A Method for Defining Edge Margin Field and Its Application

Yanjin Liu*, Jun Wu, Shuhui Xu and Biao Peng
Faculty of Mechanical Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250353, China

Keywords: Tumors of Liver, Incisal Edge, Margin Field, Aided Navigation.

Abstract: Hepatectomy is one of the main treatment methods for liver tumor resection at present. However, the key technology for accurate navigation and localization of intrahepatic tumors during surgery to achieve the resection of hepatocellular carcinoma is still unclear. This paper is written for minimally invasive laparoscopic liver resection of the tumor in the auxiliary navigation technology. This paper provides a method for defining the margin field of hepatic tumor incision margins and a model system and the application of measuring the scalpel and tumor distance. The purpose of this paper is to assist physicians in making intraoperative surgical decisions, correct the surgical path in a timely manner and achieve a low-risk effect of minimally invasive laparoscopic surgery.

1 INTRODUCTION

Liver cancer is one of the most common malignancies worldwide. (Habib, 2015) Patients with early-stage liver cancer can undergo surgical treatment such as surgical resection, liver transplantation, and tumor ablation, of which surgical resection is the preferred treatment option. (Takamoto, 2019) The incidence of liver cancer ranks sixth in the world's malignant tumors, and the mortality rate ranks second in the world's malignant tumors. China is a country with a high incidence of liver cancer. According to data released by the World Health Organization in 2015, there are about 93 million people living with hepatitis B virus in China, of which 1-5% of patients develop liver cancer, new cases account for about half of the world. Liver cancer kills about 300,000 people each year, including 40% of the elderly. (Journal of hepatology, 2018; Mareng, 2016; Huang, 2016; Della, 2016)

Before doing liver resection, the surgeon needs to evaluate the residual remaining liver volume with the help of preoperative CT liver three-dimensional reconstruction or physician experience to prevent excessive liver removal from causing liver failure. In hepatectomy, the chief surgeon roughly estimates the incision line according to the preoperative CT image, with the surgeon's clinical experience and spatial imagination ability, supplemented by color ultrasound confirmation and adjustment of the cutting line. The identification of intrahepatic duct anatomy in the process of hepatotomy is mainly determined by the general anatomical cognition of the ischemic line on the hepatic surface or the clinical experience of the surgeon to achieve anatomical hepatic resection. Make sure that the incisional margin is not less than one centimeter from the surface of the liver tumor. (Moris, 2018; Yoon, 2017)

There are many effects of margin width on the postoperative removal of hepatocellular carcinoma. In general, complete resection of the lesion and sufficient distance from the lesion is considered important to ensure eradication of malignancy and to avoid recurrence as much as possible. One centimeter margin is sufficient for most liver cancer patients, but for those who can tolerate a wide range of liver resection, two centimeter margin can helps to reduce tumor recurrence.

As we all know, the current difficulty of laparoscopic liver tumor resection is that: first of all, most of the ultrasound localization is used to perceive the two-dimensional image information of the tumor in the liver, but the depth information of the tumor cannot be determined. And the surgeon in the operation cannot accurately determine the relative position relationship between the tumor and the blood vessel due to the lack of three-dimensional information inside the liver. The above two difficulties may lead to the surgeon removing excess liver or incomplete tumor cutting so that there is no guarantee of optimal trajectory to remove the liver

Liu, Y., Wu, J., Xu, S. and Peng, B.
A Method for Defining Edge Margin Field and Its Application.
DOI: 10.5220/0012020500003633
In *Proceedings of the 4th International Conference on Biotechnology and Biomedicine (ICBB 2022)*, pages 325-328
ISBN: 978-989-758-637-8

tumor. It increasing the risk of surgery and prolonging the operation time.

Aiming at the problems of high surgical risk and long surgical time during liver tumor resection in existing techniques, this paper proposes a method for establishing a marginal field model for tumor resection and the application of measuring the distance between scalpel and tumor during liver resection surgery.

