Radiography xxx (2017) 1–5

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Does collimation affect patient dose in antero-posterior thoraco-lumbar spine?

J.B. Robinson [a,*], R.M. Ali [a,b], A.K. Tootell [a], P. Hogg [a]

[a] University of Salford, UK
[b] University of Kufa, Iraq

ARTICLE INFO

Article history:
Received 27 October 2016
Received in revised form
20 March 2017
Accepted 22 March 2017
Available online xxx

Keywords:
Collimation
Radiation dose
Lifetime attributable risk
Cancer incidence
Thoraco-lumbar spine
Scoliosis

ABSTRACT

Introduction: The purpose of this study is to determine the effect of collimation on the lifetime attributable risk (LAR) of cancer incidence in all body organs (effective risk) in patients undergoing antero-posterior (AP) examinations of the spine. This is of particular importance for patients suffering from scoliosis as in their case regular repeat examinations are required and also because such patients are usually young and more susceptible to the effects of ionising radiation than are older patients.
Methods: High sensitivity thermo-luminescent dosimeters (TLDs) were used to measure radiation dose to all organs of an adult male dosimetry phantom, positioned for an AP projection of the thoraco-lumbar spine. Exposures were made, first applying tight collimation and then subsequently with loose collimation, using the same acquisition factors. In each case, the individual TLDs were measured to determine the local absorbed dose and those representing each organ averaged to calculate organ dose.
This information was then used to calculate the effective risk of cancer incidence for each decade of life from 20 to 80, and to compare the likelihood of cancer incidence when using tight and loose collimation.
Results: The calculated figures for effective risk of cancer incidence suggest that the risk when using loose collimation compared to the use of tight collimation is over three times as high and this is the case across all age decades from 20 to 80.
Conclusion: Tight collimation can greatly reduce radiation dose and risk of cancer incidence. However collimation in scoliotic patients can be necessarily limited.

Introduction

The reduction of ionising radiation dose in radiography, whilst at the same time achieving images of optimum quality, is of paramount importance. One of the most important factors to attain this is by appropriate collimation of the primary X-ray beam. Aside from the potential for dose reduction, accurate and tight collimation can result in an improvement of image quality by reduction of scatter.[1]

Surprisingly little empirical research has been reported in the literature with regard to collimation and dose reduction. Powys et al.,[2] for example, performed three levels of collimation of a lateral projection of the facial bones and determined the comparative doses to the thyroid and the lens of the eye, using a head and thorax phantom and an Unfors dose meter. They found an appreciable reduction in dose to the thyroid with tighter collimation, although less so to the lenses of the eyes. Lee et al.[3] examined the effects of 'stepwise collimation' in scoliosis but employed only mathematically simulated dose estimations using tissue-weighting factors and a Monte Carlo method. They found that there were large decreases in effective dose generally, but less so to organs in the target site of the examination. They also pointed out that, depending upon the extent of the scoliosis, accurate collimation can be difficult due to the nature of the condition.

Limitations of the use of a single dose meter[2] and no direct dose measurements,[3] suggest that improvements can be made to the experimental design of previous research to investigate how dose varies between tight and loose collimation. This should lead to more accurate data on which to develop arguments. Our work builds directly on this previous research through the use of TLDs in a human dosimetry phantom in order to make more accurate estimations of organ dose. Using organ dose, effective dose and effective risk of radiation-induced cancer was then calculated.

For the purposes of our investigation, the thoraco-lumbar spine was chosen and antero-posterior (AP) projections performed on a

* Corresponding author.
E-mail address: johnbentleyrobinson@gmail.com (J.B. Robinson).

http://dx.doi.org/10.1016/j.radi.2017.03.012
1078-8174/

phantom. One reason for this is that to determine the extent and progression of scoliosis, X-ray examinations of this area are repeated on a regular basis during the earlier years of life when the body is more susceptible to the adverse effects of ionising radiation.[4] This will have an obvious impact on the effective risk of cancer incidence for such patients. Another reason for this choice of area is that, as mentioned by Zetterberg and Espeland,[5] one of the highest effective radiation doses in general radiography is found in lumbar spine examinations.

The purpose of our work is to determine whether differences to organ dose, effective dose and effective risk for a range of ages exist when using tight collimation compared to loose collimation, as defined in the *Data Acquisition* section below. The effects on male patients only are considered as the phantom used was male in structure.

