GYNECOLOGY

**Supraumbilical primary trocar insertion for laparoscopic access: the relationship between points of entry and retroperitoneal vital vasculature by imaging**

Jamie Stanhiser, MD; Linnea Goodman, MD; Enrique Soto, MD; Ibraheem Al-Aref, MD; Jenny Wu, MD; Anar Gojayev, MD; Benjamin Nutter, MS; Tommaso Falcone, MD

**OBJECTIVES:** Advances in laparoscopy have demonstrated that supraumbilical primary ports can be desirable in complex cases with large masses. This study evaluated distances to vital retroperitoneal vasculature that were encountered with 45- and 90-degree angle entry from the umbilicus and 2 commonly described supraumbilical entry points at 3 and 5 cm cephalad from the umbilicus.

**STUDY DESIGN:** Retrospective analysis of computed tomography scans of the abdomen and pelvis from 100 randomly selected women who were 18-50 years old with normal anatomy was performed. Three-dimensional models of sagittal sections were generated using IMPAX software. Measurements from the abdominal wall at the umbilicus and 3 and 5 cm cephalad with 45- and 90-degree angles to retroperitoneal structures were performed.

**RESULTS:** With 90-degree angle entry, the abdominal wall thickness (AWT) was thinnest at the umbilicus; however, the thickness at 3 and 5 cm was similar. AWT increased at all sites with 45-degree angle entry, and the same pattern was observed. AWT and intraperitoneal distance positively correlated with body mass index and supraumbilical entry points. With 90-degree angle entry, the aorta was 1.9 cm (95% confidence interval [CI], 1.4–2.4) and 2.5 cm (95% CI, 2.0–2.9) farther away at 3 and 5 cm cephalad compared with umbilical entry. In one-third of the cases, regardless of port placement, a vascular structure other than the aorta was the most anterior vessel. With 45-degree angle entry at the umbilicus, no vessels were encountered. With 45-degree angle entry at 3 and 5 cm cephalad, the aorta was the most anterior vessel in 1% and 2% of cases, respectively, and was noted to be 1.0 cm (95% CI, 1.0–1.0) and 2.3 cm (95% CI, 1.2–3.3) farther away than with 90-degree angle entry. A vessel other than the aorta was encountered in 4% and 7% of cases at 3 and 5 cm, respectively.

**CONCLUSION:** According to theoretic modeling, supraumbilical primary port placement can be implemented safely in laparoscopy. With supraumbilical entry, the distance to retroperitoneal vessels was greater than at the umbilicus. Compared with a 90-degree angle, with a 45-degree angle entry, it was uncommon to encounter vasculature, and all measured distances were greater.

**Key words:** laparoscopic, supraumbilical, trocar, vasculature


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Successful laparoscopic minimally invasive surgery relies on optimal port placement at the beginning of the procedure. Knowledge of the most advantageous port placement from an advanced understanding of anatomy can improve dramatically the surgical team’s operative field exposure and the technical ease and efficiency of the surgery, while reducing surgical injuries. Most injuries in minimally invasive surgery occur at the time of primary entry into the peritoneal cavity because of penetrating damage to either the viscera or the surrounding retroperitoneal vasculature.

The umbilicus commonly is selected as the site for primary trocar insertion because it offers the shortest distance between the skin and the anterior peritoneum and is cosmetically appealing. In addition, its anatomic relation to retroperitoneal vital structures is well understood. Hurd et al in 1991 retrospectively analyzed computed tomography (CT) and magnetic resonance imaging scans of 33 women and measured the distance from the base of the umbilicus to retroperitoneal vessels at 45- and 90-degree angles. It was discovered that, in women with a normal body mass index (BMI), a 45-degree angle had minimal risk of preperitoneal trocar placement or major vessel injury; however, in obese women, only the 90-degree angle consistently avoided preperitoneal placement. Hurd et al in 1992 published a similar anatomic retrospective review of CT images from 35 women and reported that, in women...
with a normal BMI, the umbilicus is 0.4 cm caudal to the aortic bifurcation. However, in overweight and obese women, they reported that the umbilicus is 2.4 and 2.9 cm caudal to the aortic bifurcation, respectively, and that the umbilicus is cephalad to the common iliac as it crosses the midline in all cases.

