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Посмертные лучевые исследования в мировом и отечественном здравоохранении: анализ литературы и мнений российских специалистов

А.И. Щеголев, У.Н. Туманова

Национальный медицинский исследовательский центр акушерства, гинекологии и перинатологии имени академика В.И. Кулакова, Москва, Российская Федерация

АННОТАЦИЯ

Несмотря на особую значимость вскрытий тел умерших больных с целью определения причины смерти и эффективности проведённого лечения, во всех странах отмечается прогрессирующее снижение их количества. Одновременно с этим наблюдается активное внедрение посмертных лучевых исследований для анализа тел умерших и погибших пациентов.

Представлен анализ данных литературы, обобщающих результаты анкетирований иностранных специалистов, а также мнений российских специалистов о возможностях и особенностях проведения посмертных лучевых исследований главным образом новорождённых и младенцев. Отмечено, что посмертные лучевые исследования проводятся как в рамках патологоанатомического вскрытия, так и судебно-медицинской экспертизы. В случаях насильственной смерти чаще проводили посмертную компьютерную томографию, при смерти от болезней — посмертную магнитно-резонансную томографию. Более часто использовалось общеклиническое оборудование, находящееся в клинических отделениях лучевой диагностики, чем оборудование, расположенное в морге, патологоанатомическом отделении или судебно-медицинском учреждении. Анализ результатов посмертных лучевых исследований в большинстве наблюдений проводили врачи-рентгенологи, намного реже имел место совместный анализ рентгенолога и патологоанатома. Подчёркивается, что в Российской Федерации посмертные лучевые исследования носят в основном единичный характер. В то же время, по мнению российских исследователей, в настоящее время — время развития персонализированной медицины, лучевых методик и информационных технологий — назрела необходимость использования посмертных лучевых исследований для объективизации и повышения точности традиционных аутопсий. При этом посмертные лучевые исследования, представляющие собой объективные оператор-независимые методы исследования тел погибших, следует рассматривать как высокоэффективный этап патологоанатомического и тем более судебно-медицинского вскрытия.

Ключевые слова: аутопсия; виртопсия; посмертная магнитно-резонансная томография; посмертная компьютерная томография; КТ; танаторадиология; обзор.

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Postmortem radiology studies in global and national healthcare: literature analysis and perspectives of Russian specialists

Aleksandr I. Shchegolev, Ulyana N. Tumanova

Research Center for Obstetrics, Gynecology and Perinatology, Moscow, Russian Federation

ABSTRACT

Despite the significant importance of autopsies for determining the cause of death and the evaluating the effectiveness of treatments, there is a progressive decrease in their number across all countries. At the same time, there is an active introduction of postmortem radiological studies to analyze the bodies of deceased patients.

The article presents literature analysis summarizing the results of surveys from foreign specialists, as well as the opinions of Russian specialists, regarding the possibilities and features of postmortem radiological studies, mainly focusing on deceased newborns and infants. It is noted that postmortem radiological studies are carried out as part of both pathoanatomical autopsy and forensic medical examination. Postmortem computed tomography in cases of violent death and postmortem magnetic resonance imaging in cases of death from diseases were performed more often. General clinical equipment located in clinical radiology departments was more frequently used than those located in the mortuary, pathology department, or forensic facility. The analysis of the results of postmortem radiological examinations was predominantly carried out by radiologists, with a joint analysis involving a radiologist and a pathologist being less common. It is emphasized that in the Russian Federation, postmortem radiological studies are mostly of a single nature. According to Russian researchers, in the current era of advancing personalized medicine, radiation techniques, and information technologies, there arises a need to use postmortem radiological studies to objectify and improve the accuracy of traditional autopsies. Postmortem radiological studies, which are objective operator-independent methods of examining the bodies of dead people, should be considered as a highly effective stage of pathology and, especially, forensic autopsy.

Keywords: autopsy; virtopsy; postmortem computed tomography; postmortem magnetic resonance imaging; thanatoradiology; review.

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全球和国内医疗保健中的放射尸检：文献分析和俄罗斯专家的观点

Aleksandr I. Shchegolev, Ulyana N. Tumanova

Research Center for Obstetrics, Gynecology and Perinatology, Moscow, Russian Federation

简评

虽然尸检对确定死因和治疗效果非常重要，但各国的尸检数量都在逐步减少。与此同时，医生正在积极引入放射尸检，以分析死亡病人的尸体。

本文介绍对文献数据的分析，这些数据总结外国专家的问卷调查结果，以及俄罗斯专家对放射尸检（主要是新生儿和婴儿）的可能性和特殊性的看法。据指出，放射尸检是在病理解剖和法医学鉴定的框架内进行的。在暴力致死的病例中，更常进行死后计算机断层扫描；在疾病致死的病例中，则进行死后磁共振成像。与停尸房、病理解剖科或法医学机构里的设备相比，临床放射诊断科的普通临床设备使用频率更高。大多数放射尸检都是由放射科医生进行分析的，而由放射科医生和病理学家共同进行分析的情况要少得多。需要强调的是，在俄罗斯联邦，放射尸检大多是零星的。同时，据俄罗斯研究人员称，在当前个性化医学、放射技术和信息技术发展的时代，有必要利用放射尸检来客观化和提高传统尸检的准确度。同时，放射尸检是独立于操作人员的客观尸体检查方法，应被视为病理解剖的高效阶段，更是法医学尸检的高效阶段。

关键词：尸检；虚拟尸检；死后磁共振成像；死后计算机断层扫描；CT；死后放射学；综述。

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INTRODUCTION

A conclusion about the cause of death is made by autopsy pathology specialists performing an autopsy of a deceased patient to confirm a clinical diagnosis or reveal a diagnostic error, establish the course of a disease and components of the dying process (thanatogenesis), evaluate the effectiveness of diagnostic and therapeutic measures, and generate mortality statistics [1]. Autopsies play a vital role in perinatal examinations, identification of hereditary and congenital diseases, and evaluation of subsequent pregnancy risk [2]. However, since the 1950s, in all countries where the consent of relatives is required for an autopsy, the number of these procedures has been progressively decreasing, mainly due to religious reasons, a long delay between death and burial, and the unwillingness of treating physicians to obtain information that may discredit their treatment strategy [3, 4].

In addition, the development of new medical equipment and diagnostic techniques allowed the ability to perform radiological examinations of people after death. Postmortem radiology was primarily used in forensic medicine. Therefore, in the 1990s, the Institute of Forensic Medicine at the University of Bern (Switzerland) began actively using 3D optical technologies for scanning corpses to better document external injuries and compare them with the suspected weapon of infliction. Then, postmortem computed tomography (CT) and magnetic resonance imaging (MRI) were introduced and compared with traditional autopsy [5]. In the United States, the Office of the Armed Forces Medical Examiner provided postmortem multispiral CT of dead members of the Armed Forces before autopsy to better assess combat injuries [6, 7]. Postmortem multispiral CT of people who died in the January 2020 earthquake in Haiti enabled rational body sorting for adequate subsequent autopsy [8].

Postmortem radiology is now used in many countries as part of a forensic medical examination and an autopsy, as reflected in the progressively increased number of publications [9, 10]. However, there is still no consensus on the objects (age group of patients and nature of abnormalities), type of apparatus, location, specialty, and qualifications of specialists performing postmortem radiology and analyzing results.

This information is undeniably important, particularly for those who intend to implement and perform such examinations in their institutions, cities, or regions. Because of its multinational and multireligious population, postmortem radiology is essential in the Russian Federation. Despite the relatively high level of radiology equipment in healthcare organizations, postmortem radiology is only used episodically in some institutions.

This paper aims to analyze the experience, recommendations, and proposals of foreign and Russian experts in postmortem radiology, considering potential opportunities and special aspects.

