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Transaortic celiac plexus block: A computed tomography simulation study

Transaortik çölyak pleksus bloğu: Bilgisayarlı tomografi simülasyon çalışması

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Abstract

Aim: Transaortic celiac plexus block (CPB) is a traditional treatment method in chronic upper abdominal pain. Knowing the technique parameters before the procedure provides convenience to the physician during the block. For this purpose, we simulated the transaortic CPB with computed tomography (CT) and thus aimed to determine the main technical parameters and the risk of complications.

Methods: This study was an observational study. We analyzed one hundred, transaxial, thin section, abdominopelvic CT images and recorded morphological disturbances such as the presence of aortic mural calcification, thrombus, and aneurysm. We drew a needle insertion pathway on each of the images, at left, seven cm away from the midline in the lumbar region. Subsequently, we recorded the penetrated organs, the needle entry angle, and the distance from the skin to the needle tip. Also, we measured the appropriate entry distance and angle for successful injection in patients that we could not provide transaortic access.

Results: In the CT-simulated images, according to defined level and distance, we could reach the aorta in 73% of the patients. The mean needle entry angle and the distance from the entry point to the needle tip was 23.33 (3.36)°, 15.25 (1.20) cm, respectively, and kidney penetration was 6.9%. We were able to access aorta in remaining 27% of patients with a mean distance of needle entry point from the midline, a mean needle entry angle, and a mean distance from the entry point to the needle tip, 10.08 (1.25) cm, 34.04 (5.43)°, and 17.09 (1.32) cm, respectively. The kidney penetration rate was 44.4% in these patients.

Conclusion: In the transaortic technique used for the CPB, successful aortic penetration is not always achieved. When the access angle and distance are increased, aortic transition can be achieved, but the risk of organ injury significantly increases.

Keywords: Celiac plexus block, Computed tomography, Transaortic, Sympathetic ganglion block

Öz

Amaç: Transaortik çölyak pleksus bloğu (ÇPB), kronik üst karın ağrısında kullanılmakta olan bir tedavi yöntemidir. İşlem öncesi teknik parametrelerin bilinmesi, blok sırasında hekime kolaylık sağlar. Bu amaçla, çalışmamızda transaortik ÇPB'yi bilgisayarlı tomografi (BT) ile simüle ettik ve böylece ana teknik parametreleri ve komplikasyon riskini belirlemeyi amaçladık.

Yöntemler: Bu, gözlemsel bir çalışmaydı. 100 hastanın, transaksiyel, ince kesit, abdomino-pelvik BT görüntüleri incelendi. Aort duvar kalsifikasyonu, trombüs ve anevrizma varlığı gibi morfolojik bozukluklar kaydedildi. Her bir görüntüde, lomber bölgede, orta hattan yedi cm solda iğne giriş yolağı çizildi. Sonrasında, görüntülerde oluşan organ penetrasyonları, iğne giriş açıları ve deriden iğne ucuna olan mesafeler kaydedildi. Ek olarak, transaortik geçişle çölyak pleksusa ulaşamadığımız hastalarda başarılı enjeksiyon için uygun giriş mesafesini ve açısını ölçtük.

Bulgular: Tanımlanmış seviye ve mesafeye göre BT ile simüle edilmiş görüntülerde hastaların %73'ünde aort içerisinden geçiş sağlayabildik. Ortalama iğne giriş açısı ve giriş noktasından iğne ucuna olan mesafe sırasıyla 23,33 (3,36)°, 15,25 (1,20) cm ve böbrek penetrasyon oranı %6,9 idi. Aorta erişemediğimiz % 27 hastada yapılan yeni ölçümde, orta hattan ortalama iğne giriş mesafesi, ortalama iğne giriş açısı ve giriş noktasından hedef noktaya olan ortalama mesafe sırasıyla, 10,08 (1,25) cm, 34,04 (5,43)° ve 17,09 (1,32) cm idi. Bu hastalarda böbrek penetrasyon oranı ise %44,4'tü.

Sonuç: Transaortik ÇPB tekniğinde, her zaman, başarılı şekilde aort penetrasyonu sağlanamaz. Erişim açısı ve mesafesi arttırıldığında, transaortik geçiş sağlanabilir, ancak organ hasar riski önemli ölçüde artar.