Despite its common use and its documented relation to vital structures, there are often times in gynecology when an umbilical port is suboptimal. In cases that involve large uteri or pelvic disease, an umbilical port is suboptimal. In cases there are often times in gynecology when documented relation to vital structures, the uterus is especially important to note. The average of this study was to evaluate the retroperitoneal structures that are encountered at 45- and 90-degree angles from the level of the umbilicus and 3 and 5 cm cephalad from it to construct and compare the possible or likely points of injury from umbilical and supraumbilical primary trocar insertion.

**Materials and Methods**

CT scans of the abdomen and pelvis of 100 female patients from the Cleveland Clinic between September 2012 and May 2013 were reviewed retrospectively. Institutional review board exemption status was obtained. Data for patients who had a CT scan performed within the study parameters were sampled randomly and then selected for review based on the inclusion criteria of female patients 18-50 years old with benign conditions and normal anatomy, without anatomic defects, masses, or abnormalities.

Baseline patient characteristics were collected that included age, ethnicity, and BMI for demographic information. Sagittal images from the patients’ CT scans were then reconstructed into 3-dimensional models with the use of the IMPAX software (Agfa Healthcare Corporation, Greenville, SC) for analysis. Entry points were designated along the anterior abdominal wall at the umbilicus and at 3 and 5 cm supraumbilically in the linea alba. Several measurements from these appointed entry points were then made. The distances between the skin and the anterior and posterior peritoneal layers were measured. In addition, the distances between the skin and vital retroperitoneal structures were measured at 90 and 45 degrees from the horizontal. All structures and measurements were identified and obtained by 3 investigators including a radiologist.

**Results**

One hundred women were included. The average age was 36.8 ± 9.7 years, with a range from 19–50 years. There was a broad range of BMI from 13–70 kg/m², with an average of 27.9 ± 8.1 kg/m². Seventy-eight percent of subjects were white; 16% were African American; 3% were Hispanic, and 3% were listed as Other.

When measured at a 90-degree entry angle, the abdominal wall thickness was least at the umbilicus, compared with all other entry points (1.7 cm [95% confidence interval (CI), 1.5–1.9 cm] vs 2.9 cm [95% CI, 2.7–3.2 cm]; P < .001); however, the thickness at 3 and 5 cm was similar (2.8 cm [95% CI, 2.6–3.1 cm] vs 2.9 cm [95% CI, 2.7–3.2 cm]; P = .85). The abdominal wall thickness was increased at all sites when measured at a 45-degree angle of entry; the same pattern was observed with the thinnest measurement at the umbilical entry (2.9 cm [95% CI, 2.6–3.3 cm] vs 4.5 cm [95% CI, 4.0–4.8 cm]; P < .001) and no significant difference between 3 and 5 cm (Table 1). Abdominal wall thickness was correlated positively with BMI at all sites and angles of entry (r > 0.65 and P < .001 in all cases) and was noted to increase 0.14 cm (95% CI, 0.137–0.143 cm) with every point of BMI increase. Abdominal wall thickness was also correlated positively with supraumbilical entry and increased an average of 1.38 cm (95% CI, 1.36–1.39 cm) and 1.42 cm (95% CI, 1.40–1.43 cm), respectively, at entry points 3 and 5 cm above the umbilicus.

To be functional, the trocar length must travel through the abdominal wall and extend into the intraperitoneal cavity; it is advantageous when some shaft length is also superior to the skin to allow for trocar adjustment. Therefore, it was deemed that at least 2 cm of trocar length in excess of the abdominal wall thickness is necessary for optimal trocar placement and use. The standard trocar shaft length is 10 cm; Table 2 provides a

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**Table 1.** Abdominal wall thickness was correlated positively with BMI at all sites and angles of entry (r > 0.65 and P < .001 in all cases) and was noted to increase 0.14 cm (95% CI, 0.137–0.143 cm) with every point of BMI increase. Abdominal wall thickness was also correlated positively with supraumbilical entry and increased an average of 1.38 cm (95% CI, 1.36–1.39 cm) and 1.42 cm (95% CI, 1.40–1.43 cm), respectively, at entry points 3 and 5 cm above the umbilicus.

