The comparison of 2-dimensional with 3-dimensional hepatic visualization in the clinical hepatic anatomy education

Jonas Jurgaitis1,2, Marius Paskonis1,2, Jonas Pivoriūnas3, Ieva Martinaitytė2, Agnius Juška3, Rūta Jurgaitienė3, Artūras Samuiliš3, Ivo Volf6, Maks Schönberger6, Peter Schenmer7, Thomas W. Kraus6, Kestutis Strupas1,2

1Clinic of Gastroenterology, Nephrology, and Surgery, Faculty of Medicine, Vilnius University, 2Center of Abdominal Surgery, Clinics of Santariskės, Vilnius University Hospital, 3Faculty of Medicine, Vilnius University, 4Institute of Anatomy, Kaunas University of Medicine, 5Center of Radiology, Clinics of Santariskės, Vilnius University Hospital, Lithuania, 6Division of Medical and Biological Informatics, German Cancer Research Center (DKFZ), 7Department of General, Visceral, and Transplantation Surgery, Ruprecht-Karls-University of Heidelberg, 8General, Visceral, and Minimal Invasive Surgery Hospital, Nordwest GmbH, Germany

Key words: clinical hepatic anatomy; hepatic resection planning; computed tomography; 3-dimensional visualization; surgical education.

Summary. Objective. To determine whether 2-dimensional or 3-dimensional hepatic visualization is better for the medical students to be used while studying the clinical hepatic anatomy.

Material and methods. Twenty-nine patients who underwent surgical intervention due to focal hepatic pathology at the Department of General Surgery, University of Heidelberg, and at Clinics of Santariskės, Vilnius University Hospital were included in the retrospective cohort study. Before the surgical intervention, the computed tomography (CT) liver scan and 3-dimensional (3D) hepatic visualization were performed. A total of 58 2-dimensional and 3-dimensional digital liver images, mixed up in random sequence not to follow each other with a specially designed questionnaire, were presented to the students of Faculty of Medicine, Vilnius University. Their aim was to determine tumor-affected liver segments, to plan which liver segments should be resected, and to predict anatomical difficulties for liver resection. Results were compared with the data of real operation.

Results. The students achieved better results for tumor localization analyzing 3D liver images vs. CT scans. This was especially evident determining the localization of tumor in segments 5, 6, 7, and 8 (P<0.05). Furthermore, the results of proposed extent of liver resection have been found to be better with 3D visualization (mean±SD – 0.794±0.175) in comparison with CT scans (mean±SD – 0.670±0.200), (P<0.001).

Conclusions. Computer-generated 3D visualizations of the liver images helped the medical students to determine the tumor localization and to plan the prospective liver resection operations more precisely comparing with 2D visualizations. Computer-generated 3D visualization should be used as a means of studying liver anatomy.

Introduction

Learning and identification of anatomy is known to be a fundamental component in any clinical specialty, particularly in surgical education, and especially, it plays a very important role in studying liver anatomy. Anatomic nomenclature is found to be different at each stage of medical training (1). Usually the first introduction to anatomical hepatic nomenclature begins in the first year of the medical studies learning human anatomy (2). Later on, students will be acquainted with the nomenclature of the Couinaud hepatic segmental anatomy. This model proposed by Couinaud in the 1960s was widely accepted in clinical practice and especially in the hepatic surgery (3). However, this is only an approximation of individually differentiated segment anatomy, and despite advantages in visualization technologies, this hepatic nomenclature remains difficult to be imagined in a non-transparent organ.

Technological advancement during the last de-
decades had an enormous impact on the methods of studying, diagnosing, and treating hepatic diseases. New image-producing techniques (computed tomography (CT), magnetic resonance imaging (MRI), color Doppler ultrasound (US)) have been developed and integrated into the clinical workflow (4). However, in many cases images are usually difficult to understand and interpret for an inexperienced staff and especially for the students. In addition, there are unique educational challenges to overcome in hepatic surgical anatomy. The typical requirements in liver surgery are to localize the tumor and to determine its relations to the intrahepatic vascular and biliary systems (5, 6). Usually in clinical settings, this is achieved with the help of 2-dimensional (2D) image stacks (CT images), from which 3-dimensional (3D) images are reconstructed in thought. Recently, specialized computer software has been used to construct 3D spatial relationships of anatomical structures and to provide detailed information useful for hepatic surgery (Figs. 1 and 2) (7–12). 3D virtual reality of the liver results from converting 2D images (from CT stacks) into 3D virtual image. This new 3D visualization of the liver facilitates the visibility of their content and allows three new methods of perception to be used, such as immersion, navigation, and interaction (9). Virtual reality is particularly relevant to the analysis of the relationship between a tumor and the vascular anatomy of the liver to plan the limits of hepatic resections.

