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Can you age bruises accurately in children? A systematic review

S Maguire, M K Mann, J Sibert, A Kemp

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See end of article for authors' affiliations

Correspondence to: Dr A Kemp, Department of Child Health, Cardiff University, Wales College of Medicine, Llandough Hospital, Penarth, Wales CF64 2XX, UK; kempam@cf.ac.uk

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Aims: To investigate whether it is possible to determine the age of a bruise in a child in clinical practice by means of a systematic review.
Methods: An all language literature search up to 2004. Included studies assessed the age of bruises in live children less than 18 years old. Excluded: review articles, expert opinion, and single case reports. Standardised data extraction and critical appraisal forms were used. Two reviewers independently reviewed studies.
Results: Of 167 studies reviewed, three were included: two studies described colour assessment in vivo and one from photographs. Although the Bariciak *et al* study showed a significant association between red/blue/purple colour and recent bruising and yellow/brown and green with older bruising, both this study and Stephenson and Bialas reported that any colour could be present in fresh, intermediate, and old bruises. Results on yellow colouration were conflicting. Stephenson and Bialas showed yellow colour in 10 bruises only after 24 hours, Carpenter after 48 hours, and Bariciak *et al* noted yellow/green/brown within 48 hours. Stephenson and Bialas reported that red was only seen in those of one week or less. The accuracy with which clinicians correctly aged a bruise to within 24 hours of its occurrence was less than 40%. The accuracy with which they could identify fresh, intermediate, or old bruises was 55–63%. Intra- and inter-observer reliability was poor.
Conclusion: A bruise cannot accurately be aged from clinical assessment in vivo or on a photograph. At this point in time the practice of estimating the age of a bruise from its colour has no scientific basis and should be avoided in child protection proceedings.

Paediatricians assessing children who have been physically abused are frequently asked to give an opinion as to how old bruises are. Estimates of age are based on an assessment of colour after inspection of the bruise with the naked eye. These clinical estimates of timescale are used by child protection agencies to determine the likely origins of the injuries and by legal agencies to investigate potential perpetrators. The characteristics of a bruise are influenced by its location, an individual's bleeding tendency and skin colour, the force of injury, depth, and extent of subcutaneous extravasation. While many textbooks[1] are definitive in their statements about the appearance of "fresh", "old", or "recent" bruises, the evidence behind this classification may not be robust. We have conducted the first systematic review to establish if it is possible to age children's bruises accurately in clinical practice. This is one of a series of systematic reviews of the medical aspects of physical abuse.

METHODS

Searching

We conducted an all language literature search of original articles, textbooks, conference abstracts, and references from these and review articles for the period up to October 2004. We used the ASSIA Applied Social Sciences Index and Abstracts (1987–2004), Caredata (1980–2004), Medline (1951–2004), Child Data (1958–2004), CINAHL (1982–2004), Embase (1980–2004), ISI Proceedings (1990–2004), PsycInfo (1987–2004), Science Citation Index (1981–2004), SIGLE (1980–2004), Social Science Citation Index (1981–2004), and TRIP databases. The search strategy is described on the *ADC* website.

Selection

Our inclusion criteria were studies assessing the age of bruises in children less than 18 years old. We excluded reviews, expert opinion, postmortem studies, single case reports, and papers where the population included children and adults but where we could not extract data that applied solely to children.

Grading the evidence

The quality of evidence is described in terms of study type and whether gold standard criteria were met, namely: where the exact age of injury was known, whether inter/intra-observer discrepancy was rated, whether the observer was blinded to the time of injury, whether abuse and predisposing medical causes for bruising were excluded, whether children only were assessed, and whether the population was representative. We have provided a detailed qualitative summary of the critical appraisal of each included paper on the *ADC* website.

Validity assessment

A panel of 15 reviewers, all with child protection expertise, conducted two independent reviews of each paper. All used standardised criteria for defining the study type and worked to specially devised data extraction, critical appraisal, and evidence forms that were based on criteria defined by the NHS Centre for Reviews and Dissemination.[2] In the event of a disagreement between two reviewers, the paper was brought to the panel to discuss, and if agreement could not be reached, a third independent review was carried out.

