Biomedical Research 2018; 29 (3): 431-436

ISSN 0970-938X
www.biomedres.info

320-slice CT angiography before hepatic intrahepatic portosystemic shunt for evaluating the puncture approach.

Na Ge, Peng Wang, Ju-Wei Shao, Ying-Wen Li, Shu-Tian Xiang, Qian He*, Jun-Ren Zeng, Wei Su, Chong-Wen Mao, Zheng-Lin Yang

Department of Radiology, the Second People's Hospital of Yunnan Province, the Fourth Affiliated Hospital of Kunming Medical University, Kunming, PR China

Abstract

Objective: This study aims to evaluate the value of 320 slice Computed Tomography Angiography (CTA) in evaluating puncture approaches by simulating Intrahepatic Portosystemic Shunt (IPS) in cirrhotic patients with portal hypertension.

Methods: A total of 30 patients with hepatic cirrhosis and portal hypertension, who underwent IPS from November 2014 to January 2017 at Yunnan Province Second People's Hospital, were selected for this study. The CTA data acquired before surgery were retrospectively analysed. The puncture distances and puncture angles from the right hepatic vein, middle hepatic vein and left hepatic vein to the portal vein and its branches were measured and compared with those acquired by Digital Subtraction Angiography (DSA). Then, the differences between the puncture distances and angles acquired by CTA and DSA were evaluated.

Results: Differences between puncture distances and angles acquired by CTA and DSA were not statistically significant (P>0.05).

Conclusions: Puncture distances and angles acquired by CTA were consistent with those acquired by DSA. This can provide an imaging basis for the preoperative surgical planning of IPS.

Keywords: TIPS, DSA, CT, Angiography, Cirrhosis, Portal hypertension.

Accepted on November 2, 2017

Introduction

Transjugular Intrahepatic Portosystemic Shunt (TIPS) is effective in the treatment of liver cirrhosis with portal hypertension complications such as variceal hemorrhage and refractory ascites [1-3]. The key to the success of the operation is to select the proper puncture approach during the operation, avoiding injury to the important structures inside and outside the liver, reducing complications, and decreasing the risk of the operation. Therefore, the preoperative evaluation of the distance between the portal vein and hepatic vein, the point of puncture, and the direction and angle of the needle are very important to ensure the success of the TIPS operation [4]. Digital Subtraction Angiography (DSA) is an invasive test. Hence, this cannot serve as a routine preoperative evaluation method for TIPS [5]. Computed Tomography Angiography (CTA) has advantages of less invasive procedure, shorter examination time and less dosage of contrast media; and it has been applied to vascular examination before TIPS [6-9]. In recent years, some scholars [10,11] have applied CTA to evaluate the simulated puncture approach in the trans-posterior segmental portosystemic shunt. However, the use of CTA before TIPS in the simulation of puncture approaches amongst the Right Hepatic Vein (RHV), Middle Hepatic Vein (MHV), Left Hepatic Vein (LHV), right branch of portal vein (RPV), portal vein trunk, and left branch of portal vein (LPV) have been scarcely reported in literatures. In the present study, the puncture distances and puncture angles from RHV, MHV and LHV to the portal vein and its branches in cirrhosis patients with portal hypertension were measured before TIPS, and the results were compared with those acquired by DSA, in order to evaluate the value of 320-slice CTA in evaluating the puncture approach in TIPS in cirrhotic patients with portal hypertension.

Materials and Methods

Subjects

General information: A total of 30 cirrhosis patients with portal hypertension (Child-Pughs A and B) who underwent TIPS at Yunnan Province Second People's Hospital from November 2014 to January 2017 were selected for this study. Among these patients, 22 patients were male and eight patients were female. The age of these patients ranged between 34-74 y old, and the median age was 52.0 y old. Among these patients, 14 patients were Child-Pugh A, and 16 patients were Child-Pugh B. These patients visited a doctor due to upper gastrointestinal bleeding. Furthermore, these patients had no contraindications of Intrahepatic Portosystemic Shunt (IPS).

