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Brief communication (Original)

Prevalence of radiosensitive organ shielding in patients undergoing computed tomography examinations: an observational service audit in Ahvaz, Iran

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Background: Radiation exposure from computed tomography (CT) is associated with deleterious effects. In-plane bismuth shields (IBS) have been suggested as an effective method to reduce radiation exposure to radiosensitive organs during CT.
Objectives: To explore the availability and usage of modern shielding tools (IBS) and conventional radiation shields for patients undergoing CT exams in five hospitals in Ahvaz, Iran.
Methods: Six radiological technology students were sent to five different hospitals of Ahvaz as observers. Data of the availability and usage of shielding tools for patients undergoing CT exams were collected.
Results: In the five hospitals evaluated, there were no IBS found. In each X-ray room at least one lead apron was available. A gonad shield and thyroid collar were available in 70% and 62% of X-ray rooms, respectively. Also there was no available lens shield. Shielding the eyes and thyroid gland were often neglected. Gonads and breasts were shielded occasionally.
Conclusions: Patients have received avoidable doses of radiation and this is a reason for concern and call for action. Adherence to safety guidelines is recommended. The provision and routine use of IBS to radiosensitive organs as well as lead-shields to the organs outside the field being scanned should be mandatory.

Keywords: Bismuth shield, computed tomography, radiation protection, shielding tools

Medical applications of computed tomography (CT) have steadily increased over the past two decade [1, 2]. In the United States, the number of CT scans has risen from 3.6 million in 1980, to 60.0 million examinations in 2007 [1, 3]. It has been estimated that 29,000 future cancers could result from CT examinations performed in United State in 2007 [4]. While CTs account for only 11% of all radiologic procedures, it responsible for 67% of the radiation to the population [5]. The international commission on radiological protection (ICRP) recommended that: “the absorbed dose to tissue from CT can often approach or exceed the levels known to increase the probability of cancer” [6]. Such radiation exposure to radiosensitive organs such as the gonads, thyroid, lens, and breast created a global concern [7, 8]. The minimize the potential effects of radiation to as low as can be achievable (ALARA) principle has been proposed to apply to all in radiological procedures [9]. In-plane bismuth shielding (IBS) has been suggested as an effective method to reduce the patient’s radiation exposure during CT exams [10, 11]. IBS serves as an additional filter that is placed on the anterior aspect of the radiosensitive organs and is intended to decrease the superficial dose produced by soft radiation yet allowing sufficient X-ray beams to pass to be able to obtain a diagnostic image [12, 13]. The effectiveness of IBS has been highlighted in literature [5, 7, 11, 14]. However, it is not widely in CT practice [12] because only conventional shields are often available.

In contrast to CRS that are intended to completely attenuate radiation for areas that are not of diagnostic interest, bismuth shields decrease radiation to areas that are being examined [13]. In fact because

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of multidirectional data acquisition in CT and the risk of metal artifacts, conventional radiation shields (CRS) (i.e. lead shields) can be employed when radiosensitive organs are located outside the field being scanned. CT has been identified as the greatest source of patient radiation exposure among all diagnostic X-ray modalities [15]. However, the practice of optimal shielding in CT has not been investigated in Iran.

The aim of this study was to explore the availabilities and usage of modern shielding tools (IBS) and CRS for patients undergoing CT exams in five hospitals in Ahvaz, Iran.

Materials and methods

We conducted an observational cross-sectional study as an audit or service evaluation in five hospitals in Ahvaz, Iran including three teaching and two general hospitals, during August 2014 to September 2014. Ahvaz is a regional provincial capital in the south-west of Iran. Six radiology technologist students agreed to participate in this audit. After preliminary coordination and training, the students were asked to attend in the control room as observers. They recorded the number of patients undergoing CT examinations, the number who were shielded, the types of examinations, and the age and the sex of the patients during two different work shifts (8 AM to 8 PM). The privacy of patients was respected. In addition, all X-ray rooms were investigated to determine the availability of various types of IBS and CRS. The CT slice number was obtained and recorded. The collected data were analyzed using the IBM SPSS Statistics for Windows (version 20, IBM Corp., Armonk, NY, USA), through descriptive statistics.

