The Use and Relevance of Gonad Protection Shields in Children during Hips Radiography

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ABSTRACT

Considering that ionizing radiation effects are cumulative and the gonads are particularly sensitive to these effects, and also the clinical importance of pelvic radiographs in children, the excess of radiation exposure to the gonads must be avoided. The purpose of this study is to demonstrate the relevance of the correct use of gonad protection shields and to evaluate their use on the hip radiographs performed in a reference clinical institution, through the retrospective analysis of pelvic radiographic images performed in children. According the image quality assessment, 20 (40%) patients were unprotected and gonads shields were incorrectly placed in 24 (80%) patients.

Keywords: Gonad Protection Shields, Hip Radiography, Radiographic Positioning Criteria, Radiology Technologists, Image Quality Criteria.

RESUMO

Dado que os efeitos da radiação ionizante são cumulativos e as gónadas são particularmente sensíveis a estes efeitos, e também pela importância clínica das radiografias pélvicas nas crianças, deve evitar-se a exposição excessiva da região gonadal à radiação. Neste estudo, pretende-se demonstrar a relevância da correcta utilização da protecção gonadal e avaliar a sua utilização em radiografias da bacia. Através da análise retrospectiva de imagens radiográficas da bacia realizadas em crianças, concluiu-se que não foi utilizada a protecção gonadal em 20 (40%) pacientes, e estas foram incorrectamente colocadas em 24 (80%) pacientes.

Palavras-chave: Protecção Gonadal, Radiografia da Bacia, Critérios de Posicionamento Radiográfico, Técnicos de Radiologia, Critérios de Qualidade de Imagem.

1. INTRODUCTION

Pelvic and hip radiographs are a common radiological exam performed for both the adult and paediatric population; whereas the clinical purpose is very different as well as also the procedures and technical aspects of the radiographic positioning (Ballinger & Frank, 1999; Sikand, Stinchcombe, & Livesley, 2003). In addition, the paediatric population necessitates specific preparation care previous to the radiological examination and an adequate communication.

The justification of practice and optimization of protection are the two basic principles of radiation protection recommended by International Commission on Radiological Protection (ICRP), particularly in paediatric patients (European Commission, 1996), including the consideration of dose reference levels, translated into the legal framework by EURATOM Directive (Council Of The European Union, 1996).

Because the considerable body corporal area irradiated and the gonads are particularly sensitive to radiation effects during pelvic radiographs, special protective shielding has to be placed, but without

compromising image quality and diagnosis. The ionizing radiation effects are cumulative, consequently inadequate shielding of the gonads must be avoided in order to reduce radiation exposure (Gul, Zafar, & Maffulli, 2005; Kenny & Hill, 1992; Wainwright, 2000). In (Kenny & Hill, 1992), the authors concluded that in a large percentage of pelvic radiographs (71%) gonad shields are not protecting mainly because the placement was inadequate or omitted. As result, gonads received a higher dose of radiation.

In paediatric diagnostic imaging, the image quality must be a constant concern and adapted to the particular clinical problem. Radiological examinations on children are usually requested to assess congenital dislocation of the hip, Legg-Calvé-Perthes disease and to diagnose nonspecific hip pain. However, under no circumstances should an image which fulfils all clinical requirements but does not meet all image criteria must ever be rejected (European Commission, 1996).

Thus, the aims of our study are to demonstrate the relevance of the correct use of gonad protection shields and to evaluate their use on hips radiographs performed in children.

1.1 Paediatric pelvic radiographic positioning

The preliminary radiographic examination of the pelvis on children includes an anteroposterior (AP) projection of both hips and the Lauenstein ("frog leg" position) projection (Ballinger & Frank, 1999). For both the radiographic projections, the symmetric positioning of the patient body is crucial, in order to assess either bony structures as joint spaces and soft tissues. However, to achieved a symmetric position in children is frequently very difficult, namely because the supine position is uncomfortable for the children; the pelvic rotation helps to compensate the discomfort when a child suffer from hip pain or dislocation.

Figure 1 depicts two examples of hips radiography positioning performed in children, and the importance of symmetry for a good hips comparison and evaluation.

