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ORIGINAL RESEARCH

To study the vertebral level of the celiac ganglion and its clinical implications

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ABSTRACT

Aim: To study the vertebral level of the celiac ganglion and its clinical implications

Materials and Methods: Peritoneal organs such as the liver and stomach were relocated to reveal the celiac ganglia in 50 cadavers. The celiac ganglia were discovered during anatomic dissections based on their relationship to the diaphragmatic crura and adrenal glands. The celiac ganglia's location, shape, and size, as well as their connection to neighbouring structures, were all documented. The celiac ganglia were separated from 10 of the 50 cadavers that did not have peripancreatic disorders and had obvious architecture, and their surfaces were marked with gadolinium chelate. The organs were transferred, the abdomen was closed, and an MRI was done on these ten cadavers.

Results: The celiac ganglia of 45 (90%) of the 50 cadavers were located between T12 and L1, whereas those of 5 cadavers (10%) were located between T11 and T12. There was one celiac ganglion on each side of the 50 cadavers. The morphology of the ganglia varied, with 84% (84/100) being lamina-shaped, 11% (11/100) being nodule-shaped, and 5% (5/100) being sickle-shaped. The right ganglia's long (left-right) diameter was 13.24±5.29 mm and the left ganglia's short (anteroposterior) diameter was 1.61±0.63 mm and the left ganglia's short (anteroposterior) diameter was 2.32±0.58 mm. The long (left-right) diameter of the right ganglia in the ten cadavers designated with MRI contrast media was 22.02±4.69 mm, while the short (anteroposterior) diameter was 2.12±0.39 mm. The long and short diameters of the left ganglia were 19.98±6.33 mm and 2.79±0.37 mm, respectively.

Conclusion: Our findings suggest that current MRI methods in cadavers may not only portray the position and shape of the celiac ganglia (assuming bigger ganglia are chosen and tagged with gadolinium), but can also be utilised to estimate the ganglia's size.

Keywords: celiac ganglion, clinical implications

INTRODUCTION

The plexus of nerves that runs along the front and sides of the abdominal aorta is the most important element of the sympathetic system in the belly. The celiac plexus is named for the highest and most dense section of the plexus, which is alongside and in front of the aorta at the level of the celiac artery.[1] The celiac ganglia are among the biggest ganglia in the celiac plexus. Neural invasion is a significant prognostic factor in pancreaticobiliary cancer.[2] According to Bhuiya et al.[3], the total incidence of perineural invasion in resected tissues was

81.4%. Patients without perineural invasion had 3- and 5-year survival rates of 80% and 67%, respectively, whereas those with perineural invasion had rates of 41% and 32%.

Intractable pain is caused by pancreaticobiliary cancer involvement in the celiac plexus or celiac ganglions.[4] The use of a celiac plexus block to relieve intractable pain caused by upper abdominal malignancy is well established.[5] Significant pain relief has been reported in 70-90% of patients, allowing a reduction in opioid use and the occurrence of opioid-related side effects. The length of alleviation varies, but most people die with little or no pain. MRI may be useful in directing therapeutic neurolysis of the celiac plexus by determining the specific location of the celiac ganglia.

Previous abdominal MRI for celiac ganglia was restricted by motion (respiratory and other) and the enormous size of the abdomen. We expect that high-resolution imaging of the abdomen will become available soon, and that knowing the MRI properties of the celiac ganglia would be useful.[6-9]

MATERIALS AND METHODS

Our hospital's institutional review board authorised this particular corpse for the investigation. The peritoneal organs such as the liver and stomach were shifted to reveal the celiac ganglia in 50 cadavers. The celiac ganglia were discovered during anatomic dissections based on their relationship to the diaphragmatic crura and adrenal glands. The celiac ganglia's location, shape, and size, as well as their connection to neighbouring structures, were all documented. The celiac ganglia were separated from 10 of the 50 cadavers that did not have peripancreatic disorders and had obvious architecture, and their surfaces were marked with gadolinium chelate. The organs were transferred, the abdomen was closed, and an MRI was done on these ten cadavers. Because celiac ganglia are often tiny, we chose 10 cadavers with bigger celiac ganglia for isolation and labelling so they could be readily seen on MRI. Six celiac ganglia were extracted for histopathological investigation from three of the ten cadavers designated with MRI contrast media. Sections were cut at 5-m thickness using a Hacker-Bright Micro Cryostat and put on glass slides for histologic examination.

