HANDY DEVICE FOR PROTECTION OF THE TESTICLES IN X-RAY EXAMINATIONS

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Abstract

We have modified the Picker lead plastic gonad capsule by mounting leaf springs in the two ducts along its opening slit, thus making it "selfsupporting" and able to adjust itself to the scrotum so that the testicles are covered as completely as possible.

Results are given of an investigation of the practical applicability and the shielding effect of the new device.

It is demonstrated that the shielding effect of the modified Picker lead plastic gonad capsule is as good as that of the common two-piece lead capsule device. From a practical point of view it is far better, because it is easily applied and causes the patient no discomfort.

Introduction

It is generally admitted by now that the gonads in men in the reproductive age should be protected by shields of capsule type whenever X-ray examinations exposing areas close to the gonads to the primary beam are carried out, i.e. by shields which fit tightly around the scrotum in order that the testicles may be efficiently protected against primary radiation as well as against scattered radiation coming from the body volume exposed to the primary beam. Even so, it is our impression that this type of shielding of the gonads is used only rarely, at least in Denmark. The main reason is probably that application of the common two-piece lead capsule device in general is considered inconvenient in the routine.

Accordingly, we tried in 1970 to find other means of protection and chanced to find a lead plastic gonad capsule produced by the firm Picker; it is provided with a slit-formed opening the edges of which are in the form of two ducts. It was suggested that it might be desirable if the ducts were provided with leaf springs which tentatively were fitted in. The result was a capsule which for one thing remains in place automatically, no matter the patient's movements, secondly it fits around the scrotum, its opening being the smallest possible. The original Picker capsule and the modified type are illustrated in Fig. 1. The problem of hygiene is solved by a disposable plastic bag which prior to each application is to be inserted into the capsule and turned over its edges.

A few tests on patients showed beyond doubt that the new device was by far more convenient than the solid two-piece capsule and besides, the patients found

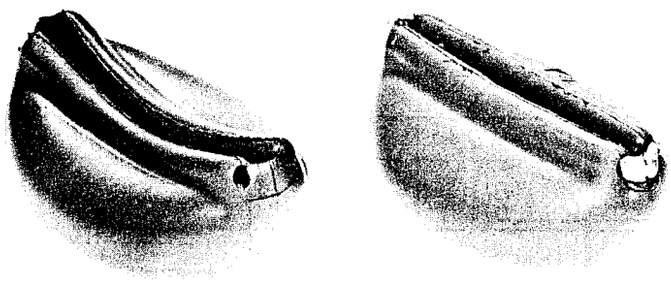

Fig. 1. Picker's original lead plastic gonad capsule and the modified capsule.

that they might easily apply it themselves. Thus, it seemed as if we actually had found a gonad shield which was more handy than the two-piece capsule and, in fact, everybody who at present have reported on the experience gained in the use of the new capsule have shared our opinion. Fig. 2 illustrates how patients in standing position manage to apply the capsule.

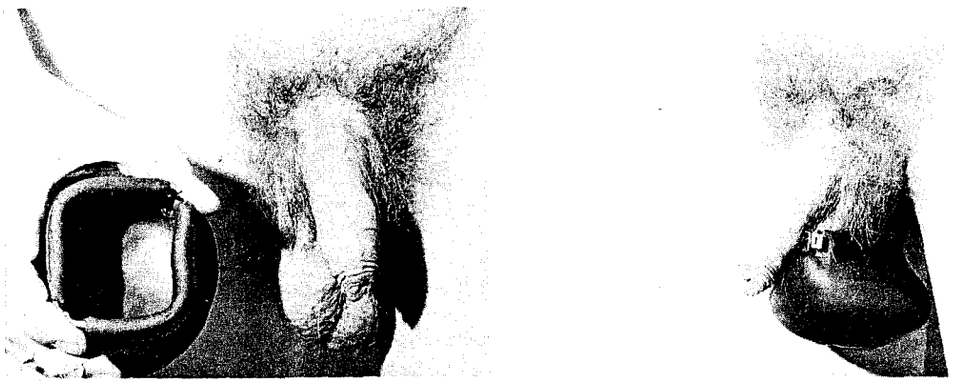

Fig. 2. Patient demonstrating how to apply the modified gonad capsule.

