Bruising in non-accidental head injured children; a retrospective study of the prevalence, distribution and pathological associations in 24 cases

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Abstract

Non-accidental head injury, be it shaking, impact(s) or a combination of the two, is characterised by subdural and/or subarachnoid haemorrhages with retinal haemorrhages, but minimal or absent external cranio–facial trauma. The classical assault scenario depicts the infant being gripped around the head, face, chest and abdomen and shaken or being gripped by a limb and swung. This gripping might be expected to leave physical evidence in the form of bruising. A study was undertaken to establish the prevalence, distribution and pathological associations of external bruising in 24 cases of fatal non-accidental head injury in children. At autopsy, 17 cases had new external bruises, 15 old external bruises and 13, a combination of both. However, seven (29%) cases showed no fresh external bruising and five (21%) showed no external bruising at all. Thus, external bruising may be absent in children with fatal intracranial injury. The face was shown to be the commonest site of bruising followed by the forehead and buttocks. Limb, chest and abdominal bruising were found to be uncommon. Retinal haemorrhages were confirmed in 23 (96%) cases. It is hypothesised that bruising, when present, may be a result of abuse in the form of punches and slaps rather than due to gripping during the assault. We discuss why gripping does not necessarily result in external bruising. © 1998 Elsevier Science Ireland Ltd. All rights reserved.

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1. Introduction

Non-accidental injury is an important cause of death world-wide and, in children less than 1 year old, is the commonest cause of serious head injury as typified by 'Shaken Baby Syndrome' [1]. Shaken Baby Syndrome is characterised by subdural and/or subarachnoid haemorrhages with associated retinal haemorrhages, but minimal or absent external cranio–facial trauma [2], and results from the infant having being shaken violently with or without a head impact. Duhaime et al. [3] believe that shaking alone does not generate sufficient force to produce life-threatening cerebral trauma; an impact, albeit against a soft surface, is always necessary.

Previous published accounts of the assault describe the infant being gripped around the head, face, chest or abdomen and shaken, or being gripped by a limb and swung [4]. Such gripping might be expected to leave some form of physical evidence, usually in the form of external bruising. However, it has been our experience that at autopsy, those infants dying of non-accidental head injury may have no external marks of violence. If any are present, they are usually in areas classically associated with other blunt force injuries, rather than gripping injuries. This paucity or lack of bruising may cause difficulties during any subsequent court proceedings.

Although injuries associated with child abuse are well documented in the literature, observations of the distribution of external bruising in those suspected of having been shaken, with or without an impact, are infrequent and poorly documented. We therefore undertook a study to establish the prevalence, distribution and pathological associations of external bruises in non-accidentally head injured children to determine whether the findings reflected the previous published descriptions hypothesising how a child may be held during the assault. The carer's account as to how the child was held during the incident was analysed, although in our experience assault is usually denied.

2. Method

Twenty-four cases of fatal non-accidental head injury in children were retrieved from the archival records of the Department of Forensic Pathology, University of Sheffield from 1990–1996. All the children were younger than 5 years of age and had sustained fatal intracranial injuries attributed to child abuse. External bruises were classified as new or old according to their colour at the time of autopsy. For the purposes of the study new bruises were classified as those which were swollen, red, blue or purple and old as green, yellow or brown. The was further modified to incorporate those bruises described as 'fresh' or 'recent' in the autopsy reports in the new bruise category.

To record the site of each external bruise, a standard international set of human body charts were photocopied onto acetate sheets and divided into 17 anatomical sites. The head was further subdivided according to the four main skull bones; frontal, parietal, temporal and occipital (Figs. 1 and 2).

