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The role of computed tomography angiography in the diagnosis of anomalies of the inferior vena cava. Clinical observations.

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ABSTRACT

This paper presents the results of clinical observation of the abnormalities of the inferior vena cava (IVC) incidentally detected in patients with various pathologies and severity during both emergency and planned examination using the equipment with various technical parameters. Abnormal IVC is its breakage at various segment levels with the continuation in the azygous or semizygous vein; it can be incidentally detected during X-ray studies. The computer-tomographic angiography (CT angiography, CTA) potential in identifying this type of vascular anomaly, rare and often asymptomatic, is of particular interest. At the same time, its relative simplicity, the use of different protocols of research and setups do not limit the capabilities, and indicate the universality of the method. A brief history and a literature review of this issue have been provided. The first publication describing the changes in anatomical structure (congenital abnormalities) of IVC were found in XVIII century in the writings by John Abernetti (UK, 1793). Certainly, today there are many methods of diagnosis that allow suspecting, identifying and assessing the nature of vascular pathology (abnormality). We believe that CT angiography has opened up new opportunities and horizons for the detection of vascular disease, including various abnormalities.

Keywords: IVC dysplasia, CT angiography, IVC abnormality, phlebography.

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INTRODUCTION

IVC abnormality is its breakage at various segment levels with the continuation in the azygous or semizygous vein [[1]]. According to [[2]], the prevalence of this disease is 0.6-2.0% of all patients with congenital defects, and less than 0.3% among the healthy population. According to other sources [[3]], the prevalence of an isolated defect is 0.1-0.3%. The literature provides a variety of synonyms and names of this disease. G. Bunkley attributes such congenital abnormalities to the abnormal drainage of the systemic veins. There is such a notion as the IVC dysplasia. This term means the absence of the venous trunk (aplasia) or its underdevelopment (hypoplasia) [[4]]. The main trunk of the venous reservoir is interrupted below the hepatic veins, and the venous drainage of the systemic circulation is carried out through the dilated azygous vein to the superior vena cava. In embryological terms it is explained by the lack of connection between the right hepatic and subcardinal veins, which results in a breakage of IVC with the continuation in the azygous vein. Thus, the discharge of venous blood from the lower body to the azygous vein system is performed at the expense of multiple anastomoses between the right subcardinal system (IVC) and the right subcardinal veins (azygous vein system). Anatomically, the IVC segment between the hepatic and renal veins is absent. At the same time, hepatic veins end directly in the right atrium; renal veins are connected to the unchanged lower part of the IVC. Despite the fact that the defect is compensated (without impaired hemodynamics), this abnormality becomes clinically relevant in the event it involves a combination of a heart defect that may complicate cardiac catheterization and surgical correction of the defect [[1]]. It should be noted that this abnormality may be associated with both cardiovascular abnormalities and malformations of other organs and systems (including multiple spleen). Knowing venous return abnormalities is extremely important in the surgical correction of the heart defect using extracorporeal circulation and must always be taken into account, at the same time, it is important that these malformations are discovered incidentally during diagnostic procedures [[1]].

Using clinical observations presented in this paper as an example, we want to demonstrate a unique CTA potential to assess the vascular bed in case of IVC abnormality in patients with various pathologies.

CLINICAL OBSERVATION No.1.

| Fig. 1 | Fig. 2 |

MPR-reconstruction, the frontal plane, the venous phase.
Lack of suprarenal IVC segment.

Male, 34 years old, applied to the hospital in April 2010, to the department of radiology, on an outpatient basis, in order to undergo computer tomography (CT) of the abdominal cavity. CT with contrast was performed on a single-slice spiral computed tomograph Siemens Somatom Emotion. Contrast medium: Ultravist. Iodine concentration: 370. Volume: 100 ml. Route of administration: intravenous. Conclusion: No

