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Virtopsy Controversies and Knowledge Gaps in the Middle-East and the Role of Virtopsy During the Present COVID-19 Pandemic

الخلافات حول التشريح الافتراضي والثغرات المعرفية في منطقة الشرق الأوسط ودور التشريح الافتراضي خلال جائحة كوفيد - 19 الحالية

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Abstract

The present review will discuss gaps in the current state of knowledge about virtopsy in the Middle East and its practical application during the covid-19 Pandemic. Published literature in different journals with strict inclusion and exclusion criteria was extensively reviewed using PubMed search engine to elucidate applications and implications of the virtual autopsy.

The present review is based upon literature survey covering a period of 17 months (June 2019 – October 2021) using the key words "Forensic Science, Virtopsy, Middle East, Radiology, Post-Mortem, Covid-19, Covid-19 pandemic". Studies using virtopsy in the Middle East are minimal and confined to four countries: Israel (56%) followed by Turkey (27%), Iran (9%) and UAE (5%). In terms of radiological modalities applied in virtopsy in the Middle East, computerized tomography (CT) was used the most (52%), followed by X-ray (38%), ultrasound (5%) and MRI (5%). The application of virtopsy in the postmortem investigations during the current Covid-19 pandemic was documented in four reports originating from a total of 32 corona-associated deaths. Of these 32 deceased, virtopsy alone was used in 19 deceased, while 13 deceased cases were examined by traditional autopsy combined with virtopsy. The mean age of the deceased was 68 (33-94)

Keywords: Forensic Medicine, Virtopsy, Middle East, Radiology, Post-Mortem, Covid-19 pandemic.

المستخلص

سيناقش العرض الثغرات الموجودة في الحالة الحالية والمعروفة بالتشريح الافتراضي في منطقة الشرق الأوسط، وتطبيقه العملي خلال جائحة كوفيد - 19. وقد تم استعراض المؤلفات المنشورة في مجلات مختلفة تحمل معايير صارمة للإدراج والاستبعاد وعلى نطاق واسع، باستخدام محرك البحث PobMed لتوضيح التطبيقات والآثار المترتبة على التشريح الافتراضي.

ويستند هذا العرض إلى مسح أدبي لمدة 17 شهراً (يونيو 2019 - أكتوبر 2021) باستخدام العبارات الرئيسية التالية "الطب الشرعي، بالتشريح الافتراضي، الشرق الأوسط، علم الأشعة، الحالة ما بعد الوفاة، كوفيد 19-، جائحة كوفيد 19-". إن الدراسات التي تستخدم فيرتوبسي في الشرق الأوسط قليلة للغاية ومقتصرة على أربع دول: إسرائيل (56%) تليها تركيا (27%) ثم إيران (9%) ثم الإمارات العربية المتحدة (5%). أما فيما يتعلق بالطرق الإشعاعية التي تطبق فيرتوبسي في الشرق الأوسط، فإن التصوير المقطعي المحوسب كان الأكثر استخداماً (52%)، يليه التصوير بالأشعة السينية (38%)، فالموجات فوق الصوتية (5%)، وأخيراً التصوير بالرنين المغناطيسي (5%). وقد تم توثيق تطبيق فيرتوبسي في التحقيقات التي أجريت بعد الوفاة خلال جائحة كوفيد 19 الحالية في أربعة تقارير لـ 32 حالة وفاة مرتبطة بكورونا. ومن بين هؤلاء الذين توفوا وعددهم 32 شخصاً، استخدمت فيرتوبسي وحدها في تحديد 19 حالة وفاة، في

الكلمات المفتاحية: الطب الشرعي، التشريح الافتراضي، الشرق الأوسط، علم الأشعة، الحالة ما بعد الوفاة، جائحة كوفيد - 19.

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years. There were 69% males and 31% females. In combination with traditional autopsy, virtopsy can be very effective in identifying the cause, mode, and the state of health a person was in before he died. However, virtopsy alone is shown to be less sensitive than traditional autopsy and, therefore, requires further research to replace traditional autopsy. It is hoped that the present paper will elucidate further the practical significance of virtopsy in the Middle East.

حين تم فحص 13 حالة وفاة عن طريق التشريح التقليدي إلى جانب فيروتوبسي. وكان متوسط عمر المتوفى 68 عاماً (33-94 عاماً)، 69% منهم من الذكور و31% من الإناث. ومقارنة مع التشريح التقليدي، فإن الفيرتوبسي يمكن أن يكون فعالاً جداً في تحديد السبب، والنمط، والحالة الصحية للشخص قبل وفاته. ومع ذلك، تبين أن الفيرتوبسي أقل حساسية من التشريح التقليدي، وبالتالي فإنه يتطلب المزيد من البحوث ليحل محل التشريح التقليدي.