POSTMORTEM RADIOLOGY IN GLOBAL AND RUSSIAN HEALTHCARE

Conditions and stages of the study

The study is based on four surveys of members of the European Society of Pediatric Radiology (ESPR) and the International Society of Forensic Radiology and Imaging (ISFRI) from 2013 to 2021, postmortem radiology literature from eLibrary and National Center for Biotechnology Information databases (PubMed and PubMed Central), and opinions of Russian round table participants "Thanatoradiology: Real opportunities for organization and practical use in the healthcare system," which was held on October 8, 2022, in Moscow as a part of II Scientific and Practical Conference of the Interregional Thanatoradiology Society "Diagnostic radiology in pathology and forensic medicine: From antemortem to postmortem."

Due to the lack of consistent and generally accepted international guidelines on organizing and using postmortem radiology, the study analyzed literature data on surveys of foreign experts performing such examinations [11–14]. However, it should be noted that these surveys only included perinatal and pediatric medical institutions.

In the first survey (2013), questionnaires were distributed to 244 ESPR members [11]. The study included 66 questionnaires from 66 corresponding institutions, with postmortem radiological examinations performed in 47 (71%) institutions in 17 countries: Australia, Austria, Brazil, Great Britain, Hungary, Germany, Israel, Ireland, Canada, the Netherlands, New Zealand, Norway, USA, Finland, France, Switzerland, and Sweden. The largest number of responses and institutions were from the United Kingdom (11), the United States (9), and the Netherlands (5).

Three subsequent surveys included members of the ESPR and ISFRI. As a result, in the second survey (2016–2017), questionnaires were distributed to members of the aforementioned societies from 25 institutions [12]. Responses from 20 institutions in 11 countries were analyzed: Great Britain, Australia, USA, and Poland (three each); the Netherlands (2); Denmark, Italy, Switzerland, New Zealand, Canada, and Japan (one each).

In the third survey (2018–2019), questionnaires were distributed to all 14 members of the ESPR Postmortem Imaging Working Group and 17 members of the ISFRI Working Group, representing 25 different institutions [13]. The analysis included responses from 11 institutions in seven countries where postmortem radiology was used in the perinatal and pediatric practice: Australia (3), Great Britain (2), the Netherlands (2), Belgium (1), Switzerland (1), New Zealand (1), and Canada (1).

A fourth survey was conducted in 2021, with emails sent to 22 members of the ESPR Postmortem Imaging Working Group from 26 institutions. The analysis included 18 responses from 18 institutions in nine countries: Great Britain (6), Australia (3), Germany (2), the Netherlands (2), Austria (1), Belgium (1), Hungary (1), New Zealand (1), and Canada (1). Results were published by Chambers et al. [14].

Some questions were repeated in the above four surveys (questionnaires), whereas others were different. The first questions referred to objects of postmortem radiology.

Analysis of survey results

According to the first survey [11], all stillborn children were examined in 32% (15 out of 47) of institutions, whereas 26% (12/47) and 17% (8/47) examined all deceased newborns and infants, respectively. Only some stillborn children (45%), deceased newborns (49%), and infants (49%) were examined in most institutions.

According to the second survey [12], only one-third (35%) of institutions used postmortem radiology for all cases of fetal and pediatric death. In the third study [13], no institutions used postmortem radiology for all the deceased patients. According to the fourth survey [14], all institutions performed examinations on a case-by-case basis, with the majority (92.9%) performed for dead newborns (age 0–28 days), infants (1–12 months), and children (1–12 yr), followed by adolescents (age 13–18 yr; 85.7%) and fetuses (42.9%). Postmortem radiological examinations of deceased newborns and infants, children, and adolescents were less common in cases of nonviolent death: 82.4%, 58.5%, and 52.9%, respectively. However, fetal examinations were more common (76.5%) [14].

Since 2004, the Robert Kilpatrick Clinical Sciences Building Leicester Royal Infirmary in Leicester, UK, has regularly performed postmortem radiological examinations for deceased newborns and children in the radiology departments (24/7) [15].

As for the location of postmortem radiology equipment, in the first two surveys, general clinical equipment was used more frequently than in the mortuary, pathology department, or forensic institution (55% vs. 45%) [12]. According to the third survey [13], all specialists performed postmortem MRI using equipment in clinical radiology departments, and none of the centers surveyed had a special MRI scanner exclusively for postmortem imaging or a scanner located in the morgue or pathology department.

Controversial data on postmortem radiology procedures (and equipment) were obtained. The most common response in the first [11] and fourth [14] surveys was radiography (81% and 100% of cases, respectively), followed by CT (51% and 88.9%, respectively), MRI (38% and 61.1%), and ultrasound (8.5% and 27.8%). In most fatal cases, two or more different scanners (techniques) were used for radiological examination of corpses, but ultrasound was performed in all cases with radiological examination. However, in the third survey, all participants reported only postmortem MRI [13]. There are ongoing debates regarding who should conduct postmortem radiological examinations and, more importantly, who will evaluate their results. According to the second survey, radiological examinations were performed in most cases (65%) by a radiologist or a radiographer at a radiology department, considerably less frequently (15%) by morgue staff or a pathologist, and only in one institution by a forensic medical examiner [12]. According to the third survey, such examinations were performed in 90.9% of institutions by a radiologist or X-ray technician and 9.1% by an MRI specialist [13].

In terms of specialists analyzing postmortem radiology results, the first survey mentioned a radiologist in most cases (89%), including a pediatric radiologist (64%); in significantly fewer cases (17%), such an analysis was performed collaboratively by a radiologist and pathologist [11]. According to the second survey, 45% and 40% of responses mentioned radiologists and pathologists, respectively [12].

Shelmerdine et al. [12] should be cited in global literature data. This study was noteworthy because it presented a consensus protocol for postmortem CT. An important objective of Chambers et al. [14] was to evaluate funding and payment systems for postmortem radiology examinations. These aspects are undeniably important and should be the subject of separate publications on the characteristics of healthcare funding systems in different countries. However, according to most participants of the fourth survey [14], the main barrier to the widespread implementation of postmortem radiology was the lack of a special, nationally centralized (whenever possible) funding source. Therefore, in 2004, the UK Department of Health and Social Care initiated postmortem radiology of corpses, mainly deceased fetuses and newborns, as well as adults, to address the issue of possible autopsies being replaced by radiological examinations [16]. Since 2010, postmortem CT has been available in all cases of child death in the Netherlands if parents decide to perform an autopsy [17].

In our country, postmortem radiology is used episodically [18–20]. However, Academician V.I. Kulakov National Medical Research Center for Obstetrics, Gynecology, and Perinatology has conducted its research since 2011 to study and implement thanatoradiology (CT and MRI) into the practice of pathological examinations of stillborn and deceased newborns [21, 22]. Some cases of postmortem CT use in forensic medical examination have been reported in the Moscow region since 2018 [23, 24].

II SCIENTIFIC AND PRACTICAL CONFERENCE OF THE INTERREGIONAL THANATORADIOLOGY SOCIETY "DIAGNOSTIC RADIOLOGY IN PATHOLOGY AND FORENSIC MEDICINE: FROM ANTEMORTEM TO POSTMORTEM": KEY POINTS OF THE ROUND TABLE

Opportunities for organization and practical use of thanatoradiology

Due to the importance of postmortem radiology in the Russian Federation, in October 2022, a round table discussion was held as a part of II Scientific and Practical Conference of the Interregional Thanatoradiology Society "Diagnostic Radiology in Pathology and Forensic Medicine: From antemortem to postmortem" on the topic "Thanatoradiology: Real opportunities for organization and practical use in the healthcare system" [25]. The meeting was moderated by Yu. A. Vasiliev, director of the State Budgetary Institution "Research and Practical Clinical Center for Diagnostics and Telemedicine Technologies" of the Moscow Department of Health, chief freelance consultant in Radiology and Investigations of the Moscow Department of Health.

All participants noted that in the Russian Federation, in accordance with Federal Law No. 323-FZ dated November 21, 2011 (Article 67),[1] all deceased persons are subjected to a pathological autopsy, including a mandatory autopsy (despite the refusal) of stillborn children and children who died up to 28 days of life. A forensic autopsy is required if a violent death is present or suspected. Accordingly, a pathological autopsy (Article 67, paragraph 1) aims to obtain data on the cause of death and the diagnosis, and a forensic medical examination (Article 62, paragraph 1) establishes the circumstances as evidence for a specific case.