The question remained, however, whether the shielding effect of the new capsule was sufficiently satisfactory. Its lead equivalent is stated to be only 0.5 mm in contrast to an equivalent of 1 mm in the case of the two-piece capsule made by Mavig and consequently, it provides less protection against the primary beam; on the other hand, the two-piece capsule must be assumed to provide a less satisfactory protection against scattered radiation because its opening around the scrotal basis is about 15 cm^2 (large model) at optimal fitting while the new capsule leaves an opening of only 10-15 cm^2, dependent on the anatomy of the patient. The shielding effect of the new capsule was therefore tested, partly by measurements during urography of hospitalized patients and outpatients, partly by phantom-measurements. The new capsule was finally tested in practice, mainly in order to obtain an impression of the patients' capacity to apply the capsule correctly.

Dose Measurements on Patients

In one series of patients the shielding effect was examined by measurement of doses accumulated during 10 routine urography examinations using no shielding and during another 10 examinations using each of the following three types of shielding: common lead rubber sheet, Mavig's two-piece capsule, and the new capsule. LiF thermoluminescence dosimeters were used for the measurements; the results are recorded in Table 1.

As regards the three groups in which shielding was used, a dosimeter was placed on top of the shielding device in addition to the gonad dosimeter on the scrotum; the former dosimeter recorded approximately the dose to be given to

	No shield	Lead rubber	Mavig capsule	Modified Picker capsule
No. of urographies	10	10	10	10
No. of films used	56	61	60	56
Mean dose externally on shielding device	(130)	380	130	85
Mean dose to gonads	130	40	24	8

Table 1. Mean gonad doses in mrad/urography with different types of shielding.

the gonads under the said conditions in the absence of shielding.

It appears from the table that the dose to the gonads was remarkably low if the new capsule was used. Even though the measurements involve a high degree of uncertainty owing to the non-standardized experimental conditions, it gave us reason to believe that the shielding effect of the new capsule was sufficient.

In order to obtain a further insight into the individual variations in doses, we continued our experiments in a minor series in which doses were measured separately during each urography, the latter including five exposures. The dosimeters were arranged as described above. The results appear from Table 2 and are to be interpreted to the effect that the two capsules are of equal value.

The conclusion to be drawn on the basis of the two tests on patients is that our measurements during urography failed to disclose any significant difference in shielding effects of the two-piece capsule[1] and the new lead plastic capsule. The tests are described in further detail in[1].

	Mavig capsule							Modified Picker capsule				
Patient	1	2	3	4	5	6	7	8	9	10	11	12
Dose externally on shield	138	73	108	125	71	85	40	110	35	75	170	30
Gonad dose	34	24	47	29	14	35	14	23	15	8	90	12
Mean dose to gonads	28							30				

Table 2. Individual gonad doses in mrad during 7 urographies using the Mavig two-piece capsule and during 5 urographies using the new capsule.

Dose Measurements on Phantom

Phantom-measurements were subsequently performed in order to determine the shielding effect under reproducible conditions. A therapy equipment with Greinacher coupling was used for the exposures. The Alderson-Rando phantom which for the occasion was provided with a gonad phantom is depicted in Fig. 3 in midline sectional view.

Two LiF dosimeters were placed centrally in the gonad phantom. The thickness of the stalk of the latter, on which the size of the opening of the new capsule depends, was chosen at 20 mm, providing about the maximum size of openings of capsules applied to patients, namely 15 cm^2, and thus an opening similar to that of the two-piece capsule. Owing to the construction of the Alderson-Rando phantom, the opening of the capsules is unfortunately turned in the posterior-cranial direction and hence their orientation is not quite in agreement

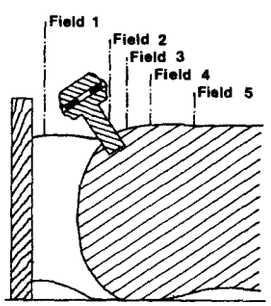

Fig. 3. Phantom in midline sectional view. Caudal field edges are sketched in.

