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Multislice computed tomography of potential liver donors

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Abstract

Objective: Multislice computed tomography (MSCT) prior to liver transplantation is an important aspect of the diagnosis of changes in the liver as fat infiltration, as well as visualization of the individual vascular anatomy and calculation of liver volume. The aim of our study was to analyze the results of the single center experience to conduct liver MSCT of donors who are preparing for the transplant donation.

Methods: We studied the MSCT evaluation results of 39 (25 male and 14 female) potential liver donors' during the 2015 - 2016 years. Liver MSCT with various standard renovations were used for more detailed visualization of blood vessels in each liver segment. Images were obtained on 64-slice MSCT (Aquilion; Toshiba Medical Systems, Tokyo, Japan). Interpretation of the results provided in accordance with embodiments of origin of the hepatic artery, portal vein anatomy and drainage of the hepatic veins.

Results. The main results of the anatomy of the hepatic artery, portal and hepatic veins are shown in Table 1, 2, 3. Based on the MSCT of 39 donor's liver, 24 donors were identified as appropriate for donation. 15 donors were contraindicated for donation due to: in 8 - were signs of fatty infiltration, 2 donors - vascular anomaly of the portal vein, benign growths were detected in 5 donors.

Conclusion. MSCT is a primary diagnostic method for the preoperative planning of surgical resection of the liver, as well as preliminary identification of hepatic pathology. According to the results and experience of our center, in 61.5% cases, liver donors were selected for donation and remaining 38.5% of the donors were excluded from organ donation, in connection with the identified contraindications.

Keywords: liver transplantation - multislice computed tomography (MSCT).

БАУЫРДЫҢ ӘЛЕУЕТТІ ДОНОРЛАРЫНЫҢ КӨПҚАБАТТЫ КОМПЬЮТЕРЛІК ТОМОГРАФИЯСЫ

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ТҰЖЫРЫМДАМА

Мақсаты: бауырдың фрагментін ауыстыру үшін операция алдындағы дайындықта және пациенттерді іріктеудегі мультиспиральды компьютерлік томография (МСКТ) жеке тамырлы анатомияны, көлемін есептеуді визуализациялауға және бауырдағы майлы гепатозды анықтауға арналған сәулелі диагностиканың маңызды әдістерінің бірі болып табылады. Зерттеудің мақсаты МСКТ мүмкіндіктерін көрсету және кейінгі хирургиялық жоспарлау үшін бауырды туыстық трансплантаттау барысында әлеуетті донорларда зерттеу нәтижелерін талдау болып табылады.

Зерттеудің әдістері. 2015-2016 жылдары бауырдың 39 әлеуетті доноры тексерілді (25 еркек және 14 әйел. Біз әртүрлі стандартты қайта құруларды, сондай-ақ бауырдың сегменттеріне қан тармырларды визуализациялауға арналған аса егжей-тегжейлі әдістерін пайдаландық. Суреттер 64-кесінді компьютерлік томографта (Aquilion; Toshiba MedicalSystems, Токио, Жапония) жасалды). Зерттеудің нәтижелерін түсіндіру құретамыр қанайналымының, тармақтағы қақпалық көктамырдың негізгі өзегін бөлу анатомиясының нұсқаларына және бауыр көктамырларының төменгі қуыс венасына ағылуының негізгі варияцияларына сәйкес бағаланды.

Нәтижелері. Әлеуетті донорлар бауырының тамыр анатомиясы нұсқаларының негізгі нәтижелері 1,2,3-кестелерде көрсетілген. Өткізілген МСКТ негізінде 24 донорға операциялар жасалды. Донорлардың осы тобында архитектоника мен бауырдың құрылымы, бауыр күретамыры мен көктамыр анатомиясы бауырды трансплантаттауға арналған көрсеткіштерге сәйкес келді. 15 әлеуетті донорда органды трансплантаттауға қарсы көрсетімдер айқындалды: 8-інде – майлы инфильтрация белгілері, 2 донорда – қақпалық көктамырдың тамыр аномалиясы, 5 донорда – қатерсіз өскіндер болды.