focal pathology of the abdominal cavity or retroperitoneal space was revealed. Suspected IVC pathology as an incidental finding. After 7 days, the patient was called again to undergo CT of the chest cavity, which results provided a detailed description of IVC pathology. An abnormal tortuosity and dilation of the individual veins was detected in the parenchyma of the right lung. At the same time, IVC is typically located up to Th12-L1 level. Right renal vein ends in the IVC in a typical point. At L2-3 level, the branch is retroaortically determined between the IVC and the left renal vein, which is connected to v. hemiazygos, ending in v. azygos at Th10 level (it is more likely that the left renal vein flows directly into v. hemiazygos, which diameter at this level is 0.8 cm). V. azygos is dilated up to 2.9x1.8 cm at Th11 level and up to 2.0x2.5 cm at the level of its ending in the superior vena cava (SVC). Suprarenal IVC segment is absent. Hepatic veins end in the right atrium. Duplication of the right renal artery. SVC is formed at the level of junction of the third right rib cartilage to the sternum, and ends in the right atrium at the level of junction of the fifth right rib to the sternum. Dimensions: 1.7x1.8 cm in the merge point of brachiocephalic veins and 2.1x1.9 cm in its end point in the right atrium.

The detected changes have been regarded as IVC dysplasia with its suprarenal department aplasia. Later, after 5 months, the patient was routinely hospitalized in the department of surgery, for invasive cavagraphy in order to clarify the diagnosis. During invasive phlebography, the changes in the IVC trunk were interpreted as stenosis at Th12-L1 level up to 65-70% (Fig. 3, 4).

Fig. 3   Fig. 4

Transfemoral invasive cavagraphy. Intraoperative images. IVC stenosis at Th12-L1.

Thus, the CTA on a single-slice spiral tomograph with extending the area of interest allowed us to characterize the abnormality throughout the entire IVC length and its branches in both the thoracic and abdominal cavities, and to identify redistribution and of venous bed and intersystem anastomoses.

During the following clinical observations, CT studies were conducted using Aquilion 64 (Toshiba). The study protocol: a typical patient positioning for the investigation of areas of interest ("footfirst", "supine"); topogram (at breath-hold); native scanning (at breath-hold); slice thickness - 5.0 mm, followed by the construction of three-dimensional images with a slice thickness of 0.5 mm; tube rotation time - 0.5 seconds; CTA in "Pulmonary" and "T-aorta" mode; trigger at the level of pulmonary trunk and aortic arch, density - 130 150 Hu; scanning time delay - 5 seconds, contrast administration rate - 4 cm/sec. Contrast medium: Iopromidum (Ultravist), iodine concentration: 100 mg/ml, volume — 100 ml. Contrast administration route: bolus, via perfusion catheter C18 inserted in the cubital vein, with the use of tomograph-synchronized OptiVantage dual-head injector. Effective dose: 555.6 and 319.9 mGy. No adverse reactions observed.

CLINICAL OBSERVATION No.2.

Female, 54 years old, delivered by emergency team to the clinic in a critical state. Preliminary diagnosis made by duty therapist: Chronic obstructive pulmonary disease, exacerbation. Pneumosclerosis.

Diffuse non-toxic goiter. Hydrothorax right. Hypertensive disease grade II, risk 4, CHF 2b. Pulmonary heart, decompensation. Type 2 diabetes, decompensation. Ascites. Retroperitoneal cyst. Hospitalized in the intensive care unit.

Complaints on admission: dyspnea, cough with green sputum, general weakness.

History: for a few hours before admission - a sharp deterioration in condition in the form of severe dyspnea, feeling shortness of breath, severe weakness, cyanosis of the upper and lower extremities.

Echocardiography: moderate fibrosis of aortic valve leaflets. Dilatation of the right heart chambers. Severe tricuspid regurgitation. Echo signs of severe pulmonary hypertension. Slight mitral regurgitation. Left ventricular hypertrophy.

CT of thorax, abdominal cavity and retroperitoneal space: CT signs of chronic obstructive pulmonary disease, bronchiolitis, bronchiectasis. Middle lobe fibroatelectasis with bronchiectasis. Pulmonary engorgement, manifestations of interstitial pulmonary edema. Frosted glass-type mass lesions in S1+2 and S6 of the left lung, with small subpleural areas of lung tissue consolidation at S1+2 - to differentiate the symptoms of alveolar pulmonary edema and pneumonic infiltration. Bilateral hydrothorax (mostly right). Slight hydropericardium. Severe pulmonary hypertension. Intrathoracic lymphadenopathy.

