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Original Article

Transdiscal-transcrural celiac plexus block simulated on computed tomography images: Technical parameters that can guide the procedure

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Abstract

Aim: Transdiscal-transcrural celiac plexus block is one of the most effective treatments for chronic upper abdominal pain. This study was done to show that simulated computed tomography (CT) measurements of celiac plexus block may be able to facilitate the practitioner during the procedure.

Material and Methods: Thin-section abdomino-pelvic CT images of 100 patients (50 females, 50 males) were retrospectively reviewed. Using special software, the transdiscal-transcrural celiac plexus block was simulated to measure the optimal distance of needle entry from the midline, as well as the optimal needle entry angle and needle tip penetration depth.

Results: The optimal needle entry distance from the midline was 4.06 ± 0.66 cm for the right side (RM) and 4.08±0.65 cm for the left side (LM). The mean optimal needle entry angle was 20.17±2.86º on the right side and 20.5±2.33º on the left. The mean optimal needle penetration depth was 11.78±1.22 cm on the right and 11.72±1.18 cm on the left side. No abdominal solid organ penetration was observed on the path of needle advancement.

Conclusion: In this study, simulated transdiscal-transcrural celiac plexus block parameters on CT provided guidance to those who performed the procedure. In addition, the absence of any abdominal solid organ penetration in the simulated virtual needle traces supports the hypothesis that the technique has a very low risk of complications.

Keywords: Celiac plexus block; computed tomography; transdiscal, sympathetic ganglion block.

INTRODUCTION

Celiac plexus block (CPB) is a proven method for the treatment of chronic visceral upper abdominal pain associated with stomach, liver, and pancreatic cancers, as well as with chronic pancreatitis (1). The celiac plexus is retroperitoneal at the levels of the T12 and L1 vertebrae. It surrounds the abdominal aorta and is in close proximity to major vital organs such as large vessels, liver and kidneys (2-7). Because of this special anatomic location, it is important to evaluate parameters such as proper needle entry site, optimal needle entry angle and needle tip penetration depth before the procedure.

Several different techniques are applied to CPB in current practice. These include fluoroscopy- or computed tomography (CT)-guided percutaneous retrocrural, transcrural or transaortic techniques, and a gastric endoscopic approach (2,3,8,9). The aim of the procedure is to reach the desired location in the celiac plexus region with the blocking needle in order to ensure proper distribution of the analgesic agent and obtain an optimal analgesic effect (10). In conventional transcrural and retrocrural CPB, which are the most commonly used procedures, the technique called "walking off" aims to reach the anterior face of the vertebra without the needle tip losing contact with the vertebra corpus in order to ensure the distribution of analgesic agent around the celiac plexus. However, the major disadvantage of this technique is the risk of injury to major organs (5,11).

The transdiscal (transintervertebral) approach was first established in 1991 by Kobayashi et al. (12). In this approach, the risk of organ puncture is minimal compared

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to the conventional method because the needle entry points are close to the midline, and the needle tip can be positioned immediately lateral or anterolateral to the aorta (12,13).

Because we believe the transdiscal technique is safer than conventional transcrural and retrocrural CPBs, in our study we performed a simulation of the transdiscal CPB technique on CT images. On these images, we measured the optimal distance of the needle entry site from midline, the optimal needle entry angle and the distance at which the needle tip reached the celiac plexus. We believe that the measured values on CT will guide physicians who perform this block before the procedure.

