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Comparison And Selection of Image Reconstruction with the Abdominal Artery Mixing Energy Spectrum Ct and Single-Energy Mode

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ABSTRACT

Objective To compare the quality of image reconstruction with the abdominal artery mixing energy spectrum CT and single-energy mode, screen image reconstruction mode which is suitable to observe the abdominal artery. Methods 80 patients were treated with GE's Gemstone CT imaging spectroscopy to obtain abdominal artery mixing energy image (140 kVp) and a single energy image within the scope of 40-140k eV. Measured CT value of the zone interested of mixed energy image and single image energy, and calculated abdominal aorta, and SNR and CNR of hepatic artery; each group of pictures do subjective image quality scores blinded by three experienced radiologists. Finally, Compared with the CT value of abdominal artery, SNR, CNR and subjective image quality scores. The data obtained use SPSS 19.0 software to do statistical analysis. Results: With the reduced of keV value, CT value of abdominal artery was gradually increased, while image noise changes. Comprehensive compared image of a single energy with image of mixed energy of each group based on objective image quality index (CT value, SNR and CNR) of the abdominal artery and subjective ratings, the results show image quality of a single energy group with 50-60 keV of abdominal artery is better than that of mixing energy group, while there are differences affect on image quality of the single energy imaging in the abdominal aorta and hepatic artery. Conclusion In different types of arterial reconstruction image obtained by conventional abdominal CT of abdomen spectrum enhanced scan, the image quality with 50-60 keV of single energy mode is superior to that of rebuild mode with mixing energy, as recommended by the abdominal artery spectrum of conventional CT scan in reconstruction mode .

Keywords: *abdomen; tomography scanners; x-ray computed; spectroscopy imaging; CT angiography; rebuilding mode*

INTRODUCTION

Abdominal CT scan arterial spectrum (Gemstone Spectral Imaging, GSI) can obtain image reconstruction in multiple mode with mixing energy (polychromatic, QC) and single energy (monochromatic, MONO). Because there are so many reconstructed image, appropriate choice of image reconstruction mode can shorten after processing time of the image and improve image quality, and increase clinical efficiency. In this study, use conventional abdominal CT to enhance scan spectrum, reconstruct different mode image of abdominal arterial, compare and study the quality of image reconstruction, and chose CT in reconstruction mode which is suitable to observe abdominal artery through abdominal artery reconstruction mode with hybrid energy

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mode and single-mode energy.

MATERIALS AND METHODS

General information

Randomly selected 80 patients who performed the abdomen GSI with enhanced CT on gem spectroscopy scan in our hospital, in which there are 48 men, 32 females, who aged 21 to 84 years, and the mean age is 53.6 years old. Patients with no history of allergy iodinated contrast. Exclusion criteria were: aortic dissection, abdominal artery after intervention, the aorta and its branches or arterial thrombosis in patients with abdominal tumor thrombus. The study is agreed by the hospital ethics committee and patients signed informed consent.

Acquisition and Reconstruction of Image

80 cases do routine abdominal scan through CT scan machine in GE Discovery CT 750 HD spectrum, then use a fast switching spectrum scanning modes with single source dual voltage (80 and 140 kVp) to do enhanced scan for liver arterial phase and portal venous phase dual-phase. The scan range is from the top to the lower pole of right kidney diaphragm with 2cm or less flat. The current of X-ray scanned by EDS CT tube is fixed at 600 mA; pitch is 0.984; and layer thickness and spacing is 5 mm. Enhanced contrast agent of scan through Ultravist (300 mg I/m1), a dose of 75mL, injection flow rate of 2.5 mL/s, and use binoculars high-pressure syringe. Reconstruct axial images with thickness of 0.625 mm, the layer of 0.625 mm with mixing energy from (140 kVp) and single energy (40 ~ 140 keV) on the basis of the arterial phase CT scan data on the spectrum. Use spectrum analysis software (GSIviewer) to reconstruct single energy image, make 10 keV to pitch in the energy range of 40 ~ 140 keV to do image reconstruction in 11 kinds of energy within a single of different energies.

