ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

New Image Modeling Features For Planning Surgical Interventions.

G Ya Hight[1]*, AE Mishvelov[2], EA Melchenko[2], CV Nuzhnaya[3], VA Epanov[1], AA Dolgalev[2], M Yu Kukharuk[3], M Yu Portnov[3], and VE Suprunchuk[3].

[1]Stavropol Regional Clinical Consultative and Diagnostic Center.
[2]Stavropol State Medical University.
[3]North-Caucasian Federal University.

ABSTRACT

The tested software complex Doctor CT-Slicer allows to create combination of individual three-dimensional models (organ, its blood vessels, neoplasms) obtained on the basis of DICOM files. Combined models can be used by the surgeon to prepare for surgery operation. The resulting multilayer model can be placed in a simulator program where it is possible to manipulate models by virtual instruments.
Keywords: HoloLens, 3D model, computed tomography, simulator, 3D printer, rendering.

Corresponding author

ISSN: 0975-8585

INTRODUCTION

Currently, the number of patients requiring high-tech surgical interventions in the provision of medical care in urology, oncology, and cardiovascular surgery is increasing. Patients for diagnosing complex pathologies are prescribed examinations based on digital technologies. Today, these methods of examination include computed and magnetic resonance imaging, ultrasound imaging with three-dimensional image reconstruction, etc. However, when assessing the situation, using a computed tomography software, performed, for example, before performing a surgical procedure due to the presence of a tumor process in the abdominal cavity, it is visually difficult to separate the tumor from the organ, and also to calculate its volumetric characteristics.

Most of the software as independent products developed for viewing, describing and reconstructing DICOM-images is of foreign manufacture and they are adapted for foreign users. The interfaces of such programs are cumbersome and difficult to customize; moreover, the use of a large amount of time (approximately 2-3 hours per patient) is spent on manual processing and reconstruction of medical images of DICOM files [1, 2].

Computed tomography (CT) is a promising method in the diagnosis of diseases of internal organs, in particular, of the kidneys. At present, multispiral computed tomography is being actively implemented with the production of isotropic voxels, the combination of which with postprocessor processing allows obtaining accurate data on tumor localization, invasion of blood vessels and neighboring organs [2].

When planning an operation, the location of the kidney tumors in relation to the surgically important vessels and adjacent organs is of paramount importance. An equally important factor is the ability to estimate the volume of the tumor in relation to the tissue. The publication [8] reports on three-dimensional visualization in interactive planning of operations for complex liver resections, while planning operations on the pancreas are rare, but data on the use of this method in kidney operations are not available. Grenacher and co-workers showed that a three-dimensional reconstruction of the pancreas with semi-automatic segmentation can be created similarly to hepatic imaging [5].

In addition, there are practically no medical programs based on the use of holographic images superimposed on real objects (HoloLens mixed reality technology) for both diagnostic physicians and clinicians.

For surgeons performing abdominal surgery, the positioning accuracy and penetration depth of the instruments are important. Often, surgeons-urologists remove the tumor, located in the medulla of the kidney, are almost blind. We use ultrasound machines and intraoperative tomographs to clarify the tumor localization. However, this method of navigation is inconvenient, cumbersome and detrimental to the health of the surgeon himself.

The developed early Doctor CT software did not fully meet the needs of the radiologist and surgeon. The disadvantages of this software were that the image processing was carried out only in the manual mode, it was not possible to isolate the anatomical structures of the organs, and the high definition of the obtained images was not achieved during their reconstruction.

Therefore, it was decided to adapt and modify the Doctor CT program using the Slicer designer software.

The target of our work is to test the developed Doctor CT-Slicer software package and compare the capabilities of the new program with its counterparts.

METHODS

The development of Doctor CT-Slicer software was carried out by the staff of the State Medical University and NCFU, the study of the possibilities of this program in the department of radiation diagnostics and in the surgical hospital of the short-term stay of the Stavropol Regional Clinical Diagnostic Center (SCCCC).