According to valid Order No. 346n of the Ministry of Health and Social Development of the Russian Federation dated May 12, 2010,[2] the type, nature, and scope of the examination are determined by the head of the forensic institution. It also determines specialists responsible for performing such an examination and involved staff of expert, scientific, educational, and other institutions. An expert should use medical technologies approved for use in the Russian Federation, primarily technologies and techniques not associated with modification, destruction, or destruction of examined objects. Moreover, paragraph 47.8 states that radiography is first performed (wherever technically possible) during an external examination of a corpse to clarify the nature and characteristics of damage or painful changes in skeletal bones. In other words, postmortem radiography is even recommended during a forensic examination; however, in accordance with the above order, only for bones. Simultaneously, according to Appendix 2 to Order No. 364n, the standard equipment for state forensic medical institutions includes an X-ray machine and a digital mobile X-ray system.

Selection of the most informative method of postmortem examination

A pathological autopsy is performed by a pathologist in accordance with Order No. 354n of the Ministry of Health of the Russian Federation dated June 6,[3] 2010, whereas histological, biochemical, microbiological, and other necessary methods of examining individual organs and tissues of the deceased people are considered an integral part of the pathological autopsy. Biological material is transferred to an appropriate structural unit of a healthcare organization to be examined. Radiology may be one of the procedures used for such mandatory examinations.

In 1969, a Soviet pathologist, I.I. Medvedev wrote about the important role of radiology, particularly X-ray, examination of a corps in guidelines for hospital anatomists *Fundamentals of pathological and anatomical technique* (Osnovy patologoanatomicheskoy tekhniki), "the X-ray method is rarely used by pathologists, although for a long time there are many reasons for its wide use, (...) therefore, it can be strongly recommended to install X-ray machines in dissecting rooms" [26]. Medvedev emphasized that X-ray examination allows the detection of even small changes in bone structure, bone tumors, osteochondropathies, calcification sites, and foreign bodies. Moreover, he stated that "the use of the X-ray method in pathology can play a great role in the development of X-ray diagnostics" [26].

Congenital abnormalities of the skeleton, which can be an independent defect or a manifestation of a syndrome, can include abnormalities of the facial skull, spine, and upper and lower extremities. In such cases, postmortem CT is the most effective and objective tool for postmortem identification of congenital abnormalities of bones, particularly small and facial bones, in stillborn and deceased newborns because of its superiority over traditional pathological autopsy [27, 28]. Accordingly, when discussing the advantages of various

[1] Federal Law No. 323-FZ dated November 21, 2011 on basics of health protection of the citizens in the Russian Federation. Link: https://base.garant.ru/12191967/.

[2] Order No. 346n of the Ministry of Health and Social Development of the Russian Federation dated May 12, 2010 on approval of the procedure for organizing and conducting forensic medical examinations in state forensic institutions of the Russian Federation. Link: https://base.garant.ru/12177987/#friends.

[3] Order No. 354n of the Ministry of Health of the Russian Federation dated June 6, 2013 on the procedure for conducting pathological autopsies. Link: https://www.garant.ru/products/ipo/prime/doc/70443162/.

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radiology methods, forensic experts named CT as a method of first choice because it provides the best visualization of injuries and fractures of bones, the degree of displacement of fragments, the course of the wound canal, hemorrhages, and foreign bodies, including bullets [29, 30]. CT also has other important advantages in forensic medicine, such as short examination duration and, accordingly, high throughput of the scanner, which is particularly important for examining bodies in cases of mass death (transport and natural disasters, military operations, or terrorist acts), as well as the availability of mobile CT modules to perform examination even directly at the place of the incident. Postmortem MRI is less popular among medical examiners than CT, although it better visualizes soft tissues and parenchymal organs.

We believe that the choice of an examination method should be based on the feasibility of obtaining maximum information in each specific case. This opinion is supported by literature data. Thus, Roberts et al. [31] found that CT is more accurate than CT in determining a cause of death in adult patients. Authors considered CT to have advantages, such as better visualization of coronary artery calcifications, hemorrhage areas, and fractures. MRI was more sensitive in acute myocardial infarction and soft tissue pathology [31]. According to Wijetunga et al. [32], a comprehensive postmortem CT and autopsy revealed more lesions in trauma deaths than either method alone, whereas Proisy et al. [33] found strong agreement between postmortem CT and autopsy data, with significant discrepancies detected primarily in lung diseases. Sieswerda-Hoogendoorn et al. [34] found a strong correlation between postmortem CT and autopsy data in cases of violent death, with no correlation in cases of natural death, and complete agreement between CT with autopsy data when the cause of death could not be determined initially. According to Krentz et al. [35], an autopsy is often superior to postmortem CT for detecting soft tissue and vascular changes, although CT is more effective for visualizing skeletal injuries.

When comparing the capabilities of postmortem CT and MRI, Arthurs et al. [36] found that MRI has higher diagnostic accuracy than CT in examining fetuses of less than 24 weeks of gestation and similar accuracy for older fetuses and newborns. Authors recommend postmortem MRI to visualize dead fetuses and children because it is the most effective method for determining brain, heart, and kidney diseases. Indeed, postmortem MRI allows one to determine the degree of brain maturity and visualize congenital abnormalities and abnormal changes [37, 38], assess the condition of lung tissue to identify those who were live-born and children with congenital pneumonia, assess the degree of pulmonary hypoplasia as a component of thanatogenesis [39–41], and determine the severity of anasarca and the volume of free fluid accumulated in serous cavities without opening cavities and tissue incisions [42, 43]. Thayyil et al. [44] reported in a large prospective study that the accuracy of postmortem MRI corresponds to the results of autopsies of dead fetuses, newborns, and infants and is lower when examining children over 1 yr of age.

To summarize, postmortem CT is the most informative method to visualize:

- traumatic, primarily mechanical, injuries, and wound channels, particularly in areas that are technically difficult for traditional dissection (bones and tissues of the facial skeleton, skull base, distal limbs, and spine);
- hemorrhages and fluid accumulations in organs, tissues, and cavities;
- air and gas accumulations in tissues, organs, lumen of blood vessels, and cavities;
- distinguishing dentition, including personal identification; and
- foreign bodies, including medical probes and catheters.

Postmortem CT is adequate for examining frozen, burned, and putrefied bodies and corpses in mummification and saponification. Limitations for postmortem CT include the low efficiency of unenhanced visualization of injuries and diseases of soft tissues, parenchymal and hollow organs, and spinal cord lesions. To assess vessels and cavities of the heart, including those with congenital abnormalities and injuries, contrast-enhanced CT should be performed [45, 46].

Postmortem MRI allows the identification of injuries and diseases of soft tissues and parenchymal organs and the examination of the brain and spinal cord, bone bruises, and hemorrhages. Compared with CT, postmortem MRI is more effective for examining dead fetuses, stillborns, and deceased newborns.

Limitations of postmortem MRI include insufficient visualization of respiratory system injuries and diseases in adult patients, as well as hollow organs, the gastrointestinal tract, and long bones. MRI images are challenging to interpret due to artifacts caused by metal elements present in the body.

Unfortunately, CT and MRI do not allow for microscopic, biochemical, toxicological, microbiological, virological, and genetic examinations of tissue and organ specimens, which are required to determine the histological picture and nature of the tumor, causative agent of the infectious process, impaired metabolic pathways, and poisonous substance. To perform this, a minimally invasive autopsy is recommended, which includes postmortem radiological examination and needle biopsy of tissue and organ specimens for the abovementioned examinations [47, 48]. This method has proven effective for postmortem diagnostics and protecting dissection staff from SARS-CoV-2 infection during autopsies of COVID-19 patients [49, 50]. Moreover, organ or tissue lesion visualization effectiveness also depends on age, body weight, and tissue condition [51].