Anahtar kelimeler: Çölyak pleksus bloğu, Bilgisayarlı tomografi, Transaortik, Sempatik ganglion bloğu

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Introduction

Celiac plexus block (CPB) is an effective treatment modality that has been used for a century in chronic visceral pain of the upper abdomen caused by chronic pancreatitis, stomach, liver and pancreatic cancer [1]. Percutaneous CPB was first described by Kappis [2] in 1919 and has undergone modifications over time. A meta-analysis of 24 articles about conventional CPB techniques has revealed good to excellent pain relief in 90% of patients in 3 months period [3]. In the transaortic approach, this ratio is reported in between 91% [4] and 93% [5]. Variations and combinations of techniques remain as means of reducing the complication and morbidity as well as increasing the success of the procedure.

The celiac plexus has a deep retroperitoneal location at the T12 and L1 vertebrae. It surrounds the abdominal aorta and is near major vital organs such as large vessels, liver, and kidneys [6-8]. Due to this particular anatomical location, it is crucial to assess parameters such as the appropriate needle placement location, angle, and depth of needle tip reaching the target. Several CPB techniques have been described to reduce the risk of organ injuries that may occur in the needle path. Fluoroscopy or computed tomography (CT)-guided percutaneous retrocrural, transcrural, transaortic, and gastric endoscopic approaches can be counted as the most commonly used methods for this purpose [6,7,9]. The goal of the procedure is to obtain adequate analgesia by providing proper distribution of the neurolytic agent around the celiac plexus via a nerve block needle [10]. The main reason for the emergence of these techniques using different needle entry points, angles, and paths is to minimize the complications and maximize the success of the injections.

The CT examination is one of the most commonly performed imaging modalities in abdominal pathologies. The great anatomical information provided by its high temporal and spatial resolutions has made CT a potent imaging method in the diagnosis of abdominal cancers such as liver, pancreas, and kidney. Nowadays, this modality has been commonly used not only for the diagnosis but also for guiding the treatment. In the literature, there are CT simulation studies made for this purpose. In light of the results obtained from these studies, new modifications are recommended for more successful injections and low complication rates [8,11].

The transaortic CPB refers to the injection of the neurolytic agent in front of the anterior wall of the aorta in the retroperitoneal space. The entrance distance defined for the transaortic technique is seven cm left from the midline at the level of L1 vertebra [12]. After skin puncture, the block needle is advanced under fluoroscopy or CT guidance. Once the target is reached, the injection is performed, and the drug surrounds the anterior and then the posterior of the abdominal aorta [13,14]. The main advantage of the transaortic approach is minimizing the risk of neurological complications arising from the spread of the neurolytic agent to the lumbar plexus or spinal cord [15]. Another advantage is that in conventional techniques, bilateral injections should be performed, whereas, in the transaortic approach, a single injection is sufficient, which reduces the risk of organ injury. Therefore, we have chosen the transaortic approach among the various CPB approaches.

In the curent study, we aimed to investigate the successful injection rate with the classical transaortic approach and to simulate the ideal way in remaining patients in whom we could not reach the aorta and to evaluate the complication rates in both circumstances. We foresee that the parameters obtained as a result of the measurements in the study will provide useful information and guidance for the practitioners performing the transaortic CPB.

Materials and methods

After approval of the Institutional Review Board (2018/15, 18/240), we analyzed the images of one hundred adult patients' transaxial, thin section (3 mm), abdominopelvic CT scans, using the Image Archiving and Communication System (PACS) of our hospital. We selected the images scanned with a pre-diagnosis of renal stone between January and October 2018. The age of the study group was determined as 40-80 years since CPB is a treatment modality used for intractable pain in upper abdominal malignancies and chronic pancreatitis usually seen in this age group. We excluded the patients who have undergone surgery in the lumbar region and patients with congenital or acquired vertebral bone pathology with any mass/cancer that could affect the subcutaneous and visceral adipose tissue. We used blocked randomization for patients' ages and genders, as they may affect the outcome of our clinical trial. This method randomizes several patients at a time in such a way as to provide that equal numbers are allocated to each group, instead of randomizing each patient separately. Thus, we have chosen 50 female, and 50 male patients among the 100 patients who met the inclusion criteria and the mean ages of these male and female patients were equal.

