ORIGINAL ARTICLE

A Correlation Study on the Peak Attenuation and the Shift Time at the Peak of the Normal Pancreas and Abdominal Aorta

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ABSTRACT

Objective To explore the relationship between the peak attenuation and the shift time at the peak of the normal pancreas and abdominal aorta by applying the multi-slice spiral computed tomography perfusion imaging. **Methods** According to the inclusive criteria, randomly chose 62 patients who received contrast-enhanced computed tomography examination for the superior or the middle abdomen, planar scanning was used first, then performed median level single-location dynamic computed tomography perfusion imaging by applying a multi-slice spiral computed tomography scanner, the tube tension was 120 kV, tube current was 200 mA, matrix was 512×512, slice thickness was 4×1, rotation time was1s/r, interval was 1s and pitch was 0. Bolus injection was done via medial cubital vein by using 50 mL contrast agent, at a flow rate of 6 mL/s with a powerful injector, and 6 seconds delayed, and data acquisition lasted for 45 seconds. These data were processed on a Start Vitreal 2.0 worker-station by using Toshiba body software package. The Time-Density Curves of the normal pancreas and abdominal aorta were drawn, the peak attenuation and the shift time of peak attenuation were recorded and the relationship between peak attenuation and the shift time were analyzed. **Results** The mean values of peak attenuation of the normal pancreas and abdominal aorta were (111.94±14.42) Hu and (351.83±74.93) Hu respectively; the mean difference was (246.10±65.86) Hu and the value of peak attenuation of the normal pancreas was positively and linearly correlated with that of abdominal aorta (γ=0.438, P<0.05). The mean shift times of peak attenuation of the normal pancreas and abdominal aorta were (37.61±7.20) and (30.77±6.26) respectively; the mean difference was (6.41±2.51) and the shift time of PA of the normal pancreas was positively and linearly correlated with that of abdominal aorta (γ=0.379, P<0.05). **Conclusion** The peak attenuation of the normal pancreas is not synchronized with the peak attenuation of the abdominal aorta. The shift time of the former is usually 6-8 seconds slower than that of the latter.

INTRODUCTION

The triple-phase scanning of the pancreas is the basis for diagnosis of pancreatic diseases. The scanning time directly affects enhancement results of the pancreas which can determine the accuracy of diagnoses of pancreatic diseases [1]. Hospitals choose a different time to conduct the triple-phase scanning whose threshold is subject to the peak attenuation (PA) of the abdominal aorta [2, 3, 4]. To understand the relationship between PA of the abdominal aorta and the best pancreatic enhancement and whether there is an inevitable link between the enhancement of the pancreas and abdominal aorta. This study used the multi-slice spiral CT perfusion imaging to explore the relationship between PA and TP of the normal pancreas and abdominal aorta and try to provide a basis for the determination of right pancreatic scanning time.

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MATERIALS AND METHODS

Clinical Data

Randomly collected records of patients who received contrast-enhanced CT examination for the superior or the middle abdomen in our hospital. Their height and weight was recorded after examination. 62 cases were selected by means of inclusive criteria, among them 47 cases were males and 15 cases were females. Their ages ranged from 18 to 75. The average age was (48.29±13.20); average height was (163.32±6.60) and average weight was (58.55±9.08).

Inclusive criteria

This means patients should be in line with the following [5, 6].

(1) Pancreatinum and related biochemical indicator are normal, without symptoms of pancreatic disease. (2) ECG and heart function are normal. (3) Basal metabolism is normal, without fever, hypertension, gout, hyperthyroidism

and tuberculosis, etc. (4) The blood circulation is normal, without heart failure or diseases originating from the heart, liver, kidneys and main blood vessels which involve the abdominal aorta and the pancreatic arteriovenous system. (5) No history of allergies and contraindication of idodine, such as diabetic nephropathy, kidney insufficiency and myasthenia gravis, etc.

CT Examination Technique

Preparations

Eliminated patients' anxiety, taught them to breath in a proper way, signed their names on the Informed Consent Form which was about the use of Iodine contrast agents. One hour before the exam, patients were required to drink water or intestinal contrast agent 300-500 mL step by step. Established channel of the medial cubital vein (Model: TERUMO SURFLO®, 0.8×19 mm). Check process was conducted under the supervision of Hospital Ethics Committee.

Methods of CT Examination

Planar Scanning: in this process, patients were in supine position, that is, their heads entered the CT scanner first and scanned from the xiphoid bone to the iliac crest by applying a multi-slice spiral CT scanner (Toshiba Aquilion 16) to perform the planar scanning of the superior or the middle abdomen. The tube tension was 120Kv, tube current was 200 mA, slice thickness was 2 mm×16, rotation time was 1.0 s/r, reconstruction slice thickness was 7 mm, reconstruction interval was 7 mm, pitch was 15(0.986), and filter function was FC10.

