Computed Tomography Celiac Trunk Topography Relating to Celiac Plexus Block

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Background and Objectives: The celiac plexus is a dense autonomic network surrounding the celiac trunk. To block this plexus, the celiac trunk is a landmark for needle placement. Needles inserted at a distance from the midline, "walking off" the vertebra, may penetrate surrounding organs. We reviewed 200 computed tomography images to investigate the celiac trunk topography relating to the block.

Methods: Two hundred computed tomography images across the celiac trunk were displayed. The celiac emergence level and celiac-aortic-vertebral anatomies were examined. On each image, 2 needle trajectories imitating walking-off technique were placed tangential to the vertebral body passing through the crus of the diaphragm on both sides: L-9s and L-4.5s (9 and 4.5 cm from the midline, respectively). The vital organs traversed by these lines were noted and analyzed.

Results: Celiac emergence levels: T_{11-12}, 6.5%; T_{12}, 34%; $T_{12}-L_1$, 31%; L_1, 28.5%. Aortic locations: 70% were anterior-left to and 29% were anterior-middle to the vertebra. Celiac runoffs: 63.5% from the aorta anterolaterally on the left, 36% from the midportion. Celiac-aortic-vertebral correlations showed a various distribution in groups; 88% L-9s and 64% L-4.5s on the right side, and 96% L-9s and 88% L-4.5s on the left side traversed different vital organs with various frequencies.

Conclusions: The celiac trunk anatomy varies. Blocking needles walking off the vertebra from a fixed distance frequently traverse vital organs. Previewing celiac-aortic-vertebral topography with a simulating block on individual patient's computed tomography (CT) image for accordant needle placement subsequently is warranted.

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The celiac plexus is a dense autonomic network surrounding the celiac trunk.[1] To block this plexus for upper intra-abdominal visceral pain, the base of the celiac trunk is an ideal target for needle placement.[2] Because of its deep location in the upper abdomen with complex vicinity of vital organs, the celiac plexus block is technically demanding. Many different block techniques were developed: posterior approaches, anterior approach, and gastric endoscopic approach.[3,4] The 3 posterior approaches: retrocrural, transcrural, and transaortic, have been the most commonly described methods for celiac plexus block in the literature and textbooks. The classic teaching for needle placement on both sides in the 3 posterior approaches is to insert the needles at a distance from the midline, aiming the body of the vertebra, "walking off" the vertebral bone, and to stop the needle advancement at a certain depth, depending on which posterior approach is chosen.[5–7] Various distances and needle insertion angles have been suggested to reach the target avoiding vital organ penetration, although the walking-off-the-bone technique remains the standard method for needle placement. It was found that a needle inserted on the left side would in most instances pass through the aorta before puncturing the crus of the diaphragm.[8] Is the needle walking-off-the-vertebra technique safe? We hypothesize that the needle "walked off" the vertebra and passed through the crus of the diaphragm may frequently traverse the vital organs in the area on both sides without recognition. In this study, we reviewed 200 upper abdominal CT images with intravenous contrast to investigate the topographic characteristics of the celiac-aorta-vertebra relationship. Lines representing "walking off" technique were used on the images to imitate the needle placement for the celiac plexus block. These needle trajectories were examined in relation to the vital organs surrounding the celiac trunk.

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MATERIALS AND METHODS

This retrospective review study of CT images was approved by the institutional review board of the Bronx-Lebanon Hospital Center, Albert Einstein College of Medicine.

Transaxial abdominal CT scan images with intravenous contrast from 200 adult patients were retrieved from the intramural Imagecast (GE Healthcare, Allendale, NJ) system. All studies were carried out with the slices made at 1-cm intervals. By scrolling the images and following the aorta downward from the level at the aortic hiatus of the diaphragm, the axial slice across the celiac trunk was identified for each patient using the following criteria: (1) it was the first anterior branch of the abdominal aorta; (2) it divided into the left gastric, common hepatic, and/or splenic arteries; and (3) it was different from the superior mesenteric artery caudad with different branches.