Based on our own thanatoradiology experience [52–54], we believe that comprehensive postmortem radiology, including CT for accurate visualization of skeletal abnormalities and gas accumulations, MRI for tissue and organ assessment, and contrast-enhanced CT for assessment of blood vessels

and the heart, should be used for a complete examination of stillborn and deceased newborns. However, radiological procedures are currently selected due to the availability of the corresponding equipment or the possibility of conducting such an examination.

Selecting an institution for postmortem examination

According to Order No. 346n of the Ministry of Health and Social Development dated May 12, 2010,[4] the standard equipment of state forensic medical institutions includes an X-ray machine and a digital mobile X-ray system so such institutions can perform radiological examinations.

CT and MRI require particular premises and appropriate equipment. As for large forensic medical examination institutions that examine living persons and dead bodies, the optimal strategy would be creating a radiology office with a CT and/or MRI scanner based on such an institution. Indeed, in Switzerland, joint activities of the Institute of Forensic Medicine and the Institute of Diagnostic Radiology at the University of Bern led to conducting such postmortem CT examinations since 2000 [5]. At the Department of Forensic Medicine at the University of Copenhagen (Denmark) since 2002 and the Victorian Institute of Forensic Medicine in Melbourne (Australia) since 2005, all incoming corpses are subject to postmortem CT before autopsy [16, 55]. An interesting solution is to use mobile scanners, which are tomographs mounted on special vehicles that can be driven to the location of a corpse [56].

In Russia, any X-ray examinations are regulated by state sanitary and epidemiological rules and regulations, such as SanPiN 2.6.1.1192-03, which has been in effect since May 1, 2003.[5] These rules establish basic requirements and standards for ensuring the radiation safety of personnel, patients, and the general public when conducting diagnostic, preventive, therapeutic, or research X-ray procedures. There are no procedures to receive additional approval from Roszdravnadzor authorities for postmortem X-ray examinations. This was probably one reason pathologists participating in the above round table spoke about the need to conduct such studies in radiology departments of those healthcare institutions with pathology departments. Some proposals were made regarding using a separate room with its entrance and equipment. The above analysis of four surveys with foreign specialists shows that the same equipment is commonly used in clinical practice for living patients. However, in most of these institutions, postmortem examinations are conducted in the morning, in the evening, or at specially designated times when there are no appointments with living patients; hence, the principle of separating these flows was complied with.

Even though bodies are delivered and subjected to postmortem radiological examination in sealed plastic bags, SanPiN 2.6.1.1192-03 provides for mandatory wet cleaning of walls, washing floors, and thorough disinfection of elements and accessories of the X-ray machine, as well as monthly full-scale cleaning by wiping surfaces of the room, equipment, and accessories with a 1%–2% acetic acid.

Selecting a specialist for conducting a postmortem examination and analyzing the results obtained

As for those who should directly perform postmortem radiological examinations, all round table participants name radiologists, X-ray technicians, or radiotherapists. However, the type and extent of postmortem radiological examination before autopsy should be determined by a joint decision of a radiologist and a dissector. Because a pathological autopsy is performed after evaluating the medical history, which includes clarification of the clinical course and treatment of disease and antemortem laboratory tests and investigations, a radiologist should also be provided with available clinical information before conducting a radiological examination. This is confirmed by Fernandes et al. [57], who showed that awareness about clinical information improved the diagnostic accuracy of traditional autopsy by 8% and minimally invasive autopsy (including postmortem imaging and tissue sampling) by 12%.

In forensic medicine, the algorithm for postmortem radiological examination should be designed collaboratively based on the examination statement or decision, considering information on death circumstances, the postmortem period, and an external examination of the corpse. However, in 2010, the Republican Bureau of Forensic Medicine of the Ministry of Health of the Republic of Tatarstan began to provide special training in diagnostic radiology for internists and medical examiners [58].

During the round table, Russian experts agreed that a radiologist should also analyze and post-process images, including 3D modeling. From a legal point of view, additional certificates are not required for such activities, but a radiologist should have special knowledge of patterns of nonspecific postmortem changes in internal organs and associated radiological signs [59, 60]. When introducing postmortem radiology, a radiologist, pathologist, or medical examiner should analyze images and prepare a report [61].

Some additional questions occurred when discussing special aspects of introducing postmortem radiology in the

[4] Order No. 346n of the Ministry of Health and Social Development of the Russian Federation dated May 12, 2010 on approval of the procedure for organizing and conducting forensic medical examinations in state forensic institutions of the Russian Federation. Link: https://base.garant.ru/12177987/#friends.

[5] Resolution No. 8 of the Chief State Sanitary Inspector of the Russian Federation dated February 18, 2003 on implementation of SanPiN 2.6.1.1192-03. Link: https://base.garant.ru/4179018.

Russian Federation. For example, how much postmortem radiology data (i.e., full description or a summary conclusion) should be presented in a pathological or forensic autopsy report and whether particular combined protocols are required. Most participants agreed that a separate complete thanatoradiology report with a conclusion should be prepared even in case of discrepancies with the macroscopic and microscopic examination of a corpse. However, as with clinical guidelines, postmortem radiology reports should be unified, containing technical parameters of equipment and scanning modes.

A separate discussion is required to determine whether results of postmortem radiological examinations may or should be provided to relatives upon their request and to what extent.

CONCLUSION

Therefore, literature data and opinions of Russian specialists indicate the feasibility and urgent need to use postmortem radiology to make traditional autopsy more objective and accurate. Such examination should be considered the first stage of a pathological and forensic autopsy.

The key to effective thanatoradiological examination is close cooperation between radiologists, pathologists, or medical examiners. The collaboration of specialists and available equipment makes it possible to determine practical aspects of postmortem radiological examinations to obtain the most informative results in each case.

When determining the best place to install CT and/or MRI equipment, factual circumstances of the regional medical care and the availability of equipment and radiologists in healthcare institutions should be considered. However, for comprehensive implementation of postmortem radiology into pathological and forensic practice, a centralized solution is required for some organizational issues.

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REFERENCES

1. Connoly AJ, Finkbeiner WE, Ursell PC, Davis RL. Autopsy pathology: A manual and atlas. 3th ed. Elsevier Inc.; 2016. 400 p.

2. Ernst LM. A pathologist's perspective on the perinatal autopsy. *Semin Perinatol*. 2015;39(1):55–63. doi: 10.1053/j.semperi.2014.10.008

3. Oluwasola OA, Fawole OI, Otegbayo AJ, et al. The autopsy knowledge, attitude, and perceptions of doctors and relatives of the deceased. *Arch Pathol Lab Med*. 2009;133(1):78–82. doi: 10.5858/133.1.78

4. Levy B. Informatics and autopsy pathology. *Surg Pathol Clin*. 2015;8(2):159–174. doi: 10.1016/j.path.2015.02.010

5. Thali MJ, Yen K, Schweitzer W, et al. Virtopsy, a new imaging horizon in forensic pathology: virtual autopsy by postmortem multislice computed tomography (MSCT) and magnetic resonance imaging (MRI): A feasibility study. *J Forensic Sci*. 2003;48(2):386–403.

6. Eastridge BJ, Mardin M, Cantrell J, et al. Died of wounds on the battlefield: Causation and implications for improving combat casualty care. *J Trauma*. 2011;71(S.1):S4–8. doi: 10.1097/TA.0b013e318221147b

7. Eastridge BJ, Mabry RL, Seguin P, et al. Death on the battlefield (2001–2011): Implications for the future of combat casualty care. *J Trauma Acute Care Surg*. 2012;73(6 Suppl 5):S431–437. doi: 10.1097/TA.0b013e3182755dcc

8. Berran PJ, Mazuchowski EL, Marzouk A, Harcke HT. Observational case series: An algorithm incorporating multidetector computerized tomography in the medicolegal investigation of human remains after a natural disaster. *J Forensic Sci*. 2014;59(4):1121–1125. doi: 10.1111/1556-4029.12422

9. Baglivo M, Winklhofer S, Hatch GM, et al. The rise of forensic and post-mortem radiology: Analysis of the literature between the year 2000 and 2011. *J Forensic Radiol Imaging*. 2013;1(1):3–9.