This study was designed to determine whether 2-dimensional or 3-dimensional hepatic visualization is better to use for medical students while studying the clinical hepatic anatomy.

**Methods**

Twenty-nine patients who underwent surgical intervention due to focal hepatic pathology at the Department of General Surgery, University of Heidelberg, and at Clinics of Santariškės of Vilnius University Hospital were included in a retrospective cohort study. Before the surgical intervention, the computed tomography (CT) liver scan and 3-dimensional (3D) hepatic visualization were performed for all the patients. 3D images were obtained with software designed at the Division of Medical and Biological Informatics, German Cancer Research Center (DKFZ). Imaging data sets were transferred to the Department of Medical and Biological Informatics of the German Cancer Research Center. 3D liver reconstructions were performed using software system embedded in the radiological workstation CHILI®. This task consisted of the following steps: 1) segmentation of the liver parenchyma and the tumor using manual and/or semiautomatic algorithm; 2) vessel segmentation using an automatic algorithm; 3) editing of the hepatic vessels to separate the portal system from the hepatic venous system; 4) visualization of 3D liver reconstruction with the help of the OrgaNicer (10, 13).

Estimating the sample volumes for the study, based on the data from medical literature, 3D images were expected to be helpful in increasing the precision of liver resection up to 31% (9). Minimum 3 respondents and 29 observations were computed in each group (CT and 3D), and this would be sufficient in order to get the expected results. This sample volume is sufficient to ensure the second rate deviation not higher than 20% with the first rate 5% deviation in order to check unilateral hypothesis.

Four digital data packages with different combinations of CT scans and 3D liver images were created. One data package set consisted of 29 CT scan stacks and 29 3D images, totally composing 58 clinical cases. Each case was presented as an individual clinical case. In order to avoid the results achieved analyzing the CT and 3D images as the common interrelated data of one and the same patient all CT and 3D images were randomized by the computer and presented in random numerical sequence so as to avoid following each other. For demonstration of the images in computer-generated random order, a special program was developed.

A specially designed questionnaire was developed. In the questionnaire, 58 cases were briefly described. The disease description of the same patient has been presented together with CT images and it has been...
different from disease description presented with 3D image in age and order of sentences without changing the etiology of the disease. Within the questionnaire, the segments invaded by the tumor and the segments intended for resection could be marked. The respondent in the questionnaire had the possibility to choose either a full or atypical segment resection. Additionally, the anatomical structures that could complicate the operation, such as hepatic and portal veins could be marked.

Four students of the Medical Faculty of Vilnius University who had completed courses of human anatomy, radiology, and abdominal surgery were randomly chosen and were asked to fill in the questionnaire. The collected data from filled in questionnaires have been compared with the findings received during surgery and with the extent of liver resection. Moreover, the part of properly determined segments using CT scan images and the part of properly determined segments using 3D images for each case have been evaluated. The evaluations were made in such a way: if the student, according to the given image, planned to resect the segment and it was resected during real surgery or if he did not plan to resect it and the segment was not resected, the segment was found to be determined properly, otherwise it was considered to be wrong. The properly determined segments of one patient have been divided by 8, and it has been considered as a part of properly determined segments. The differences between determination of lesion localization according to segments, the extent of hepatic resections and the anatomical structures, the limiting the resection extents when analyzing 2D and 3D images were evaluated.

Statistical analysis

Statistical analysis was processed by SPSS statistical programs package (version 15.0 for Windows). As the data did not satisfy the normality precondition, the nonparametric tests were used: Mann-Whitney test to compare two groups, Kruskal-Wallis test in order to compare more than two groups. To analyze categorical variables, chi-square and Fisher’s exact tests have been applied. The descriptive statistics has been presented in the form of mean ± standard deviation or frequency tables. The level of significance was set at ≤0.05. Two-sided P values are given.

Results

The patients’ descriptive statistics and the etiology of focal hepatic lesions are presented in Tables 1 and 2.