RESULTS

The total records found after applying the search strategy was 6831. Scanning the titles for duplicates and relevancy reduced the total to 1495. We reviewed the full text of 167 studies, including six from references. Twelve papers required translation. Three papers (see *ADC* website) met our inclusion criteria and were robust enough on critical appraisal to be included.[3–5]

Bariciak and colleagues[5] assessed the ability of different clinicians to age bruises on examination. They evaluated inter-observer accuracy of age estimation and bruise characteristics and whether levels of clinical training had any influence. Fifty children under 18 years of age were enrolled into the study from the children's hospital emergency department; the skin complexion was documented in 39 cases as fair or medium. In each case the exact age of the injury that caused the bruise was known. Children were excluded when abuse was suspected or when there was any medical condition predisposing to bruising. A group of 16 emergency paediatricians, eight other physicians, and 39 trainees were asked to examine one bruise from each child. They were asked to give an exact age estimate of the bruise to within hours of its occurrence and to estimate the age in the broad categories of ''fresh'' (<48 hours), ''intermediate'' (48 hours to 7 days), or ''old''(>7 days). There were 26 fresh, 20 intermediate, and four old bruises.

The accuracy of individual observers (range 0–100%), the inter-observer variability ($\kappa = -0.03$) on age estimates and the inter-observer reliability on agreement of colour, tenderness, swelling, or abrasions was poor. They found a significant association between colour and bruise age ($p < 0.001$), namely red/blue and purple colours were more commonly seen in bruises <48 hours old, and yellow, brown, and green bruises were most often seen in bruises over seven days. However, the converse of this also applied: red/blue and purple were identified in up to 30% (4/13) of observations in bruises older than seven days, and yellow/brown or green were seen in up to 23% (9/39) of observations of bruises less than 48 hours old. The authors report that estimates of the exact age of bruises to within 24 hours of their occurrence are inaccurate (40% overall). There was improved accuracy of 76.2% overall for the assessment of age into broad categories among emergency paediatricians, in contrast to other physicians and trainees whose overall accuracy was 52.7%. The authors therefore urged extreme caution in estimating bruise age on direct examination. No single characteristic (for example, colour, swelling) or the site of the bruise was significantly correlated with dating accuracy.

Stephenson and Bialas[3] studied 36 accidental bruises in 23 white children (13 boys) who were recruited from an orthopaedic ward with a known timed injury. The bruises were photographed on day 1, and 10 children (14 bruises) were re-photographed 3–9 days later. The photographs were carried out in a standardised manner; a standardised colour chart was included. A single assessor, blind to the time of injury for colours present and age of injury (using the same broad categories above[5]) assessed the photographs. There were 15 fresh, 20 intermediate, and 12 old bruises.

The authors concluded that not all colours appear in every bruise and different colours appear in the same bruise at the same time. Blue, brown, grey, and purple colours are not discriminatory as they can occur any time between days 1 and 14. Red occurred only in injuries of less than or equal to one week (15/37 bruises). Yellow occurred only after one day (10/42 bruises) and green was seen in 9/32 bruises of more than two days old. At repeat photography, one child had a blue bruise on the arm and a green/yellow bruise on the leg that were sustained at the same time.

In the estimation of ages of bruises from photographs, the only consistently accurate finding was that no photograph of an injury older than 48 hours was estimated as fresh; all other estimates had errors. The assessor felt he could estimate the age of bruise in 44/50 photographs but was only correct in this estimate in 24/44 cases. The accuracy was unrelated to the age of child, presence of fracture, or the site of the bruise. Small numbers of children, no statistical analysis, and no mention of how the study was powered limited the study. Although all bruises were assessed after admission to an orthopaedic ward with a specific history of trauma, there was no attempt to exclude pre-existing bruises, and no mention of the time from injury to assessment. The authors acknowledge that the study did not assess intra-observer variability.

The paper by Carpenter[4] primarily addressed patterns of bruising in babies attending a health visitor clinic. The population was predominantly middle and lower social class, with no comment on ethnicity: different colours were seen in the 32 bruises that were analysed. Colour could not be matched with age except that yellow only appeared in bruises over 48 hours old.

