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Gonad protection in young orthopaedic patients

Nicholas Kenny, John Hill

Abstract

***Objective*—To determine whether gonad shields are correctly positioned on the pelvic radiographs of children with slipped capital femoral epiphysis.**

***Design*—Retrospective study of radiographs taken of children treated by in situ pinning of slipped capital femoral epiphysis between 1 January 1983 and 31 December 1988.**

***Setting*—Three teaching hospitals in north west England.**

***Patients*—32 patients with complete set of radiographs.**

***Results*—An average of 10·8 anteroposterior pelvic radiographs plus 8·9 lateral hip radiographs had been performed per patient. Gonad shields had been completely omitted in 137 (40%) anteroposterior pelvic radiographs performed on the 32 patients at the time of completion of the study. In 100 (29%) the gonad shields were adequately protecting the gonads, but in 109 (31%) the gonad shields were not protecting the gonads due to incorrect positioning of the shield. The incorrect positioning of the gonad shields was more commonly found in girls than boys (64 *v* 45; $p<0·012$), presumably because of the difficulty in determining gonadal position in relation to surface landmarks. Absence of gonad shields was also more commonly seen in girls (82 *v* 55; $p<0·005$), but this is not easily explained.**

***Conclusions*—Gonad shields are not protecting the gonads in a large percentage of anteroposterior pelvic radiographs (71%) because they have been omitted or inadequately placed. This avoidable excess radiation exposure to the gonads, combined with the inability to shield the gonads in lateral hip radiographs and the large number of radiographs performed, results in the gonads receiving a higher dose of radiation than may otherwise be the case, and may increase the potential for disease in the future offspring of these patients.**

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Introduction

Diagnostic radiology provides an essential method of investigating and monitoring the progress of hip disorders in children. One such disorder is slipped capital femoral epiphysis, and numerous pelvic radiographs may be required throughout the course of diagnosis and treatment.

The effects of ionising radiation are cumulative. The gonads are particularly sensitive to the effects of radiation, especially at or below reproductive age. Inadequate shielding of the gonads will increase the exposure of these organs to radiation and its harmful effects.

The aim of this study was to determine the extent of gonadal radiation exposure due to the inadequate positioning of gonad shields in children with slipped capital femoral epiphysis.

Patients and methods

The clinical notes and radiographs of all children treated by pinning in situ for slipped capital femoral epiphysis in three hospitals in north west England between 1 January 1983 and 31 December 1988 were obtained. Any child with an incomplete set of radiographs was excluded from the study.

The total number of anteroposterior pelvic and lateral hip radiographs taken over the six year period for each child was determined. The presence or absence of gonad shields in all anteroposterior pelvic radiographs was recorded, and if shields were present, whether the gonads were effectively protected was recorded. The position of the gonads in boys was considered to be within the scrotal sac, which is readily visible on a plain pelvic radiograph. The female gonads were considered to rest adjacent to the ischial spines, which are also readily visible on a plain pelvic radiograph. The gonad shield was considered to be inadequately positioned when these areas were not fully shielded. Extreme examples of bad positioning and inadequate size are shown in the figures. Positioning of the shields in boys and girls was compared by Kendall's τ test.

Results

There were 32 children available for the study, average age 12·5 (range 8-15) years. There were 15 boys and 17 girls. Twelve children (38%) had bilateral slips. A total of 346 anteroposterior pelvic radiographs

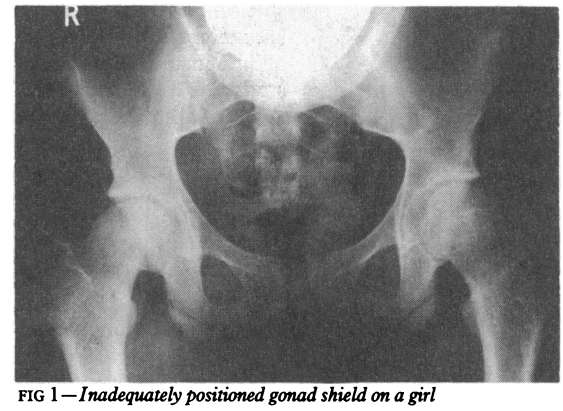

FIG 1—*Inadequately positioned gonad shield on a girl*

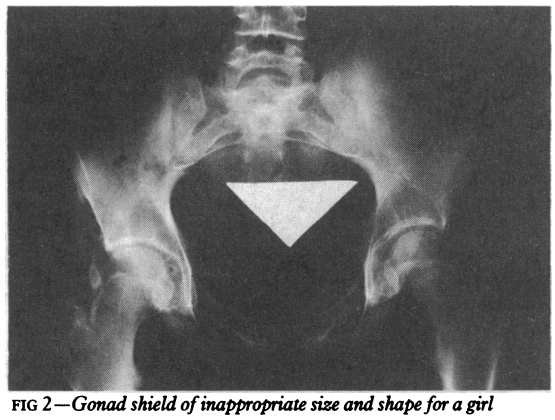

FIG 2—*Gonad shield of inappropriate size and shape for a girl*

had been taken (mean average 10·8 (range 5-25) per child, plus 8·9 (5-16) lateral hip radiographs).