The most commonly performed liver resection surgery was right hepatectomy, totally 11 operations.

| Characteristics | Patients (n=29) | Percentage (100%) |
|-----------------|----------------|-------------------|
| Gender          |                |                   |
| Female          | 13             | 44.8%             |
| Male            | 16             | 55.2%             |
| Age, years      |                |                   |
| Average         | 59             | 25–81             |
| Number of lesions per case |                |                   |
| Number of lesions | Patients (n=29) | Percentage (100%) |
| 1               | 18             | 62.06%            |
| 2               | 4              | 13.79%            |
| 3               | 4              | 13.79%            |
| 4               | 2              | 6.9%              |
| Multiple (>5)   | 1              | 3.46%             |
| Location of lesion | Segments | Number of lesions | Percentage (100%) |
| 1               | 1              | 1.52%             |
| 2               | 5              | 7.58%             |
| 3               | 2              | 3.03%             |
| 4               | 8              | 12.12%            |
| 5               | 13             | 19.70%            |
| 6               | 12             | 18.18%            |
| 7               | 10             | 15.15%            |
| 8               | 15             | 22.73%            |
Table 2. The etiology of focal liver lesions

| Etiology                                      | Number (n=29) | Percentage (100%) |
|-----------------------------------------------|---------------|-------------------|
| Metastasis                                    |               |                   |
| Metastasis of colon adenocarcinoma            | 17            | 58.61%            |
| Metastasis of pancreatic adenocarcinoma       | 1             | 3.45%             |
| Metastasis of ovary cancer                    | 1             | 3.45%             |
| Metastasis of breast cancer                   | 2             | 6.9%              |
| Tumors of undetermined etiology               | 1             | 3.45%             |
| Primary liver cancer                          |               |                   |
| HCC                                           | 3             | 10.34%            |
| Liver angiosarcoma                            | 1             | 3.45%             |
| Cholangiocarcinoma                            | 1             | 3.45%             |
| Benign tumors                                 |               |                   |
| Focal nodular hyperplasia                     | 1             | 3.45%             |
| Hemangioma                                    | 1             | 3.45%             |

Fig. 1. 2-Dimensional CT scan on the left and 3-dimensional liver visualization on the right
The tumor can be seen in segments 5, 6, and 8. Notice how clearly veins can be identified and followed.

Fig. 2. 2-Dimensional CT scan on the left and 3-dimensional liver visualization on the right
The tumor can be seen in segments 7 and 8.
Right hepatectomy with supplementary performed left lobe atypical resection was performed in three patients (10.34%). The atypical liver resections were performed on four patients (13.79%). One complicated central liver resection was performed, in addition to one right and one left expanded liver resections were performed (3.45% each). Other types of operations, such as anatomical segmental resection, left hepatectomy, left hepatectomy with atypical right lobe segmental resection were performed on the patients (3.45% each accordingly). The liver transplantation was performed on one non-operable patient with HCC (3.45%).

Four patients involved in the study did not undergo surgery (13.79%). Two of them were not operated on because of carcinomatosis, one patient due to a large non-operable tumor and the age limit and one patient due to multiple hepatic lesions. The patients did not undergo neoadjuvant therapy or any other procedures in order to devascularize the tumor or increase the hepatic tissue volume before the operation.

**The compatibility of the proposed operation extent with the real operation data**

In order to insure which of the operation planning method (CT scan or 3D visualization) is more similar to the real data of operations, the groups by the correctly selected segments of the liver have been compared. Our study showed that 3D visualization did help in naming correctly the affected segments of the liver for proper anatomical liver resections. The students correctly suggested a mean of 0.670±0.200 anatomical liver resections using CT 2D scans and a mean of 0.794±0.175 using 3D visualization. The difference has been found to be significant (P<0.001). We can assume the same tendency can be found in atypical resections as well. However, we could not get statistically significant difference (means of 0.875±0.159 using CT 2D and 0.908±0.141 using 3D visualization, respectively, P=0.081) (Fig. 3, 4).

We have analyzed the dependence between the accuracy of the classification and the method (CT scan or 3D visualization) in different liver segments using chi-square test (or Fisher’s exact test). The results have shown the localization of the lesion in segment to be better using 3D visualization method in 4–8 segments. Having chosen segment, four students gave 93 (80.17%) correct answers using 3D visualization images and selected 76 (65.52%) true answers using CT scans. Additionally, students made 23 (19.83%) mistakes using 3D visualization and selected 40 (34.48%) wrong answers using CT scans. Those findings are statistically significant (P=0.012). Segment 5 was estimated similarly, as the students gave 79 (6.1%) correct answers using 3D visualization and chose 64 (55.17%) correct answers using CT scans. These differences are significant (P=0.043). The same tendency has been noticed after the evaluation of segments 6, 7, and 8 (P=0.011, P=0.002, and P=0.002, respectively) (Table 3).
The comparison of 2-dimensional and 3-dimensional visualizations in education