DISCUSSION

Having analysed the relevant literature over a 30 year period, only a handful of papers met our inclusion criteria. All applied to predominantly white children. Most published work in this field is based on personal practise or ''expert'' opinion. We reviewed a large number of pathology textbooks and the references that they contained, but we failed to identify the scientific evidence on which they base their theory of colour evolution within a bruise over time.

We did not include some frequently quoted papers, such as Wilson's review article,[6] or papers where we could not extract data specifically on children. Langlois and Gresham[7] studied the changes of colour in bruises over time: 369 photographs were taken of 89 subjects with an age range of 10–100 years. The results were summarised for cases younger than 65 years and those older than 65 years. The authors did not state how many children were in the study. Only a proportion of the subjects had their bruises assessed more than once and the time interval varied widely. The key finding that is often quoted from this study, is that yellow was not seen in bruises less than 18 hours old in subjects under 65 years old. This statement is based on an analysis of 33 bruises. Even in this study, red, blue, and purple/black were non-discriminatory, and yellow may never appear in a bruise. One must be cautious in quoting papers where the data are based on an unknown number of older children and include very elderly subjects where the pathological evolution in bruising may be very different.

We conclude that in clinical practice assessment of the age of a bruise in children is inaccurate. To identify possible perpetrators, corroborate explanations for injuries, or confirm that injuries have occurred at several different times we need to be able to estimate the age of a bruise with a high degree of accuracy. Bariciak *et al* confirm that we cannot do this; they state that the accuracy of ageing a bruise to within 24 hours of its occurrence is less than 50%.

Although these papers would broadly support the association between red/blue/purple colour and recent bruising and yellow/brown and green with older healing bruises, there is clear evidence that any of these colours can be observed in a bruise at any time before it finally resolves. Accurate colour discrimination with the human eye is poor. Bariciak and colleagues[5] show poor intra-observer reliability in colour assessment, a finding reinforced by Munang and colleagues,[8] who noted an extremely poor correlation in colour definition within and between different observers, either on direct

visualisation of the bruise or in photographs. This applies equally to yellow as to other colours.

Yellow colouration has traditionally been associated with older resolving bruises; however, results on yellow colouration were conflicting. Carpenter observed yellow colouration only after 48 hours, and Stephenson and Bialas[3] state that yellow bruising is not seen before 24 hours. The latter finding was based on an observation of yellow in only 10 bruises. Bariciak and colleagues,[5] however, noted yellow/green/brown bruising within 48 hours. This is the full extent of scientific evidence that is published relating yellow colouration to the age of a bruise. Anyone estimating the age of a bruise because it is yellow needs to be aware of the limits of published evidence to support their opinion.

Because bruises contain different colours at any one time, and not all colours appear in any one bruise, no significance can be attached to the absence of yellow or red. Similarly this throws doubt on the often quoted statement that bruises of different colour occurred at different times. Photography of a bruise can be misleading. The two dimensional image loses the contours of the bruise and any associated swelling,[3] and the photographic colour reproduction is unreliable[8]

Further research into a scientific assessment of bruising is indicated. Options may include the assessment of standardised measurements of colour through digital imaging techniques, or forensic techniques such as spectrophotometry[9–11] and ultraviolet photography.[12–14] If it is possible to develop an accurate calibration of the colour of a bruise, and overcome the huge variation in human colour discrimination, the method could be applied in more extensive studies of the type described here.[3 5] Studies need to include children of different skin colour and age.

The scientific evidence that we have presented in this systematic review of the literature concludes that we cannot accurately age a bruise from clinical assessment in vivo or from a photograph. Any clinician who offers a definitive estimate of the age of a bruise in a child by assessment with the naked eye is doing so without adequate published evidence. While many individuals may feel that they can make an accurate estimate based on their own clinical experience, this may be difficult to support in Court.

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Authors' affiliations

S Maguire, J Sibert, A Kemp, Department of Child Health, Cardiff University, Wales College of Medicine, Llandough Hospital, Penarth, Wales, UK
M K Mann, Support Unit for Research Evidence, Cardiff University, Wales, UK

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Welsh Child Protection Systematic Review Group: M Barber, P Barnes, R Brooks, M James-Ellison, N John, A Maddocks, A Naughton, C Norton, H Payne, L Price, B Ranton, C Woolley

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