Observational Study of Skeletal Surveys in Suspected Non-accidental Injury

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AIM: To document variability in the standard of skeletal surveys received for a second opinion in suspected non-accidental injury (NAI).

MATERIALS AND METHODS: The skeletal surveys of 50 consecutive infants and children under 2 years of age were reviewed. A simple scoring system was developed based on fulfilment of specific parameters. Each radiograph was then assigned a score reflecting its overall clinical quality.

RESULTS: There was an average of 10 radiographs per skeletal survey (range 2–13). Of the 50 surveys assessed, there were 37 different combinations. These included five babygrams. No survey complied with the current draft guidelines of the British Society of Paediatric Radiologists (BSPR).

CONCLUSIONS: There is significant variability in skeletal surveys referred for a second opinion in suspected NAI. Standardization of projections and improvement in the quality of radiographs obtained for this indication is required. The study highlights the need for the development and dissemination of definitive national guidelines.


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Key words: non-accidental injury, skeletal survey, image quality.

INTRODUCTION

The diagnosis of suspected non-accidental injury (NAI) is a sensitive and topical issue. Radiology plays a pivotal role, and it has been estimated that greater than 80% of diagnosed child abuse-related injuries in the United States are detected through medical imaging [1]. Radiographs may be the only documentation of injury and furthermore may be used as evidence in court. The need for high-quality radiographs, even at the expense of increased radiation dose has been recognized [2]. The American College of Radiology (ACR) has published definitive guidelines for skeletal surveys in the child with suspected physical abuse [2]. Currently only draft guidelines are available for practitioners in the United Kingdom. These can be found on the British Society of Paediatric Radiologists’ (BSPR) website [3]. In the absence of national guidelines, there are likely to be differences in the number and quality of images obtained in skeletal surveys throughout the UK. The purpose of this study was to evaluate and document variability in skeletal surveys received for a second opinion in suspected NAI.

METHOD

The skeletal surveys of 50 consecutive patients were reviewed. The surveys were referred for a second opinion in suspected NAI between January 2000 and September 2002. Exclusion criteria included:

(1) Surveys in which only selected relevant or worrying films had been sent with the accompanying referral letter
(2) Surveys with less than three films (except for babygrams) in order to further reduce the likelihood of including surveys in which radiographs had been retained by the referring hospital
(3) Surveys in patients greater than 2 years of age

General data collected included referring county, number of radiographs per survey, specific projections obtained, and whether radiographs were original or copy, and film/screen or digital.

Assessment of Clinical Image Quality

All radiographs were individually assessed and assigned an image-quality score. The Commission of European
Communities Quality Criteria [4] were not felt to meet the requirements of the study. Each image was therefore assigned a quality score based on a simple system devised for this purpose. Fig. 1 summarizes the criteria that were considered in each evaluation. For each criterion except collimation, a score of 0 or 1 was available. A score for each collimation mark visible on the radiograph to a maximum of 4 was also available. Certain provisos were attached to the fulfillment of given criteria as follows: all handwritten criteria except for radiographer’s identification were penalized (score = 0). Adequate exposure allowed visualization of bony and soft tissue details with or without a spotlight. Significant artefact obscured bony or joint detail. Insignificant artefact was at a distance from the anatomical area of interest except in the case of the assistant’s hand(s). The presence of the assistant’s hand(s) on the radiograph was always penalized (score = 0) because of its radiation dose implications. The sum of scores for each radiograph reflected the clinical image quality. Based on this system, the maximum possible score for any radiograph was 15.

RESULTS

The 50 children had a total of 467 radiographs performed as part of routine skeletal surveys. The average was 10 radiographs per survey per child with a range of two to 13. Of the 467 radiographs, 48 (10%) did not comply with the draft standards (Fig. 2). The majority of radiographs were copies (94%), and only a small number were digital (12%). No survey completely complied with the projections recommended in the draft guidelines (Table 1).

Of the 50 skeletal surveys there were 37 different film combinations. These included a “babygram” (single frontal and lateral exposures of the entire child) in five patients (10%). Table 2 lists the most frequent combination of projections, which (like the babygram) was performed in five patients (10%). Table 2 also shows how the radiographs in this commonest survey differed from the BSPR guidelines.

