

## **CQ47 Can Postmortem Images of Children Obtain Anatomical Information Comparable to an Autopsy?**

### **Grade of recommendations: C1**

Postmortem MRI of children, when combined with a minimal biopsy, usually provides anatomical information comparable to an autopsy.

The central nervous system, heart, urinary tract, and musculoskeletal system usually display a high degree of agreement between MRI and autopsy findings. Although the sensitivity to detect lung infections and intestinal abnormalities is low, most abnormalities can be excluded if the MRI is negative after death because of its high specificity. With CT it is effective to detect traumatic changes. Ultrasonography also provides excellent diagnostic findings in the visualization of congenital malformations. Generally, sensitivity is low but specificity and negative predictive values are high.

### **Explanation-----**

#### **Postmortem images with childhood deaths**

Because the cause of death in childhood differs greatly from that in adults, the usefulness of postmortem images in estimating the cause of death may differ from that in adults. When the degree of agreement with the anatomy is used as a reference standard, the degree of diagnostic accuracy of various diagnostic methods such as plain radiographs, postmortem CT, postmortem ultrasound, and postmortem MRI should be described. In addition, it should be noted how postmortem MRI change in diagnostic accuracy depending on the organs and pathological conditions.

#### **Plain radiography with newborns**

There has been a report of the effectiveness of routine postmortem imaging in all cases of childhood death [1]. Postmortem plain radiography was performed on all deaths at a single institution during neonatal and infancy, and a study report of 1,027 cases was conducted for the purpose of diagnosing and evaluating bone dysplasia, fractures, and other bone abnormalities. As a result, the detection rate of abnormal findings was 12.3%, 33 accidental findings, 19 meaningful findings, 20 diagnostic findings, and 2 false positive findings were identified. Only 2 of 739 cases (0.27%) could not detect abnormalities without a routine X-ray examination. It has been concluded that cost-effectiveness is not good in all cases and that reasonable selection criteria for postmortem image recording should be established [1]. However, in this study, the examination method was simple radiography, and the targeted diseases were limited to bone dysplasia, fractures, other bone abnormalities, and diseases with a considerably low prevalence. It must be kept in mind that a low detection rate does not immediately indicate the sensitivity or specificity of a test.

### **Comparison of postmortem CT and postmortem MRI**

A comparison of autopsy and postmortem CT/MRI diagnostic capabilities was reported for 82 patients (53 fetuses, 29 children) with regard to the main pathological findings related to the cause of death and five body organ systems [2]. Postmortem MRI showed a correct diagnosis in 24 of 55 cases, 43.64% (31.37 to 56.73%). The correct diagnosis with postmortem CT was 18 out of 55 cases, 32.73% (21.81 to 45.90%), and postmortem MRI was deemed superior. Postmortem CT had a low diagnostic accuracy of 28.6% (8.1 to 46.4%) especially in fetuses under 24 weeks from gestation [2].

### **Examination of the usefulness of postmortem ultrasound**

Ultrasonography has become the main method for diagnostic imaging with living children. Ultrasonography can also be expected to be as useful as postmortem images. Comparing postmortem ultrasonography and autopsy determinations in 75 cases for the visualization of birth defects in fetuses showed a sensitivity of 81.5% (63.3-91.8%) and a specificity of 97.9% (89.1-99.6%) in detection of brain abnormalities. In particular, the sensitivity and specificity in fetuses of less than 24 weeks was 100%. Abnormalities in the lungs, heart, abdomen, and urinary tract show large differences in sensitivity from 18.2 to 100%, but specificities are consistently reported to be 100% [3].

### **Postmortem MRI of fetal and childhood deaths**

The most systematic evaluation of postmortem images of fetal and childhood mortality is the UK postmortem series of MRI studies [4, 5].

There is a systematic review [5] that examines the accuracy, acceptability, and cost-effectiveness of postmortem MRI [5]. Patients from 9 studies meeting the inclusion criteria were extracted from 539 papers and compared with 146 fetuses, 11 children, and 24 adults [5]. The sensitivity and specificity in determining the cause of death or the clinically most important findings by postmortem MRI were as follows: fetus 69%, 95%; pediatric 28%, 64%; and adult 28%, 64%, respectively. Relatively high sensitivity and specificity were observed in fetuses, but not in postnatal children and adults [5].