2 SOFTWARE AND METHODS FOR 3D RECONSTRUCTION OF DICOM IMAGING DATA

2.1 Software

Design and simulation of 3D virtual liver surgery based on CT scan data, the 64-row thin layer scanning dataset of the patient's abdominal liver was collected. In this paper, Mimics software developed by the Belgian company Materialise was used for three-dimensional reconstruction of the liver, intrahepatic tumors and their intrahepatic blood vessels.

2.2 The Basic Steps of Modeling Medical Image Processing Software Mimics

DICOM data read: We first imported a standard Dicom3.0 format image file formed from more than 400 CT scans of the patient's abdomen into Mimics software. After receiving the command, the software will automatically generate coronal and sagittal images based on the cross-sectional images, which are shown separately in Fig. 1.

Threshold profile extraction and three-dimensional reconstruction: Due to the different CT values of different tissues, the CT difference between the corresponding tissues and organs themselves is small and the difference with other surrounding tissues and organs is large, so that use the threshold setting tool in the toolbar to set the corresponding threshold to segment the image. Mimics will split all the pixels extracted under a template called Mask, and Mimics will provide a series of editing and modification operations for this template to extract and refine the required tissues and organs. By editing the template, we can do 3D modeling to achieve the transformation from a 2D image to a 3D solid, as shown in the lower right corner of Fig. 1. (Mi, 2021)

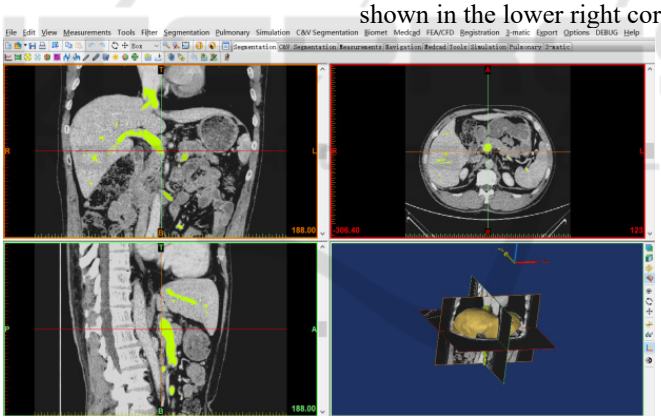

Figure 1: Three-dimensional images reconstructed after the patient CT was imported into Mimics.

3 A METHOD FOR DEFINING THE MARGIN FIELD OF HEPATIC TUMOR INCISION MARGINS

3.1 Define the Method

The envelope is a convex surface that tightens the tumor. After the threshold segmentation extraction of the intra-abdominal tumor by Mimics software, the model of the tumor is exported, and the contour of the outer surface of the tumor is known to be uneven, and the surface of the concave area on the tumor surface is first obtained by the convex surface of the tumor surface algorithm to obtain a convex surface model of the tight enveloping tumor, and the convex surface obtained by smoothing it is the envelope surface of the tumor, as shown in Figure 2(a).

Then, a point A is randomly selected on the envelope surface, the crossing point A is the tangent plane Σ of the envelope surface, and the straight line segment perpendicular to the tangent plane Σ is the

normal segment at a certain point A on the envelope surface. By analogy, taking all the points on the tumor envelope as the starting point, each point on the envelope surface is made perpendicular to the normal segment of the tangent plane Σi at the point, the length of the normal segment is set as 1cm per unit length, and finally a new convex surface composed of the end point of the unit length normal segment is obtained, so that the new convex surface is defined as a tangent edge surface 1cm away from the tumor outer network, and its principle is regarded as the uniform expansion deformation of the tumor model. In summary, the outward expansion deformation is based on all the points on the envelope surface, and the convex surface that expands and deforms by 1 cm is defined as the tangent edge surface of the tumor. The distance from any point on the cut edge surface to the tumor should be no less than 1 cm, as shown in Fig. 2(a).

