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Left Upper Quadrant Laparoscopic Instrument Placement: Effects of Insertion Angle and Body Mass Index on Distance to Posterior Peritoneum by Magnetic Resonance Imaging

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Abstract

Objectives—To determine the ideal angle for insertion of laparoscopic instruments at Palmer's Point.

Study Design—Abdominal magnetic resonance images were reviewed for 75 women between ages 18 and 50 years old. The distance from the skin to the retroperitoneal structures were determined perpendicular to the spine and angled 45 ° caudally.

Results—When instruments are inserted perpendicular to the skin in the axial plane and peritoneum perpendicular to the spine, the distance from skin to posterior was 10.0 ± 0.2 cm and to the aorta was 11.3 ± 0.2 cm. If instruments are inserted at an angle 45° caudally, this distance increased to 16.6 ± 0.2 cm.

Conclusions—When Inserting laparoscopic instruments at Palmer's Point, insertion perpendicular to the skin in the axial plane and angled 45° caudally in relation to the spine offers an increased margin of safety compared to insertion perpendicular to the spine, particularly in thin women.

Keywords

laparoscopy; surgical complications; anatomy

Background and Objectives

Laparoscopic injury of retroperitoneal structures is an uncommon but potentially fatal complication of inserting laparoscopic instruments into the abdomen. When instruments are inserted at a periumbilical location, the risk of major vessel injury is between 0.5 and 6.4 per 1,000 laparoscopies.^{1, 2, 3} Anatomic studies suggest that, in order to minimize the risk of major vessel injury, the angle of instrument insertion near the umbilicus should be 45° from horizontal in most women, but closer to 90° from horizontal in women with body mass index (BMI) > 30 kg/m².^{4, 5}

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In the last two decades, the left upper quadrant (LUQ) has been recommended as an alternative site for primary trocar insertion, particularly in women who are at increased risk of having periumbilical bowel adhesions due to previous surgery.^{6, 7} The site for LUQ insertion is known as Palmer's Point, which Raoul Palmer described as being “three cm below the middle of the left costal margin.”⁸ The risk of injuring retroperitoneal structures when inserting laparoscopic instruments at Palmer's Point is unknown.

The ideal angle of insertion of laparoscopic instruments at Palmer's Point is also uncertain, and variation exists between authors in the recommendations for angle of insertion at the LUQ entry site. Based on clinical experience, some surgeons recommend inserting instruments perpendicular to the skin, suggesting an angle of insertion perpendicular to the tangent of the curve of the skin in the axial plane, and perpendicular to the spine.^{7, 9} One group proposes insertion of instruments at Palmer's Point “vertically,” and yet another recommends insertion at a 45° angle from the horizontal and in the sagittal plane.^{10, 11} Others recommend inserting instruments at a 45° angle in a caudal direction, either “toward the hollow of the sacrum” or “in a plane parallel to the patient's longitudinal anatomic axis.”^{12, 6} However, little anatomic data is available to support these conflicting recommendations.

One anatomical study reported that the distance from a location near Palmer's Point to the aorta was 11.5 cm (range: 7.5-21.5 cm).¹³ However, this report did not indicate the direction or angle of these measurements or the effect of BMI. As a result, no recommendations were made about direction or angle of instrument insertion in the left upper quadrant.

Thus, we designed this anatomic study using magnetic resonance imaging (MRI) to determine which insertion angle for laparoscopic instruments at Palmer's Point is least likely to come into contact with retroperitoneal structures, and whether or not insertion angle should be varied according to the patient's BMI.

Materials and Methods

Two hundred and forty eight medical records were randomly chosen for review from the more than 1200 women who had abdominal MRI studies between January 1, 2006 and July 15, 2008 at the University Hospitals Case Medical Center Department of Radiology. MRI studies were performed using half-Fourier acquisition single-shot turbo spin-echo (HASTE) T2-weighted images (MRI settings: TR/TE 1000/60, matrix size: 256 × 256, 5 mm slice) with fields of vision adjusted for each patient. Patients were excluded if they were less than 18 or more than 50 years of age, weighed greater than 136 kg (300 pounds) or were found to have large intra-abdominal tumors, ascites, or gross anatomical deformities that would normally contraindicate laparoscopy. Upon review of the radiographic films from the remaining 211 patients, an additional 27 were excluded because the left costal margin could not be determined on frontal MRI, and 109 were excluded because record of the patient's height and/or weight could not be found. The final study population consisted of the remaining 75 patients (Table I).

