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Image Visualization in Post-Mortem Surgery at the Cutting Edge of Technology

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Abstract

For medicolegal investigations, radiological evidence of natural causes of adult death in postmortem imaging is quite valuable. Particularly postmortem computed tomography (PMCT) is being utilised more frequently as a triage tool following external inspection and prior to a thorough autopsy. Radiologists and forensic pathologists frequently handle a variety of fatalities from natural causes. The cardiovascular, neurological, pulmonary, gastrointestinal, and metabolic systems are the most often observed natural causes of mortality. This review offers a summary of the research on organ system-specific postmortem imaging of the most common natural causes of adult mortality.

Keywords: Post-mortem imaging Visualization • Computed tomography • Magnetic resonance imaging volume rendering

Introduction

Over the past three decades, postmortem imaging has become a hot topic, and forensic radiology has become more widely used in the field of forensic medicine. In several medicolegal centres throughout the world, postmortem computed tomography (PMCT) and, to a lesser extent, PMCT angiography (PMCTA), postmortem magnetic resonance (PMMR), postmortem angiography (PMMRA), and image-guided biopsies, are well-established imaging techniques. Because PMCT is so good at recognising foreign bodies, including projectiles, showing skeletal fractures, detecting gas and bleeding, and contributing to natural causes of death, many forensic institutes regularly employ it [1]. In the years that followed, PMCTA, PMMR, and PMMRA were launched as an addition to autopsy due to PMCT's diminished capacity to portray vascular abnormalities and to discern soft tissue interfaces. Particularly where natural causes of death are suspected and where unenhanced PMCT might not precisely capture or identify pathologic abnormalities, PMCTA as a supplemental technique to whole-body PMCT demonstrates its worth. There are affordable choices for PMCTA by enteroclysis pumps or PMCTA kits, even though not every institution has the possibility, practicality, and equipment for PMCTA and PMMR. Since 2015, PMCT has been used in our institution as a triage tool following an external inspection but before a complete autopsy. This review gives a summary of the literature on postmortem radiological imaging of the major organ systems-based natural causes of adult mortality [2].

Cardiovascular system

Sudden death is thought to frequently result from cardiomegaly. Since in situ cardiac measurements can serve as early warning signs of heart disease disease, efforts have been made to use them. By measuring the circumference of the left heart ventricle, it is possible to forecast the actual heart weight and use it as a marker for cardiomegaly on PMMR and PMCT [3]. In order to predict cardiomegaly, further studies have either presented new formulas based, among others, on the cardiothoracic ratio on PMCT or set new limits for the cardiothoracic ratio on PMCT. According to Winklhofer et al., a PMCT cardiothoracic ratio threshold of 0.57 can be used to diagnose cardiomegaly with a specificity of 95%. However, it's crucial to remember that postmortem imaging cardiac measures shouldn't be compared to normative value thresholds set by autopsy measurements [4-5]. It is still necessary to determine the normal values for postmortem imaging cardiac measures. It was discovered that the measures from an autopsy tend to be underestimated by the cardiac PMMR assessment of myocardial wall thickness. Even though myocardial infarction is the most common cause of cardiovascular system death, unenhanced PMCT only barely shows it. Indirect markers of potential sudden cardiac death risk factors, like coronary artery calcification, previous bypass surgery, coronary stents, or calcified scars from previous myocardial infarctions, are just suggestive and not conclusive proof of myocardial infarction. a correlation between the findings and myocardial ischemia, Postmortem imaging can show anatomic abnormalities in the coronary arteries or myocardial bridges. However, there is substantial evidence in the literature that PMMR is harmful. the most effective way to portray this diseased entity before autopsy [6].

Identification of the infarction area is made possible by PMMR, but provides proof of its age as well. The difference between acute, using T2-weighted images, acute and chronic infarction can be determined. peripheral hyperintense margins and central hypointese zones, hyperplaces that are intense and areas that are not intense. even pernicious. A crucial result is that myocardial infarctions can be seen on PMMR as hypointense regions since these cardiac lesions are not always yet clearly visible at a global level. knowing their location and precise Prior localisation may enable focused histological probing [7]. either through guided biopsies or autopsy. In reality, the fusion of The best accuracy is achieved in the myocardium using PMMR and guided biopsy. accuracy in identifying acute or chronic myocardial infarction before autopsy ischemia. Pathological myocardial enhancement on PMCTA (targeted or whole body) can also be used to represent ischemic heart disease. PMCTA is a useful technique in cases of severe coronary artery stenosis and occlusions since it may quickly identify these conditions. even if the exact pathomorphological cause is unknown, abrupt cardiac death Not always possible to offer. PMMR tests for the heart are also provide instruments for evaluating the patency of coronary arteries. On unenhanced PMCT, the pericardial sac (hemopericardium) can be shown to contain blood. However, pericardial tamponade is primarily diagnosed clinically. Target sign, flattening of the right ventricular wall, compression of the coronary sinus and pulmonary arteries, and, to a lesser extent, hepatic and renal vein distension, are postmortem symptoms that point to a fatal hemopericardium and a pericardial tamponade. The target sign, also known as the armoured heart sign, was proposed as a sign of a fatal pericardial tamponade by Watanabe et al. because its origin can be accounted for by a beating myocardium. Shiotani et al. described it as the most frequently observed PMCT finding in cases of aortic dissection leading to hemopericardium. Since pulmonary thromboembolism is thought to be a sudden, unexpected death due to the acute onset of symptoms, it is frequently seen in forensic institutions [7].

