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# Principles of fetal postmortem ultrasound: A personal review

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ABSTRACT

Postmortem imaging has produced much scientific literature in the recent years in the medical literature, including fetal death conditions, but ultrasound is the least studied imaging modality although it is the most widely used in the living fetus and newborn. We describe the experience of our department in 20 years of postmortem fetal ultrasounds. Through more than a thousand cases analyzed, we describe the technique and images obtained by post-mortem ultrasound in the particular setting of fetal death. We will discuss its abilities and limitations.



## 1. Introduction

There are 2 main reasons for the rapid growth of postmortem imaging in the field of fetal death. The first one is the worldwide shortage of foetopathologists and the second is an increase in the proportion of refusals for autopsy in this setting [1–4]. This rapidly raised the rationale for alternative methods to maintain the quality of post-mortem reports, which were until now mainly based on standard autopsy [5]. Imaging definitely can play a major role, all the more so as the diagnostic accuracy of antenatal imaging has dramatically increased. Ultrasound is the least investigated post-mortem imaging modality [6].

Foetopathology encompasses two different situations. The first one is unexpected in utero death (IUD) at any stage of pregnancy, whether or not a cause was suspected on the basis of clinical data and/or prenatal imaging. The second one is medical termination of pregnancy (TOP), which is allowed in France until the last day of pregnancy. In the first setting, the goal is to try to establish the cause of death to offer adequate counseling for a future pregnancy. In the second setting, the aim is to achieve the comprehensive assessment of fetal malformations in order, ultimately, to improve prenatal counseling as far as a risk of recurrence can involve a future pregnancy.

There are basically 3 etiologies of fetal death: malformation (TOP and IUD), infections (placental and fetal) and vascular conditions (mostly placental), making investigations less complex than in a forensic setting.

A comprehensive review of the literature referenced in PubMed addresses only five articles, which address the question of post-mortem ultrasound [7–11].

Chronologically, the first article written by Furness et al. includes fetuses and newborns for which autopsy was refused [7]. This article introduces the use of ultrasound as an alternative to autopsy in targeted situations, in addition to standard radiographs. Then, during a 10-year period no other article was published to support this preliminary report, despite the contemporary dramatic evolution of this technique.

The second article, by Fariña et al., refers to an adult population (89 patients) but also 19 children [8]. This is a comparative study between an ultrasound-guided autopsy (histological samples by ultrasound-guided biopsies) and conventional autopsy. The diagnostic agreement between the two techniques for determining the cause of death was 83%. This study concluded that ultrasound was valuable in situations of autopsy refusal or infectious diseases, thus supporting the potential value of ultrasound as a tool to guide postmortem-targeted biopsies.

The third article was published in a journal of legal medicine, by Uchigasaki et al., and reports post-mortem ultrasound experience in 158 adult patients [9], describing the sonographic findings without comparison to standard autopsy.

The fourth article, written by Charlier et al., compares the results of ultrasound and autopsy in 38 adult patients [10], concluding by a very limited interest of postmortem ultrasound in a forensic setting.

The latest study, published in 2014 by Cain et al., shows the potential value of ultrasound in addition to autopsy in cases of in utero fetal death in only two young macerated fetuses [11].

## 2. Principles of fetal postmortem ultrasound

In our department, we have achieved more than 1000 post-mortem fetal ultrasound examinations over a period of 20 years.

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Whole-body radiographs are still routinely performed in our imaging department and in all cases of TOP where autopsy is refused or the foetopathologist believes it is worthwhile, an ultrasound scan is performed in addition to X-ray.

Examinations were performed on a Philips iU22 system (Philips Healthcare, Eindhoven, The Netherlands). Three probes were used: 8–5 MHz micro-convex probe (mainly for brain study), 12–5 MHz linear probe (for almost all other explorations) and 17–5 MHz probe especially for the youngest fetuses ( < 18–20 WG) and superficial explorations.