Locating Palmer's Point

The location of Palmer's Point was determined for every patient in two planes, axial and sagittal (Figure 1). The point 3 cm below the left mid costal margin was determined on a coronal T2 weighted MR image that showed the ribs, and the axial plane at this level was designated as L₀ (Figures 2 and 3). The relative location of the mid-clavicular line was determined in patients for whom both chest x-rays and MRIs were available. The distance from the midline to midpoint of the clavicle was determine to be 70.9 ± 0.4% of the distance

from the midline to the internal aspect of the peritoneal cavity and used to determine Palmer's Point in the L_0 axial section.

Perpendicular Insertion Line

The “perpendicular insertion line” was designated as the direction perpendicular to the skin in the axial plane and perpendicular to the patient's spine. To determine this line of insertion, the tangent to the skin surface was visually estimated at Palmer's Point in the L_0 axial section, and a line was drawn perpendicular to it (Figure 2). The distance was measured from the skin surface at Palmer's Point to the posterior peritoneum (D_0), and the angle of this line from vertical was determined. Then, the distance was measured from this line to the aorta (D_X). We measured the distance from the skin surface at Palmer's Point to the aorta (D_A), and the angle of this line from vertical was determined.

45° Insertion Line

The “45° insertion line” was designated as the direction perpendicular to the skin in the axial plane and 45° caudally in relation to the patient's spine in the sagittal plane (Figure 3). The height of the posterior peritoneum was measured relative to the surface of the MRI table beneath Palmer's Point (P_0) and 5 to 12 cm caudal to this level (P_C), which was the most caudal MRI level available. The change in height between P_0 and P_C was added to D_0 and designated as D_{0+} . The distance from Palmer's Point to the posterior peritoneum at 45° (D_{45}) was calculated using the Pythagorean Theorem ($D_{45}^2 = D_{0+}^2 + D_0^2$).

Abdominal Wall Thickness

The anterior abdominal wall thickness, (T_0), perpendicular to the tangent of the skin at Palmer's Point was measured from skin surface to anterior peritoneum (Figure 2). The anterior abdominal wall thickness in the 45° insertion line (T_{45}) was calculated using the Pythagorean Theorem ($T_{45}^2 = T_0^2 + T_0^2$) (Figure 3).

Patients were divided into three groups according to BMI: normal weight (BMI < 25 kg/m²), overweight (BMI 25-30 kg/m²) and obese (BMI > 30 kg/m²). Distances are presented as the mean $\pm$ standard error of the mean (SEM), and differences between groups were compared using ANOVA. P values < 0.05 were considered significant (Table I).

Results

The perpendicular insertion line at Palmer's Point was $21 \pm 1^\circ$ from vertical in the axial plane. The average distance for the entire study population from the skin surface to the posterior peritoneum in this line (D_0) was 10.0 ± 0.2 cm (range 6.4 – 14.1 cm). This distance from the line of insertion lateral to the aorta, (D_X), was 4.3 ± 0.2 cm (range 0.6 – 7.7 cm). The average distance from the skin to the aorta was 11.3 ± 0.2 cm (range 8.2 – 16.7 cm), and the angle from vertical in the axial plane was $49 \pm 1^\circ$.

When the patients were divided into three groups according to BMI (normal weight, overweight, and obese), the distance to the posterior peritoneum in the perpendicular insertion line, (D_0), increased with BMI ($P < 0.0001$, ANOVA) (Table I). D_0 was less than 12 cm (i.e., the approximate length of a Verres needle and standard laparoscopic trocar) in 100% (34/34), 85% (4/27), and 79% (3/14) of normal weight, overweight and obese patients, respectively. The retroperitoneal structure beneath this line of insertion was the lower pole of the kidney in approximately half the cases and the paravertebral muscles in the other half.