The Pancreatic CT Perfusion Scanning: in this process, center levels of the abdominal aorta, the pancreas, the portal vein and the spleen were selected as the perfusion scanning levels which were able to show high quality images and performed the continuous volume scanning. The tube tension was 120 kV, tube current was 200 mA, slice thickness was 1 mm×4, reconstruction interval was 1s, pitch was 0.Bolus injection of a non-ionic Iodine contrast medium-Iohexol 50 mL. (Iohexol Injection®, The Yangtze River Pharmaceutical Group, 300 mgI/ mL) was done via the channel of the medial cubital vein by using VISTRON high pressure injector and the flow rate was at 6 mL/s, delayed 6s, rotation time was 1.0 s/r , time of data collection lasted for 45s. At last 180 perfusion images were produced totally. Patients were injected contrast agent 50-60 mL according to their weight after the perfusion scanning. The general contrast-enhanced scanning would be completed at the rate of 2.5-3.0 mL/s.

Data Measurements: in this process, collected imaging data were relayed to the Vitrea 2 workstation. The abdominal artery was the input artery, the portal vein and splenic vein were the output veins. Center area of the cross section of the abdominal aorta was Region of Interest (ROI), it ranged from 12.86 to 15.66 mm^2. The size difference of ROI was ensured to less than 10% and ROI would stay away from the edge. The same way was used to get the pancreatic ROI which stayed away from the edge and blood vessels. Performed the pancreatic ROI three times and averaged the results. Time-density curve (TDC) could be produced by using Toshiba software packages **(Figure 1a)** and each pancreatic perfusion image **(Figures 1b-f)**. Worked out PA and TP of the pancreas according to the TDC and delayed time, and figured out differences between the peak and peak time.

Statistical Analysis

Applied SPSS16.0 software package to perform the statistics analysis. Data expressed as mean ± standard deviation. Tested PA and TP of the normal pancreas and abdominal aorta. Utilized Pearson's to conduct the correlation analysis which helped to understand the relationship between TP of the normal pancreas and that of the abdominal aorta. $P<0.05$ meant statistically significant, instead $P>0.05$ meant no statistically significant.

RESULTS

PA range of the normal pancreas is (85-152) Hu, the average is (111.94±14.42) Hu, meanwhile, TP range is (26-50), the average is (37.56±6.90). PA range of the abdominal aorta is (179-540) Hu, the average is (351.83±74.93) Hu; meanwhile, TP range is (18-46), the average is (30.82±6.73). The different PA and TP of the normal pancreas and abdominal aorta are statistically significant. Meanwhile, the correlations are positive **(Table 1)**. PA of the normal pancreas is less than that of the abdominal aorta and the difference is (246.10±65.86) Hu; its TP is slower than that of the abdominal aorta and the difference is (6.54±2.97).

These figures came from the same patient (male, 64y). In Figure A, red line stands for enhancement curve of the abdominal aorta, while yellow line means enhancement curve of normal pancreas. In the colorful perfusion images, the color scale on the right side means dose of perfusion and its upper portion refers to large dose, the lower portion means small dose.

DISCUSSION

Advantages of multi-slice spiral CT are volume acquisition of data and formation of isotropic images. It is widely used because of its higher temporal resolution. The short scanning time and effective reconstruction algorithm set the step for multi-phase CT scan for organs. Contrast agent injected into tissues and organs shows bolus images at different phases. Comparative analyses of the different density and blood supply changes of each phase can greatly improve the rate of lesion detection, the accuracy

Table 1: PA & TP of the normal pancreas and abdominal aorta.

	PA range (Hu)	the average (Hu)	TP range (s)	the average (s)
pancreas	85-152	111.94±14.42	22-52	37.56±6.90
abdominal aorta	179-540	351.83±74.93	18-46	30.82±6.73
γ		0.438		0.434
P		<0.05		<0.05