The sites of all recent external bruises drawn on identical body charts at the time of autopsy by the original pathologist were reproduced on the acetates. The acetates from all 24 cases were then overlaid one upon the other and photocopied to produce
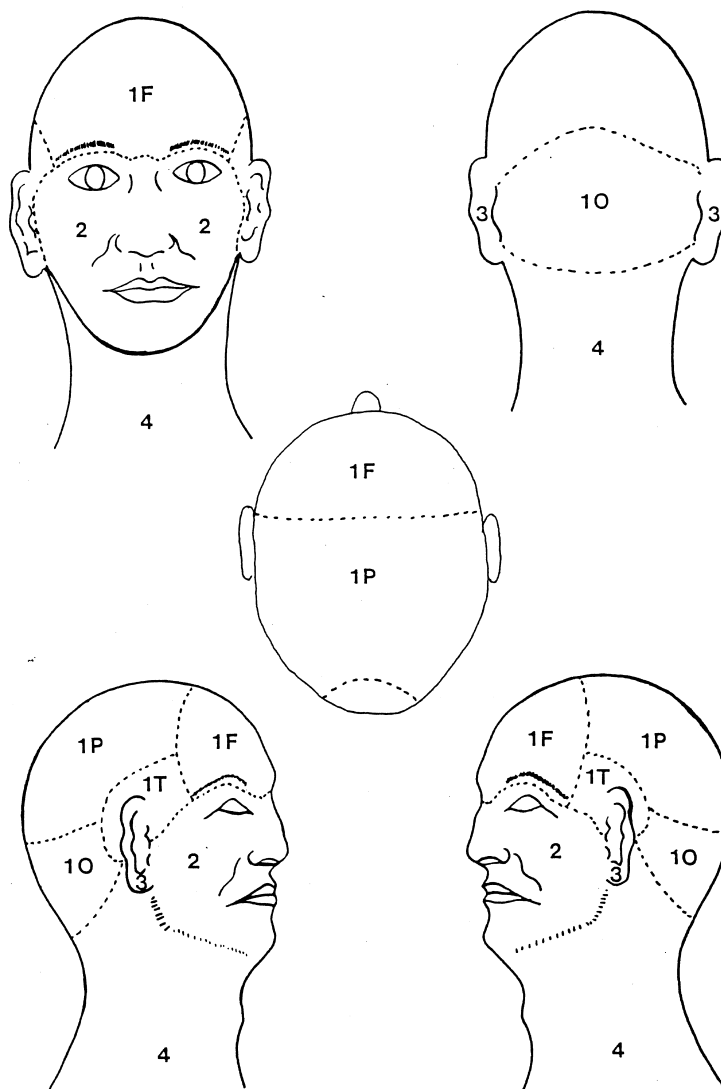
Fig. 1. Numbered anatomical sites; the head and neck.

composite diagrams (Figs. 3–5). The sites of old external bruises were recorded separately and then the total number of all external bruises in each location were expressed as a percentage of the total number for all cases (Figs. 6 and 7). Finally, the position of all additional internal soft tissue bruises were recorded (Table 1). Microscopic examination was performed by the original pathologist in any case where doubt existed whether the lesion was a bruise.

