PHYSICIAN AND PATIENT RADIATION DOSE IN VARIOUS CT GUIDED BIOPSY PROTOCOLS

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1. ABSTRACT

CT guided biopsies may generally be performed according to three different procedures; standard CT guidance, real- time CT fluoroscopy guidance, or incremental needle insertion with intermittent short CT fluoroscopy "flashs" to check for needle tip location. The dose to the operator is highly dependent on the working technique, the selected exposure parameters and the use of protecting devices. When real time guidance is judged as justified, use of a lead protecting cover on the patient positioned close to the scan plane will reduce the dose to operator significantly.

2. INTRODUCTION

CT fluoroscopy is a very useful modality for performing interventional procedures such as complex biopsy and drainage. However, there is a potential to deliver considerable radiation doses both to the patient and the operator. Fluoroscopy times of more than 500 s from one procedure were reported after the introduction of the real time CT [1]. The entire dose is imparted on the same area of the patient skin, which means the skin dose may approach the magnitude of Gy. ICRP's estimated threshold for skin erythema is in the range 3 to 5 Gy [2]. Furthermore, measurements of dose to the operators finger shows potential doses of more than 300 mGy from a single procedure, which should be compared with the ICRP dose limit of 500 mGy per year. The various commercial CT fluoroscopy systems on the marked, are shown on Impacts website http://www.impactscan.org/ctfluoro.htm [3]. Three of these CT fluoroscopy systems are now represented in Norway: GE Hispeed CT/i with "Smart view", Siemens Somatom Plus 4 with "Care vision", and Marconi PQ Series with "Continuous CT", providing patient skin dose rates from 4.7 to 7.0 mGy/s during fluoroscopy. The aim of our study was to measure radiation dose to both the operator and the patient during CT-guided biopsies, using various clinical protocols, and appropriate radiation protection measures. In order to gain experience and confirm results from similar studies [4, 5], an experimental phantom study was also performed.

3. MATERIALS AND METHOD

About sixty patients from two hospitals undergoing lung or bone biopsies were included in the clinical survey. One of the hospitals was using real time techniques; the other was intervening outside the gantry. The scan parameters were noted for each patient both for the preparatory CT exam as well as for the CT fluoroscopy series, together with the corresponding values of weighted CT dose index and dose length product. Two thermoluminescence dosimeters (TLD100 LiF, Harshaw, Bicron, NE) were placed on the operator' s glabella, and three or five 1 cm interspaced TLD's were positioned on the patients skin along the z-axis, centred in the biopsy plane. The operator was also supplied with bilateral finger ring dosimeters (Figure 1). In addition, the scattered radiation around the gantry was measured in various distances from isocentre with a Torso Alderson phantom as "patient", with scan plan centred through heart and lungs between vertebra Th 7 and Th 8 (Figure 2). The CT dose index on patient entrance was measured with a calibrated 10 cm ionisation chamber (Radcal Corp., Monrovia). The dose to the operator was measured in various distances from the scan plane with and without lead protecting covering on top of the phantom, both with ionisation chamber (Capintec inc., Montvale, NJ), and with ring dosimeters placed on a ISO-finger phantom (draft, ISO/TC85/SC2/WG7). A protecting glove was also tested (Radiaxon Radiation protective, WRP, Malaysia).