Research method

Inspection equipment: (1) CT scanner: 320-slice, 640-layer dynamic volume CT scanner (Aquilion ONE, Toshiba Medical Systems, Japan). (2) High pressure injector: Automatic high pressure double-barreled syringe (Ulrich, Germany). (3) Postprocessing workstation: Vitrea Workstation (Vitrea fx Version 4.60, Toshiba Medical Systems, Japan). (4) DSA: DSA system (Innova IGS 530, GE, USA).

Contrast media: Non-ionic contrast media (iopamidol, 18.5 g (I)/50 ml (or) bottle; manufacturer: Bolaike Xinyi Medicine Industry Co., Ltd. (Shanghai, China), product batch number: 1504005E, national drug approval number: H20053387).

The total amount was 60-100 ml (1-1.5 ml/kg), and no more than 2 ml/kg of body weight. Injection rate: 3-5 ml/s. A 20 G intravenous indwelling trocar was placed in the median cubital vein.

Examination steps

Scan preparation: This study was approved by the Committee for Scientific Research Ethics and Medical Ethics of our hospital. Patients fasted after dinner on the day before the examination. Patients were instructed to drink 800-1,000 ml of warm boiled water at 1-2 h before the examination, and drank 300-500 ml of warm boiled water again before scanning.

Scanning range and scanning parameters: Scan range: from the top of the diaphragm to the level of the iliac crest.

Scan parameters: 0.5 × 80 slice detector array, 120 KV, Automatic Exposure Control (AEC), reference image (base thickness: 5 mm; standard deviation: 7.5), pitch: 0.863, rate of turn (Rot): 0.5 s/turn, and matrix: 512 × 512. The abdominal aorta (celiac section) was set as the Region of Interest (ROI), wherein the ROI area was ≤ 2/3 of the lumen area of the abdominal aorta (celiac section). The threshold was 220 HU for triggering the arterial phase scanning. The acquisition time of the portal phase was 50-60 s, while the acquisition time of the hepatic vein phase was 60-70 s.

The raw data were reconstructed with a slice thickness of 0.5 mm and a gap of 0.25 mm. Data were transmitted to the Vitrea postprocessing workstation for postprocessing, and the Maximum Intensity Projection (MIP) and Volume Rendering (VR) reconstructed images were obtained. The MIP reconstructed images had thicknesses of 30-50 mm, and a reconstructed gap of 25 mm.

Image quality evaluation

The CT value of the portal vein in the portal vein phase was as follows: grade I CT value was <120 HU, grade II CT value was within 120-150 HU, and grade III CT value was >150 HU. In the portal vein phase, the difference between the portal vein CT value and hepatic parenchyma CT value was as follows: the difference in grade I CT value was <20 HU, the difference in grade II CT value was 20-50 HU, and the difference in grade III CT value was >50 HU. The degree of enhancement of the portal vein in the portal venous phase, and the difference between the portal venous phase portal vein CT value and liver parenchyma CT value were both at grades II and III of the image quality, which conform to the diagnostic criteria.

Measurements were performed by two abdominal radiologists, and the mean values of two measurements were recorded.

Data measurement

Puncture distance in simulated TIPS: Point H was set at the opening of the branch of the hepatic vein. Another point, point A, was set on the RHV approximately 10 mm from point H; and point P was set at the bifurcation of the portal vein. Next, points R, M and L were set on the RPV, PV and LPV approximately 10 mm from point P; and the distances of AR, AM and AL, that is, the distances from the RHV to the RPV, PV and LPV were measured.

Point H was set at the opening of the branch of the hepatic vein, point B was set on the MHV 10 mm from point H, and point P was set at the bifurcation of the portal vein. Then, points R, M and L were set on the RPV, PV and LPV at approximately 10 mm from point P, and the distances of BR, BM and BL, that is, the distances from the MHV to the RPV, PV and LPV, were measured.