The presence or absence of retinal haemorrhages and subdural haemorrhages were recorded. Fractures, both old and new were noted, if present. The clinical history
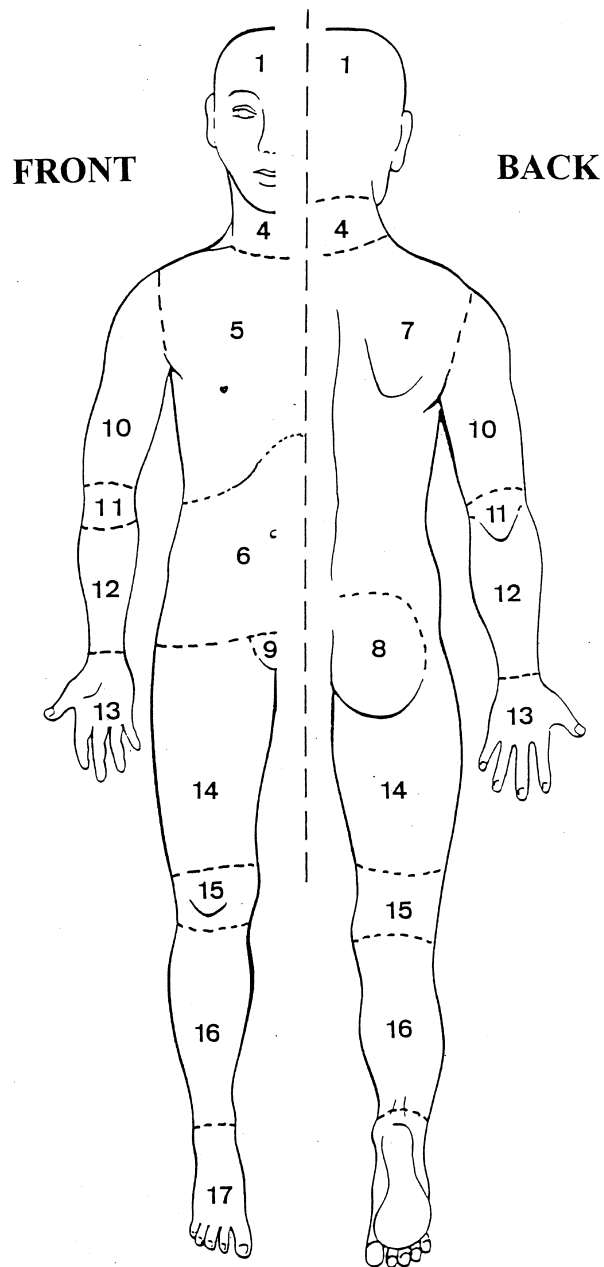
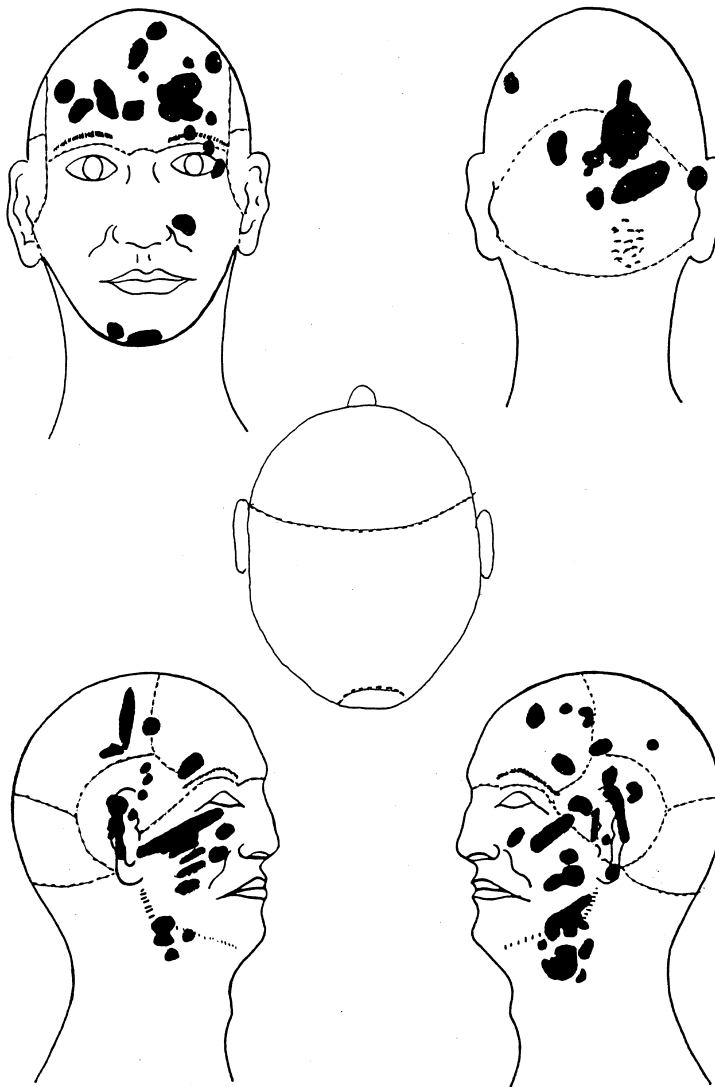Fig. 2. Numbered anatomical sites; front and back of body.

Fig. 3. Head and neck areas with composite bruising for all 24 cases.

obtained at the time of presentation of the infants to hospital, especially if bruising was present on admission, and any subsequent history of the circumstances related to the infant admission which may have been volunteered during interviews with the infant's carers were recorded. The time intervals between the incident and death, and between death and the autopsy were recorded (Table 1).

