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Virtual Autopsies in the Forensic Field: Achievements and Limitations

Autópsias Virtuais no Âmbito Forense: Alcances e Limitações

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Abstract

Virtual autopsy is an innovative method that has solidified its relevance in the field of forensic imaging. There are various post-mortem techniques, but post-mortem computed tomography and post-mortem magnetic resonance imaging stand out in the forensic area. This approach is capable of providing relevant expert evidence for Forensic Pathology, by analyzing images collected in a non-invasive way and preserving the integrity of the corpse, with the aim of clarifying the cause and circumstances of death, identifying the corpse and carrying out thanatological and anthropological studies. The main aim of this paper is to explain the scope and limitations of the virtual autopsy approach and its applicability in the forensic field, focusing essentially on post-mortem computed tomography and post-mortem magnetic resonance imaging techniques. But could virtual autopsy replace invasive autopsy at some point? Or will it only be seen as a complement? Is it feasible to use this approach as a screening method? The authors aim to clarify these and other questions through a narrative review. To this end, a survey was carried out by searching PubMed and other databases from 1 January 2015 to 31 November 2023, including content that proved pertinent outside this time frame. In conclusion, virtual autopsy can be recommended as a practical diagnostic alternative when conventional autopsy is not possible and can play a role as a screening method, especially for traumatic deaths.

Keywords

Virtual autopsy; Virtopsy; Postmortem imaging; Forensic imaging.

Resumo

A autópsia virtual é um método inovador, que tem vindo a solidificar a sua relevância na área da imagiologia forense. Há várias técnicas post mortem, contudo na área forense evidenciam-se a tomografia computorizada post mortem e a ressonância magnética post mortem. Esta abordagem é capaz de fornecer elementos periciais relevantes para a Patologia Forense, através da análise de imagens recolhidas, de forma não invasiva e preservando a integridade do cadáver, com o intuito de esclarecer a causa e as circunstâncias da morte, a identificação do cadáver e a realização de estudos tanatológicos e antropológicos. O objetivo principal deste trabalho é expor os alcances e as limitações da abordagem da autópsia virtual assim como a sua aplicabilidade no âmbito forense, focando, essencialmente, nas técnicas de tomografia computorizada post mortem e de ressonância magnética post mortem. Mas será que a autópsia virtual poderá vir a substituir a autópsia invasiva, em algum momento? Ou será considerada, apenas, como um complemento? O uso desta abordagem como um método de "screening" será exequível? São estas e outras questões que os autores pretendem esclarecer através de uma revisão narrativa. Para isso foi realizado um levantamento por pesquisa na PubMed e outras bases de dados a partir de 1 de janeiro de 2015 até 31 de novembro de 2023, tendo sido incluído conteúdo que se mostrou pertinente fora desse espaço temporal. Como conclusão, a autópsia virtual pode ser recomendada como uma alternativa prática de diagnóstico quando a autópsia convencional não é possível e pode desempenhar um papel como método de "screening", sobretudo para mortes traumáticas.

Palavras-chave

Autópsia virtual; Virtópsia; Imagem post mortem; Imagem forense.

Introduction

Forensic imaging brings together forensic science and imaging, and its purpose is, through the application of different medical imaging methods, to solve forensic problems.[1] Virtual autopsy is a recent method that has been gaining notoriety in the last decades. In the literature, virtual autopsy takes on other names such as virtopsy, virtual necropsy, digital autopsy, minimally invasive or non-invasive autopsy.

The term virtopsy is derived from "virtus" which means useful and efficient, which is combined with "autos" and "opsis" which refers to "seeing with one's own eyes".[2] It constitutes a methodology that provides relevant expert elements for Forensic Pathology, which can be used as a complement to the classic form of autopsy, particularly in situations where there is a high infectious contagious risk.[3]

In virtual autopsy, medical imaging techniques are performed in the post-mortem examination, such as post-mortem computed tomography (PMCT), post-mortem tomography angiography (PMCTA) or post-mortem magnetic resonance imaging (PMMRI), with the aim of clarifying the cause and circumstances of death, identifying the corpse, and carrying out thanatological and anthropological studies. This innovation in the field of forensic medicine collects, analyzes and processes the information obtained from the exams carried out, in a non-invasive way, preserving the integrity of the body.[1]

The COVID-19 pandemic highlighted the importance of controlling the transmission of an infectious agent, in a reality of great proximity between the professional and the corpse.

