Hepatic volumetry with PhotoShop in personal computer

Yi Lu, Zheng Wu, Chang Liu and Hao-Hua Wang

Xi'an, China

BACKGROUND: **Convenient way to clarify liver volume or tumor volume in the liver is eagerly demanded by hepatobiliary surgeons, for so many aspects of clinical work need to know the liver volumetry. At present, some methods have been used to measure the liver volumetry, such as computed tomography (CT) scans, three-dimensional ultrasound volumetric system[1] and 3-dimensional sonography[2,3] et al. But enough volumetric information was failed to obtain by surgeons and a new way of measuring the liver volumetry that can be operated by themselves is exigent. Whereas we devise a new method of using PhotoShop in personal computer to measure the liver volumetry.**

METHODS: **A piece of whole CT film was transformed to a high quality digitized image by digital camera or scanner and then the digitized image was conducted as JPEG file into personal computer. The JPEG image file of CT film was opened by PhotoShop. Determining the edge of interested areas, and the data of pixel values of the interested areas divided by 1 cm^2 pixel value will produce the actual area with the unit of square centimeter. If section thickness of CT scan is 1 cm, the sum of the areas of the liver or tumor in all sections naturally is the volume of the liver or tumor.**

RESULTS: **Comparison of 10 hepatic volumes gained by this method and those gained by the GE Prospeed CT set showed a good relativity between the two groups. The volumes of three right lobes were calculated by this method before lobectomy and their real volumes were obtained postoperatively by a volumenometer. Their variation was limited to 5%.**

CONCLUSIONS: **Hepatic volume obtained by PhotoShop is reliable. This method can be used to measure hepatic volume perfectly to meet clinical demand, and many parameters such as liver resection rate, graft volume can be achieved. The disadvantage of this method is the step of copying the pixel value from PhotoShop to Microsoft Excel.**

(*Hepatobiliary Pancreat Dis Int 2004; 3: 82-85*)

KEY WORDS: **hepatic volumetry; PhotoShop**

Author Affiliations: Department of Hepatobiliary Surgery, First Hospital, Xi'an Jiaotong University, Xi'an 710061, China (Lu Y, Wu Z, Liu C and Wang HH)

Corresponding Author: Yi Lu, MD, Department of Hepatobiliary Surgery, First Hospital, Xi'an Jiaotong University, Xi'an 710061, China (Tel: 86-29-5274009; Fax: 86-29-5263190; Email: luyi169@sina.com)

Introduction

Convenient way to clarify liver volume or tumor volume in the liver is eagerly demanded by hepatobiliary surgeons. The sensitivity of hepatoma to chemotherapy, rate of hepatectomy, liver regeneration after selective portal vein embolization or lobectomy, and graft size matching in living related liver transplantation all involve in hepatic volumetry.[4-11]

Computed tomography (CT) scans have made estimating hepatic volume possible for many years.[12-17] Surgeons and oncologists, however, fail to obtain enough volumetric information in their daily work because hepatic volumetry is only used as a medical research reference that might be accomplished with this tedious algorithm[18] and time-consuming complex devices. Even if volumetric program is available in CT device, radiologists do not know what volume parameters clinicians need. Possibly the rational way to perfectly use hepatic volumetry is having hepatic volume measured by hepatobiliary surgeons themselves. To meet this demand, we performed hepatic volumetry with PhotoShop in personal computer.

Methods

Instruments

The necessary hardware for this project was a personal computer installed with PhotoShop (version 5.0) working in Windows (Win98 operative system). The CT scan films were developed by the GE Prospeed CT set. An Olympus c-900 digital camera (1.31 million pixels) and an Acer 620UT Scanner were utilized to digitize film photos.

Algorithm

Image digitization

A piece of whole CT film was transformed to a high-quality digitized image by a digital camera or scanner. Subsequently the digitized image as a JPEG file was put into a personal computer with transferring PC card

or floppydisk adapter.

Pretreating photos

The JPEG image file of the CT film was opened by PhotoShop. The common or contrasted CT scan of the liver was performed for 12 sections with 1 cm thickness. Each section including the liver was cut using a rectangular marqeen tool with a same square area and pasted on the consequently established new file board. The ruler mark beside the each CT photo was included. Attention was also paid to extra sections that may exist around the tumor or other lesions.