The aortic locations were examined in relation to the body of the vertebra at the level of the celiac trunk emergence. They were designated as follows: anterior to the left lateral one third of the vertebral body (l), anterior to the middle one third of the vertebral body (m), and anterior to the right lateral one third of the vertebral body (r). The celiac emergence levels were determined by scrolling images cephalad and caudad from the slice across the celiac trunk to observe the skeletal changes of the vertebral bodies with the rib attachments. They were referred as the levels of intervertebral space or the body of the vertebra. The celiac runoffs from the aorta were checked and noted as follows: from the left aortic wall (L), from the mid–anterior aortic wall (M), and from the right aortic wall (R). The celiac-aortic-vertebral correlations were observed. They were divided into the groups of L-l, M-m, L-m or M-l, L-r, and R-l, respectively (Fig. 1).

On each image, lines representing needles "walking off" the body of the vertebra technique were applied (Fig. 2), 2 lines for each side. The original image was rotated 180 degrees to

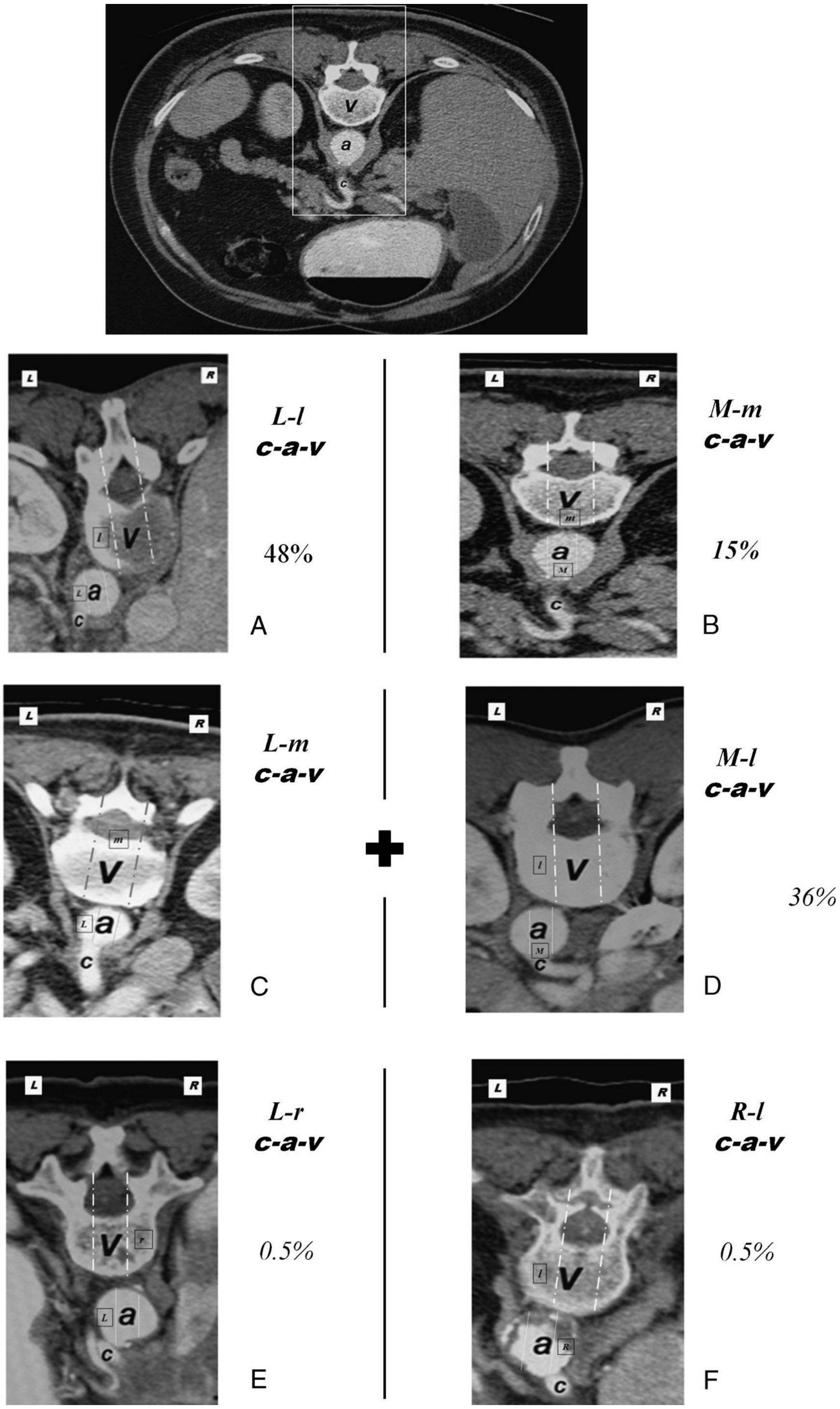

FIGURE 1. The various celiac-aortic-vertebral correlations (c-a-v) with their prevalences demonstrated as an inset image from the individual full-view CT. The celiac trunk (c) emerges from the left (L), the middle (M), or the right (R) aspect of the aorta (a) that is correlated to the left one third (l), the middle one third (m), or the right one third (r) of the vertebral body (v). A, L-l c-a-v group. B, M-m c-a-v group. C, L-m c-a-v group. D, M-l c-a-v group. E, L-r c-a-v group. F, R-l c-a-v group.

mimic a prone position for the virtual procedure. The first line was placed in such a way that it was from a point 9 cm lateral to the midline (ie, the spinous process of the vertebra) on the skin surface, projected tangentially to the body of the vertebra and passed the crus of the diaphragm, line 9 (L-9); 9 cm was the longest distance between the midline and the needle insertion point recommended in the literature.[9] The second line was placed 4.5 cm from the midline on the skin surface, trajected tangentially to the vertebral body and passed through the diaphragmatic crus, line 4.5 (L-4.5); 4.5 cm was an arbitrary