The results of this systematic review showed that the published data on postmortem MRI were small in number, varied, and had poor study designs, and the data on the acceptance rate and economic efficiency were insufficient. As a result, the following large-scale forward-looking study was conducted to more closely evaluate the value of postmortem MRI and examine whether it could replace conventional autopsy with limited autopsy findings with minimal invasiveness [4].

### **Results of a large-scale forward-looking study by postmortem MRI**

Two centers in London have been investigating the degree of agreement between postmortem MRI and conventional autopsy findings in delineating major morbidity-related morbid findings [4]. In

addition to postmortem MRI of the whole body, the clinical course, antemortem/postmortem specimen examination, and other image examinations are combined [4]. Subjects were examined for 4.5 years (without exclusion criteria), divided into 24 weeks or less, fetuses older than 24 weeks, and children under 16 years of age.

A total of 400 cases were included, including 277 fetuses and 123 children, and 357 cases (89.3%, 95% CI 85.8-91.9) had postmortem MRI consistent with normal dissection findings. By age, 175/185 cases for fetuses under 24 weeks (94.6%, 90.3-97.0), 88/92 cases over 24 weeks (95.7%, 89.3-98.3), 34/42 cases for newborns (81.0%), 66.7-90.0), 45/53 infants more than 1 month old (84.9%, 72.9-92.1), and 15/28 infants aged 1-16 years (53.6%, 35.8-70.5). Overall, the lower the age, the better the rate of agreement was obtained [4].

In 165 patients (41.3%), the conventional method of autopsy was determined to be unnecessary but was actually performed, and the rate of agreement between postmortem MRI and conventional autopsy was high at 99.4% [4].

The accuracy of postmortem MRI is lower in older children, when it is evaluated from the clinical course and test values, it was comparable to conventional autopsies in delineating causes of death and major pathological findings in fetuses, newborns, and infants [4]. In addition, it was concluded that for postmortem MRI it is easier to obtain consent from the family and it can be an alternative to the conventional autopsy when selecting and differentiating cases [4].

### **Diagnostic accuracy of postmortem MRI by organ**

The 400 subjects in this study were reported by the Magnetic Resonance Imaging Autopsy Study (MaRIAS) Collaborative Group, with diagnostic accuracy by organ and disease by reference to the degree of agreement with conventional autopsies. The results are shown in the table below [6-10].

The central nervous system shows high diagnostic accuracies for dysplasia and hemorrhages, but the sensitivity of ischemic changes in antemortem was only 68.0% (48.4 to 82.8%) [6].

In the chest, the accuracy of the heart malformation diagnosis was very high [6], but the sensitivity for lung abnormalities was low at 39.6%, and the sensitivity to lung infection was very low at 12.5% [8]. The specificity and negative predictive value of lung abnormalities are close to 100%. Postmortem MRI of the lungs without abnormal findings was found to be useful in that most important chest lesions at the time of the autopsy can be excluded [7].

In the abdomen, sensitivity to intestinal abnormalities is a low 50%, but specificity and negative predictive values are above 90%, and the agreement with overall anatomy is 87.4% (83.6 to 90.4%). It has been concluded that postmortem MRI are a useful alternative or adjunct to autopsy for detecting abdominal anatomical abnormalities [9].

Postmortem MRI sensitivity to musculoskeletal abnormalities is low at 51.1% (37.0-65.0%), but specificity and negative predictive value are high at 98.2% (96.2-99.2) and 93.8% (90.8, 95.9).

Abnormalities are more likely to be ruled out if the postmortem MRI finding is negative, in some cases, abnormalities in areas not examined by a conventional autopsy may be determined by postmortem MRI, and clinically useful abnormalities may be identified even when they are not directly related to the cause of death [10].