THE MRI METHOD

All tests were performed on 1.5-T MR imagers with gradients of 38 mT/m and slopes of 120 mT/m per second. Axial T1-weighted in-phase and opposed-phase imaging, axial 3D fast spoiled gradient-echo imaging, and coronal 3D fast spoiled gradient-echo imaging were among the MRI procedures used. T1-weighted in-phase and opposed-phase images were acquired in a single dual-echo acquisition with the following parameters: TR/TE, 150/4.2 for in-phase images and 150/2.1 for opposed-phase images; flip angle, 90°; matrix, 256/ 256; field of view, 26-32 cm; section thickness, 5 mm (gap, 0.5 mm); number of signals acquired, one; and sampling bandwidth, 30 or 60 kHz. The following parameters were used to acquire all 3D spoiled gradient-echo images: TR range/TE range, 4-7.5/1.5-2.2; flip angle, 15°; matrix, 256/ 256; field of view, 26-32 cm; section thickness, 5 mm; and number of signals recorded, one. Reconstruction of MR images was done in 2.5-mm intervals.

IMAGE EVALUATION

Our procedures were similar to those of Dal Pozzo et al.[10], who used an opaque contrast solution to label the celiac ganglia in an anatomic specimen to reveal their location, shape, and size on CT. We employed gadolinium chelate to label the celiac ganglia so that they would appear brighter on T1-weighted images than other viscera such as the liver, pancreas, adrenal gland, and crura. A single radiologist sought to identify these ganglion zones based on variations in signal strength and celiac ganglia location.

The original MRI data were transferred to a workstation, and the MR pictures of the ten cadavers were examined. The celiac ganglia's location, shape, and size, as well as their connection to neighbouring structures, were all documented.

STATISTICS

The dimensions of the celiac ganglia on each side are presented as the mean (SD). To quantify differences between dissection- and MRI-derived measures, the two-tailed Student's t test and analysis of variance were performed. Fisher's exact chi-square test was used to compare their differences in location and morphology. Significant differences were defined as p values less than 0.05.

RESULTS

CELIAC GANGLIA DISSECTION ANATOMY

45 (90%) of the 50 cadavers had celiac ganglia between T12 and L1, whereas 5 (10%) had celiac ganglia between T11 and T12.

Table 1: Celiac ganglia of the cadavers

Celiac ganglia	Number	%
T12 and L1	45	90
T11 and T12	5	10

These ganglia were discovered in the upper section of the retroperitoneum, in front of the diaphragmatic crura, medial to the adrenal glands, and near the aorta between the celiac artery origin and the superior mesenteric artery (SMA). 74% (37/50) of the left ganglia were located between the left adrenal gland and the left diaphragmatic crura. 80% (40/50) of the right ganglia were at the superior angle as a consequence of the left renal vein entering the inferior vena cava (IVC) and were commonly partially or totally covered by the IVC.

There was one celiac ganglion on each side of the 50 cadavers. The morphology of the ganglia varied, with 84% (84/100) being lamina-shaped, 11% (11/100) being nodule-shaped, and 5% (5/100) being sickle-shaped. The right ganglia's long (left-right) diameter was 13.24 ±5.29 mm and the left ganglia's short (anteroposterior) diameter was 1.61±0.63 mm and the left ganglia's short (anteroposterior) diameter was 2.32± 0.58 mm.

Table 2: Morphology of ganglia at Dissection

Morphology	Number	%
Lamina-shaped	84	84
Nodule-shaped	11	11
Sickle-shaped	5	5

The long (left-right) diameter of the right ganglia in the ten cadavers designated with MRI contrast media was 22.02 ±4.69 mm, while the short (anteroposterior) diameter was 2.12± 0.39 mm. The long and short diameters of the left ganglia were 19.98± 6.33 mm and 2.79 ±0.37 mm, respectively.

ANATOMY OF CELIAC GANGLIA ON MRI

All right and left ganglia were recognised as hyperintense relative to liver and spleen on T1-weighted MR images of ten cadavers. Each side had one celiac ganglion.