Finally, we recorded the clinical history, the pathologists' opinions as to the cause of death and the mechanism of injuries i.e. whether the infant was considered to have been shaken and/or showed evidence of blunt head trauma (Table 2).
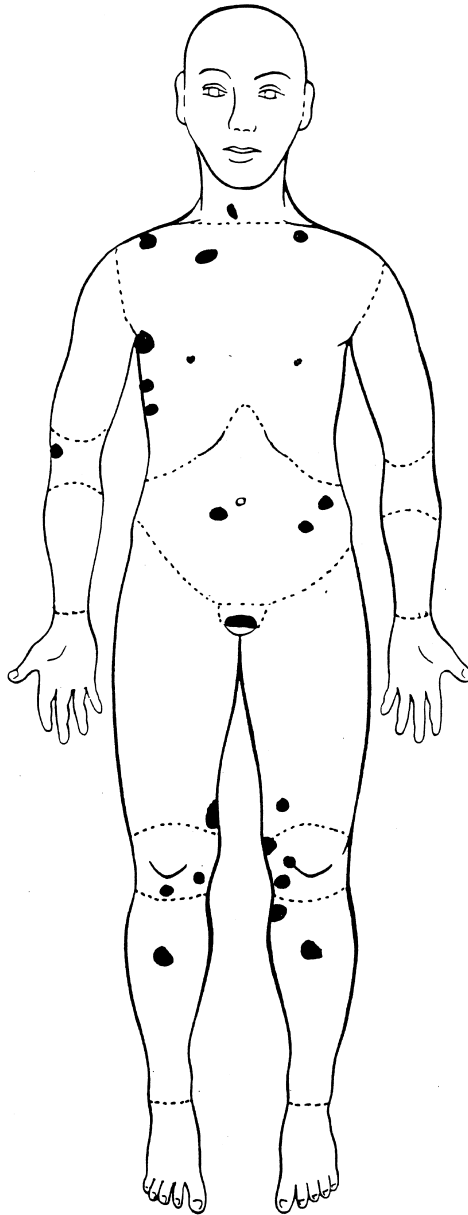
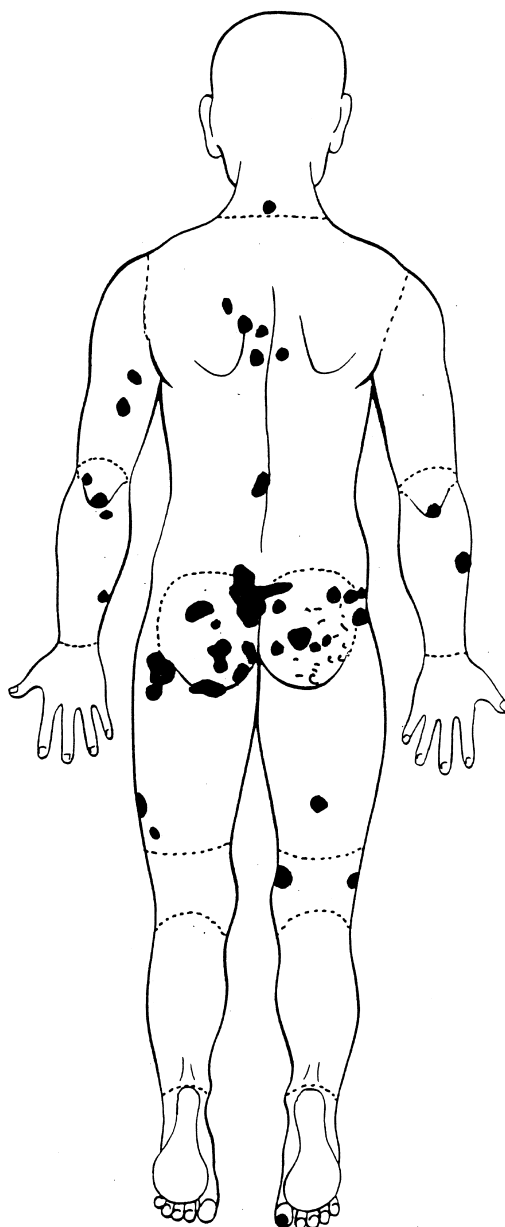Fig. 4. Frontal areas with composite bruising for all 24 cases.

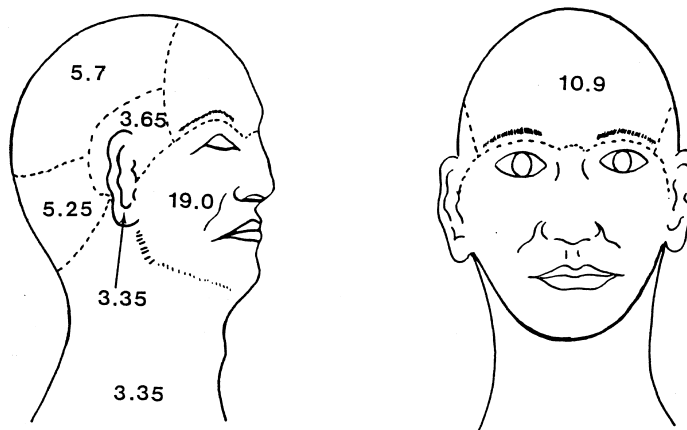Fig. 5. Back areas with composite bruising for all 24 cases.

Fig. 6. Head and neck areas with percentages for both old and new for all 24 cases.

3. Results

The 24 cases showed a male:female ratio of 14:10 with a mean age of 9 months (range 1.5–32 months). Seventeen (71%) cases had new external bruises, 15 (63%) cases had old external bruises and 13 (54%) cases had a combination of new and old external bruises. Seven (29%) cases showed no evidence of new external bruising. Of these, six had internal bruising to the face, scalp and chest. Only one case showed no fresh external or internal bruising. Five (21%) cases showed no evidence of either new or old external bruising but all had internal bruising with the head been the commonest site (Table 1).