Liquid in the abdominal cavity (ascites). IVC abnormality.

The study revealed the IVC pathology. Inferior vena cava ends in azygos vein, no IVC hepatic segment is present (hepatic veins end in the right atrium - Fig. 5, 6). Azygos vein diameter ~ up to 1.8 cm. The hepatic artery extends away from the superior mesenteric artery. Polysplenia (Fig. 7).
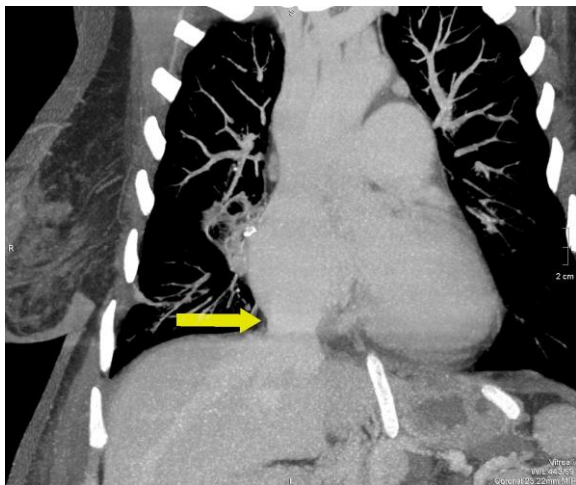

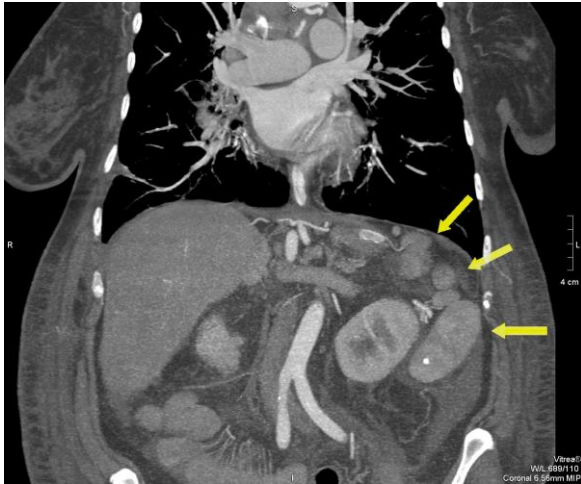| **Fig. 5** | **Fig. 6** |
| MIP-reconstruction, the frontal plane, the venous phase. | MIP-reconstruction, the sagittal plane, the venous phase. |

Hepatic veins ending in the right atrium.

Fig. 7
MIP-reconstruction, the frontal plane, the arterial phase.
Polysplenia (multiple spleens).

An important aspect of the clinical example is that the possibility of simultaneous expansion of areas of interest during the CTA ensured identification of the abnormality, as well as evaluation of its character without using any special methods of image contrast enhancement for the investigation of the IVC, along the entire length without increasing the duration of the study, subject to the critical condition of the patient.

CLINICAL OBSERVATION No.3.

Male, 60 years old, hospitalized in the cardiology department No.2, routinely (for the selection of therapy, follow-up examination).

Complaints: pressing retrosternal pain, shortness of breath (up to 2-3 times a day) after walking 50m, going upstairs to the 1st floor, insignificant household activities, sometimes at rest, in the early morning hours; corrected with Nitrospray. Strengthening of the inspiratory dyspnea, especially at night, in a horizontal position, takes up a forced sitting position.

Anamnesis: CHD clinic since May 2011, after suffering an acute myocardial infarction (AMI), underwent stenting of the anterior coronary artery (ACA). October 2011 - stenting of the circumflex branch (CFB). April 2012 - stenting of the anterior interventricular artery (AIVA), diagonal branch (DB). July 2013 - angioplasty with stenting of the CFB medial segment. Continuous intake of Aspirin, Carvedilol, Atorvastatin, Ramipril. Noted deterioration in the form of increased frequency of angina attacks, increased dyspnea, increased frequency of nocturnal attacks of breathlessness, weakness, the progressive reduction in exercise tolerance. In 2014, the CT results revealed an aneurysm of the abdominal aorta, in 2015, consultation with a vascular surgeon, no surgical treatment was offered, recommendations to continue the conservative therapy.

