Radiography xxx (2013) 1–6

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

# An evaluation of paediatric projection radiography in Ireland

Kate Matthews [a,*], Patrick C. Brennan [b], Mark F. McEntee [b]

[a] School of Medicine and Medical Science, University College Dublin, Dublin 4, Ireland
[b] Faculty of Health Sciences, University of Sydney, Australia

ARTICLE INFO

*Article history:*
Received 8 May 2013
Received in revised form
19 August 2013
Accepted 3 October 2013
Available online xxx

*Keywords:*
Paediatric radiography
Justification
Optimisation
Diagnostic Reference Levels
Paediatric patient size

ABSTRACT

*Purpose:* This study investigated common paediatric radiography examinations in Ireland and analysed any potential for improvement by considering compliance with requirements for justification, the range of doses delivered and potential Diagnostic Reference Levels, and technique approaches that enhance optimisation.

*Method:* Referral information, Dose Area Product (DAP) dose, technique details and patient data were gathered from 568 paediatric examinations performed across several hospitals. The examinations were mobile infant chest ($n = 66$), chest ($n = 266$), abdomen ($n = 96$), lumbar spine ($n = 14$), full spine ($n = 5$), pelvis ($n = 151$) and skull ($n = 28$). Data were analysed to allow comment on the adequacy of justification, the range of doses being delivered and possible Diagnostic Reference Levels (DRLs), and the potential for optimisation of radiographic technique.

*Results/conclusions:* Results indicate that the principle of justification is generally applied well in paediatric practice.

Dose results indicate that age-related doses are generally comparable to published data, although dose variations exist within and between hospitals. Although differences between minimum and maximum DAP values were substantial, differences between the first and third quartile values were rarely greater than a factor of three. With regard to DRLs, age-related, 75th centile DAP values are presented for five paediatric X-ray examinations. While DAP DRLs stated as a function of age are a pragmatic approach to preliminary DRL values, size related DRLs are acknowledged as a better approach and the necessity of objective paediatric patient size measurement is emphasised.

With regard to potential for optimisation, small samples limited analysis of factorial influences on DAP. However, trends indicate that objective consideration of kVp and mAs, careful collimation, and matching of exposure to baby weight in neonates and to measured patient depth in children could all contribute to better optimisation. These factors are all within the radiographer's control, thus highlighting the pivotal role of the radiographer in ensuring that the principle of optimisation is attained.



## Introduction

Whilst modalities such as ultrasound, computed tomography and magnetic resonance are frequently and increasingly utilised in the examination of children, projection radiography remains a fundamental tool in the investigation of a wide spectrum of paediatric pathology.[1,2] At the reported low radiation doses delivered in paediatric projection radiography,[3] it is widely accepted that the overall radiation risk is small. However, though small, the risk of stochastic effects is greater in childhood than for a similar exposure in adulthood.[4] The practical importance of increased radiation sensitivity in children is that radiographers must make every effort to ensure that paediatric radiation exposure is justified and optimised.

Various advisory statements and organisations clearly prioritise achievement of the highest standards of justification and optimisation for paediatric radiography.[4–7] While the International Atomic Energy Agency have reported that: "*there is relatively little quantitative literature and audit of practice on the protection of paediatric patients*",[7] a number of research papers have reported diverse findings that could contribute to better justification or optimisation in paediatric radiography. Such findings are fairly comprehensively reflected in ICRP Publication 121,[8] which offers advice addressing appropriate use of x-ray procedures for children, and also optimisation measures such as careful immobilisation, accurate field size limitation, use of protective shielding, careful selection of exposure factors, consideration of additional filtration, appropriate use of grids and appropriate image processing in digital

* Corresponding author. Tel.: +353 1 7166528; fax: +353 1 7166547.
*E-mail address:* kate.matthews@ucd.ie (K. Matthews).

1078-8174/$ – see front matter © 2013 The College of Radiographers. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.radi.2013.10.001

image acquisition. This array shows there are many ways that the radiation risk accruing from radiographic examinations in childhood can be minimised. For high standards to be achieved, radiographers must be aware of how their own day to day practices compare with such objective research evidence reporting good practice.

The purpose of the current study was therefore to establish how some common paediatric radiography examinations are performed so that current practice could be compared with published research. The investigation focussed on common paediatric radiography examinations in Ireland with the objectives of analysing any potential for improvement in terms of:

- compliance with requirements for justification;
- comparison of doses delivered with proposed Diagnostic Reference Levels;
- technique approaches that enhance optimisation.

This research has been previously presented in overview at the 2012 ISRRT World Congress in Toronto.