Table 3. The comparison of 2D (CT) and 3D in regard to correct segment classification

| Correctly defined segments | 2D (CT)      | 3D          | P value |
|----------------------------|--------------|-------------|---------|
| Segment (1)                |              |             |         |
| False                      | Number       | 22          | 13      | 0.099  |
|                           | % in group   | 18.97%      | 11.21%  |         |
| True                       | Number       | 94          | 103     |         |
|                           | % in group   | 81.03%      | 88.79%  |         |
| Segment (2)                |              |             |         |
| False                      | Number       | 18          | 13      | 0.335  |
|                           | % in group   | 15.52%      | 11.21%  |         |
| True                       | Number       | 98          | 103     |         |
|                           | % in group   | 84.48%      | 88.79%  |         |
| Segment (3)                |              |             |         |
| False                      | Number       | 16          | 11      | 0.306  |
|                           | % in group   | 13.79%      | 9.48%   |         |
| True                       | Number       | 100         | 105     |         |
|                           | % in group   | 86.21%      | 90.52%  |         |
| Segment (4)                |              |             |         |
| False                      | Number       | 40          | 23      | 0.012* |
|                           | % in group   | 34.48%      | 19.83%  |         |
| True                       | Number       | 76          | 93      |         |
|                           | % in group   | 65.52%      | 80.17%  |         |
| Segment (5)                |              |             |         |
| False                      | Number       | 52          | 37      | 0.043* |
|                           | % in group   | 44.83%      | 31.9%   |         |
| True                       | Number       | 64          | 79      |         |
|                           | % in group   | 55.17%      | 68.1%   |         |
| Segment (6)                |              |             |         |
| False                      | Number       | 57          | 38      | 0.011* |
|                           | % in group   | 49.14%      | 32.76%  |         |
| True                       | Number       | 59          | 78      |         |
|                           | % in group   | 50.86%      | 67.24%  |         |
| Segment (7)                |              |             |         |
| False                      | Number       | 55          | 32      | 0.002* |
|                           | % in group   | 47.41%      | 27.59%  |         |
| True                       | Number       | 61          | 84      |         |
|                           | % in group   | 52.59%      | 72.41%  |         |
| Segment (8)                |              |             |         |
| False                      | Number       | 46          | 24      | 0.002* |
|                           | % in group   | 39.66%      | 20.69%  |         |
| True                       | Number       | 70          | 92      |         |
|                           | % in group   | 60.34%      | 79.31%  |         |

*A significant difference was detected.

Prediction of anatomical limitations

The next step in planning surgery was to foresee the probable challenges during the procedure. However, the unbiased index showing which method of operation planning is more advantageous has not been clearly stated. Consequently, it had to be found out if the same probable challenges during the operation could be noticed using CT scans and 3D visualization. This is a very problematic question. Two methods have been used, such as estimating the total difficulty (left hepatic vein + medium hepatic vein + right hepatic vein + left portal vein + right portal vein; the maximal score is six) and the comparison of methods, taking difficulties individually. There was found no statistically significant difference (P=0.786) between two methods (CT scans and 3D visualization) estimating the total difficulty, and no statistically significant difference was found comparing which method, either 3D visualization or 2D CT scans, was better in regard to possible/individual anatomical difficulties (Table 4).
The comparison of the proposed operation plans

The plans made using CT scans images with real operations in every segment paying attention to anatomical and atypical resection as well as the plans made using 3D visualization with real operations in every segment in regard to the anatomical and atypical resection have been compared. The difference comparing the proposals for liver resection using CT scans with the real operation has been found to be statistically significant. Students chose different operation plans for segments 5, 6, and 7 (P=0.044, P=0.035, and P=0.029, respectively) (Table 5). On the other hand, no statistically significant difference comparing proposals for liver resection using 3D visualization with the real operation has been found (Table 5).

