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Application of different level iterative reconstruction in CT examination of liver tumors

Huafeng Zhang, Yanting Luo

Sun Yat-sen University cancer center, Guangdong, 510050, China;

Abstract: **To evaluate the feasibility of iDOSE iterative reconstruction technique in reducing body radiation dose at enhanced CT of liver tumors. 65 patients with known or suspected liver tumors were underwent hepatic enhanced 256 slice CT scan. Routine and low dose CT scans were acquired sequentially during the hepatic portal venous phase after contrast injection. Routine dose data were reconstructed by using filtered back projection (FBP, group A), low dose acquisition with FBP (group B) and seven different levels of iterative reconstruction algorithm (iDOSE1-iDOSE7, group C). Quantitative noise and CNR measurements were performed. Sharpness of tumors, contrast between tumors and normal liver tissue and image quality were graded and compared among three groups. Low dose acquisitions were obtained with 71% dose reduction. Group C had the lowest image noise (P=0. 001) and had the highest CNR of iDOSE1-iDOSE7 than that of FBP (P=0.001). No significant difference of SNR and CNR values were found among iDOSE2, iDOSE3, iDOSE4. Group C obtained identical observer image quality scores than group A (P>0.05). The iDOSE iterative reconstruction technique can enables 50% radiation dose reduction in CT imaging of liver tumors, while maintains the diagnostic quality of routine dose CT.**

Keywords: Liver neoplasms; Tomography, X-ray computed; Iterative reconstruction; Low dose

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*Corresponding Author: Yuhua Song, 15206950172@163.com

1. Introduction

In recent years, With CT technology rapid development, application range is becoming more and more widely, Application number increase sharply, according to reports[1], CT examination in the United States each year are more than 60 million times, at the same time, caused by ionizing radiation danger, such as tumor and genetic effect also is a major concern. In 1990, Naidich[2] put forward the low-dose scan, the main methods include lowering tube Voltage, according to the layer thickness or body quality automatic tube modulation, the drop of low noise filtration function, etc, of which the effect of tube current modulation is more bright. It can make the abdominal scan dose by 40% ~ 60%[3]. However, for the liver, it lack of good natural contrast, using the filtered back the projection(FBP) for the raw data reconstruction, it limits the dose further reduced, and often lead to noise level increased, image quality drop significantly, and then influence the diagnosis[4].

To make up for the noise rise and resulting in a decline in image quality, abroad researchers using iteration iterative reconstruction (IR) algorithm for low dose scanning and reconstruction. In the chest, abdomen CT examination and colon , under the premise of quality satisfies requirement of diagnosis, low dose CT imaging scanning with IR algorithm can be reduce the radiation dose in the image. Our study used low dose CT scanning iDOSE reconstruction to evaluate the feasibility of the assessment of liver tumor.

2. Data and Methods

2.1. General data

65 patients with liver cancer or liver tumor review accepted the liver CT scans, 34 cases of male, female 31Cases, age 34-83, .This test approved by the hospital ethics committee , all patients were signed informed consent.

2.2. Instrument and method

Using Philips offerings CT. Patients are with supine position. First breathless positioning and CT scan, and then use Ulrich REF XD 2051 syringe to 4.0ml/s rate by the elbow Intravenous injection for alcohol 350mgI/ml, 80ml iodine after add 10ml Saline solution. In conventional arterial radiation after injection of contrast medium Dose (30s) after injection drug, portal routine dose (after drug injection 55 s) door pulse low dose (portal period immediately after regular scans) and delay Late period of routine dose (note medicine after 120 s) scans. Low doses of scanning when using iDOSE software by adjusting the tube current, make the forecast radiation dose was lower than normal dosea by 50%. Conventional dose scanning parameters: 120kV; 66-256mAs; pitch0.09; Reconstruction thickness 3mm; Layer between 3mm; X-ray tube rotation speed 0. 75 s/rot; The matrix of 512 by 512. Application of ACS automatic tube current System technology.

2.3. Reconstruction of image analysis

2.3.1. Image reconstruction

Group A: conventional dose scan using FBP, Group B: the low-dose scanning of was adopted by FBP, group C: iDOSE reconstruction algorithm generate images. In iterative reconstruction, iDOSE level is 50%.

2.3.2. Noise and comparison of noise ratio quantitatively calculated

One radiologist having 5 Years f experience in abdominal CT scanning and reconstruction of image reconstruction measured the liver parenchyma of the three groups and the right vertical ridge of average CT mean and the SD. The ROI area is 100. 00mm^2. Liver parenchyma SD as image noise, Calculated CNR = (ROI liver-ROI muscle)/SD background.

2.3.3. Image quality analysis

Using PACS, and display three types of images (the regular dose of FBP reconstruction, low dose FBP reconstruction, portal phase low dose iDOSE). The window is 250 HU and the window is 45 HU. The evaluation included the tumor edge sharpness, tumor and normal liver tissue contrast, image subjective noise, the overall quality of sound and image is divided into four grades.

2.4. Statistical analysis

SPSS 17.0 statistical software were used in this study. The variance analysis were used with F test, when P<0.05, it has statistically significant.