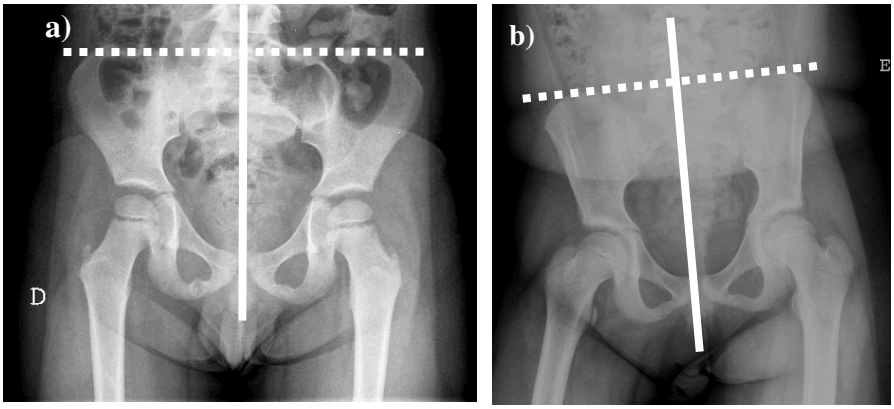

Figure 1. *Examples of correct (a) and incorrect (b) hips radiographic positioning.*

Therefore, the radiology technologist must perform every effort to explain all procedures to the child and have assurance that correct positioning was reached; or for an active child, one more effective and safety immobilization method must be used (e.g. Velcro strip). It is essential to remove diapers before the radiological exam, as well as clothes of abdomen and pelvis, to prevent significant artifacts on the radiographic image.

The following table summarizes an example of good radiographic technique provided by the (European Commission, 1996) which considers one set of radiographic technique parameters to achieved the best quality criteria for AP hips projections.

Table 1. *Examples of good radiographic technique for the AP projection of the pelvis.*

	Infants	**Older children (5 year old)**
Patient position:	supine	supine
Radiographic device:	table	grid table
Focus-to-film distance:	100 cm	100 cm
Radiographic voltage:	60-70 kV	70-80 kV
Automatic exposure control:	none	both laterals chambers
Exposure time:	< 10 ms	< 50 ms
Protective shielding:	gonad capsules should be employed for male patients and gonad masks or shields for female patients, when diagnostically possible	

1.2 Image quality criteria and radiation protection

The image quality criteria for a particular kind of radiograph includes all the aspects deemed necessary to produce an image of standard quality and of good practice (European Commission, 1996). The following guidelines of radiographic imaging of paediatric patients are adequate for the most frequent clinical indications and include:

- *Diagnostic requirements.* Image quality must be adapted to the particular clinical problem and depends on the age of the patient. A lower level of image quality may be acceptable for certain clinical indications, but the radiograph taken from a non-collaborative patient it is not an excuse for producing inferior images which is often associated with an excessive radiation dose.
- *Correct positioning.* Is the most frequent cause of inadequate image quality in paediatric radiographs; however, a good patient communication and sufficient skill and experience of the radiology technologist are some imperative prerequisites to fulfil this quality criterion. In non-collaborative patients, an effective immobilization often is required.
- *Radiation dose to the patient.* The reference doses established by the ICRP, for AP pelvis projection in paediatric examinations are of 200 μGy (Gray – unit of absorbed dose) for infants and 900 μGy for five year old children (Council Of The European Union, 1996; ICRP, 2001).
- *Protective shielding.* When directly pelvic exposure is necessary, gonads must be protected and without impairing necessary diagnostic information. In trauma patient's evaluation and for the Lauenstein projection, gonad shields are unsuitable. The protective shields have different sizes and shapes according patient age and gender, respectively. Gonad shield for boys consist in lead capsules which must be placed over a sponge located on the scrotum and at level of the trochanters. In girls, lead contact shields must be placed in mid-pelvis and the shield top at the level of the anterior superior iliac spine (ASIS). The touch of the pubic symphysis in a child must be avoided during patient positioning or placing the gonad shield.

The correct placement of gonad shield in children is illustrated in Figure 2. The gonad protection is considered correctly placed and with an appropriate size when this lead shield doesn't covers any relevant bone structure. In the gonad shielding, the partial superimposition of the lower part of the sacroiliac joints and sacrum is allowed in female child (see arrows of Figure 2a), and for male patients gonad shielding must be placed below pubic symphysis (see ✳ of Figure 2b).