10. Tumanova UN. Formation and development of postmortem radiological research in the world and in Russia. *REJR*. 2020;10(4):250–263. (In Russ). doi: 10.21569/2222-7415-2020-10-4-250-263

11. Arthurs OJ, van Rijn RR, Sebire NJ. Current status of paediatric post-mortem imaging: An ESPR questionnaire-based survey. *Pediatr Radiol*. 2014;44(3):244–251. doi: 10.1007/s00247-013-2827-6

12. Shelmerdine SC, Gerrard CY, Rao P, et al. Joint European society of paediatric radiology (ESPR) and international society for forensic radiology and imaging (ISFRI) guidelines: Paediatric postmortem computed tomography imaging protocol. *Pediatr Radiol*. 2019;49(5):694–701. doi: 10.1007/s00247-018-04340-x

13. Whitby E, Offiah AC, Shelmerdine SC, et al. Current state of perinatal postmortem magnetic resonance imaging: European society of paediatric radiology questionnaire-based survey and recommendations. *Pediatr Radiol*. 2021;51(5):792–799. doi: 10.1007/s00247-020-04905-9

14. Chambers G, Shelmerdine SC, Aertsen M, et al. Current and future funding streams for paediatric postmortem imaging: European society of paediatric radiology survey results. *Pediatr Radiol*. 2023;53(2):273–281. doi: 10.1007/s00247-022-05485-6

15. Rutty GN, Swift B. Accuracy of magnetic resonance imaging in determining cause of sudden death in adults: Comparison with conventional autopsy. *Histopathology*. 2004;44(2):187–189. doi: 10.1111/j.1365-2559.2004.01741.x

16. O'Donnell C, Rotman A, Collett S, Woodford N. Current status of routine post-mortem CT in Melbourne, Australia. *Forensic Sci Med Pathol*. 2007;3(3):226–232. doi: 10.1007/s12024-007-9006-8

17. Van Rijn RR, Beek EJ, van de Putte EM, et al. The value of postmortem computed tomography in paediatric natural cause of

death: A Dutch observational study. *Pediatr Radiol*. 2017;47(11):1514–1522. doi: 10.1007/s00247-017-3911-0

18. Halikov AD, Alexandrov DZ, Trofimova TN, et al. Virtual autopsy of a stillborn with Cantrell's pentad. *Neurosurgery Neurology Childhood*. 2009;(1):14–19. (In Russ).

19. Byval'tsev VA, Stepanov IA, Semenov AV, et al. The possibilities for diagnostics of prescription of death coming based on the changes in the lumbar intervertebral disks (the comparison of the morphological, immunohistochemical and topographical findings). *Forensic Medical Examination*. 2017;(4):4–8. (In Russ). doi: 10.17116/sudmed20176044-8

20. Borshchevskaya VN, Solonkina AD, Globa IV. Postmortem computed tomographic diagnosis of pulmonary embolism in the practice of a forensic medical expert (pilot study). In: Materials of the II Scientific and practical conference of the Interregional Thanatoradiological Society "Radiation diagnostics for pathological anatomy and forensic medical examination: from lifetime to postmortem", 7–8 October. Moscow; 2022. P. 118–121. (In Russ). doi: 10.54182/9785988117094_2022_118

21. Tumanova UN, Fedoseeva VK, Liapin VM, et al. Postmortem computed tomography of stillborn with bone pathology. *Medical imaging*. 2013;(5):110–120. (In Russ).

22. Tumanova UN, Shchegolev AI. The role and place of thanatoradiological studies in the pathological examination of fetuses and newborns. *Bull Exp Biol Med*. 2022;173(6):691–705. doi: 10.1007/s10517-022-05615-y

23. Klevno VA, Chumakova YV, Dubrova SE. Forensic medical examination and post-mortem computed tomography in case of death from mechanical asphyxia: Diagnostic difficulties. *Forensic Medicine*. 2019;(S1):54. (In Russ).

24. Klevno VA, Chumakova YV. Virtopsy: New method of research in national practice of forensic medicine. *Forensic Medicine*. 2019;5(2):27–31. (In Russ). doi: 10.19048/2411-8729-2019-5-2-27-31

25. Shchegolev AI, Tumanova UN. II Scientific and practical conference of the Interregional Thanatoradiological Society "Radiological diagnostics for pathological anatomy and forensic medicine: From lifetime to postmortem". *Forensic Medicine*. 2022;8(4):105–110. (In Russ). doi: 10.17816/fm759

26. Medvedev II. Fundamentals of pathoanatomical technology. 3nd revised and updated. Moscow: Medicine; 1969. 288 p. (In Russ).

27. Tumanova UN, Fedoseeva VK, Lyapin VM, et al. Acardiac fetus: Postmortem computed and magnetic resonance tomography imaging. *Diagnostic Int Radiol*. 2016;10(2):23–30. (In Russ).

28. Tumanova UN, Lyapin VM, Burov AA, et al. VACTERL association of newborn: Postmortem ct and mri imaging for autopsy. *REJR*. 2017;7(2):191–208. (In Russ). doi: 10.21569/2222-7415-2017-7-2-191-208

29. Kokov LS, Kinle AF, Sinitsyn VY, Filimonov BA. Possibilities of computed tomography and magnetic resonance imaging in forensic medical examination of mechanical trauma and sudden death (a literature review). *Emergency medical care. N.V. Sklifosovsky Magazine*. 2015;(2):16–26. (In Russ).

30. Kovalev AV, Kinle AF, Kokov LS, et al. Actual possibilities of postmortem imaging in forensic medicine practice. *Consilium Medicum*. 2016;18(13):9–25. (In Russ).

31. Roberts IS, Benamore RE, Benbow EW, et al. Post-mortem imaging as an alternative to autopsy in the diagnosis of adult deaths: A validation study. *Lancet*. 2012;379(9811):136–142. doi: 10.1016/S0140-6736(11)61483-9

32. Wijetunga C, O'Donnell C, So TY, et al. Injury detection in traumatic death: Postmortem computed tomography vs open autopsy. *Forensic Imaging*. 2020;(20):100349. doi: 10.1016/j.jofri.2019.100349

33. Proisy M, Marchand AJ, Loget P, et al. Whole-body post-mortem computed tomography compared with autopsy in the investigation of unexpected death in infants and children. *Eur Radiol*. 2013;23(6):1711–1719. doi: 10.1007/s00330-012-2738-1

34. Sieswerda-Hoogendoorn T, Soerdjbalie-Maikoe V, de Bakker H, van Rijn RR. Postmortem CT compared to autopsy in children; Concordance in a forensic setting. *Int J Legal Med*. 2014;128(6):957–965. doi: 10.1007/s00414-014-0964-6

35. Krentz BV, Alamo L, Grimm J, et al. Performance of post-mortem CT compared to autopsy in children. *Int J Legal Med*. 2016;130(4):1089–1099. doi: 10.1007/s00414-016-1370-z

36. Arthurs OJ, Guy A, Thayyil S, et al. Comparison of diagnostic performance for perinatal and paediatric post-mortem imaging: CT versus MRI. *Eur Radiol*. 2016;26(7):2327–2336. doi: 10.1007/s00330-015-4057-9

37. Whitby EH, Variend S, Rutter S, et al. Corroboration of in utero MRI using post-mortem MRI and autopsy in foetuses with CNS abnormalities. *Clin Radiol*. 2004;59(12):1114–1120. doi: 10.1016/j.crad.2004.04.018

38. Tumanova UN, Serova NS, Shchegolev AI. Use of the postmortem MRI for the cerebral lesions diagnosis in the fetuses and newborns. *REJR*. 2017;7(3):8–22. (In Russ). doi: 10.21569/2222-7415-2017-7-3-8-22

39. Tumanova UN, Lyapin VM, Bychenko VG, et al. Postmortem magnetic resonance imaging in the diagnosis of congenital pneumonia. *Bulletin Russ State Med University*. 2016;(4):44–50. (In Russ).