3. Results

3.1. The result of CT examination of liver

All 65 patients were successfully completed. Among them, 50 cases of liver cancer were transferred. There were 8 cases of metastatic tumor, 5 cases of hepatic hemangioma and 2 cases of focal nodular hyperplasia. The number of intrahepatic lesions was no statistical significance different in 3 groups (P>0. 05).

3.2. Noise and CNR analysis in three groups

C group image noise is the least, CNR is the most highest (P< 0.05). C group of noise decreased by 32.83% compared to group B, and it also was reduced by 10.37 % than group A (table 1, Figure 1).

Table 1. Comparison of image noise and CNR in three groups

Group	noise	CNR
A group	13. 21±3. 44	2. 51±1. 72
B group	18. 02±4. 03a	2. 46±1. 31
C group	11. 79±2. 53ab	3. 42±1. 82ab

Note: Compare with group A, aP<0.05, Compare with group B, bP<0.05.

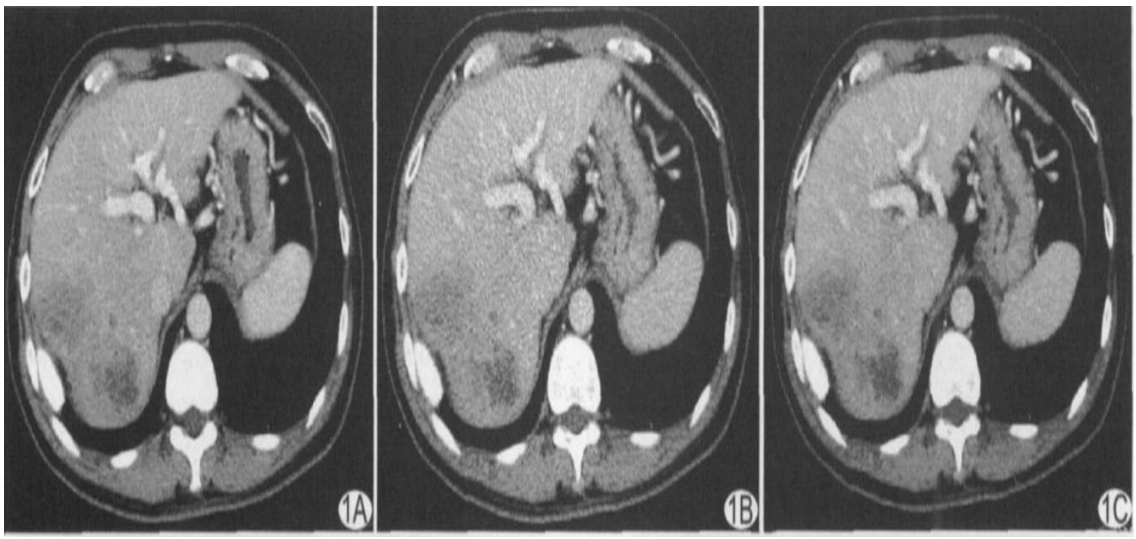

Figure 1. enhancement CT scan of liver carcinoma in the liver right lobe A. FBP reconstructed image; B. Low-dose scanning of FBP ; C. Low dose scanning of iDOSE reconstruction.

3.3. Reconstruction of image quality analysis of iDOSE^1-iDOSE^7

The image quality were best in iDOSE^{3}and iDOSE^4, but there were no significant difference of SNR and CNR values was found among iDOSE^2, iDOSE^3, iDOSE^4, iDOSE^6 and iDOSE^7 have lowest noise than the other (P<0.05), Table 2 and Figure 2.

Table 2. Comparison of subjective scores in group images

Group	CT Value	SD	SNR	CNR	Score
iDOSE[1]	60.44±7.23	9.55±1.23	6.55±1.26	1.26±0.54	2.88±0.54
iDOSE[2]	60.31±8.26	8.88±1.32	7.08±1.62	1.36±0.84	1.96±0.54
iDOSE[3]	60.41±7.85	8.06±1.37	7.69±1.52	1.44±0.84	1.55±0.65
iDOSE[4]	60.36±7.48	7.38±1.54	8.44±1.64	1.52±0.74	1.68±0.54
iDOSE[5]	60.07±5.66	6.66±1.22	9.38±2.54	1.69±1.33	2.33±0.58
iDOSE[6]	59.66±7.25	5.99±1.31	10.36±2.14	2.02±0.26	2.64±0.89
iDOSE[7]	58.96±8.26	4.97±1.05	11.26±2.54	2.47±0.47	2.88±0.47
F	16.33	12.84	22.36	18.65	21.36
P	0.001	0.001	0.001	0.001	0.001

