Insights Imaging (2013) 4:723–727
DOI 10.1007/s13244-013-0281-5

PICTORIAL REVIEW

Electronic collimation and radiation protection in paediatric digital radiography: revival of the silver lining

J. Bomer · L. Wiersma-Deijl · H. C. Holscher

Received: 2 August 2013 / Accepted: 5 August 2013 / Published online: 28 August 2013
© The Author(s) 2013. This article is published with open access at Springerlink.com

Abstract In digital radiography we are now able to electronically collimate images after acquisition. This may seem convenient in paediatric imaging, but we have to be aware that electronic collimation has two major downsides. Electronic collimation implicates that the original field size should have been smaller and the child has been exposed to unnecessary radiation. Also, by use of electronic collimation, potentially important information may be lost. The "silver lining", denoting the X-ray beam collimation, can serve as a useful radiation protection instrument to check for proper field size and detect unnecessary exposure. Furthermore, the silver lining confirms all exposed anatomy is shown in the final image, and thus may also serve as a quality assurance instrument as the patient has the right to all acquired information.

Teaching Points

- *The ability to electronically collimate an image after acquisition may serve to enhance contrast in the region of interest.*
- *The ability to electronically collimate an image after acquisition carries the risk of overexposure.*
- *The ability to electronically collimate an image after acquisition carries the risk of losing important information.*
- *The silver lining can serve as a quality control instrument for proper collimation.*
- *The patient has the right to all information obtained during an X-ray examination.*

Keywords Paediatrics · Radiation protection · Digital radiography · Radiographic image enhancement · Patient rights

J. Bomer · L. Wiersma-Deijl · H. C. Holscher
Radiology Department, Haga Teaching Hospital/Juliana Children's Hospital, Leyweg 275, 2545 CH Den Haag, The Netherlands

J. Bomer (✉)
Elandstraat 109, 2513 GN Den Haag, The Netherlands
e-mail: j.bomer@hagaziekenhuis.nl

Introduction

The change from screen-film radiography to digital imaging has provided us with many advantages, to which we have quickly become accustomed. Images are immediately available throughout the entire hospital directly after acquisition, images can be shared amongst hospitals easily, and images can be archived and retrieved without loss of quality. Digital post-processing techniques may suppress artefacts and noise, and serve to increase sharpness and contrast, thereby improving image quality. However, in spite of these many advantages, we should be aware that digital imaging also has its downsides.

The great facility of digital imaging compared with screen-film radiography has caused a tremendous increase of the use of imaging. Clinicians rely less and less on their clinical examination, and the threshold for imaging—and thus radiation exposure—seems to lower throughout the years [1]. With the growing use of imaging, radiologists and radiological technologists should nowadays be even more aware of optimisation of technique and the ALARA principle.

The ability to post-process digital images to seemingly optimal images has caused direct feedback in technical factors to become lost. Loss of this feedback results in a lack of optimisation of technical factors, thereby causing unnecessary high levels of radiation exposure [2]. However, the same values as in analogue imaging still hold true [3]. We should try to keep the dose low and sometimes even accept suboptimal images as long as they provide us with the necessary information. This is especially a topic of concern in paediatric imaging, as children are more vulnerable to the stochastic effects of ionising radiation because of a higher cell turnover in developing organs and because of their longer life expectancy [4, 5].

In this article we describe the use of electronic collimation as a post-processing technique and illustrate both its usefulness and potential drawbacks.

Electronic collimation and the "silver lining"

Proper collimation is one of the aspects of optimising the radiographic imaging technique. It prevents unnecessary exposure of anatomy outside the area of interest, and it also improves image quality by producing less scatter radiation from these areas. Keeping the amount of scatter low is especially important in digital imaging, as digital image receptors are more sensitive to the low-intensity scatter beams, which cause a reduction in image contrast [6].

With post-processing techniques in digital imaging it is possible to apply digital shutters to the image after acquisition and thus electronically collimate an image to the area of interest. By narrowing down the field of view, contrast can be specifically optimised in the region of interest (Fig. 1a–c). In this way, electronic collimation can serve to improve image quality.