This forced need for change demonstrated the possibility of consolidating virtopsy, without jeopardizing the greater purpose of Forensic Medicine. The objective was to increase this reality with an increase in the number of requests for post-mortem examinations and greater availability of data, which led to an increase in publications in this area.[1,4]

Therefore, it is important to understand whether this tool can replace conventional autopsy or whether it will only be considered a complementary means, or even whether it can be used solely as a screening tool. Another important question is whether its use will increase knowledge in the area of Forensic Medicine or whether it will simply be considered unnecessary.

The main objective of this paper is to carry out a narrative review of the literature, with the purpose of exposing achievements, limitations and applicability in the forensic field of virtual autopsy. As a complement, post-mortem medical imaging techniques such as PMCT and PMMRI will also be characterized.

2. Material and Methods

The research strategy consisted of surveying complete articles from January 1, 2015 to November 31, 2023, including content that proved to be relevant outside this period of time, published in Portuguese or English, on digital platforms. As other inclusion criteria, studies carried out on humans were highlighted, in the forensic field (excluding hospital articles), in the area of medicine or forensic radiology and focusing on the potential applicability of the technique. Articles that did not meet the aforementioned criteria were excluded from the literature review. The analysis of the Legal Medicine Treaty and chapters of published books on the subject was also carried out.

The PubMed search was based on the MeSH terms: "postmortem imaging" and "forensic imaging". To formalize the research equation, it was completed with the words "autopsy" and "virtual autopsy". The Web of Science, ÍndexRMP and Acta Médica Portuguesa databases were also consulted.

The selection process of published studies is explained in Figure 1, highlighting 44 studies as pertinent references.

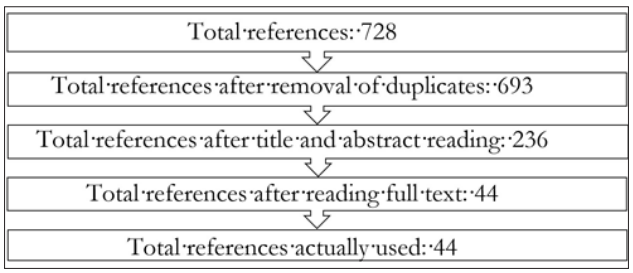

Figure 1 – Scheme of the study selection process

3. Discussion and Conclusion

Postmortem imaging has been explored in forensic practice, given the increased recognition and acceptance in the scientific community.[5] It brings together non-invasive techniques such as conventional radiology, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI) and minimally invasive techniques, such as angiography and biopsy.[6]

Many institutions have already facilities dedicated to forensic imaging and the use of post-mortem images is already part of the death investigation process.[7] However, this use depends on the availability and ease of integration of the approach with the traditional autopsy workflow. For example, in Melbourne, PMCT is performed on all admissions before the traditional autopsy, resulting in approximately 5000 examinations per year. In Berlin, however, it is only carried out in certain cases, such as homicides, resulting in 250 examinations per year.[5]

Currently, virtopsy includes the fusion or individual use of techniques such as PMCT and PMMRI and the use of digitalization of optical surfaces through three-dimensional photogrammetry.[6,8,9,10]

Imaging is particularly attractive as it produces evidence of high diagnostic credibility and documentary power. However, choosing the appropriate technique requires technical knowledge of each method, as well as the advantages and disadvantages of its use in each case.

Virtual autopsy uses several techniques. However, the focus was on those mostly used in the forensic field: PMCT and PMRI.