Figs. 1 and 2 show the alpha numeric site coding system adopted in this study. Subsequent figures show the distribution of external bruises within these sites. The face (area 2) showed the greatest percentage of both new (16.4%) and old (2 1.6%) external bruising when considered individually as well as the highest percentage (19%) when considered together. The second commonest site was the forehead (area 1F) with 15.1% of new, 6.7% of old and 10.9% combined. The back (area 7) was the second commonest site of old external bruising (11.5%) when old bruising was considered alone. The buttocks (area 8) showed an equally high distribution of both new (11.1%) and old (12.2%) external bruising (Table 3).

External bruising to the limbs was found to be uncommon, with no external bruising to the anterior aspects of the upper limbs (included in areas 10 and 12), posterior aspects of the lower limbs (included in area 16) and no external bruising to the hands (area 13). Where external bruising occurred on the limbs, it was predominantly sited around the elbows and knees. Similar scanty external bruising was observed over the chest and trunk areas (areas 5 and 6).

Retinal haemorrhages were present in 23 out of 24 cases (96%). The exceptional case (case 19) was that of a child whose body had been exhumed after her twin was
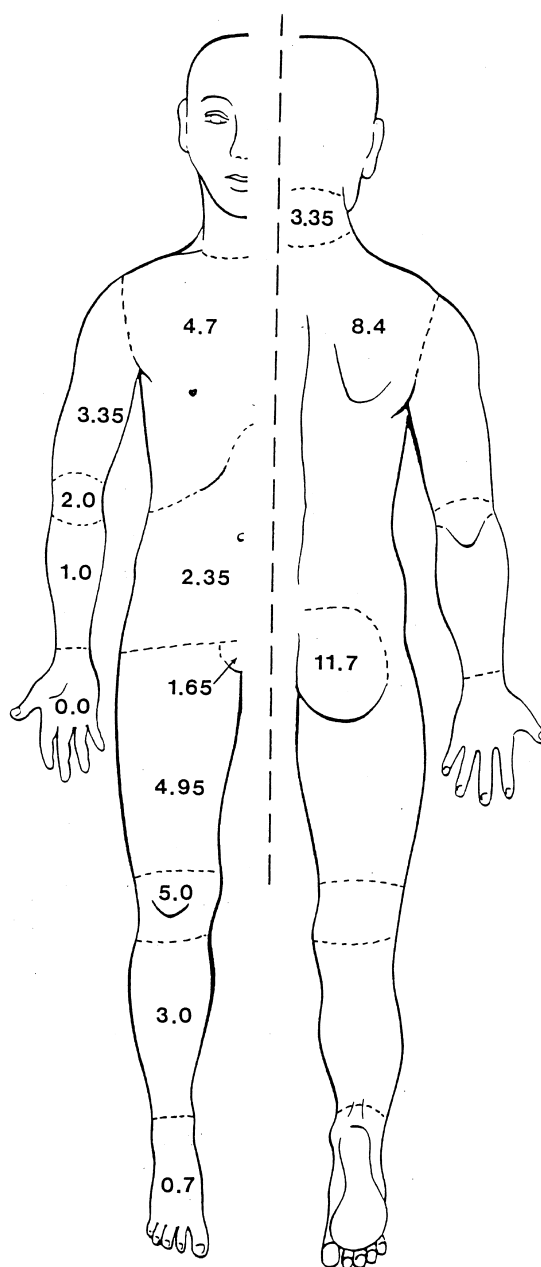
Fig. 7. Front and back areas with percentages for both old and new for all 24 cases.

Table 1
The site of bruising and timings related to the incident, death and autospy of 24 cases of non accidental head injured children

Case	Sites of old bruising	Sites of external bruising	Internal bruising not visible externally	Time from incident to death (days)	Time since death to autopsy (days)
1	–	–	Scalp	Unknown	1
2	1P,2,3,5,6,7, 8,10,14,15	2,4,14	1F,1P	0	1
3	2,4,5,6,	3	–	3	1
4	1P,1T,2,7	1P,1T	1T,1O	3	0
5	5,6,7	4	1F,1O	1	1
6	1P	1F	1F,1P	3	1
7	1T,2	1F,1T	1F,1T	0	1
8	1F,1T,2	–	1F,1T,,1P,1O	10	0
9	7	–	–	6	1
10	–	1P	1P	0	2
11	1F	1F,1P,1O,7,10, 14,15,16	1F	0	0
12	–	–	1O	4	0
13	–	1O	1P,1O,1T	2	0
14	1P,2	1F,1P,1T,2,3	1F	1	1
15	–	–	2	3	0
16	–	–	1F	14	1
17	1F	5,16	1F,1O	1	1
18	1P,1O,2,8,9,17	1P,1O,2,4,7,8,17	1P,1T,1O	0	0
19	–	–	1O,5	2	Buried
20	1P,1O,2,4,6,7, 12,14,15,16	1F,1T,1O,2,3,5,6, 12,14,15	1O,1P,5	1	0
21	1O,2,8,15	1F,1O,8,9	1F,1P,1O	1	0
22	–	1F,2,4,10	1F,1O,2	0	1
23	–	1F,1O	1O	5	1
24	1F,1T,3,5,10,12	1F,1O,2,7	1F,1T	1	1

