

# GUIDELINES FOR SKELETAL SURVEYS IN SUSPECTED CHILD ABUSE

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## ***Abstract***

### **Introduction**

Child abuse imaging differs from general musculoskeletal imaging in that there is exceptional necessity for high quality images. The images are directly involved in legal processes and the child and the family faces major consequences if imaging is sub-optimal. The consequences of misdiagnosis are serious. Should head trauma or fractures be overlooked, or if the radiological diagnosis is uncertain, abused children may be sent home with violent parents or caregivers. Conversely, where no abuse has taken place, but the certainty of the diagnosis is questionable, the unnecessary hospitalization of an innocent family may result.

In Southern Denmark approximately 15-20 children per year are examined. The examinations are performed in four different radiology departments throughout the region. Until the autumn of 2012, a variety of imaging protocols and techniques were used in pediatric skeletal surveys. This led to difficulties, because some cases are subject to second opinion report. In many cases, supplemental images or a complete reexamination of the child was required in order to facilitate a second opinion, resulting in unnecessary exposure.

### **Methods**

An initial consensus meeting with 20 participants was arranged in 2012. Pediatric radiologists, managers and radiographers with special competencies in pediatric radiology attended. Research evidence, cases and clinical experience was discussed.

A follow-up meeting was arranged in 2013 with similar participants. This second meeting focused mainly on follow-up skeletal surveys in children <2 years of age

## Results

The first meeting resulted in the agreement on which projections to acquire, image quality criteria, how to cooperate with the parents, radiologic evaluation criteria and the role of the radiographer in imaging the abused child. The second meeting resulted in consensus on the necessary projections required for follow-up skeletal surveys.

## Conclusion

Common protocols for child abuse imaging have been established and fully implemented in the Region of Southern Denmark. Annual meetings have also been established where legal aspects, best practice and best evidence in imaging and cooperation with pediatric departments is discussed.

**Keywords:** Battered child syndrome, Consensus development, Exposure technique, Fracture, Image quality, Non-accidental injury, Lead marker, Patient handling, Pediatric radiography, Radiography, Side marker, Skeletal survey

## Introduction

Radiologic imaging in suspected child abuse is a specialized procedure that demands high radiographic and radiological skills. Optimal image quality is crucial, as the legal and social consequences of misdiagnosis are significant. Unlike everyday radiological procedures, the images acquired in suspected child abuse are not only tools for diagnostics, but are also legal documents which may play a decisive role in the court of law. The demands for consistent documentation are paramount in these cases (Michelsen, Hansen, Myhre, & Johannessen, 2010). Therefore, the imaging procedures must be performed consistently and be reproducible. Furthermore, the images must be of superior quality in order to both expose abuse and to allay suspicion where no abuse has occurred. Noisy, blurred, or otherwise poor images might result in fractures being overlooked, allowing the potential for an assaulted child to be sent home with abusive parents (Oral, Yagmur, Nashelsky, Turkmen, & Kirby, 2008; Sieswerda-Hoogendoorn, Boos, Spivack, Bilo, & van Rijn, 2012). Unfortunately this situation will often allow continued abuse and can ultimately result in the death of the child. For *battered child syndrome* the mortality rate is reported as being 15 to 38 % (Oehmichen, Auer, & König, 2006). In the event of *shaken baby syndrome* less than 35 % have no permanent injury (Carbaugh, 2004).

Conversely, if suspicion of abuse cannot be disproven, innocent parents may be held under suspicion unnecessarily. This scenario can have significant negative consequences for the parents as well as for the child. Therefore, it is important to emphasize that low quality imaging has major

consequences for the children and parents whether or not abuse actually occurred. Poor images may also compromise the ability to assess the trauma mechanism and the time of injury. Finally, a poorly completed examination may need to be repeated, which leads to unnecessary radiation dose.

Radiologic examination for suspected child abuse is rare, there being 15-20 annual cases in Southern Denmark with approx. 1.2 million inhabitants. This number may only represent a fraction of actual cases. Danish social authorities estimate that 5-6 % of all children have experienced physical abuse. Most of these remain unrecognized, as it is suggested that only 1 in 1000 are seen in the radiology department. Four departments in Southern Denmark perform child abuse imaging. In the Odense University Hospital of Southern Denmark, approximately eight cases per annum are referred for skeletal surveys and an additional 10-12 cases are seen in other hospitals throughout the region. Before 2012, the department of radiology at the University Hospital occasionally performed second opinion on cases from the other regional departments. This presented difficulties, since the image quality and projections differed across the institutions. Given that each department encountered a low volume of pediatric abuse cases, it was seen to be necessary to establish a standardized procedure in order to secure consistent high quality imaging at a regional level.