At the 45 ° insertion line, the average distance for the entire study population from the skin surface at Palmer's Point to the posterior peritoneum (D_{45}) was 16.6 ± 0.2 cm, and increased with BMI ($P < 0.0001$, ANOVA). This distance was greater than 12 cm in all patients studied. Values for the three study groups are illustrated in Table I.

The average anterior abdominal wall thickness for all groups in the perpendicular insertion line (T_0) was 2.7 ± 0.1 cm (range 1.1 – 5.1 cm) and increased with BMI ($P < 0.0001$, ANOVA). The abdominal wall thickness at the 45 ° insertion line (T_{45}) was 3.9 ± 0.2 (range 1.6 – 7.2 cm) and also increased with BMI ($P < 0.0001$, ANOVA). Table I highlights these values for the three study groups.

Comment

Many laparoscopists have found Palmer's point to be a useful and apparently safe location for LUQ entry, and our data highlights these advantages.^{6,7,10-12} A clear advantage of instrument insertion at this location is that the abdominal wall is consistently thin, even in obese patients (Table I). The average thickness we measured perpendicular to the abdominal wall was 2.7 cm for the entire group, with a maximum thickness of 5.1 cm.

Another advantage is that no major retroperitoneal vessels lie directly below Palmer's point when instruments are placed perpendicular to the skin surface in the axial plane (Figure 2). In every case, the line of insertion was lateral to the aorta, and the average distance from the theoretical instrument tip placed in this direction to the aorta was greater than 4 cm. These findings also suggest that directing instrument insertion more medial in the axial plane would decrease the distance of the instrument tip from the aorta, thereby increasing the risk of vessel injury.

An important finding of our study is the relatively short distance to the posterior peritoneum in some patients when instruments are inserted in a direction perpendicular to both the skin in the axial plane and to the patient's spine (designated as the “perpendicular insertion line” in our study). In this direction, the average distance to the posterior peritoneum (D_0) was 10 cm (4 inches) for all patients, and was less than 7 cm (2.8 inches) in 12% (4/34) of patients in the normal weight group (BMI < 25 kg/m²). It is likely that surgeons who routinely use this angle of insertion avoid retroperitoneal injuries by “very shallow” insertion of laparoscopic instruments.^{7, 9, 14} Perpendicular insertion of instruments to their full 12 cm length is more likely to result in injury to retroperitoneal structures, particularly the left kidney, which we found is commonly located below Palmer's Point in this direction.

It is not surprising that the distance to the posterior peritoneum is significantly increased using an insertion direction 45° caudally from the patient's spine in the sagittal plane (designated as the “45° insertion line” in our study). The distance to the posterior peritoneum in this path (D_{45}) averaged greater than 16 cm and was never less than 12 cm in our patients. Based on these measurements, it appears that insertion at Palmer's Point in 45° insertion line offers the greatest margin for safety. This corresponds to the recommendation of Howard et al that instruments inserted at Palmer's Point should be directed 45° caudally “in a plane parallel to the patient's longitudinal anatomic axis”.⁶

One unexpected finding in our study was that the distance between the laparoscopic instrument tip and the aorta (D_x) did not increase with BMI as we anticipated (Table I). This may be explained by the subtle changes of insertion angle with increasing BMI. As BMI increases, the anterior abdominal wall becomes rounder in the axial plane, thus the insertion angle (perpendicular to the skin) increases such that the instrument tip is directed more toward the midline.

Our results are in agreement with a previous anatomic study that used computerized tomography to examine the left upper quadrant study in regards to laparoscopic instrument insertion.¹³ This study examined distances of various organs from the skin surface 2 cm below the left costal margin in the mid-clavicular line, a point 1 cm cephalic to Palmer's Point.⁸ The average thickness of subcutaneous fat at this point was 2.3 cm, but thickness of the entire anterior abdominal wall was not reported. Although the angles of measurement were not specified, the average distances from the point of insertion to the left kidney and aorta were 10 and 11.5 cm, respectively. These distances are remarkably similar to those we found perpendicular to the patient's spine from Palmer's Point to the posterior peritoneum and aorta of 10.0 ± 0.2 and 11.3 ± 0.2 cm, respectively.