Determination of the edge of interested areas

The edges of the liver or tumor were accurately margined by the lossa tool controlled with computer mouse. The easy way for determining a sharp edge of a well-proportioned area is using magic wand tool. The magic wand tool point was held at an interested area to determine the edge automatically. When manual or automatic tracing margin was not expected, the grow tool or similar tool in selection icon was used to modify the edge determined. These edge-tracing methods were selected to determine the different interested area in a photo. After one photo was finished, it was put on the desktop (Figs. 1 and 2).

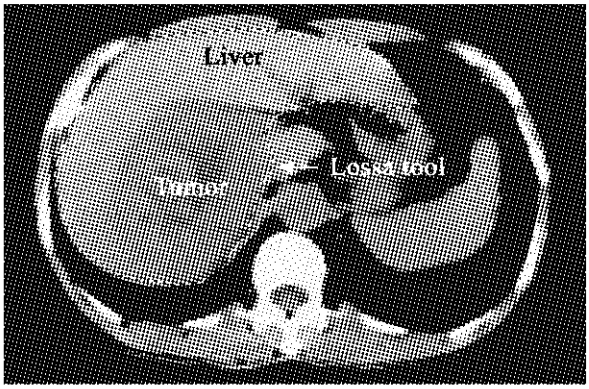

Fig. 1. The JPEG image file of CT film is opened by PhotoShop. The edges of the liver were accurately margined by the lossa tool.

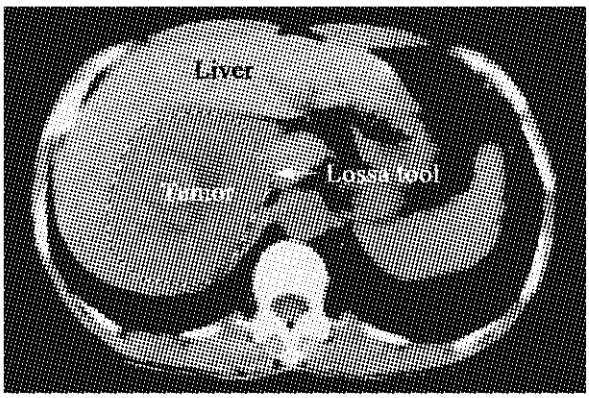

Fig. 2. The JPEG image file of CT film is opened by PhotoShop. The edges of tumor were accurately margined by the lossa tool.

Detection of the pixel of interested areas

All the works determining edges were recorded automatically. The history icon was opened in the right-lower corner and lossa or magic wand tool was chosen, which stands for an area being margined. Then the histogram in the image icon was opened and the pixel of the specific area was listed. The pixel value was put into the Microsoft Excel form, which could be easily established before or at the same time. The pixel values were recorded one by one logically in the Microsoft Excel form for further calculation. The last important step in this procedure was to determine the standard area. After creation of a 1 cm^2 area referencing the ruler indictor marked beside the CT photo by the rectangular marqeen tool, the pixel value of the area of 1 cm^2 was copied into the Excel.

Calculation of volumes

The pixel values of interested areas regularly listed in the Excel were divided by 1 cm^2 pixel value to get the actual area with the unit of square centimeter. The volume of each section was calculated by area multiplying section thickness according to the trapezoid approximation theory, which describes the volume of each section, a product of the half height between adjacent sections. If section thickness of CT scan was 1 cm, the sum of the areas of the liver or tumor in all sections naturally was the volume of the liver or tumor. With the volume values of the tumor, liver, right liver, right posterior lobe, and left lateral lobe, many parameters such as liver resection rate and graft volume could be prognosticated.

Results

Comparison of 10 hepatic volumes gained by this method and those gained by the GE Prospeed CT set showed a good relativity between the two groups. Three right lobes volumes were calculated by this method before right lobectomy of the liver, and their real volumes were obtained by volumenometer after operation. Their variation was limited within 5%.

Discussion

Volume and volume change of the liver, liver lobes and liver tumor are informative for hepatobiliary surgery. So many hepatobiliary operation need to know the liver or tumor volumetry, such as hepatectomy, living related liver transplantation et al. Living related liver transplantation as a new and effective way to cure the fulminant liv-

er failure is recognized in almost all liver transplantation centers when it was firstly performed in 1989 in Australia.[19] For a successful living related liver transplantation, the graft size is the key element[20,21] and consequentially knowing the liver volumetry of donor is so significant to guaranty the safety of donor.

