CQ 52: Is it necessary to optimize CT and MRI acquisition parameters for postmortem imaging?

Recommendation Grade: C1

In postmortem imaging, unlike in clinical examinations, imaging techniques that differ from those used in the living can be employed, as there are no concerns about radiation exposure or motion artifacts. The objectives of postmortem imaging are diverse, including not only the investigation of cause of death, but also personal identification, evaluation of stab and gunshot wounds, and estimation of postmortem interval (postmortem changes). Therefore, it is necessary to apply acquisition parameters tailored to the deceased for both CT and MRI. In particular, for MRI, it should be noted that sequences commonly used in living subjects cannot be directly applied due to temperature-related changes after death. Optimization of imaging protocols according to the condition of the body is therefore recommended.

Explanation

● Background

Postmortem imaging is conducted under conditions in which physiological homeostasis has ceased, unlike in living individuals. In particular, a decrease in body temperature affects image contrast. Furthermore, in postmortem examinations, there are no concerns regarding cardiac pulsation, respiration, peristalsis, or patient motion, nor is radiation exposure a limiting factor. Because of these differences from clinical imaging, optimization of acquisition parameters is necessary.

However, when postmortem images are compared with antemortem or clinical images, caution is required. Unwarranted or unnecessary modifications to imaging parameters may lead to inappropriate interpretation of findings and should therefore be avoided.

● Optimization of postmortem CT acquisition

CT is the most widely used modality in postmortem imaging. In clinical practice, CT acquisition parameters are optimized to minimize radiation exposure and avoid motion artifacts, typically through the use of low-dose, high-speed scanning protocols. In contrast, these constraints are irrelevant in postmortem CT, enabling significant improvements in image quality. Accordingly, high-dose scanning was initially recommended. For multidetector-row CT (MDCT) systems with 16 or more detector rows, a slice thickness of less than 2 mm (approximately 1 mm for systems with 4 or more rows), a CT automatic exposure control (CT-AEC) setting of standard deviation ≤3 for the head and neck, ≤8 for the whole body, and a CT pitch factor of less than 1 are recommended[1]. Postmortem CT systems vary across facilities, ranging from the latest models to older machines, and optimization must therefore be tailored to each scanner's specifications. High-dose imaging imposes a substantial load on the X-ray tube, and in older systems, full-body scans may require cooling periods. Iterative reconstruction methods are well established in clinical use, and deep learning–based reconstruction is also expected to reduce artifacts, as discussed later, and should be actively utilized[2].

Optimization of postmortem CT acquisition should focus on reducing noise and artifacts[3]. Dual-energy CT and high tube voltage settings can reduce metal artifacts and streak artifacts from the upper limbs[4], while a lower helical pitch helps reduce windmill artifacts. Artifact-reduction techniques widely used in clinical practice can also be effectively applied to postmortem CT. In particular, single-energy metal artifact reduction (SEMAR) has been shown to reduce metal artifacts and improve image clarity, allowing for more accurate interpretation[5]. In addition, a technique known as *fused CT* has been developed to further reduce noise by allowing cumulative exposures that exceed the output of a single X-ray tube[6]. Fused CT involves acquiring multiple images of the same slice and combining them, which allows noise to be minimized to an extreme degree[7].

It is generally recommended that postmortem CT be performed without altering the position of the body[1]. More recently, attempts have been made to detect dynamic injuries of the spine and spinal cord by taking advantage of cervical mobility. One such approach, known as *postmortem kinetic CT*, involves neck extension through gravitational traction in addition to standard scanning. This technique has been reported to improve the diagnostic accuracy for vertebral dislocation[8]. Furthermore, neck extension elevates the mandible, thereby shifting streak artifacts caused by dental treatments and enhancing visualization of the upper cervical spine.

● Optimization of postmortem MRI acquisition

Since body temperature in the deceased drops due to the loss of homeostasis and approaches the ambient temperature, it is generally lower than in living individuals unless the body is exposed to extremely high environmental temperatures. The effects of temperature changes on image contrast vary depending on the modality, but MRI is particularly sensitive, with contrast significantly affected by temperature fluctuations[9] (see column). In postmortem MRI, when using inversion recovery (IR) sequences such as short-tau inversion recovery (STIR)[10] or fluid-attenuated inversion recovery (FLAIR)[11] [12], it is recommended that the inversion time (TI) be optimized according to body temperature. On the other hand, for T1-weighted and T2-weighted imaging, care must be taken not to arbitrarily modify acquisition parameters, as this may alter image contrast and make it difficult to distinguish between postmortem changes and contrast alterations due to parameter adjustments. To correctly interpret signal changes caused by normal postmortem processes, imaging parameters that affect contrast should, in principle, be fixed to the same settings as those used in clinical practice[1].