Қорытынды. МСКТ донордың бауырын хирургиялық резекциялауды операция алдында жоспарлауға арналған негізгі диагностикалық әдіс болып табылады. Осы әдіс бауырдың патологиялық өзгерістерін анықтаумен негізделген бауырды органдық трансплантауға белгілі бір қарсы көрсетімдерді табуға мүмкіндік береді. Осы нәтижелерге байланысты 38,5% әлеуетті донор донорлықтан шығарылды. МСКТ қорытындысының жиыны бойынша операцияға донорларды іріктеуге 61,5% жағдай расталды.

Маңызды сөздер: бауырды трансплантау - мультиспиральды компьютерлік томография (МСКТ).

ВЛИЯНИЕ ИНДЕКСА МАССЫ ТЕЛА БЕРЕМЕННОЙ НА ГРАФИК КРИВОЙ РОСТА ВЫСОТЫ СТОЯНИЯ ДНА МАТКИ

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РЕЗЮМЕ

Цель исследования: мультиспиральная компьютерная томография (МСКТ) в предоперационной подготовке и отборе пациентов для пересадки фрагмента печени является одним из важных методов лучевой диагностики для визуализации индивидуальной сосудистой анатомии, расчета объема и выявления жирового гепатоза в печени. Целью нашего исследования является демонстрация возможностей МСКТ и анализ результатов исследования у потенциальных доноров при родственной трансплантации печени для последующего хирургического планирования.

Методы. За 2015-2016 гг. было обследовано 39 потенциальных донора печени (25 мужчин и 14 женщин. Нами были использованы различные стандартные реконструкции, а также более детальные методы для визуализации сосудов к сегментам печени. Изображения были получены на 64-срезовом компьютерном томографе (Aquilion; Toshiba Medical Systems, Токио, Япония). Интерпретация результатов исследования оценена в соответствии с вариантами артериального кровоснабжения, анатомии деления основного ствола воротной вены на ветви и основным вариациям впадения печеночных вен в нижнюю полую вену.

Результаты. Основные результаты вариантов сосудистой анатомии печени потенциальных доноров представлены в таблицах 1, 2, 3. На основании проведенного МСКТ 24 донорам были проведены операции. У данной группы доноров архитектоника и структура печени, анатомия печеночных артерий и вен соответствовали показаниям для трансплантации печени. У 15 потенциальных доноров выявлены противопоказания к органной трансплантации: у 8 – были признаки жировой инфильтрации, 2 доноров – сосудистая аномалия портальной вены, доброкачественные образования обнаружены у 5 доноров.

Выводы. МСКТ является основным диагностическим методом для предоперационного планирования хирургической резекции печени донора. Данный метод позволяет обнаружить определенные противопоказания к органной трансплантации печени, обусловленное выявлением патологических изменений печени. В связи с этими результатами 38,5% потенциальных доноров были исключены из донорства. Отбор доноров, по итогам заключения МСКТ, для операции подтверждены 61,5% случаев.

Ключевые слова: трансплантация печени - мультиспиральная компьютерная томография (МСКТ).

Introduction

Liver transplantation is one of the perspectives for effective treatment of patients, suffering from end-stage hepatic cirrhosis [1-5]. Patients with unrespectable hepatic neoplasm shall be also referred to the recipients group [6]. Liver transplantation from living-related donors solves the problem of donor organs deficit and provides an opportunity to choose an optimal period with risk minimization for a donor [7].

An important role in preoperative preparation and selection of patients for liver transplantation belongs to the imaging of parenchyma and vascular architectonics, having a crucial significance for surgical resection. Quantitative, metric and anatomic indicators of liver (dimensions, shape, volume, density, segmental formation), detection of structural changes (fatty infiltration, abnormal development, etc.) play the key role during donor selection [8].

Multislice computed tomography - is an obligatory method of examination, included in preoperative preparation protocol, as it objectively visualizes the whole liver and topographic anatomy of abdomen cavity in a very short space of imaging time (during one breath-holding). 3-phase bolus contrasting allows to very accurately visualizing an anatomy of vascular liver structure.

Safety of this method is identified by non-invasiveness, high imaging speed with post-processing digital data processing, resolution capability in visualization of parenchyma and vascular liver anatomy [4,8]. Multislice CT, during examination of potential donors, gives more diagnostic information, than a traditional set of investigations, replacing an X-Ray contrast angiography [6,9-12]. The aim of this research is to demonstrate the opportunities of multislice computed tomography in examination protocol of potential donors during liver transplantation.