The gonad shields effectively protected the gonads in only 100 (29%) anteroposterior radiographs and was completely omitted in 137 (40%). The gonad shield in the remaining 109 (31%) of anteroposterior radiographs did not adequately protect the gonads. The gonads were therefore exposed to irradiation in 71% of all anteroposterior pelvic radiographs (table). The unsatisfactory positioning of gonad shields was more commonly seen in girls than boys (64 *v* 45; $p<0·012$). Girls were also more likely to have had their shields omitted (82 *v* 55; $p<0·005$).

Positioning of gonad shields in anteroposterior pelvic radiographs in boys and girls treated for slipped capital femoral epiphysis

Gonad shields	Boys	Girls	Total
No (%) present with satisfactory positioning	57 (36)	43 (23)	100 (29)
No (%) present but unsatisfactory positioning	45 (29)	64 (34)*	109 (31)
No (%) absent	55 (35)	82 (43)**	137 (40)
Total	157	189	346

* $p<0·012$. ** $p<0·005$.

Discussion

The results indicate that these children receive many radiographs throughout the course of their illness, with avoidable excess gonadal irradiation due to the inadequate positioning or complete omission of gonad shields.

The inadequate positioning of gonad shields is more common in girls, presumably because of the difficulty in identifying gonadal position in relation to surface landmarks. The complete absence of gonad shields is less easily explained, and girls were more likely to have their gonad shields omitted. It is generally accepted that the first pelvic radiograph of any series can be performed without gonadal shielding to prevent obscuring bony or soft tissue structures that may be relevant to the condition under investigation. Subsequent radiographs, however, should include gonadal shielding. If initial radiographs without gonad shielding are ignored there is still an unacceptable omission rate of 30% in all anteroposterior pelvic radiographs in this study.

Gonadal shielding is generally used more in children than adults.[1,2] A prospective multicentre study that measured irradiation doses to the gonads during diagnostic radiographic examinations in the late 1970s found that gonadal shields were used in about 70% of hip radiographs in children.[2] Our study suggests that the use of shields in children has not increased during the past decade.

Public awareness of the dangers of radiation is increasing, and the public is becoming more safety conscious. A recent survey in *Which?* magazine of 502 adults who had received radiological investigation over a 12 month period found that 42% of men and 66% of women had not received gonadal shielding in radiographs taken of areas where it is correct practice to shield the gonads.[3] The survey pointed out that hospitals often do not follow procedures that are recommended to keep radiation doses to a minimum, the infrequent use of gonad shields being just one example.

The consequence of this avoidable excess of radiation to the gonads, combined with the inability to shield the gonads in lateral radiographs and the radiation exposure received during the operative procedure, results in these structures receiving an unacceptable and avoidable dose of radiation throughout the course of treatment.

No attempt was made directly to measure the radiation dose to the gonads during this study as such an intervention may have influenced the positioning of gonad shields and hence would not reflect everyday practice. An estimate of the radiation doses involved can be otained from published measurements of mean radiation doses to the gonads during various radiological procedures.[2] Measured radiation doses to the gonads can, however, vary widely within an individual centre and also between centres. The true dose received by the gonads can be accurately calculated only by direct measurement during each radiological examination. The gonadal radiation doses measured by Wall *et al*[2] had standard deviations ranging between 50% and 150% of the mean. If calculations are based on the mean values, a typical radiation dose to the gonads during an anteroposterior pelvic radiograph of 0·146 cGy for boys and 0·033 cGy for girls can be assumed. Additionally a dose of 0·018 cGy for boys and 0·04 cGy for girls can be determined for lateral radiographs of the hip. On this basis boys received a mean radiation dose of 1·74 cGy and girls of 0·71 cGy. As a result of the wide variation of measured doses and the variation in the number of radiographs performed for each individual, the actual gonadal radiation doses may be a few orders of magnitude greater than these calculations.

Radiation is cumulative and the risks of radiation are greatest for the young.[4] The main late effects of exposure to low levels of radiation are an increased incidence of cancer in the exposed individual and hereditary disease in the exposed individual's offspring. The probability of either of these effects occurring, but not their severity, depends on the radiation dose.