MATERIAL and METHODS

The study was approved by the ethics committee of our institution. Between January and October 2018, thin-section (3 mm) non-enhanced abdomino-pelvic CTs performed for the evaluation of urolithiasis were retrospectively reviewed using the Picturing Archiving and Communication System of our hospital. The age range of the study group was determined as 40–80 years because CPB is a method used to control severe and persistent pain occurring in abdominal cancers such as pancreatic and gastric cancer, and inflammatory events such as chronic pancreatitis. Patients with any mass/cancer that could affect subcutaneous and visceral adipose tissue, those with congenital or acquired vertebral bone pathology and those with a history of surgery at the lumbar region were excluded from the study. Images of 100 patients (50 females and 50 males) who met the inclusion criteria were evaluated. The reference parameters and lines for transdiscal-transcrural CPB simulation were determined using the technique described in 1991 by Ina et al. (14). Measurements were performed using special software (Medixant. RadiAnt DICOM Viewer [Software]. Version 4.6.5. URL: https://www.radiantviewer.com) on thin-section images obtained from two separate CT devices (Aquilion; Toshiba Medical Systems, Otawara, Japan) with 64- and 320-detectors that made by the same company. All measurements were made at the level of the T12-L1 intervertebral disc. On CT images, the optimal distance of the needle entry site from the midline, the optimal needle entry angle and needle tip penetration depth were evaluated separately for each patient. Measurements were recorded carefully for right and left sides. The possible differences and possible relationships between these measurements for both body halves (right and left) and both genders (females and males) were evaluated statistically. In addition, in the CT-simulated transdiscal-transcrural CPB procedure, possible abdominal organ injuries in needle advancement traces were examined virtually.

Transdiscal-Transcrural CPB Technique

All the procedures were performed under sterile conditions. The needle entry point in this procedure was appropriately selected with the guidance of CT or fluoroscopy for accurate injection. The block can be performed in either prone or lateral positions. Monitoring included non-invasive arterial blood pressure, heart rate, electrocardiogram, and non-invasive arterial oxygen saturation. In the prone position, after asepsis, local anesthetic was administered to the skin and subcutaneous tissue at the puncture site, which was 2.5-5 cm left of the midline at the level of the T12-L1 intervertebral disc. Under fluoroscopic or CT guidance, a 22-gauge, 15-cm needle was used. After skin puncture, the tip was advanced toward the midline, just lateral to the facet joints. When the needle tip encountered the disc, the needle was advanced until the tip just penetrated it. The needle tip continued to be advanced. After passing the diaphragmatic crus, the aorta was penetrated, and the needle tip reached the celiac plexus in the preaortic area. Then the analgesic agent was slowly given. Penetration was confirmed further by the loss of resistance technique with a syringe containing 5 ml of sterile saline. The aspiration was confirmed to be negative for blood, cerebrospinal fluid, or lymph before any injection was attempted (13).

Measurement Parameters

On thin-section CT images, the above-mentioned transdiscal CPB measurements were simulated and recorded at the level of the T12-L1 intervertebral disc. For this purpose, the main lines drawn on both sides combined the dorsal skin at the posterior and the diaphragmatic crus in the anterior midline, passing through the lateral side of the facet joint (Figure 1, 2 and 3). The distance between the points where the line crossed the dorsal skin and the middle part of the spinous process was measured, and the distance from the midline to the needle entry was found (RM for the right side, LM for the left side). Next, the angle between the main line and the vertical line passing through the middle of the spinous process on both sides was recorded as the optimal needle entry angle. Finally, the needle tip penetration depth was determined by calculating the length of the main line drawn at the beginning (Figure 1, 2 and 3).

