

Slice Wars vs Dose Wars in Multiple-Row Detector CT

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QUESTION:

Are we seeing the end of the slice wars and the beginning of the dose wars in multiple-row detector computed tomography?

ANSWER:

The short answer is yes. At this point in time, it seems that the so-called slice wars with regard to the number of slices provided per computed tomographic (CT) gantry rotation may be reaching a plateau. At the same time, increasing concerns about radiation dose due to CT examinations are fueling the efforts to reduce radiation dose and leading to the beginning of the so-called dose wars.

Since 1998, there have been evolutionary advances in multiple-row detector computed tomographic (MDCT) technologies, with demand for improved spatial and temporal resolution and 3-D imaging. This has led to rapid competition among manufacturers as to who can provide the MDCT scanner that yields the highest number of slices per CT gantry rotation. The slice wars can be traced back to the first 4-slice MDCT scanner that became commercially available and clinically adopted. For the past 10 years, the number of CT slices that can be obtained per CT gantry rotation has been increasing. It went from 4 to 16 to 64 to 256 and now to 320 slices. One of the intended goals of the generational evolution in MDCT imaging has been to image the most challenging organ, the heart. Cardiac imaging, to a large extent, seems to be the determining

force behind the slice wars. However, the increasing number of slices and the increasing complexity in the performance of cardiac CT imaging has led to the development of protocols that can yield high radiation dose (expressed in terms of "effective dose"). In general, the demand for shorter scan times (high temporal resolution) and thinner slices (high spatial resolution) requires higher tube current to maintain good image quality. In addition, in certain cardiac CT protocols (retrospective electrocardiographically gated), excessive tissue overlaps (low pitch) are required to ensure that the entire region is captured during helical scanning. The combination of these factors leads to higher patient doses in certain cardiac CT protocols.

What has prompted the discussion regarding the end of the slice wars? Now that MDCT scanners have the capability to scan the entire heart or brain in 3 to 5 gantry rotations (with most 64-row detector scanners) or in a single rotation (as in 256-row detector or 320-row detector scanners), it is reasonable to expect the end of the slice wars. Even though technologies such as flat-panel detectors are capable of scanning larger areas (such as the entire chest or abdomen and pelvis), these technologies remain works in progress. The issues of high radiation dose, increased scatter radiation, and other aspects will need to be resolved before such technologies become clinically viable. At the same time, the demand for such technology may not be as urgent compared with the demand

for scanning the entire heart or brain.

Now that the ability to scan an entire organ such as the heart or brain exists, it seems the efforts have moved toward lowering radiation dose in MDCT protocols without compromising image quality.

The number of CT examinations performed in the United States has been growing at a rate of approximately 10% for the past 10 years, with nearly 67 million procedures performed in 2006 alone [1]. Among the installed CT scanners in the United States, nearly 80% are MDCT scanners. The apparent increase in the number of CT procedures and the growth in protocols that can yield high radiation dose is drawing more attention to the overall radiation burden to the population from medical radiation exposure [2]. The increase in media attention regarding the radiation dose from CT procedures is leading to the beginning of the dose wars among CT manufacturers and users alike.

Although cardiac CT imaging is capable of imaging the most rapidly moving organ, it unfortunately has the possibility of yielding a very high radiation dose. Coronary CT angiography is the best example to represent the argument that the dose wars have begun in computed tomography. Coronary CT angiography, normally performed in retrospective electrocardiographic mode, requires high tube current and excessive tissue overlap, which leads to increased levels of radiation dose. The effective dose can be as

high as 15 to 20 mSv (10 mSv = 1 rem) [3]. In addition, if one considers that a patient undergoing CT angiography also gets additional scans, such as calcium-scoring scans and bolus-tracking scans (10 to 20 single-slice scans to track contrast, depending on a variety of factors, including patient physiology and technologist experience), these can result in a radiation dose (effective dose) on the order of 20 to 25 mSv. Therefore, radiation dose has become a prime concern with MDCT scans, which is paving the way to the beginning of the dose wars.

Many efforts are under way to improve radiation dose in CT imaging. Some examples are as follows:

1. Prospective electrocardiographically triggered coronary CT angiography can yield radiation doses similar in magnitude to those used in fluoroscopically guided diagnostic catheterization procedures. The advantage of prospectively gated CT angiographic protocols is that the data are acquired only during a certain part of the RR cycle and with the least amount of tissue overlap (axial imaging and no pitch), reducing the dose of radiation significantly from 12 to 18 mSv (in retrospective electrocardiographically gated protocols) to 3 to 7 mSv [4,5].
2. Dual-source CT scanners with electrocardiographically controlled dose modulation can yield a radiation dose on the order of 3 to 7 mSv for coronary CT an-

giography with high temporal resolution (<100 ms) [6].

3. Newly introduced 320-row MDCT scanners with scan coverage of 160 mm provide an opportunity to cover the entire heart in a single gantry rotation and therefore can yield a radiation dose of 3 to 7 mSv.

The preconditions for most cardiac CT imaging protocols mentioned above are careful patient selection (heart rate < 70 beats/min) and the careful monitoring of system performance to ensure the complete acquisition of data for the desired region. In addition, dose modulation techniques available on 16-slice and 64-slice scanners have vastly improved in terms of reducing patient dose during routine CT protocols.

The efforts made by CT manufacturers that are contributing to the dose wars may seem altruistic in nature, but to a large extent, they are among the salient objectives in selling scanners. Because of the demand to lower radiation doses, CT scanner manufacturers are making efforts to develop various strategies to reduce radiation dose by improving dose modulation techniques, making hardware improvements such as adding additional beam filters, improving detector dose efficiency, developing protocols that do not overlap excessively (prospective triggering), and developing reconstruction algorithms that can accommodate lower tube current, thereby creating the possibility to lower radiation doses.

Even though the meaning of word *war* is strong, it is a welcome change to see the beginning of the dose wars, because they will benefit all interested parties (ie, patients, users developing new clinical CT protocols, and manufacturers developing new CT technologies). The picture is not all rosy, however; now that it is possible to acquire CT images very quickly, and some at low doses, there seems to be a growing trend of additional scans being tagged to existing protocols. The use of protocols such as CT perfusion and cardiac wall function scanning is beginning to increase. This increase may lead to scan wars in the very near future.

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