The Ethical Committee of Ahvaz Jundishapur University of Medical Sciences approved the study (No. IA/P/8/20/1865).

Results

The frequency of the CT examinations performed is shown in **Figure 1**. Number, age and sex of patients were collected in **Table 1**. Availability and usage of shielding tools in five hospitals evaluated is also shown in **Table 2**.

In five hospitals there were visited, there were no types of IBS designed specifically for use in CT. The availability of CRS varied between hospitals. In six X-ray rooms, at least one lead apron was available. Gonad shields and thyroid collars were available in 70% and 62% of the X-ray rooms. There were no lens shields found. We found that shielding the eye's lens and thyroid gland were not regarded important. Technologists covered patients with lead aprons in 8% of cases when performing CT exams of the head (i.e. brain, paranasal sinus, etc). They applied gonadal lead-shields on patients in only 5% of cases when performing CT exams of the chest. The prevalence of radiosensitive organs shielding against scatter radiation was 3.6%. There were no significant differences between the five hospitals regarding availability and application of shielding tools.

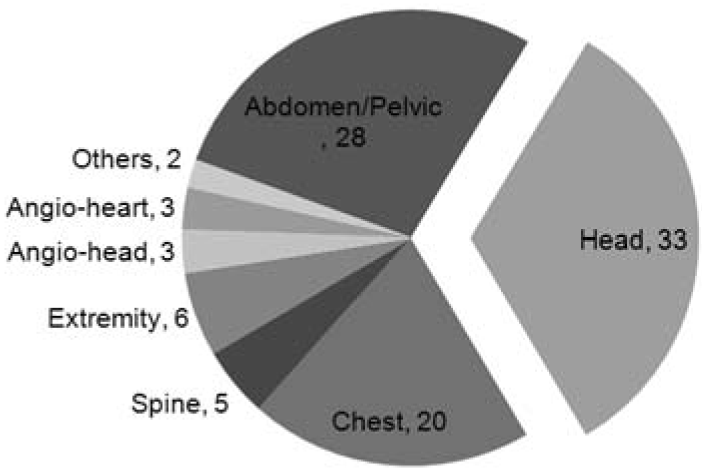

Figure 1. Frequency of the CT examinations performed in five hospitals evaluated

Table 1. Number, age, and sex of patients

Hospital	X-Ray room	CT slice no.	No. of patients			Age (y)				
			Male	Female	Total	<10	10–25	25–40	40–60	<60
H1	1	64	42	18	60	4	10	23	15	8
	2	1	9	6	15	0	4	6	3	2
H2	1	16	39	26	65	3	12	16	23	11
H3	1	1	12	13	25	0	5	6	9	5
H4	1	2	18	12	30	2	5	4	10	9
H5	1	16	28	16	44	1	7	9	11	16

Table 2. Availability and usage of shielding tools in five hospitals evaluated

Radiosensitive organs	Availability of IBS (%)	Availability of CRS (%)	Prevalence of shielding (%)
Gonads	0	70	3.6
Thyroid	0	62	0
Eye	0	0	0
Breast	0	100*	2.6

*Lead apron

Discussion

This study evaluated the prevalence of radiosensitive organ shielding in patients undergoing CT examinations in five hospitals in Ahvaz, Iran. The effectiveness of IBS to reduce radiation exposure of patients during CT exams has been highlighted by several international publications over the past two decades [7, 11, 14]. Laughlin and Mooney reported a 57% reduction in radiation dose without any effect on quality of images when performing CT of the chest with a bismuth thyroid-shield [7]. Perisinakis et al. performed a study to assess the eye lens dose reduction using in-plane bismuth eye-shielding in pediatric patients undergoing CT of the head. He reported that the mean eye lens dose reductions were 34% when eye globes were entirely included in the field of scans [5].

