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The evaluation of vasculature in post-mortem angio-computed tomography for anatomy research purposes: method description based on celiac trunk analysis

Jakub Batko et al., Post-mortem CT celiac trunk analysis

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ABSTRACT

Background: Anatomical research based on deceased body specimens is a time-consuming process that requires a great deal of skill and time to perform correctly. Three-dimensional medical image analysis is an excellent tool for anatomic evaluation, but it often includes patients with comorbidities in the study group, which can skew the results. The purpose of this study was to develop and evaluate methods for anatomic research based on postmortem contrast-enhanced computed tomography angiography 3D reconstruction of the celiac trunk.

Materials and methods: Postmortem contrast-enhanced computed tomography angiography of 105 (28.6% female, age 50.8±18.7) decedents without abdominal trauma or tumor was analyzed. The abdominal portion of the aorta and the celiac trunk with its branches were reconstructed and evaluated. The type of celiac trunk was evaluated. The results were analyzed.

Results: The celiac trunk, splenic artery, and common hepatic artery were visualized in all cases. The left gastric artery was visible in 97.1% of cases. The dorsal pancreatic artery was visualized in 61.0% of cases. The most common type of celiac trunk was 1 (88.6%), and the rarest types were 2, 3, and 6 (1.0%). We observed 4 morphologies of the truncus celiacus that did not fit the classification presented previously.

Conclusions: This study has demonstrated that three-dimensional reconstruction of postmortem contrast-enhanced computed tomography is an excellent tool for performing accurate morphometric analyzes for anatomic research purposes. This method can serve as a source for anatomic studies in the healthy population.

Key words: post-mortem CT, celiac trunk, post-mortem 3D visualisation, RadiAnt

INTRODUCTION

Anatomical research has long been associated with dissection. In this form of research, the researcher is exposed to fumes of formaldehyde (formalin) for a long time, which can lead to serious health complications, including the development of cancer [2, 3]. On the other hand, dissection is a time-consuming process that is highly dependent on manual skills. If performed incorrectly, it cannot be recovered. To avoid these problems, modern anatomy research is supported by studies based on medical imaging and its three-dimensional reconstruction [1, 5, 8]. However, in order to perform a correct analysis, patients should not have comorbidities, which is a challenge because medical imaging is usually performed as part of the diagnostic process. The data collected during such an examination can have great clinical implications for the surgical treatment of various diseases and the diagnosis of certain disorders. To solve the above problems, postmortem contrast-enhanced computed tomography angiography can be considered a valuable source for anatomical research. It is performed in selected departments of forensic medicine as a valuable tool to support autopsy in the search for cause of death and other important information [4, 14]. However, the visualization method could also be used in anatomy departments to provide medical images of donors for future research and teaching purposes.

Therefore, the aim of this study is to evaluate the usefulness of postmortem contrast-enhanced computed tomography angiography for anatomic studies, develop the research method, and discuss its limitations. To evaluate this method in practice, we performed studies on a previously well-described region of the truncus celiacus.

MATERIALS AND METHODS

Study population

Postmortem contrast-enhanced computed tomography angiography (CTA) scans (16-detector row computed tomography Somatom Emotion, Siemens AG, Germany) of 105 (28.6% female, age 50.8±18.7) human bodies imaged between 2012 and 2017 were retrospectively evaluated. Scanning parameters were 130 kVp, 50 mAs, and 240 mAs, reconstructed slice thickness of 0.75 mm, collimation 16 × 0.6 mm. The oily liquid contrast agent: 6% Angiofil (Fumedica, Muri, Switzerland) kerosene oil solution via unilateral or bilateral access to the femoral vessels according to the procedure used by the Technical Working Group Postmortem Angiography Methods [4]. Results were obtained using RadiAnt DICOM Viewer three-dimensional reconstruction software (Medixant. RadiAnt DICOM Viewer [Software]. Version 2022.1. Feb 10, 2022. URL: https://www.radiantviewer.com).

Reconstructions for the present work were based on arterial phase acquisition results. Three-dimensional volume rendering reconstructions were performed and evaluated. The quality of imaging for research purposes was graded: Images were classified as high quality if all celiac main branches with their branches were fully visible, medium quality if one celiac branch was not fully visible, and low quality if one of the celiac main branches was not visible or more than two celiac branches were not visible.

Analysis of the celiac trunk

The types of the celiac trunk were taken from the research of Adachi [4] and determined by two different researchers. If the evaluation of the type differed between the researchers, the evaluation was repeated and reported as the final result.

The diameter of the aorta, celiac trunk and each of its branches was measured. The distances from the origin of the celiac trunk to each branch, the angle of origin, and the location were measured and evaluated. The distance between the origin of the celiac trunk and the origin of the abdominal aorta and the aortic bifurcation was measured.

Statistical analyzes

Data were analyzed using IMB SPSS Statistics 28.0 (Predictive Solutions, Pittsburgh, PA, USA). Categorical variables are presented as number (n) or percentages. Quantitative variables are presented as mean with standard deviation. Normal distribution was examined using the Shapiro-Wilk test. Group comparisons between quantitative variables were performed using the U-Mann Whitney test. The p value < 0.05 was considered significant.