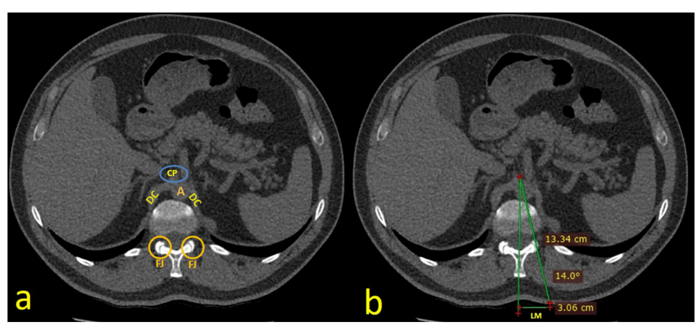

Figure 1. Transdiscal-transcrural celiac plexus block (CPB) image simulated by computed tomography (CT) in a 48-year-old male patient. a) Axial thin-section non-enhanced abdomino-pelvic CT image shows the basic anatomical structures important for the procedure. b) Left-sided CT-simulated transdiscal-transcrural CPB taken from the same section demonstrates the distance (3.06 cm) of the appropriate needle entry site from the midline on the back, the optimal needle entry angle (14°), and the needle tip penetration depth (13.34 cm). (CP= Celiac plexus area, A = Aorta, DC = Diaphragmatic crus, FJ = Facet joint, LM = Distance of the needle entry point from the midline).

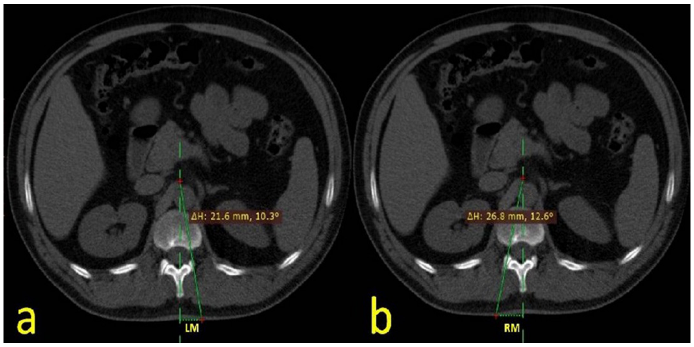

Figure 2. Transdiscal-transcrural celiac plexus block (CPB) image simulated by computed tomography (CT) in a 52-year-old woman. Axial thin-section non-enhanced CT simulated CPB images (a and b) passing through the same level show the distances of the appropriate needle entry points from the midline at the back (2.16 cm on a and 2.68 cm on b) and the optimal needle entry angles (10.3° on a and 12.6° on b). (RM = Distance between the needle entry point and midline on the right side, LM = Distance between the needle entry point and midline on the left side).

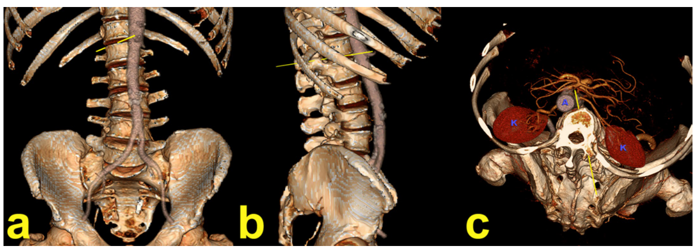

Figure 3. Transdiscal-transcrural celiac plexus block (CPB) image simulated by three-dimensional computed tomography in a 52-year-old man. Three-Dimensional coronal (a), sagittal (b) and oblique coronal (postero-superior view) (c) volume-rendered images demonstrate the needle trace (yellow line) in a transdiscal-transcrural CPB (A = Abdominal aorta, K = Kidney)

Statistical Analyses

After the data were transferred to the computer, detailed statistical analysis was performed with SPSS 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Descriptive statistics were given as number, percentage, average, standard deviation, minimum and maximum values. The compatibility of the continuous data with normal distribution was determined by the Kolmogorov-Smirnov test. The Mann-Whitney U test was used for analysis of continuous data that did not fit the normal distribution, and a t-test was used for analysis of continuous data that fit the normal distribution. Statistical significance was accepted as $p<0.05$.

RESULTS

The study group consisted of 50 female and 50 male participants with a mean age of 60.72±11.46 years. There was no statistically significant difference in age distribution of male and female participants (p=0.54). For the 100 participants included in the study, CPB was simulated using CT images. The optimal distance of the needle entry site from the midline (RM and LM), optimal needle entry angle and optimal needle tip penetration depth was calculated for each patient using special software. All measured parameters and their relationship to gender and related body half are shown in from Table 1 to Table 3 in detail.