Discussion

It is still under discussion, whether liver anatomy should be classified using portal system or some other one (3, 16, 17). However, the liver anatomy is variable and changes with tumor growth, the operations preceded, the regenerative growth (12). Therefore, a computer-based 3D segmental anatomy of the liver has been developed. A very high level of interest in this type of hepatic visualization is apparent from more than 100 quotations in the literature focused on 3D liver anatomy (18). During the past decade, the advancement of novel technological progress has outpaced the ability of medicine to put these achievements to practice. Image acquisition modalities have developed from early generation computed tomography scanners capable of simulating 3D reconstruction to the current day multidetector spiral computed tomography and magnetic resonance imaging (19). Parallel development has occurred in the fields, which use the modalities such as anatomy, operative planning, and hepatic lesion targeting (6, 9, 20). Hepatic surgery is considered a very challenging procedure and many aspects must be taken into consideration. Individual liver anatomy variations, the calculation of the liver

| Prognosis of anatomical difficulties | 2D(CT) | 3D   | P value |
|-------------------------------------|--------|------|--------|
| Left hepatic vein                   |        |      |        |
| False                               | Number | 95   | 101    | 0.277  |
| True                                | Number | 21   | 15     |        |
| Middle hepatic vein                 |        |      |        |
| False                               | Number | 54   | 63     | 0.237  |
| True                                | Number | 62   | 53     |        |
| Right hepatic vein                  |        |      |        |
| False                               | Number | 47   | 39     | 0.277  |
| True                                | Number | 69   | 77     |        |
| Left portal vein                    |        |      |        |
| False                               | Number | 90   | 95     | 0.414  |
| True                                | Number | 26   | 21     |        |
| Right portal vein                   |        |      |        |
| False                               | Number | 47   | 47     | 1.000  |
| True                                | Number | 69   | 69     |        |
| Other                               |        |      |        |
| False                               | Number | 96   | 95     | 0.863  |
| True                                | Number | 20   | 21     |        |

Table 4. The comparison of 2D (CT) scans and 3D visualization in regard to prognosis of anatomical difficulties

Medicina (Kaunas) 2008; 44(6)
volumes can be quite easily achieved from standard radiological equipment (CT, US). However, definition of the devasculization zones, the relation of tumors and vessels, and the determination of the minimal resection volume have been found to be very problematic (21–27). The neophyte finds it to be even more complicated, particularly while studying hepatic anatomy and surgical procedures. The new revolutionary visualization technology provides interactive stereo viewing of the complex structures from the numerous real and theoretical vantage points correctly and in the way the viewer desires without the need of biological materials. These features may ensure a new, more efficient, educational framework that can be spread across the medical institutions (17).

All the standard radiological visualization methods are very complicated and focus on what can be computed, concentrating on the given images from a frequency or band-pass point of view. Alas, this is not the way the human being perceives the images. Human eyes can perceive stereo, perspective, depth, color, motion, and much more. The fact that 3D visualization may be accomplished on the computer screen and may help to create a user-friendlier environment, which has a high importance for a novice in analyzing and learning of hepatic anatomy, has been found to be advantageous. The image can be easily managed in virtual space being rotated and observed from different angles, magnified or reduced. One structure can be hidden and another can be highlighted using transparent function for any structure. In addition, structures are colored differently to help the user to identify the parts desired using less effort. 3D visualization gives even deeper perspectives in hepatic anatomy learning. Vessels (hepatic veins, portal veins, arteries and bile ducts) can be continuously observed in 3D space in contrast to CT, MRI standards, where vessels can be analyzed only using image by image in stacks. Therefore, it could be helpful in identifying the relationship of the vessels, their anatomical variations and Couinaud's liver segments more properly. Moreover, 3D visualization enables the integration of vascular system into semitransparent hepatic parenchyma.

Our study showed that the identification of the tumors and the proposals of resection increased significantly after introducing 3D visualization to the students. Presumably, 3D visualization improves the knowledge of the segmental anatomy and the precise localization of the pathology in the liver. Moreover, students have found 3D perspective to be user-friendlier, easier to master, and easier to see the liver and its alterations as a whole. 3D view has been found to be more visually expressive and interactive (28).

### Table 5. The comparison of 2D(CT), 3D visualizations, and real operations according to frequency

| Segment number | Properly proposed part | 2D (P value) | 3D (P value) | Performed resection |
|----------------|------------------------|--------------|--------------|---------------------|
| Segment (1)    | Number % in group      | 18 15.50%    | 13 11.20%    | 1 3.40%             |
| Segment (2)    | Number % in group      | 14 12.10%    | 9 7.80%      | 3 10.30%            |
| Segment (3)    | Number % in group      | 12 10.30%    | 5 4.30%      | 3 10.30%            |
| Segment (4)    | Number % in group      | 38 32.80%    | 25 21.60%    | 5 17.20%            |
| Segment (5)    | Number % in group      | 44 37.93% (0.044)* | 67 57.80% | 17 58.60%          |
| Segment (6)    | Number % in group      | 43 37.07% (0.035)* | 54 46.60% | 17 58.60%          |
| Segment (7)    | Number % in group      | 35 30.20% (0.029)* | 56 48.30% | 15 51.70%          |
| Segment (8)    | Number % in group      | 61 53.00%    | 64 55.20%    | 15 51.70%          |

*Only significant P values are presented.