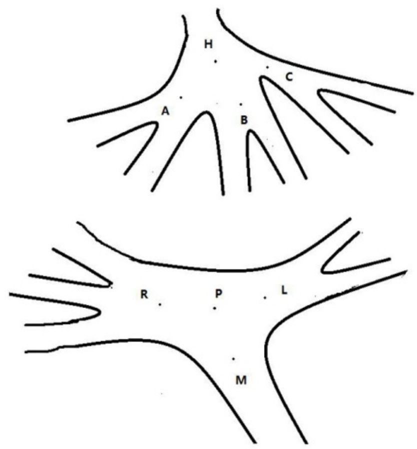

Figure 1. Schematic plot of the TIPS puncture point of the CTA simulation. Point P was set at the bifurcation of the portal vein, and points R, M and L were set on the RPV, PV and LPV approximately10 mm from point P. Points R, M and L were the simulated puncture points on the RPV, PV and LPV, and point H was set at the opening of the branch of the hepatic vein. Points A-C were set on the RHV, MHV and LHV approximately 10 mm from point H. Points A-C are the simulated puncture points on the RHV, MHV and LHV.

Point H was set at the opening of the branch of the hepatic vein, point C was set on the LHV 10 mm from point H, and point P was set at the bifurcation of the portal vein. Then, points R, M and L were set on the RPV, PV and LPV at approximately 10 mm from point P, and the distances of CR, CM and CL, that is, the distance from LHV to RPV, PV and LPV, were measured (Figure 1).

Measurement of puncture angles by CTA

In accordance with the direction of blood flow, a puncture on the hepatic vein into the portal vein trunk or its branches was defined as a retrograde puncture of IPS.

Point H was set at the opening of the branch of the hepatic vein, point A was set on the RHV approximately 10 mm from point H, point P was set at the bifurcation of the portal vein, points R, M and L were set on the RPV, PV and LPV approximately 10 mm from point ∠P, and ∠AR, ∠HAM,∠HAL, ∠HAR, ∠HAM and ∠HAL, that is, the angles of retrograde puncture of the RHV into the RPV, PV and LPV, were measured.

***Figure 2.** Puncture distances and angles of CTA and DSA before and after TIPS. A and B: The distances and angles of retrograde punctures that passed through the RHV into the portal vein trunk in CTA simulation before TIPS are shown. C and D: The distances and angles of retrograde punctures that passed through the RHV into the portal vein trunk measured by DSA are shown. E and F: The distances and angles of retrograde punctures that passed through the RHV into the portal vein trunk measured by CTA after TIPS are shown.*

Point H was set at the opening of the branch of the hepatic vein, point B was set on the MHV approximately 10 mm from point H, point P was set at the bifurcation of the portal vein, points R, M and L were set on the RPV, PV and LPV approximately 10 mm from point ∠P, and ∠HBR, ∠HBM, ∠HBL, ∠HBR, ∠HBM and ∠HBL, that is, the angles of retrograde puncture of the MHV into RPV, PV and LPV, were measured.

Point H was set at the opening of the branch of the hepatic vein, point C was set on the LHV approximately 10 mm from point H, point P was set at the bifurcation of the portal vein, points R, M and L were set on the RPV, PV and LPV approximately 10 mm from point P, and ∠HCR, ∠HCM, ∠HCL, ∠HCR, ∠HCM and ∠HCL, that is, the angles of retrograde puncture of LHV into RPV, PV and LPV, were measured.

It is important to note that point P was set at the bifurcation of the portal vein, points R, M and L were set on the RPV, PV and LPV approximately 10 mm from point P, and points R, M and L were the planned puncture points on the RPV, PV and LPV. Point H was set at the opening of the branch of the hepatic vein, points A-C were set on the RHV, MHV and LHV approximately 10 mm from point H, and A-C are the planned puncture points on the RHV, MHV and LHV.

According to the above methods, the DSA puncture distances and angles were retrospectively measured (Figure 2).

Statistics analysis

Data were statistically analysed using statistical software SPSS21.0 Measurement data were expressed as mean ± standard deviation ($\bar{x}$ ± SD). Relevant samples were compared using paired t-test. Image quality evaluator consistency was evaluated using the weighted kappa test. Kappa coefficients: 0.00-0.20, slight consistency; 0.21-0.40, fair consistency; 0.41-0.60, moderate consistency; 0.61-0.80, substantial consistency; 0.81-1.00, almost perfect consistency. Data with a frequency of 0 were expressed as crosstabs and percentage. The consistency of the surveyor for data measurement was measured using the Inter-Class Correlation Coefficient (ICC) test. A reliability coefficient of <0.4 indicates poor reliability, and a reliability coefficient of >0.75 indicates good reliability. P<0.05 was considered statistically significant.