3.1 Post Mortem Computed Tomography

PMCT is already an essential part of routine post-mortem examinations in forensic medicine institutes,[11] being the whole-body PMCT without contrast the basis for most examinations.[5,8] It is an objective technique used for documentation and storage of evidence, ensuring future accessibility.[12]

The most used CT equipment is the helical multidetector. For certain anatomical areas, it is considered the one that provides images with the best quality[12] and with superior contrast resolution, allowing differentiation between soft tissues and fluids.[10,13]

Due to the short acquisition time[14] and image processing by multiplanar reformatting or three-dimensional reconstructions, the results are quickly available[11] and provide easier interpretation of the results in meetings and courts.[10]

PMCT is widely used in the forensic field, especially in evaluating the cause of death, identifying the individual, estimating age and post-mortem interval.

In general, PMCT presents a better performance compared to autopsy in detecting craniofacial, brain, thoracic and bone lesions, in the presence of foreign bodies and pathological gas collections.[5,8,15,16,17] PMCT is considered useful as a preliminary investigation method, being a potential strategic guide for autopsies.[11] However, unlike the spatial resolution and excellent contrast particularly for bone, it has a low discriminatory power in abdominal lesions, parenchymal organs and soft tissues and still lacks assessment of the vascular component, being only effective in situations of large hemorrhages.[5,15,18,19] It is worth noting that PMCT provides decisive information to determine the cause of death when the external examination is performed instead of a complete invasive autopsy.[20] Furthermore, it has great relevance in the practical analysis of traumatic injuries and, therefore, in the assessment of traumatic death.[11,17,21] In the best forensic practice, it is important in distinguishing between findings related to trauma and post-mortem changes considered normal.[15] PMCT is used, especially, in blunt trauma, ballistics studies and investigation of charred or putrefied corpses.[8] Using three-dimensional reconstruction it is possible to identify complex fractures and their orientation, without the risk of displacement through direct manipulation.[10] In multiple trauma patients, such as in road accidents, the morphological analysis of fractures provides information

about the dynamics of the applied forces, allowing a better reconstruction of the accident.[22]

Likewise, PMCT is the ideal method for detecting radiopaque foreign bodies such as projectiles, explosives, medical implants, swallowed or aspirated foreign bodies,[8,11,16] and allows rapid guidance for targeted extraction during autopsy.[10] This technique not only allows the three-dimensional localization of the projectile, but also the consideration of injuries to soft tissues, organs and bones along the trajectory, contributing to the correct prediction of the trajectory.[12,17,22,23] On the contrary, PMCT has a low sensitivity for detecting injuries to solid organs in the absence of contrast, making it difficult to demonstrate the path of a stab wound.[16,21,22]

Recently, PMCT has been used in burns, allowing differentiation between physiological post-mortem changes and those related to the action of the heat. In fire-related deaths, PMCT shows typical signs of heat injuries such as thermal fractures, muscle retraction, thermal epidural hematoma, and thermal tissue destruction. It also allows the assessment of occult injuries from pathological processes ante-mortem.[22] PMCT is not only capable of identifying a severely burned body with signs of traumatic or heat-induced fractures, but also allows the location of foreign bodies in burn victims.[18]

PMCT can provide findings that, although non-specific, are highly suggestive of drowning, such as hemodilution, aqueous emphysema and collection of paranasal, tracheal and frontal sinus fluids.[24,25] In the literature, the suggestion is to perform it before the autopsy, as it helps to understand whether the victim was alive or dead when the submersion occurred.[26]

In natural causes of death, it has limitations due to the poor ability to differentiate soft tissue interfaces and to document vascular changes.[27] In cases of sudden cardiac death, the sensitivity of PMCT is low in recognizing coronary stenoses or zones of infarction, but it is significant in identifying calcifications of coronary arteries, heart valves and hypertrophic/dilated cardiomyopathy.[22]

PMCT allows estimation of the post-mortem interval, as the post-mortem changes identified can provide an index for an objective interval estimate. However, the proposed parameters, including a decrease in intrarectal gas and an increase in intrahepatic gas, need to be standardized in order to have a concrete role.[22,28]

Personal identification of a body is based on comparing post-mortem images with ante-mortem examinations. The paranasal sinuses are also used for imaging comparison due to the high interpersonal variability. To estimate age, PMCT can provide information on tooth eruption, skeletal growth and metaphyseal fusion, with ossification of the clavicle being useful in individuals between 10 and 35 years of age.[22]