The comparison of 2-dimensional and 3-dimensional visualizations in education
The students have achieved poorer results in tumor localization and resection proposals using 2D CT scans, as they lack deeper knowledge in radiology and the vascular system of the liver determining the correct liver segment. In addition, CT stacks must be viewed and analyzed separately without summarizing the views, which can be difficult for an inexperienced eye to follow (29, 30).

We found no evidence whether 3D visualization helps to choose atypical liver resection or not. Hypothetically, atypical liver resections are not very common in practice (this method was used only in 13.79% of 29 cases) because of its disputable indications and outcomes. Naming of atypical resection has been avoided by the students.

No proof that 3D visualization helps the students to suspect the resection challenges performing the operation has been found. There must have been no difference between both applied visualization methods clearly demonstrating intrahepatic structures and determining whether the liver vessel is affected. On the other hand, it can be suspected that the students having no clinical practice are likely to avoid surgical challenges and to mark as much anatomical limitations as possible despite the method used.

Our study showed that the 3D visualization assists students in making better decisions while planning the liver surgery. Consequently, it can be assumed that 3D liver visualization can help in mastering surgical liver anatomy while studying.

To conclude, 3D liver visualization should take strong position in surgical practice and especially while studying surgical anatomy. It is highly important for every novice to learn the precise preoperative preparation such as the localization of the tumor and its boundaries, the defining extent of the liver resection, estimating the remaining and the functional tissue, etc (27). This study has shown that 3D liver visualization helps the students to deepen their knowledge in the complicated segmental liver anatomy, to determine the alteration processes more successfully and to suggest more precise liver resections. We hope that in the nearest future this method will become a part of the education process in every curriculum for medical student.

Conclusions

Our study has shown 3-dimensional liver visualization to be helpful to students naming the affected liver segments and localizing the tumors as well as finding more solid solutions in comparison with the data of the real operations on critical liver segments.

Dvimačio ir trimačio kepenų vizualizavimo palyginimas mokantis klinikinę kepenų anatomiją

Jonas Jurgaitis1,2, Marius Paškonis1,2, Jonas Pivoriūnas3, Ieva Martinaitytė3, Agnus Juška3, Rūta Jurgaitienė4, Artūras Samuiliūs5, Ivo Volf6, Maks Schöbinger6, Peter Schemmer7, Thomas W. Kraus8, Kęstutis Strupas1,2

1Vilniaus universiteto Medicinos fakulteto Gastroenterologijos, nefrourologijos ir chirurgijos klinika, 2Vilniaus universiteto ligoninės Santarinkščių klinikų Pilvo chirurgijos centras, 3Vilniaus universiteto Medicinos fakultetas, 4Kauno medicinos universiteto Anatomijos institutas, 5Vilniaus universiteto ligoninės Santarinkščių klinikų Radiologijos centras, Lietuva, 6Vokietijos vėžio tyrimo centro (DKFZ) Medicininės informatikos skyrius, 7Ruprecht-Karls Heidelbergo universiteto Bendrosios, vidaus organų ir transplantavimo chirurgijos departamentas, 8Northwest GmbH ligoninės Vidaus organų ir minimaliai invazinės chirurgijos klinika, Vokietija

Raktažodžiai: klinikinė kepenų anatomija, kepenų rezekcijos planavimas, kompiuterinė tomografiija, trimatis vizualizavimas, chirurgijos mokslas.

Santrauka. Tyrimo tikslas. Nustatyti, kuris iš vizualizavimo metodų – dvimatis ar trimatis tinkamesnis medicinos studentams mokantis klinikinę kepenų anatomiją.

Tyrimo medžiaga ir metodai. I retrospektyvų kohortinių lyginamąjį tyrimą įtraukti 29 pacientai, kuriems nustatyta židinė kepenų patologija ir jiems Heidelbergo universiteto Chirurgijos klinikoje bei Vilniaus universiteto ligoninės Santarinkščių klinikose atliktos kepenų rezekcinės operacijos. Prieš operaciją visiems pacientams atlikta kompiuterinė tomografija ir trimatė (3D) kepenų vizualizacija. Dvimačiai ir trimačiai 58 kepenų skaitmeniniai vaizdai sumažyti tarpusavioje, kad neitų vienas po kito, ir kartu su specialiai sudaryta anketa buvo pateikti Vilniaus universiteto Medicinos fakulteto ketvirtjo kurso studentams. Jie turėjo nustatyti
naviko lokalizaciją, planuojamus rezeuot segmentus bei anatominius rezekcijos sunkumus. Gauti rezultatai buvo palyginti su atliktu operacijų radiniais ir kepenų rezekcinų operacijų apimtimis.