What are the clinical implications of this study? To date, only one retroperitoneal injury has been reported using the LUQ entry technique.⁶ Other complications reported include colon, abdominal wall injuries, and subcutaneous emphysema.^{10,14-17} With just under 2,000 reported cases of LUQ entry in the literature to date, the actual risk of retroperitoneal injury using this technique remains uncertain. An important goal of this study was to provide anatomical information that might help minimize the risk of retroperitoneal injuries when using this technique.

In conclusion, our data suggests that instrument insertion at Palmer's Point perpendicular to the skin in the axial plane and 45° caudally in relation to the patient's spine might offer an increased margin of safety compared to insertion perpendicular to the patient's spine, particularly in thin women. In obese patients, insertion of instruments perpendicular to the spine appears to be a reasonable alternative, since both the abdominal wall thickness and distance to the posterior peritoneum increase with BMI. If insertion perpendicular to the spine is performed in relatively thin patient, very shallow instrument insertion is recommended to avoid injuring posterior peritoneal structures. Regardless of the angle of insertion relative to the spine, instruments should be placed perpendicular to the skin surface in the axial plane and not angled toward the patient's midline to minimize the risk of injuring the aorta.

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Figure 1. Trocar insertion planes

In the axial plane (A), the trocar is inserted perpendicular to the skin surface. In the sagittal plane (B), the trocar can be inserted either perpendicular (0°) or 45° caudally in relation to the patient's spine. Palmer's Point ($\otimes$), is located 3 cm below the costal margin in the mid-clavicular line.

Figure 2. Axial section at Palmer's Point

Measurements were made at this level, (L_0), perpendicular to the skin, from Palmer's Point to the posterior peritoneum (D_0), from Palmer's Point to the aorta (D_A), from D_0 to the aorta (D_X), from the skin surface to the anterior peritoneum (T_0), and from the posterior peritoneum to the MRI table (P_0).

Figure 3. Sagittal view at Palmer's Point, left of midline and angled 21° medially (Plane B in Figure 1)

Measured distances (D_0 , P_0 , and T_0) are those described in Figure 2. The distance from the posterior peritoneum to the MRI table was also measured 5-12 cm caudal to this level (P_c), the most caudal MRI level available. Calculated distances include T_{45} , the distance from the skin to the posterior peritoneum, and D_{45} , abdominal wall thickness in the 45° insertion line.

Table 1
Average Distances in Axial & Sagittal Planes

	Normal <25 kg/m ² n = 32	Overweight 25-30 kg/m ² n = 28	Obese >30 kg/m ² n = 15	P value
Age average (year ± SEM)	40.4 ± 1.4	42.8 ± 1.6	34.6 ± 2.6	0.017
Skin surface to peritoneum, D ₀ (cm ± SEM)	9.0 ± 0.3	10.4 ± 0.4	13.4 ± 0.4	<.0001
Skin surface to aorta D _A (cm ± SEM)	10.3 ± 0.3	11.5 ± 0.5	11.4 ± 0.3	NS ^a
Line of insertion to aorta, D _x (cm ± SEM)	4.6 ± 0.3	4.2 ± 0.3	4.2 ± 0.2	NS
Abdominal wall thickness in axial plane, T ₀ (cm ± SEM)	2.2 ± 0.1	2.9 ± 0.1	3.7 ± 0.3	<.0001
Skin surface to retroperitoneum at 45 degree angle, D ₄₅ (cm ± SEM)	13.3 ± 0.5	17.2 ± 0.7	19.2 ± 0.6	<.0001
Abdominal wall thickness at 45 degree angle, T ₄₅ (cm ± SEM)	3.1 ± 0.2	4.1 ± 0.2	5.3 ± 0.4	<.0001

Data is presented as mean ± SEM

^aP values <.05 were considered statistically significant, otherwise reported as, NS