The use of electronic collimation implies, however, that the original field size has been overestimated. In the era of film-screen radiography radiologists could check the field size by simply looking at the silver lining. The silver lining denotes a millimetre-wide white margin around the radiographic image (see Fig. 1a). These margins appear bright on the image as beyond the edges of the collimated beam no X-rays hit the detector [7]. This silver lining thus shows how the light beam diaphragm was used to position the X-ray beam and, as it is technique-independent, it is present in both film-screen and digital images. However, when images have been electronically collimated in digital radiography, we are no longer able to see the silver lining. Digital radiography systems may even have software that automatically removes the silver lining, as it has been suggested that this may affect viewing conditions [8].

When images have been electronically collimated, image boundaries may no longer correspond to the original field size and unnecessary exposure may easily go unnoticed to the responsible radiologist. Especially in children, who come in varied sizes and tend to move around a lot, it is tempting to use a larger field size and electronically collimate the image to an optimum afterwards. This is illustrated by a survey of 493 radiological technologists by Morrison et al. [9] in which almost half of the questioned technologists claimed to use electronic collimators greater than 75 % of the time in paediatric radiography.

Electronic collimation does not only result in unnecessary exposure, it also causes areas to be hidden from view on the final digital image. Goske et al. [10] already showed a case of a stomach perforation of an infant initially missed secondary to electronic collimation. We further stress the importance of assessing the entire image with three more cases.

Publication of these cases and images has been approved by the institutional review board.

Case 1

A 6-month-old baby boy was referred for a pelvic X-ray because of restricted abduction of the right hip. On the presented image (Fig. 2a), there were no signs of dysplasia and the hips appeared normal. Because the image had clearly been electronically collimated, the radiologist asked for the original image. On the original non-collimated radiograph, a left distal femur fracture was suspected (Fig. 2b). An additional lateral view of the femur was made, confirming the fracture (Fig. 2c). This was followed by the non-accidental injury protocol.

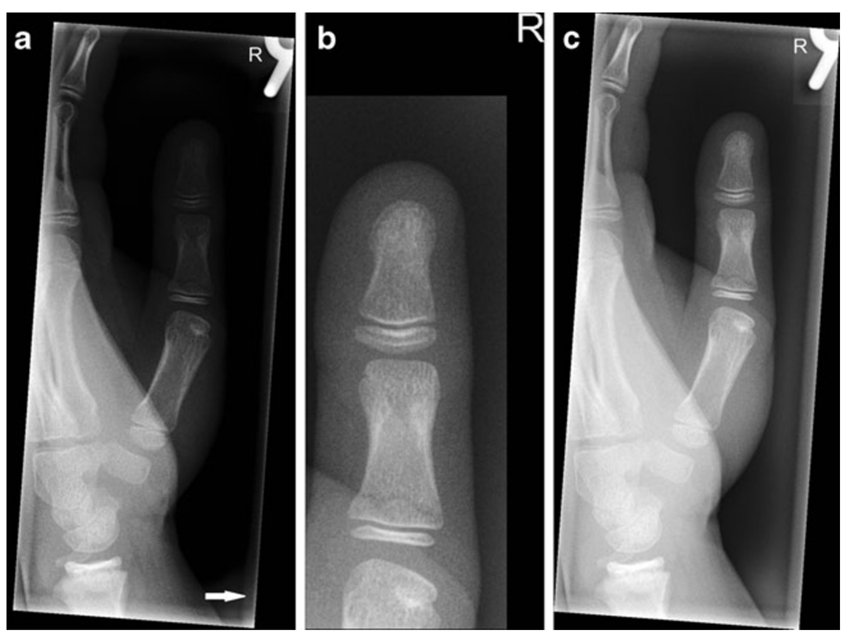

Fig. 1 Technical optimisation of the image. **a** The original image shows an overexposed image of the thumb (*arrow* denotes the silver lining). **b** Electronically collimated image to optimise the region of interest. **c** Final image with preservation of the original field of view