Evaluation of images and selected arterial phase

Measure and assess image quality for mixed groups and single energy image energy image of the abdominal aorta and hepatic artery. Image measurement and evaluation use unified window width, window level and threshold. CT values measured by an experienced radiologist blinded alone; CT image rating by an experienced physician and a director of two physicians, use this score only when three physician ratings is coincide; If score by inconsistent, re-reading to discuss common consensus score.

By calculating CT value of the abdominal aorta and hepatic artery, SNR (signal-to-noiseratio, SNR) and CNR (contrast-to-noise ratio, CNR) to objectively evaluate image quality. SNR = SItissue / SDbackground, CNR = (SI1-SI2) / SDbackground, SItissue is CT value of abdominal aorta and hepatic artery, SI1 is CT value of abdominal aorta and hepatic artery, SI2 is CT value of the psoas muscle and liver parenchyma, and SDbackground is standard deviation of the surrounding air. Using the same set of images for each ROI value measurements.

Subjective evaluation of artery image quality by vascular reconstruction MIP and VRT images to do grade scoring. According to the density of blood vessels, blood vessels and blood vessels of different edge sharpness, vessel branches to reach the number of stages, vessels and adjacent tissue contrast and image noise, use five scoring criteria: 5 scores is excellent, 4 scores is good, 3 scores is general, 2 scores is bad but it can be used for differential diagnosis), and 1 score is divided into poor (it can not be used for diagnosis).

Statistical analysis

Use SPSS19.0 statistical software for data analysis. Hybrid energy image (QC) and CT value of each group of single energy image (MONO) artery, SNR, CNR and subjective image quality score (score first converted to rank) were compared using a completely randomized design of single factor analysis of

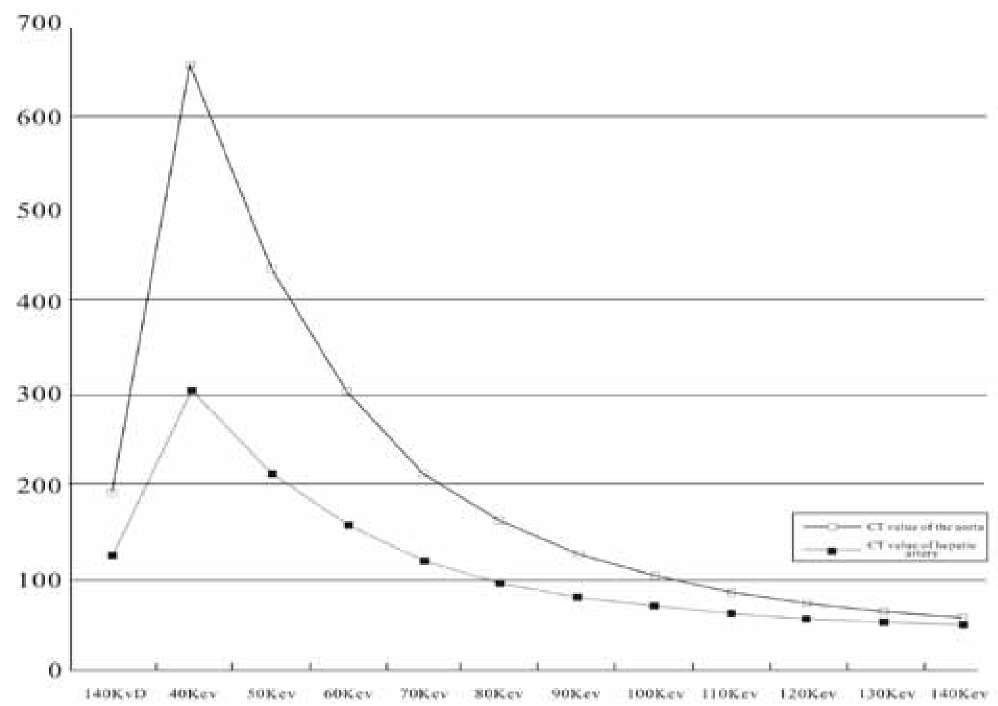
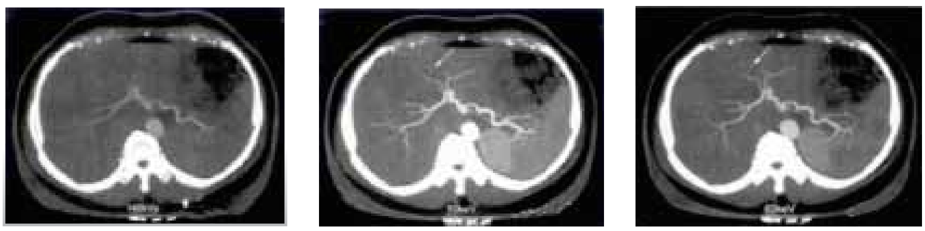


