Radiography xxx (2013) 1–5

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Review article

Can cross sectional imaging contribute to the investigation of unexplained child deaths? A literature review

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ARTICLE INFO

Article history:
Received 27 August 2013
Received in revised form
26 November 2013
Accepted 10 December 2013
Available online xxx

Keywords:
CT
MRI
Imaging
Autopsy
Post mortem
Medico-legal

ABSTRACT

Background: This review examines the factors that can influence an investigation into the unexpected death of a child before considering if using imaging techniques could be of benefit.
Method: A systematic search strategy was adopted to search databases using keywords, these results were then subjected to inclusion and exclusion criteria to filter and refine the evidence base further.
Discussion: More research is published on the use of MRI in comparison with other modalities. There is evidence in the case of MRI in particular that its use could be of benefit in identifying and ruling out potential causes of death in children.
Conclusion: More research is needed on the use of CT but the routine use of MRI in child death investigation could now be considered. Ethical considerations appear to be a barrier to research in this area and discussions as to how such considerations can be overcome is necessary.

Introduction

The purpose of this review is to identify and critically appraise the evidence that could support the increased use of cross sectional imaging in the investigation of child deaths that are initially unexplained. Should the evidence be sufficient, the routine introduction of imaging into autopsies on children could result in greater accuracy, speedier establishment of cause of death and a less invasive overall procedure.

Epidemiology

The death of a child remains a tragic but thankfully rare event. The Department of Education (2010) reports an estimated 5000 child deaths per year in the UK. This figure incorporates a significant proportion of neonatal deaths and 65% of child deaths in 2009–2010 were under one year of age.[1] The Office of National Statistics identified 254 unexplained deaths of infants accounting for 8% of overall infant deaths in 2010. This figure incorporates sudden infant deaths (SIDS) and cases where cause of death is reported as unascertained, such as deaths involving fire.[2]Creighton and Tissier (2003) report an average of 79 child homicides per year.[3]

The overwhelming majority of child deaths can have a cause attributed to them. However the statistics are significant in terms of unexplained deaths and homicide as a high number are still regarded as “unexplained”. Both in cases where cause of death can be attributed and those cases where it cannot, high level investigations are required to ensure causes of death are ascertained. In addition, the investigation must make sure that the burden of proof as to a person’s guilt or innocence is reached and when possible, that closure is brought to surviving relatives. For many years, the autopsy or post mortem has remained the cornerstone of medico-legal practices but there is growing evidence that forensic radiology could be of considerable benefit to any investigation into an unexplained death of a child. The work of numerous centres, notably the Virtopsy™ project in Switzerland has seen the evidence base for the use of forensic radiology grow dramatically.[4]

Investigating the unexplained death of a child

“Sudden infant death syndrome” (SIDS) became a registerable cause of death in the UK in 1971 and the rather non-specific term “cot death” has been in use since the 1950s. Considerable conjecture still exists around these terms. In essence, SIDS is a diagnosis of exclusion, when no other cause of death can be identified. However, ruling out homicide as a cause of death remains a highly important step. A multi-disciplinary approach is necessary to ensure no important evidence in the investigation of an unexplained death is

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1078-8174/$ – see front matter © 2013 Published by Elsevier Ltd on behalf of The College of Radiographers.
http://dx.doi.org/10.1016/j.radi.2013.12.004

missed.[5] The involvement of different disciplines in an investigation is of paramount importance with the legal principle of beyond reasonable doubt being of great significance.[6] The greater amount of evidence that involvement of imaging may provide could represent the difference between that standard being made or not.

The acronym SUDI or Sudden Unexplained Death of an infant is used in some countries as an umbrella term that encapsulates not just those that die of SIDS but other unexplained deaths.[7]

Table 1 from Busuttil and Keeling (2009) demonstrates factors that would cause concern in an investigation of an unexplained death of a child:

Of the estimated 500 child deaths per year, a large proportion occur in hospital, particularly in the neonatal period. The significance of this is that these children are more likely to have been under medical observations in the immediate pre-death period. A large proportion of these will be those born prematurely and/or in respiratory distress, those with known intra-uterine pathology and those who have had a traumatic birth that result in admission to a special care baby unit or similar unit. Being present at such a unit means their vital signs will be monitored immediately prior to death meaning a cause of death can potentially be more easily attributed and the child would be expected to be under close observation, thus reducing the likelihood of external interference. The 2008 CMACE study gave the most common causes of neonatal deaths to be as a result of respiratory disorders (37.7%), major congenital abnormality (21%) and neurological disorders (14.2%). Unexplained deaths accounted for 2% of the population from this study that reflects the neonatal period only (Tables 2 and 3).[8]