The mean distance of the proper needle insertion site from the midline was 4.06±0.66 cm for the right side (RM) and 4.08±0.65 cm for the left side (LM). In females, this value was 4.18±0.75 cm on the right and 4.15±0.64 cm on the left. In males, it was found to be 3.95±0.55 cm on the right and 4±0.65 cm on the left. There was no statistically significant difference between males and females and right/left side (p=0.89 for genders, p=0.17 for the right and p=0.26 for the left side) (Table 1, 2 and 3).

The mean optimal needle entry angle was 20.17±2.86 degrees for the right side and 20.5±2.33 degrees for the left side. For females, this value was 20.4±3.43 degrees on the right and 20.84±1.81 degrees on the left. In the male population, the mean angles were found to be 19.94±2.16 degrees on the right and 20.16±2.73 degrees on the left. No statistically significant difference was detected between the values of female/male and right/left sides for this parameter (p=0.36 for genders, p=0.1 for the right side, p=0.17 for the left side) (Table 1, 2 and 3).

As the last parameter, the proper penetration depth of the needle tip for optimal analgesia was evaluated. The overall mean value was 11.78±1.22 cm for the right side and 11.72±1.18 cm for the left side. In females, the value was 11.82±1.53 cm on the right and 11.73±1.42 cm on the left. In the male population, the mean penetration depth was 11.75 ± 0.82 cm on the right and 11.7±0.8 cm on the left. There was no statistically significant difference between the two groups (p=0.69 for genders, p = 0.99 for the right side and p=0.84 for the left side) (Table 1, 2 and 3).

Table 1. Distribution of measurements (distance of the needle entry site from midline, optimal needle entry angle and needle tip penetration depth) for both body halves, and related statistical analyses for all participants (50 men and 50 women) in the study group

Whole Participants (n = 100)	Age (Year)	Needle Entry Angle for Left Side (Degree)	Needle Entry Angle for Right Side (Degree	Needle Penetration Depth for Left Side (cm)	Needle Penetration Depth for Right Side (cm)	Needle Entry Distance from Midline for Left Side (cm)	Needle Entry Distance from Midline for Right Side (cm)
Mean	60.72	20.5	20.17	11.72	11.78	4.08	4.06
Median	60.5	20.65	20.2	11.63	11.69	4.09	4.03
Std. Deviation	11.46	2.33	2.86	1.18	1.22	.65	.66
Minimum	40	10.1	12.1	8.66	8.93	2.12	2.67
Maximum	80	27.7	24.6	15.15	15.29	5.95	6.23
***p value**		0.36		0.69		0.89	

***T Test**

Table 2. Distribution of measurements (distance of the needle entry point from midline, optimal needle entry angle, and needle tip penetration depth) for both body halves in the male participants and their statistical relationships with the measurements in women participating in the study

Men Participants (n = 50)	Age (Year)	Needle Entry Angle for Left Side (Degree)	Needle Entry Angle for Right Side (Degree	Needle Penetration Depth for Left Side (cm)	Needle Penetration Depth for Right Side (cm)	Needle Entry Distance from Midline for Left Side (cm)	Needle Entry Distance from Midline for Right Side (cm)
Mean	61.44	20.16	19.94	11.7	11.75	4	3.95
Median	61.5	20.55	19.8	11.69	11.77	4.09	4.02
Std. Deviation	10.79	2.73	2.16	.8	.82	.65	.55
Minimum	41	10.1	15	9.98	10.21	2.12	2.67
Maximum	80	27.7	24.3	13.43	13.49	5.95	5.27
*p value	0.54	0.17	0.1	0.84	0.91	0.28	0.17

*Mann-Whitney U Test (the p value shows the statistical relationship regarding the technical measurements between the men and women participating in the study)

Table 3. Distribution of measurements (distance of the needle entry point from midline, the optimal needle entry angle and the needle tip penetration depth) for both body halves in the women participants and their statistical relationships with the measurements in men participating in the study