For radiation induced genetic defects to occur, the gonads (either the testes or ovaries) have to be irradiated before or during reproductive life. The health effects to be expected from the low levels of radiation exposure prevalent in diagnostic radiology will not be observable in the short term. They will be delayed by many years and will usually be indistinguishable from those observed from other causes, rendering it difficult to pinpoint their origin. The real genetic risk in humans is therefore difficult to establish. The risk coefficients that have been used by the National Radiological Protection Board for calculating the risk of genetic effects at low dose rates are those recommended by the International Commission on Radiological Protection as 2% per Gy for all subsequent generations to either parent,[5] although these figures have been revised upwards slightly.[6]

A recent report examined the observed excess of childhood leukaemia and lymphoma near the Sellafield nuclear plant in Cumbria.[7] The findings suggest an effect of ionising radiation on fathers that may be leukaemogenic in their offspring. The authors postulate that this may be due to the direct effect of radiation on germ cells producing a mutation in sperm that may be leukaemogenic in children. A further independent

study of leukaemia clusters seems to support this hypothesis.[8] These studies are the first direct evidence in humans of a link between gonadal irradiation and disease in subsequent offspring.

The probability of a fatal cancer being induced in an individual from a series of x ray examinations is very small. The lifetime risk of developing a fatal cancer from a single pelvic radiograph is estimated to be between 15 per million and 55 per million in all age groups.[9] Latest estimates have placed this risk much closer to the upper limit.[6] This risk increases in children and with the number of radiographs performed over the lifetime of the individual.

Although the genetic and somatic risks associated with the doses of radiation received by the patients in this study are small, we should not be complacent about the need to keep radiation doses to a minimum. A recent report by the Royal College of Radiologists and the National Radiological Protection Board outlined the dangers of radiation and recommended methods of reducing the radiation exposure to patients.[10] It is of importance to all people using diagnostic radiology. The implementation of medical audit encourages us to assess our methods and to improve our practices.[11] It is our duty, therefore, to take the effects of radiation more seriously and to use all possible means to reduce avoidable and unnecessary exposure of our patients.

More care should be taken in the correct positioning of gonad shields and their use should be more rigidly enforced. Methods of more effectively shielding the female gonads by determining their site in relation to surface landmarks should be investigated. Radiology departments should more rapidly introduce dose saving equipment such as rare earth screens and carbon fibre components, the utilisation of which has been slow,[12] although there are signs that the use of rare earth screens has recently increased.[13]

Orthopaedic surgeons rely heavily on radiation for diagnosing disease. They share a responsibility to reduce the radiation exposure to their patients by avoiding unnecessary radiographs and limiting the number of views requested. They should be aware of the need to keep the radiation exposure to their patients to a minimum and to utilise other methods of investigation where possible.

This study has been limited to children with slipped capital femoral epiphysis, but there are other disorders of the hip in children that require radiological investigation, such as Perthes disease and congenital dislocation of the hip, which may similarly require numerous radiographs to be performed throughout the course of treatment. There is no technical reason why the positioning of gonad shields in these conditions should be any different from that in slipped capital femoral epiphysis, though the number of radiographs performed may be different. Improper positioning of gonad shields in these two groups may therefore be similar to that in slipped capital femoral epiphysis, and the increased risk of gonadal radiation exposure may be similarly increased.

Other methods of investigation such as ultrasound scanning, magnetic resonance imaging, and scintigraphy are playing an increasing part in the management of congenital dislocation of the hip and Perthes disease but have not found a role in the management of slipped capital femoral epiphysis. These methods reduce the radiation exposure to the patient, but plain radiography remains the prime investigative procedure for patients with slipped capital femoral epiphysis.

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Murmurs in pregnancy: an audit of echocardiography

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Murmurs are frequently heard during pregnancy and are almost invariably benign. Despite this it is common practice to seek a cardiac opinion with a view to having echocardiography. The purpose of this study was to audit the use of echocardiography in this situation.

Patients, methods, and results

The case notes and echocardiograms of 103 pregnant women referred for a cardiac opinion between 1 July 1989 and 30 August 1991 were examined. This represented 2·2% of 4680 women seen in the antenatal clinic during the period. Patients with a known history of cardiac problems were excluded. Women were referred during all stages of pregnancy, 52 between weeks 20 and 28 of gestation. After examination by a senior cardiologist, echocardiography and Doppler studies were carried out by an operator unware of the clinical assessment using a Hewlett-Packard 77020AC phased array system with a 2·5 or 3·5 MHz duplex probe and a 1·9 MHz continuous wave probe.

Clinical findings were subdivided into three categories. The murmur was classed as a "flow murmur" if it was ejection systolic and short or soft; "possibly pathological" if it was ejection systolic and loud or long; and "pathological" if it was diastolic, pansystolic, or late systolic or the electrocardiogram was abnormal.

Echocardiographic findings were classed as normal, which included trivial mitral regurgitation and mildly increased aortic or pulmonary velocities through anatomically normal valves, or abnormal. The clinical and echocardiographic findings were then compared.

Eighty one women (79%) were thought clinically to have benign flow murmurs of pregnancy, and the echocardiographic and Doppler results were normal in all of these. In 15 subjects the murmur was considered possibly pathological: 12 were normal and three abnormal. Seven patients had clinically pathological