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Minimally invasive autopsy – endoscopic approach to post-mortem diagnostics

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Abstract

The noticeable decline in the number of autopsies performed in recent years requires investigation into the causes of the phenomenon and attempts to prevent it. One potential cause of this trend is fear of disfiguring the body. Carrying out autopsies using a minimally invasive method may reduce the decrease in the number of autopsies performed. The first work on the development of the method and its continuation gave promising results. This allows us to start a discussion on attempts to introduce the method. The solution seems especially justified when the alternative is to completely abandon post-mortem examinations using the traditional method. Laparoscopy and thoracoscopy are tools that allow for accurate imaging and analysis of organ changes. Enriching them with additional tests using endoscopic techniques may have a positive impact on the accuracy of autopsy diagnoses. The development of a clear protocol for minimally invasive post-mortem diagnosis requires further research to determine the accuracy of the method.

Key words: *autopsy, minimally invasive diagnostics, diagnostic methods, post-mortem diagnostics, post-mortem laparoscopy.*

Introduction

Post-mortem examination of corpses has been, and continues to be, a basic source of knowledge, enabling understanding of the laws governing the body, the paths of occurrence and development of diseases, and the mechanisms of death [1]. Autopsies make it possible to verify the diagnosis made during life, assess the effectiveness of the treatment method, and indicate the cause of death [2]. Due to the development of new treatment methods, a significant increase in the importance of autopsy is expected to assess side effects and long-term novel therapeutic strategies [2, 3]. For years, there has been a noticeable decrease in the number of autopsies carried out [2, 4–7]. For several years there has been a noticeable decline in the number of autopsies performed [2, 4–7]. One of the factors contributing to the expression of opposition to performing an autopsy is the fear of disfiguring the body [4, 8, 9]. With the development of medical technologies and related minimally invasive diagnostic and surgical methods, there are opportunities to use them for post-mortem diagnostic purposes [10]. These include endoscopic techniques that enable the assessment of internal organs through small accesses, which leave cosmetically small marks on the body. The first attempts to use a laparoscope to perform autopsies took place in Israel in the 1990s [11, 12]. The promising results shown by the authors resulted in continuation of research in other centres around the world [4, 13, 14]. Currently, the wide availability of endoscopic tools enables a significant spread of minimally invasive methods of post-mortem diagnostics.

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Aim of the study

The aim of the study was to present the possibility of using minimally invasive endoscopic techniques, in particular laparoscopic examination and thoracoscopy, in post-mortem diagnostics.

The place of autopsy in modern medicine

In many countries, there has been a visible decline in the number of autopsies performed over recent years [2, 4–7, 15–24]. The reasons for this phenomenon are diverse, occurring both on the side of doctors and patients. From the medical perspective, the fear of detecting a medical error and the belief that the procedure is pointless in light of advanced diagnostic technologies are the main factors influencing the decision to abandon autopsy [2, 4, 25, 26]. The inaccuracy of this belief is proven by the fact that there is only a slight decrease in the percentage of incorrect diagnoses, despite the use of modern diagnostic methods [2, 27, 28]. Analyses show a discrepancy of 10–35% between the diagnoses made by clinicians and the autopsy results [2, 7, 29–33]. Moreover, the above-mentioned views are contrary to the educational value that autopsy results may have for doctors [2, 34]. We should also not overlook the importance of the psychological burden that a patient's death has on the doctor. This may be a factor sufficiently influencing the decision to abandon the procedure [4]. Moreover, talking to relatives and offering an autopsy are also described by doctors as difficult [35]. The costs of performing a traditional autopsy may be an independent factor in reducing the percentage of autopsies performed [25]. The role of autopsy in the education of future generations of students and medical staff should not be ignored, because it is an irreplaceable element of teaching. The use of minimally invasive techniques would increase the educational value by reducing emotional reactions among students during the procedure [2, 7, 36]. Maintaining current trends combined with changes in medical curricula in the future may result in the possibility of practicing medical professions for people who do not participate in autopsies and who will not understand their importance for the treatment process and determining the cause of death [2, 7].