The most frequent projections obtained were of the lateral skull and the lower limbs in 48 children each (96%). Excluding the babygram, the least frequent projection was of the feet in only 13 children (26%). Radiographs of the hands were also relatively infrequent (Fig. 2).

The least fulfilled quality criterion was a means of identifying the radiographer(s) who performed the study (Fig. 1). This was present on only 103 radiographs (22%).

Of the 163 (35%) radiographs with significant artefact, the presence of the hand(s) of an assistant holding the child in position was identified in 150 (32%). Other artefacts alone or in combination included lines, buttons and ID bands. Relative to the number of radiographs obtained for a given projection, the assistant’s hands were most likely to appear on radiographs of the limbs, while AP skull radiographs were the most likely to be overexposed and significantly rotated (Fig. 3).

In some instances handwritten information was present on the radiographs and positive scores were not assigned. These included side marker (11%), hospital number (6%), date of birth (6%), patient’s name (3%), and date of examination (2%). No radiograph scored the maximum of 15 points. Scores ranged from 4 to 14. The median score was 12; the modal

Table 1 – BSPR draft guidelines

<table>
<thead>
<tr>
<th>Anatomical site</th>
<th>Projection</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skull</td>
<td>AP</td>
<td>Towne’s if occipital injury suspected</td>
</tr>
<tr>
<td></td>
<td>Lateral</td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>AP</td>
<td>Including both clavicles</td>
</tr>
<tr>
<td></td>
<td>Oblique</td>
<td>Right and left (for ribs)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>AP</td>
<td>Including pelvis and hips</td>
</tr>
<tr>
<td>Spine</td>
<td>Lateral</td>
<td>Entire spine</td>
</tr>
<tr>
<td></td>
<td>AP humerus</td>
<td>Right and left</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>AP radius and ulna</td>
<td>Right and left</td>
</tr>
<tr>
<td></td>
<td>Oblique PA hand</td>
<td>Right and left</td>
</tr>
<tr>
<td></td>
<td>AP femur</td>
<td>Right and left</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>AP tibia and fibula</td>
<td>Right and left</td>
</tr>
<tr>
<td></td>
<td>DP foot</td>
<td>Right and left</td>
</tr>
</tbody>
</table>

The table only reflects initial routine projections. The guidelines advocate additional coned and lateral views when initial views suggest an abnormality. Other imaging techniques for neurological examinations are also mentioned [3]. AP, anteroposterior; DP, dorsoplantar.
scores were 12 and 13 in 121 radiographs each. One hundred
and thirty-four radiographs (29%) scored a total of 13 or 14,
while 213 (46%) scored a total of 11 or 12 points.

DISCUSSION

The study has shown that currently in England there is wide
variability in the number and standard of radiographs obtained
for skeletal surveys in suspected NAI. However the limitations
of the study are first that it did not review surveys from a
random selection of radiology departments throughout the
country. Although surveys were referred from 22 British
counties including district general and teaching and paediatric
hospitals, referral bias cannot be excluded. Second, despite our
best efforts, some incomplete surveys may have been included
in the study, although we think this unlikely. However, this
raises the issue of which radiographs should be sent when a
second opinion is sought in suspected NAI. The simplest (and
arguably best) solution is to include them all.

Exposures of individual anatomical regions should be
made on separate films [3]. A significant number of
babygrams were performed and referred for a second
opinion. Babygrams do not provide images of the skeleton
of sufficient quality for the diagnosis of NAI and should not
be obtained in this clinical context [5].

No survey completely complied with the BSPR draft
guidelines. The reasons for this were that all views of the
hands were performed as straight AP radiographs (and not
oblique as recommended), and no routine oblique chest
radiographs were performed. The value of delayed chest
radiographs in the dating of rib fractures has been well
documented [6], however, the routine performance of left and
right oblique chest views at initial presentation is more
controversial. Even excluding oblique projections only three

Table 2 – Most frequent skeletal survey obtained (in five out of 50
surveys)

<table>
<thead>
<tr>
<th>Radiographic projection</th>
<th>Variation from BSPR draft guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP skull</td>
<td>–</td>
</tr>
<tr>
<td>Lateral skull</td>
<td>–</td>
</tr>
<tr>
<td>AP chest</td>
<td>–</td>
</tr>
<tr>
<td>AP pelvis</td>
<td>Abdomen omitted</td>
</tr>
<tr>
<td>AP both upper limbs</td>
<td>Hands omitted</td>
</tr>
<tr>
<td>AP both lower limbs</td>
<td>Feet omitted</td>
</tr>
</tbody>
</table>

AP, anteroposterior.

