



## Pathology & Biology Section – 2008

### G11 Child Abuse: Practical Case of Autopsical, Radiological, and Anatomopathological Studies

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The goal of this presentation is to illustrate the potential of postmortem multislice computed tomography (MSCT) and magnetic resonance imaging (MRI) in cases of death secondary to child abuse.

This presentation will impact the forensic community by providing an example of forensic application of the MSCT and MRI.

A 17-month-old male baby was discovered pale and unconscious in his bed by her mother at home. An attempt of cardio-pulmonary massage was immediately begun by the father of the child. The medical rescue team was called by the mother. The reanimation attempt was unsuccessful and the rescue physician could only objective the death of the child. The reanimation performed was slight, with oxygen mask apposition and cardiac massage. No injection was performed. The external examination performed at home revealed that rigor mortis was already present and revealed the presence of numerous ecchymoses. The explanation of the parents was thought to be inconsistent with the corpse examination. The police investigators discovered that the family of the baby was known by the social services. Furthermore, a brother of the dead child had already been taken away from his family because of neglect. The dead child had been hospitalized one month prior because of a left humeral fracture. The parents explained that the child suffered from minor beta thalassemia and heterozygous drepanocytosis. The circumstances of home death of this baby were unclear and a medicolegal autopsy was ordered. Postmortem multi-slice computed tomography (MSCT) and magnetic resonance imaging (MRI) examinations were performed in order to determine cause of death of the baby and make an exhaustive visceral and skeletal study.

#### *Imaging study:*

- A full body MSCT exploration was performed the day of death. Axial MSCT was performed with a 16 x 0.75 mm collimation on a Sensation 16 unit (Siemens, Erlangen, Germany). Two- (2D) and three dimensional (3D) reconstructions were obtained on a Leonardo workstation (Siemens, Germany). 2D reconstructions were obtained using Multi Plane Reconstruction (MPR) and Maximum Intensity Projection (MIP) modes. 3D reconstructions were obtained using Volume Rendering Technique (VRT) mode. Image interpretations were performed by a board-certified radiologist.
- A focused cerebral postmortem MRI was also performed the day of death. Axial acquisitions were performed in spin-echo T1-weighted, T2-weighted, and T1-weighted gradient echo sequences. Image interpretations were performed by a board-certified pediatric neuroradiologist.
- A postmortem full body radiological study was performed in the medico-legal department. This study consisted of skull radiographs (antero-posterior and lateral incidences), thorax, abdomen and pelvis radiographs (antero-posterior incidence), upper and lower member radiographs.

*Autoptical and anatomic-pathologic studies:* autopsy was performed by two board-certified forensic pathologists. All three body cavities (cranium, thorax, and abdomen) were examined. Anatomic-pathology was performed after a fixation in 10% formalin.

Results of the different explorations were finally compared:

#### *Imaging study:*

- *MSCT:* On cranial CT, diffuse oedema was visible with loss of the gray/white matter differentiation. Spontaneous pericerebral hyperdensities were visible in left frontal and right temporo-parietal areas. No skull or face fracture was visible.
  - > On thoracic CT, no pleural or pericardic effusion was noted. Lungs appeared oedemato-congestive. Bone analysis revealed presence of 4 left rib fractures, with different MSCT aspects. One fracture concerned the posterior arch of the 6th rib, with osteosclerosis of its edges, attesting of the beginning of its consolidation. Two concerned the anterior arc of the 7th and 8th rib with a MSCT visible callus, attesting to their old productions. The last fracture was on the 9th rib, displaced, without MSCT consolidation sign.
  - > On abdominal and pelvic level, no bone traumatic lesions were visible. No visceral lesion was clearly visible, but the natural contrast due to lack of internal fat (as is common in adult cases) was obviously bad. However spontaneous intra hyperdensities were visible within the mesenteric root and in intra peritoneal situation behind the abdominal anterior wall. They were interpreted as possible fresh blood.



## Pathology & Biology Section – 2008

> The appendicular skeleton exploration confirmed the presence of a right humeral fracture with a callus, attesting to its old production.

- *MRI*: Bilateral subdural haematomas were visible in sub-fronto-parieto-temporal areas with varying signal intensities. They appeared as acute hematomas, with spontaneously hyper- and hyposignals on T2-weighted images. Subdural pericerebral hypersignal on gradient echo images were visible in left frontal and right temporo-parietal areas. A right frontal meningeal hemorrhage was also present. Interpeduncular and intra ventricular haemorrhages were also noted. Petechial haemorrhages within the posterior part of the corpus callosum were suspected.
- *Plain X-rays exploration*: It confirmed the callus of the right humeral shaft. Three left ribs fractures were noted, affecting the 7th, the 8th and the 9th ribs. No other bone traumatic lesion was noted.

### *External inspection:*

The body was thin stout build, naked, measuring 79 cm tall, weighted 8.6 kg. An immobilisation of the right upper member was noted, secondary to the fracture and the hospitalisation dating from one month. Anthropomorphic measurement revealed an increase cranial perimeter of 48 cm. Numerous ecchymoses were noted on the body. Red ecchymoses were noted on the face, in peribuccal localisation,

and bi frontal regions. Ruptures of fraenum, the tongue, and the superior lip were noted. Red ecchymotic lesions were also visible on both lower members. Brown ecchymoses of 0.5 cm in diameter were noted at the anterior face of the left hemi thorax.