Finally, based on the envelope surface isometric expansion to obtain a plurality of convex surfaces, consisting of a plurality of progressively deformed and expanded convex surfaces of the field, we define it as the margin field of the tumor, wherein the interval between each surface of the margin field is 1 cm, as shown in Figure 2 (b), the distance from the above-mentioned cut edge surface to the tumor surface contour is 1 cm, the cut edge surface is the tumor 1 cm margin field.

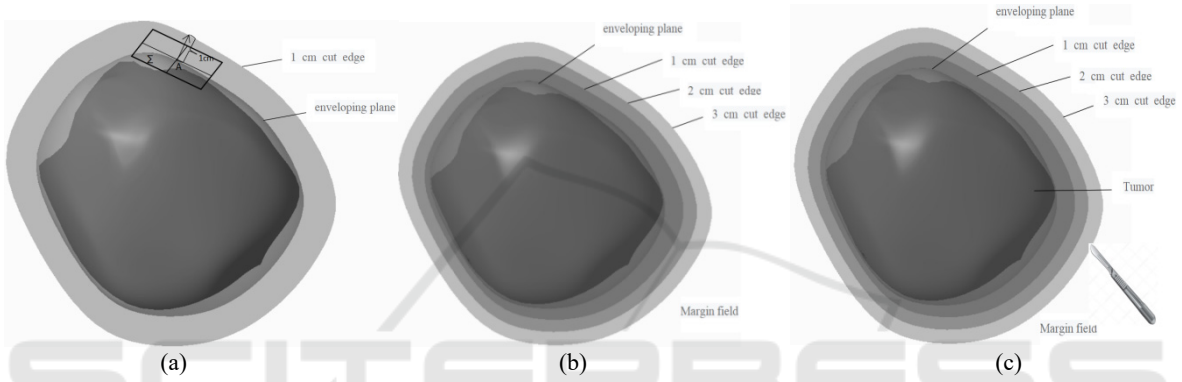

Figure 2: The outer contour surface, envelope surface, and marginal field of the tumor.

3.2 Distance Calculation Application Between Scalpel and Tumor Based on Margin Margin Field

In the future minimally invasive liver tumor resection, robot technology will be continuously introduced for the requirements of accurate removal of liver tumors, and under the motion simulation model based on robot surgical action, the definition and visualization of the margin field provide the robot with distance parameters to know the distance d of the scalpel and the tumor boundary. According to the distance between the margin field and the envelope surface, it is named, as shown in Fig. 2(c). Such as 1cm margin field, 2cm margin field and 3cm margin field, etc. Assuming that the scalpel head is located between the 2cm to 3cm margin field in the simulation model of robot motion, it is obvious that the distance from the scalpel head to the tumor is 2 to 3cm. In summary, the definition of marginal field can be used in future robotic minimally invasive surgery to measure the distance between the scalpel and the intrahepatic tumor, providing auxiliary guidance for physicians when removing the tumor during surgery, and avoiding the risk of surgery caused by the scalpel touching the tumor.

3.3 Establishment System for Marginal Fields

Fig. 3 Further provides an establishing module for tumor margin margin field, comprising: establishing module 1, determining module 2, envelope creation module 3 and determining module 4. Wherein, the establishment of module 1 for obtaining the patient's imaging data, through the three-dimensional reconstruction of the body data to obtain a model of the relative position relationship between the tissues; judgment module 2, for calling the relative position information between the tumor and other tissues to determine the resectability of the tumor, if yes (intrahepatic tumor has resectability), into the envelope creation module 3, if not, end; the envelope creation module is used to establish an envelope surface according to the external contour information of the tumor surface, the envelope surface is the convex envelope of the tumor; determine module 4, It is used to determine the tumor 1 cm margin and margin field based on the envelope surface of the