### *Purpose*

Our aim was to develop common guidelines for suspected child abuse imaging throughout the Region of Southern Denmark.

## **Methods**

The research unit at the university hospital arranged two interdisciplinary consensus meetings. All regional stakeholders in the area were invited to a meeting with 20 participants. Those attended were mainly pediatric radiologists and radiographers from the four departments, but two managers also participated. In the first meeting, evidence from the literature was presented. Image examples were also reviewed and evaluated. Procedural strategies were discussed. The four main topics of the first meeting were:

- The number of images and projections required.
- Radiological Evaluation Criteria.
- Radiation dose and image quality.
- Rights and roles of parents and family.

With a few exceptions among the radiographers, the same participants attended the second meeting. Discussions centered on which projections should be repeated in follow-up surveys in

children below 2 years of age. New evidence on this topic had been published between the two meetings (Harper, Eddleman, & Lindberg, 2013).

## Results and discussion

### *The Number of Images and Projections*

For children at the age of 0-2 years, a total skeletal survey must be performed strictly following the protocol outlined in Table 1 (Rijn & Sieswerda-Hoogendoorn, 2012). Agreement was established to use a protocol which included a total of 35 images and cranial CT. Cranial CT was deemed necessary since 60-80% of abuse deaths are caused by intracranial injury (Geller, 2011; Kemp, 2011; Oral et al., 2008; Scavarda et al., 2010). Cranial CT can be performed without sedation, preferably before the skeletal survey, as the child is more likely to cooperate in the early phases of the examination. However, CT does not replace conventional images of the skull, as fractures may be overlooked in CT, especially when no impression fractures are present or if fracture lines run parallel to the scan plane (Geller, 2011; van Rijn & Sieswerda-Hoogendoorn, 2012).

Antero-Posterior (AP) images are acquired on all long bones and AP plus lateral images on elbows, wrists, knees and ankles. The joints are examined in separate images in order to visualize definitively ‘corner and bucket handle’ fractures of the metaphysis. These classic metaphyseal lesions are highly specific for child abuse (Table 2) but are easily overlooked due to geometrical distortion when the joints are evaluated on

**Table 1.**  
**Total Skeletal Survey children < 2 years**

Anatomic region	Projection	14-day follow-up
Chest, skeletal (low kVp)	AP+LAT + 2 oblique views	X
Skull	AP+LAT	
Cervical Spine	LAT	
Lumbar Spine	LAT	
Pelvis	AP	
Femora	AP	X
Knees	AP+LAT	X
Lower Legs	AP	X
Ankles	LAT	X
Feet	AP	X
Humeri	AP	X
Elbows	AP+LAT	X
Forearms	AP	X
Wrists	LAT	X
Hands	AP/PA	X
Cranial CT	X	

For children aged 2-5 yrs skeletal survey is performed individually as prescribed by a pediatric radiologist.  
 For children aged 5-15 yrs only the suspected region is examined  
 For all age groups supplemental MRI may be performed within 1-2 days.

images of the long bones alone.

The spine requires imaging in both AP and lateral planes, as the chest and pelvic images are evaluated in the AP plane only. Physical side-markers are mandatory and must be visible in all images in order to exclude any potential ambiguity in the validity of the images.

The standard agreed protocol, including AP and lateral skull projections results in 35 images. In addition, cranial CT is also performed routinely.

The above protocol may be repeated after 10-14 days if the initial examination is normal, but suspicion of abuse is still present. In follow-up surveys, cranial CT, skull, pelvic and spine images are omitted as they rarely provide new information. Follow-up surveys include the remaining images. On occasion, cranial MRI may result in new information in >20% of the cases (Harper et al., 2013). For children at 2-5 years of age imaging is individually assessed and above 5 years of age, only the suspected region is examined.