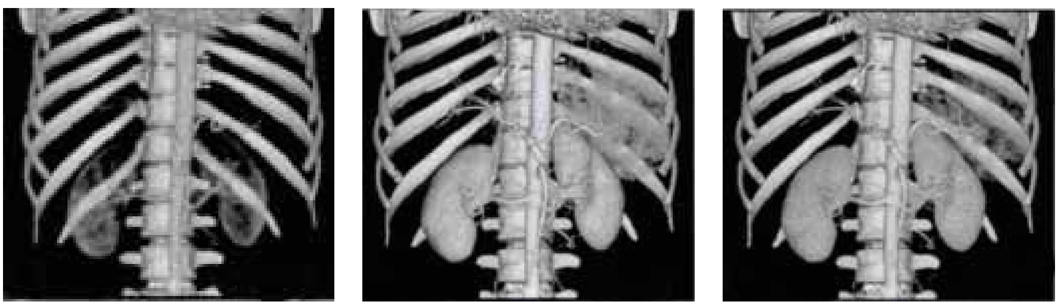
Fig. 1: Energy - density curve.

Note: CT values of hepatic artery and abdominal aorta decreased with the increase of energy, CT value of a mixture of both energy image (140 kvp) and mono-energetic image of 70 keV is very close.



(a) 140 kvp | *(b) 50 keV* | (c)60keV

Fig. 2 (A) MIP images



(a) 140 kvp | (b) 50 keV | (c)60keV

Fig. 2 (B) VRT images

Note: Compared with 140 kvp image, 50keV and 60keV image of abdominal aorta and hepatic artery has a higher CT value and clarity (the same window width, window level and threshold), missing 50keV and 60keV arrows of MTP, VRT image show more small intrahepatic arterial branches

Table 1 The comparative of the objective indicators and subjective indicators of images between QC group and each MONO group

groups		Abdominal aorta			Hepatic artery			Subjective ratings Image Quality
		CT value	SNR	CNR	CT value	SNR	CNR	
QC	140 kvP	193.7±36.2	30.9±14.6	21.0±10.9	123.6±31.9	20.1±10.7	8.7±6.8	3.0±0.5
MONO	40 keV	654.6±131.1	43.2±18.0	35.8±15.3	304.0±64.1	20.2±8.3*	13.2±6.1	2.8±0.4*
	50 keV	435.1±84.5	47.7±22.1	37.8±18.1	212.6±43.3	23.5±10.5*	13.8±7.0	3.7±0.8
	60 keV	301.7±56.3	44.1±21.6	32.7±16.6	157.6±32.3	23.2±11.4*	12.0±7.0	4.0±0.7
	70 keV	212.4±36.2*	33.2±16.3*	21.8±12.4*	118.7±22.3*	18.7±8.9*	7.9±4.7*	3.1±0.5*
	80 keV	161.8±26.5	18.3±7.0	11.0±4.7	95.5±16.4	11.0±4.4	3.5±2.1	2.3±0.5
	90 keV	126.2±19.0	12.1±4.2	6.2±2.6	78.7±13.5	7.7±2.8	1.8±1.2	1.6±0.7
	100 keV	101.5±13.9	9.7±3.4	4.1±1.8	68.2±11.9	6.7±2.5	1.1±0.8	1.1±0.3
	110 keV	84.0±10.3	8.0±2.7	2.5±1.2	60.9±10.8	5.9±2.2	0.8±0.5	1.0±0.0
	120 keV	71.6±8.0	6.9±2.3	1.5±0.9	55.5±10.4	5.4±2.0	0.7±0.5	1.0±0.0
	130 keV	62.3±6.2	6.0±2.0	0.8±0.6	51.7±9.7	5.0±1.9	0.7±0.6	1.0±0.0
	140 keV	55.0±5.3	5.2±1.8	0.5±0.3	48.1±10.0	4.7±1.8	0.9±0.7	1.0±0.0