Detailed measurements were performed using a special software (RadiAnt DICOM Viewer 4.6.5, Medixant, Poznan, Poland) on thin section (3 mm) images acquired from two separate CT devices with 64- and 320- detectors (Aquilion; Toshiba Medical Systems, Otawara, Japan) of the same brand. All calculations were performed at the level of the L1 vertebral body. On CT images, the needle entry angle and the distance from the entry point to needle tip were evaluated separately for each patient. The possible differences and possible relationships of these measurements for both genders were statistically evaluated. Additionally, when seven cm distance from the midline was accepted as the optimal entry point, patients who could not be accessed through the aorta were also identified. In those patients, technique parameters (the needle entry angle and the distance from the skin surface to needle tip) and the optimal needle trace passing through the aorta, which is necessary for an optimal plexus block was redrawn. For this purpose, in the simulated transaortic CPB procedure, vital abdominal organ injuries such as kidney and lung penetrations in the needle advancement traces were also examined (Figure 1). Since the use of the transaortic CPB technique is contraindicated, patients with an aortic aneurysm and extensive mural calcification were recorded.

CT Parameters

In the current study, the needle entry angle and the distance from the entry point to needle tip were evaluated as the main parameters. The measurements were performed on thin-

section CT images by simulating a transaortic CPB at the level of the L1 vertebral body (Figure 2.a). As described in the literature, a distance of seven cm from the midline was marked in the left lumbar region by the classical transaortic CPB technique [12,16]. The main line was drawn between the defined point and the celiac plexus region, passing through the aorta. The angle between the main line and the vertical line passing through the middle of the spinous process was recorded as the needle entry angle. The distance from the entry point to the needle tip was measured by calculating the length of the main line.

Statistical analysis

After the data were transferred to the computer environment, the SPSS 21.0 package program was used for the detailed analyses. Descriptive statistics were given as number, percentage, mean, standard deviation, minimum, and maximum values. The Kolmogorov-Smirnov test was applied to determine the consistency of continuous data to normal distribution. T-test was used for the analysis of continuous data that conforms to the normal distribution, and the Fischer's Exact Test was performed for the comparison of the discrete variables. Statistical significance was accepted as $P<0.05$.

Results

The study group consisted of 50 female and 50 male patients, and the mean age was 60 (12.2) (40 - 80) years. In 100 patients enrolled in the study, transaortic CPB was simulated on thin-section CT images. The needle entry angle and the depth required by the needle tip were measured using special software for each patient. All measured parameters and their distribution according to gender are shown in Table 1 in detail. The ratio of extensive aortic mural calcification was observed in 2% of the patients in the CT-simulated images (Figure 2.b). We could not reach aorta with the simulation of classic transaortic CPB in 27% of patients. Among this group, 16 were male, and 11 were female, and there was no statistically significant difference between the genders regarding this subject ($P=0.36$) (Table 1).

When the needle entry point was seven cm left to the midline at the L1 level in the lumbar region, we could reach the aorta in 73% of the patients (n:73). In these patients, the mean needle entry angle was found as 23.33 (3.2)° (ranging 16.3 - 33°). This value was 22.98 (2.8)° in males and 23.69 (3.52) in females. The distance from the entry point to the needle tip was 15.25 (1.2 cm) (ranging 11.81 – 19.43 cm) in this group. This value was found as 15.41 (1.12) cm and 15.09 (1.29) cm in males and females, respectively. There was no statistically significant difference between the patients regarding the needle entry angle and the distance from the entry point to the needle tip ($P=0.26$, $P=0.18$). The ratio of kidney penetration was observed in 6.9% of the patients in the CT-simulated images (Table 2).