40. Tumanova UN, Serova NS, Bychenko VG, Shchegolev AI. Possibilities of postmortem radiological studies for evaluation of lung lesions. *REJR*. 2018;8(2):198–221. (In Russ). doi: 10.21569/2222-7415-2018-8-2-198-221

41. Tumanova UN, Lyapin VM, Bychenko VG, et al. Potentialities of postmortem magnetic resonance imaging for identification of live birth and stillbirth. *Bull Exp Biol Med*. 2019;167(6):823–826. doi: 10.1007/s10517-019-04631-9

42. Tumanova UN, Lyapin VM, Bychenko VG, et al. Postmortem MRI characteristics of nonimmune fetal hydrops. *REJR*. 2018;8(4):172–183. (In Russ). doi: 10.21569/2222-7415-2018-8-4-172-18

43. Tumanova UN, Lyapin VM, Bychenko VG, et al. Possibilities of postmortem magnetic resonance imaging for evaluation of anasarca in newborns. *Bull Exp Biol Med*. 2019;166(5):671–675. doi: 10.1007/s10517-019-04415-1

44. Thayyil S, Sebire NJ, Chitty LS, et al. Post-mortem MRI versus conventional autopsy in fetuses and children: A prospective validation study. *Lancet*. 2013;382(9888):223–233. doi: 10.1016/S0140-6736(13)60134-8

45. Grabherr S, Heinemann A, Vogel H, et al. Postmortem CT angiography compared with autopsy: A forensic multicenter study. *Radiology*. 2018;288(1):270–276. doi: 10.1148/radiol.2018170559

46. Tumanova UN, Lyapin VM, Bychenko VG, et al. Postmortem computed tomography angiography of newborns. *Bull Exp Biol Med*. 2020;170(2):268–274. doi: 10.1007/s10517-020-05049-4

47. Ben-Sasi K, Chitty LS, Franck LS, et al. Acceptability of a minimally invasive perinatal/paediatric autopsy: Healthcare professionals' views and implications for practice. *Prenat Diagn*. 2013;33(4):307–312. doi: 10.1002/pd.4077

48. Blokker BM, Weustink AC, Wagensveld IM, et al. Conventional autopsy versus minimally invasive autopsy with postmortem MRI, CT, and CT-guided biopsy: Comparison of diagnostic performance. *Radiology*. 2018;289(3):658–667. doi: 10.1148/radiol.2018180924
49. Shchegolev AI, Tumanova UN. Persistence of SARS-CoV-2 in deceased patients and safe handling of infected bodies. *Bulletin of RSMU*. 2021;(3):5–11. doi: 10.24075/brsmu.2021.029
50. Raviraj KG, Shobhana SS, Raviraj KG, et al. Findings and inferences from full autopsies, minimally invasive autopsies and biopsy studies in patients who died as a result of COVID19: A systematic review. *Forensic Sci Med Pathol*. 2022;18(3):369–381. doi: 10.1007/s12024-022-00494-1
51. Tumanova UN, Shchegolev AI, Kovalev AV. Technical and methodological support for postmortem radiation examinations in the pathological departments and the forensic bureau. *Forensic Medical Examination*. 2021;64(2):51–57. (In Russ). doi: 10.17116/sudmed20216402151
52. Tumanova UN, Fedoseeva VK, Lyapin VM, et al. Identification of gas accumulations in the bodies of fetuses, still-borns and dead newborns at postmortem computed tomography study. *Consilium Medicum*. 2016;18(13):26–33. (In Russ).
53. Tumanova UN, Lyapin VM, Shchegolev AI, et al. Epignatus of a newborn: Postmortem CT and MRI imaging for autopsy. *REJR*. 2017;7(4):90–107. (In Russ). doi: 10.21569/2222-7415-2017-7-4-90-107
54. Tumanova UN, Lyapin VM, Kozlova AV, et al. Galen vein aneurysm in a newborn: Postmortem MSCT with contrast enhancement of vessels within the autopsy. *REJR*. 2019;9(2):260–274. (In Russ). doi: 10.21569/2222-7415-2019-9-2-260-274
55. Poulsen K, Simonsen J. Computed tomography as routine in connection with medico-legal autopsies. *Forensic Sci Int*. 2007;171(2-3):190–197. doi: 10.1016/j.forsciint.2006.05.041
56. Fetisov VA. Advantages and disadvantages of CT scanners and their placement options for postmortem cross-sectional imaging (UK specialists experience). *Consilium Medicum*. 2016;18(13):34–37. (In Russ).
57. Fernandes F, Castillo P, Bassat Q, et al. Contribution of the clinical information to the accuracy of the minimally invasive and the complete diagnostic autopsy. *Hum Pathol*. 2019;(85):184–193. doi: 10.1016/j.humpath.2018.10.037
58. Spiridonov VA. To the question of the development of virtual autopsy in Russia, or what to do? *Forensic Medicine*. 2016;(2):93–94. (In Russ).
59. Dubrova SE, Filimonov BA. Postmortem computed tomography and its features: What should clinical radiologists know? *Consilium Medicum*. 2016;18(13):38–47. (In Russ).
60. Shchegolev AI, Tumanova UN, Lyapin VM. Pathological estimation of the time of fetal death. *Pathology Archive*. 2017;79(6):60–65. (In Russ). doi: 10.17116/patol201779660-65
61. Tumanova UN, Shchegolev AI, Kovalev AV. Organization of postmortem radiological examination in the structure of pathological departments and forensic bureaus. *Forensic Medical Examination*. 2021;64(1):57–63. (In Russ). doi: 10.17116/sudmed20216401157

СПИСОК ЛИТЕРАТУРЫ

1. Connoly A.J., Finkbeiner W.E., Ursell P.C., Davis R.L. Autopsy pathology: A manual and atlas. 3th ed. Elsevier Inc., 2016. 400 p.
2. Ernst L.M. A pathologist's perspective on the perinatal autopsy // Semin Perinatol. 2015. Vol. 39, N 1. P. 55–63. doi: 10.1053/j.semperi.2014.10.008
3. Oluwasola O.A., Fawole O.I., Otegbayo A.J., et al. The autopsy knowledge, attitude, and perceptions of doctors and relatives of the deceased // Arch Pathol Lab Med. 2009. Vol. 133, N 1. P. 78–82. doi: 10.5858/133.1.78
4. Levy B. Informatics and autopsy pathology // Surg Pathol Clin. 2015. Vol. 8, N 2. P. 159–174. doi: 10.1016/j.path.2015.02.010
5. Thali M.J., Yen K., Schweitzer W., et al. Virtopsy, a new imaging horizon in forensic pathology: Virtual autopsy by postmortem multislice computed tomography (MSCT) and magnetic resonance imaging (MRI): A feasibility study // J Forensic Sci. 2003. Vol. 48, N 2. P. 386–403.
6. Eastridge B.J., Mardin M., Cantrell J., et al. Died of wounds on the battlefield: Causation and implications for improving combat casualty care // J Trauma. 2011. Vol. 71, N S1. P. 4–8. doi: 10.1097/TA.0b013e318221147b
7. Eastridge B.J., Mabry R.L., Seguin P., et al. Death on the battlefield (2001–2011): Implications for the future of combat casualty care // J Trauma Acute Care Surg. 2012. Vol. 73, N 6, Suppl. 5. P. 431–437. doi: 10.1097/TA.0b013e3182755dcc
8. Berran P.J., Mazuchowski E.L., Marzouk A., Harcke H.T. Observational case series: an algorithm incorporating multidetector computerized tomography in the medicolegal investigation of human remains after a natural disaster // J Forensic Sci. 2014. Vol. 59, N 4. P. 1121–1125. doi: 10.1111/1556-4029.12422
9. Baglivo M., Winklhofer S., Hatch G.M., et al. The rise of forensic and post-mortem radiology: Analysis of the literature between the year 2000 and 2011 // J Forensic Radiol Imaging. 2013. Vol. 1, N 1. P. 3–9. doi: 10.1016/j.jofri.2012.10.003
10. Туманова У.Н. Становление и развитие посмертных лучевых исследований в мире и России // REJR. 2020. Т. 10, № 4. С. 250–263. doi: 10.21569/2222-7415-2020-10-4-250-263
11. Arthurs O.J., van Rijn R.R., Sebire N.J. Current status of paediatric post-mortem imaging: An ESPR questionnaire-based survey // Pediatr Radiol. 2014. Vol. 44, N 3. P. 244–251. doi: 10.1007/s00247-013-2827-6
12. Shelmerdine S.C., Gerrard C.Y., Rao P., et al. Joint European society of paediatric radiology (ESPR) and international society for forensic radiology and imaging (ISFRI) guidelines: Paediatric postmortem computed tomography imaging protocol // Pediatr Radiol. 2019. Vol. 49, N 5. P. 694–701. doi: 10.1007/s00247-018-04340-x
13. Whitby E., Offiah A.C., Shelmerdine S.C., et al. Current state of perinatal postmortem magnetic resonance imaging: European society of paediatric radiology questionnaire-based survey and recommendations // Pediatr Radiol. 2021. Vol. 51, N 5. P. 792–799. doi: 10.1007/s00247-020-04905-9
14. Chambers G., Shelmerdine S.C., Aertsen M., et al. Current and future funding streams for paediatric postmortem imaging: European society of paediatric radiology survey results // Pediatr Radiol. 2023. Vol. 53, N 2. P. 273–281. doi: 10.1007/s00247-022-05485-6
15. Rutty G.N., Swift B. Accuracy of magnetic resonance imaging in determining cause of sudden death in adults: Comparison with conventional autopsy // Histopathology. 2004. Vol. 44, N 2. P. 187–189. doi: 10.1111/j.1365-2559.2004.01741.x