Note: The overall difference of above-mentioned variables between both groups is $P = 0.000 < 0.05$. The pairwise comparison between QC group and MONO is as follows: * represents the value of the corresponding variable comparison is greater than 0.05, and the difference was not statistically significant; The value which is not marked * indicates the corresponding variable comparison of P values is less than 0.05, and the difference was statistically significant.

variance, the overall difference between the groups is statistically significant, QC and MONO with each group of pairwise comparisons use multiple comparisons paired t-test (Dunnett method). Average number recorded as x ± s, $P < 0.05$ was considered statistically significant.

RESULTS

The overall difference between CT value of each set of images abdominal aorta and hepatic artery, SNR, CNR and subjective image quality scores of the group was statistically significant, $P < 0.05$. Pairwise comparison results of MONO group and QC group of CT value of abdominal aorta and hepatic artery, SNR, CNR and subjective image quality scores are shown in Table 1.

CT value of abdominal aorta and hepatic artery in each MONO group decreased gradually with the increase of energy, the difference of CT value of abdominal aorta and hepatic artery is gradually reduced (Fig. 1).

Through comprehensive comparison of objective image quality index (CT value, SNR and CNR) of abdominal aorta and the hepatic artery, and subjective ratings in each MONO group and QC group, abdominal aorta and hepatic artery image quality in 50 ~ 60 keV group is better than QC group, besides abdomen aorta and its major branches show better, it also is able to display QC group can not display or display unclear more small arterial branches (Figure 2-7). The results showed that there are differences affect between the single energy imaging in the abdominal aorta and hepatic artery image quality. While low energy segments (40 ~ 60 keV) of single energy image can be improved CT value and CNR of hepatic artery, but SNR unchanged; and CT value of the abdominal aorta, SNR and CNR (40 ~ 60 keV) in a single low-energy segment energy image are improved.

DISCUSSION

Gem spectrum CT imaging is a new technology in energy CT imaging, which use single source instantaneous double kVp (80/140) with the acquisition technique [1] to scan, and obtained the image-based material according to the level of energy raw scan data reorganization. Finally, using the corresponding base substance absorption curve calculated 101 single virtual image of a specific energy range (40 ~ 140keV) inside, while access to conventional energy combined image (QC). In mixed mode energy, CT value is constant, and image is relatively constant contrast between different tissues. Since there are difference between absorbing X-rays in the same kind of tissue in the presence of different energy level, CT value of the organization will change accordingly as the energy change. And each organization has a specific X-ray absorption curves at different energy levels conditions, and contrast between different tissue in the image changed with the changes of the energy. On the other hand, changes in energy level may change image noise, affecting the image quality. X-ray beam of high energy can increase the penetrate tissue to capacity of photons, so that more photons reaching the detector, to reduce the quantum noise; low energy X-ray beam due to the reduced penetration, reducing the number of photons reach the detector, so that the noise increase. Therefore, spectrum CT improved image quality by adjusting the energy suitable energy levels [2-3].

Currently the time of clinical application of spectrum CT imaging is also very short, and its various clinical value is still in the exploratory stage [4-8]. In this study, conventional contrast enhanced abdominal CT scan spectrum, do image reconstruction in abdominal artery mixing energy mode and single mode energy, comparative evaluation of image quality on objective indicators and subjective indicators, investigate artery value of CT imaging spectroscopy in the clinical application of abdominal, but also select the appropriate mode for image reconstruction for clinical basis. CT value, SNR and CNR is the most important objective indicators in abdominal artery image quality evaluation. Arterial CT value is an important indicator of the degree of enhancement of the arteries, a high degree of vascular enhancement, means that it is possible to obtain a good image of the artery; good SNR is the basis to clearly display the anatomy of the abdominal artery and the lesion on CT, and under certain SNR conditions, sufficient CNR is the fundamental guarantee to show abdominal artery disease. Subjective evaluation of abdominal artery image is generally assessed based on artery MIP and VRT image. Therefore, the evaluation of abdominal artery image quality, must be combined with objective indicators and subjective evaluation of the abdominal artery imaging quality to comprehensive consider.