Electrocardiography: Sinus rhythm with a heart rate = 66 bpm. Normal electrical axis of the heart. Inferior heart attack with Q-wave, the T-wave of indefinite age.

Doppler ultrasound of the carotid arteries: the echo signs of extracranial atherosclerosis of the arteries of brachiocephalic trunk and aortic arch. Stenosis: the right carotid bifurcation 30%, the right internal carotid artery 35-40%, the right subclavian artery 30%, the left carotid bifurcation 25-30%. S-shaped tortuosity of the left common carotid artery.

Echocardiography: Disorders of local contractility of the left ventricular myocardium. Indurated and dilated aorta. Moderate fibrosis of aortic valve leaflets. Echo-signs of moderate aortic stenosis. Slight aortic insufficiency (apparently of atherosclerotic genesis). Left ventricular hypertrophy. Dilatation of the left atrium. Moderate mitral regurgitation. Echo signs of moderate pulmonary hypertension.

CT of abdominal cavity and retroperitoneal space (spot imaging of the abdominal aorta): Deformation of abdominal aorta, with an angular bend in the infrarenal section. At a distance of about 4.4 cm distal from the mouth of renal arteries - aneurysmal expansion (Fig. 8) over a length of about 5.6 cm (due to the protrusion of the posterior and left lateral wall), with a maximum diameter of 6.7 cm. The formation of the inferior vena cava is observed at the renal level of the aorta through merging of the common iliac veins (with the renal veins ending in them) - Fig. 9, 10.
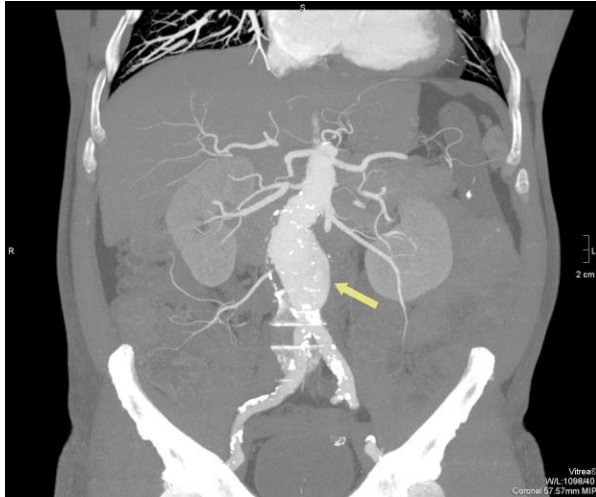
Fig. 8
MIP-reconstruction, the frontal plane, the arterial phase.
Aneurysm of the abdominal aorta.
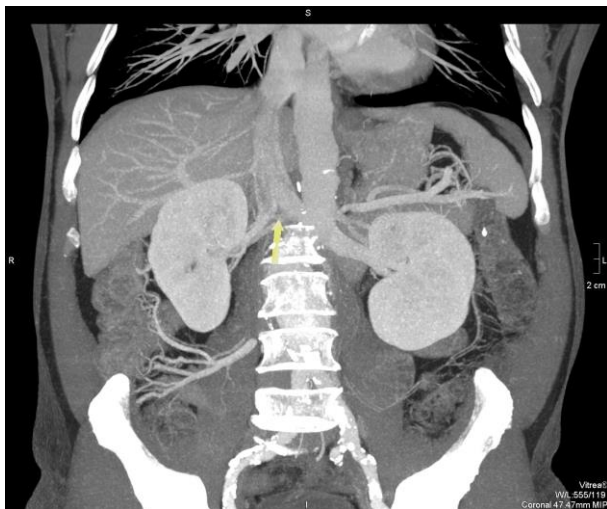
Fig. 9
MIP-reconstruction, the frontal plane, the venous phase.
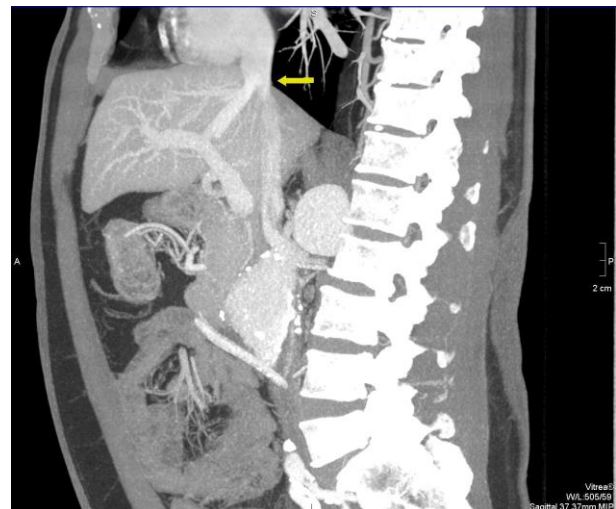
Fig. 10.
MIP-reconstruction, the sagittal plane, the venous phase.