But it is hard to estimate the volume only with surgeon's experience in reading CT films.[22] It is also inconvenient for surgeons to consult radiologists frequently. Previously studies have been focused on organ volumetry in personal computer.[23-25] For instance visual C++ language was used to calculate organ volume by sketching the edge of interest area manually on a piece of A4 size transparency and subsequently scanning the picture into computer. The regional growing method used under visual C++ language is sophisticated. Kao et al[25] using his stereologic method can finish organ volumetry in a short time on a personal computer. But this method needs to develop special computer program.

PhotoShop as a user-friendly software is widely used by surgeons and basic researchers to manage image data[26,27] and it even was used in medical criminology.[28] The histogram in image icon could automatically count the pixel of an interested area.[29,30] The pixel is decided by quality of the image. Simply, the pixel reflects the seeds on a unit line or in a unit area. For example, a 1-inch-by-1-inch image with a resolution of 72 ppi contains a total of 5184 pixels (72 pixels wide×72 pixels high=5184). The same 1-inch-by-1-inch image with a resolution of 300 ppi would contain a total of 90 000 pixels. In an image, therefore, the pixels of an interested area can be transferred to area value in square centimeter conferencing the real ruler marked on the image.

The lossa tool controlled with computer mouse and the magic wand tool can trace the edge of an interest area either manually or automatically depending on the edge property. Growing and similar tool modifying the edge tracing leads to more accurate margin sketching. All of these ensure a reliability of hepatic volumetry by PhotoShop. The disadvantage of this method is the step of copying the pixel value from PhotoShop to Microsoft Excel. There is no way in inputting the pixel value with computer language. If some improvement is made in this aspect, hepatic volumetry with PhotoShop will become easier.

Competing interest

The author or authors do not choose to response to the statements listed in Instructions for Authors.

References

1 Xu HX, Yin XY, Lu MD, Liu GJ, Xu ZF. Estimation of liver tumor volume using a three-dimensional ultrasound volumetric system. Ultrasound Med Biol 2003;29:839-846.
2 Lang H, Wolf GK, Prokop M, Nuber B, Weimann A, Raab R, et al. 3-dimensional sonography for volume determination of liver tumors-report of initial experiences. Chirurg 1999;70: 246-250.
3 Lin LW, Ye Z, Xue ES, Gao SD, He YM. Intraoperative ultrasonography in hepatobiliary surgery. Hepatobiliary Pancreat Dis Int 2002;1:425-428.
4 Yanaga K, Honda H, lkeda Y, Nishizaki AT, Yamamoto K, Sugimachi K. Significance of liver size in hepatic surgery. HPB Surg 1997;10:195-199.
5 lkegami T, Nishizaki T, Yanaga K, Kakizoe S, Nomoto K, Ohta R, et al. Living-related auxiliary partial orthotopic liver transplantation for primary sclerosing cholangitis-subsequent removal of the native liver. Hepatogastroenterlerology 1999;46: 2951-2954.
6 Uesaka K, Nimura Y, Nagino M. Changes in hepatic; lobar function after right portal vein embolization. An appraisal by biliary indocyanine green excretion. Ann Surg 1996;223:77-83.
7 Garcia-Valdecasas JC, Fuster J, Charco R, Bombuy E, Fondevila C, Ferrer J, et al. Changes in portal vein flow after adult living-donor liver transplantation: does it influence postoperative liver function? Liver Transplant 2003;9:564-569.
8 Maetani Y, Itoh K, Egawa H, Shibata T, Ametani F, Kubo T, et al. Factors influencing liver regeneration following living-donor liver transplantation of the fight hepatic lobe. Transplantation 2003;75:97-102.
9 Hoshida Y, Shiratori Y, Koike Y, Obi S, Hamamura K, Teratani T, et al. Hepatic volumetry to predict adverse events in percutaneous ablation of hepatocellular carcinoma. Hepatogastroenterology 2(X)2;49:451-455.
10 Fujii Y, Shimada H, Endo I, Morioka D, Nagano Y, Miura Y, et al. Risk factors of posthepatectomy liver failure after portal vein embolization. Hepatobiliary Pancreat Surg 2003;10: 226-232.
11 Vogl TJ, Schroeder H, Trapp M, Straub R, Schuster A, Schuster M, et al. Multi-sequential arterial chemoembolization of advanced hepatocellular carcinomas: computerized tomography follow-up parameters for evaluating effectiveness of therapy. Rolo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr 2000;172:43-50.
12 Hiroshige S, Shimada M, Harada N, Shiotani S, Ninomiya M, Minagawa R, et al. Accurate preoperative estimation of liver-graft volumetry using three-dimensional computed tomography. Transplantation 2003;75:1561-1564.
13 Wakabayashi H, Nakano S, Ishimura K, Hagiike M, Okano K, Maeba T, et al. Changes in arterial and portal perfusion in embolized and nonembolized hepatic lobes after poxtal vein embolization evaluated by helical computed tomography. Surg Today 2001;31:991-995.
14 Noda T, Todani T, Watanabe Y, Yamamoto S. Liver volume in children measured by computed tomography. Pediatr Radiol 1997;27:250-252.
15 Zhou KR, Yan FH, Tu BW. Arterial phase of biphase enhancement spiral CT in diagnosis of small hepatocellular carcinoma. Hepatobiliary Pancreat Dis lnt 2002;1:68-71.
16 Li YM, Lv F, Xu X, Ji H, Gao WT, Lei TJ, et al. Evaluation of liver functional reserve by combining D-sorbitol clearance rate and CT measured liver volume. World J Gastroenterol 2003;9:2092-2095.