In this study, we use the abdominal aorta and liver aorta as the represent of major and small abdominal artery, do a comparative study of image quality in different abdominal artery reconstruction mode, while compare the single-energy imaging to the abdominal aorta with the larger diameter and hepatic arterial with smaller diameter of imaging quality whether exists different. The results showed that CT values of the hepatic artery and abdominal aorta decreased with energy level gradually increased. In the low-energy image segment, the degree of enhancement of the hepatic artery and abdominal aorta were significantly improved, and contrast was in enhancement, but the noise increases; In the high-energy image segment, the degree of enhancement of the abdominal aorta and hepatic artery were significantly lower, and contrast was in weakened, but hardened image artifacts and noise were in reduction. In the contrast of objective indicators and subjective scoring of each MONO image group and QC group image, 70keV mono-energetic image as a watershed group, the hepatic artery and abdominal aorta show the same results with the QC group ($P > 0.05$).

Image quality of abdominal aorta and hepatic artery are worse compared with QC group ($P < 0.05$) in 80～140 keV Group , while in the group of less than 70keV mono-energetic image, although each objective indicators of abdominal aorta and most objective indicators of hepatic artery are higher compared with QC group ($P < 0.05$) in 40 keV, but subjective scores of SNR hepatic artery in two sets of image, abdominal aorta, and hepatic artery did not differ ($P> 0.05$), while the noise of 40 keV image significantly increase, affecting the observation of MIP and VRT image of abdominal aorta and hepatic artery, and for elevated CT values in adjacent tissues, the abdominal aorta and hepatic artery in VRT image occlusion by adjacent tissues, and showed unclear. Therefore it can not explain image quality of abdominal aorta and hepatic artery in 40keV group is superior to QC group. Each objective indicators of abdominal aorta and partial objective indicators of hepatic artery and scores are higher compared with QC group ($P < 0.05$) in 50 ~ 60keV group. Although there is no difference in SNR of hepatic artery between 50 ~ 60 keV group and QC group ($P > 0.05$), but CNR hepatic artery in the former are higher than the latter ($P < 0.05$), which can displayed more small arterial branches that can not be displayed or display unclear for the latter, integrated objective indicators and subjective ratings, whether the display results of abdominal aorta or hepatic artery, all showed that effects of hepatic artery and abdominal aorta in QC group are worse than that in 50 ~ 60 kev group. Thus image quality of abdominal aorta and hepatic artery in 50 ~ 60keV group is better than that in QC group. The results also show that the difference of CT values between the hepatic artery and abdominal aorta increase with the decreasing ofenergy levels, and there are some different affect of image quality for the single energy between the abdominal aorta and hepatic artery in the low-energy segments (40 ~ 60 keV). The main difference is reflected in changes in the small arteries of the SNR. Low energy with single-energy image segment can significantly improve the SNR of abdominal aorta, while SNR of the hepatic artery had little effect. On the one hand, mainly because of hepatic artery with smaller diameter, less filling contrast, the degree of CT value of hepatic artery increased with energy decreases is far less than the magnitude of abdominal aorta; on the other hand, the image noise was reduced as the energy increased, and abdominal artery and hepatic artery has the same noise at the same energy level. Therefore partially CT value of Hepatic artery increased due to offset the increased noise, SNR of hepatic artery almost had no change, and CT value of the abdominal aorta increased by a big margin, and the rate of increase is greater than the noise. So the single-energy image in low-energy segment significantly improve SNR of abdominal aorta.

CONCLUSION

In summary, in different spectrum-mode image with reconstruction of the abdomen CT scan of the arteries, image quality of mono-energetic mode reconstructed is better than that of mixing energy mode image reconstruction in 50 ~ 60 keV group, in addition to the abdominal aorta and its major branches displayed image is better than a conventional hybrid energy, a number of other smaller arterial branches can clearly display that, and it was recommended as CT scan spectrum of conventional reconstruction mode of the abdominal artery. How to go through CT scanning technology, without affecting the abdominal vascular image quality and significantly increasing radiation dose, we only go through by reducing the contrast agent concentration, dosage and injection rate. thereby reducing the incidence of contrastinduced nephropathy is our next research's way.

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