subsequently admitted to hospital with signs suggestive of child abuse. Unilateral or bilateral subdural haemorrhages were present in all 24 cases.

Ten out of the 24 cases (42%) were found to have fractures of which seven (29%) had more than one fracture. Six cases had skull fractures of which four were unilateral. Two cases involved the occipital bones with extensions to the temporal or parietal bones. The remaining cases involved the frontal, panetal or temporal bones singly or in combination (Table 2). Three cases had rib fractures (two right sided, one left) which involved the 4th to 6th ribs; two of these had both old and new fractures and the remaining case had new only. Two of these showed no associated external bruising. The right clavicle was broken (fresh) in one case and three cases had fractures of the long bones (humerus, tibia and femur). One case with bilateral tibial fractures (case 16) showed no evidence of external bruising at the time of the autopsy but had associated internal soft tissue bleeding.

The original pathologists' opinions as to how the infant had sustained its injuries were

Table 2

The cases details, number of old and new external bruises, site and number of fractures and proposed mode of death in 24 cases of non-accidentally head injured children

Case	Sex	Age (months)	Clinical history	Number of bruises (old/new)	Mode of death	Fractures
1	F	7	Stopped breathing	–	Shaken	N
2	F	21	Collapsed at home	36/6	Shaken/Blunt Trauma	N
3	M	2.5	Shaken and thrown	4/2	Shaken	N
4	M	20	Fell onto a toy	10/6	Shaken/Blunt Trauma	N
5	M	2.5	Fell to floor whilst father changed nappy	4/1	Shaken	N
6	M	4	Father dropped baby as he stumbled over the family dog	2/1	Shaken/Blunt Trauma	Rt and Lt Parietal
7	F	2	Vomited during feed. During resuscitation father dropped twice	2/2	Shaken	N
8	F	11.5	Found unresponsive at home	8/–	Shaken/Blunt Trauma	N
9	M	3.5	Fell between knees whilst being rocked	7/–	Shaken/Blunt Trauma	N
10	F	4	Reluctant to feed. Became floppy	–/2	Shaken	N
11	M	6.5	Fell from rear child seat of a car into foot well during a journey	3/15	Shaken/Blunt Trauma	4th Lt and 6th Rt ribs
12	M	3	Fitted at home. Stopped breathing	–	Shaken	Rt humerus
13	M	3	Choked during feed	–/2	Blunt Trauma	Fronto–parietal
14	M	18	Fell out of bed and vomited. Mother attempted resuscitation	3/13	Shaken/Blunt Trauma	N
15	F	1.5	Child failing to feed. Father shook baby	–	Shaken/Blunt Trauma	N
16	F	1.5	Admitted to hospital. No history	–	Shaken/Blunt Trauma	5th and 6th Rt rib. Both tibias
17	M	1.5	Fell 3 feet onto carpeted floor and then rolled and hit head on hearth	1/4	Blunt Trauma	Rt and Lt skull Rt femur
18	M	11	Feed attempted at midnight. Dead in morning	18/13	Blunt Trauma	Lt temporal Lt occipital
19	F	3	Exhumed. Originally thought to be 'near miss' cot death so no autopsy	–	Shaken	5th and 6th Rt ribs
20	M	32	Fell downstairs	27/50	Blunt Trauma	Lt occipital to parietal Rt clavicle
21	M	24	Fell from potty rendering himself unconscious	19/9	Shaken/Blunt Trauma	N
22	F	4	Fell from car seat on a carpeted floor. Hit head on toy	–/14	Blunt Trauma	2×Rt parietal
23	F	5	Breathing difficulties	–/2	Shaken/Blunt Trauma	N
24	M	20	Fell from bed striking head on a toy.	8/10	Shaken/Blunt Trauma	N