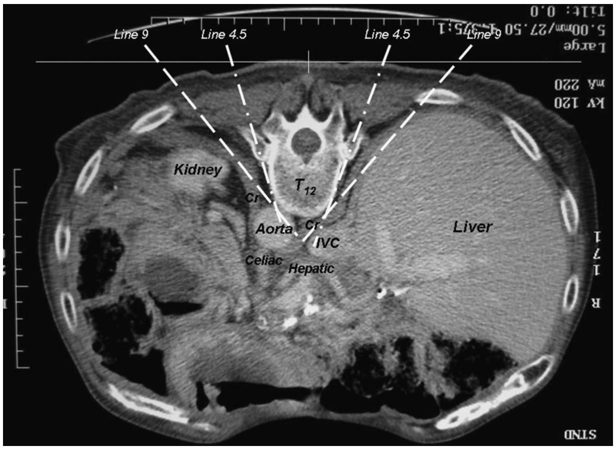

FIGURE 2. The trajectories of the needles walking off the body of the vertebra. Line 9 is the trajectory of a needle inserted 9 cm from the midline walking off the vertebral body, passing through the crus of the diaphragm. Line 4.5 is the trajectory of a needle inserted 4.5 cm from the midline walking off the vertebral body, passing through the crus of the diaphragm. T_{12} indicates the 12th thoracic vertebral body; Cr, the crus of the diaphragm; Celiac, the celiac trunk; Hepatic, the common hepatic artery; IVC, the inferior vena cava.

distance between the midline and the needle insertion point, adapted as the halfway of 9 cm. The vital organs traversed by line-9s and line-4.5s were recorded.

Statistical Analysis

The sample size was determined with Cochran's formula for continuous variables.[10] The components of the sample size formula were set as follows: (*a*) the α level at 0.01, (*b*) the estimated SD of the mean distance from the midline for needle insertion being 0.5 cm from a pilot study, and (*c*) the acceptable margin of error for mean being 0.1 cm (99% confidence intervals). A 20% size increase was added to cover the possible skewed data distribution.

The celiac emergence levels, aortic locations, and celiac runoffs were ranked as percentiles for their appearances at each level and location. The celiac-aortic-vertebral correlations in groups L-l, M-m, L-m or M-l, L-r, and R-l were analyzed and expressed as percentiles for the prevalence of the various groups. The types of vital organs traversed by line-9s and line-4.5s on both right and left sides were listed. Their traverse frequencies were ranked as percentiles as well.

RESULTS

The demography of the 200 patients whose CT images of the upper abdomen were reviewed included 98 men and 102 women, aged 53.2 (SD, 16.9) years. One hundred seven patients had normal upper abdomen. Ninety-three patients had pathologic findings including chronic pancreatitis (n = 70), pancreatic cancers (n = 21), liver cancer (n = 1), and esophageal cancer (n = 1). Among 70 chronic pancreatitis patients, 5 were complicated with pseudocyst formation, 2 with acute episode, 1 with pancreas necrosis, 1 with cystic adenoma of the right adrenal gland, and 1 with splenic cyst.