In some cases where the child has siblings who are below 2 years of age, the siblings should also be subject to a full skeletal survey, as violence often takes place against all children in the family (Vitale, Squires, Zuckerbraun, & Berger, 2010)

### *Radiation Dose and Image Quality*

Consensus in the literature indicates that skeletal surveys should be performed by two radiographers with special skills in the field of child abuse imaging (Dubbins, 2008). Whilst typically very low doses in pediatric radiography is appropriate, in child abuse imaging exposure parameters should be set to sufficiently high values in order to produce low noise images (Erfurt, Hahn, Roesner, & Schmidt, 2011; Faerber, Fordham, Singh, Kleinman, & Perez-Rossello, 2011; Paul K. Kleinman, 1998). Trabeculae must be visualized sharply in order to be delineated clearly. Cortical and cancellous bone must also be demonstrated with clarity. To meet these criteria, a speed class of 100 is used where we would normally use 200-400 in pediatric fracture diagnostics, resulting in substantially higher mA values.

### *Radiological Evaluation Criteria*

At the University Hospital, two pediatric radiologists view the images independently and write individual interim reports. The radiologists will then meet and write a final report in cooperation. If the child is examined in a regional hospital with only one pediatric radiologist, images are always subject to second opinion at the University Hospital. The child does not leave the department until the images are approved by a pediatric radiologist, in case supplemental images or retakes are necessary

## *Rights and Roles of Parents and Family*

<b>Table 2. Specificity of lesions for child abuse                      (P.K. Kleinman, 1990; van Rijn &amp; Sieswerda-Hoogendoorn, 2012)</b>	
High specificity i.e. the lesions are highly correlated with physical abuse	Classic metaphyseal lesions Posterior rib fractures Scapular fractures Spinous process fractures Sternal fractures
Moderate specificity* i.e. the lesions might be linked to child abuse, but could also occur accidentally	Multiple fractures, especially bilateral Fractures of different age Vertebral fractures Finger fractures Complex skull fractures Pelvic fractures
Low specificity, i.e. suspicion of child abuse only occurs if the other signs of maltreatment are present or if the history of trauma is inconsistent with the injuries	Clavicular fractures Long bone shaft fractures Linear skull fractures Subperiosteal new bone formation
*Low and moderate specificity lesions become highly specific if the history of trauma is inconsistent with the injuries	

Dialogue at the meetings revealed differences in how the radiologic departments cooperated with the pediatric departments. Where close cooperation with the imaging department and the pediatric staff was established, procedures were carried out smoothly. An experienced pediatric nurse would accompany the family as recommended in the literature (Dubbins, 2008). The accompanying nurse would become the family's primary contact person, and was able to participate in the imaging procedure, support the family, and answer questions afterwards. Having an accompanying nurse also ensures protection of the child. Potentially abused children

under no circumstances should be left alone with their parents. Unfortunately, there are examples in the literature of parents assaulting their children during the hospital stay (Southall, Plunkett, Banks, Falkov, & Samuels, 1997).

Despite this, it is important that the parents are recognized as being the primary caregivers of the child, even if they may have acted violently. Thus, parents are in most cases, free to accompany the child during the examination. In most cases, it is unknown if the child definitely has been abused. Even in cases where abuse is known, it may not be certain that the parents are the ones who acted violently. When interacting with the parents, radiographers must keep in mind that the parents are to be considered innocent until proven guilty.

Should parents fail to cooperate during the diagnostic procedure, the radiographers should normally be able to resolve the situation with communication skills. However, should communication fail, the management of the pediatric department may take actions necessary in order to ensure completion of the required examinations. In extreme cases, the custody of the child may be taken over by the pediatric department. However, this option has never been exercised in the hospitals included in the present study.

## **Perspective**

In conclusion, our effort has contributed positively by achieving consensus on establishing a consistent protocol criterion at a regional level. Since its implementation in 2012, there has been only a single case needing supplemental images and no total re-examinations have been necessary for second opinion reports. The protocol guidelines provided an enhanced focus on cooperation between the radiology and the pediatric departments and also provided a forum for continued discussion. Even more importantly, the consensus achieved has served to lower the potential risks of overlooking radiological signs of abuse.

## References

Carbaugh, S. F. (2004). Understanding shaken baby syndrome. *Adv Neonatal Care*, 4(2), 105-114; quiz 115-107.

Dubbins, P. P., J; Johnson, K; Maguire, S; Wall, LM; Jaspan, T; Hobbs, C; Stoodley, N; Chapman, S; Kemp, A. (2008). *Standards for Radiological Investigations of Suspected Non-accidental Injury*: Royal College of Radiologists.