In the ten cadavers studied, 16 (80%) of the 20 celiac ganglia were found between the celiac artery and the SMA, in front of the diaphragmatic crura, and near to and medial to the aorta. Four (20%) of the twenty celiac ganglia were at the SMA level. On MR scans, the right and left celiac ganglia were displayed at the same level in 8 (8%) of 10 cadavers. Almost all celiac ganglia were visible at the pancreatic level. The right celiac ganglia were seen at the head and body of the pancreas in 40% (4/10) and the left in 60% (6/10); at the head of the pancreas, the right celiac ganglia were seen in 30% (3/10) and the left in 20% (2/10); and at

the body and tail of the pancreas, the right celiac ganglia were seen in 30% (3/10) and the left in 20% (2/10). The location of the celiac ganglia in the pancreas did not vary substantially between the right and left ganglia (Fisher's exact chi-square, $p > 0.05$).

The IVC, right adrenal gland or kidney, right diaphragmatic crura, SMA, and pancreas created a region in which 8 (80%) of 10 right celiac ganglia were found. The open area produced by the left adrenal gland or kidney, left diaphragmatic crura, and SMA contained 9 (90%) of the 10 left ganglia.

There were 9 right ganglia in front of the right diaphragmatic crura and 1 right ganglia in front of the aorta. The left ganglia were 7 and 3, respectively, in front of the left diaphragmatic crura and the aorta ($p = 0.21$).

The celiac ganglia of the 10 cadavers were lamina-shaped in 65% (13/20), nodule-shaped in 15% (3/20), and sickle-shaped in 20% (4/20) on MR images.

Table 3: Morphology of ganglia at MRI

Morphology	Number=20	%
Lamina-shaped	13	65
Nodule-shaped	3	15
Sickle-shaped	4	20

On MR scans, the long and short diameters of the right ganglia were 25.03±7.55 mm and 2.61±0.66 mm, respectively, and 20.32±5.58 mm and 3.11±0.77 mm, respectively. The ganglia sizes evaluated on MR images did not change substantially from those obtained after dissection ($p > 0.05$). The MR image diameters were bigger than the dissection diameters; however, only the short diameter of the right celiac ganglia was substantially different ($p< 0.001$).

HISTOLOGY OF CELIAC GANGLIA

In the 5 gadolinium-marked celiac ganglia taken from three cadavers, histologic analysis confirmed the presence of ganglion cells. Sparse nerve fibers were present among the ganglion cells.

DISCUSSION

There are preganglionic parasympathetic fibres, preganglionic and postganglionic sympathetic fibres, and afferent fibres in the celiac plexus. The celiac ganglia are clusters of nerve cell bodies from postganglionic sympathetic nerves. Nerve fibres go from the plexus to the upper abdominal organs mostly via following blood arteries to the organs. The stomach, liver, gallbladder, pancreas, adrenal glands, and kidneys are among the organs supplied.[1] The celiac plexus consists of a diffuse network of nerve fibres and multiple ganglia that lie over the anterolateral surface of the aorta at the T12 or L1 vertebral level.[1] The network of nerve fibres is fine and difficult to identify in cadaver dissection. Dal Pozzo et al.[10] observed that the celiac ganglia were detected during anatomic dissections due to their proximity to the diaphragmatic crura and adrenal glands; also, the right ganglia are near to the IVC. In our investigation, 90% of the 50 cadavers had ganglia at the T12 or L1 level. These ganglia were discovered in front of the diaphragmatic crura, medial to the adrenal glands, and near the aorta between the celiac trunk origin and the SMA. Most left ganglia were located between the left adrenal gland and the left diaphragmatic crura, whereas most right ganglia were located at the superior angle formed by the entry of the left renal vein into the IVC and were usually partially or totally covered by the IVC.

We also assessed the celiac ganglia diameters during dissection. The long (left-right) diameter of the right ganglia in the ten cadavers marked with MRI contrast media was 22.02±4.69 mm, while the short (anteroposterior) diameter was 2.12±0.39 mm. The long and short diameters of the left ganglia were 19.98±6.33 mm and 2.79±0.37 mm, respectively.

These measurements were comparable to those reported by Ward et al.[1]. Celiac plexus block is used to relieve severe upper abdominal discomfort caused by pancreatitis or pancreatic tumours. Bony landmarks, fluoroscopy, sonography, or CT may all be used to guide the block. To minimise serious issues, technologies such as CT or MRI, which may detect soft tissue, particularly the celiac plexus, are suggested.