Materials and Methods

We have examined 39 potential liver donors (25 males and 14 females), age range was from 18 to 53 years, mean age of which - 38,1 years.

Multislice CT was included into the examination program after conducting various tests: study of anamnesis, clinical laboratory data, ultrasound investigation, doppler investigation of liver vessels, etc.

MSCT was performed on Aqulion-64 (Toshiba) computed tomography scanner along with digital processing systems. As a contrast agent we used nonionic iodine-containing dimmeriodixanol 320 mg/ml, in amount of 2,0 ml/kg of body mass, with the speed of 4,0-5,0 ml/sec, providing the preliminary normal age indicators of serum creatinine and absence of allergic reaction to iodine. During imaging, images of arterial phase were obtained on 18-24 sec, portal phase on 30-40 sec. On 55-70 second of investigation, from the beginning of contrast agent injection, there came a late venous phase, required for complete visualization of hepatic veins and inferior vena cava. The obtained data were processed at Vitrea workstation with the use of program pack for graphical processing. We have applied programs of multi-planar reconstructions (MPR), reconstructions in maximum intensity projections (MIP), 3D-reconstructions of volume rendering techniques (VRT) [13-14].

Results

For the period from 2013 till 2015, 24 surgeries were performed. 15 potential donors were excluded after the conducted MSCT, in connection with the identified counterindications to liver transplantation.

Each potential donor underwent measurement of liver parenchyma density on CT images without contrast enhancement from the center to the periphery of the right and left lobes.

8 (20,5%) patients out of total number of examined patients were excluded from the list with signs of fatty infiltration, liver density was less than 46HU at 120 κVP. Detection of hepatic steatosis is very important and can be a factor of implant rejection.

Surgeries for two patients (5,1%) were cancelled in connection with anatomic mismatching of portal vein and its branches for living-related liver transplantation. Availability of acute angle, less than 600, origin of segmental branch from the portal vein stem is connected to the increased risk of portal vein thrombosis at the site of anastomosis in post-operative period.

Diagnosable abnormal changes of liver parenchyma, including fluid cysts (N = 3) and hemangioma (N = 2) were also estimated as counterindication to resection.

Intrahepatic small calcification and extrahepatic changes, such as cysts or nephritic calculus (n = 5), gallstones (n = 2) do not impacted to the selection for exclusion of a patient.

Angioarchitecture of liver (according to MSCT-angiography) is estimated for arterial blood supply variations, divided according to the detected flows to hepatic lobes, type of portal vein main stem division into branches and main variations of hepatic veins return into interior vena cava. Figure 1 shows vascular architectonics of liver.