Women Participants (n = 50)	Age (Year)	Needle Entry Angle for Left Side (Degree)	Needle Entry Angle for Right Side (Degree	Needle Penetration Depth for Left Side (cm)	Needle Penetration Depth for Right Side (cm)	Needle Entry Distance from Midline for Left Side (cm)	Needle Entry Distance from Midline for Right Side (cm)
Mean	60	20.84	20.4	11.73	11.82	4.15	4.18
Median	60	21.05	20.9	11.59	11.65	4.1	4.07
Std. Deviation	12.16	1.81	3.43	1.47	1.53	.64	.75
Minimum	40	12.1	12.1	8.66	8.93	2.58	2.54
Maximum	80	24.6	24.6	15.15	15.29	5.34	6.23
*p value	0.54	0.17	0.1	0.84	0.91	0.28	0.17

*Mann-Whitney U Test (the p value shows the statistical relationship regarding the technical measurements between the men and women participating in the study.)

DISCUSSION

Transdiscal-transcrural CPB is a relatively new technique compared to conventional CPB techniques. Compared to the conventional technique, the proximity of the needle entry point to the midline on the back and the vicinity of the midline and the trace where the needle advances reduce the risk of possible organ injuries. It is another advantage for this technique that finer needles can be used (13). Although those procedures are performed with the CT or fluoroscopy guidance, it may be useful to have pre-procedure information about the needle entry site, appropriate entry angle and the needle tip penetration depth in order to provide optimal analgesia. In this study, we aimed to share the results of our technical measurements by simulating the transdiscal-transcrural CPB on CT images, thus determining the optimal needle entry site and angle, as well as the appropriate penetration depth.

CPB is one of the most effective treatments used to control persistent pain arising from upper abdominal malignancies and chronic pancreatitis (7,15-18). Other beneficial effects are that it significantly reduces the need for opioid use and increases the patient's oral intake and bowel movements (19). Percutaneous celiac block was first described by Kappis in 1919 (20) and has been modified over time (19,21). However, in patients with organomegaly or anatomical anomalies, it should be avoided as it may cause liver and kidney injuries and even paraplegia and pneumothorax (3,18,22). However, the transdiscal approach is a relatively new, alternative technique and the risk of kidney or liver injury is low because the needle entry site is close to the midline (23). Another advantage is that it can be successful even when applied from one side. This technique was also used for superior hypogastric plexus block, and successful results were obtained (23).

The rate of pain reduction after the procedure with conventional CPB ranges from 85% (18,24) to 94% (19,24). With a transaortic approach, this rate is between 91% (24,25) and 93% (4,24). Ina et al. (13), in their study evaluating a series of 58 cases, specified that complete relief of pain was achieved in 100% of patients with transdiscal CPB. They reported the ability to bring the needle tip closer to the aortic lateral or anterolateral wall on both sides in this technique as the reason for this successful result. In CT-simulated images, we placed the lines representing needle tips on both sides so they were positioned in the immediate right lateral aspect of the aorta in the majority of participants and determined other technical parameters accordingly.

There are a very limited number of studies in medical literature on the radiographic and tomographic anatomy of CPB (6,16,17). Previous radiological studies of CPB were mostly performed with conventional antecrural or retrocrural techniques and their comparisons (5,8,12,26,27). Kambadakone et al. (6) reported that computed tomography (CT) is superior to other imaging guidance modalities and emphasized that accurate depiction of the retroperitoneal anatomy and the position of the needle tip helps avoid crucial anatomic structures such as the pancreas, aorta, celiac artery, and superior mesenteric artery. In their retrospective observational study, Tewari et al. (27) examined the differences between retrocrural and transaortic neurolytic CPB for pain relief in patients with upper abdominal malignancy and found that the retrocrural technique provided superior pain relief when compared to the transaortic technique. Kong et al. (5) performed a CT-simulated fluoroscopy-guided transdiscal-transcrural CPB in the case of a participant with pancreatic cancer who suffered from severe epigastric pain. Due to the penetration of kidney on the right side and aorta on the left, they simulated the transdiscal pathway on CT before the procedure and successfully performed the transcrural CPB within a narrow angle without the need for a bilateral approach. Yang et al. (7) reviewed 200 CT images to investigate celiac trunk topography relating to the block and reported that previewing celiac-aortic-vertebral topography with a simulated block on a patient's CT image for accordant needle placement was warranted. Sir et al. (16) also reported the importance of pre-procedure CT guidance in transaortic CPB in a very recent paper and, similar to our study, discussed main measurements such as mean distance of needle entry point from the midline, needle entry angle, distance from the entry point to the needle tip, and major organ penetrations.

