RADIATION PROTECTION OF PATIENTS DURING CT FLUOROSCOPY

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Abstract

CT fluoroscopy provides pseudo real-time cross sectional imaging and has been used in our clinic for biopsies, drainage and pain control. In the fluoroscopic configuration the radiologist stands in the room adjacent to the table as in conventional angiography. Because of concerns regarding patient doses, measurements were made to estimate doses.

Effective doses were calculated using the method of Huda and the data of NRPB. It was found that as far as the patient is concerned, two minutes of CT Fluoroscopy gave a similar effective dose as a standard abdomen CT exam. As in other CT scanners, the scattered dose decreases rapidly away from the radiation plane and is 1 mGy per minute at 10 from the image plane.

1. CT Fluoroscopy/Background

Our existing CT Scanner (Toshiba Express SX) can be used for fluoroscopic CT. In this pseudo real-time mode eight 512x512 frames are displayed per second. For each progressive frame only one eighth of the data (or 45^0) is changed. All the other back projections remain the same facilitating fast computation. The scanner can operate up to 50 mA for a fluoroscopy time of 120 seconds. The fluoroscopy system appears just as a normal angiography suite with a footswitch and video monitor in the room. When the scanner was first installed we carried out some measurements to look at staff and patient doses. Only patient doses are reported here.

2. Methods

Measurements were performed with the standard 32 cm diameter cylindrical acrylic dosimetry phantom, using a Radcal model 9010 dosimeter with a uniform response 10 cm CT chamber (model 20X5-10.3CT). Scatter measurements were made with a Keithley 36150 radiation survey meter. Because the surface dose changes in the phantom on a cyclic basis because of tube rotation, most measurements were made in the integral mode of operation.

3. Calculation of effective dose

There are two basic ways to approach the calculation of effective dose in CT. One is to estimate from actual CT scans the percentage volume of an organ irradiated to give average organ doses, and using doses from phantom measurements and tissue weighting factors arrive at E. This is extremely time consuming, so most efforts have been directed at computational methods using Monte Carlo techniques. Here average organ doses are estimated using a mathematical model of the body. The NRPB(National Radiological Protection Board, Oxford, UK) have been one of the groups involved in this and have published their data [1,2].

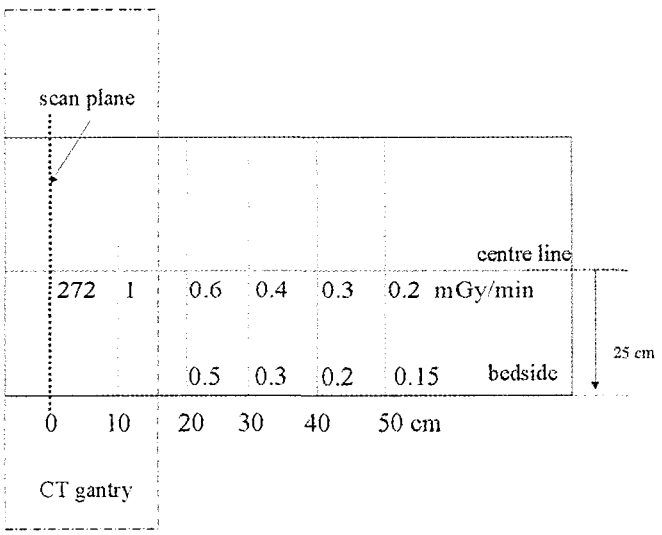
Dr Walter Huda and his colleagues at New York State University have built upon the work of NRPB to provide conversion factors from CTDI measurements [3-6], which are more commonly used by manufacturers to describe scanner performance. Over the thorax and abdomen the conversion factor from imparted energy to effective dose varies from about 15 to

23 mSv per J^5(The author suggest an average value of about 18). Because of this relatively small variation, given the many assumptions we make to calculate any human effective dose, it is straightforward to pro rate the effective dose for different slice sequences.

4. Patient dose

Measurements made in the acrylic phantom were converted to patient effective dose by calculation of energy imparted to the phantom. For normal single slice operation of the CT scanner for the abdomen at 120 kVp and 200 mAs and the effective dose was 0.24 mSv per cm slice. For fluoroscopic operation of the CT scanner for the abdomen at 120 kVp and 50 mA and 1 cm slice thickness the effective dose was 3.56 mSv per minute. Two minutes of CT fluoroscopy therefore gives an effective dose similar to a standard abdomen CT exam.

5. Radiation scatter



The radiation scatter was measured under the same scan conditions as for fluoroscopic CT described above. Because of the highly collimated narrow x-ray beam, the scattered radiation decreases rapidly outside the actual beam. At 10 cm from the beam plane on the surface of the phantom the air kerma dose rate has dropped to 1 mGy per minute(272 mGy per minute in the beam).

6. Clinical uses

For us the major uses so far for CT fluoroscopy have been 1.Biopsies: probably the most commonly used application 2. Drainage: Abscesses mostly, and again main advantage over US is visualizing the fluid collection deep in abdomen/pelvis, and ensuring safe pathway to access collection via percutaneous route (avoiding bowel, major vessels etc.), and 3. Much less commonly, injection of structures such as celiac plexus for pain control.

7. Future fluoroscopic CT

Several manufacturers have shown prototype multislice scanners which are capable of fluoroscopic use [7], and which we be available in the next 24 months. In general these are multislice scanners with slice thicknesses of less than 1 cm. As the effective dose increases as

the slice thickness decreases in order to counteract the reduction in data, procedural doses are likely to be in excess of current CT doses.

References

[1] NRPB Report R249 Survey of CT Practice: Dosimetric Aspects 1991.
[2] NRPB Report R250 Survey of CT Practice: Normalised Organ Doses 1991).
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[4] Huda W and Atherton JV Energy Imparted in Computed Tomography Medical Physics 1995:22: 1263-1269.
[5] Atherton JV and Huda W Energy Imparted and Effective Dose in CT Medical Physics 1996 23:735-741.
[6] Huda W Atherton JV et al Estimation of Effective Dose in CT of Pediatric Patients Radiology 1997 203:417-422).
[7] Radiological Society of North America 86th Scientific Assembly and Annual Meeting, Chicago, Illinois, November 26th 2000.

Topical Session 3

RADIOLOGICAL PROTECTION IN INTERVENTIONAL RADIOLOGY, INCLUDING FLUOROSCOPY NOT CARRIED OUT BY RADIOLOGISTS