In determining the sex of the corpse, PMCT has a say in establishing skeletal dimorphism, particularly in the skull and pelvis.[22,28]

In addition, it is important to know that errors and deficiencies in the image itself can occur, such as poor positioning of the body, which would lead to image artifacts.[29] To reduce the incidence of metallic artifacts from projectiles, algorithms can be used to reduce metallic artifacts such as Interactive Metal Artifact reduction (iMAR, Siemens ®).[11]

The post-mortem examination of computed tomography can also be complemented with other techniques such as biopsy guided by PMCT and PMCT with pulmonary ventilation, the most impactful being the PMCTAngio.[5] The angiography technique was developed as a complementary technique of the virtopsy, in order to increase the diagnostic power of PMCT.[8,30,31,32] The sensitivity of PMCT in relation to solid organs increased up to 81% after contrast injection, making it comparable to classic autopsy.[10] The post-mortem vascular system is empty or partially filled with blood clots, therefore, perfusion of a volume under a certain pressure is necessary. However, the injection pressure must be monitored to avoid extravasation into adjacent tissues.[5] A venous injection is performed after the arterial injection, except in the case of suspected venous pathology where the venous injection is performed first.[33]

The injection sites used are neck, femoral, axillary, or subclavian vessels. Administration can be carried out manually, by modified cardiopulmonary machine, by cardiopulmonary resuscitation procedures such as chest compressions or by pressure-controlled perfusion devices (e.g. Virtangio®).[22]

The injected substances are divided into 6 groups: corpuscular preparations in gelatin or agar, corpuscular preparations in aqueous solution, water-soluble contrast, oily contrast, plasters and various formulations.[5] The oily contrast remains within the lumen, even in heavily modified vessels in putrefied corpses.[10] It is recommended to collect samples of body fluids for microbiological and toxicological analyses before contrast injection.[10] The approach is characterized by multiple sequential acquisitions, with a whole-body scan and three angiographic phases (arterial, venous and dynamic), and a finding identified in two phases is considered significant.[8,10]

In another protocol, of Japanese origin, the contrast medium is administered into a peripheral venous vessel and circulation is via a cardiopulmonary resuscitation technique with chest compressions, immediately after death.[7,8] In England, as cardiovascular causes are the main indication for autopsy, targeted coronary angiography is most commonly used.[8,10] Percutaneous puncture and direct administration of contrast into the left ventricle is another alternative.[13]

PMCTAngio demonstrates greater sensitivity in identifying skeletal and vascular injuries, while traditional autopsy provides more information about the anatomy and macroscopic pathology of the organ.[8,22] Thus, PMCTAngio's main objectives are to identify the source of hemorrhage, quantify blood loss, and detect anatomical and pathological vascular variations.[32] It is recommended in cases of death due to blunt trauma, road accidents, falls from height, suspected cardiovascular death, death after surgical intervention and penetrating or ballistic injuries.[32]

In cases of cardiovascular death, it allows the analysis of the myocardium and coronary arteries, identifying stenoses, intravascular plaques and calcifications,[8] proving to be useful in cases of sudden cardiac arrest, ischemic disease and pulmonary thromboembolism.[13] Contrast oily material mimics a pulmonary fat embolism, and a biopsy of the lung tissue guided by PMCT is recommended before contrast injection.[10]

Recently, this technique has proven useful in the characterization of stab and firearm injuries. By checking the contrast material at an extravascular level, the direction and depth of the piercing blow[13] and the trajectory of the projectile are documented, which can be understood by non-medical professionals.[8,10]

The advanced state of putrefaction can lead to artefacts and to non-visualization of blood vessels, making it difficult to interpret post-mortem blood clots and intravascular thrombi.[13]

Angiographic techniques take longer, which is why they have not yet been adopted in forensic institutions.[33] Although, in the future, this modality may replace autopsy, currently it should only be considered as a complement in forensic pathology.[13]

Briefly, the previously described advantages and limitations of PMCT and PMCTAngio are mentioned in Tables 1 and 2, respectively, as well as their applicability in the forensic field.

