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Perspective

A Perspective on Cardiac CT Imaging Technique

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Cardiovascular disease is a leading cause of morbidity and mortality in the world. Cardiovascular imaging technique is a key for cardiovascular disease diagnosis and treatment. In coronary imaging, the cardiac CT is of high spatial and temporal resolution. Compared with other medical imaging modality, the cardiac CT has a unique advantage in coronary stenosis detection, plaque assessment and stent visualization [1]. Currently, cardiac CT has been widely applied clinically and play important role in cardiovascular disease diagnosis and treatment.

In cardiac imaging, the imaging technique with the high spatial and temporal resolution is required, considering that the heart is in faster motion and the coronary is tortuous and thin. For example, the LAD (left anterior descending) proximal segment of coronary is 3.5mm and distal segment of coronary is only 0.8mm. A fine isotropic spatial resolution is demanded. For coronary imaging, the ideal spatial resolution should be less than 0.3mm. Temporal resolution is equally important parameter in cardiovascular imaging due to heart motion. For ideal coronary imaging, the temporal resolution should be 40ms. Especially, the temporal resolution should be 8ms in vessel spasm. For achieving high temporal resolution, the CT gantry rotational velocity should be faster than 0.2s/rot (rotation). The gantry centrifugal force is then nearly 75G at 0.2s/rot and the gantry will bear huge mechanic force. The overcoming of the huge impact becomes a challenging technique for cardiac CT.

At early stage of CT application, the CT scanning was very slow and was not appropriate to cardiac imaging. With CT progress of geometry and scanning mode, the performance of cardiac CT is significantly improved. In CT scanning mode development, there are several important stages to improve scanning velocity. First, the slip ring technique was introduced to supply the power and capture data. Second, helical scan mode are employed in 1990. Third, the multi-row detector is applied. Nowadays, dual-sources CT has been developed. These techniques dramatically enhance the CT imaging performance and make cardiovascular imaging become feasible. Currently, the 64 slices CT with a fraction of second rotated velocity is widely applied in cardiac imaging. For slower scanning velocity (0.5s/rot), 1-4 heart cycles are taken to obtain enough projection data. ECG gating technique is usually introduced to choose the same heart phase in different heart cycle and the projection data is then captured in multi-heart cycles [2-3]. In this mode, the data is from different heart cycle. The imaging peroid is decreased in each heart cycle and the temporal resolution is equivalently improved. However, the cardiovascular image is degraded at high or irregular heart rate. Essentially, the most effective mode for improving the temporal resolution is to increase the scanning velocity. At present, the fasted cardiac CT scanning velocity reaches 0.27s/rot. For a higher temporal resolution, the scanning velocity and scanning coverage should be increased further. The dual-sources CT with two tubes at 90 degree was utilized clinically [4]. Siemens CT Temporal resolution is about 83ms. The Toshiba CT has 320 row detectors. The scanning coverage is 16cm to cover entire heart in one scanning [5]. Besides, dual-energy CT is emerging as an advanced imaging technique, which has become one of the forefronts in the recent CT technology. It can increase the amount of information about the tissue by applying X-rays at two different energies. The dual-energy CT was applied in cardiac CT. This technique reduces the dose and improves contrast resolution. The coronary plaque can be clearly discriminated. These techniques have made CT become the most important imaging mode in cardiovascular diagnosis.