IVC formation by merging of the common iliac veins, with the renal veins ending in them; ending of the hepatic veins.

Analyzing the clinical observations, it is fair to note that the IVC abnormality was an accidental discovery made in all presented examples; at the same time, its detailed assessment was performed during CT angiography, in portal (venous) contrast phase.

SUMMARY

Inferior vena cava abnormalities are a rare pathology, identified in most cases by chance during X-ray studies, which has been demonstrated by our observations, without the intense IVC filling with contrast medium, which is quite obvious. The important point is that in order to fill the entire IVC with the contrast medium the perfusion catheter must be installed in the peripheral vein of the lower limb for better visualization of the main venous trunks and their branches. In our observations, the main task during the CT scan was to assess the state of internal organs in cases №1 and №2, and the aorta state in the case №3, with the implementation of appropriate scanning protocols, including CTA (contrast medium is administered through the perfusion catheter installed in the cubital vein), followed by analysis of the images obtained during arterial (aorta and its branches), portal/venous (portal veins, and veins of inferior vena cava) and excretory phase (excretory renal function). Filling the inferior vena cava with contrast medium is usually observed during portal phase, in a limited area, caudal to the ending point of the renal veins in the right atrium.

If turning to the history, one of the first publications describing such IVC abnormality was discovered in 1793, when in St. Bartholomew hospital in the UK, John Abernetti drew up the narrative of his sections. One of his observations described two autopsy protocol of the bodies: a child (girl) aged about 10 months, and a boy [[5],[6]]. In the future, with the development of medicine and the advent of CT and CTA, it was possible to detect such abnormalities not only *in vivo*, but also determine the level of the breakage and the subsequent course of the modified vessels. CT is an important diagnostic step in clarifying the nature of the abnormality [[7]]. Analysis of clinical cases and the observations by other authors show that the invasive angiography was preceded by CTA and magnetic resonance angiography/MRA [[8]]. In our observations, as we have already noted, the IVC abnormalities were an accidental discovery and were identified by non-invasive method: in one case, in a female patient during emergency CT scanning of the chest and abdomen, and in two other cases - in male patients during routine examinations of the abdominal cavity.

It should be noted that the literature has described the cases where such abnormalities are combined with anomalies and pathologies of other organs [9], as in one of our cases - IVC abnormality is combined with a multiple spleen. Simultaneous detection of various types of anomalies is possibly due to the fact that the CT, unlike other radiological methods, ensures expansion of areas of interest (in the presented cases - examination of the chest cavity with the abdominal cavity), followed by assessment of the state of organs and tissues of the selected level. CTA allowed for assessment of the nature of IVC abnormalities, which is important in case of the required surgical intervention in the thoracic and abdominal organs [10].

CONCLUSION

Based on the results of our clinical experience, data, literature and presented clinical observations, we consider that the CTA is a procedure with high diagnostic capabilities, which is as good as the invasive methods of diagnosis, and allows revealing various anomalies of development, and should certainly be used as a method of choice for cardiovascular pathology evaluation.

ACKNOWLEDGEMENTS

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