On an unenhanced PMCT, postmortem clot development prevents a conclusive diagnosis of pulmonary thromboembolism. Inexperienced readers may be misled by centrally positioned hyperdense material in the primary pulmonary arteries and the pulmonary trunk. In both circumstances (post-mortem clots and thromboembolism), PMCTA will identify contrast medium filling flaws in a less invasive manner, and PMCT-guided biopsy will ultimately make the diagnosis. Indirect findings have recently been suggested as pulmonary thromboembolism indicators. On an unenhanced PMCT, perivascular edoema of the lower extremities, a clearly abnormal form of the pulmonary trunk and artery content, and congestion of the venous vessels are all considered to be strongly suggestive of pulmonary thromboembolism. With encouraging outcomes, PMMR has also been described as an adjuvant in the preautopsy identification of pulmonary thromboembolism. Larger investigations are still required to fully understand this medical condition, though [8].

Gastrointestinal system

Intestinal obstruction and gastrointestinal bleeding are the most common natural causes of death from the digestive system, but they are rather uncommon in a forensic environment. Adhesions, hernias, and malignancies are the etiologies of intestinal blockage in 80% of all cases. For this clinical entity, a case history of fever, abdominal distension, vomiting (bilious to feculent), and stomach discomfort is particularly suspect. Bowel blockage will cause intestinal strangling, ischemia with or without perforation, necrosis, and ultimately sepsis if left untreated. For the detection of intestinal blockage in living patients, computed tomography has a reported sensitivity and specificity of 95%, with the primary findings being proximal bowel dilatation and distal bowel decompression. Closed-loop obstruction, also known as volvulus, is a unique type of bowel blockage that can theoretically be found anywhere throughout the digestive tract but is most frequently found in the sigmoid colon [9]. A diagnosis can be made using certain radiological indicators, such as the "bird beak" sign (the change from a distended to a restricted lumen), the "coffee bean" sign (a distended closed loop), or the "whirlpool" sign (a twisting of the mesenterium with vessels). The fact that these symptoms have also been mentioned in unenhanced PMCT is particularly intriguing. The vast majority of upper gastrointestinal haemorrhages are caused by ulcers, esophageal varices, and neoplasms, whereas lower gastrointestinal bleeding is caused by haemorrhoids, colitis, diverticular disease, neoplasms, and angiodysplastic lesions. For the diagnosis of gastrointestinal bleeding, PMCT is a useful tool. The predominant observation is hyperdense stomach and/or intestinal material, frequently with clot formation. Blood clots can often be difficult to distinguish from other hyperdense stomach contents. The postmortem radiological appearance of gastrointestinal bleeding appears to be affected by the hemorrhage's sudden onset or gradual development. If the precise location of the bleeding source needs to be determined, PMCTA is the preferred option [9,10].

Central nervous system

Still a leading source of morbidity and mortality, intracranial haemorrhage. It is a broad word that refers to the extravascular collection of blood in various intracranial regions. Hyperattenuation in parenchymal, subarachnoid, subdural, intraventricular, or epidural regions is a symptom of intracranial bleeding. Trauma, hemorrhagic stroke, high blood pressure, and ruptured aneurysms are the most frequent causes of cerebral haemorrhage. The haemorrhage itself can cause increased intracerebral pressure, hematoma expansion, intraventricular components, stroke, and hydrocephalus, which is caused by cerebrospinal fluid blockage or surrounding edoema. In postmortem brain imaging, the classic anatomy is lost, including the ability to distinguish between grey and white matter, sulci and gyri, and recognisable ventricles. However, with a focus on further examination of the case, differentiating intra- parenchymal haemorrhages from extraaxial haemorrhages appears to be pertinent with relation to the method of death [11].