We tried to obtain an ideal transaortic approach by changing our entry point and angle in the remaining 27% of patients whose aorta could not be reached with classic transaortic CPB in the CT simulation. When the optimal needle trace passing through the aorta was found on those patients, a cross line was drawn to the skin. The distance between the skin surface and midline was noted. Instead of seven cm distance defined for the classic transaortic CPB, we found the distance 10.08 (1.25 cm) (ranging 8 – 13.46 cm). The low needle entry angle was 34.04 (5.43)°, and the distance from the entry point to needle tip was 17.09 (1.32) cm in those patients. The measured parameters were shown in Table 3. Additionally, major organ penetrations were reevaluated in those patients with modified traces on CT images. In these images, we did not observe any lung or liver penetration, while in 12 patients (44.4%), we observed kidney penetration (Figure 2.c).

Table 1: The distribution of age, number of extensive aortic mural calcification, number of patients in whom aorta was not reached at 7 cm, and their statistical relationship with gender in the study group

	Total (n: 100)	Male (n: 50)	Female (n: 50)	*P*-value
Age Mean (SD), year	60.00 (12.09)	60.00 (12.15)	60.00 (12.15)	1
Number of extensive aortic mural calcification (%)	2 (2%)	1	1	1
Number of patients in could not be reached at 7 cm (%)	27 (27%)	16	11	0.36

n: Number of patients, SD: Standard deviation

Table 2: Needle entry angle, distance between the skin surface and the needle tip, and number of kidney penetration, and their statistical relationship with gender in the study group

	Total (n: 73)	Male (n: 34)	Female (n: 39)	*P*-value
Needle entry angle (SD), degree	23.33 (3.36)	22.98 (2.81)	23.69 (3.52)	0.26
Distance between skin surface and needle tip (SD), cm	15.25 (1.20)	15.41 (1.12)	15.09 (1.29)	0.18
Number of kidney penetration (ratio)	5 (6.9%)	0	5	0.06

n: Number of patients, SD: Standard deviation

Table 3: The detailed measurements of the patients in the study group whose aorta cannot be reached in simulations using the classic distance of 7 cm from the middle line

	Number of patients in whom aorta was not reached at 7 cm (n: 27)
Distance from midline (SD), cm	10.08 (1.25)
Needle entry angle (SD), degree	34.04 (5.43)
Distance between skin surface and needle tip (SD), cm	17.09 (1.32)
Number of kidney penetration (ratio)	12 (44.4%)

n: Number of patients, SD: Standard deviation

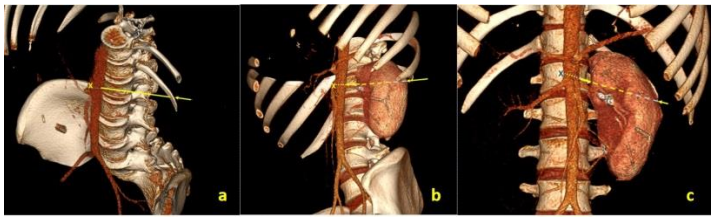

Figure 1: Three Dimensional oblique coronal (a and b) and coronal (c) volume-rendered images demonstrate the needle trace in an transaortic celiac plexus block. Kidney penetration is seen as figure b and c. (X= celiac plexus location)

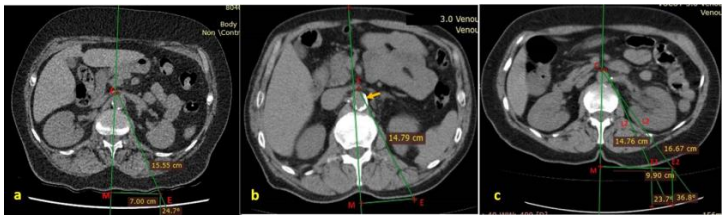

Figure 2: Axial thin section noncontrast abdomino-pelvic CT images at L1 vertebra level; a. Needle entry point (E1) is 7 cm left from the midline (M) in accordance with the classical transaortic celiac plexus block technique. A line was drawn between E and the celiac plexus (C), passing through the aorta. The angle between this line and the vertical line passing through the middle of the spinous process was recorded as the needle entry angle. b. Yellow arrow points extensive aortic mural calcification. c. Needle entry point in classical transaortic (CPB) technique, the main line is not passing through the aorta (L1). When a new line (L2) is drawn from the celiac plexus oppositely which is passing through the abdominal aorta, the new (optimal) needle entry point is located at a point farther from the midline (7 cm vs. 9.9 cm). The needle entry angle is 23.7° for L1, while it is 36.8° for L2. The distance from entry point to needle tip (C) is 14.76 cm for L1 and it is found as 16.67 cm for L2. This trace is penetrating the left kidney as a complication. (M= Midline, C= Celiac plexus, E1= Entry point 1, E2= Entry point 2, L1= Line 1, L2: Line 2)