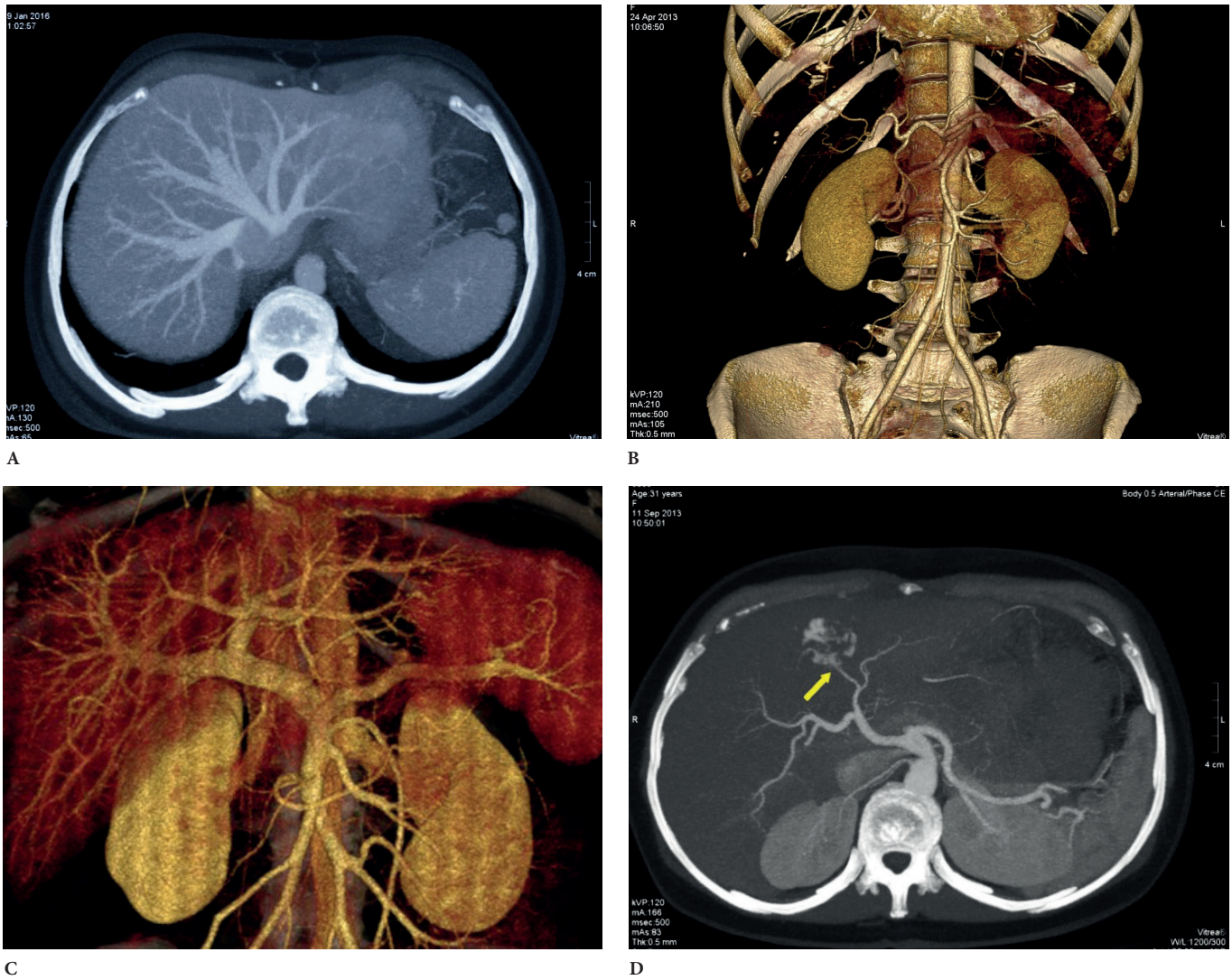

Figure 1- (A) MIP-reconstruction image of normal hepatic veins of the donor in axial projection; (B) 3D-reconstruction image of normal hepatic artery and branches of the celiac trunk of the donor; (C) MIP-reconstruction image of normal portal vein of the donor in coronal projection; (D) MIP-reconstruction image of the arteries of the donor liver in axial projection with hemangioma (arrow) of the left lobe of the liver and supplying branch of the left hepatic artery.

In compliance with the classification of S.V. Gautier and co-authors, variants of arterial blood supply in donors were systematized (Table 1).

During estimation of portal blood supply of liver, variants of portal vein branching, presented in Table 2, were distributed as follows: typical bifurcation was detected in 35 (89,7%) examined patients, trifurcation was detected in 3 patients, that is 7,7%, combination of portal vein bifurcation with the presence of small branches - in 1 patient (2,5%).

Variations of hepatic veins return into the interior vena cava were identified and systematized in Table 3. Separate (individual) return of the right, median and left hepatic veins - in 4 patients, that is 10,2%; Availability of the right hepatic vein and common stem of median and left hepatic veins - in 32 donors (82,0%); Additional veins of the right lobe, including veins individually returning into the interior vena cava, were detected in 30,8% - 12 patients.

Table 1 Arterial blood supply of liver in donors.

Description	Number of patients (n - 39)	Frequency, %	Literature data 6
Classic origin of proper hepatic artery from common hepatic artery with division into right and left hepatic arteries.	25	64,1	55,7
Absence of proper hepatic artery	2	5,1	10,5
Availability of a branch from the left ventricular artery to II and III liver segments	3	7,7	12,5
Common hepatic artery origins from the superior mesenteric artery, no any additional arteries.	6	15,4	2,9
The right hepatic lobe is supplied with blood from the superior mesenteric artery, the left lobe is supplied from the proper hepatic artery	1	2,5	7,6
The right hepatic lobe obtains an additional branch from the superior mesenteric artery if there is the right and the left hepatic arteries with classic division.	2	5,1	2,9

Table 2 Variants of hepatic portal vein branching in donors.