Polish law gives the patient the opportunity to decide not to perform a pathological autopsy. The objection must be expressed in a statement included in the medical documentation. The patient's legal representative may also express an objection [37]. The reasons for the patient's objection to perform an autopsy are very heterogeneous. The patient believes that they have already endured enough burdensome medical procedures, and by resigning from the autopsy they will somehow avoid additional suffering [4, 5]. It is also associated with the fear of body disfigurement as a result of the procedure [4, 5, 13, 24, 38]. Metaphysical and religious reasons are also of great importance [2, 7, 9, 13, 24, 38–41]. One of them is giving special symbolic and emotional meaning to the heart and brain [2, 42]. Although most religions do not prohibit performing an autopsy, resignation for religious reasons may be caused by the obligation to conduct a quick funeral and the fear of desecrating the body [24, 40, 43]. Another factor that negatively influences the impression of opposition to performing an autopsy is the image shaped by the media [2]. Reports and film images that have little to do with reality seem to have a significant, often negative, impact. Conducting a minimally invasive autopsy using endoscopic techniques, thanks to minimal invasiveness and avoiding disfigurement of the corpse, makes the autopsy less traumatic for patients and their families. This directly results in greater acceptability of the procedure [2, 4, 11, 12, 38, 40, 44, 45]. This is particularly important when the alternative is to completely refrain from performing an autopsy, such in the case of examining foetuses, where determining the cause of their death and any pathologies present is an important issue. The use of minimally invasive techniques in this case also gives promising results and has a positive impact on the number of consents given for autopsy by reducing traumatization and subsequent improvement in the acceptability of the procedure for parents, providing grounds for popularizing the method [9, 45–52].

Minimally invasive autopsy

Minimally invasive autopsy using a laparoscope involves the assessment of body cavities and the organs located in them through small accesses located in the abdominal or chest wall ("keyhole"), leaving no significant cosmetic defect. There are several terms in the literature describing this diagnostic method: MinImAL (Minimally Invasive Autopsy with Laparoscopic tissue sampling), ABC-scopy (All - Body - Cavity - sco-

py), and Videoautopsy [53, 54]. The procedure technique is based on the protocols used in laparoscopic surgery [4, 5, 7, 55, 56]. The tools used are the same as those used in surgical procedures [4, 5, 7, 13, 55, 56]. So far, no clear position has been developed indicating the order of the organs examined. In published reports, the authors, based on their research, suggest starting the treatment of parenchymal organs such as the liver, kidneys, and adrenal glands to maintain a clean operating space for as long as possible [4]. Accidental damage or starting the examination by opening organs filled with content, such as the stomach or intestines, would cause the contents to leak out, limiting visibility. This also applies to elements of the circulatory system, including the heart, from which blood could flood the surgical field, additionally generating artifacts. However, there is currently no clear consensus on a universal examination protocol that includes techniques for examining individual organs and avoiding the formation of artifacts. Laparoscopic examination of the abdominal cavity allows for a detailed assessment of the organs and collection of material for toxicological and histopathological tests [54]. Moreover, the appropriate location of the trocars in the abdominal wall allows for free navigation in space and significantly facilitates the operator's access to the organs being assessed. Examination of the thoracic organs can be performed in one of 2 ways: using thoracoscopy with the placement of ports within its walls or by puncture and access through the diaphragm from the abdominal side [4, 57]. Thoracoscopy allows for a more accurate assessment of the mediastinal vessels [4]. Studies have shown high detection rates for abdominal and thoracic haemorrhages and spleen, liver, and diaphragm injuries, and slightly lower detection rates for mesenteric haematomas, and injuries of large vessels and lungs [12, 38]. Diagnostic effectiveness has also been demonstrated for the detection of myocardial hypertrophy and post-infarction scars, hepatic steatosis, pneumonia, and the occurrence of cancer metastases [54]. Difficulties in imaging are found in the posterior part of the mediastinum and the retroperitoneal space [5, 12, 38]. Areas that are not easy to assess also include the interstitium and posterior surface of the liver, and the internal surface of the stomach and intestines [4]. Respiratory tract and pulmonary embolism also cause significant diagnostic inconvenience [4]. Previous studies have shown that the cause of death could be determined in over 90% of cases [4]. The possibility of precise assessment of the location of penetrating and blunt injuries has been demonstrated, which is particularly important in the case of forensic medical examination [11]. The results of the laparoscopic autopsy were consistent with the results of traditional autopsy, but certain pathologies were noticed only during conventional post-mortem diagnostics [4, 13, 14, 58]. In determining the cause of death, combining data from the deceased's medical records with the results of laparoscopic autopsy turned out to be particularly useful [4]. The possibility of collecting organ sections for histopathological examinations, samples for toxicological tests, and material for genetic analyses are unquestionable advantages of using the endoscopic method [5, 12]. It is also important to use a suction device with a reservoir to determine the amount of fluid in the body cavities, which is crucial in the case of pericardial tamponade and bleeding and leakage into the pleural and peritoneal cavities. An additional advantage of using an endoscope during autopsy is the ability to directly document changes and the course of the entire procedure in the form of photos or video [40]. Moreover, ongoing research has shown a shorter time to perform a minimally invasive autopsy using endoscopic techniques than in a traditional autopsy. Combining endoscopic autopsy with complementary methods of minimally invasive diagnostics shows promising results [5]. The analysis of clinical data regarding the deceased improves the precision and correctness of the diagnosis made as a result of minimally invasive diagnostics [6, 7]. Laparoscopic techniques were also used during autopsies for the diagnosis of foetuses, newborns, and paediatric patients [46, 47, 53, 59]. Importantly, precise post-mortem foetal diagnostics provides key information for further medical care and genetic risk for couples planning further attempts to conceive a child [53, 60, 61]. After completing the examination, the places where the trocars were placed can be secured with surgical sutures, leaving minimal traces of the procedure.

