Available online at www.sciencedirect.com
ScienceDirect
Forensic Science International 163 (2006) 93–101
Forensic Science International
www.elsevier.com/locate/forsciint

Representation of cerebral bridging veins in infants by postmortem computed tomography

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Received 1 August 2005; received in revised form 2 November 2005; accepted 7 November 2005
Available online 20 December 2005

Abstract

The postmortem diagnosis of shaken baby syndrome, a severe form of child abuse, may be difficult, especially when no other visible signs of significant trauma are obvious. An important finding in shaken baby syndrome is subdural haemorrhage, typically originating from ruptured cerebral bridging veins. Since these are difficult to detect at autopsy, we have developed a special postmortem computed tomographic (PMCT) method to demonstrate the intracranial vein system in infants.

This method is minimally invasive and can be carried out conveniently and quickly on clinical computed tomography (CT) systems. Firstly, a precontrast CT is made of the infant's head, to document the original state. Secondly, contrast fluid is injected manually via fontanel puncture into the superior sagittal sinus, followed by a repeat CT scan. This allows the depiction of even very small vessels of the deep and superficial cerebral veins, especially the bridging veins, without damaging them. Ruptures appear as extravasation of contrast medium, which helps to locate them at autopsy and examine them histologically, whenever necessary.

Keywords: Shaken baby syndrome; Bridging veins; Subdural bleeding; Postmortem computed tomography (PMCT)

1. Introduction

Shaken baby syndrome is a particularly severe form of child abuse. This is typically triggered when a crying baby cannot be comforted and the carer loses patience. The baby is grasped by the arms or round the chest (seldomly by the neck) and violently shaken. While the infant's head is severely thrown back and forth, the head can reach high levels of translational and rotational velocity. The consequences are diffuse axonal injuries (DAI) with brain swelling as well as injuries to the bridging veins with subsequent subdural bleedings [1,2]. In cases with a fast and massive increase of intracranial pressure, the subdural bleedings require comparatively little space.

Shaking can also be combined with direct injury to the head. These direct injuries can occur if, while being shaken, the baby's head is hit against a hard surface, such as a bed, wall, or other object (shaken impact syndrome).

Lethal infantile subdural haematomas in violently shaken infants with a lack of external signs of injury are repeatedly published in forensic and paediatric journals [3–6]. Investigators are frequently confronted with delinquents'

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0379-0738/$ – see front matter
doi:10.1016/j.forsciint.2005.11.015

self-serving declarations, such as the injuries resulted from falls from changing tables or other such minor accidents. As a consequence, it is forensically important to discriminate accidental causes and intentional violence [7–10]. There is, however, no universally valid appraisal procedure to help distinguish between these causes. Whenever several ruptures of bridging veins are detected, intense violence, such as severe shaking, is more likely to be the cause than a minor accident [11].

If the body exhibits no visible external signs of injury, only autopsy may help to exclude the possibility of misinterpretation as sudden infant death syndrome (SIDS). It should also be kept in mind that newborns sometimes suffer subdural bleedings from ruptured bridging veins as a delivery complication. Literature also reports anecdotal cases of foetal subdural haematomas caused by automobile accidents or assaults on the mother [12,13].

As the detection of ruptured bridging veins is difficult, even with established methods, we have developed a postmortem computed tomographic (PMCT) method to demonstrate the intracranial vein system in infants.

2. Current status of established methods

2.1. Standard method of brain removal

The technique used in forensic autopsies of infant brains depends on the age of the infant. In the early infant months, the skull sutures are soft and unossificated, so that a special head dissection method in newborns can be employed. In cases of older infants with suspected head trauma, the Flechsig cut can be used (Werkgartner [14]; Krauland [15]). With both techniques, in order to reduce the risk of artificial ruptures, less traction is applied to the parasagittal bridging veins than with other methods.

2.2. Head dissection in newborns

A common technique for opening the intracranial cavity of newborns is to use a special cut, in order to gain an overview of the tentorium and the falx in its entirety and to be able to discover possible ruptures. The result of this cut looks like the handle of a basket, so in German we talk about the ''Korbhenkelschnitt'' [17].

The typical procedure after removing the galea aponeurotica is to insert the scalpel into the region of anterior fontanel approximately 1 cm to the side of the midline and then cut the bone and dura with cartilage scissors, 1 cm parallel to the midline, back towards the occipital region. From there the cut is taken along the typical saw-cut line for adults up to the frontal region and then back to the anterior fontanel. If an adequate safety margin to the midline is left, the bridging veins are easily visible under the resulting ''basket handle'' strip of at least 2 cm (Fig. 1).

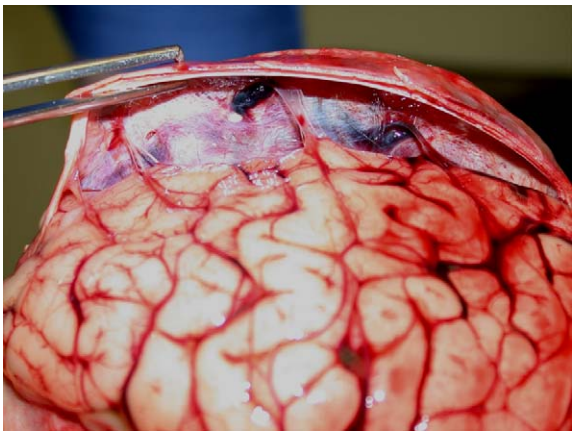

Fig. 1. The ''Korbhenkelschnitt''. The tweezers lift the rest of the skull and the bridging veins are easily visible under the resulting ''basket handle'' strip.

The disadvantage of this method is that after cutting the dura the blood runs out of the vascular system, so that the veins to be examined are collapsed.

2.3. Flechsig cut

The Flechsig cut is a special cut through the brain on a horizontal plane in situ before the calvarium is taken off (Werkgartner [14]; Krauland [15]) (Fig. 2). This technique has advantages over the removal of the whole brain: already at dissection it offers a good orientation of the intracranial and intracerebral situation. Moreover, this method reduces the traction to the parasagittal bridging veins. Although it is possible to see ruptured bridging veins of the lower brain surface if the brain is carefully extracted, it is not possible to see the parasagittal veins in the top half of the brain unless it is removed from the calvarium. If there are no particularly strong adhesions, the dura mater can be loosened from the calvarium along with the brain using a special long and curved spatula. The dura is then cut in strips starting from the lateral margin and going up to the parasagittal region in order to avoid damaging the individual veins.

This method however cannot be used if the dura is firmly attached to the bone, as is often the case with infants. In these cases, the bridging veins may be damaged postmortally. It is then difficult to prove vital injuries to bridging veins, in particular when the infant has died shortly afterwards. There does not then appear to be a satisfactory way to prepare the bridging vein ruptures without artificial damage.

2.4. X-ray examination according to Maxeiner

For this method the Flechsig cut is also used. After cutting through the brain on a horizontal plane in situ before the calvarium is taken off, a balloon catheter is placed and blocked in the occipital sagittal sinus and approximately 5–15 ml of contrast medium (barium sulphate solution) are