● Modalities and Optimization in Pediatric and Fetal Death Cases

Fetal imaging presents unique challenges due to the extremely small body size and high water content, which result in reduced tissue resolution and contrast across all imaging modalities. A previous report assessing modality selection for stillbirths in the perinatal period recommends the use of ≥7 T MRI or micro-CT for fetuses who died before 20 weeks of gestation, and ultrasound or 1.5 T to 3 T MRI for those who died after that point[13].

MRI is particularly useful for soft tissue contrast, and its use in postmortem imaging of fetuses and children has been especially promoted in Europe[14 15]. Sequences typically include T1-weighted, T2-weighted, and diffusion-weighted imaging. Detailed anatomical structures can be evaluated through 3D acquisition techniques. In particular, 3D constructive interference in steady state (CISS) offers a higher signal-to-noise ratio than conventional T2-weighted images, making it well suited for detailed structural assessment[16].

Ultrasound is also highly valuable in pediatric and fetal postmortem imaging due to its excellent tissue contrast and its applicability for guiding tissue sampling[17]. However, because fetal bodies are extremely soft and tend to collapse under their own weight due to gravity, direct contact with the ultrasound probe is often difficult. To address this, a technique has been reported in which the fetus is submerged in a water-filled container for scanning[18].

Guidelines for postmortem CT in pediatric cases have been proposed based on a joint survey by the European Society of Paediatric Radiology (ESPR) and the International Society for Forensic Radiology and Imaging (ISFRI)[19]. The recommended acquisition protocol includes single-pass whole-body scanning with the smallest effective field of view (FOV), a tube voltage of 120 kVp, tube current between 200 and 299 mAs (without the use of automatic exposure control, AEC), helical pitch of 0.5–0.8, and a gantry rotation time of 1 second. In suspected cases of abuse, conventional radiographs of the limbs are additionally recommended to detect metaphyseal fractures.

For very small bodies, such as stillbirths, imaging parameters—particularly mAs—should be adjusted according to body weight. One report based on phantom experiments suggests using mAs values ranging from 200 mAs for bodies ≤0.5 kg, up to a maximum of 1,000 mAs for those >3 kg. This approach prevents overexposure and helps to suppress ring artifacts[20].

Column: Temperature-Related Changes in Imaging Contrast

Typically, body temperature decreases after death. The impact of this temperature change on imaging contrast varies depending on the modality. In CT and ultrasound, contrast is primarily influenced by changes in tissue density, whereas in MRI, it largely depends on the behavior of hydrogen nuclei[21]. In CT, no major changes occur unless the tissues freeze[22]. However, in MRI, image contrast decreases with a drop in body temperature, and scanning at deep body temperatures below 10 °C is not recommended[23]. Recently, temperature-controlled cooling systems have been developed to support quantitative postmortem MRI[24].

○ Literature Search Strategy and Selection (as of November 21, 2023)

【PubMed】

#	Search formula	Number of articles

1	(postmortem OR cadaver) AND (computed tomography OR magnetic resonance OR imaging) AND (imaging technique OR scan parameter) AND optimization	1,159
2	(postmortem) AND ((computed tomography OR magnetic resonance)) AND protocol	464
3	#2 AND optimization	39

【医中誌 Ichushi-Web (Japan Medical Abstracts Society Database)】

#	Search formula	Number of articles
1	((死後/AL or (死後検査/TH or Autopsy/AL or (死亡時画像診断/TH or Ai/AL)) and imaging/AL) and (MRI/TH or MRI/AL) and (X 線 CT/TH or CT/AL)) and (PT=会議録除く)	1,153
2	#1 and (小児/TH or 小児/AL)	90

●Additional Sources Not Captured by the Search Strategy

References［1］，［5］，［6］，［9］，［14］，［15］，［21］，［22］

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