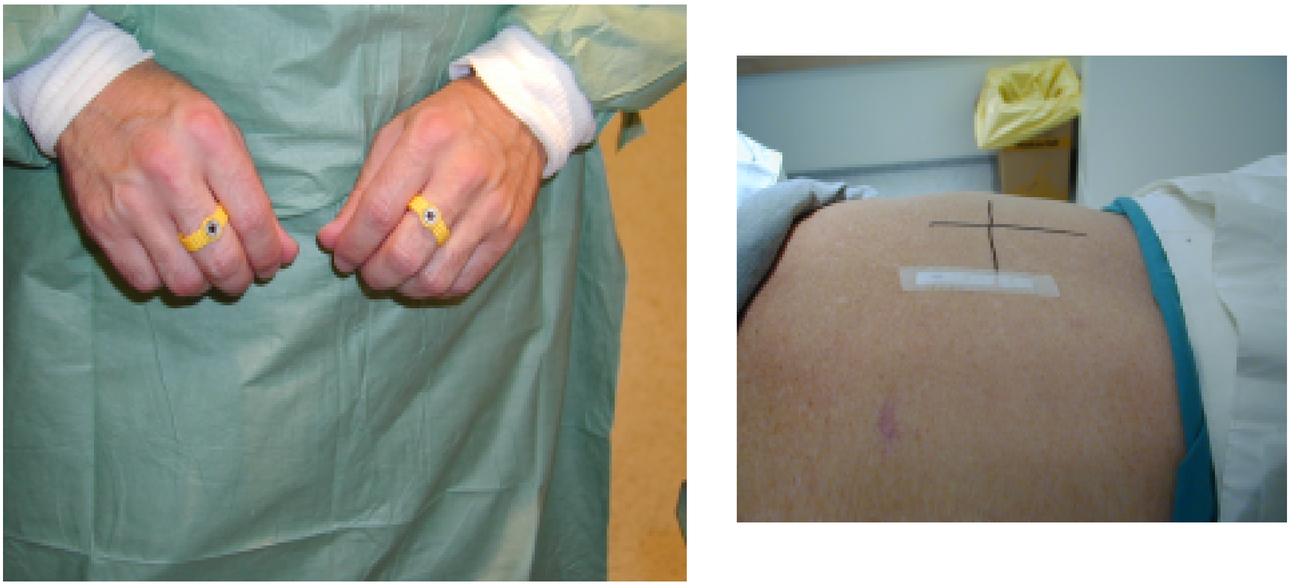

Figure 1: Measurements of the dose to the operator fingers and to the patients skin during CT biopsies

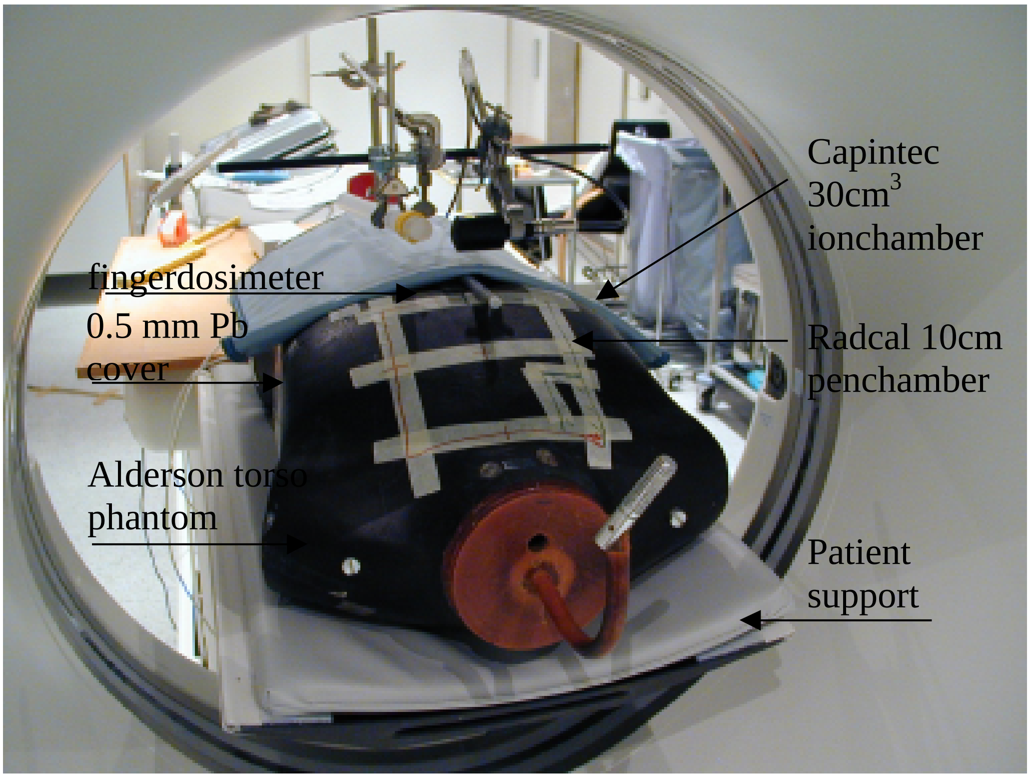

Figure 2: Experimental set up for measuring scattered radiation in various distances from the scan plane and $CTDI_{10cm}$ at patient entrance during real time biopsy of lung lesions

4. **RESULTS**

The results from 18 real time biopsy procedures show that the doses to the operator's right hand fingers were 54±93 (0 – 350) mGy (mean±sd, range), while the doses to glabella were 0.2±0.1 (0.1 – 0.4) mGy. The maximum patient skin doses measured with TLD were 131±148 (11 – 623) mGy. For biopsies performed outside the gantry with short CT fluoroscopy "flashes" to check for needle tip location (39 patients), the doses to the operator's fingers were in most cases < 10 μGy, as were the doses to operator's glabella. In this hospital the maximum patient skin doses from the fluoroscopy were 39.4±54.6 (4.4 - 270.3) mGy, thus significantly lower compared to the other hospital, owing the use of lower tube current (10 – 30 mA instead of 50 mA) [6].

We found from phantom measurements that a lead cover (0.5 mm Pb eq.) put on the patient's stomach adjacent to the scan plane reduced the scattered radiation in 10 cm distance with more than 80% due to that scattered radiation from patient was stopped (Table 1 and 2). The lead cover had less effect closer to the scan plane, and some differences were found between the ionisation chamber measurements and the TLD measurements, probably due to differences in what the dose meters could "see" of the radiation beam. The protection gloves we tested were less effective.