1. Introduction

Virtopsy is a type of autopsy that employs virtual techniques for the purpose of postmortem assessment. The term 'virtopsy' is a blend of virtual and autopsy. It was first coined by Prof. Richard Dirnhofer, former head of the Institute of Forensic Medicine of the University of Bern, Switzerland [1]. Postmortem imaging is gaining rapid recognition in the field of forensic radiology and is considered one of the most popular alternatives to traditional autopsy. Different imaging modalities can be utilized depending on the type of tissue involved; for example, CT scanning is better suited for bones and air distribution abnormalities, whereas MRI is employed for the assessment of soft tissue changes. Those modalities are not limited to computed tomography scans and MRI imaging but also include CT angiography and 3D surface scanning [2]. Virtopsy can be practiced in multiple ways, including the "virtobot," which is basically a gigantic machine that integrates all the four major imaging modalities mentioned above. A virtobot put on trailer is called "virtomoblie". This version has been conceived for the purpose of making virtobot well suited for sites of mass disasters. Virtopsy is gaining more significance in the present-day forensic literature for two reasons: first because of its relative effectiveness as 80% concordance has been shown between traditional autopsy and virtopsy in terms of cause of death identification. Second, virtopsy is a bloodless, fast, minimally invasive procedure and has a better acceptance among a lot of religious and cultural groups [3].

2. Methodology

PubMed database was used for our literature search. The present review is based upon literature survey covering a period of 17 months (June 2019 – October 2021) using "Forensic Science, Virtopsy, Middle East, Radiology, Post-Mortem, Covid-19, Covid-19 pandemic" as keywords to narrow down our search to the most related topics. In addition, these keywords were combined in various ways with "AND" and "OR". No language restrictions were placed. Screening of titles of research results was based on screening of abstracts and then by retrieving and screening of the full text article.

3. Virtopsy Vs Traditional Autopsy

The word 'Autopsy' means to see by oneself, and this was the norm for thousands of years dating back to Ancient Greece. Nowadays, due to recent advances in imaging technology, the term Virtopsy was created. Consequently, rivalry started between the supporters of classical or traditional autopsy technique and the recently developed Virtual Autopsy or virtopsy technique [4].

While a traditional autopsy is invasive and hands-on-technique, virtopsy is more of a hands-off technique and minimally invasive. Virtopsy and autopsy both have their respective advantages one over the other. Yet, autopsy still has the advantage over virtopsy in its overall sensitivity [5]. The main advantages that Virtopsy has over traditional autopsy is that it is less time-consuming and does not contaminate the cadaver as well as the pathologist.

It also can be done after the cadaver has decomposed. Religious beliefs also favor virtopsy because it does not violate the body. Jews feel very strongly against Autopsy. Virtopsy is superior in detecting bone fracture lines and the depth of foreign bodies. Also, it is superior when it comes to certain cases of cranial and skeletal trauma. Virtopsy is more sensitive than autopsy in detecting vascular lesions, haemorrhages, and bone abnormalities. Yet, it lacks sensitivity when it comes to parenchymal lesions.

Traditional Autopsy has its advantages over virtopsy as the pathologist can assess the smell, feel, and touch of cadaver, which are absent in virtopsy. Parenchymal abnormalities were also better detected when a traditional autopsy was performed. Conventional autopsy is also superior to virtopsy when assessing soft tissue. In a study [5], authors reviewed 50 cadavers where traditional autopsy and virtopsy were performed. The conventional autopsy was more sensitive in detecting signs than virtopsy. As stated earlier, the traditional autopsy has its edge in its overall sensitivity, while virtopsy has some aspects where it is more sensitive. Yet, its overall sensitivity lags behind. Virtopsy can complement traditional autopsy regarding bone fractures and vascular lesions. It is not clear whether virtopsy will replace traditional autopsy in the near future; nevertheless, with recent technological advances in imaging it seems that virtopsy may have more role in forensic pathology.