Potential causes of sudden death of a child

Most instantaneous deaths will be cardiovascular in origin and are likely to be related to congenital heart disease (CHD). Pathologists are likely to be alerted to the presence of CHD by cardiomegaly visualised at post mortem. A genetic metabolic disease and bacterial and viral infection also represents common causes of child death. Within the neonatal period, hypoxia at birth and acute intestinal obstruction are considered more common causes of death.[6]

Imaging with autopsy

Until the 1970's, the X-ray examination was the only imaging readily available. Since that time, other imaging techniques have been developed to the clinical benefit of patients globally. In forensic practice, use of imaging incorporates chiefly X-rays, CT and MRI scanning. Whilst the former has been in use for many decades,[4] the use of CT and MRI scanning in forensic medicine is a more recent phenomenon with particular progress since the advent of MDCT (multi-detector computed tomography). Levy and Harcke (2011) regard cross sectional imaging as making radiology's contribution to autopsy more effective, potentially increasing accuracy and speed.[6]McPhillips in Busuttil and Keeling (2009) identifies that post mortem imaging in paediatric deaths is rarely used but does bring potential benefits.[7] These benefits are given as high resolution volumetric scans being obtained in a short time but do acknowledge the time taken to report such images. Anecdotal evidence suggests that limited access to the scanners may preclude the use of cross-sectional imaging.

Table 1
Factors in the history causing concern in SUDI (Sudden Unexplained Death of an Infant).[7]

Many GP/accident and emergency attendances without clear evidence of illness
Apparent life threatening events (ALTEs), especially if more than one and starting at less than 4 weeks of age and un-witnessed or if the same person finds the baby each time.
Age under 1 year
Epistaxis
Seizures- especially unexplained
Death occurs during the day when the baby was apparently well earlier
ALTE in siblings
Previous SUDI in sibling
Death on anniversary of previous SUDI
Parental involvement with the media after child's death

Table 2
Characteristic imaging findings in non-accidental trauma.[10]

Metaphyseal corner ("bucket handle") fractures
Fractures in different stages of healing/periosteal reaction
Spiral fractures in infants and toddlers
Fractures caused by unusual mechanisms (such as to the posterior ribs)
Fractures in unusual locations (such as to the thoracic spinous process)
Multiple skull fractures

Radiological signs raising suspicion of homicide in children

In living patients under two years of age, skeletal surveys are undertaken to demonstrate any potential sign of mistreatment. The 2008 report from the Royal College of Radiologists and Royal Society of Paediatrics and Child Health gave firm guidance as to the imaging techniques to be used in cases of suspected non accidental injury (NAI). Such guidance is based upon specific injuries that could be regarded as suspicious, particularly in the absence of coherent clinical history. This skeletal imaging has been the historical method of examining children and this 2008 guidance does begin to introduce other imaging techniques into the examination.[9] Blickman et al. (2009) listed the following skeletal injuries as characteristic of non accidental trauma:

Given that the musculoskeletal system changes little in the period immediately after death, these characteristic signs could still be visualised on a post mortem skeletal survey. Blickman et al. (2009) also identify parieto-occipital subdural haematoma, hepatic or splenic tears, dudodenal haematomas and pancreatic injury as suspicious injuries that can be identified by computed tomography.[9] However, questions may remain about the reliability of post mortem soft tissue imaging given the physiological changes that would occur and how they may manifest themselves.

Absence of any radiological signs of NAI may be reassuring but would not definitively rule out abuse. Follow up imaging should also be considered in some cases.

Pathological appearances raising suspicion of abuse

Busuttil and Keeling (2009) listed the findings seen at post mortem that may raise suspicion of an un-natural cause of death.

Table 3
Pathological findings causing concern.[7]

Petechial haemorrhages on face or neck
Pallor around nose/mouth
Torn frenulum
Bruises
Heavily blood stained secretions from mouth/nose
Blood in pharynx
Rib fractures (recent or old)
Any other injury
Blotchy haemorrhages on lung
Alveolar haemorrhage>10% alveoli
Siderophages in lung

Please cite this article in press as: Beck JJW, Can cross sectional imaging contribute to the investigation of unexplained child deaths? A literature review, Radiography (2013), http://dx.doi.org/10.1016/j.radi.2013.12.004