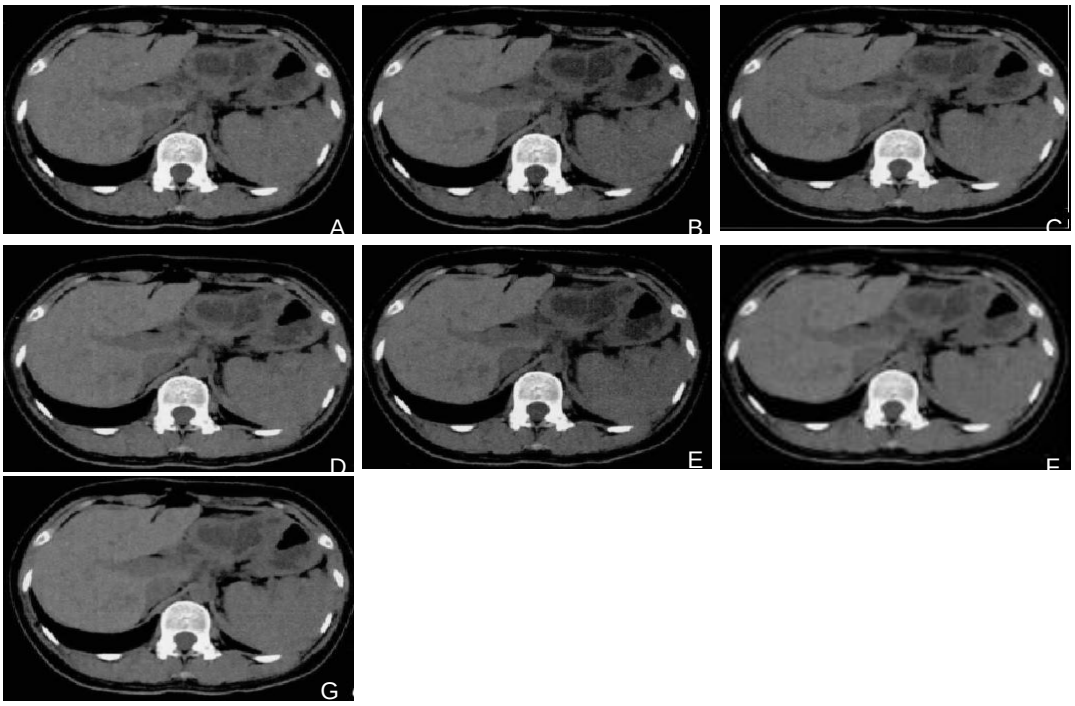

Figure 2. Reconstruction of image quality of iDOSE[1]-iDOSE[7] (A-G).

4. Discussion

With the in-depth study of low-dose CT, the research focuses on how to improve image reconstruction in recent years than the early stage of simple reduction of the scanning condition.Each manufacturer proposed their own image reconstruction technology, such as Philips, IDOSE, GE ASIR, Siemens eagle eye technology, etc. Its core is an iterative reconstruction of raw data to obtain acceptable image at lower doses.

The principle of iterative technology: start with a hypothetical premise and calculate the presupposition. The projection of the period image is compared with the actual projection, calculating the calibration coefficient and correct the hypothesis object. The object is then iterated through the new iteration until the final image is generated and then end the iterative process. Iterative algorithms can direct consistent or inconsistent data tried the noise model, and the noise was improved in the final reconstruction[5]. A mathematical model is used to selectively identify and remove image noise to make the graph noise reduction. Iterative reconstruction techniques for selective removal of noise can enables it to obtain a better image quality at a lower dose[6]. The scanning dose should be reduced appropriately and the iterative reconstruction could be applied in clinical diagnostic requirements for thoracic, abdominal and colonic CT images[7-9].Our study used a prospective study of self-control design to evaluate the low dose quantitative enhanced CT combined with iDOSE iterative reconstruction of liver tumors situation. IDOSE is a new generation of

IR algorithm characterized by double space, multi-noise model and anatomic model. There are used to describe and accurately describe the noise. At the same time, the anatomical model is adopted to accelerate the reconstruction process and improve image resolution, and maintain the image to be real, eliminate wax-like artifacts too. Our study showed that the image noise was reduced by about 32.83% with iDOSE iteration than low dose FBP reconstruction. And the image noise of FBP reconstructed image decreased by about 10.37 percent than the conventional dose-gate phase scan. The results of were simar to Flicek[10-12]. The research shows that IR algorithm can significantly reduce noise water. Reducing noise levels can improve the CNR of liver parenchyma. In our study, FBP There was no significant difference of CNR in low dose FBP reconstructed image and conventional dose, but the all of them were lower than Low dose scanning iDOSE reconstruction ($P<0.05$).

Limitations of this study: First, the application of ACS automatic low in routine scanning. The dose-scan technique dynamically adjusts the current of each scanning layer and fails to follow the body index to individualized scanning. It cannot the possible influence of body mass index on image quality[13-14]; Second, application of iDOSE reconstruction of the prototype, it cannot be evaluated on the computational speed of the technology. The reconstruction speed may have an impact on its clinical application[15]. Three, Only the radiation agent reduced by about 50%, the image quality is evaluated. To further reduce the radiation dose, we will evaluate the application of iDOSE iterative reconstruction technique in Lower the maximum limit of radiation dose.

5. Conclusion

To sum up, the application of iDOSE iterative reconstruction technique can be significantly reduced image noise and obtain better image quality in liver tumor .With the rapid development of computer technology and the development of various improved iterative algorithms. The IR algorithm will be better used in clinic.

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