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The Technical Study of 3DCT Reconstruction in Urological System

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Abstract: Objective To inquire into the technique of three dimensional (3D) reconstruction in spiral CT for urological diseases. **Methods** Retrospectively reviewed 54 cases successively underwent 3D reconstruction, in which contrast CT was performed in 46 cases by power or manual peripheral injection and received 50-100ml contrast media each. The examinatoin was performed on PQ 6000 spiral scanner and 3D reconstruction were obtained from voxel Q workstation. The scan parameters, timing of enhancement, pattern of 3D reconstruction, methods and skills in reconstruction were reviewed and analysed on by one. **Results** the scan parameters, dosage, form, timing of enhancement CT varies with different purposes. To learn the skills of reconstruction by a process of trial and find shaded surface display(SSD) and volume rendering (VR) technique showing vividly malformation, mass and stone of kidney. VR was more soft and SSD revealed strong stereoscopic effects. Maximum intensity projection (MIP) was very useful in CT urography and stenosis of renal artery. **Conclusions** To set a sensible scanning plan, mate properly scanning parameter and determine optimal timing of scanning plan, mate properly scanning parameter and determine optimal timing of scanning are all the important prerequisites for high quality 3D reconstruction in urological diseases. To grasp skillfully method and skill of 3D reconstruction is also a indispensable factor.

Keywords: spiral CT ; three dimensional reconstruction; urological system; scan parameter

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泌尿系疾病三维 CT 重建技术研究

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摘要：目的 探讨泌尿系疾病患螺旋 CT 三维重建技术。方法 回顾分析了 54 例成功进行了泌尿系螺旋 CT 三维重建的病例，其中 46 例使用了造影剂，扫描及重建分别在 PQ6000CT 机和工作站上进行，逐一分析各病例的扫描参数、扫描时间、三维重建类型、方法、技巧。结果 扫描参数、造影剂量等随检查目的不同而有所不同，重建技巧通过训练可以掌握，SSD 及 VR 技术能生动的显示肾的畸形、肿块和结石，最大密度投影法适合于 CT 尿路成像和肾动脉狭窄的显示。结论 设计合理的扫描计划、匹

配合适的参数、选择最佳扫描延迟时间,是获得泌尿系高质量三维重建图象的前提条件，熟练地掌握三维重建方法和技巧也是不可缺少的成功要素。

关键词：螺旋 CT；三维重建；泌尿系统；扫描参数

The method and skill of 3D reconstruction are more complicated in diagnosis of urological diseases than in that of osteoarticular diseases. Usually they are used to show stenosis of renal artery and a few in other aspects. We have successfully performed 3D reconstruction in 54cases with renal and ureteral diseases on PQ6000 spiral CT scanner since 1998. Following is the retrospective study of scan parameters and 3DCT reconstructional technique for obtaining better 3D images.

1 Materials and Methods

1.1 Patients

Stenosis of renal artery 7, renal malformation 15, renal stone 8, renal hydrops 3, renal cancer 9, renal pelvic cancer 5, ureterostenosis 3, injury of bladder and ureter 2, ureterolith 1, ureteral ploypi 1.

1.2 Methods

Onipique or 60%~70% compound meglumine diatrizoate 50~100ml was administered into a peripheral vein by power or manual injection in 46 cases. Images from PQ6000 spiral CT scanner were sent for 3D recostruction in voxel Q workstation with software of View-mode, Viewport and Packages. To summarize the method, the scan parameters, parameter mating, optimal contrast timing, reconstruction pattern were retrospectively studied one by one for optimization through statistics and analysis.

2 Results

The main scan parameters in 54 cases were shown in Tab 1. There is no statistical difference in virtual studies obtained with a pitch of 1.0 and 1.5 (p=1). Images with a 0%, 25% overlap of reconstructed slices are inferior to virtual images with a 75% slice overlap (p<001). There is little difference in a quality of virtual images produced by an 150, 175, and 200mA. respectively. For stenosis of renal artery 100ml contrast medium was administered by a power injector at a rate of 2.8~3.0ml/s and delayed time about 25s. For renal or ureteric stereoscopic image, the dose given by manual injection except two cases by power injector was 50~100ml . The dose was 50~70ml and delayed time 5~12minutes in CT urography. The statistics results indicated that 3D reconstruction images varied with different reconstruction patterns. Both SSD and VR images can show the size, shape and location of urinary bladder, ureter, kidney and renal mass stereoscopically (Fig1), especially good in showing renal malformation such as duplication of kidney, malrotation of kidney, horseshoe kidney (Fig2) and ectopia kidney (Fig3). It can also clearly show the number, size, shape and location of renal stones. The image of MIP was suitable for indicating the stenosis of renal artery, the therapeutic effect of internal and the presence of accessory renal artery. It can also show