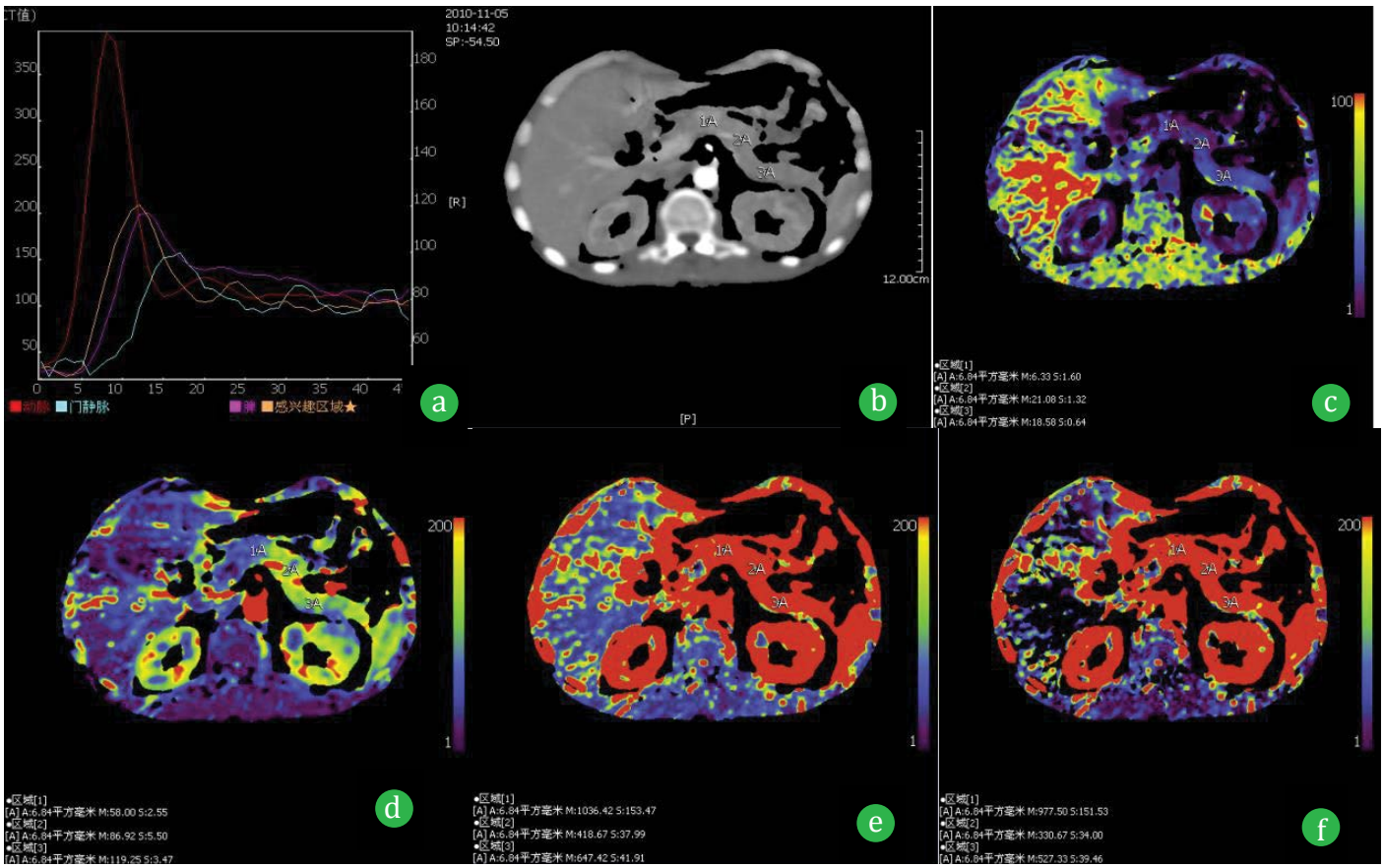

Figure 1. Parameter values of perfusion. **(a).** is TDC, **(b).** is MIP, **(c).** is BF, **(d).** is BV, **(e).** is MTT, **(f).** is PS.

of disease diagnosis and reduce the rate of misdiagnosis. The key to multi-phase CT scan is the selection of scanning time. The length of time will directly affect the accuracy of the quantitative and qualitative diagnoses, after contrast agent was injected.

Also, the selection of scanning time is a touchstone of a successful or failed clinical scanning. So, for a multi-phase scanning it is very important. Owning to different time selection of different organs and many other influencing factors, this study adopts perfusion imaging technique to explore the relationship between TP of the normal pancreas and that of the abdominal aorta. It helps to determine the multi-phase scanning plan. At present, there are different reports about pancreatic inspection programs. McNulty *et al.* [1] used contrast agent 150 mL totally, the flow rate was 4 mL/s. The time phases of triple-phase enhancement scanning were set as follows: arterial phase was 20s, pancreatic phase was 35s, and portal vein phase was 60s. Fishman *et al.* [2] used contrast agent 120 mL totally, the flow rate was 3 mL/s, adopted biphasic contrast enhancement, the delayed time of arterial phase and portal vein phase were 25s and 55s respectively. Prokesch *et al.* [3] used contrast agent 140 mL totally, the flow rate was 4 mL/s, adopted biphasic contrast enhancement, pancreatic phase was 40s and portal vein phase was 70s. Hui *et al.* [4] used contrast agent 120 mL totally, the flow rate was 5 mL/s, adopted triple-phase enhancement scanning, arterial phase was 20s, pancreatic phase was 45s, and portal vein phase was 80s. Factors that may cause these differences are instruments, processing workstations, concentration and amount of contrast agent and the flow rate etc. Finding a method which can reflect the changes of contrast medium in pancreas over time is vital for time selection of pancreas scanning.