The materials of the study were images of patients' organs (DICOM files) obtained using magnetic resonance imaging on the PHILIPS "Ingenia 1.5T" and multispiral computed tomography on the "Aguilion Prime" company Toshiba during 2015-2018. In the course of testing the program, HoloLens mixed reality glasses were used.

To perform a retrospective analysis of CT images it is recommended to use two-dimensional processing or the construction of three-dimensional reconstructions of organ systems. The standardized form of assessment includes such parameters as the location, size and spread of the tumor over the body of the kidney or metastasis to other organs in the abdominal cavity. Software can also be used to compare the information content of a three-dimensional image and conventional two-dimensional CT images.

The advantage of three-dimensional reconstruction is an increase in diagnostic capabilities in determining the localization of a tumor, which is caused by a change in topographic-anatomical landmarks, that based on the tumor boundaries are distinguished, with a widespread lesion of internal organs (kidneys). Thus, a three-dimensional reconstruction based on the combination of the phases of the study provides more detailed and visual information (Fig. 1).

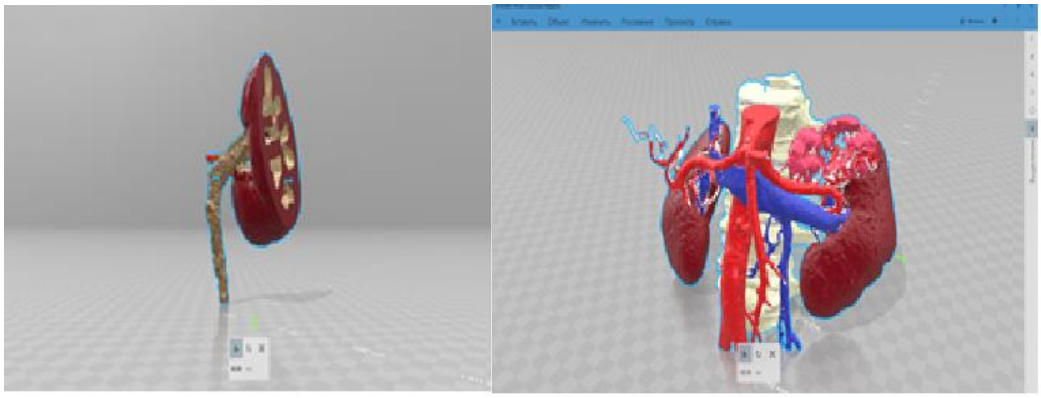

Figure 1: On the left is a healthy kidney, on the right is a CT scan showing signs of heterogeneous volume in the left kidney, 57.8x 37.3x 43.9mm in size

In accordance with the proposed software package, the visualization of the tumor, its localization in accordance with the segmental structure seemed better with the three-dimensional reconstruction of CT images. Invasion of the portal vein or the inferior vena cava, the aorta in surgery for the removal of the kidneys is not a contraindication to surgery, however, the possibility of prosthetics with an extended lesion may be very difficult. This problem can be solved by replacing traditional two-dimensional images with 3D models and holographic technologies (using headset glasses to visualize images), which allows determining the tactics of a surgeon before the operation. Three-dimensional reconstruction should provide a high degree of reliability of data on vascular invasion and the depth of penetration of the tumor, so that the surgeon is able to see the full surgical field. Three-dimensional reconstructions present the tumor more clearly in comparison with two-dimensional and, moreover, can significantly reduce the time required for the analysis of conventional CT slices (Fig. 2).