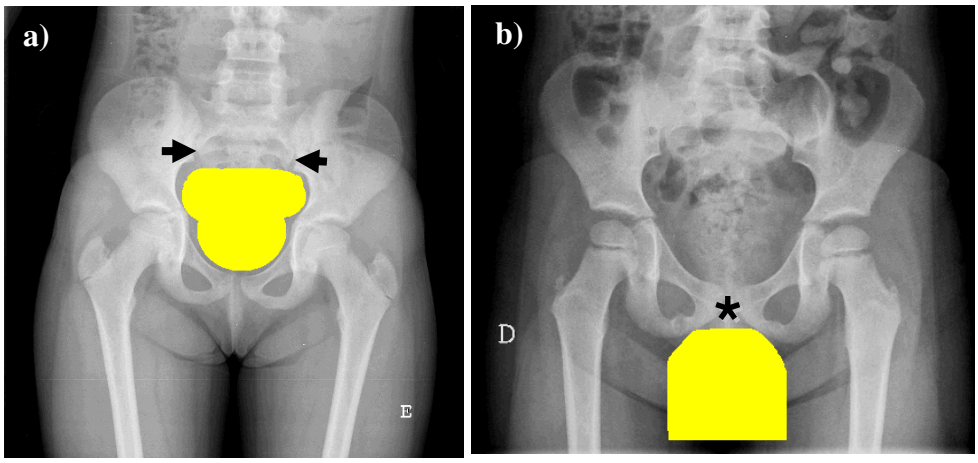

Figure 2. *Examples of a correct placement and appropriate size of gonad shield in a female patient (a) and a male patient (b).*

The remaining of this paper is organized as follows. In the next section, paediatric patients and the methodology used for the image quality assessment are described. Then, in section three, the image quality criteria and general assessment are presented and discussed, considering the gonad protection shields placement and size and radiographic positioning. Finally, the conclusions are pointed out in the last section.

2. PATIENTS AND METHODS

2.1 Paediatric patients

This study included all pelvic radiographs of paediatric patients aged 3 months to 11 years old performed in the Radiology Department of Hospital S. João E.P.E. of Porto, and were collected between January to May 2010. The 50 children in the study had at least one radiograph taken – the AP hips projection, but it was not possible to obtain clinical information. All additional projections were excluded.

2.2 Image quality assessment

Through the retrospective analysis of 50 AP hips projections performed in children, the image quality was assessed by a single person for consistency, using a standard proforma considering the following criteria:

- *No rotation or symmetry*. Evaluation of symmetrical reproduction of the pelvis with iliac wings and obturator foramina at the same distance of midsagittal line.
- *No tilting*. Bilateral bone structures at the same horizontal line.
- *Proper central ray.*
- *Visualization of an adequate contrast*. Visualization of spongiosa and cortex bone and soft tissues.
- *Gonad shielding*. Evaluation of the gonad shield presence, correct placement and appropriate size according age and gender.

These image quality criteria are considered of major importance in radiographic evaluation of children. Each criteria were scored according their presence (score 1) or absence (score 0), obtaining a total of 8 points of appropriateness of the results.

An image general assessment was also performed in order to evaluate other radiographic technical parameters of minor importance nevertheless with influence in both image quality and radiation protection, namely: appropriate field size and x-ray beam limitation, markers use and full coverage of the region of interest without omitting anatomical features, giving a total of 4 points of appropriateness of the results.

3. RESULTS

Of the 50 children included in this study, 24 boys and 26 girls, 30 (60%) presented an age between 3 months and 2 years, and only 16 (32%) are older children (over then 5 year old). The results obtained are summarized in tables 2 and 3.

Table 2. *Image quality criteria assessment results.*

	No (%) present (n=50)
1. No rotation or symmetry	37 (74)
2. No tilting	29 (58)
3. Proper central ray	36 (72)
4. Visualization of adequate contrast	48 (96)
5. Gonad shield present	30 (60)
6. Gonad shield correctly placed	6 (20)
7. Gonad shield size	10 (33.3)
8. Gonad shield no covering bone structures	24 (48)
Total (perfect score = 8)	**4.4**

As observed in table 2, the gonad shield was present in 30 (60%) hips radiographs but only 6 (20%) were correctly placed and 10 (33.3%) with the appropriate size protecting effectively the children. The symmetry positioning was achieved in 37 (74%) patients.

The absence of gonad protection was found equally for both female and male patients, as well as the incorrectly placement of protection shields between genders.