**Table 2.** The average age was 36.8 ± 9.7 years, with a range from 19–50 years. There was a broad range of BMI from 13–70 kg/m², with an average of 27.9 ± 8.1 kg/m². Seventy-eight percent of subjects were white; 16% were African American; 3% were Hispanic, and 3% were listed as Other. When measured at a 90-degree entry angle, the abdominal wall thickness was least at the umbilicus, compared with all other entry points (1.7 cm [95% confidence interval (CI), 1.5–1.9 cm] vs 2.9 cm [95% CI, 2.7–3.2 cm]; P < .001); however, the thickness at 3 and 5 cm was similar (2.8 cm [95% CI, 2.6–3.1 cm] vs 2.9 cm [95% CI, 2.7–3.2 cm]; P = .85). The abdominal wall thickness was increased at all sites when measured at a 45-degree angle of entry; the same pattern was observed with the thinnest measurement at the umbilical entry (2.9 cm [95% CI, 2.6–3.3 cm] vs 4.5 cm [95% CI, 4.0–4.8 cm]; P < .001) and no significant difference between 3 and 5 cm (Table 1). Abdominal wall thickness was correlated positively with BMI at all sites and angles of entry (r > 0.65 and P < .001 in all cases) and was noted to increase 0.14 cm (95% CI, 0.137–0.143 cm) with every point of BMI increase. Abdominal wall thickness was also correlated positively with supraumbilical entry and increased an average of 1.38 cm (95% CI, 1.36–1.39 cm) and 1.42 cm (95% CI, 1.40–1.43 cm), respectively, at entry points 3 and 5 cm above the umbilicus.
list of the BMIs at which the measured abdominal wall distance with each access location and angle of entry reaches 8 cm and therefore represents the maximum BMI for standard trocar use. At each site, the 90-degree entry angle permitted a higher maximum BMI to accommodate the desired trocar length.

When the trocar was introduced at a 90-degree angle, the aorta was encountered 1.9 cm (95% CI, 1.4–2.4 cm) and 2.5 cm (95% CI, 2.0–2.9 cm) farther away when the entry point was moved 3 or 5 cm cephalad, respectively. (8.5 cm [95% CI, 8.0–9.2 cm] vs 10.1 cm [95% CI, 9.5–10.7 cm] vs 10.6 cm [95% CI, 10.0–11.2 cm]; P < 0.1; Table 1), compared with entry at the umbilicus. However, in approximately one-third of cases regardless of port placement, a vascular structure other than the aorta was the most anterior retroperitoneal vascular structure (30% at umbilicus, 33% at 3 cm, and 36% at 5 cm). Of these cases, the most common anterior vessel was the right common iliac vessels at the umbilicus (43%) and the superior mesenteric vein supraumbilically (67% at 3 cm and 81% at 5 cm; Table 3).

When the trocar was introduced at a 45-degree angle at the umbilicus, no vessels were encountered. When the entry point was moved to 3 or 5 cm cephalad, the aorta was the most anterior retroperitoneal vascular structure in only 1% and 2% of cases, respectively, and was noted to be 1.0 cm (95% CI, 1.0–1.0 cm) and 2.3 cm (95% CI, 1.2–3.3 cm) further away than with 90-degree angle entry. A vessel other than the aorta was encountered in 4% and 7% of cases at 3 and 5 cm, respectively (Table 4). The risk of encountering vasculature was significantly much higher with 90-degree angle entry than with 45-degree angle entry (P < .001).