Aortic locations in relation to the vertebral column: 140 were anterior to the left one third of the vertebra (l) (70%) (Figs. 1A, D, and F); 58 were anterior to the middle one third of the vertebra (m) (29%) (Figs. 1B, C); and only 2 were anterior to the right one third of the vertebra (r) (1%) (Fig. 1E).

Celiac trunk emergence levels: 13 were at T_{11-12} intervertebral space (6.5%); 68 were at T_{12} vertebral body (34%); 62 were at $T_{12}-L_1$ intervertebral space (31%), and 57 were at L_1 vertebral body superior to the transverse process of the vertebra (28.5%).

Celiac trunk runoffs from the aorta: 127 emerged from the left aortic wall (L) (63.5%) (Figs. 1A, C, and E); 72 emerged from the anterior aortic wall (M) (36%) (Figs. 1B, D); and only 1 emerged from the middle right aortic wall (R) (0.5%) (Fig. 1F).

The prevalence of the celiac-aortic-vertebral correlations: L-l: 95 (48%) (Fig. 1A), M-m: 30 (15%) (Fig. 1B), L-m or M-l: 72 (36%) (Figs. 1C, D), L-r: 1 (0.5%) (Fig. 1E), and R-l 1 (0.5%) (Fig. 1F).

Eighty-eight percent of L-9s on the right side traversed the vital organs including the aorta (68%), the right kidney (58%), the liver (24%), the inferior vena cava (4%), and the tumor mass (1%), in descending order; 64% L-4.5s on the right side traversed the vital organs including the inferior vena cava (48%), the aorta (10%), the right kidney (4%), the liver (4%), and the portal vein (1%), respectively (Table 1).

Ninety-six percent of L-9s on the left side traversed the vital organs including the aorta (90%), the left kidney (64%), the spleen (6%), and the inferior vena cava (6%) in descending order; 88% of L-4.5s on the left side traversed the vital organs including the aorta (84%) and the left kidney (4%), respectively (Table 1).

DISCUSSION

The celiac plexus lies in front of the aorta at the level of the celiac trunk.[1,2] Successful blockades of the plexus result from the close location of the needle tip to the plexus. Although a celiac arteriogram has been suggested for the close needle placement to the celiac trunk,[11] most techniques for celiac plexus block rely on bony landmarks. Blocking needle walking off the L_1 vertebra with the guidance of fluoroscopy or CT has remained the standard practice using the bony landmarks.[5–7] The anatomic variations of the celiac ganglia and plexus in relation to the celiac artery and the vertebral column have been studied previously in a small amount of cadavers.[2] To our knowledge, radiographic characteristics of the celiac trunk and its surroundings in relation to the needle placement for celiac plexus block have not been studied on a large scale.

In our study, all 200 celiac trunks emerged from the aorta above the transverse process of the L_1 vertebra. Majority of them (93.5%) were located between the T_{12} vertebral body and the upper L_1 vertebral body. This is consistent with the description in

TABLE 1. The Frequencies of Vital Organ Traverse by Line 9s and Line 4.5s

	Line 9s		Line 4.5s	
	Right Side	Left Side	Right Side	Left Side
Liver	24%	0	4%	0
Spleen	0	6%	0	0
Kidney	58%	64%	4%	4%
Aorta	68%	90%	10%	84%
Inferior vena cava	4%	6%	48%	0
Portal vein	0	0	1%	0
Tumor mass	1%	0	0	0

the anatomy textbooks.[12,13] Our findings indicate that a blocking needle inserted in a coronal plane superior to the transverse process of the L_1 vertebra should be closer to the plexus requiring less effort for cephalic needle angling. However, the distance from the midline to the 12th rib in the plane superior to the transverse process of the L_1 is shorter than the distance in the plane inferior to the transverse process. If the distance required for needle insertion is longer than the anatomic limitation in that plane, the needle then has to be inserted inferior to the transverse process with a cephalad angle aiming the celiac trunk.