Perfusion imaging can reflect characteristics of the contrast medium in organ tissues over time. CT perfusion imaging of pancreas [7] refers to inject contrast agent via the median cubital vein and perform dynamic scan several times for slices of pancreas which can produce high quality images and get TDC of each pixel. On the one hand, these curves reflect changes of contrast agent concentration in the pancreas, and on the other hand, they reflect the changes of perfusion dose in pancreatic tissue indirectly. TDC reflects the whole process in which contrast medium was injected into the pancreas and the abdominal aorta and it faded at last. This set of cases delayed 6s after getting the perfusion and the scan lasted for 45s, the contrast agent in the body tissue can be shown clearly within the 96s. The pancreas is a peritoneal organ which is seldom affected by the respiration. Moreover, patients had been trained how to breathe calmly before scanning, so respiratory movement didn't impact on these cases during the scanning, patients did not need to hold their breath. This set of cases included a complete arterial phase, that is, the cycle time was about 22s, and average peak time of the abdominal aorta was in 35.90s.

Study on this set of cases shows that: PA of the normal pancreas is (85-152)Hu, the average is (111.94±14.42) Hu. TP is (26-50), the average is (37.56±6.90). PA of the abdominal aorta is (179-540) Hu, the average

is (351.83±74.93) Hu; TP is (18-46), the average is (30.82±6.73). PA of the normal pancreas is less than that of the latter and the difference is (246.10±65.86)Hu. TP of the normal pancreas is slower than that of the abdominal aorta, and the difference is (6.54±2.97)s. Hui's [4] research shows that (1) the average PA of peripancreatic artery is (322.57±87.64) Hu and the average time of reaching the peak is 30s ; (2) the average PA of pancreas is (126.78 ±24.74) Hu and the average time of reaching the peak is 40s; (3) the average PA of pancreatic portal vein is (191.58±37.93) Hu and the average time of reaching the peak is 45 s; (4) the average PA of liver is (119.50±23.84) Hu and the average time of reaching the peak is 60 s. Xiao-li's [8] research shows that TP of the abdominal aorta is (16.10-34.40)s, and the average is (23.38±4.92)s. Findings of this study is that PA and TP of the pancreas lag behind PA and TP of the abdominal aorta. This difference can be explained by characteristics of arterial blood circulation. First, contrast agent was injected through the ulnar vein and flowed into the right atrium via the superior vena cava. Then it would flow into the pulmonary artery and finish pulmonary circulation, after the systemic circulation it would reach the abdominal aorta and at last it would reach the pancreas and reinforce it by through branches of the abdominal aorta. Therefore, the path that contrast media reaches the normal pancreas is longer than that of the abdominal aorta. So in theory, PA of the abdominal aorta is higher than that of pancreas, even though the flow rate doesn't change while TP of the abdominal aorta is shorter than that of the pancreas. These findings are consistent with theories. Secondly, artery has small multilevel branches and the number increases and the resistance to blood flow increases correspondingly, so when the contrast agent passes through branches of artery the blood flow will slow down, which will affect PA and TP. Thirdly, branches of the pancreatic artery supply other visceral organs, that will make PA of the pancreas become lower. Compared with other scholars' findings, PA of this set of cases is low. This can be caused by the fast injection rate which will result in a temporary spasm of the peripheral vein and reduce the returned blood volume. Therefore contrast agent which reached the aorta will decrease and TP of the pancreas will be affected eventually. Findings of this study are similar to results of Yamashita's [9] and Min-jie's [10] researches.

Range of perfusion flow rate is 5-10 mL/s. This study adopts one flow rate only, to explore the relationship between PA and TP of the normal pancreas and abdominal aorta. Conclusion is that the best PA of the normal pancreas is not synchronized with that of the abdominal aorta, TP of the abdominal aorta is early completed in 6~7s. There may be some limitations, but the limitation is very small. The temporal differences between PA of organs lie in blood circulation, instead of the flow rate or concentration of the contrast medium. Further research is needed to be done to explore whether the different flow rate and perfusion condition will inference the PA and TP of the pancreas.

In short, no matter what kind of check methods will be used, high quality images of the pancreas, foci and surrounding structures of foci are the keys to diagnoses of pancreatic diseases. This purpose can be achieved by using the multi-slice spiral CT. The judgment of accurate scanning time is the key to access to high quality triple-phase pancreatic images.

Conflict of Interest

The authors declare that there is no conflict of interests.

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