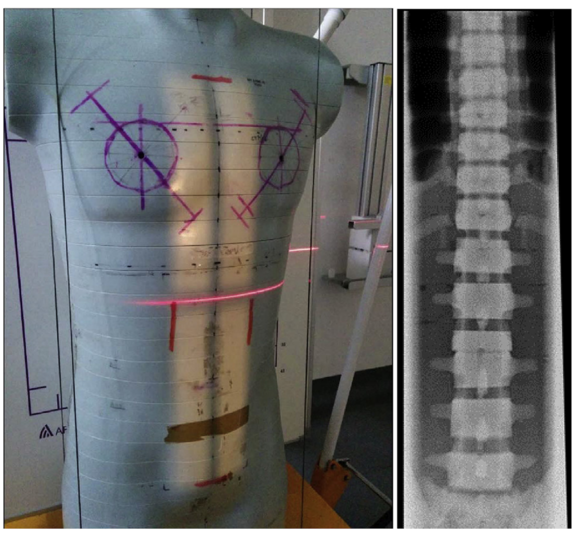

Figure 1. Photograph and radiograph showing extents of tight collimation.

Method

Our method uses an adult male dosimetry phantom with installed thermo-luminescent dosimeters (TLDs). This was exposed under tight and loose collimation for AP spine (see Figs. 1 and 2). Using the TLD data, organ dose and effective dose were calculated along with effective risk for a range of ages.

Dosimetry measurements

A CIRS (Computerized Imaging Reference Systems Inc.) Atom model 701-D adult male dosimetry phantom was used for direct dose measurements and included 271 locations for TLD placement (CIRS, Norfolk Virginia). Annealed TLDs (TLD100H [LiF: Mg, Cu, P] (Thermo Fisher Scientific, Waltham, Massachusetts)) were placed in each location for the exposures. The charges on the exposed TLDs were read using a Harshaw 3500 TLD reader (Thermo Fisher Scientific, Waltham, Massachusetts). Prior to use, the TLDs were grouped into batches of similar response. Calibration exposures at 75 kVp and various mAs values were then applied directly to the TLDs with a source distance of 100 cm. These were completed for randomly-selected TLDs from each group along with an Unfors Mult-O-Meter 401 (Billdal, Sweden) in order to produce calibration factors for each group, as seen in Table 1. These calibration factors, along with readings of background radiation, were applied to the raw exposure figures obtained from the phantom TLDs (see Table 2). Great care was taken to position each specific TLD in exactly the same location within the phantom for both tight and loose collimation exposures in order to account for any variation in response between different individual TLDs.

Imaging equipment

X-ray exposures were made using a Wolverson Arcoma Arco general radiography system (Arcoma, Annavägen, Sweden) with a Varian 130 HS X-ray tube and high-frequency generator. Total filtration was 3 mm Al (inherent 0.5 mm, added 2.5 mm Al). Quality

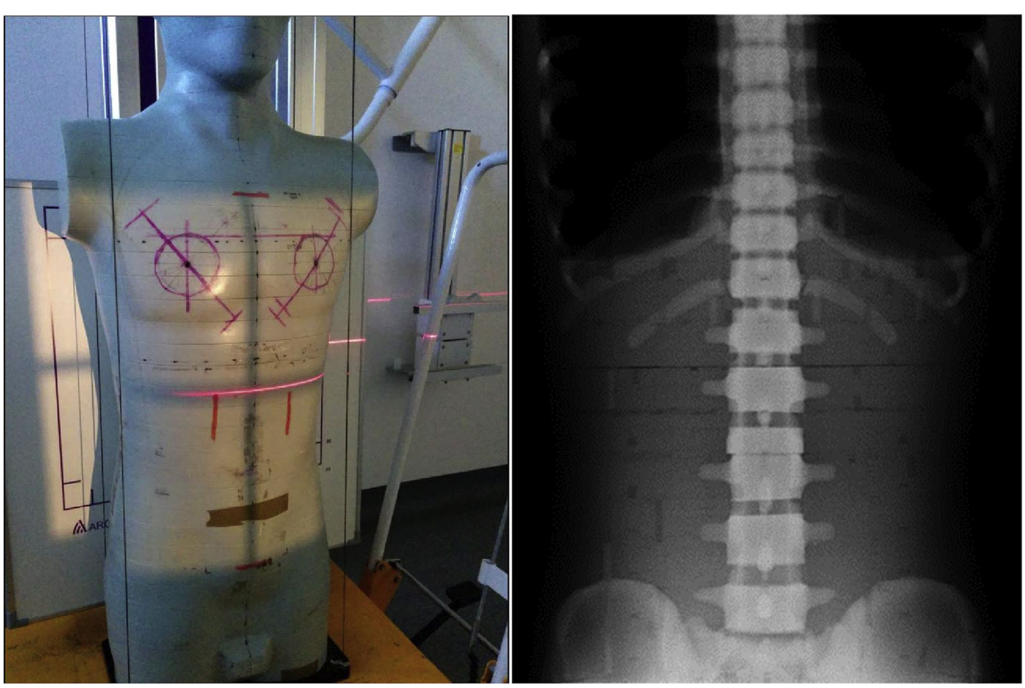

Figure 2. Photograph and radiograph showing extents of loose collimation.