The first four criteria, concerning radiographic positioning have presented better results, with an average percentage above 50%, comparing with the results achieved in radiation protection criteria. Taking into account that a large percentage (60%) of paediatric patients are in neonatal age, gonad protection should not be neglected. Thus, the importance given for the use of gonad protection is lower than expected and required during these radiological examinations.

The average score obtained of 4.4 shows satisfactory appropriateness results concerning image quality criteria in this paediatric population.

Table 3. *General image assessment results.*

	No (%) present (n=50)
1. Appropriate Field Size	15 (30)
2. Appropriate x-ray beam limitation	21 (42)
3. Markers (right or left)	50 (100)
4. Overall coverage of the region of interest	12 (24)
Total (perfect score = 4)	**1.96**

Concerning general image assessment, the resulted score of 1.96 is unsatisfactory considering the influence of the markers use (in 100% of the images) verified comparing to the others radiographic technical parameters. An excessive dose will be expect taking into account that 42% of the x-ray beam limitation and 30% of the field size used on pelvic radiographs weren't appropriate. Furthermore, only 12 radiographs get an overall coverage of the region of interest. These general radiographic technical parameters described in table 3 are the responsibility of the radiology technologist and depend on sufficient skills and professional experience.

Figure 3 illustrates two pelvic radiographs incorrectly performed; on Figure 3a the image quality is not enough because gonad protection shield wasn't positioned correctly and has an inadequate size covering bone structures compromising the diagnosis. In Figure 3b the insufficient x-ray beam limitation and inappropriate field size concerning patient age in addition to the absence of gonad protection shield illustrate an inappropriate practice and that must be avoided.

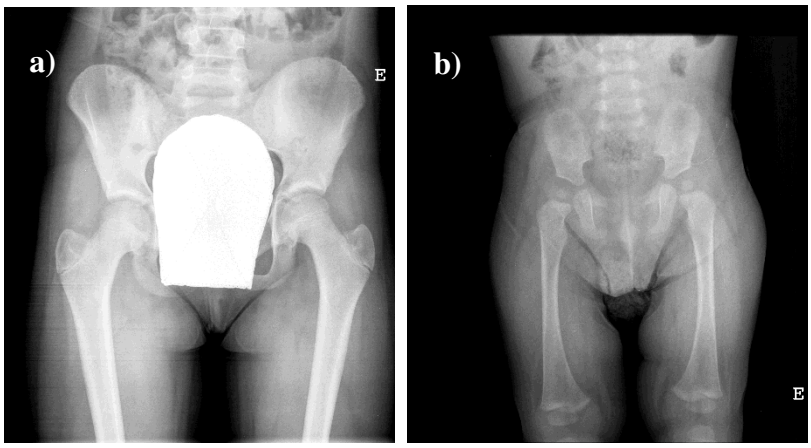

Figure 3. *Examples of incorrect placement and inappropriate size of gonad shield in a female patient (a) and of inappropriate* x-ray beam limitation and field size *(b).*

4. CONCLUSIONS

In this study we evaluate the use and relevance of gonad protection shields on hips radiographs performed in children. According to the image quality assessment, results are satisfactory considering the overall criteria, namely those related to the radiographic positioning (above 50%). However, regarding the radiation protection criteria appropriateness, 20 (40%) patients were unprotected and gonads shields were incorrectly placed in 24 (80%) patients.

Considering others radiographic technical parameters, the general image assessment results are unacceptable of our point of view, especially as a result of inappropriate practice and must be avoided, in order to reduce excessive radiation dose in paediatric population. The results indicate that the children receive an excessive radiation dose related not only with the complete absence or malposition/ use of gonad shields but also with others radiographic technical parameters, as example the x-ray beam limitation and the field size.

In view of the smaller size, the age dependent body composition, the lack of cooperation and many functional differences comparing with adults, the quality appropriateness of radiographic images in paediatric patients is a challenge for all radiology technologists. However, it is not a justification for producing inferior quality images or adopts inappropriate practices. Furthermore, an informed radiology technologist and the application of the best practice during the radiographic examination will ensure a better image quality and consequently improve diagnosis.

The application of the current guidelines must be assessed and followed as far as possible, and efforts should be made to decrease radiation exposure. More care should be taken in the correct positioning of gonad shields and their use must be more emphasized its use in clinical departments. However, it is generally accepted that first pelvic radiographs can be performed without gonad shielding to prevent bony or soft tissue structures covering.

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