the whole collecting system including the renal calyces, rencal pelvis, ureter and urinary bladder and observe if there is destruction, filling defect, dilation, stenosis or stone. Additionally, the best images could be obtained by skillfully using the workstation, properly cutting technique, carefully adjusting the CT threshold, contrast, brightness and gradient of the image, sensiblely using pseudocolour and rotating technique.

Tab 1 CT scan parameters in 54 cases

Kinds of disease`	Slice thickness (mm)	Reconstruction Interval(mm)	Pitch
Stenosis of renal artery	2, 3	1, 2	1.0
Renal tumor, stone	4	2	1.0, 1.5
Congenital malformation	4, 5	2, 3	1.5
CT urography	4, 5, 8	2, 3	1.5

3 Discussion

Spiral CT has become popular in a period of 10 years in clinical practice because of its advantages such as high speed and powerful function of post-processing. 3DCT reconstruction is one of the main functions of post-processing. Helped with computed software, a directly stereoxcopic image of organs can be reconstructed from the volume data.[1,2] In comparison with conventional 3D reconstruction, it not only can short the reconstructional time and reduce or eliminate step artifact or false image, but also can nearly show in real time. So the image is more figurative and stereoscopic.

3.1 Scan plan

A reasonable scanning plan is of prime importance for a high quality 3 dimensional reconstruction.

3.1.1 Patient preparation: Train them to hold breath and explain to him before handing for cooperation.

3.1.2 Program design and parameters selection

(1) scan length: Scan length varies according to the size of interesting area. In case of bilateral renal area or the whole urinary course examination, special attention must be paid in determination of the scan length for a satisfactory reconstruction result.

(2) thickness: Theoretically the thinner the thickness, the sharper the image and the less distortion, but it may limit the scan length and makes more CT tube damage at the scan time. We should take a thinner thickness in a narrow interested region or transverse structures such as the renal artery, usually less than 3mm. Brink also think that a optimal thickness is 2mm in the stenosis of renal artery.[3] While in broader area such as the CT urography or a longitudinal structure (kidney, ureter, abdominal aorta etc), scanning thickness should be increased and reconstruction interval keep narrow, usually less than 3mm. Meanwhile we found some imaging quality was not obviously

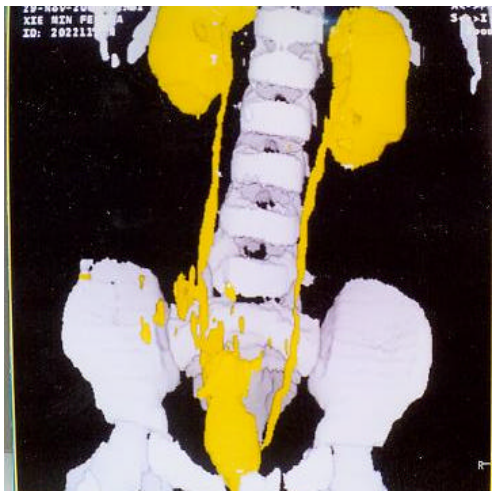

Fig1. 3DCT image showing multiple fractures of pelvis and extravasation of contrast medium due to injury of urinary bladder

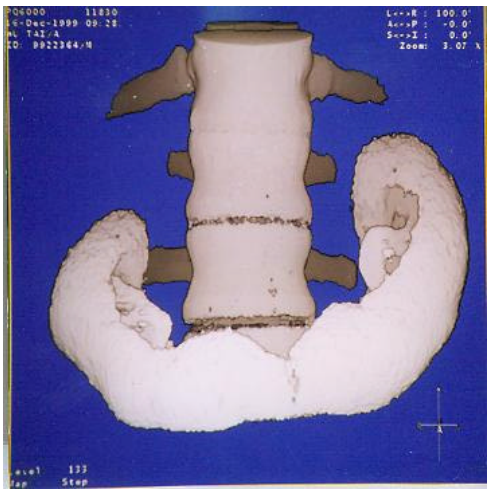

Fig2. 3Dimage of horseshoe kidney (slice thickness 5mm, reconstr. interval 3mm, pitch 1.5)

affected if a thicker slice and a thinner reconstruction interval were used at the same time..