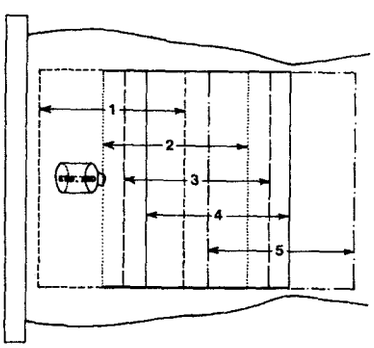

Fig. 4. Location of fields on the anterior surface of the phantom.

with that of capsules used on patients. A treatment applicator providing a field size of 17 x 25 cm on the anterior surface of the phanton was used at a distance of 70 cm from focus. The position of the fields used appears from Fig. 4.

At field 1, the gonad phantom is in the primary beam; as regards fields 2-5, their caudal field edges are at distances of 2.5, 5, 7.5, and 12.5 cm, respectively, from a point centrally between the dosimeters. Doses were measured at 60, 90, and 120 kV (total filtration equivalent to 4 mm Al). The results are recorded in Table 3, except the results obtained by common lead rubber sheet since these values, when outside the primary beam, were almost the same as those obtained without shielding. The doses are expressed in µrad/mAs at the given focus-skin distance.

	No shield			Mavig capsule			Modified Picker capsule		
	60 kV	90 kV	120 kV	60 kV	90 kV	120 kV	60 kV	90 kV	120 kV
Field 1	8200	21000	38000	75	350	920	42	270	700
Field 2	550	1900	3700	72	270	570	39	165	400
Field 3	270	1050	2200	48	230	470	43	150	350
Field 4	135	540	1150	19	73	200	16	71	170
Field 5	32	155	350	3	20	61	3	20	50

Table 3. Gonad doses in µrad/mAs measured on phantom.

It will be noted that the shielding effect of the new capsule was not in any case found inferior to that of the two-piece capsule. It should be mentioned that the results are impaired by some uncertainty because due regard has not been paid to the exact reproducibility of the orientation of the capsules. This may explain why the dose at 60 kV with the new capsule was found to be higher in field 3 (43 µrad/mAs) than in fields 1 and 2.

The diagram in Fig. 5 illustrates the results obtained at 90 kV, including the results obtained by lead rubber sheet shielding. As mentioned, the shielding effect of a lead rubber sheet against scattered radiation is seen to be almost negligible.

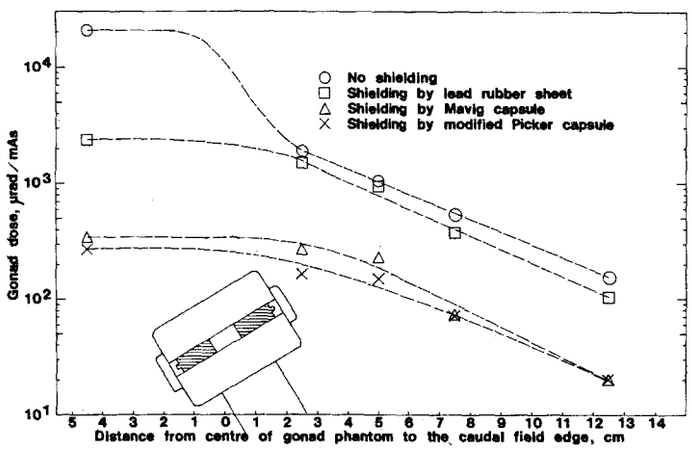

Fig. 5. Graphical representation of the results obtained by measurements on phantom at 90 kV.

The results obtained by the Mavig two-piece capsule and recorded in Table 3 have been compared with those of similar measurements performed by STIEVE[2] in an autopsy series; The reduction factors in our series (ratio of dose measured externally on the capsule to gonad dose) were generally found to be 2-3 times higher than those reported by STIEVE. According to our opinion, part of the explanation may be that, as already mentioned, the opening of the capsules in our phantom set-up is turned more backwards than is normally the case if they are used on patients.

It is not easily comprehensible why the shielding effect of the new capsule appears to be superior to that of the two-piece capsule, taking into consideration that the lead equivalent of the latter is highest (1 mm versus 0.5 mm) and that the sizes of openings were almost identical during measurements on phantom. The explanation may be that the form and orientation of the openings of the two capsules have a marked influence on the amount of scattered radiation to pass through the opening and that doses contributed by radiation through the capsular walls at 0.5 and 1 mm lead equivalent are negligible as compared with the doses contributed by scattered radiation through the opening.