Supplementary procedures

Certain limitations of the endoscopic method require the search for alternative methods to complement the examination. The overriding features of additional tests, to be consistent with the main objectives of the endoscopic examination, should be feasibility and minimal invasiveness. Combining

laparoscopic autopsy with transnasal endoscopic examination of the gastrointestinal tract and bronchi as part of a minimally invasive autopsy protocol allows for a synergistic increase in the precision of the results. Conducting a transnasal endoscopic examination alone enables the cause of death to be determined in 40.9% of cases [62]. Transnasal access makes it possible to avoid difficulties such as jaw clenching due to rigor mortis or blockage of the oral cavity of other aetiology [62]. Endoscopy of the respiratory tract would allow for the assessment of the nasal cavity, pharynx, larynx, trachea, and bronchi, which are difficult to visualize during laparoscopic examination [62]. Endoscopic assessment of the digestive tract will enable the assessment of the internal surface of the oesophagus, stomach, and intestines, which pose significant diagnostic difficulties when using only the laparoscopic method [4, 5, 62]. This will make it possible to keep the field clean during laparoscopic examination [4]. Moreover, it reduces the chances of missing lesions and foreign bodies occurring in the digestive tract [5]. It is also possible to collect contents from the gastrointestinal tract for toxicological tests, which is important in the case of poisoning. Information about the last meal obtained during diagnostics may be useful in determining the time of death [62]. Transnasal examination may be of particular value in cases of death due to exposure to high and low temperatures, ingestion of corrosive substances, aspiration of a foreign body into the lungs, or drowning due to the detection of changes typical of the gastrointestinal tract [62]. Another of the difficulties limiting the possibility of introducing a laparoscopic autopsy is the inability to examine the inside of the skull and brain, resulting in the lack of complexity of the procedure [7]. The cranial cavity is one of the three main body cavities of which the opening and assessment is necessary during autopsy. Examination of the contents and walls of the skull often provides key information regarding the cause of death. Conducting the examination using the traditional method significantly reduces the minimally invasive and non-disfiguring potential of laparoscopic autopsy. Therefore, it is necessary to consider introducing tests that will enable the identification of intracranial injuries with a certain probability, which will allow decisions to be made about subsequent diagnostic steps. Endoscopic evaluation of the internal structures of the eye provides guidance relevant from the point of view of forensic medicine, and it is an additional diagnostic tool [63]. Studies show the presence of pathological intraocular changes in up to 86% of all autopsy cases [64]. Introducing the endoscope inside the eyeball allows you to omit corneal opacity, which makes ophthalmoscopy examination difficult and inconclusive [65]. The test itself takes a few minutes and can be performed even many hours after death [65]. Moreover, endoscopic analysis of changes inside the eyeball enables the assessment of the time between head injury and death [65]. In each case, head injuries resulted in intraocular changes, and in 80% of them they were bilateral [65]. The most common were fundus haemorrhages, including retinal breaks and vitreous haemorrhages [65]. Optic disc oedema was present in 60% of cases of death as a result of head trauma, but not in cases of death from other causes [65]. Intraocular findings were also present in cases of violent asphyxiation [65]. Importantly, analysis of the inside of the eyeball without the need to extract it from the eye socket allows the examination to be carried out without additional disfigurement of the corpse [65]. Moreover, during the examination, the vitreous humour can be collected and is used, among others, for toxicological analyses and for determining the time of death [66, 67]. With the use of minimally invasive endoscopic techniques, it is also possible to evaluate the middle ear [68]. In the case of a conventional autopsy, its assessment poses a significant risk of serious disfigurement of the body as a result of penetrating the skull bones with a chisel. Examination of this area of the body is particularly important in the case of death due to sepsis or inflammation of unknown origin, so it cannot be omitted in the case of post-mortem diagnostics [69, 70]. The cranial sinuses may also be subject to post-mortem endoscopic evaluation, which has an important diagnostic value in the case of drownings [71, 72]. Moreover, penetration of the endoscope into the sinuses also allows for indirect assessment of damage to the skull base [71]. In cases where it is necessary, laparoscopic autopsy can be supplemented with endoscopic joint examination. This allows tissue fragments to be collected and assessed without the need to disfigure the body [73]. Algorithms regarding the course of the procedure should be developed based on surgical and orthopaedic procedures [73]. Additionally, the examination may be preceded by radiological techniques of non-invasive imaging diagnostics, such as magnetic resonance imaging or computed tomography, which alone are insufficient due to the inability to collect samples for histopatho-