Pre-procedure CT simulation can reduce organ injuries by providing useful insight into the anatomy of the site, such as appropriate needle entry site, optimal entry angle and the appropriate needle tip penetration depth for each patient. Fluoroscopy can monitor the course of the needle dynamically and provides distribution of both contrast and analgesic substance (5). In this way, the advantages of both imaging techniques can be utilized to understand the specific anatomy of the celiac plexus region before the procedure. Existing medical literature reports that transdiscal CPB procedures are shorter than conventional techniques, and they can be performed unilaterally, thus reducing the risk of major organ penetration (5). With conventional techniques, intervertebral disc penetration during the procedure raises concerns about possible complications, such as discitis and disc degeneration. However, it has been reported that the transdiscal approach does not increase such complications related to disc penetration (4,5).

In this study, we aimed to simulate the transdiscal-transcrural CPB on CT images of 100 consecutive participants in order to determine technical parameters of the procedure and to guide physicians who will perform the procedure. We used thin-section (3 mm) CT images to properly show the diaphragmatic crura and abdominal aorta, which are important anatomical structures for providing accurate measurements and increased detail. There was no statistically significant difference in measurements between genders or between body halves (right/left). Major organ penetration was not seen in any of the CT-simulated transdiscal CPBs. To the best of our knowledge, there are no other studies in the medical literature that have described technical parameters related to this particular technique in this way, and these parameters can guide anesthesiologists and radiologists who wish to perform the procedure.

Our study has some limitations, and primary is its retrospective design. Also, the direct lines we used in simulated images may not clearly reflect the process, which is actually quite dynamic because of variables such as needle movement. Although it is known that retroperitoneal anatomy does not significantly change with postural differences, it should be acknowledged that measurements taken in the supine position on CT scan are actually a limitation for any CPB performed in the prone or lateral decubitus position. CPB has been performed for the treatment of upper abdominal and visceral pain, but the participants we examined were not selected from this population, and this may be counted as another limitation. However, because our main aim was to investigate technical parameters of the procedure and to guide physicians who will perform the procedure, we selected a study population with an age range from 40–80 who were not cancer patients. In the current study, we simulated the CPB on existing CT images acquired within a specified date range and belonging to a relatively small sample size. This small number of participants might have affected the mean distance and angle values and, accordingly, the statistical results. However, to the best of our knowledge after a literature search, this is the first study of this subject. Finally, the lack of the height and weight information of the participants in the hospital data system, which may affect subcutaneous and retroperitoneal adipose tissue thickness, may also be considered a limitation. The retrospective design of the study and the fact that the hospital data system did not contain this information prevented us from overcoming this limitation.

CONCLUSION

Unlike conventional CPB, the transdiscal-transcrural CPB is an effective method for reducing pain in patients with abdominal cancer or chronic pancreatitis, and the complication rate is lower due to the nature of the technique. CPB can be applied more easily and effectively after identifying patient-specific anatomic information via CT simulation. The risk of organ penetration is also negligible when using the transdiscal-transcrural technique. For patients who cannot undergo CT before the procedure, the procedure can be performed more easily by using fluoroscopic imaging in conjunction with the technical parameter measurements we have established in our study.

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