17 Guiney MJ, Kruskal JB, Sosna J, Hanto DW, Goldberg SN, Raptopoulos V. Multi-detector row CT of relevant vascular anatomy of the surgical plane in split-liver transplantation. Radiology 2003;229:401-407.
18 Mahr A, Levegrun S, Bahner ML, Kress J, Zuna I, Schlegel W. Usability of semiautomatic segmentation algorithms for minor volume determination. Invest Radiol 1999;34:143-150.
19 Strong RW, Lynch SV, Ong TH, Matsunami H, Koido Y, Balderson GA. Successful liver transplantation from a living donor to her son. N Engl Med 1990;322:1505-1507.
20 Wang WX, Fan ST. Live donor liver transplantation in adults: graft size, related anatomical anomaly and imaging evaluation of donor. Hepatobiliary Pancreat Dis Int 2002;1:14-17.
21 Fan ST, Lo CM, Liu CL. Experience of donor right lobe hepatectomy in adult-to-adult live donor liver transplantation: clinical analysis of 89 cases. Hepatobiliary Pancreat Dis Int 2002;1:166-171.
22 Liu WY, Jin Y, Rong RH. Multi-phase helical CT in diagnosis of early hepatocellular carcinoma. Hepatobiliary Pancreat Dis Int 2003;2:73-76.
23 Lin XZ, Chang TM, Tsai HM, Sun YN, Sheu BS, Jen CM. Liver, spleen and tumor volume measured by personal computer. Hepatogastroenterterology 1999;46:838-842.
24 Zhuge B, Fend HQ, Zhou HQ. Volume rendering based on sorted volumetric data. Space Med Med Eng (Beijing) 2003; 16:243-247.
25 Kan SC, Wang G. Radiology volumetry on a personal computer with a stereologic method. Acad Radiol 1998;5:665-669.
26 Caruso RD, Postel GC. Image annotation with Adobe Photoshop. J Digit Imaging 2002;15:197-202.
27 McDaniel J, Pillal SD. Gel alignment and band scoring for DNA fingerprinting using Adobe Photoshop. Biotechniques 2002;32:120-123.
28 Nikitin SA, Demidov IV. Use of Adobe Photoshop software in medical criminology. Sud Med Ekspert 2000;43:32-33.
29 Chalazonitis AN, Koumarianos D, Tzovara J, Chronopoulos P. How to optimize radiological images captured from digital cameras, using the Adobe Photoshop 6. 0 program. J Digit Imaging 2003;11(Epub ahead of print).
30 Caruso RD, Postel GC. Image annotation with Adobe Photoshop. J Digit Imaging 2002;15:197-202.

Received March 10, 2003
Accepted after revision August 14, 2003