Erfurt, C., Hahn, G., Roesner, D., & Schmidt, U. (2011). Pediatric radiological diagnostic procedures in cases of suspected child abuse. *Forensic Sci Med Pathol*, 7(1), 65-74. doi: 10.1007/s12024-010-9148-y  
<http://dx.doi.org/10.1007/s12024-010-9148-y>

Faerber, E. N., Fordham, L. A., Singh, S. P., Kleinman, P. K., & Perez-Rossello, J. M. (2011). *ACR-SPR Practice Guideline for Skeletal Surveys in Children*: American College of Radiology.

Geller, E. (2011). *Imaging in Child Abuse*. Medscape Reference. Retrieved from Medscape website: <http://emedicine.medscape.com/article/407144-overview>

Harper, N. S., Eddleman, S., & Lindberg, D. M. (2013). The utility of follow-up skeletal surveys in child abuse. *Pediatrics*, 131(3), e672-678. doi: 10.1542/peds.2012-2608  
<http://dx.doi.org/10.1542/peds.2012-2608>

Kemp, A. M. (2011). Abusive head trauma: recognition and the essential investigation. *Archives of disease in childhood - Education & practice edition*, 96(6), 202-208. doi: 10.1136/adc.2009.170449  
<http://dx.doi.org/10.1136/adc.2009.170449>

Kleinman, P. K. (1990). Diagnostic imaging in infant abuse. *AJR Am J Roentgenol*, 155(4), 703-712.  
<http://dx.doi.org/10.2214/ajr.155.4.2119097>  
PMid:2119097

Kleinman, P. K. (1998). *Diagnostic imaging of child abuse* (Vol. 2. ed.). St. Louis, Mo.: Mosby.

Michelsen, N., Hansen, B. V. L., Myhre, A. K., & Johannessen, T. (2010). *Lægehåndbogen - Børnemishandling*. *Lægehåndbogen*. Retrieved 4/12 2012, from <http://www.sundhed.dk/sundhedsfaglig/laegehaandbogen/paediatri/tilstande-og->



[sygdomme/socialpaediatri/boernemishandling/](http://sygdomme/socialpaediatri/boernemishandling/)

Oehmichen, M., Auer, R. N., & König, H. G. (2006). *Forensic Neuropathology and Associated Neurology*. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg.

Oral, R., Yagmur, F., Nashelsky, M., Turkmen, M., & Kirby, P. (2008). Fatal abusive head trauma cases: consequence of medical staff missing milder forms of physical abuse. *Pediatr Emerg Care*, 24(12), 816-821. doi: 10.1097/PEC.0b013e31818e9f5d  
<http://dx.doi.org/10.1097/PEC.0b013e31818e9f5d>

Scavarda, D., Gabaudan, C., Ughetto, F., Lamy, F., Imada, V., Lena, G., & Paut, O. (2010). Initial predictive factors of outcome in severe non-accidental head trauma in children. *Child's Nervous System*, 26(11), 1555-1561. doi: 10.1007/s00381-010-1150-x  
<http://dx.doi.org/10.1007/s00381-010-1150-x>

Sieswerda-Hoogendoorn, T., Boos, S., Spivack, B., Bilo, R. A., & van Rijn, R. R. (2012). Educational paper: Abusive Head Trauma part I. Clinical aspects. *Eur J Pediatr*, 171(3), 415-423. doi: 10.1007/s00431-011-1598-z  
<http://dx.doi.org/10.1007/s00431-011-1598-z>

Southall, D. P., Plunkett, M. C., Banks, M. W., Falkov, A. F., & Samuels, M. P. (1997). Covert video recordings of life-threatening child abuse: lessons for child protection. *Pediatrics*, 100(5), 735-760.  
<http://dx.doi.org/10.1542/peds.100.5.735>  
PMid:9346973

van Rijn, R. R., & Sieswerda-Hoogendoorn, T. (2012). Educational paper: imaging child abuse: the bare bones. *Eur J Pediatr*, 171(2), 215-224. doi: 10.1007/s00431-011-1499-1  
<http://dx.doi.org/10.1007/s00431-011-1499-1>

Vitale, M. A., Squires, J., Zuckerbraun, N. S., & Berger, R. P. (2010). Evaluation of the siblings of physically abused children: a comparison of child protective services caseworkers and child abuse physicians. *Child Maltreat*, 15(2), 144-151. doi: 10.1177/1077559509360250  
<http://dx.doi.org/10.1177/1077559509360250>