The distance from the anterior peritoneum to the posterior peritoneum correlated positively with BMI, race other than white, and entry locations 3 and 5 cm cephalad from the umbilicus. With every point of BMI increase, the intraperitoneal distance increased 0.17 cm (95% CI, 0.17–0.18 cm; P < .001). The intraperitoneal distance increased an average of 0.33 cm (95% CI, 0.24–0.42 cm) for race other than white and 0.30 cm (95% CI, 0.28–0.31 cm) and 0.70 cm (95% CI, 0.68–0.71 cm), respectively, for the 3 and 5 cm supraumbilical entry points (P < .001). There was no association between BMI and whether the aorta or another vessel was the most anterior vascular structure that was encountered.

**COMMENT**

The literature supports the effective use of supraumbilical primary port placement in minimally invasive surgery for complex cases with large uteri and pelvic masses and to facilitate robotic assistance. In these cases, the supraumbilical port can improve operative unimpeded manipulation of laparoscopic instruments. The present study evaluated whether the advanced cephalad distance from the umbilicus effects the risks of encountering retroperitoneal vessels when establishing laparoscopic access. Our study confirms that, with both 90- and 45-degree angle entries, the abdominal wall thickness is least at the umbilicus compared with points 3 and 5 cm cephalad. However, abdominal wall thickness does not differ significantly between the 3- or 5-cm cephalad entry points. Intuitively, the distance traveled through the abdominal wall with 90-degree angle entry is less than with a 45-degree angle entry, which our study also confirms. Compared with 90-degree angle entry, the additional abdominal wall distance that must be traversed when the trocar is introduced at a 45-degree angle entry is an average of 1.2 cm (95% CI, 1.0–1.4 cm) at the umbilicus and 1.6 cm (95% CI, 1.4–1.8 cm) with entry at both 3 and 5 cm cephalad. When entry points with 90-degree angle entry are compared, the most anterior vascular structure when entering at the umbilicus is the aorta in 70% of cases and is only 8.5 cm (95% CI, 8.0–9.2 cm) away from the skin at this entry point. Compared with umbilical entry, the most anterior vessel is approximately 1.9 cm (95% CI, 1.4–2.4 cm) and 2.5 cm (95% CI, 2.0–2.9 cm) further away from the 3- and 5-cm supraumbilical skin entry points and is

### TABLE 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Umbilicus, cm</th>
<th>3 cm</th>
<th>5 cm</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-degree abdominal wall thickness</td>
<td>1.7 (1.5–1.9)</td>
<td>2.8 (1.5–1.9)</td>
<td>2.9 (2.7–3.2)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>45-degree abdominal wall thickness</td>
<td>2.9 (2.6–3.3)</td>
<td>4.4 (4.0–4.8)</td>
<td>4.5 (4.1–4.9)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>90-degree distance from skin to retroperitoneal vessel</td>
<td>8.5 (8.0–9.2)</td>
<td>10.1 (9.5–10.7)</td>
<td>10.6 (10.0–11.2)</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Data are given as mean (95% confidence interval).


### TABLE 2

<table>
<thead>
<tr>
<th>Location</th>
<th>Angle, degrees</th>
<th>BMI, kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umbilicus</td>
<td>90</td>
<td>74.98</td>
</tr>
<tr>
<td>Umbilicus</td>
<td>45</td>
<td>64.61</td>
</tr>
<tr>
<td>3 cm SU</td>
<td>90</td>
<td>65.09</td>
</tr>
<tr>
<td>3 cm SU</td>
<td>45</td>
<td>54.73</td>
</tr>
<tr>
<td>5 cm SU</td>
<td>90</td>
<td>64.83</td>
</tr>
<tr>
<td>5 cm SU</td>
<td>45</td>
<td>54.47</td>
</tr>
</tbody>
</table>

BMI, body mass index; SU, supraumbilical.