To compare the results of research (CT and MRI reconstructions), the following programs we used:DoctorCT, Vitrea, Doctor-Slicer. We formed a group of 180 patient with kidney disease. After that this group was divided into 3 subgroups.In the first subgroup we developed the DoctorCT program, the results of 60 clinical cases were processed using the Vitrea program, the results of 60 clinical cases were processed using the new DoctorCT-Slicer software. The bulk of patients examined for diseases of parenchymal organs. The examination also identified 10 patients with tumor processes (with a maximum size of 6.1 by 5.8 mm) in the kidneys; in 15 clinical cases, metastasis of tumors to the kidneys from distant organs was detected; one clinical case was with two tumors and metastases in one kidney; 10 clinical cases were investigated with renal hydronephrosis; one patient was examined with myxoma of the heart.

ISSN: 0975-8585

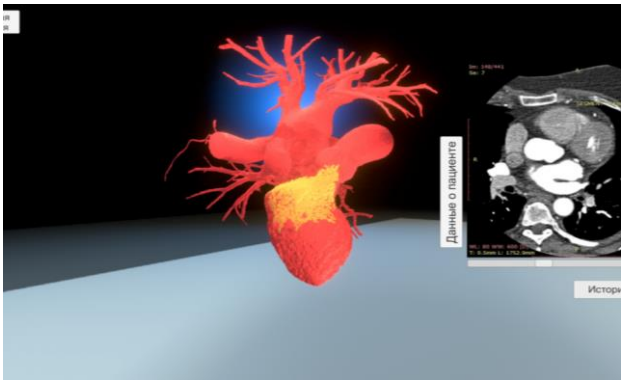

Figure 2: Reconstruction of the heart with a tumor and Dicom-images

The results of the study. When processing DICOM files in Vitrea and DoctorCT, it was not possible to obtain a clear 3D reconstruction of the kidney with hydronephrosis and recognize the structure of the kidney. Reconstruction in these kidney programs required the use of contrast. On the processing of data from one clinical case, the operator took 2.5 -3 hours.

The approved software complex DoctorCT-Slicer allowed to identify 10 tumors in the kidneys, while building a clear 3D model of the kidney with a tumor, to "paint" the reconstruction, to separate the borders of the tumor from healthy tissue. With the help of DoctorCT-Slicer software, they reconstructed (reconstructed) and examined the structure and internal structure of the kidney with hydronephrosis, the enlarged dimensions of the cup-pelvis area. The functionality of the program allowed the reconstruction of the organ without the use of a contrast agent. For the first time, computerized tomograms without the use of contrast agents were reconstructed in more than 30 clinical cases.

An important functional advantage of the new program was also the fact that it was possible to transfer the obtained images to augmented reality glasses - HoloLens.

CONCLUSION

The DoctorCT-Slicer software allows for an automated assessment of the shape and volume of detected tumors; in this software, it is possible to isolate the anatomical structures of organs by tinting objects;

Downloading the obtained 3D models of an organ or organ systems with the presence of a simulation module will allow preoperative simulation actions, including using holographic reality glasses.

REFERENCES

[1] Torii R., Oshima M. An integrated geometric modelling framework for patient-specific computational haemodynamic study on wide-ranged vascular network. Comput Methods Biomech Biomed Engin 2011; 15(6): 615-625. doi: 10.1080/10255842.2011.554407

[2] Pettersson J. Knutsson H. Borga M. Proceedings of the 18th international conference on pattern recognition / Ed. by A. Bovik. - Automatic hip bone segmentation using non-rigid registration: HongKong, China. Piscataway, 2006.http://dx.doi.org/10.1444/05064556131864073

[3] Murphy S. V., Skardal A. Journal of Biomedical Materials Research Part A. – 2013. C. 272-284

[4] Kirkman MA, Ahmed M, Albert AF, Wilson MH, Nandi D, Sevdalis N.The use of simulation in neurosurgical education and training. J Neurosurg. 2014 Aug;121(2):228-246. doi: 10.3171/jns131766.

[5] Wen Z.H., Yao F., Wang Y.U. 64 Slice spiral computed tomog-raphy and three dimensional reconstruction in the diagnosis of cystic pancreatic tumors. Experimentalandtherapeuticmedi-cine. 2016; 11: 1506-1512.