The aortic location observation showed that 70% were anterior to the left one third of the vertebra and 29% were anterior to the middle one third of the vertebra. The celiac run-off data revealed that 63.5% celiac trunks emerged from the left aortic wall and 36% from the mid–anterior wall. The left-to-middle location of the aorta in relation to the vertebral column (99%) and the left-to-middle emergence of the celiac trunk running off from the aorta (99.5%) imply the following 3 statements: (1) the blocking needle insertion on the left side should never be the same as that on the right side; (2) the distance from the midline for the left side needle insertion should be shorter, and the angle should be more vertical than that for the right side to detour the vertebra and reach the anterolateral aspects of the aorta; and (3) if the celiac trunk emerges from the left anterolateral wall of the aorta while the aorta is located anterior to the left one third of the vertebra, such as in the *L-l* celiac-aortic-vertebral group (Fig. 1A), the blocking needle inserted on the left side should take a further shorter distance from the midline with a near-perpendicular angle to avoid the vertebra and reach the base of the celiac trunk. In the meantime, the needle for the right side should be inserted more laterally with a much more horizontal angle and travel a longer distance to reach the right side base of the celiac trunk.

However, the prevalence in different celiac-aortic-vertebral correlation groups was quite diverse. Forty-eight percent of patients had an L-l combination, 36% patients appeared L-m or M-l, and 15% patients presented as M-m. We propose to preview individual image before each procedure to see the type of celiac-aortic-vertebral distribution and to perform a simulating block avoiding vital organs and bony contact on the image to obtain the measurements of the distances and angles for accordant needle placement in the subsequent procedure as we previously described.[14]

With regard to the trajectory path of the blocking needle after having walked off the vertebra, 88% L-9s and 64% L-4.5s on the right side, whereas 96% *L*-9s and 88% *L*-4.5s on the left side traversed different vital organs with various frequencies. The possibilities of organ puncture by the needle lines in our series are higher than the rates reported in the literature. Most literature reviewing the incidence of complications from neurolytic celiac plexus block reported only major complications such as paraplegia, aortic dissection, retroperitoneal hemorrhage, backache, and orthostatic hypotension.[15–17] There were a few article that looked at the incidence of organ puncture, including non-English journals. Titton and colleagues[18] reported that the complications related to puncture of the pancreas, liver, stomach, and colon were rare. Tolksdorf et al[19] reported 41% possibility of organ puncture for spinal nerve, liver, kidney, aorta/aortic wall, pancreas, and lymphomas in a modeling study applied to CT images of 50 patients with suspected upper abdominal tumors. Ochiai et al[20] performed CT-guided retrocrural celiac plexus block in 16 patients with the average distances of puncture sites to the midline to be 3.84 cm on the right and 4.06 cm on the left. Their predicted organ puncture rates were 43.8% for the right lung, 12.5% for the left lung, 56.2% for the right kidney, and 68.8% for the left kidney if the needle inserted 7 cm lateral to the midline. Although the predictive organ puncture rate is high, the overall incidence of major complications has been determined to be low (1/683, 0.15%).[15] We assume that these frequent organ penetrations may be often innocent enough, resulting in innocuous and thus insignificant sequelae. The difference of the organ puncture frequency between our study and those in the reports in the literature appears to be related to the different distances from the midline for needle insertion and the difference in retrocrural versus transcrural approaches. However, it is not necessarily true that the shorter insertion distance results in less frequent organ puncture. Once again, we would emphasize treating patients individually by performing a preprocedural simulating block to get actual distances on both sides for subsequent procedure with either C-arm or CT guidance.

The data presented here did not show the tumor mass effect on the celiac-aorta-vertebra variations, although it is not conclusive owing to the small number of the patients who had upper abdominal malignancies secondary to our community hospital's settings. Tumor mass altering surrounding vital organs' anatomy will certainly change the plot of a blocking needle placement even if it does not change celiac-aorta-vertebra distribution.

In conclusion, the celiac-aortic-vertebral anatomy varies among patients. Needles walking off the vertebra in a fixed distance from the midline on both sides for celiac plexus block frequently traverse vital organs. Previewing celiac-aortic-vertebral topography with a simulating block on individual patient's CT image for accordant needle placement subsequently is warranted.

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