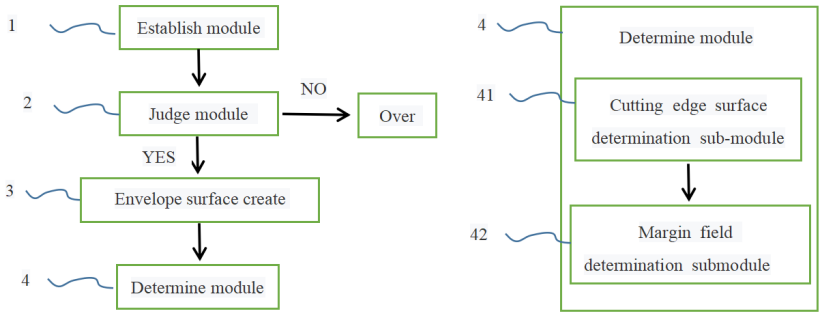

Figure 3: The overall structure diagram of the system for the establishment of tumor margin field.

tumor. According to the model established by the system, the situation of intrahepatic tumors in the human body is effectively simulated, and then according to the location relationship between tumors and intrahepatic blood vessels in the liver, a reasonable anatomical direction is selected to determine how to achieve complete resection of tumors with the purpose of minimizing liver damage.

4 CONCLUSION

In this paper, we first elaborate on the global impact of liver cancer incidence and the limitations of treatment strategies and surgical treatment options, and then propose the establishment method and distance measurement application of a tumor excision margin field model for the reasons why it is difficult to know the depth of intrahepatic tumor information, resulting in greater surgical risk and long surgical time.

This paper analyzes the three-dimensional reconstruction process of CT body data of Mimics software, and it can be seen that Mimics can well display the corresponding three-dimensional anatomy of the human body, so that doctors can make detailed, reasonable and accurate disease diagnosis; this paper also provides a definition method and establishment system of tumor margin margin field; finally describes the application of tumor margin margin field to measure the distance between scalpel and tumor in future robotic minimally invasive surgery, based on the scalpel in real time positioning feedback information in the three-dimensional model. In this way, it assists physicians in making intraoperative decisions, can change the surgical path in time, and finally achieves accurate resection of lesion areas in robot-assisted liver tumor resection and achieves low-risk surgical results.

ACKNOWLEDGMENTS

This research was supported by the Natural Science Foundation of Shandong Province (Application No. ZR202109280010).

REFERENCES

Della Corte C, Triolo M, Iavarone M, Sangiovanni A. Early diagnosis of liver cancer: an appraisal of international recommendations and future perspectives. Liver Int 2016; 36:166-76.

EASL Clinical Practice Guidelines: Management of hepatocellular carcinoma. Journal of hepatology2018; 69: 182-236.

Habib A, Desai K, Hickey R, et al. Locoregional therapy of hepatocellular carcinoma [J]. Clin Liver Dis, 2015, 19(2): 401-420.

Huang YQ, Lu X, Min H, Wu QQ, Shi XT, Bian KQ, Zou XP. Green tea and liver Cancer risk: A meta-analysis of prospective cohort studies in Asian populations. Nutrition2016; 32: 3-8.

Marengo A, Rosso C, Bugianesi E.Liver Cancer: Connections with Obesity, Fatty Liver, and Cirrhosis. AnnuRevMed 2016; 67: 103-17.

Mi Meng; Huang Dongning; Yang Kaixing. Treatment of extra-articular scapular fractures with assistance of 3D reconstruction measurements with Mimics software 2021; 23(8): 688-693.

Moris D, Vernadakis S. Laparoscopic Hepatectomy for Hepatocellular Carcinoma: The Opportunities, the Challenges, and the Limitations. Annals of surgery 2018; 268: e16.

Takamoto T, Makuuchi M. Precision surgery for primary liver cancer [J]. Cancer Biol Med, 2019,16(3):475-485.

Yoon YI, Kim KH, Kang SH, Kim WJ, Shin MH, Lee SK, et al. Pure Laparoscopic Versus Open Right Hepatectomy for Hepatocellular Carcinoma in Patients with Cirrhosis: A Propensity Score Matched Analysis. Annals of surgery 2017; 265:856-863.