4. Lack of Research on Virtopsy in the Middle-East

Virtual autopsy's main disadvantage is that it requires the use of high technology imaging devices. Considering that most of the Middle Eastern countries are less developed than western countries, there is little to no utility of virtopsy, not to mention that there are not many well-established forensic

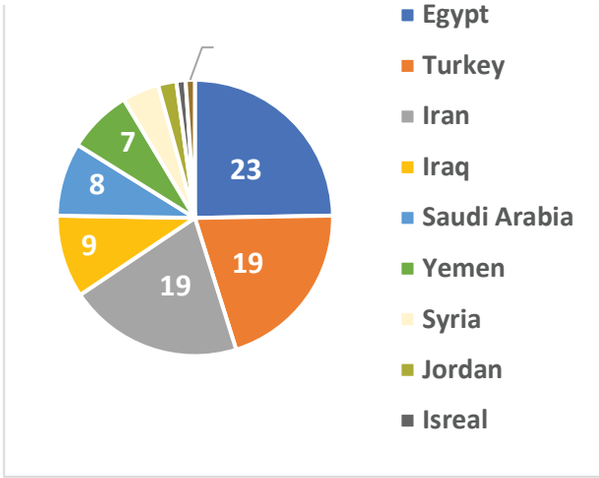

Figure 1a- *Distribution of Middle East countries which employed Virtopsy during Covid-19 pandemic*

medicine or forensic pathology centers in this part of the world. Egypt is the only Arab country that has a long history in traditional forensic medicine practice and autopsy which dates to ancient times. In Egypt, forensic discipline as a medical science started in the late nineteenth century. Saudi Arabia and Kuwait are relatively recent in their Forensic pathology history and have a lot of potential to expand and upgrade the service [6]. The first virtual autopsy performed in Saudi Arabia was in the year 2014 [7]. Because of this, there is very little research about virtual autopsy or non-invasive autopsy in the Middle East, excluding Israel and Turkey, which seem to have more research published on virtopsy than all the other Middle Eastern countries.

Overall, more than half of the studies in the Middle East were conducted in Israel, while the UAE contributed the smallest segment. Israel counted for 57% of the total number of research in the Middle East, which is 12 out of 21, while Turkey has exactly half of that amount being the largest two segments in the chart, leaving only three studies, two of which were conducted in Iran, while the remaining one was conducted in the UAE (Figures-1a and 1b).

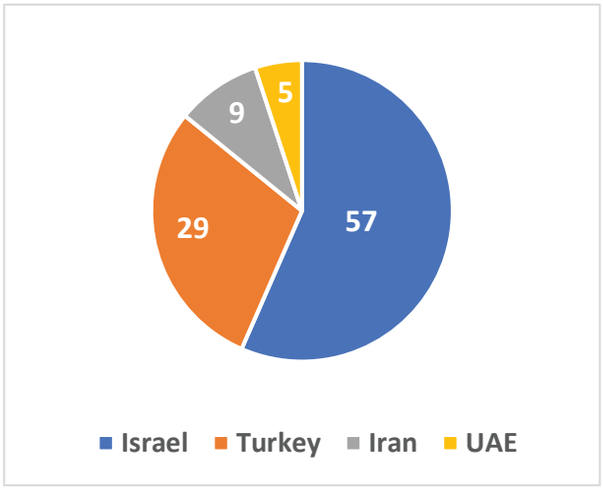

Figure 1b- *Research by country: Percentage of total research done using post-mortem imaging technology in the Middle East region featuring Israel, Turkey, Iran, and UAE.*

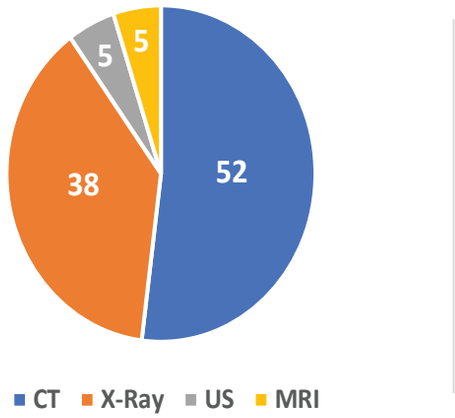

Figure 2- *Number of studies showing the use of various radiological modalities during Covid-19 pandemic.*

The use of various radiological modalities during Covid-19 pandemic is shown in the figure-2. CT scan was the most used radiological modality in these studies, while the US and MRI were used the least. Almost half of these studies were conducted using the CT radiological modality which counted for about 52% while the second largest segment was the X-ray, which made up 38% of the total, leaving US (5%) and MRI (5%).

The pie charts do not show countries in the Middle East (around 14 countries) which did not have any published research related to the application of modern technology in postmortem imaging. This reflects a huge gap of knowledge present within the literature about the region and even within the countries that have some studies in postmortem imaging. Moreover, number of studies done do not make significant addition to the existing state of knowledge about the application of virtopsy in forensic medicine in the Middle East.