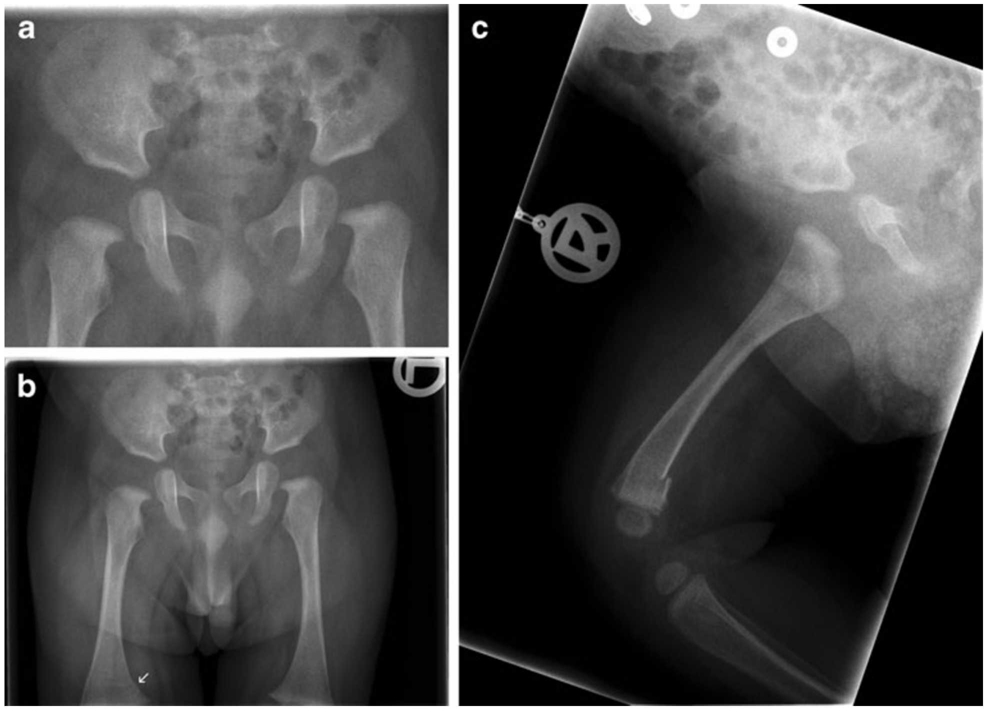

Fig. 2 **a**–**c** A 6-month-old boy with restricted movement of the right hip. **a** Electronically collimated AP view of the pelvis, normal hips. **b** Original non-collimated view shows right distal femur fracture (*arrow*). **c** Lateral view confirming fracture

Case 2

A 3-year-old girl was referred for an X-ray of the cervical spine, because of mild torticollis after a fall. On the electronically collimated images (Fig. 3a) the fracture of the right clavicle, responsible for the torticollis would be missed (Fig. 3b).

Case 3

An 11-month-old baby girl was referred for abdominal X-ray, in addition to abdominal ultrasound, because of continuous crying and a painful abdomen (Fig. 4a, b). In the initially presented radiographs no abnormalities were found and the child was admitted to the hospital for observation. The

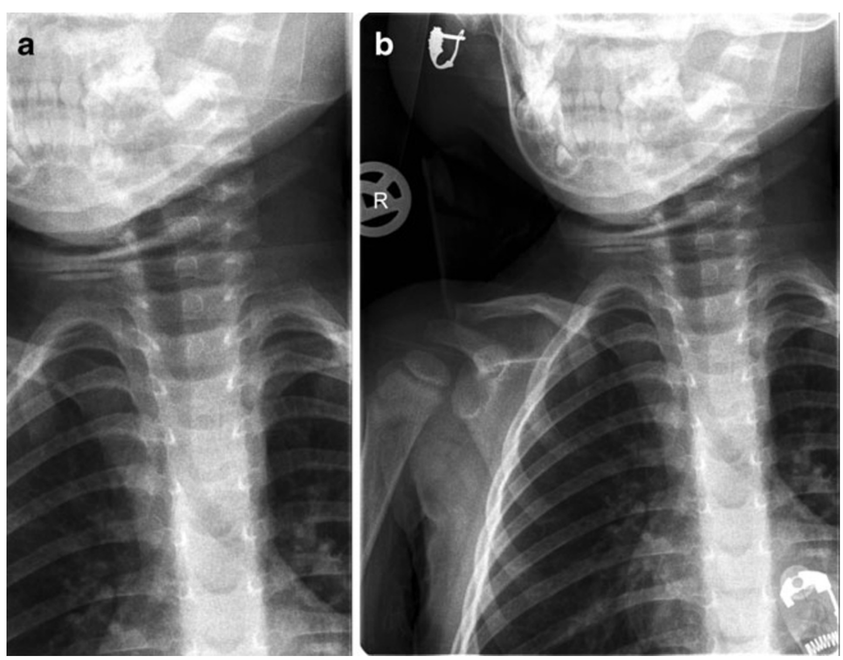

Fig. 3 A 3-year-old girl with mild torticollis after minor trauma. **a** Electronically collimated AP view of the cervical spine shows no abnormalities. **b** Original non-collimated AP view shows right clavicle fracture