Ethical statement

This study was approved by the Bioethical Committee of the Jagiellonian University, Cracow, Poland (No. 1072.6120.241.2021 approved in 2021). The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki.

RESULTS

According to the computed tomography protocol, 61% of the images were classified as very good quality and 39.0% as intermediate quality. There were no poor quality images in this study. The main cause of poor to moderate quality was visualization of the dorsal pancreatic artery, which was poorly visualized in these cases. In 2.9% of cases, intermediate quality was determined because of poor visualization of the branches of the left gastric artery.

All celiac branches were reconstructed and visualized. Semiautomated reconstruction was challenging in the pancreatic region. In the other regions, the terminal branches of each celiac trunk were captured in 97.1% of cases. (Figure 1).

The most common celiac trunk type was 1 (88.6%). Types 2, 3, and 6 were present in only one case. Type 5 was present in 5 cases (4.8%). 4 cases (3.8%) did not meet the classification criteria (in 3 cases, we observed multiple origins of the left gastric artery, and in one case, we observed a common origin of the hepatic artery from the superior mesenteric artery and an additional trunk for the left and right gastric artery). The diameter of the celiac trunk was 7.2±1.7 mm. The distance between the celiac trunk and the origin of the abdominal aorta was 7.4±2.9 cm and between the celiac trunk and the aortic bifurcation was 13.2±1.5 cm (Figure 2).

The diameter of the splenic artery was 6.1±1.3 mm. The length from the origin of the celiac trunk to the splenic artery was 20.0±6.6 mm, the angle of origin was 106.5±28.1º, and the origin was most often anterior in 35.2% of cases and least often posterior in 1.0%. Pancreatic branches of the splenic artery were visible in 61% of cases.

The left gastric artery was visualized in 97.1% of cases. The diameter of the left gastric artery was 3.8±1.1 mm. The length from the celiac trunk to the origin of the left gastric artery was 14.7 mm±5.4 mm, the angle of origin was 126.4±31.2 º, and the site of origin was upward in 80.8% of cases and downward in 1.0% of cases. The terminal branches of the left gastric artery were visualized in 100% of the cases in which the left gastric artery was visible.

The diameter of the common hepatic artery was 5.1±1.2 mm. The length from the origin of the celiac trunk to the common hepatic artery was 12.4±9.2 mm, the angle of origin was 121.2±30.1 º, and the site of origin was right in 49.5% of cases and left and downward in 1.0% of cases. The terminal branches of the common hepatic artery were visible in all cases.

In 14.3% of cases, we observed that the diaphragmatic arteries originated from the truncus celiacus. In 2 decedents (1.9%), we found the origin of the gastroduodenal artery in the celiac trunk.

DISCUSSION

This study describes a new useful research method for anatomical studies. It is based on postmortem CT visualization, which allows detailed visualization of anatomical structures. Significant differences between postmortem and normal low dose CT should be mentioned. In postmortem CT, higher radiation doses are used for better imaging quality so as not to harm the patient. In addition, a hydrophobic paraffin-based contrast agent is used, as opposed to the hydrophilic iodine contrast agent used in low-dose radiation CT patients. These features provide more detailed anatomical images compared to steady-state visualization methods. It should be considered especially for studies of small anatomic structures that cannot be visualized by other means. Postmortem CTA can be a useful tool for anatomical research. It is a very sufficient source that could be performed more frequently for scientific purposes. Collaboration between the departments of anatomy and forensic science could also be a part of the collection of imaging data for scientific and didactic purposes. However, there should be clear inclusion criteria for ethical consultation during data collection so that donors accept the proposed analysis. The process of three-dimensional reconstruction is reproducible, simpler, and faster compared with classical anatomical dissection, and it allows the analysis of anatomical structures in their correct localization. This method can increase the quality and quantity of anatomical examinations and improve safety because researchers are not exposed to formalin. All of these factors can lead to more reliable anatomical studies based on imaging of younger, deceased human bodies, with no or well-defined clinical or disease biases. The collection of computed tomography scans and multicenter collaboration may lead to the development of a large database of computed tomography scans, which can greatly improve anatomic research. Our study revealed some rare variations of the truncus celiacus. Similar and other rare cases have been previously reported in the literature [6, 10]. Postmortem CTA could be a suitable tool to study rare variations of the truncus celiacus in a representative, large population. Our results are comparable to those of other studies based on dissection, medical image analysis, and reconstruction, which further demonstrates the usefulness and quality of the proposed method [1, 5, 7, 9, 11–13].

The main limitations of using this method are access to CT scanners and qualified technicians, similar to the contrast injection method. In addition, as in the present case, rapidly decomposing parts of the human body, such as the pancreas, and their surroundings may be difficult to visualize.

CONCLUSIONS

Three-dimensional reconstruction of postmortem contrast-enhanced computed tomography is an excellent tool for performing precise morphometric analyzes for anatomic research purposes. Visualization of vessels near rapidly decomposing organs can be challenging. Three-dimensional reconstruction analysis with contrast-enhanced computed tomography after death may be an alternative for dissection studies.

