Radiation Dose Reduction to the Male Gonads During MDCT: The Effectiveness of a Lead Shield

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OBJECTIVE. Our study was designed to quantify the effect of a standard gonad shield on the testicular radiation exposure due to scatter during routine abdominopelvic MDCT.

SUBJECTS AND METHODS. Routine abdominopelvic MDCT was performed in 34 patients with gonadal lead shielding and 32 patients without this shielding; the testes were not exposed to the direct beam during the examination. We estimated the testicular dose administered with thermoluminescent dosimetry, taking into account each patient's body weight and body mass index (BMI).

RESULTS. With a 1-mm lead shield, the mean testicular dose was reduced from 2.40 to 0.32 mSv, a reduction of 87%. The difference was found to be statistically significant ($p < 0.0001$). No correlation between testicular dose and body weight or BMI was found.

CONCLUSION. Shielding the male gonads reduces the testicular radiation dose during abdominopelvic MDCT significantly and can be recommended for routine use.

CT examinations account for approximately 35–45% of the total medical radiation exposure in the Western world [1, 2]. In addition, the number of routine CT scans is constantly increasing. In the United States, it has risen from 3.6 million examinations in 1980, to 13.3 million examinations in 1990, to 33.0 million examinations in 1998 [3]. With the broad clinical introduction of MDCT equipment, a further increase in the overall number of CT studies can be expected. Obviously, any simple dose reduction method that does not impair diagnostic image quality should be considered for clinical use.

A straightforward method of reducing the radiation exposure to the gonads in male patients is lead shielding of the testes. Shielding of the gonads has been a routine dose-reduction method during X-ray exposure in conventional radiography for many years. However, in routine CT, gonad shields are not widely used, possibly because it is considered difficult to protect the gonads from a multidirectional X-ray source.

The weighting factor for the gonads is 0.20, according to the Recommendations of the International Commission on Radiological Protection [4]. Therefore, the dose to the gonads contributes 20% of the effective whole-body dose. This relatively high factor represents the radiation sensitivity of the gonads due to the risk of mutagenesis.

The goal of our prospective study was to measure the effect of a standard male gonad shield on the testicular radiation exposure during routine abdominopelvic MDCT.

Subjects and Methods

The dose reduction achievable by shielding the male gonads was studied in 66 men who underwent routine abdominopelvic MDCT in our institution. Informed consent was obtained from each patient before the examination.

The (craniocaudal) scanning range was planned on the basis of an initially performed scanogram (tube voltage, 120 kV and 50 mA). The length of the area scanned was individually adapted, starting above the diaphragm and ending at the bottom edge of the symphysis (Fig. 1). The examination was performed without gonadal shielding in 32 patients (mean age, 60.4 ± 15.5 [SD] years) and with gonadal shielding in another 34 patients (mean, 61.5 ± 12.7 years). Demographic data of both patient groups were comparable regarding height, body weight, and body mass index (BMI) (Table 1) Testes capsules with 1-mm lead shielding (Testes-Capsule TK, Dr. Goos-Suprema) were used for gonadal protection (Fig. 2). Depending on the patient's anatomy, one of two sizes of the capsules was used. The technicians explained to the patients how to attach the capsules themselves.

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TABLE 1 **Demographic Data and Mean Gonad Dose Including SD and Range of the Two Patient Subgroups Examined With and Without Gonad Shielding**

Subgroups of Patients	No. of Patients	Mean					SD	Range (mSv)
		Age (yr)	Height (m)	Weight (kg)	Body Mass Index	Gonad Dose		
With gonad shielding	34	60.4 (34–87)	1.74 (1.62–1.87)	77.6 (61–95)	25.7 (19.7–32.9)	0.32	0.15	0.1–0.7
Without gonad shielding	32	61.5 (25–84)	1.75 (1.59–1.98)	79.7 (45–115)	26.1 (17.8–37.2)	2.40	0.61	1.2–3.6

Note.—The data in parentheses are ranges. The difference between the dose values with and without gonad shielding was statistically significant with a p value of less than 0.0001.

Placement of the testicles and the gonad shield within the scanning range was carefully avoided so that the testicular dose was due only to scatter. All examinations were performed with a 16-MDCT scanner (SOMATOM Sensation 16, Siemens Medical Solutions) using a routine abdominal examination protocol. The patients were placed in supine position and scanned in craniocaudal direction using standardized scanning parameters (tube voltage 120 kV, effective tube current–time product 150 mAs_{eff}) at 16×1.5 mm collimation. The gantry rotation time was 0.5 sec with a table feed of 24 mm per rotation for all patients. The scanner software displayed an effective CT dose index of 10.5 mGy for this protocol. All scans were obtained after the patients received an IV injection of 100 mL of contrast medium (iopromide, Ultravist 370, Schering) followed by a 30-mL saline chaser delivered at a flow rate of 3.5 mL/sec.

Fig. 1.—Scanogram obtained in 54-year-old man (scanning parameters, 120 kv and 50 mA) with scanning range drawn from above diaphragm to bottom of symphysis.