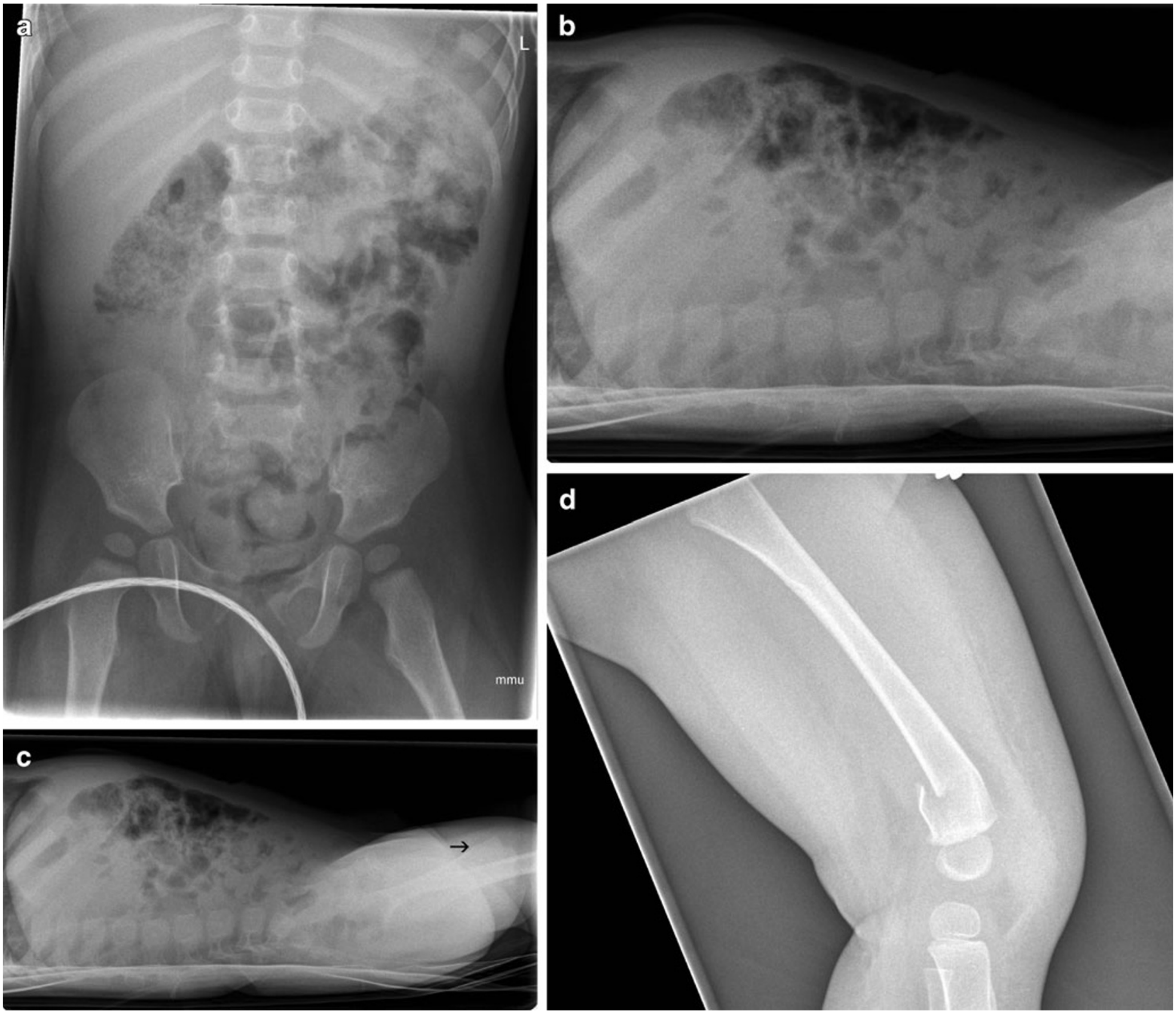

Fig. 4 An 11-month-old girl with continuous crying and "abdominal cramps". **a**, **b** Electronically collimated AP and lateral X-rays of the abdomen show no abnormalities. **c** One day later, lateral X-ray of the left femur shows distal metaphyseal fracture. **d** Original non-collimated lateral X-ray of the abdomen shows contour irregularity on the ventral side of the femur, corresponding with the fracture site (*arrow*)