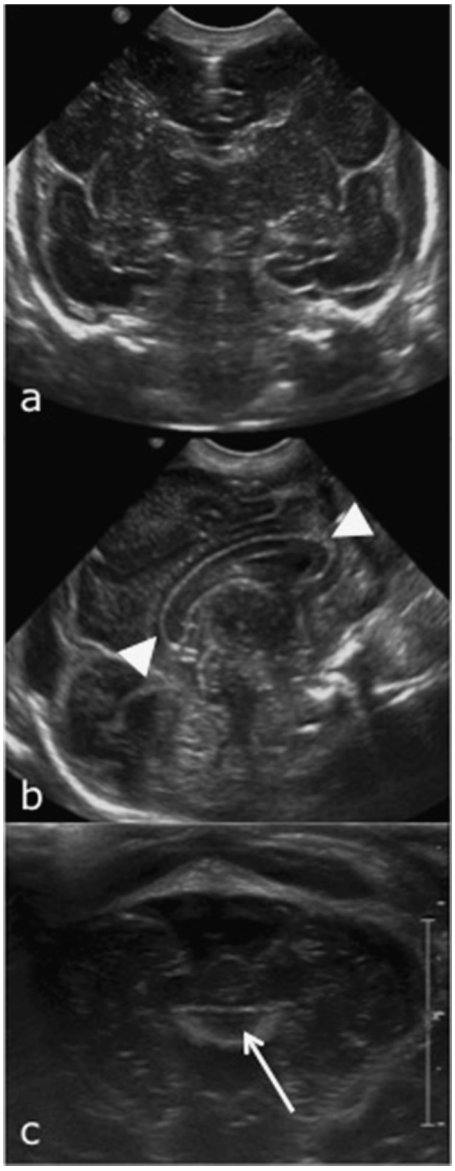


**Fig. 1.** Normal brain in postmortem US: with micro-convex probe (8–5 MHz) in coronal (a) and sagittal planes (b) by the anterior fontanelle window with the corpus callosum (arrowheads) and posterior fossa with high-frequency linear probe (12 MHz) by occipital window in prone position (c), showing the forth ventricle (white arrow).

Unlike in deceased adults and children, fetal post-mortem ultrasound study can be exhaustive. Image resolution is excellent compared to living patients, even with poorer contrast resolution, probably due to body temperature, a postmortem change known for MRI [12]. Circulatory arrest in organs is also likely to alter their acoustic properties, as clinical ultrasound devices are designed and optimized to study in vivo perfused organs. A brain study can be achieved, mainly through the anterior fontanelle, with both a micro-convex probe and a high-frequency linear probe (12 MHz) [Fig. 1], making it anatomically as informative as a transfontanellar neonatal ultrasound. In particular, brain global gyration [Fig. 1a], morphology of the ventricular system and of the corpus callosum can be attested [Fig. 1b]. The study of the posterior fossa is often better from the suboccipital posterior approach acoustic window [Fig. 1c], with a high-frequency linear probe. The study of the orbits, essentially the analysis of the eyeballs, is carried out in an axial and sagittal plane with morphological and biometric analyses [Fig. 2d]. The entire spinal cord can be studied using high-frequency linear probes with excellent image resolution [Fig. 3]. The vertebral segmentation is also achievable but is obtained systematically by plain radiographs [Fig. 3]. The cervical area and thyroid can be investigated [Fig. 2c].

At the chest level [Fig. 4], the trachea can be studied because of its liquid contents, through an axial cervico-thoracic scan. The esophageal ultrasound study is more difficult due to the relative post-mortem decrease in contrast resolution. Its continuity may be assessed in some cases in a sagittal study, like in the antenatal period. The gastroesophageal junction is easily identified, then the objective can be to demonstrate, in a retrograde analysis, its continuity upwards to the cervical region. The presence, size and echogenicity of the thymus can be determined [Fig. 4a]. The absence of air provides a comprehensive analysis of the lung parenchymas in the great majority of cases and the segmentation of lobes and fissures can be performed [Fig. 4c and d], sometimes facilitated by a pleural postmortem effusion, which is a normal taphonomic finding. The study of the heart and great vessels remains difficult. Intravascular and intracardiac clots associated with a low-contrast resolution in the middle and upper mediastinal (except thymus) limit cardiac and large mediastinal vessels ultrasound exploration [Fig. 4b]. In our experience, the analysis of the atrioventricular and ventriculo-arterial connections is feasible. The morphology of the proximal pulmonary artery is sometimes feasible. The origin and side of the aortic arch can be determined [Fig. 4a]. The presence and morphology of diaphragmatic cupula is easy by sagittal scans [Fig. 4c and d].

In the abdominal area [Fig. 5], the entire liver parenchyma can be analyzed, as well as the gallbladder [Fig. 5a and c]. The study of the spleen is feasible in the great majority of cases. The pancreas is often difficult to analyze precisely because of the loss of contrast resolution. Intravascular thrombosis hampers the study of large

**Fig. 2.** Reformatted sagittal view with three images of postmortem US with high-frequency linear probe (12 MHz) of the normal spinal cord from the skull to the sacrum in prone position.