REDUCTION OF RADIATION DOSE FOR PEDIATRIC PATIENTS IN COMPUTED TOMOGRAPHY

With the latest advances in radiology technology, new CT machines now offer more rapid and sophisticated patient scanning, hence better image quality and lesser radiation exposure to the patient. However, acquiring the latest technologies does have its drawbacks. Due to the more complex capabilities of these high-end CT scans, not only has it greatly expanded the utility of CT but the usage has also correspondingly increased. The radiation effects on children cells are cumulative and radiation-related risk increases with each dose. Remember that children are not small adults and have quite different imaging needs. Here are some of the practical ways to reduce radiation dose for the pediatric patient.

BEAM ENERGY

The X-ray tube potential (kVp) is selected when setting up the scan protocol and determines the x-ray photon energy. Decreasing kVp in children can reduce the radiation dose and may improve soft tissue contrast. A lower dose scan may also be more adequate for follow-up studies such as for ventriculoperitoneal shunt evaluation.

Factors to take into account when lowering the kVp:

1. The milliAmpere-second (mAs) will likely have to be increased to keep noise levels constant
2. Weight- or size-based kVp/mAs/dose technique chart should be used to determine when a lower kVp is appropriate
3. A lower kVp may require longer scan times because of mAs limits that can increase motion artifacts
4. A lower kVp may increase iodine conspicuity but not necessarily improve other soft tissue contrast.

TUBE CURRENT

The tube current determines the number of electrons accelerated across the x-ray tube and, thus, the number of x-rays produced. Hence, if there is increase in tube current, it follows that there will also be increase in dose. Adjusting mAs for patient body size can offer a potentially significant reduction in radiation dose.

PITCH

During scanning, the table moves through the gantry either in a continuous mode for helical scanning or in a step-and-shoot mode for axial scanning. The scan pitch is the ratio of the table feed per table gantry rotation divided by the beam width. Hence, the dose is inversely proportional to the pitch. This is actually true for older CT scanners especially in single-slice CT scans. Modern scanners using automatic exposure control, patient dose and image noise are not affected by pitch.

Nevertheless, with a pitch greater than one, the table travels more than the width of the beam giving a faster scan and lower radiation. This is said to be recommended for pediatric patients. With a pitch less than one, the table travels less than the width of the beam where there will be overlapping of the beam, increasing radiation exposure. These changes do not occur when the pitch is equal to one.

OVER-RANGING

Over-ranging refers to the part of the scan that does not include a complete rotation at a given slice location. This extension of scan length is a side effect of the data interpolation needed to reconstruct sections in helical CT. It does not generate image beyond the planned section length but it does increase radiation dose. The dose from helical over-ranging is far greater for children than for adults and typically occurs at the end of the acquisition.

Generally, it is better to perform a single helical scan acquisition rather than multiple scans. A large aperture has significant excess dose at the ends of the acquisition and is not recommended unless a long acquisition is used, in which case the scan will complete more rapidly with a larger aperture. A short scan range will obtain dose-reduction benefits if a smaller aperture is used, because it will reduce overscan excess radiation dose.

The over-ranging could also be avoided by changing the scanning protocol from helical to axial mode. Short scan range may also reduce overscan excess radiation dose. Those who uses third generation CT scanners may use dynamic collimator which actually blocks overhanging by 50%. These collimator blades open and close at the start and end of the scans.

SCAN PHASES

The number of scan phases refers to the number of times the same patient anatomy is radiated, such as might occur in a multiphase liver study or a brain perfusion scan. Multiphase scans significantly increase the dose to an organ. For example, a CT perfusion of the head study warrants multiple acquisitions of the same anatomy. This can be useful to produce intensity time distributions for a contrast material. However, that portion of anatomy scanned multiple times receives a significantly higher dose, and, therefore, scan protocol optimization is essential. It is advised that the use of multiphase CT scanning in children should be limited to absolute necessity.

TUBE CURRENT MODULATION

Scanner dose control with automatic tube current modulation uses localizer images to adjust the mAs based on patient anatomy. The mAs modulation will decrease CT radiation dose for smaller patients, it will increase for larger patients. Incorporation of angular tube current modulation can further reduce mA depending on patient dimension. Combining these both results in optimum mAs reduction using both rotation and also longitudinal position.

It is important to position the patient at the center of rotation to maximize the tube current modulation. When the patient is located below the center rotation, the anterior-posterior (AP) projection localizer image will appear to show a smaller patient, leading to a reduction in mAs and possibly poor image quality. Conversely, if the patient is located above the center of rotation, the AP projection localizer image will appear to show a larger patient, leading to an increase in mAs and dose.

JUSTIFICATION

The benefits of doing the CT scan must always outweigh the risks of radiation exposure. One should also consider other imaging modalities that do not use ionizing radiation such as ultrasound and MRI. If the request does not meet the standard indication for a CT scan, please speak to the referring physician. It will then be decided what test is needed or if ever, no test would be needed at all. Remember, unnecessary CT scan that are cancelled gives zero radiation to the patient. This is the easiest and most important step in reducing overall radiation exposure.

References:

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