following day a swollen left upper leg was noted by a nurse. An X-ray of the left femur was made, demonstrating a distal femoral fracture (Fig. 4c). When asked for the original non-collimated X-ray of the abdomen, the distal femoral fracture could be seen retrospectively, thereby confirming that the fracture was already present at first presentation and probably the cause of the initial crying (Fig. 4d). This was followed by the non-accidental injury protocol.

The silver lining in radiation protection

As with screen-film radiography, monitoring of radiation exposure remains a topic of concern in digital imaging. The use of electronic collimation is one of the practical aspects that deserve special attention. In film-screen radiography, the silver lining used to be an important quality control element of the radiological examination. With the advent of digital techniques and the possibility to electronically collimate images, this quality control element has lost consideration. *Without visualisation of the silver lining around the image, the radiologist is unable to check if the X-ray beam has been adequately collimated.* As the radiologist is responsible for image quality and radiation protection, he or she should be aware of this shortcoming and visibility of the silver lining should be checked regularly. In this way, the silver lining may once again serve as a quality control element.

The silver lining and the right to all information

As the cases above illustrate, electronic collimation has the potential to mask patient information included on the image. Electronic collimation may be used to optimise contrast and suppress noise in the region of interest, but an image with the original field size should always be sent to the PACS. This does not only count for manual electronic collimation but also in case of automatic removal of the background, as use of such software carries the inherent risk of inaccurate alignment of the electronic shutters and the exposure field.

The radiologist is responsible for interpreting the entire image as the patient has the right to all information acquired during an X-ray examination.

Conclusion

This article discusses the use of electronic collimation in digital imaging. The ability to electronically collimate an image after acquisition carries the risk of overexposure. The silver lining can serve as a quality control instrument for field size. If field size has been overestimated, we can use electronic collimation to optimise image quality. However, the original images should always be sent to the PACS as they may contain critically important information and the patient has the right to all information at all times.

Conflicts of interest The authors declare no conflicts of interest. No funding was received for this work. Institutional Review Board (IRB) approval was obtained. Written informed consent from all patients was waived by the IRB.

Open Access This article is distributed under the terms of the Creative Commons Attribution License which permits any use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.

References

1. European Society of Radiology (2011) White paper on radiation protection by the European Society of Radiology. Insights Imaging 2:357–362
2. Don S (2011) Pediatric digital radiography summit overview: state of confusion. Pediatr Radiol 41:567–572
3. Willis CE (2009) Optimizing digital radiography in children. Eur J Radiol 72:266–273
4. Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, Board on Radiation Effects Research, Division on Earth and Life Studies, National Research Council of the National Academies (2006) Health risks from exposure to low levels of ionizing radiation: BEIR VII Phase 2. The National Academies Press, Washington DC, pp 267–312, Retrieved from: www.nap.edu/catalog.php?record_id=11340
5. Brenner DJ, Elliston CD, Hall EJ, Berdon W (2001) Estimated risks of radiation-induced fatal cancer from pediatric CT. AJR Am J Roentgenol 176:289–296
6. Herrmann TL, Fauber TL, Gill J et al (2012) Best practices in digital radiography. American Society of Radiologic Technologists, Albuquerque
7. de Ru VJ, Scheurleer JS, Welleweerd J (2006) Radiobiologie en Stralingsbescherming, 5th edn. Elsevier, Maarssen, pp 211–212
8. McNitt-Gray MF, Eldredge SL, Tagawa J, Huang HK (1992) Automic removal of unexposed background in digital radiographs. Proc SPIE 1653:451–457
9. Morrison G, John SD, Goske MJ et al (2011) Pediatric digital radiography education for radiologic technologists: current state. Pediatr Radiol 41:602–610
10. Goske MJ, Charkot E, Herrmann T et al (2011) Image gently: challenges for radiologic technologists when performing digital radiography in children. Pediatr Radiol 41:611–619