Table 3
The percentage of new and old bruising in the different anatomical sites

Site of new bruise	New (%)	Old (%)	New and old (%)
1F	15.1	6.7	10.9
1P	5.3	6.1	5.7
1O	6.5	4.0	5.25
1T	4.6	2.7	3.65
2	16.4	21.6	19.0
3	4.0	2.7	3.35
4	5.3	1.4	3.35
5	4.0	5.4	4.7
6	2.0	2.7	2.35
7	5.3	11.5	8.4
8	11.1	12.2	11.7
9	1.3	2.0	1.65
10	2	4.7	3.35
11	2.6	1.4	2.0
12	0.7	1.4	1.0
13	0	0	0
14	7.2	2.7	4.95
15	3.3	6.7	5.0
16	2.6	3.4	3.0
17	0.7	0.7	0.7

noted. Seven cases (29%) were suspected to have been subjected either to one or more episode of shaking; five (21%) were considered to have received some form of blunt head trauma; twelve (50%) were thought to have sustained a combination of both types of trauma. The carers admitted to having shaken the infant in only five cases (21%). Of these five cases, three had no evidence of visible external bruising anywhere upon the body and only one had no internal bruising.

The mechanism of injury and the presence of bruising and skull fractures were correlated using three groups; shaken only, blunt head trauma only, and a combination of the two. It was found that of those suspected of being shaken only, 43% had no external bruising or skull fracture; all had internal bruising (cases 1, 12 and 19). In those suspected of receiving blunt head trauma only, all had fresh external bruising and skull fractures. In those who were thought to have sustained both types of injury, 33% had no fresh external bruising (cases 8, 9, 15 and 16) and only one had a skull fracture (case 6). Only one case in this group had no internal bruising (case 9).

4. Discussion

Non-accidental injury is an important cause of death world-wide and, in children less than 1 year old, is the commonest cause of head injury as typified by the Shaken Baby Syndrome [1]. Although Caffey (1946) is credited with first drawing attention to the combination of long bone fractures and subdural haemorrhages as a result of child abuse [5], Knight draws our attention to the fact that Ingraham had previously suggested in

1939 that some subdural haemorrhages in infants were traumatic in origin [6]. Kempe (1962) introduced the term 'battered child syndrome' which evolved into the clinical entity known as 'the abused child' [7] although this had been recognised in all its clinical entirety since Tardieu (1860) [8].

Bruises are common external manifestations of child abuse [9]. 79% of our cases showed either old or new external bruises either alone or in combination confirming previous reports that bruising may be present in up to 90% of physically abused children [10]. A racial difference has been reported with the suggestion that bruises are more frequently a manifestation of child abuse in whites than blacks [11]. The possibility that the bruise is a result of an accident must always be excluded by assessment of the history, site, pattern, stage of child development and the presence or absence of other bruises [12–15]. Accidental bruising is more likely to be found on surfaces overlying superficial bony edges e.g. shins, forearms, hips and eyebrows [16] whereas those on the buttocks, chest, abdomen and face, especially the cheeks, mouth and ears are more suggestive of abuse [4,17–19]. This bruising may be as a result of slaps, punches or gripping in which case 'fingertip' bruising may be observed.

The colour of bruises evolves with time. This change may be used as a rough guide in an attempt to age the bruise although it is notoriously inaccurate [20]. If there is any doubt that a lesion is a bruise, microscopic examination should be performed. However even this is not considered to be accurate since a bruise may take minutes to days to develop [4]. Yellow is the colour commonly accepted as the final shade of a bruise before it disappears. The ambiguity of ageing bruises is a result of several factors, including depth, size and thickness of the bruise, skin colouring, the amount of blood present at the site of injury, the location of the injury, and the relative position of the haemorrhage within the layers of the skin and subcutaneous tissues [21]. It is possible for two bruises inflicted at the same time on the same part of the body to be of different colours. At present there are several schemes which attempt to age bruises according to their colour [22]; none of these is reliable.

In general there is a paucity of literature concerning the distribution of external bruises in cases of non-accidental head injured children. The descriptions of a child being gripped about the chest or abdomen whilst being shaken or swung by the limbs might be expected to leave a mark in the form of an external bruise, although this observation is poorly quantified. Buchanan reviewed the injuries in 251 living, abused children and found the arms and legs a frequent site of bruising [23]: our findings do not support this report. The observation that 29% of our cases had no fresh external bruising also differs from that of Showers et al who quote a figure of 47% in their series [24]. The concentration of bruises on the cheeks and about the ears (Fig. 3) is typical of slaps and punches; their shapes, in the cases studied, were also more typical of such methods of causation rather than by gripping.