Description	n - 39	%	Literature data 6
Typical bifurcation of the portal vein	35	89,7	80%
Trifurcation of the portal vein	3	7,7	7,6%
Combination of portal vein bifurcation with presence of small branches	1	2,5	7,6%

Table 3 Return of hepatic veins into the interior vena cava.

Description	n - 39	%	Literature data 6
Separate return of the right, median and left hepatic veins	4	10,2	39,9%
Availability of the right hepatic vein and common stem of median and left hepatic veins	32	82,0	12,5%
Additional veins of the right lobe, including veins individually returning into the interior vena cava	12	30,8	10,5%

Discussion

MSCT is a highly-sensitive method for fatty hepatosis diagnostics with indicator of 91,9% [15-18]. According to literature data, changes in portal venous anatomy are detected in 20% of patients [19]. During studying of arterial anatomy of a donor liver, an important aspect was to identify the main sources of liver blood supply, availability of additional arterial branches. While comparison and analysis of literature data, frequency of arterial bed variants is various.

The largest frequency of classic origin of proper hepatic artery from common hepatic artery according to data of N.N Abramov and co-author Michels N.A, [7,20], is detected in the overwhelming majority of cases (55%-55,7%). In our research, the frequency of this variant coincides with the results of Erbay N. etal. [21] and amounts to 64,1%. Quantity of potential donors with the absence of proper hepatic artery is 5,1% of the total number of examined patients. In accordance with S.V. Gautier and coauthors [6] - 10,5%. Availability of branches from the left ventricular artery to the left hepatic lobe is detected in 12,5% [7]. Additional branches from the left ventricular artery to II or III liver segments were visualized by us in 7,7% cases (n - 3). Blood supply of the right hepatic lobe from the superior mesenteric artery is detected in the only one case. Moreover, the left lobe is supplied from the proper hepatic artery. The same variant of architectonics occurs in 7,6% according to the results of other researchers [6-7,20]. In our research, share of variants of arterial hepatic blood supply, where the common hepatic artery origins from the superior mesenteric one (no additional branches) is 15,4% of the total number of donors, that substantially exceeds data of N.N. Abramov and co-authors in 5,3 times (2,9%). In 5,1% of cases, the right hepatic lobe gets and additional branch from the superior mesenteric artery, if there is classical division of hepatic arteries, against 2,9% in our case. Variants of hepatic portal vein branching coincide with literature data [6-7]. However, the frequency of portal vein bifurcation combination with presence of small branches in donors of our researches is 3 times lower. Upon the results of our studies, in 82% of cases there is the presence of the right hepatic vein and common stem of median and left hepatic vein. Nevertheless, according to literature data [6-7], larger frequency of detection is individual return of main hepatic veins (39,9%). Additional hepatic veins of the right lobe are registered in 10,5% of cases. Upon the results of our researches, they are observed 3 times more often. Variants of caval outflow - union of median and left hepatic vein, presence of additional veins, play an important role for drawing a virtual line for a fragment resection.

In order to visualize an anatomy of hepatic arteries and veins, portal vein, as well as the nature of their division, CT-angiography is the least invasive and the most informative visualization method. An advantage of CT-angiography is maximum possible resolution in 3D imaging, multi-planar reconstruction (MPR), reconstruction in maximum intensity projections (MIP), volume rendering technique (VRT), which allows to reveal minimal changes in internal organs, including blood vessels. Moreover, screening of potential liver donors can identify comorbidity, which was used as exclusionary criteria.

Improvement of software provides an opportunity to obtain 3D images including virtual ones (VRT). During analysis of MSCT data on arterial blood supply, we have used the classification of SV. Gautier and co-authors, which is based on

pathologic-anatomical material. During analysis of portal veins return with the use of MSCT method, we made an accent to the location of three main veins - right, median and left, as it identified the variant of liver fragment. Besides, large additional veins were identified, which could impact the process of liver fragment resection.

Conclusion

MSCT is highly-informative method in studying the anatomic features of structure and blood supply of liver and in addition to that, it proved itself as the method for selection of potential donors. Analysis of images with the use of reconstruction technique - MPR, MIP, VRT, 3D-image, in axial and coronal projections is obligatory. MSCT-criteria for selection of potential liver donors require further study (in connection with the growing requirement to the quality of visualization and analysis of obtained data).

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