Results

Observer consistency assessment

Image quality consistency assessment: The Kappa coefficient of surveyor consistency of the portal enhancement degree was 0.630, and the surveyor measurement was highly consistent. The difference between the portal vein CT value in portal phase and hepatic parenchyma CT value was highly consistent, and both of these revealed a result of grade III, which accounted for 29/30 (96.67%).

Parameter measurement consistency of assessment: The consistencies of the parameter values of AR, AM, AL, BR, BM, BL, CR, CM, CL, ∠HAR, ∠HAM, ∠HAL, ∠HBR, ∠HBM, ∠HBL, ∠HCR, ∠HCM and ∠HCL measured by two physicians were evaluated using the ICC test, and the reliability coefficients were all >0.90 (P=0.000<0.05). Therefore, reliability was good.

Measurement of puncture distances by CTA

The measurement of puncture distances by CTA is shown in Table 1.

***Table 1.** CTA measured the puncture distance (Unit: mm).*

	M	SD	95% confidence interval of mean		Min	Max
			Lower limit	Upper limit		

AR	53.15	6.5	50.72	55.57	40.7	66.87
AM	57.56	8.2	54.49	60.62	42	77.06
AL	40.68	6.87	38.12	43.25	29.57	56.64
BR	54.26	7.09	51.62	56.91	38.33	70.66
BM	54.73	7.25	52.03	57.44	42.41	73.63
BL	39.77	7.61	36.93	42.61	27.1	64.61
CR	60.04	7.01	57.42	62.66	46.09	74.42
CM	56.49	7.89	53.55	59.44	40.42	71.25
CL	37.55	5.7	35.42	39.68	26.34	50.21

Measurement of puncture angles by CTA

The measurement of puncture angles by CTA is shown in Table 2.

Table 2. *CTA measured the angle of puncture (Unit: °).*

	M	SD	95% confidence interval of mean		Min	Max
			Lower limit	Upper limit		
∠HAR	155.68	12.6	150.97	160.38	115.58	174.63
∠HAM	138.73	10.73	134.72	142.73	111.14	160.01
∠HAL	131.19	16.09	125.18	137.2	102.51	166.92
∠HBR	138.14	19.33	130.93	145.36	108.98	174.28
∠HBM	154.31	15.64	148.47	160.15	124.39	178.19
∠HBL	149.68	17.3	143.22	156.14	117.79	179.8
∠HCR	88.37	15.35	82.63	94.1	57.26	117.31
∠HCM	104.25	14.36	98.89	109.61	73.12	135.22
∠HCL	97.85	16.44	91.71	103.99	71.8	135.31

Comparison of the puncture distance and angle between CTA and DSA

In the 30 cirrhotic patients with portal hypertension, TIPS puncture guided by DSA was performed. Among these patients, the needle passed through the RHV in 13 patients (43.33%), the needle passed through the MHV in 15 patients (50%), and the needle passed through the LHV in two patients (6.67%). Furthermore, the puncture needle entered into the RPV in one patient (3.33%), needle entered into the trunk of portal vein in 25 patients (83.33%), and entered into the LPV in four patients (13.33%). The differences in puncture distances and angles between CTA and DSA were not statistically significant (P>0.05, Table 3).

Table 3. *Comparison of puncture distance and angle between CTA and DSA.*

Index	CT angiography (n=30)	DSA (n=30)	t	P
Angle (Unit: º)	142.75 ± 10.82	143.19 ± 14.45	-0.18	0.859
Distance (Unit: mm)	56.60 ± 8.04	59.73 ± 8.04	-1.986	0.057

Discussion

TIPS is one of the effective interventional therapies for cirrhotic portal hypertension [1,2]. The understanding of the spatial distribution of hepatic veins and portal veins before TIPS can reduce the risk of blind and error puncture of blood vessels and bile duct, improving the safety of surgery. Although DSA is the gold standard for angiography examination, it is an invasive examination; and it is not suitable to serve as a routine evaluation method before TIPS. At present, ultrasound, CTA and Magnetic Resonance Angiogram (MRA) have been applied for the preoperative evaluation of TIPS [12,13].