Rezultatai. Studentai, nustatydami navikų lokalizaciją, geresnį rezultatų pasiekė naudodami trimąčiu kepenų vizualizavimui. Didžiausiai skirtumai gauti 5, 6, 7 ir 8 segmentuose (p<0,05). Studentai, planuodami kepenų rezekciją, geresnios rezultatų pasiekė taip pat naudodami trimąčiu vizualizavimui. Palygint su realiai atliktomis operacijomis, studentai tiksliau suplanavo rezekcinius kepenų vizualizavimui (vidurkis±SN – 0,794±0,175) nei naudodami kompiuterinės tomografijos vaizdus (vidurkis±SN – 0,670±0,200), (p<0,001).

Išvados. Trimat kepenų vizualizaciją padeda medicinos studentams tiksliu nustatyti naviko lokalizaciją kepenyse ir tiksliu suplanuoti kepenų rezekcinės operacijos palyginus su dvimačiais kepenų vaizdais. Trimat kepenų vizualizacija turėtų būti naudojama studijuoju kepenų anatomiją.

Adresas susirašinėti: J. Jurgaitis, VU Medicinos fakulteto Gastroenterologijos, nefrouologijos ir abdominalinės chirurgijos klinika, Santarūsių g. 2, 08661 Vilnius. El. paštas: jonas.jurgaitis@anta.lt

References
1. Rutkauskas S, Gedrimas V, Pundzis J, Barauskas G, Basevičius A. Clinical and anatomical basis for the classification of the structural parts of liver. Medicina (Kaunas) 2006;42(3):98-106.
2. Azeis V, Vaicekauskas V, Jurgaitienė R. Širdies ir kraujagyslių, vidaus organų ir nervų sistemų anatomijos modulis. (The anatomic model of cardiovascular, visceral and nervous systems). Kaunas; 2007.
3. Couinaud C. Le Foie: Etudes Anatomiques et chirurgicales. Paris, France: Mason; 1957.
4. Marks SC Jr. Recovering the significance of 3-dimensional data in medical education and clinical practice. Clin Anat 2001;14(1):90-1.
5. Lamadé W, Glombitza G, Demiris AM, Cardenas C, Meirzer HP, Richter G, et al. Virtual operation planning in liver surgery. Chirurg 1999;70:239-45.
6. Glombitza G, Lamadé W, Demiris AM, Göpfert MR, Mayer A, Bahner ML, et al. Virtual planning of liver resections: image processing, visualization and volumetric evaluation. Int J Med Inf 1999;53:225-37.
7. Meirzer HP, Thorn M, Vetter M, Hassenpflug P, Hastenteufel M, Wolf I. Medical imaging: examples of clinical applications. IDPRS Journal of Photogrammetry and remote sensing 2002;56(5):311-25.
8. Meirzer HP, Thorn M, Cardenas CE. Computerized planning of liver surgery – an overview. Comput Graph 2002;26:569-576.
9. Lamadé W, Glombitza G, Fischer L, Chiu P, Cardenas CE, Thorn M, et al. The impact of 3-dimensional reconstructions on operation planning in liver surgery. Arch Surg 2000;135:1256-61.
10. Jurgaitis J, Paskonis M, Samulis A, Volf I, Schobinger M, Brimas G, et al. Trimat kepenų vizualizacijos taikymas kepenų chirurgijoje. (Three-dimensional visualization: applications in liver surgery.) Lithuanian Surgery 2006;4(4):283-91.
11. Wald C, Bourquain H. Role of new three-dimensional image analysis techniques in planning of live donor liver transplantation, liver resection and intervention. J Gastrointest Surg 2006;10(2):161-5.
12. Jurgaitis J, Paskonis M, Mehrabi A, Kashfi A, Gragert S, Hinz U, et al. Controlled-surgical education in clinical liver transplantation is not associated with increased patient risk. Clin Transplant 2006;20(Suppl 17):69-74.
13. Meirzer HP, Schenmer PM, Schobinger M, Norden M, Heiman T, Yelin B, et al. Computer based surgery planning for living liver donation. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. 34, Part 30. 2004. p. 291-295.
14. Terminology committee of the IHPBA. Terminology of liver anatomy and resections. HPB Surg 2000;2(3):333-9.
15. Lunevičius R. Terminai kepenų anatomijai ir rezekcijoms apibūdinti: Brisbane 2000 metų sistema būtina naudotis ir Lietuvoje. (Terminology for definition of liver anatomy and resections: it is essential to use Brisbane 2000 system in Lithuania.) Lithuanian Surgery 2007;5(2):108-18.
16. Healey JE Jr, Schroy PC. Anatomy of the biliary ducts within the human liver. Analysis of the prevailing pattern of branchings and the major variations of the biliary ducts. Arch Surg 1953;66:599-616.
17. Fischer L, Thorn M, Neumann JO, Schobinger M, Heimann T, Grenacher L, et al. The segments of the hepatic veins – is there a spatial correlation to the Couinaud liver segments? Eur J Radiol 2005;52(2):245-55.
18. Marescaux J, Clement J-M, Tassetti V, Mutter D, Cotin S, Ayache N. Virtual reality applied to hepatic surgery simulation: the next revolution. Ann Surg 1998;228(5):627-37.
19. Van Leeuwen MS, Fernandez MA, van Es HW, Stokking R, Dillon EH, Feldberg MA. Variations in venous and segmental anatomy of the liver: two- and three-dimensional MR imaging in healthy volunteers. AJR Am J Roentgenol 1994;162:1337-45.
20. Silverstein JC, Dech F, Edison M, Jurek P, Hleton WS, Espat NJ. Virtual reality: immersive hepatic surgery educational environment. Surgery 2002;132:274-7.
21. Hemming AR, Reed A, Lanhgam MR, Fujita S, Willem J, Howard RJ. Hepatic vein reconstruction for resection of hepatic tumors. Ann Surg 2002;235(6):850-8.
22. Schlusselberg DS, Smith WK, Woodward DJ, Parkey RW. Use of computed tomography for a 3-dimensional treatment planning system. Comput Med Imaging Graph 1998;12:25-32.
23. Soyer P, Bluemke DA, Bliss DF, Woodhouse CE, Fishman EK. Surgical segmental anatomy of the liver: demonstration with spiral CT during arterial portography and multiplanar reconstruction. AJR Am J Roentgenol 1994;163:99-103.
24. Schiano TD, Bodian CD, Schwartz ME, Glajchen N, Min AD. Accuracy and significance of computed tomographic scan...
assess of hepatic volume in patients undergoing liver transplantation. Transplantation 2000;69:545-50.