Radiosensitive organs of superficial location and often proximity or inclusion in the field of the scan, are subjected to the primary and scatter radiation while they often are uncommon primary CT evaluation sites [7, 10, 12]. Lack of or inadequate shielding will increase the exposure of these organs to radiation and be risks for malignancy [8, 12]. According to results of this study, IBS were not available in five hospitals evaluated and radiosensitive organs were not shielded when included inside the scan. For organs outside the field of the scan such as: thyroid gland during head examinations and testes during abdominopelvic CT, a relevant reduction of the organ dose can be easily obtained using lead shields [13].

The sensitivity of a tissue to radiation is directly proportional to its rate of proliferation. Therefore human gonads support a large number of stem cells and are thus extremely sensitive to radiation [9, 16]. Absence or inadequate gonadal protection may cause direct gonadal damage and mutation [17] and shielding is advocated as an effective method to reduce the potential effects even on future generations [9, 16]. According to Hohl et al., shielding the male gonads during abdominopelvic CT with standard lead-gonadal shield reduces the testicular dose against scattered radiation up to 87% [3]. We found that gonad shielding was applied only in 3.6% of cases. It also appeared that even gonadal shielding was not regarded and it as a matter for concern. In chest and head CT examinations, radiology technicians covered patients with gonad lead-shield or lead apron in only 5% and 8% of cases, respectively. The lens of the eye is highly sensitive to radiation [5]. “When the eye is exposed to radiation, cells located at the front of the lens can be damaged or destroyed. The affected cells migrate to the back of the lens, where they can collect and form an opacity that may impair vision and lead to cataracts”

[12]. Head CTs accounted for 33% of all CT imaging performed in this study. According to Perisinakis et al. this may result in a significant (0.03 Gy to 0.13 Gy) radiation dose to the eye lens [5]. In our study, where bismuth and lead-lens shields were not available in the five hospitals evaluated, the lenses were never shielded during CT. Like McLaughlin and Mooney [7], in the six X-ray rooms evaluated in this study, the gantry angulation was employed for eye protection during routine brain CT. A much greater dose reduction can be obtained by the use of an angled gantry than by the use of the IBS during brain CT [7].

Breast and thyroid are among the most radiosensitive organs [8, 12]. Thoracic CT is a commonly ordered test and it may result in a significant radiation dose to breasts (20–35 mGy) and thyroid (15.2–17.6 mGy) [7, 8]. It has been estimated that "delivery of 1 Rad (0.01 Gy) to a women's breast before the age of 35 fractionally increases her risk of breast cancer by 13.6%" [8]. However, in this study thyroid shielding was never regarded in CT practice and breast shielding was regarded in 8% of cases when performing CT exams of the head.

While all of the five hospitals evaluated benefited from adequate lead-shielding tools (lead apron, thyroid collar, and gonadal shield) to protect patients against scatter radiation, they were employed only in 3.6% of cases. This is in contrast to a report by Iball and Brettle [18]. The results of this study indicate that patients in the hospitals investigated are receiving avoidable yet significant radiation, which is a reason for concern. It seems that the main reasons for omission or inadequate shielding during CT practice are the result of lack of adequate shielding tools and/or lack of concern. Unfortunately, shielding tools that were available were not used optimally.

Conclusion

We recommend strict adherence to safety guidelines to protect patients from potential harm of radiation. Provision and routine use of IBS to radiosensitive organs and lead shields to the organs outside the field of scan, are urgently recommended. A comprehensive radiation protection training course should be scheduled throughout the country to reduce the patient's radiation dose during CT exams. More inspection and supervision by health authorities to observe shielding application by radiology technicians is also recommended. Provision of the written shielding protocols for correct use of protection tools may avoid confusion over when and how shields should be applied without compromising diagnostic results. More studies and education are needed to improve current radiation hazards that can be easily avoided.

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Conflict of interest statement

The authors have no conflicts of interest to declare.

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