Ultrasound

Ultrasound can help understand the diameter, blood flow rate and patency of the portal vein and hepatic veins, and display the spatial conformation of the portal vein and hepatic veins. Pinter [14] revealed that during TIPS, ultrasound can dynamically detect the position of the catheter head in real time, display surrounding vascular morphology and spatial location, reduce the blindness of puncture, and improve the success rate of puncture. However, these ultrasound findings were significantly affected by ascites and intestinal gas and operator proficiency. Therefore, its clinical applications are limited to a certain extent.

Magnetic resonance imaging (MRI)

MRI has an advantage in observing vascular distributions, detecting dilated and tortuous vessels and the branches of the portal vein with variations in its origin, and displaying branches of the portal vein at grade VI and above [15,16]. However, since its scanning speed is slow, it is easily affected by the degree of patient coordination.

CTA

CTA can clearly display the trunk of the portal vein and the branches of the portal vein and hepatic veins at grades IV and V, and the difference in its display effect, compared with DSA, was not statistically significant [17]. Through MIP, VR and multiplanar reconstruction images, it can display the morphology, distribution and spatial structure of hepatic vessels in a multi-direction and multi-angle manner. This enables the detection of the presence of a stenosis or thrombus, and the determination of whether the patient has open collateral circulation, and provides an imaging basis for the selection of stent width, puncture point and target, and the evaluation of the puncture angle in IPS [18-21]. Chen et al. [22] revealed that CTA can accurately observe the anatomy and variation of the portal vein and its branches, and measure the width of the portal vein and its branches. The width of the portal vein measured in the study conducted by Chen et al. was 15.39 ± 0.41 mm, while the diameter of the portal vein trunk measured in the present study was 16.75 ± 2.16 mm. This result in the present study was similar to that revealed by Chen. In addition to the measurement of the width of portal vein and its branches, the selection of puncture distances and angles is also an important part of the preoperative evaluation of TIPS. A short puncture approach can reduce the possibility of the error puncture of hepatic vessels and bile duct during the operation, and a shorter puncture approach results in shorter stent length, followed by a lower incidence of restenosis formation in the stent pseudomembrane after operation. Therefore, it is particularly necessary to select the shortest puncture approach before the operation. The result of study conducted by Patidar et al. [23] revealed that the puncture distance in IPS was the shortest when it passed through the LPV. In the present study, the puncture distance through the LPV was far shorter than the puncture distances through the LPV and portal vein trunk, which was consistent with the results reported by Patidar. In the present study, the angles of the retrograde puncture that passed through the RHV and MHV into the LPV, RPV and portal vein trunk were similar, but both of these were larger than the angles of the retrograde puncture that passed through the LHV into the LPV, RPV and portal vein trunk. Hence, although the puncture distances through the LPV are shorter than the puncture distances through the RPV and portal vein trunk, we believe that retrograde puncture through the RHV and MHV is better than retrograde puncture through the LHV. In the present study, all 30 cirrhotic patients with portal hypertension underwent TIPS, and all retrograde punctures passed through the RHV. Among these cases, the puncture entered into the RPV in one patient (3.33%), entered into the portal vein trunk in 25 patients (83.33%), and entered into the LPV in four patients (13.33%). These show that the retrograde puncture through the RHV into the portal vein trunk has certain advantages in TIPS. In the present study, the puncture distances and angles of the retrograde punctures that passed through the RHV into the portal vein trunk revealed by the CTA simulation before TIPS were not different from those revealed by DSA. This shows that the assessment of the puncture approach by CTA simulation before TIPS has certain value for guiding the selection of stent length and puncture angle in clinic.

Acknowledgements

We are particularly grateful to all the people who have given us help on our article.

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*Correspondence to

Qian He

Department of Radiology

The Second People's Hospital of Yunnan Province

The Fourth Affiliated Hospital of Kunming Medical University

PR China