25. Lang H, Radtke A, Liu C, Frhauf NR, Peitgen HO, Brolsch ChE. Extended left hepatectomy – modified operation planning based on three-dimensional visualization of liver anatomy. Langenbecks Arch Surg 2004;389:306-10.

26. Hermoe L, Laamari-Azjal I, Cao Z, Annet L, Lerut J, Da-want BM, et al. Liver segmentation in living liver transplant donors: comparison of semiautomatic and manual methods. Radiology 2005;234:171-8.

27. Neumann JO, Thorn M, Fischer L, Schobinger M, Heimann T, Radeleff B, et al. Branching patterns and drainage territories of the middle hepatic vein in computer-simulated right living-donor hepatectomies. Am J Transplant 2006;6:1407-15.

28. Frericks BB, Caldarone FC, Nashan B, Savellano DH, Stamm G, Kirchhoff TD, et al. 3D CT modeling of hepatic vessel architecture and volume calculation in living donated liver transplantation. Eur Radiol 2004;14:326-33.

29. Vernon T, Peckham D. The benefits of 3D modelling and animation in medical teaching. J Audiov Media Med 2002;25(4):142-8.

30. Bogetti JD, Herts RB, Sands MJ, Carroll JF, Vogt DP, Henderson M. Accuracy and utility of 3-dimensional computed tomography in evaluation of donors for adult related liver transplants. Liver Transpl 2001;7(8):687-92.

31. de Barros N, Rodrigues CJ, Rodrigues AJ JR, de Negri Germano MA, Cerri GG. The value of teaching sectional anatomy to improve CT scan interpretation. Clin Anat 2001;14(1):36-41.

32. Laeck D, Oussoultzoglou E, Bachalier P, Lemarque P, Weber JC, Nakano H, et al. Hepatic metastases of gastroentero-pancreatic neuroendocrine tumors: safe hepatic surgery. World J Surg 2004;25:689-92.

Received 27 December 2007, accepted 12 June 2008

Straitpsnis Gautas 2007 12 27, priimtas 2008 06 12