Table 1 – Advantages, limitations and applicability of the PMCT technique

PMCT	
Advantages	**Limitations**
Widely available equipment	Limited differentiation of normal and pathological postmortem changes
Relatively easy handling	Limited visualization of pathology in soft tissue, organ parenchyma and vessels
Short image acquisition time	Limited ability to diagnose cardiac causes of death
Excellent visualization of the skeletal system, gas collections, lung parenchyma, calcifications, acute hemorrhage and fluids	(Use of ionizing radiation)
Identification of radiopaque foreign bodies such as projectiles and their fragments, medical implants, swallowed or aspirated foreign bodies	
Detection of radiologically suspicious areas for post mortem histological examination	
Possibility of biopsy and angiography guidance	
Applicability	
Trauma, especially skeletal system trauma (accidents, falls, contusion trauma) Ballistic trauma Drowning Foreign body detection Air/gas detection Age estimation and sex determination Identification of the individual	

Table 2 – Advantages, limitations and applicability of the PMCTAngio technique

PMCTAngio	
Advantages	**Limitations**
Visualization of the vascular system, with possible assessment of stenoses or occlusions	Technically more challenging
Method of choice for detection of the bleeding source	Extended acquisition time
Good contrast of soft tissues and parenchymal organs	Requires preparation of the cadaveric body
	(Use of ionizing radiation)
Applicability	
Trauma, especially vascular trauma (accidents, blunt trauma, penetrating and ballistic trauma) Suspected natural death due to cardiovascular pathology Sudden or unexplained death Death after medical or surgical intervention	

3.2 Postmortem Magnetic Resonance Imaging

PMMRI was introduced in forensic investigations in the 1990s, having been proposed as a pre-autopsy technique, with promising results.[7]

The contrast between anatomical structures is due to differences in the MRI signal, which is directly related to the intrinsic properties of the tissues, such as proton density, and tissue relaxation specificities.[10]

The signal intensity is also dependent on body temperature,[5] that is, reducing the body temperature of corpses leads to a reduction in T1 and T2 signals, which affects image contrast and requires sequence adjustments to adapt to post-mortem conditions.[13]

The role of PMMRI as a viable alternative to invasive autopsy has been investigated. However, it is still reported by the vast majority of studies only as a complementary examination,[34] requiring further studies, especially in the adult population.[18]

The ideal protocol consists of T1 and T2-weighted sequences acquired in three different axes, with three-dimensional acquisition and multiplanar reconstruction.[8]

In 2017, the first MRI with a high magnetic field intensity of 7 tesla (T) was authorized for clinical use and has been used in forensics. Greater magnetic field strength has the potential to provide a higher signal-to-noise ratio, improving image quality and spatial resolution.[35] The maximum achievable contrast-to-noise ratio increases as the signal-to-noise ratio and field intensity increase. Therefore, high-field PMMRI is beneficial in analyzing small lesions, including microbleeds, and in visualizing brain and skull anatomy.[34,35]

PMMRI offers high spatial resolution and allows superior visualization for the precise assessment of soft tissue injuries and pathologies,[18,36,37] especially in the head and neck, spinal column, abdomen, extremities and cardiovascular system regions.[5,13,17] For this reason, PMMRI is important in the diagnosis of natural death and in the evaluation of traumatic soft tissue injuries.[10,17] In contrast, traumatic bone injuries are barely visible on PMMRI.[38] Therefore, PMRI has been recommended in cases of blunt and penetrating trauma, medical errors and in estimating age.[10]

An important interest of PMMRI is the cardiovascular imaging, especially in cases of sudden death,[10] being superior to PMCT in diagnosing cardiac anomalies, such as myocardial infarction or ischemia, ventricular hypertrophy/dilation, tamponade and cardiac contusions.[5,13,39]

At the level of the nervous system, it offers sensitive results in the detection of craniocerebral, spinal cord or ligament injuries.[34] It helps to differentiate between traumatic and non-traumatic origins of cerebral hemorrhages, with increased sensitivity in high magnetic field PMMRI.[39] The detection of coup and contrecoup injuries allows the description of the impact, leading to the diagnosis of acceleration and deceleration injuries. 7T cerebral PMMRI is capable of excluding shearing brain injuries.[35]