logical examination [74–79]. This will enable the assessment of parenchymal organs that are difficult to fully assess using endoscopic techniques. In addition, post-mortem angiographic examination can also be performed, which is a minimally invasive technique [80]. Moreover, imaging tests also enable the assessment of brain and skull structures that are not accessible by endoscopic examination [81–83].

Limitations

The initial difficulty slowing down the introduction of the procedure into routine use is the lack of tools necessary to carry out laparoscopic examination of corpses in autopsy rooms [13]. In contrast to surgical operations, where the procedures are carried out at adapted stations, there is no need to use specially dedicated sectional tables. However, the use of mobile trolleys with the possibility of rotation and change of position has a positive effect on the comfort and quality of the procedure [13]. The need to train staff is also an important issue. The solution in this case is cooperation with surgeons who routinely perform laparoscopic procedures and training of a full interdisciplinary team combining medical professions [4]. Such a system brings benefits to both parties: surgeons training dissectors get the opportunity to practice manual skills on cadavers, which may translate into an increase in the quality of the operations they perform. Defining exclusion criteria is necessary to construct the conditions under which endoscopic autopsy can be performed. Demonstrating synergism with other minimally invasive methods will allow a protocol to be defined for minimally invasive cadaver examination and will contribute to increasing the accuracy of the method. Currently, one of the limitations is the lack of a developed method for minimally invasive assessment of the brain and the inside of the skull. Moreover, in the case of post-mortem examination using an endoscope, it is not possible to weigh the organs, which is an important diagnostic feature allowing the detection of hypertrophy.

Conclusions

Post-mortem examination can be performed to a satisfactory level using endoscopic techniques. A thorough analysis of available reports allowed directions to be set for research on the development of technique and preparation. The introduction of minimally invasive laparoscopic autopsy as an alternative tool to traditional autopsy may be one of the key factors, as well as education about the functions and need for autopsy, enabling a reduction in the percentage of objections and omissions with a subsequent increase in the number of autopsies. However, it seems necessary to develop clear procedures for performing laparoscopic autopsy. The key component to be determined is the number, size, and location of trocars. This directly affects the comfort and quality of the examination. The order of the examined organs is also important, to minimize the possibility of artifacts, contamination of the surgical field, or destruction of lesions that are key to making a diagnosis. The topography of the autopsy room and the composition of the team also require optimization. In this case, the subjective feelings of the doctors performing the procedure are particularly important. Comprehensive education of interdisciplinary teams will enable further development and improvement of the endoscopic autopsy method. For the procedure to be competitive, it is also necessary to determine the approximate costs of the procedure, the time necessary to perform it, its predictive value and diagnostic precision compared to traditional autopsy. It is also necessary to specify indications and exclusions in the case of using minimally invasive techniques during forensic medical autopsies.

Conflict of interest

The authors declare no conflict of interest.

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