**Table** Diagnostic accuracy of postmortem MRI by organ/pathology

	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
CNS abnormality [6]	87.5%	74.1%	62.8%	92.2%	78.6%
Brain malformation	80.1 – 92.4%	68.0 – 79.4%	55.0 – 70.7%	87.4% - 95.3%	73.9 – 82.6%
Intracranial bleeding	88.4%	95.2%	73.1%	98.2%	94.3%
Antemortem ischemic changes	75.5 – 94.9%	92.1 – 97.1%	59.7 – 83.2%	95.9 – 99.2%	91.3 – 96.4%
	100.0%	99.1%	87.0%	100.0%	99.1%
	83.9 – 100%	97.2 – 99.7%	67.9 – 95.5%	98.8 – 100%	97.4 – 99.7%
	68.0%	96.1%	58.6%	97.4%	94.0%
	48.4 – 82.8%	93.4 – 97.8%	40.7 – 74.5%	94.9 – 98.7%	91.0 – 96.1%
All heart abnormalities [7, 8]	72.7%	96.2%	72.7%	96.2%	-
Cardiac anomalies	58.2 – 83.7%	93.5 – 97.8%	58.2 – 83.7%	93.5 – 97.8%	-
	92.6%	99.1%	89.3%	99.4%	-
	76.6 – 97.9%	97.4 – 99.7%	72.8 – 96.3%	97.8 – 99.8%	-
Chest abnormalities other than of the heart [7]	39.6%	85.5%	53.7%	77.0	71.8%
	31.0 – 48.9%	80.7 – 89.2%	42.9 – 64.0%	71.8 – 81.4%	67.1 – 76.2%
Lung infection	12.5%	92.6%	25.0%	84.2%	79.3%
	5.9 – 24.7%	88.6 – 95.2%	12.0 – 44.9%	79.3 – 88.1%	74.3 – 83.6%
Abdomen [9]	72.5%	90.8%	64.1%	93.6%	87.4%
	61.0 – 81.6%	87.0 – 93.6%	53.0 – 73.9%	90.2 – 95.8%	83.6 – 90.4%
Kidney	80.0%	98.6%	83.3%	98.2%	97.0%
	60.9 – 91.1%	96.4 – 99.4%	64.1 – 93.3%	95.9 – 99.2%	94.5 – 98.4%
Intestine	50.2%	95.2%	26.3%	98.2%	93.7%
	23.7 – 76.3%	92.1 – 97.1%	11.8 – 48.8%	95.9 – 99.2%	90.3 – 95.9%
Musculoskeletal system [10]	51.1%	98.2%	79.3%	93.8%	92.7%
	37.0 – 65.0%	96.2 – 99.2%	61.6 – 90.2%	90.8 – 95.9%	89.7 – 94.9%

## Literature search formula and literature selection (2019/6/2)

PubMed

#	Search formula	Number of documents
1	Search (((("postmortem imaging") OR "postmortem CT") OR "postmortem MRII") OR "postmortem computed tomography")	726
2	Search (("infant") OR "child") OR "adolescent"	3,695,381
3	Search (#1) AND #2	160

## References

- [1] Arthurs OJ et al: Routine perinatal and paediatric post-mortem radiography: detection rates and implications for practice. *Pediatr Radiol* 2013; 44: 252-257 (Level 5)
- [2] Arthurs OJ et al: Comparison of diagnostic performance for perinatal and paediatric post-mortem imaging : CT versus MRII. *Eur Radiol* 2016; 26: 2327-2336 (Level 4a)
- [3] Tuchtan L et al: Diagnosis of congenital abnormalities with post-mortem ultrasound in perinatal death. *Diagn Interv Imaging* 2018; 99: 143-149 (Level 4b)
- [4] Thayyil S et al: Post-mortem MRI versus conventional autopsy in fetuses and children: a prospective validation study. *Lancet* 2013; 382: 223-233 (Level 4b)
- [5] Thayyil S et al: Diagnostic accuracy of post-mortem magnetic resonance imaging in fetuses, children and adults: a systematic review. *Eur J Radiol* 2010; 75: e142-148 (Level 4a)
- [6] Arthurs OJ et al: Diagnostic accuracy and limitations of post-mortem MRI for neurological abnormalities in fetuses and children. *Clin Radiol* 2015; 70: 872-880 (Level 4a)
- [7] Arthurs OJ et al: Diagnostic accuracy of post-mortem MRI for thoracic abnormalities in fetuses and children. *Eur Radiol* 2014; 24: 2876-2884 (Level 4a)
- [8] Taylor AM et al: Postmortem cardiovascular magnetic resonance imaging in fetuses and children : a masked comparison study with conventional autopsy. *Circulation* 2014; 129: 1937-1944 (Level 4a)
- [9] Arthurs OJ et al: Diagnostic accuracy of post mortem MRI for abdominal abnormalities in foetuses and children. *Eur J Radiol* 2015; 84: 474-481 (Level 4a))
- [10] Arthurs OJ et al: Diagnostic accuracy of postmortem MRI for musculoskeletal abnormalities in fetuses and children. *Prenat Diagn* 2014; 34: 1254-1261 (Level 4a)