Discussion

The main significant result of our study was that the abdominal aorta could not always be reached with the defined transaortic approach. In these patients, the distance of the needle to the midline and the angle of entry can be increased so that aortic passage can be achieved, but this increases the risk of organ injury.

There are very few studies on the radiographic anatomy of CPB in the literature [15,17]. Previous radiological studies of the CBP were related to conventional antecrural or retrocrural techniques [8,11]. To the best of our knowledge, this is the first CT simulation study for transaortic CPB. In the current study, we investigated the specific technical parameters related to transaortic CPB by simulating the procedure on CT images to estimate the success and complication rates.

The most common clinical complication of the CPB is back pain and diarrhea, and the worst one is the increased risk of retroperitoneal bleeding due to iatrogenic aortic puncture, which may occur up to 0.5% in patients with hypertension or coagulopathy [16]. Since this is a radiological study, we could not evaluate clinical complications. However, according to the simulation results, we were able to evaluate the risk of vital organ and anatomical structure injuries. In the current study, the rate of kidney penetration was 6.9% in the classical transaortic approach. However, this rate was 44.4% in patients whom we could not reach the aorta by the classical approach and determined a more lateral entry point at the skin. In the CT simulation study of retrocrural CPB of 108 patients applied by Gabriela et al. [11], renal injury rates were 0.92% at 4.5 cm, and 23.25% at 9 cm left from the midline. On the other hand, in the transaortic CPB study performed by Abbas et al. [18], no kidney damage was observed in any patient. Such a significant difference between radiological study and clinical study may indicate that every radiologically evaluated renal penetration may not occur in clinical practice, or even if it occurs, it may not manifest clinically. Prospective randomized clinical trials are needed on this issue.

The most severe complications to be recognized and treated in the transaortic CPB are those associated with aortic injury. Therefore, this procedure is contraindicated in patients with an aortic aneurysm, extensive mural calcification, and mural thrombus was observed [16]. In the study, we observed 2% extensive mural calcification, 17% mild mural calcification, no aortic aneurysm, and thrombus. Therefore, it is keenly recommended to examine the anatomical structures and changes in the celiac region with CT before the procedure.

The most important information given in the results of the study is the anatomic variability, complexity, and individuality of the region. In patients with upper abdominal tumors, deterioration of celiac anatomy, or growth in lymph nodes is common. These changes can sometimes make the procedure impossible. For this reason, CT simulation of transaortic CPB before administration increases the chance of successful injection and reduces the risk of complications. Alternative techniques such as an epidural catheter, spinal port, and especially splanchnic block, can be considered if there is a risk observed in the pre-procedural CT simulation.

There were some limitations to our study. Firstly, direct lines we used in simulated images may not reflect the process that was very dynamic, such as needle movement. The second limitation although it is known that the retroperitoneal anatomy does not show a significant change with postural changes, the fact that our measurements were performed on CT images taken in supine position could be seen as a limitation for the CPB performed in the position of prone or lateral decubitus. Besides, we used CPB for the treatment of upper abdominal and visceral pain, but the patients we examined were not selected from this population, and this can be counted as the third limitation. In our study on CT images taken within the specified date range, the sample size was small due to rigid inclusion criteria, and since this study was performed on existing patient images, the height and weight information of the patients could not be reached, and these can be considered as other limitations.

Conclusion

In case of abdominal tumors, there may be alterations in the shape and size of the tumor and personal anatomical variations in the needle path do not allow us to administer the transaortic CPB technique always successfully. However, in the light of our initial and preliminary reports, we can suggest that modification in the needle entry point and angle may result in accurate injection, but on the other hand, it can significantly increase the risk of organ injuries.

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