### *Autopsy and anatomo-pathology:*

The scalp had a large hemorrhagic infiltration at its deep part, in right fronto-parietal regions, more limited in left frontal and right occipital regions. The right temporal muscle presented a hemorrhagic infiltration. No endo or exo cranial skull fracture was visible. However, a bilateral subdural hematoma was noted in fronto-parietal areas. A hematoma was also visible around the posterior fossa. The cervical spine was surrounded by epidural hematomas.

The chest exploration revealed presence hemorrhage around the 6th, 7th, 8th, 9th left ribs. Three calluses were found for the 7th, 8th, 9th left ribs. A consolidated callus was noted for the 6th rib. The inferior part of the right lung presented a hemorrhagic infiltration.

A periumbilical ecchymosis at the deep part of the anterior abdominal muscles was present. Many small bowel loops presented a superficial hemorrhagic infiltration.

A hematoma of the right kidney artery was found, continued by a retro peritoneal hematoma. A limited hemorrhagic intra peritoneal effusion was present.

Microscopic studies confirmed the existence of the rib fractures. The fracture located to the 6th rib presented a remodelling bone callus. The fractures of the 7th, 8th, 9th ribs presented cartilaginous callous. The right humeral shaft presented an ossifying cartilaginous callus.

Haemorrhagic infiltration was confirmed around the aorta, within the mesenteric root, the tongue, and within the anterior abdominal wall. The peri aortic, peri umbilical, and left flank haemorrhages were antemortem, contemporary of the death. The tongue lesions consisted of recent and old haemorrhages. The mesenteric root haemorrhage was antemortem, with inflammatory elements, permitting determination that it dated from several hours before death.

The subdural hematoma was confirmed to be acute. It presented polymorphonuclears and ischemic neuronal damage associated with a recent cervical spine epidural haemorrhage.

Several authors have compared postmortem imaging and autopsy results in neonatal death. MRI offers high resolution images of the entire neonate while leaving the body intact. Compared with other imaging techniques such as conventional x-ray and CT scan, the high spatial resolution and the high tissue contrast that can be generated by MRI are advantages. The different tissue contrasts that T1-, T2- or proton density weighted MR sequences provide can give additional information about the lesions or disease processes. Compared with autopsy, postmortem MRI has proven to be especially useful in the evaluation of the central nervous system. The high water content of the neonatal brain makes it difficult to handle during autopsy, even when adequately fixed. Subdural haemorrhages are the commonest type of injury found and this is in keeping with pathological evidence and studies using computed tomography. They are caused by damage to the bridging veins, which drain from the cortex into the superficial venous sinuses. It is important to note that different signal intensities of subdural haematomas do not necessarily indicate repeated bleeds at different times. Subtemporal blood is not well seen on CT, especially with its decreased multiplanar imaging capability. Extra-axial fluid collections can have the same density as cerebrospinal fluid on CT, and it is difficult to differentiate enlargement of the subarachnoid spaces and subdural effusions. MR is superior to CT when differentiating these extra-axial collections. Isolated subarachnoid haemorrhages can be difficult to detect on MR studies. MRI is useful at postmortem to direct the autopsy and brain cutting to focal areas of axonal injury.

Hart et al. in 1996 investigated the correlation between postmortem MRI of the head and autopsy findings in suspected child abuse. Autopsy was more effective in detection of subarachnoid hemorrhage, suture separation, extracranial injuries and very small hematomas. According to these authors, MRI findings were useful in directing



## Pathology & Biology Section – 2008

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the autopsy and brain dissection to focal areas of abnormality. They found that postmortem MRI and autopsy were complementary and that each may disclose abnormalities missed by the other. In half of the eight cases of child abuse examined in this study, the combination of MRI and autopsy added valuable information compared with the results of autopsy alone.

In this case, combination of MRI and MSCT were able to determine the diagnosis of child abuse. Indeed, multiple fractures, of different ages were diagnosed. Skeletal fractures were suggestive of non accidental injuries because of their localisations: posterior arch of one rib, and association of recent and old fractures. Presence of an old right spiral humeral fracture was suggestive of child abuse; spiral fractures are classically secondary to torsional force. Cranial MRI was highly suggestive of intentional trauma. The MRI aspects of peri-cerebral hematoma are clearly visible compared to MSCT images. This exploration confirmed the pericerebral bleeding and objectified lesion not visible at the autopsy time as intra ventricular hemorrhage.

Limits of the MSCT are well illustrated by this case: the lack of tissue contrast because of the lack of fatty tissue is the highest limit of the technique. It does not permit a correct examination of the visceral trauma and lesions. However, diagnosis of intra peritoneal bleeding was possible and confirmed by autopsy. For skeletal trauma evaluation, MSCT was more efficient in our case than plain X-Rays. However, Cattaneo stated that radiology detected only 47%, autopsy 65%, while CT scans detected 34% of rib fractures. Rib fractures are quite unusual even in the setting of severe accidental trauma in infants and rarely if ever result from vigorous cardiopulmonary resuscitation. These injuries are usually clinically occult and typically result from excessive anteroposterior compression of the chest during shaking or with impact. Involvement of the posterior arc of the rib is most common, although fractures occur at all rib sites in abuse. Rib fractures tend to occur at multiple levels at similar points along the arcs of adjacent ribs, are often symmetric, and most frequently involve the middle ribs.

In this case, the autopsy was superior to imaging for the diagnosis of hematoma of the right kidney with a retro peritoneal hematoma and cervical epidural spine hemorrhage. The anatomo-pathology study did not confirm the suspected petechial haemorrhage within the posterior part of the corpus callosum.

This case report illustrates the potential of MSCT and MRI concerning battered child exploration in terms of determination of cause of death, visceral and skeletal evaluations, and age determination of lesions thus permitting the diagnosis of child abuse.

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