The testicular dose (photon equivalent-dose) was estimated with LiF:MgTi thermoluminescence dosimetry After the scanogram was done, the technician fixed one thermoluminescent dosimeter with adhesive tape (Harshaw TKD 2000, Bicron Technologies) onto the scrotum of each patient as near as possible to one of the testicles. In 34 patients, the gonadal shield was attached subsequently.

Radiation doses to the testicles with and without the gonadal shielding were measured and compared using the Student's t test. Statistical significance was set at a p value of less than 0.05. The influence of a patient's weight and BMI on the dose values was studied using Pearson's regression analysis.

Results

Patient compliance was very good; no patient refused to participate after putting on the gonadal shield. The use of the protective device decreased the mean testicular dose from 2.40 to 0.32 mSv (Table 1), a reduction of 87%. The difference between the dose received by the testicles with and that received by the testicles without gonadal shielding was significant, with a p value of less than 0.0001. The image quality was not impaired by beam-hardening artifacts due to the capsules in any examination.

No correlation between the radiation dose to the gonads and BMI or body weight was found. The Pearson's correlation coefficient r between the gonadal dose and BMI was 0.30 with and –0.33 without shielding of the gonads. In correlations between the gonadal dose and body weight, the Pearson's correlation coefficient r was found to be 0.35 with and –0.50 without shielding of the gonads.

Discussion

The ALARA principle (as low as reasonably achievable) describes best the concept of radiation protection [4]. Any protection measure that is easy to use, does not impair image quality, and significantly reduces X-ray exposure should be used.

Only a few reports on radiation protection with lead shielding can be found in the CT literature [5–7] (Table 2). Price et al. [5] examined a wraparound protective device for shielding the

Fig. 2.—Photograph of two sizes of gonadal shields (1-mm lead) (Testes-Capsule TK, Dr. Goos-Suprema) used to protect testicles.

TABLE 2 Comparison of Two Literature Reports and Present Study Regarding Study Type, Examination Technique, Testicular Dose in mSv With and Without Gonad Shielding as Well as Dose Reduction Percentage

Study	Study Type	Scanning Protocol	Testicular Dose (mSv)		% Reduction
			With Shielding	Without Shielding	
Hidajat et al. 1996 [6]	Phantom study, 1-mm testicular capsule	Single-slice sequential, 10-mm slice thickness, 250 mAs/slice, 120 kV	1.46	0.07	95
Price et al. 1999 [5]	Phantom study, 1-mm wraparound apron	Single-slice spiral, 10-mm slice thickness, 220 mA, 120 kV	0.82	0.19	77
Present study	Patient study, 1-mm testicular capsule	16-slice spiral, 16 × 1.5 mm collimation, 150 mAs_{eff}, 120 kV	2.40	0.32	87

male gonads from both direct and indirect radiation using a phantom and a single-detector CT scanner. Hidajat et al. [6] studied a lead apron, testes capsules, and thyroid collar for dose reduction in the uterus and ovaries, testes, and thyroid gland, respectively, on a single-detector sequential CT scanner. Fricke et al. [7] used an in-plane bismuth breast shield in chest MDCT examinations in children. To the best of our knowledge, no reports have been published on the effect of gonad shielding in routine clinical MDCT examinations.

Price et al. [5] studied a male Alderson radiation therapy phantom (Alderson Research Laboratories) and protected the testes with a 1-mm lead wraparound shield. Abdominal CT scans were acquired on a single-detector helical CT scanner (HiSpeed, GE Healthcare) with 10- slice thickness and a pitch of 1.5:1 and exposure parameters of 220 mA and 120 kVp. They reported a mean gonadal dose of 0.82 mGy without and 0.19 mGy with gonadal shielding, a 77% reduction. Hidajat et al. [6] used a male Alderson radiation therapy phantom and protected the testes with a 1-mm lead testicular capsule. Abdominal CT scans were acquired on a single-detector sequential CT scanner (Somatom Plus, Siemens Medical Solutions) with a slice thickness of 10 mm and an exposure of 250 mAs per rotation. They reported gonadal doses of 1.46 mSv without and 0.07 mSv with gonadal shielding, a 95% reduction. Both studies avoided direct irradiation of the testes. The relative reduction of 87% that we found in our clinical study agrees well with the 77% and 95% reductions found in the studies using phantoms.

We have shown that this reduction in radiation exposure also applies to the special case of testicular radiation exposure during abdominopelvic MDCT examinations; a nearly 90% reduction in exposure was achieved without any diagnostic impairment. The variation in the recorded testicular dose within both groups (range of the gonad dose in Table 1) is apart from the statistical variation likely due to the different anatomic position (z-axis) of the testicles and the thermoluminescent dosimeter. The potential influence of backscattering effects from inside the lead capsules can be disregarded because the opening of the attached capsule has a diameter of only 1.75 inches (4.45 cm). Interestingly, we found no correlation between the gonadal dose and the patient's body weight or BMI. This is probably due to the minor diameter variation in the lower pelvis.

In conclusion, the capsules that we used as gonadal shields are commercially available, easy to use, and well accepted by patients. We can recommend routine use of gonadal shields in male patients undergoing abdominopelvic MDCT examinations and therefore the incorporation of the shields into the daily routine.

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This article is dedicated to Achim Stargardt who passed away in June 2004.

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