(3) reconstruction interval: We can arbitrarily and retrospectively select interval with no increase in X-ray dosage. The narrower the interval, the more overlapping images, from which we can reconstructed the 3D images better. Generally speaking, a 50% or more than 50% overlap of reconstructed slices should be used. Some of our cases, employed 8mm thickness, thinner interval was crucial for better images. This also proved that a thinner internal not only improve longitudinal resolution of the image, but also do not increase X-ray dosage.[1,4,5]

Fig3. 3DCT (the colour SSD image, black-and-white VR image and colour VR image from the left side to right side) of fusional pelvic kidney associated with dissecting aneurysm of aorta. The spiral CT parameter is selected with slice thickness 8mm, reconstruction interval 2mm, Pitch 1.5

(4)Pitch: 1.0 for small interested region and pitch 1.5 for large region.

(5) kV, mA: The quality of 3D image was mainly determined by space resolution on axial image rather than density resolution, so lowering of kV, mA will be both beneficial to extend scan area and reduce CT tube load.

3.2 Selection of optimal timing for enhancement

To make sure the optimal timing of

enhancement and make a testing flash of contrast medium first and then proceed to scan according to the observed peak time in aorta.[6]

In renal stereoscopic reconstruction, CT scan can start immediately after a bolus injection. Delayed scanning is necessary in CT urography, usually more than 5 minutes. In hydronephrotic the time should be longer.

3.3 Reconstruction pattern

All kinds of reconstruction patterns can be used in urological 3D imaging, including SSD, VR and MIP. In order to demonstrate the actual state of urological structures and abnormality effectively, reconstruction pattern single or in combination can be used. SSD is suitable for showing stereoscopicly the shape of kidney, ureter and bladder. It is not as smooth as VR, but strengthen stereoscopic effect. MIP is more useful in demonstrating the renal artery and urinary system, so it is strongly indicated in the above imaging.[3]

3.4 Methods and skills in 3DCT reconstruction

3.4.1 Determining interested area

Naturally the interested area is confined to the urological system but sometimes some structures such as the spine and larger vessel are included for control without interruption. The reconstruction region should be as small as possible in three ways:

(1) Determining interested region on axial images with the key VOI at the beginning.
(2) Interested region drawn with the function of segmentation slice by slice.
(3) Unnecessary tissue and structure should be removed with volume sculpting technique on 3DCT image.

3.4.2 Editing

Image are edited according to different showing purposes. In SSD it is important to select the appropriate CT threshold value. As the threshold value is not fixed. It must be adjusted carefully according to the density of the tissue per se. When we use the technique of VR, first we should select suitable condition for showing the interested structures, then regulate it in detail. The technique of MIP is simple with Angio software. After the 3D image is acquired, we should also adjust carefully the threshold value, brightness, contrast and gradient of the image. To secure knowledge of the internal structure on a renal stereoscopic image, first one should regulate a suitable window width and window level, then use the technique of random cutting or window opening to facilitate observation from different directions. In addition, in order to make image more vivid, different tissue such as kidney, vessel, renal pelvis and background of image can be artificially coloured separately or all together according to requirements.

3.4.3 Image inspection

The stereoscopic image of kidney and collecting system can be observed from different angles by rotation. We can also observe the image along an arbitrary axis and store it one by one and show it in a film.

3.5 Clinical significance

3D reconstruction can stereoscopically demonstrate the morphology of renal artery, kidney, renal

stone and renal mass. It can also show vividly renal malformation such as malrotation of kidney, ectopia kidney,horseshoe kidney and duplication of kidney. CT urographic image can show renal pelvis, renal calyces, ureter and bladder. In a degree, it reflects secretory and excretory renal functions. There is promising prospect in showing urological stone, mass and stenosis.[7,8,9]

In a word, many factors such as careful preparatory work, a sensible plan, proper choosing and mating of scan parameters, a optimal timing of contrast are all essential in acquiring high quality 3D image. To grasp skillfully the reconstructional method and skill is also very essential factor to success.

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