## Research design and overview

The study was conducted in 18 hospital departments nationwide. This was a stratified sample including 12 general hospitals of varying size, three tertiary referral paediatric hospitals and three neonatal/obstetric hospitals. The examinations studied were chest, mobile chest, pelvis, skull, abdomen, AP and lateral lumbar spine and PA spine, chosen because these examinations involve a potential dose to more radiosensitive tissue such as eyes, thyroid, breast and gonads. The largest centre undertook more than 21,000 of these examinations per annum, the smallest undertook less than 50 per annum, reflecting guidance that representative dose data should be drawn from a range of practice and not just from specialised high volume centres.[5,9] The caseload of the surveyed departments represented 72% of relevant paediatric examinations undertaken nationwide annually.

Approval to gather the research data was sought separately in each hospital, and no hospital required a full submission for Ethical Approval, permitting the research to proceed under the permission of the relevant Clinical Director in each department. Following this approval, one of two researchers conducted an information session with the radiographers in each hospital, and recruited volunteers to record referral, technique and dose data, along with patient demographics such as weight, age and gestation at birth on a paper form, copies of which were left in each X-ray room.

Calibrated Dose Area Product (DAP) meters [Diamentor range, PTW Freiburg], with ranges between 0.1 to $10^6$ cGy cm$^2$ were used to measure DAP for each examination. Where DAP meters were inherent in equipment, the primary calibration was checked against a secondary standard (a Radcal MDH multimeter) at the start and end of the data collection period by one of two researchers. In other departments and for mobile examinations, a tube-head DAP meter was attached to the light beam diaphragm and calibrated in situ by one of two researchers. Over the seven DAP meters used during the study, accuracy and consistency were measured from ±2% (for the DAP meter used for mobile neonatal chest radiography) to ±8%. These values are within published recommendations on acceptable tolerance of ±10%.[10] Data were collected for varying lengths of time (between four and twelve weeks) in each hospital, over a period of 18 months.

In total, anonymised dose, technique and patient data were gathered from 568 examinations performed on children from preterm birth to age fifteen. Not all examinations were returned from every hospital because the caseloads did not permit this. Not all necessary data was completed on every form: for example in some forms radiographers did not record clinical histories and hence these could not be used in the justification analysis but were still useful when considering doses; in other forms details of exposure parameters or doses were not recorded making the details useless to consideration of optimisation or DRLS, but still useful when justification was considered.

## Justification

### *Method*

Reported clinical information was analysed by one researcher to allow comment on adequate justification. The evidence of justification looked for was a record of clinical referral data that had relevance to the examination requested, and RCR Referral Guidelines[11] were used as the reference for appropriate information.

### *Results*

Overall, complete clinical referral data were given in nearly 94% ($n = 519$) of examinations and were relevant to the examination requested. In 3.5% ($n = 19$) of examinations, the clinical referral data did not appear to form the basis for a justified examination. 2.4% ($n = 13$) of examinations were performed without a written or electronic clinical history. These overall results are categorised by examination in Table 1.

### *Discussion*

Clearly good practice prevails, with nearly 94% of examinations overall being justified by a complete and relevant clinical history. However, in nearly 6% of examinations overall, justification is less

**Table 1**
Deficiencies in clinical data by examination.

| Examination | Requests without any clinical history | Requests without appropriate clinical history | Total apparently unjustified examinations |
|---|---|---|---|
| Lumbar spine ($n = 14$) | 7% ($n = 1$) | 14.3% ($n = 2$ performed for low back pain) | 21.4% ($n = 3$) |
| Pelvis ($n = 132$) | 2.3% ($n = 3$) | 7.6% ($n = 10$ performed under age 4 months for DDH or suspicion of septic arthritis | 9.8% ($n = 13$) |
| Abdomen ($n = 83$) | 1.2% ($n = 1$) | 4.8% ($n = 4$ performed where US preferable) | 8.4% ($n = 5$) |
| Chest ($n = 256$) | 2.3% ($n = 6$) | 1.2% ($n = 3$ histories not justifying CXR) | 3.4% ($n = 9$) |
| Mobile chest ($n = 66$) | 3% ($n = 2$) | 0 | 3% ($n = 2$) |
| Totals ($n = 551$) | 2.4% ($n = 13$) | 3.5% ($n = 19$) | 5.9% ($n = 32$) |

Please cite this article in press as: Matthews K, et al., An evaluation of paediatric projection radiography in Ireland, Radiography (2013), http://dx.doi.org/10.1016/j.radi.2013.10.001