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Ethical statement

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Conflict of interest: None declared

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Table 1. Celiac trunk branches morphometry comparison. CT – celiac trunk.

	Common hepatic artery		**Left gastric artery**		**Splenic artery**		**P**
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Artery origin angle [º]	121,2	30,1	126,4	31,2	106,5	28,1	<0.001
Distance from CT origin [mm]	20,6	8,5	14,7	5,4	20	6,6	<0.001
Artery origin diameter [mm]	5,1	1,2	3,8	1,1	6,1	1,3	<0.001

Figure 1. Visualization of abdominal aorta branches. Good quality visualization of celiac trunk. 1. Celiac trunk, 2. Common hepatic artery, 3. Left gastric artery, 4. Splenic artery, 5. Superior mesenteric artery, 6. Left renal artery 7. Right renal artery, 8. Aorta bifurcation.

Figure 2. Celiac trunk origin distance to abdominal aorta origin and to aorta bifurcation.


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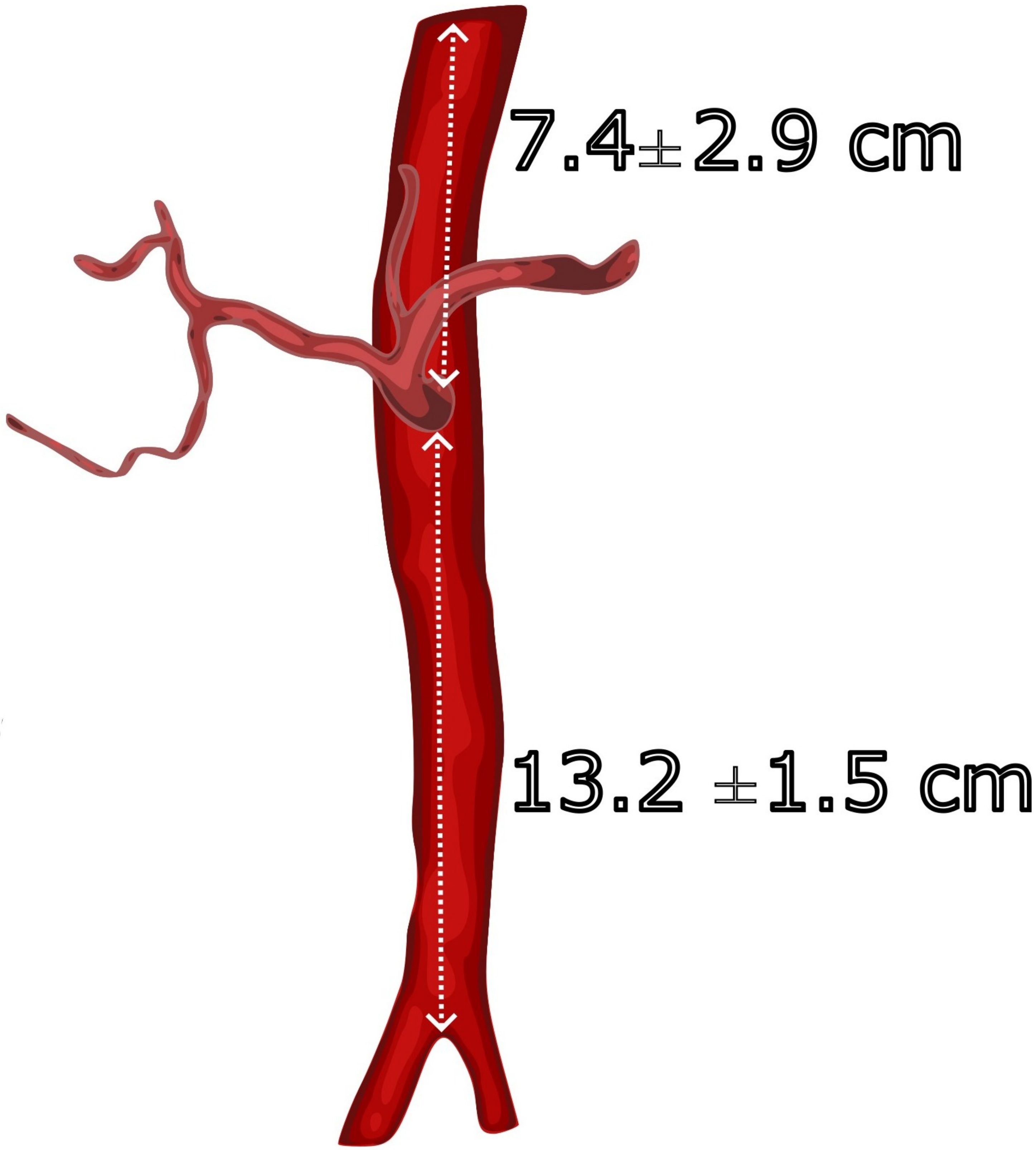
7.4±2.9 cm
13.2 ±1.5 cm