*The BMI at which 8 cm of the 10 cm of standard trocar length are embodied in the abdominal wall.

the aorta in 67% and 64% of cases, respectively. When the trocar was introduced with a 45-degree angle entry at the umbilicus, no vessels were ever encountered in this study and were encountered in only 5% and 9% of cases at the 3- and 5-cm entry points, respectively. The clinical assumption is that the 45-degree angle was maintained during the entire entry procedure. In clinical practice, the angle may change such as with abdominal wall elevation or other ergonomic considerations. Additionally, with 45-degree angle entry, the aorta was noted to be approximately 1.0 cm (95% CI, 1.0–1.0 cm) and 2.3 cm (95% CI, 1.2–3.3 cm) further away from the skin, compared with 90-degree angle entry at 3 and 5 cm cephalad, respectively.

The increased distance from the skin to retroperitoneal vessels at the 3- and 5-cm entry points compared with the umbilicus most likely is due to the observed increase in abdominal wall thickness at these access points. However, intraperitoneal distance was also observed to increase at these 2 supraumbilical points, albeit to a lesser extent. The increased distance that was observed at these supraumbilical entry points and with the 45-degree angle entry compared with the 90-degree angle entry may translate to a decreased risk of vessel injury when primary laparoscopic access is established with these methods. It is important to remember that standard trocar length is 10 cm; a long trocar for bariatric patients is 15 cm. Similarly, the standard Veress insufflator needle length is 12 cm, and a long Veress needle for bariatric cases is 15 cm. Because these lengths are longer than the measured distance from the skin to the retroperitoneal structures with entry at the umbilicus and nearly equidistant or longer than the distances measured with entry at 3- and 5-cm cephalad, careful control in addition to upward displacement of the abdominal wall is essential when the primary trocar or Veress needle is inserted. Advantageously, elevation of the abdominal wall at the time of laparoscopic entry can be expected to artificially increase these measured distances.

Interestingly, one-third of the time with 90-degree angle entry, regardless of the site of access, the aorta was not the closest vascular structure to be encountered. Initially, we attributed this observation to the high BMI of our study population, because previous studies have found the umbilicus is caudal to the bifurcation of the aorta in obese patients. However, in the present study, there was no significant association between BMI and whether the aorta or another vessel was the most anterior vascular structure that was encountered. Of note, this study did find that both the abdominal wall thickness and the intraperitoneal distance correlated positively with BMI. Table 2 illustrates the maximum BMI for each location and angle of entry for which a standard-length trocar remains useful. This was defined as when 8 of the 10 cm of standard trocar shaft length are embedded in the abdominal wall, leaving 2 cm of trocar length to be divided inferior to the anterior peritoneum and superior to the skin. Greater than the BMIs that are listed in Table 2, a bariatric trocar should certainly be considered, both to avoid failed entry and to improve functionality. If failed entry is observed below these listed BMIs, it is likely due to avulsing the peritoneum from the abdominal wall along an altered angle of entry or “skiving.” In these instances, the trocar can be removed and reinserted with attention to keeping the trajectory true to the appropriate angle.

Jeong et al reported in 2014 that the vertical distance between the umbilicus and the aortic bifurcation in 257 Korean women who were 8–93 years old was correlated negatively with advancing age, so that the distance from the skin to vasculature decreased as a woman’s age increased. Unfortunately, the abdominal wall thickness was not measured in
that study, and so it is unclear whether the observed decreased vertical distance with advancing age was due to decreased abdominal wall thickness, decreased intraperitoneal distance, or a combination of these factors. Our study included only premenopausal women; therefore, when our findings are applied, it should be considered that postmenopausal age may affect the distance from skin to retroperitoneal vital structures and that further study is warranted.

This study was constructed to be a theoretic model from analysis of sagittal CT images and reflects the distances of a noninsufflated abdominopelvic cavity as illustrated in the Figure. With primary insertion of either a trocar or the Veress needle, there is no pneumoperitoneum; therefore, these measured distances are likely applicable. However, once pneumoperitoneum is obtained, these distances are expected to increase because of gas insufflation increasing the space between the anterior and posterior peritoneum. Nonetheless, this study supports that supraumbilical primary port placement theoretically may reduce the risk of retroperitoneal vascular injury because of increased distance from vital structures when laparoscopic access is established. This study also supports the use of a 45-degree angle of insertion, even with higher BMI.

REFERENCES