16. O'Donnell C., Rotman A., Collett S., Woodford N. Current status of routine post-mortem CT in Melbourne, Australia // Forensic Sci Med Pathol. 2007. Vol. 3, N 3. P. 226–232. doi: 10.1007/s12024-007-9006-8
17. Van Rijn R.R., Beek E.J., van de Putte E.M., et al. The value of postmortem computed tomography in paediatric natural cause of death: A Dutch observational study // Pediatr Radiol. 2017. Vol. 47, N 11. P. 1514–1522. doi: 10.1007/s00247-017-3911-0
18. Халиков А.Д., Александрова З.Д., Трофимова Т.Н., и др. Виртуальная аутопсия мертворожденного с пентадой Кантрелла // Нейрохирургия и неврология детского возраста. 2009. № 1. С. 14–19.
19. Бывальцев В.А., Степанов И.А., Семенов А.В., и др. Возможности диагностики давности наступления смерти по изменениям в поясничных межпозвонковых дисках (сопоставление морфологических, иммуногистохимических и томографических результатов) // Судебно-медицинская экспертиза. 2017. № 4. С. 4–8. doi: 10.17116/sudmed20176044-8
20. Борщевская В.Н., Солонкина А.Д., Глоба И.В. Посмертная компьютерно-томографическая диагностика тромбоэмболии легочной артерии в практике судебно-медицинского эксперта (пилотное исследование) // Материалы II Научно-практической конференции Межрегионального танаторадиологического общества «Лучевая диагностика для патологической анатомии и судебно-медицинской экспертизы: от прижизненной к посмертной», 7–8 октября. Москва, 2022. С. 118–121. doi: 10.54182/9785988117094_2022_118
21. Туманова У.Н., Федосеева В.К., Ляпин В.М., и др. Посмертная компьютерная томография мертворожденных с костной патологией // Медицинская визуализация. 2013. № 5. С. 110–120.
22. Tumanova U.N., Shchegolev A.I. The role and place of thanatoradiological studies in the pathological examination of fetuses and newborns // Bull Exp Biol Med. 2022. Vol. 173, N 6. P. 691–705. doi: 10.1007/s10517-022-05615-y
23. Клевно В.А., Чумакова Ю.В., Дуброва С.Э. Судебно-медицинская экспертиза и посмертная компьютерная томография в случае смерти от механической асфиксии: сложности диагностики // Судебная медицина. 2019. № S1. С. 54.
24. Клевно В.А., Чумакова Ю.В. Виртопсия — новый метод исследования в практике отечественной судебной медицины // Судебная медицина. 2019. № 2. С. 27–31. doi: 10.19048/2411-8729-2019-5-2-27-31
25. Щеголев А.И., Туманова У.Н. II Научно-практическая конференция Межрегионального танаторадиологического общества «Лучевая диагностика для патологической анатомии и судебно-медицинской экспертизы: от прижизненной к посмертной» // Судебная медицина. 2022. № 4. С. 105–110. doi: 10.17816/fm759
26. Медведев И.И. Основы патологоанатомической техники. 3-е изд., испр. и доп. Москва: Медицина, 1969. 288 с.
27. Туманова У.Н., Федосеева В.К., Ляпин В.М., и др. Плодакардиус: посмертная компьютерная и магнитно-резонансная томография // Диагностическая и интервенционная радиология. 2016. Т. 10, № 2. С. 23–30.
28. Туманова У.Н., Ляпин В.М., Буров А.А., и др. VACTERL ассоциация у новорожденного: посмертная КТ и МРТ визуализация при патологоанатомическом исследовании // REJR. 2017. Vol. 7, N 2. P. 191–208. doi: 10.21569/2222-7415-2017-7-2-191-208
29. Коков Л.С., Кинле А.Ф., Синицын В.Е., Филимонов Б.А. Возможности компьютерной и магнитно-резонансной томографии в судебно-медицинской экспертизе механической травмы и скоропостижной смерти (обзор литературы) // Неотложная медицинская помощь. Журнал им. Н.В. Склифосовского. 2015. № 2. С. 16–26.
30. Ковалев А.В., Кинле А.Ф., Коков Л.С., и др. Реальные возможности посмертной лучевой диагностики в практике судебно-медицинского эксперта // Consilium Medicum. 2016. Т. 18, № 13. С. 9–25.
31. Roberts I.S., Benamore R.E., Benbow E.W., et al. Post-mortem imaging as an alternative to autopsy in the diagnosis of adult deaths: A validation study // Lancet. 2012. Vol. 379, N 9811. P. 136–142. doi: 10.1016/S0140-6736(11)61483-9
32. Wijetunga C., O'Donnell C., So T.Y., et al. Injury detection in traumatic death: Postmortem computed tomography vs open autopsy // Forensic Imaging. 2020. N 20. P. 100349. doi: 10.1016/j.jofri.2019.100349
33. Proisy M., Marchand A.J., Loget P., et al. Whole-body post-mortem computed tomography compared with autopsy in the investigation of unexpected death in infants and children // Eur Radiol. 2013. Vol. 23, N 6. P. 1711–1719. doi: 10.1007/s00330-012-2738-1
34. Sieswerda-Hoogendoorn T., Soerdjbalie-Maikoe V., de Bakker H., van Rijn R.R. Postmortem CT compared to autopsy in children; Concordance in a forensic setting // Int J Legal Med. 2014. Vol. 128, N 6. P. 957–965. doi: 10.1007/s00414-014-0964-6
35. Krentz B.V., Alamo L., Grimm J., et al. Performance of postmortem CT compared to autopsy in children // Int J Legal Med. 2016. Vol. 130, N 4. P. 1089–1099. doi: 10.1007/s00414-016-1370-z
36. Arthurs O.J., Guy A., Thayyil S., et al. Comparison of diagnostic performance for perinatal and paediatric post-mortem imaging: CT versus MRI // Eur Radiol. 2016. Vol. 26, N 7. P. 2327–2336. doi: 10.1007/s00330-015-4057-9
37. Whitby E.H., Variend S., Rutter S., et al. Corroboration of in utero MRI using post-mortem MRI and autopsy in foetuses with CNS abnormalities // Clin Radiol. 2004. Vol. 59, N 12. P. 1114–1120. doi: 10.1016/j.crad.2004.04.018
38. Туманова У.Н., Серова Н.С., Щеголев А.И. Применение посмертной МРТ для диагностики поражений головного мозга у плодов и новорожденных // REJR. 2017. Т. 7, № 3. С. 8–22. doi: 10.21569/2222-7415-2017-7-3-8-22
39. Tumanova U.N., Lyapin V.M., Bychenko V.G., et al. Postmortem magnetic resonance imaging in the diagnosis of congenital pneumonia // Bulletin Russ State Med University. 2016. № 4. С. 44–50.
40. Туманова У.Н., Серова Н.С., Быченко В.Г., Щеголев А.И. Возможности посмертных лучевых исследований для оценки поражений легких // REJR. 2018. Т. 8, № 2. С. 198–221. doi: 10.21569/2222-7415-2018-8-2-198-221
41. Tumanova U.N., Lyapin V.M., Bychenko V.G., et al. Potentialities of postmortem magnetic resonance imaging for identification of live birth and stillbirth // Bull Exp Biol Med. 2019. Vol. 167, N 6. P. 823–826. doi: 10.1007/s10517-019-04631-9
42. Туманова У.Н., Ляпин В.М., Быченко В.Г., и др. Посмертная МРТ-характеристика неиммунной водянки плода // Российский электронный журнал лучевой диагностики. 2018. Т. 8, № 4. С. 172–183. doi: 10.21569/2222-7415-2018-8-4-172-18
43. Tumanova U.N., Lyapin V.M., Bychenko V.G., et al. Possibilities of postmortem magnetic resonance imaging for evaluation of anasarca in newborns // Bull Exp Biol Med. 2019;166(5):671–675. doi: 10.1007/s10517-019-04415-1