Experience gained in Practice

The results obtained by testings in practice of the new lead plastic capsule are discussed below. The main object was to learn how many patients would manage to apply the new capsule correctly on themselves. With this end in view, a brief, illustrated instruction was prepared. The tests were performed on outpatients who met for examination in a diagnostic X-ray hospital department throughout two months; it must be admitted that it proved impossible to include all patients who appeared during the said period, partly because one physician, always the same, had to be present and supervise that application was correct in all cases, partly because we were interested primarily in the applicability of the device among young patients. It must also be admitted that the patients were not selected at random in the statistical sense of the word since selection was dependent on various practical circumstances. As the object of the investigation merely was to obtain an impression of the applicability of the device, without aiming at a direct collation with other gonad shields, the bias thus introduced is hardly of any significance.

A total of 46 patients received a lead plastic capsule - provided with a disposable plastic bag - and the written instruction immediately after they arrived in the changing room. Two or three minutes later, the examiner would appear and supervise that the capsule had been correctly applied. Thirty-one out of the 46 patients managed to apply the capsule completely correctly within the allowed interval of time. Seven patients found application rather difficult or they applied it slightly incorrectly which, however, had no essential influence on its shielding effect. Application was unsuccessful in three cases, either because of some genito-anatomical deviations or because surgery recently had been performed on the scrotum; in two of these cases, the examiner managed to apply the capsules to the patients in supine position. Two elderly patients failed to apply the capsule because they had not brought their glasses and could not read the instruction. Three patients had applied the capsule in such a way that one testicle was above the opening although there was no anatomical explanation of the phenomenon. They were all able to apply the capsule correctly after they had been told of their mistake. Not a single patient refused to participate and all tried to apply the capsule (except the two patients who had not brought their glasses). Nobody found it inconveniencing to wear the capsule, and nobody complained of having found it too difficult to apply. It is our impression, however, that application might be facilitated in some cases if the capsule were a little larger, but if so, its capacity to remain in place might be reduced in other cases and thus, we cannot recommend any changes in size until further experiments have been carried out. Application may be facilitated if the scrotum and the disposable plastic bag are sprinkled with talc pow-

der prior to application; it is not necessary, however, and was not done in any case in the present investigation.

Thus, the result of the testings in practice was that about 80% of the patients (38 out of 46) managed personally to apply the capsule sufficiently correctly. If the instruction could be revised on the basis of the experience gained, the results would probably be better.

Conclusion

The new lead plastic capsule seems to fulfil all reasonable requirements to a gonad shield to be used by men and it fulfils also the first five out of the six requirements set up by STIEVE[2]: (1) It must be suitable for all types of examination and hence, it must fit tightly around the scrotum; (2) The opening admitting the root of the scrotum must be as small as possible; (3) It must be easily applicable, preferably by the patient himself; (4) It must be as small as possible; (5) It must be hygienic in use. The sixth requirement set up by STIEVE, namely that the gonad shield must attenuate primary radiation to 2%, is not fulfilled, however, since this would require a lead equivalent of 1 mm at 150 kV in stead of the 0.5 mm in the lead rubber capsule. In consideration of the applicability of the capsule, it might be reasonable to be content with the 0.5 mm which is apparent also from the results of measurements performed in the present investigation from which it may be inferred that the gonad dose contributed by primary radiation through the lead rubber wall, even at high voltages somewhat beyond 120 kV, is not of great consequence as compared with the dose inevitably contributed by scattered radiation through the capsular opening.

As already mentioned, it is our impression that gonad shields of capsule type are used only on too rare occasions during X-ray examinations of areas close to the gonads. We are of the opinion that one reason is that the hitherto used capsules are highly inconvenient in use and another that a certain sense of modesty may be in evidence. Such obstacles are apparently eliminated by the new capsule which patients may apply to themselves. Accordingly, there is no longer any excuse why an effective gonad protection should not be used in all cases in which areas close to the gonads in men in the reproductive age are exposed to the primary beam. In this context, X-ray examination of areas close to the gonads refers to all types of X-ray examination in which the gonads either are in the primary beam or are less than about 10 cm from the edge of the beam.

References

1. E. Lindholmer and O. Berg: Proc. 3rd Nordic Radiation Protection Conference, Copenhagen 1971, p. 51 - 57 (in Danish).
2. F. E. Stieve: Fortschr. Röntgenstr. 1959, 90, 1, p. 373 - 386.