The CT image reconstruction and processing are equally important technique in cardiovascular imaging. The CT image reconstruction algorithm has made a great progress with the development of CT hardware. Traditional CT image reconstruction methods are usually filtered back projection and iterative algorithm. The filtered back projection algorithm is an effective analytical method which is widely used commercially. The iterative reconstruction algorithm is more general reconstruction algorithm. Iterative reconstruction algorithm with motion compensation are less sensitive to noise and missing data as it occurs in the cardiac application due to ECG gating [6,7]. Statistical iterative reconstruction algorithm is an effective iterative reconstruction algorithm in cardiac CT image. The disadvantage of iterative algorithm is complex computation. For the larger cone-beam of cardiac CT, the image artifact is severe. The dedicated cone-beam cardiac CT reconstruction algorithm is required. These algorithms include modified 3D filtered back projection algorithm and Katsevich algorithm to overcome the artifact of image in larger cone-beam angle [8]. Recently, the compressed sensing theory has been popular in cardiac CT image reconstruction. Compressed sensing theory show that a high-quality cardiac CT image can be reconstructed from far fewer data than what is usually considered necessary according to the Nyquist sampling theory. The compressed sensing reconstruction methods based total variation and dictionary learning are applied in cardiac CT image reconstruction [9,10]. These novel algorithms are especially appropriate to cardiac CT image reconstruction in preserving image detail and suppressing the noise. Beside, the dedicated cardiovascular image processing software image has been developed. The trend of cardiovascular image processing will be more precise and more efficient.

In future, cardiac CT technology will extend current development. The scanning velocity will be increased and larger detector arrays may be employed. Faster rotation times and broader detector arrays will lead to much shorter acquisition time, resulting in high spatial temporal resolution.4D cardiac CT may become possible in the future. On other hand, the CT gantry is too heavy to increase scanning velocity further owing to technology limitation. The image distortion will be severe with larger detector arrays. Recently, the adaptive scanning technique is gradually focused on to improve cardiac CT image quality [11,12]. In multi heart cycle mode, the scanning velocity is varied with heart rate. The image quality can be improved at higher heart rate or irregular heart rate. The heart rate adaptive gantry variable velocity scanning may be available which, in combination with a non linear table movement, could lead to an reduce dose usage and increase temporal resolution at slow velocity. The adaptive scanning mode may open up a new cardiac imaging mode.

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REFERENCES

1. Sun Z, Davidson R, Lin CH. Multi-detector row CT angiography in the assessment of coronary in-stent restenosis: a systematic review. Eur J Radiol. 2009; 69: 489-495.
2. Bahner M, Boesel. Retrospectively ECG gated spiral CT of the heart and lung. European Radiology. 1999; 9: 106-109.
3. Kachelriess M, Ulzheimer S, Kalender WA. ECG-correlated image reconstruction from subsecond multi-slice spiral CT scans of the heart. Med Phys. 2000; 27: 1881-1902.
4. Petersilka M, Bruder H, Krauss B, Stierstorfer K, Flohr TG. Technical principles of dual source CT. Eur J Radiol. 2008; 68: 362-368.
5. Tabibian B, Roach CJ, Hanson EH, Wynn BL, Orrison WW Jr. Clinical indications and utilization of 320-detector row CT in 2500 outpatients. Comput Med Imaging Graph. 2011; 35: 266-274.
6. Nielsen T, Manzke R, Proksa R, Grass M. Cardiac cone-beam CT volume reconstruction using ART. Med Phys. 2005; 32: 851-860.
7. Rit S, Sarrut D, Desbat L. Comparison of analytic and algebraic methods for motion-compensated cone-beam CT reconstruction of the thorax. IEEE Trans Med Imaging. 2009; 28: 1513-1525.
8. Wang G, Zhao S, Heuscher D. A knowledge-based cone-beam x-ray CT algorithm for dynamic volumetric cardiac imaging. Med Phys. 2002; 29: 1807-1822.
9. Yu H, Wang G. A soft-threshold filtering approach for reconstruction from a limited number of projections. Phys Med Biol. 2010; 55: 3905-3916.
10. Guang-Hong Chen, Jie Tang. Prior Image Constrained Compressed Sensing (PICCS) and Applications in X-ray Computed Tomography. Med Phys. 2008; 35: 660-663.
11. Barrett HH, Furenlid LR, Freed M, Hesterman JY, Kupinski MA, Clarkson E, et al. Adaptive SPECT. IEEE Trans Med Imaging. 2008; 27: 775-788.
12. Liu J, Wang K, Xu H. The ideal variable velocity scanning mode in cardiac computed tomographic imaging. J Comput Assist Tomogr. 2013; 37: 306-310.

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