Distance from scan plane (cm):	Dose in air without lead protecting cover on patient (_Gy/ 10 mA 60 sec):	Dose in air with lead protecting cover on patient (_Gy/10 mA 60 sek):	Percentage dose reduction from scattered radiation (%):
5	396	400	0
10	167	14	91,6
20	45	4	91,1
30	15		
40	8		
60	3		

Table 1: Doses from scattered radiation in various distances from the scan plane normalised to the exposure parameters (GE Highspeed/"smart view" at 120 kV 10 mA 60 sec) measured with a 30 cm^3 ionisation chamber (Capintec inc., Montvale, NJ) positioned 5 cm above the phantom with or without a lead protecting cover (0,5 mm Pb eq.) placed on the top of the "patient" 2.5 cm from the scan-plane.

Distance from scan plane (cm):	Dose on ISO-finger without lead protecting cover on patient (_Gy/10 mA 60 sec):	Dose on ISO-finger with lead protecting cover on patient (_Gy/10 mA 60 sec)	Dose on ISO-finger protected with glove, without lead protecting cover on patient (_Gy/10 mA 60 sec)
5	523	392 (25,0 %)	401 (23,3 %)
10	225	38 (83,1 %)	182 (19,0 %)
30	18		

Table 2: Doses from scattered radiation in various distances from the scan plane normalised to the exposure parameters (GE Highspeed/"smart view" at 120 kV 10 mA 60 sec) measured with two finger dosimeters (TLD100 LiF, Harshaw, Bicron, NE) positioned 5 cm above the phantom with or without a lead protecting cover (0,5 mm Pb eq.) placed on the top of the "patient" 2.5 cm from the scan-plane, with or without a thin protecting glove (Radiaxon Radiation protective, WRP, Malaysia). The figures in parentheses are the calculated percentage of dose reduction.

5. DISCUSSION AND CONCLUSION

Situation of the problem: Due to its obvious clinical benefits, the range of applications of real time CT fluoroscopy is likely to rise, as will the potential for high skin and body doses to both operator and patient. Measures to reduce the doses should therefore be carefully considered before introducing the imaging modality into clinical use in a hospital.

Achieved results and optimisation of the procedure: Limiting the use of CT fluoroscopy to check for needle position (i. e. performing the intervention outside the gantry) particularly minimised the doses to the operator's fingers, and should be the recommended technique. Use of tube currents in the range of 10–30 mA gave significantly lower patient skin doses than previously reported, but still provided sufficient image quality during fluoroscopy in order to control the different steps of the procedure.

Devices to reduce doses and quantification of the efficiency of that optimisation: In real-time CT guidance a lead protecting cover positioned close to the scan plane on the patient's entrance reduced scattered radiation to the operator with more than 90%. The thin gloves tested in the study were almost useless, but there may be others on the marked. As a summary, a practical memo list of ten points is suggested concerning radiation protection in CT guided intervention:

TEN RADIATION PROTECTION RULES CONCERNING RADIOLOGICAL GUIDED BIOPSY

1. **JUSTIFICATION.** Consider clinical indication. Unless you need to biopsy through air-filled cavities or bone, use ultrasound guided as the first option.
2. **WORKING TECHNIQUE.** Consider incremental needle insertion outside the gantry with intermittent short CT fluoroscopy "flashs" to check for needle tip location instead of real time intervention.
3. **KEEP THE FINGERS OUT OF THE PRIMARY BEAM.** The dose rate in the primary beam is more than 100 times higher then the dose rate only 1-2 cm beside. In case of real time intervention consider the use of needle holders to decrease the dose to the fingers.
4. **DISTANCE.** The scattered radiation from the patient increase inversely proportional with the square of the distance. Consider which personnel groups need to be present in the laboratory and the positioning of them relative to the patient.
5. **EXPOSURE PARAMETERS.** Consider the necessary image quality (image noise). The tube current suggested by the manufacturer can most certainly be reduced without loss of information content (the images are only used for orientation purposes, not diagnosis).
6. **RESTRICT THE EXPOSURE TIME.** The foot pedal is not a coach for the foot...
7. **USE LEAD APRONS.**
8. **CONSIDER PERSONAL RADIATION PROTECTIVE DEVICES** such as thyroid shields, lead glasses and gloves.
9. **CONSIDER SHIELDING** of the scattered radiation from patient with a lead protecting cover positioned close to the scan plane on the patient's entrance.
10. **DOSE MONITORING.** Suspend the personal dosimeter from the shirt collar *on the outside* of the lead apron. Consider finger dosimetry when using real time techniques.

6. REFERENCES:

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