Dal Pozzo et al.[10] used CT to locate the celiac ganglia at the level of the celiac trunk and SMA. The celiac ganglia were found to be tiny oval or laminar structures with a lesser density than the diaphragm. The celiac ganglia so revealed matched identically in location, shape, and size to the anatomic structures previously reported in vivo, according to CT of the material. Fukuda et al.[11] discovered neural plexus invasion on CT in common bile duct cancer. Increased attenuation of the fat between the common bile duct and the appropriate hepatic artery was discovered to be connected with neural plexus invasion in the hepatoduodenal ligament by those researchers.

In patients with advanced pancreatic cancer and other intra abdominal malignancies, CT is frequently utilised to locate the celiac plexus for neurolytic blocks. Hol et al.[12] described celiac plexus blocks conducted in an open MRI scanner, including needle guiding through an optical tracking device and picture collection in near real time. In all cases, the needle placement was simply guided by MRI. The MRI approach enables superb soft tissue imaging and direct monitoring of needle movement while avoiding ionising radiation exposure. Celiac plexus blocks may be safely done in an open MRI scanner. However, no papers to our knowledge have characterised the typical architecture of the celiac plexus or ganglia on MRI.

The celiac ganglia are roughly 2 cm long on the long axis. So far, detailed in vivo MRI has been hampered by motion (respiratory and elsewhere) and the vast size of the abdomen. However, strategies for better registration of breathing or multiple-breath-hold acquisitions, or more efficient data acquisition, are likely to improve the spatial resolution of abdominal MR images.[6-9] Mitchell et al.[13] reported that adrenal corticomedullary contrast medium could be depicted on high resolution T2-weighted images using current MRI techniques. The celiac ganglia were identified in cadavers utilising commercial MRI techniques such as gradient-refocused-echo T1-weighted in-phase and out-of-phase imaging and 3D rapid spoiled gradient-echo fat-suppressed T1-weighted imaging.

We validated the MRI patterns of the celiac ganglia in cadavers by isolating and labelling the ganglia with T1-shortening contrast media. Six celiac ganglia were sectioned and examined under light microscopy from the ten cadavers scanned by MRI to confirm the existence of ganglion cells. The signal intensity of the celiac ganglia on MRI T1-weighted images was greater than that of the liver and spleen for unknown reasons. One probable cause is that cadaver celiac ganglia lost water or that gadolinium chelate entered the celiac ganglia surfaces, shortening their T1 time.

The majority of celiac ganglia were found between the celiac artery and the SMA, in front of the diaphragmatic crura and medial to the aorta, according to our findings. On axial T1-weighted MR images, almost all celiac ganglia could be observed at the pancreatic level. The majority of right celiac ganglia were found in the open space produced by the IVC, right kidney, right diaphragmatic crura, and SMA, whereas the majority of left ganglia were found in the open space formed by the left adrenal gland or kidney, left diaphragmatic crura, and SMA.

On axial MR images, we measured the long and short diameters of the celiac ganglia. These two sizes were equivalent to the ganglia's right and left diameters and anteroposterior diameters upon dissection. We excluded measuring the superior-inferior diameters of the ganglia because they are difficult to estimate on MR images. The long and short diameters of the celiac ganglia determined on MR images did not vary substantially ($p > 0.05$) from those obtained during dissection.

To the best of our knowledge, ours is the first research suggesting that when bigger ganglia are chosen and tagged with gadolinium, current clinical MRI methods can reveal the celiac ganglia in cadavers. The proportions and architecture of the celiac ganglia in cadavers may vary from those in vivo. Moving the viscus, dissecting and isolating the celiac ganglia, and labelling the celiac ganglia with MRI contrast material prior to conducting cadaveric MRI may result in differences in the position, morphology, and size of the celiac ganglia between cadaveric and in vivo MR images. A better test of MRI capacity would be to scan cadavers before to dissection, trying to identify the celiac ganglia, and then proving or disproving the diagnosis during dissection. This modification would eliminate the study's shortcomings.

CONCLUSION

Our findings reveal that current MRI methods in cadavers may not only portray the position and shape of the celiac ganglia (assuming bigger ganglia are chosen and tagged with gadolinium), but can also be utilised to estimate the ganglia's diameters.

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