44. Thayyil S., Sebire N.J., Chitty L.S., et al. Post-mortem MRI versus conventional autopsy in fetuses and children: A prospective validation study // Lancet. 2013. Vol. 382, N 9888. P. 223–233. doi: 10.1016/S0140-6736(13)60134-8
45. Grabherr S., Heinemann A., Vogel H., et al. Postmortem CT angiography compared with autopsy: A forensic multicenter study // Radiology. 2018. Vol. 288, N 1. P. 270–276. doi: 10.1148/radiol.2018170559
46. Tumanova U.N., Lyapin V.M., Bychenko V.G., et al. Postmortem computed tomography angiography of newborns // Bull Exp Biol Med. 2020. Vol. 170, N 2. P. 268–274. doi: 10.1007/s10517-020-05049-4
47. Ben-Sasi K., Chitty L.S., Franck L.S., et al. Acceptability of a minimally invasive perinatal/paediatric autopsy: Healthcare professionals' views and implications for practice // Prenat Diagn. 2013. Vol. 33, N 4. P. 307–312. doi: 10.1002/pd.4077
48. Blokker B.M., Weustink A.C., Wagensveld I.M., et al. Conventional autopsy versus minimally invasive autopsy with postmortem MRI, CT, and CT-guided biopsy: Comparison of diagnostic performance // Radiology. 2018. Vol. 289, N 3. P. 658–667. doi: 10.1148/radiol.2018180924
49. Shchegolev A.I., Tumanova U.N. Persistence of SARS-CoV-2 in deceased patients and safe handling of infected bodies // Bulletin of RSMU. 2021. N 3. P. 5–11. doi: 10.24075/brsmu.2021.029
50. Raviraj K.G., Shobhana S.S., Raviraj K.G., et al. Findings and inferences from full autopsies, minimally invasive autopsies and biopsy studies in patients who died as a result of COVID19: A systematic review // Forensic Sci Med Pathol. 2022. Vol. 18, N 3. P. 369–381. doi: 10.1007/s12024-022-00494-1
51. Туманова У.Н., Щеголев А.И., Ковалев А.В. Техническое и методическое обеспечение проведения посмертных лучевых исследований в патологоанатомических отделениях и бюро судебно-медицинской экспертизы // Судебно-медицинская экспертиза. 2021. Т. 64, № 2. С. 51–57.
52. Туманова У.Н., Федосеева В.К., Ляпин В.М., и др. Выявление скоплений газа в телах плодов, мертворожденных и умерших новорожденных при посмертном компьютерно-томографическом исследовании // Consilium Medicum. 2016. Т. 18, № 13. С. 26–33.
53. Туманова У.Н., Ляпин В.М., Щеголев А.И., и др. Эпигнатус у новорожденного: посмертная КТ- и МРТ-визуализация при патологоанатомическом исследовании // REJR. 2017. Т. 7, № 4. С. 90–107. doi: 10.21569/2222-7415-2017-7-4-90-107
54. Туманова У.Н., Ляпин В.М., Козлова А.В., и др. Аневризма вены Галена у новорожденного: посмертная КТ с контрастным усилением сосудов при патологоанатомическом исследовании // REJR. 2019. Т. 9, № 2. С. 260–274. doi: 10.21569/2222-7415-2019-9-2-260-274
55. Poulsen K., Simonsen J. Computed tomography as routine in connection with medico-legal autopsies // Forensic Sci Int. 2007. Vol. 171, N 2-3: P. 190–197. doi: 10.1016/j.forsciint.2006.05.041
56. Фетисов В.А. Преимущества и недостатки вариантов размещения компьютерных томографов для посмертной визуализации (опыт специалистов Великобритании) // Consilium Medicum. 2016. Т. 18, № 13. С. 34–37.
57. Fernandes F., Castillo P., Bassat Q., et al. Contribution of the clinical information to the accuracy of the minimally invasive and the complete diagnostic autopsy // Hum Pathol. 2019. Vol. 85. P. 184–193. doi: 10.1016/j.humpath.2018.10.037
58. Спиридонов В.А. К вопросу развития виртуальной аутопсии в России, или что делать? // Судебная медицина. 2016. № 2. С. 93–94.
59. Дуброва С.Э., Филимонов Б.А. Что должен знать клинический рентгенолог об особенностях компьютерной томографии трупа? // Consilium Medicum. 2016. Т. 18, № 13. С. 38–47.
60. Щеголев А.И., Туманова У.Н., Ляпин В.М. Патологоанатомическая оценка давности внутриутробной гибели плода // Архив патологии. 2017. Т. 79. № 6. С. 60–65.
61. Туманова У.Н., Щеголев А.И., Ковалев А.В. Организация проведения посмертных лучевых исследований в структуре патологоанатомических отделений и бюро судебно-медицинской экспертизы // Судебно-медицинская экспертиза. 2021. Т. 64, № 1. С. 57–63. doi: 10.17116/sudmed20216401157

AUTHORS' INFO

*** Aleksandr I. Shchegolev,** MD, Dr. Sci. (Med.), Professor;
address: 4 Akademika Oparina street, 117997 Moscow, Russia;
ORCID: 0000-0002-2111-1530;
eLibrary SPIN: 9061-5983;
e-mail: ashegolev@oparina4.ru

Ulyana N. Tumanova, MD, Dr. Sci. (Med.);
ORCID: 0000-0002-0924-6555;
eLibrary SPIN: 7555-0987;
e-mail: u.n.tumanova@yandex.ru

ОБ АВТОРАХ

*** Щеголев Александр Иванович,** д-р мед. наук, профессор;
адрес: Россия, 117997, Москва, ул. академика Опарина, д. 4;
ORCID: 0000-0002-2111-1530;
eLibrary SPIN: 9061-5983;
e-mail: ashegolev@oparina4.ru

Туманова Ульяна Николаевна, д-р мед. наук;
ORCID: 0000-0002-0924-6555;
eLibrary SPIN: 7555-0987;
e-mail: u.n.tumanova@yandex.ru

* Corresponding author / Автор, ответственный за переписку