The reason for the paucity or complete lack of external bruising in those who have been gripped is probably multifactorial although to date it remains unexplained. Three of the five carers who admitted shaking their infants gave descriptive information regarding how they held the child. All three described holding the infant just below the armpits with their hands around the chest. Although an adult may be expected to grip the infant with more force than would be expected in the normal handling of an infant, this cannot

be confirmed. The degree of force used may also be insufficient to cause bruising. The additional presence of clothing may act as a barrier between the fingertips and underlying skin thus cushioning the grip.

Since a bruise may take an indefinable length of time to develop or may develop and disappear in a relatively short time, attention should be directed to the original hospital examination where bruising may have been recorded, but which is subsequently absent at the time of autopsy. An extensive internal examination including dissection of the limbs is also necessary to demonstrate bruises not yet visible externally at the time of the autopsy. In our series there were nine cases where death occurred three days or more following admission. Of these, two cases had external bruises at autopsy which were not present on admission. Five of the cases with no fresh external bruises at autopsy had prolonged time between admission and death but none had fresh bruising at the time of admission; four of these cases however had internal bruising, two of which had failed to develop external bruising 10 and 14 days respectively after the incident.

Head injury is the commonest cause of death in physical child abuse. Such children may be shaken, be struck about the head and face with the hand or fist, or be 'swung' against a hard surface such as a wall or item of furniture. The majority of paediatricians and many pathologists accept that shaking alone may cause death; some workers, e.g. Duhaime et al., believe that some form of impact must also occur [3]. Whatever the form of fatal head injury, the child must have been held in some way during the assault. The aim of this study was to review the distribution and severity of bruising, both external and internal, on a series of infants who had died of their head injuries.

The exact mechanism producing an intra-cranial injury remains controversial. Most authors favour a process of manual shaking resulting in a 'whiplash' type movement of the head on its fulcrum, the neck [1,25–27]. However, since the 'assault' is usually unwitnessed, others have questioned whether the action of shaking alone is sufficient to cause the head injury and whether an impact is also necessary [3,28]. In our study, the original pathologist considered that 29% had been shaken alone, 21% had sustained blunt head injury only and 50% had had a combination of both. On review of the cases which the original reporting pathologist had considered to have been due to shaking only, two had fresh external and five fresh internal bruising to the scalp area indicating an episode of fresh blunt trauma to this area which may have taken the form of an impact without a skull fracture, gripping or a slap or punch.

Five cases where death was considered to have occurred as a result of blunt head trauma showed external bruising of which 16% of all the new bruises in these five cases were on the face, 14% on the buttocks and 10% on the forehead. Three of the five cases (60%) had bruising in the occipital region. All these bruises were relatively large, measuring up to 10 cm in diameter. All five cases had skull fractures, although no distinct pattern emerged. Three had more than one skull fracture suggesting more than one blow to the head.

It is hypothesised that children may be gripped by the ankles [4] and swung to impact the head on a surface. Only one of these five cases showed limb bruising, one on each of the lower legs in the region of the knees. The limbs, however, were not fully dissected in the majority of the cases studied. Such a practice undertaken in the absence of any external evidence of injury, however slight, has in the past led to unfavourable comment

from the Coroners concerned. If any external bruise or abrasion was noted, it was incised. These injuries cannot be dismissed as an accidental injury due to the young age of the infant (1.5 months). Injuries to the lower legs and feet of infants in the pre-toddler age group are rare, in both clinical and pathological practice. Bruises about the shins and ankles, especially where they involve deeper tissues, are almost diagnostic of 'gripping'.

In those cases considered to have been subjected to both vigorous shaking and blunt head trauma, 67% had new external bruises, with 23% on the forehead, 19% to the face and 16% to the lower legs. The parietal region and buttocks respectively both accounted for 8% of all new external bruising. The high percentage of external bruising found on the lower legs in this group supports the idea of infants being held by their extremities and shaken/swung. Again, four of the cases however showed no new external bruising and none of these cases had skull fractures.

Retinal haemorrhages are quoted as being present in between 50% to 80% of shaken babies [29–31]. We found an even higher percentage of cases (96%) to have retinal haemorrhages, confirming their value as an indicator of child abuse.

This study illustrates the distribution and prevalence of external bruising in non-accidental head injured children. It highlights the fact that external bruising may be completely absent at the time of hospital admission as well as at the time of the autopsy even in the presence of a severe intracranial haemorrhage. Internal bruising is usually demonstrated at autopsy although it may not manifest externally despite a considerable time period between the incident and death.

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