In this review, we outline the two cerebral haemorrhages that occur most frequently and result in natural death. Increased attenuation along the tentorium cerebelli and in the basal cisterns, sylvian fissure, and subarachnoid space on brain CT scans are characteristic findings of extraaxial subarachnoid haemorrhage (SAH), and they are frequently combined with intraventricular components that are caused by trauma or ruptured aneurysms. These characteristics are frequently identified in postmortem imaging, but they cannot be verified during standard autopsy, leading to the correction of pseudo-SAH. This symptom is frequently observed in conjunction with venous congestion, hypoxic ischemic encephalopathy, global ischemia, and brain swelling [12].

In contrast, those with asymmetric acute/subacute intraventricular and intraparenchymal haemorrhage with a history of anticoagulant medication are more likely to experience genuine SAH. Therefore, pseudo-SAH is a diagnostic trap that can be found on both antemortem and postmortem CT. As lethal as SAH, intracerebral haemorrhage happens twice as often.

Respiratory system

Because of the typical postmortem features, such as dependent density, unspecific ground glass attenuation, and consolidation, imaging reporting of the lungs in the postmortem context is difficult. The degree of ventilation might sometimes restrict the postmortem detection of pulmonary disorders. As a result, some research have looked into the possibility of increasing the sensitivity of PMCT for pulmonary discoveries by performing data acquisition during pulmonary ventilation in the deceased. Ventilation is a useful tool for differentiating between poorly ventilated and consolidated lung sections and other illnesses like pneumonia or tumours as well as typical postmortem findings. This method has equipment and hazards, such as movement artefacts and stomach dilatation. Pneumothorax detection is straightforward with PMCT and is frequently observed at our facility, particularly in putrefied remains. The presence of free air in the pleural space is referred to as pneumothorax. It may be iatrogenic, putrefaction- or trauma-related, or spontaneous. For instance, spontaneous pneumothorax has been linked to bullae, which are more frequently found in the upper lungs and emphysema-like alterations. There is proof that smoking and chronic obstructive lung disease are linked to spontaneous pneumothorax.

This pathological entity can be easily missed at autopsies since it requires a unique examination approach, yet it is relatively straightforward to find with PMCT. One of the most prevalent lung diseases, pneumonia continues to be the fourth greatest cause of mortality worldwide and is a major factor in many serious consequences, including sepsis, which can lead to multiorgan failure and death. Ageing, comorbidities, immunological deficiencies, alcohol addiction, corticosteroid usage, and even hereditary variables are risk factors. The distinction between pneumonias obtained in the community and those acquired in hospitals is a common one. 25% of cases of community-acquired pneumonia are caused by bacterial infection with Streptococcus pneumonia [14]. Mycobacterium tuberculosis (TB), which affects around one-fourth of the world's population latently, is a significant pathogen that also causes pneumonia. The most common site of infection for TB is the lungs, where it can cause cavitating lung lesions in the apices and upper lobes, well-defined centrilobular nodules, and tree-in-bud signs that are visible on PMCT. TB is one of the top ten killers in the world and can affect almost any part of the body. Lethal hemoptysis is a serious consequence of TB-associated pneumonia. In addition, numerous other infections, including viruses and fungi, can also cause pneumonia.

Even if there are numerous supportive treatments available, the COVID-19 viral pandemic has recently had an impact on the entire planet. Pneumonia can have a wide range of radiographic appearances, and because of density-related alterations or extra pleural effusions that compress the lower lobe of the lung, postmortem diagnosis of the condition can be difficult. Missed diagnoses of pneumonia, a prevalent cause of death from natural causes, are common major errors on thoracic ageing, according to Traill's paper from 2010. Gonoi et al. recently disclosed useful characteristics, such as relationships with segmental and centrilobular opacities in pneumonia, to diagnose pneumonia on unenhanced PMCT. When performing an autopsy, PMCT can warn pathologists of potential dangerous communicable diseases like tuberculosis and give them the opportunity to take the necessary safety precautions, such as wearing personal protective equipment in a designated high-risk autopsy suite with adequate ventilation [15].

Conclusion

In the fields of forensic medicine and forensic radiology, natural causes of death are the most frequent causes of death and make up a sizable portion of the knowledge in these fields. To identify diseases that lead to natural death, every forensic radiologist or forensic pathologist who reports radiological findings in postmortem imaging should be conversant with normal anatomy and appearance in both the deceased and the living. Without performing an autopsy, we can identify frequent natural causes of death by visualising postmortem imaging. As a triage tool, PMCT is improved by this.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

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