injury during infraumbilical insertion of the Veress needle or sharp cannula. In four women, either the right or left iliac arteries were located caudal to the umbilicus. In addition, the space between common iliac arteries was at least partly occupied by the course of the left common iliac vein in all patients, and completely in 28%. In a review of 47 injuries to major blood vessels during laparoscopy, 28 were sustained during insertion of a Veress needle or primary cannula. Of interest, of those 28 injuries, only 6 affected the aorta, whereas the remainder were to iliac vessels.[12] Therefore, whereas a 45-degree insertion angle may successfully direct the Veress needle or cannula caudal to the level of the aortic bifurcation, it does not necessarily obviate potential jeopardy to proximate iliac vessels should the vessels be in midline position. Furthermore, premature Trendelenburg positioning may also increase the risk of retroperitoneal vascular injury by aligning iliac vessels with the axis of a preconceived 45-degree insertion angle, especially in thin patients with little retroperitoneal fatty tissue. With this in mind, prudence dictates that insertion of the Veress
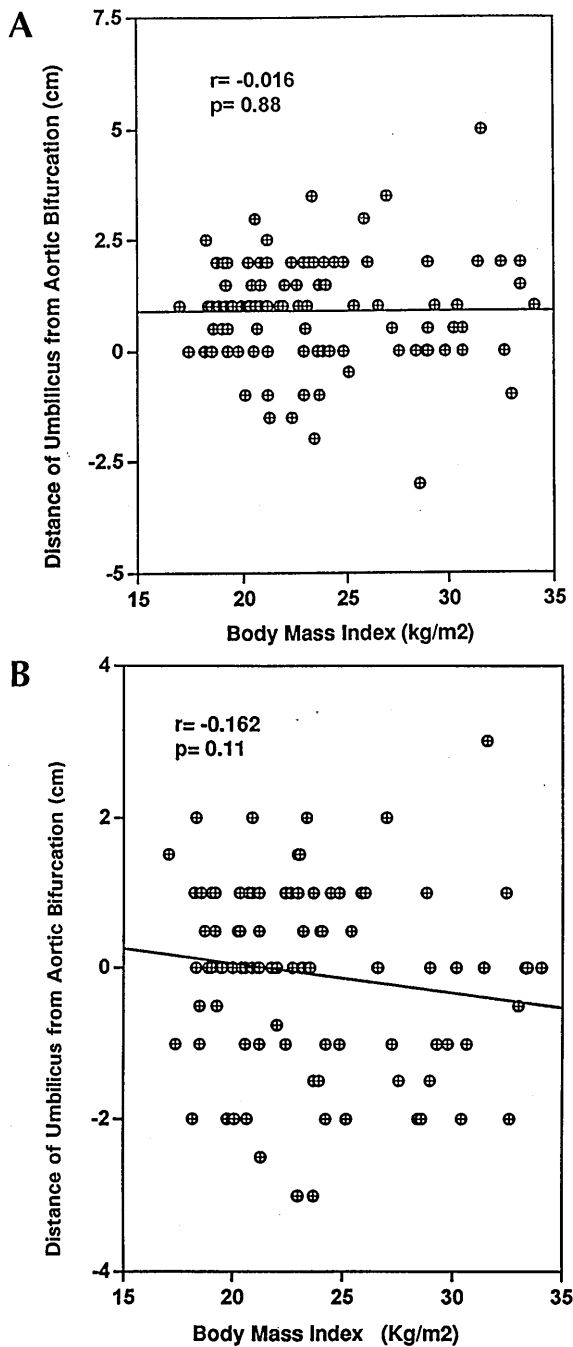


FIGURE 1. Distance between aortic bifurcation and umbilicus in correlation with body mass index for (A) supine and (B) steep Trendelenburg positions.

common iliac artery, not the aorta, was caudal to the umbilicus in three women and the right common iliac artery in one.

needle or primary cannula be done while the patient is maintained in supine position.

The limited variability in location of the aortic bifurcation in relationship to lumbar vertebrae was established in pathologic studies[13, 14] and verified in computerized tomography images in live subjects.[11, 15] In addition, the anatomic relationship between the umbilicus and aortic bifurcation can be altered by placing the patient in dorsolithotomy position.[10] Based on randomly chosen abdominal computed tomography studies performed in 39 unanesthetized women, the location of the umbilicus, but not the aortic bifurcation, was negatively correlated with BMI.[11] In nonobese, overweight, and obese women, the aortic bifurcation was cephalad to the umbilicus by 0.4 cm, 2.4 cm, and 2.9 cm, respectively. Using similar BMI definitions, we could not confirm a correlation between BMI and the location of the aortic bifurcation relative to the umbilicus during laparoscopy. This discrepancy could be related to the smaller size of that study or that it was based on computed tomography images taken from women in the supine position. Although taking specific measurements per se may be more accurate than radiographic images, dynamic changes created by perfusion of living tissues, respiration, Trendelenburg position, and general anesthesia may further explain this inconsistency.

Although operative laparoscopic surgery is a relatively new modality, as with other surgical traditions, early teachings rapidly become habits and can silently evolve into sacred cows. Whenever a particular complication remains associated with a surgical procedure, it is prudent to question whether it is related to the belief system that underlies the technique itself rather than to level of difficulty or operator skill. The risk of injuring the retroperitoneal vessels with the Veress needle or sharp cannula is linked not only to the fact that the anatomic location of these structures may place them directly in line with the angle of insertion.

As demonstrated in this study, regardless of body habitus, no particular angle of insertion can guarantee that these vessels will be completely avoided in every patient. Injury to the vessels may also be related to adequacy of the skin incision, sharpness of the device, degree of abdominal wall elevation, control of force during entry into the peritoneal cavity, presence of intervening fibrotic scar tissue, and native thickness of the abdominal wall. Rather than relying on a particular angle of insertion, which by itself can impart an erroneous sense of security, vascular injury is best averted by using a method that minimizes insertion force and controls the depth of insertion.

Predicated on dimensions of the Veress needle and relative distances from the umbilicus to the aortic bifurcation, to avoid preperitoneal insufflation in an obese patient, a 90-degree angle of insertion could be "safe."[10] Given the variable position of the aortic bifurcation in relation to the umbilicus regardless of BMI, we believe that a similar angle of insertion can be safe in nonobese patients as long as the depth of insertion is carefully tailored to the thickness of the abdominal wall at the base of the umbilicus (up to 3 cm in nonobese and overweight women, 6 cm in the obese[10]) while it is securely elevated to its maximum extent in a similarly perpendicular fashion (90 degrees).

In final consideration, the risk of injuring retroperitoneal vessels during peritoneal entry can be minimized by maintaining the patient in supine position and applying operative techniques that are tailored to the underlying vascular anatomy (which is quite variable) and to the thickness of the intervening abdominal wall. Regardless of whether a 90- or 45-degree angle is used to direct the Veress needle or primary cannula into the peritoneal cavity, matching the depth and force of insertion to the thickness of the subumbilical tissue may be the best sentinel for these vessels.

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