Fig. 3 – Figures along the y-axis represent absolute numbers of radiographs for individual projections penalized (score = 0) for the reasons indicated. Lower
limbs include feet, and upper limbs include hands. Abdomen/pelvis include those in which one or other region was exposed singly or in combination. For
explanation of the term “Others” please see the legend for Fig. 2.
surveys complied completely with the current guidelines. Widespread publication of the final version of the guidelines is indicated.

The BSPR guidelines stipulate an AP view of the abdomen to include the pelvis and both hips [3]. The majority of surveys reviewed in this study included a view of the pelvis alone (Fig. 2). Injuries to intra-abdominal organs and viscera in cases of abuse have been well documented [7–9]. Injuries to the abdomen are the second most common cause of child fatalities in NAI, with an estimated mortality of 40–50% [10,11]. Radiographs of the abdomen may reveal evidence of free intraperitoneal air or dilated loops of bowel as a result of ileus or obstruction (by intra-mural haematoma for example). These reports support the need for, and reflect the importance of, abdominal radiographs in suspected NAI. Interestingly, the ACR guidelines recommend only an AP view of the pelvis (to include the mid and lower lumbar spine), and not the entire abdomen [2].

Although unusual, fractures of the hands and feet in infants are highly specific for NAI. As with other skeletal injuries in child abuse, there may be no external evidence. Nimkin et al. [12] published features of 22 hand and foot fractures in 11 patients. They emphasized the value of oblique hand views in detecting subtle buckle fractures, and consequently altered their routine skeletal survey to include oblique rather than straight views of the hands. Small patient numbers were involved, however, to our knowledge this is currently the only study in which this issue has been addressed. Results from larger studies in this area would be interesting.

Less than half of all radiographs showed four collimation marks. It is not only important to improve image quality by reducing the glare from unexposed margins, but careful collimation also reduces patient dose. In the case of digital images, electronic shutters exist allowing the radiographer to compensate for poor collimation. The British Institute of Radiology [13] encourages all final (digital) images to show the edges of the radiation field. Thus four collimation marks should be visible on all radiographs whether they are film/screen or digital.

That an assistant’s hand was irradiated in a third of radiographs has implications for radiation exposure. Improved technique particularly in views of the limbs is warranted. AP and lateral skull radiographs were the most likely to be overexposed, rendering the soft tissues difficult to visualize. The presence (or absence) of scalp swelling may be the only clue as to the age of a skull fracture. Optimization of radiographic parameters for AP and lateral skull radiographs would be beneficial.

Only a fifth of the radiographs demonstrated a means of identifying the radiographer(s) involved. In order to establish continuity of evidence it is advised that the name or initials of the radiographer(s) performing the investigation is recorded on the radiographs at the time of the examination [14]. Although we could not find it specifically stipulated, we recommend that details not be handwritten on radiographs. It is possible to argue that handwritten details were included on the radiograph at a later date. The practice of handwritten details may also increase the incidence of errors (such as incorrect side markers).

ACR guidelines [2] recommend a minimum spatial resolution of 10 line pairs/mm for all radiographs obtained as part of a skeletal survey in suspected NAI. These guidelines predate the widespread use of digital systems, which cannot achieve this degree of spatial resolution [15]. The full implication of the reduced spatial resolution of digital systems in the clinical context of NAI is uncertain. We made no attempt to assess the quality of images in terms of spatial resolution requirements for the detection of subtle fractures. The spatial resolution required when using digital systems is not known, and such an assessment was outside the scope of this study.

In conclusion, allowing for patient mobility, there is no reason why radiographs performed as part of skeletal surveys in suspected NAI should score less than 13 based on the system reported in this article.

Our results highlight the need for the publication and widespread distribution of definitive guidelines for skeletal surveys in suspected NAI. Much emphasis is currently placed on evidence-based medicine. If best medicine is to be practised, then all infants presenting with suspected NAI should have the same (complete) skeletal survey performed, regardless of which UK department they present to.