Dose reduction in multislice CT by means of bismuth shields: results of in vivo measurements and computed evaluation

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Abstract

Purpose. We investigated the amount of patient dose reduction in the thyroid, lens of the eye and the breast when using bismuth protections in multislice computed tomography (CT) exams as well as their influence on the quality of diagnostic images.

Materials and methods. The radiation dose was measured by using thermoluminescence dosimeters. The study was conducted on the two CT scanners installed in our radiology department (64 and eight slices). The shield effects on the CT image were evaluated by measuring the signal-to-noise ratio in a phantom and in vivo, and by verifying the presence of artefacts on patients’ images. The obtained organ-dose reduction factors were used to evaluate the effects of shielding on the effective dose.

Results. The shielding attenuation ranged from 30% to 60% depending on the CT scan protocols and organs. The difference between shielded and unshielded signal-to-noise ratio was statistically significant but within the standard requirements for quality assurance. Results were in agreement with the radiologists’ perception of image quality. The use of the shields allowed up to 38% reduction of effective dose.

Conclusions. Use of bismuth shields significantly decreases both organ and effective radiation dose, with a consequent reduction in health risk for the patient, quantified in 1.4 fewer cases of radiation-induced tumours every 5 years in our centre (12,100 exams/year), in agreement with the risk factors proposed by Publication 60 of the International Commission on Radiological
Protection (ICRP). The relative inexpensiveness of these protections, their easy application and their substantial lack of influence on image quality suggest their massive introduction into routine clinical practice.

**Keywords** Bismuth shields · Computed tomography · Patient dose · Radiation effects

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**Introduction**

The recent advent of multislice spiral computed tomography CT has led to a significant increase in the use of CT imaging in medical practice, which now provides more than 30% of all medical X-rays. Indeed, in countries with the highest levels of health care – classified by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [1] as level I countries – the contribution of CT procedures to the collective dose from medical examinations has risen from 18% in the 1980s to 41% in 1990s (34% worldwide). The number of CT examinations per 1,000 people has increased from 11 to 48 over the same period [1–3].

Due to the lack of overlying tissues, the radiation dose delivered to superficial radiosensitive organs often incidentally included in the scan area, such as the eyes, the thyroid and the breast, may be very significant and approaches, or even exceeds, the dose level for the induction of radiogenic effects. Furthermore, when a multislice CT scanner is used in the helical mode, regions adjacent to the scan volume may lie within the imaged volume [4]. Therefore, this potentially high radiation exposure makes it increasingly important to develop optimisation strategies capable of keeping the CT patient dose as low as possible whilst allowing for diagnostic images addressing the clinical question.

Several methods may be implemented to reduce the radiation dose to the patient in CT examinations. A number of papers [5–7] have recently investigated the use of thin overlying bismuth radioprotective shields to reduce the radiation dose to superficial radiosensitive organs. Although some authors [5, 6] support the use of such shields, one paper [7] states that the application of shields for the eyes, the thyroid and the breasts is unnecessary: with regard to the eye, because the dose to the eye lens is low compared with the 5-Sv threshold dose for radio-induced cataract (although they do not consider that lens opacity may be induced by doses as low as 0.5 Sv [8]); as regard to the thyroid, because the reduction of total energy imparted is only modest; with tumors radio-indotti ogni 5 anni nel nostro centro (12100 esami/anno) in accordo con i fattori di rischio proposti dall’International Commission on Radiological Protection (ICRP) pubblicazione 60. Il relativo basso costo di queste protezioni, la facilità di utilizzo e la sostanziale ininfluenza sulla qualità dell’immagine ne suggeriscono l’introduzione estensiva nella routine clinica.

**Parole chiave** Protezioni di bismuto · Tomografia computerizzata · Dose · Effetti delle radiazioni