PMMRI has been proposed for cases of hanging and manual strangulation due to its sensitivity to detect hemorrhages in the neck muscles, regional intramuscular edema and adenopathy in this type of death, highlighting hematomas located around fractures of the laryngeal structures.[8,10,18,38]

It is also the modality of first choice in neonatal and pediatric post-mortem imaging[5,8,13] and it has special value in the evaluation of child abuse due to the detection of injuries to soft tissues or parenchymal organs.[10,35] However, the low sensitivity of this technique in detecting non-cardiac thoracic lesions, especially at the pulmonary level should be referred.[40]

Another area being investigated is the diagnostic power of high-field PMMRI in firearm injuries.[34] In craniocerebral gunshots, the energy transferred by the projectile can cause hypointense lesions in the parenchyma surrounding the bullet's path, in the T2 sequence.[34] However, its use in the

imaging evaluation of injuries of this type remains restricted.[37] Additionally, we conclude that ferromagnetic projectiles or fragments present significant movements, while non-ferromagnetic projectiles do not undergo spatial changes. Furthermore, the latter rarely cause artefacts in PMMRI,[36] unlike metallic objects, which can cause signal loss and pronounced artefacts. If necessary, it is recommended to test the use of magnetic attraction with a bullet fragment similar to the ammunition found in the body.[8,37]

From another perspective, some publications discussed the use of PMMRI in assessing bone age, particularly in anatomical regions such as the iliac crests, knees, clavicles, teeth, wrists and ankles.[8]

As more specific artifacts, the influence of temperature on the contrast of T1 and T2-weighted images and vascular stasis, in particular venous stasis, is to be emphasized as it can mimic hemorrhage in the T2-weighted sequence.[5]

Practical limitations are based on the cost-effectiveness ratio,18 with high acquisition and maintenance costs and long acquisition times. It is characterized by a high degree of difficulty and necessary knowledge, which leads to dependence on medical and technical personnel with specific training in the area.13 Furthermore, due to limited access, only a few Forensic Medicine institutes have the possibility of carrying out the PMRM as the first line of action.[5,8,34,36,37,39]

In the literature and despite the few publications,[33] the use of contrast in PMMR is described, with the designation of PMMR angiography (PMMRAngio).[6]

The previously mentioned advantages, limitations and applicability of the PMMRI technique are summarized in Table 3.

Table 3 – Advantages, limitations and applicability of the PMMR technique

PMMR	
Advantages	**Limitations**
Excellent visualization of organs and soft tissues	Long image acquisition time
Excellent spatial resolution	More complex approach
(No use of ionizing radiation)	Interpretation limited by postmortem artifacts and body temperature
	Special approach in the case of metallic objects lodged in the body
	3D reconstructions require specific sequences
	More complex guided biopsies
Applicability	
Traumatic organ injuries (blunt, perforating) Organ damage from local disease (natural death) Strangulation Child abuse Bone age estimation Medical negligence, death after surgical intervention Foreign body detection Identification of the corpse	

3.3 PMCT versus PMMR

PMCT presents a lower contrast resolution in soft tissues than PMMRI, therefore, it will not be the ideal technique for lesions of parenchymal organs.[8,41,42] It is valuable in cases of death from neurological, gastrointestinal and unnatural causes, aiming mostly at the detection of bone injuries. In traumatic organ injuries, sensitivity is not high.[22] When compared to PMMRI, PMCT requires less acquisition time, is widely available and less expensive.[39]

PMMRI is useful in deaths of young individuals with cardiac or neurological problems. PMMRI is performed mainly in a specific anatomical region and not as a screening method, as in the case of PMCT.[8] Regarding bone lesions, the use of certain sequences in PMMRI can produce equally good visualization and allows the differentiation of entry and exit wounds and the detection of bone lesions characteristic of gunshot wounds.[34] From another perspective, PMMRI allows the examination of cartilage which cannot be done with PMCT, useful in estimating the bone age of the corpse. Although the preferred approach for cadaveric bodies is PMCT, PMMRI produces valuable data for the identification[10] and preservation of anatomical details of the decomposing brain, unlike the cerebral liquefaction observed on PMCT.[5,13] The combination of both postmortem techniques mentioned above can be beneficial in detecting hemorrhage[43] or in cases of hanging and manual strangulation, where it is described as a possible replacement for invasive autopsy.

3.4 Final Considerations

The general advantages of virtopsy are based on its non-invasive characteristics, being frequently used when there are cultural oppositions to invasive autopsy, providing an acceptable cultural and scientific alternative.[2,5,30] In research, it is regularly applied before traditional autopsy to locate traumas, patterns and pathological changes, including areas not routinely investigated, such as the face and limbs.[3,6,22] Additionally, it has the ability to store data permanently, subject to further analysis and subsequent discussion, even after the burial or cremation of the corpse. It is possible to improve the image through reformatting and digital reconstruction in 2D or 3D.[2] The use of increased radiation and the use of contrasts not used in clinical practice is not an issue, given the fact that it is an examination on a corpse.[6] Virtopsy assists in cadaveric identification and estimation of bone age, being useful in mass disasters.[11] Post-mortem techniques also have the potential to protect the team of professionals who would perform the autopsy, in cases of the presence of sharp objects, explosives and infectious diseases.[5,30] Given the large volume of cases and the risk of performing invasive autopsies, the Covid-19 pandemic was relevant in the development of this approach, allowing it to function as triage and investigation in cases of infected deceased individuals or with suspected infection, with the intention of increasing the number of cases examined and reducing the risk of contamination and dissemination of the infectious agent.[44] The invaluable social value of forensic imaging and the potential for it to be used in any unpredictable pandemic in the future were noted.[6]

However, due to its high cost and not being accessible in all institutions, it is not widely used.[6] In addition, the presence of image artifacts impairs quality and spatial resolution, highlighting the need for qualified personnel in post mortem image interpretation.[18] Likewise, virtopsy being a virtual approach, makes it impossible to use traditional senses such as smell or touch.[2,6,30]

As a last consideration, can the use of virtopsy effectively replace conventional autopsy? Or could it be used as a screening method?

In the literature review carried out, the answer to these questions is still not unanimous. Therefore, taking into account the direct and indirect costs, advantages and limitations of virtual autopsy, it can be used as an alternative method of post-mortem diagnosis, as a complementary method or as a screening method only in selected cases in which it can provide additional information relevant to the

traditional investigation.[22] Chosen cases are mainly traumatic deaths involving more than one part of the body, such as road accidents, falls from heights or gunshot wounds,[7] as validity of the virtual autopsy is greater for this type of death, compared to others.[45]

In the area of ballistic trauma, the virtual autopsy carried out before the traditional autopsy helps to identify the location of projectiles and fragments, saving a lot of time in their eventual recovery. The assessment of the bullet's trajectory also helps in reconstructing the relative positions of the victim and the aggressor's during the alleged incident.[13,45]

Despite the advantages of virtual autopsy in identifying conditions that would otherwise not be detected with the naked eye at autopsy, it cannot, yet, completely replace conventional autopsy for several reasons, one of which is the relevance of external examination in the characterization of injuries that involve the skin, such as contusions, abrasions and other wounds.[45]

In short, virtopsy can be recommended as a practical diagnostic alternative when conventional autopsy is not possible and it can play a role as a screening method for traumatic deaths.[22,45]

Ethical Disclosures / Divulgações Éticas

Conflicts of interest: The authors have no conflicts of interest to declare.
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Confidentiality of data: The authors declare that they have followed the protocols of their work center on the publication of data from patients.
Confidencialidade dos dados: Os autores declaram ter seguido os protocolos do seu centro de trabalho acerca da publicação dos dados de doentes.
Protection of human and animal subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).
Protecção de pessoas e animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pelos responsáveis da Comissão de Investigação Clínica e Ética e de acordo com a Declaração de Helsínquia da Associação Médica Mundial.

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