5. COVID-19 Pandemic

Coronavirus disease-19 (COVID-19) is a newly emerging pandemic spreading around the world, and during the first half of 2020, it was the main concern for public health. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the infection that leads to clinical coronavirus disease. In December 2019, the first case was diagnosed in Wuhan (China) after which the infection spread to other parts of China, Europe, and finally to the rest of the world [8]. The virus is transmitted among humans through multiple routes, including direct inhalation of droplets contaminated with the virus that has been released in the environment through sneezing or coughing. It is also transmitted through body fluids, oral or nasal mucous, and through contaminated objects and surfaces. People who are infected with the Covid-19 virus have a wide range of clinical presentations; they could have an asymptomatic infection or some signs and symptoms such as fever, cough, malaise, and shortness of breath.

The severity of the COVID-19 infection varies from one patient to another. Some factors could play a role in determining the severity of the presentation including the age of patient, presence, or absence of chronic diseases (obesity, diabetes, hypertension), and if other comorbidities are present or not [9].

COVID-19 infection can be diagnosed with mul-

tiple tests and techniques. The principal test being used is obtaining a sample from the upper airway either by the nasopharyngeal or oropharyngeal swab. The specimen is then tested through a real-time reverse transcription polymerase chain reaction (RT-PCR) test. Other ways of diagnosing COVID-19 include blood testing, chest x-ray, and chest CT scan [9].

During the coronavirus disease, studies revealed that about 20% of the patients were admitted to the intensive care units (ICU) with 49% developing coagulopathy [10]. In another study [11], authors concluded that around 3.4 % of the patients eventually developed acute respiratory distress syndrome (ARDS), which was also seen in majority of the death cases.

Managing COVID-19 patients has been the major focus of clinicians during this pandemic. Unfortunately, to this moment there is no definitive management plan despite trying different treatment protocols and modalities. Multiple treatments and medications are being tried in managing covid-19 patients including antimalarial drugs, antibiotics, anti-viral, and corticosteroids [9]. The newly developed Covid-19 vaccine has a well-established efficacy in the protection against infection, reduction of hospital admission and lowering the rates of complication and mortality [12].

Despite a significant number of deaths, the number of postmortem autopsy and virtopsy studies is too low. As more attention is directed toward the clinical and pathological studies of the virus, new postmortem strategies should also be given due attention.

6. Virtopsy in COVID-19 Pandemic Patients

Under this title, we examined in detail four studies out of a total number of 32 cases who died of COVID-19 infection and underwent virtopsy performed under strict safety measures to prevent the spread of infection to the health workers. Safety measures taken included using N95 masks, protection of eyes, negative pressure examination room and COVID19 testing for all of the staff involved in these procedures.

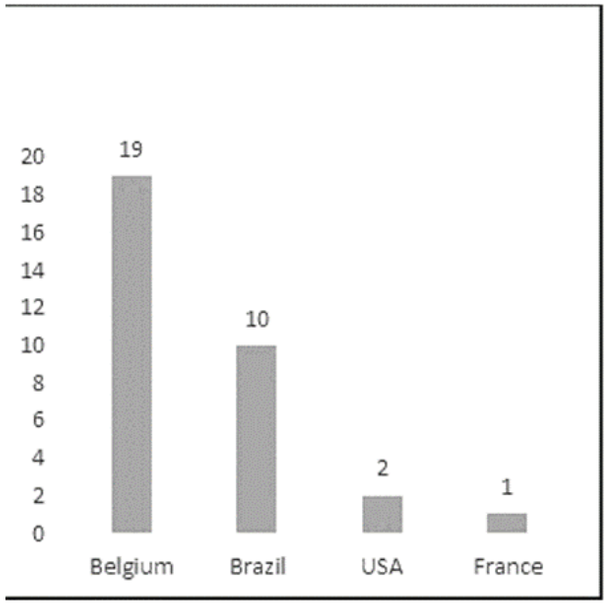

Figure 3- *Distribution of Virtopsy performed on worldwide bases during Covid-19 pandemic.*

Analyzing and reviewing the studies variabilities of age, gender, region, and the used imaging modalities with their outcomes will conduct a significant impact on the future of postmortem imaging in COVID-19 pandemic.

6. 1 Age distribution of Covid-19 patients who underwent virtopsy

The average age of all 32 deceased who underwent virtopsy was 68 years, with most of the deceased being above the age of 50 years while a few of them were below 50 years of age. The youngest participant was 33-year-old and the oldest was 94 years of age. We took in our consideration that most of the participants were above the age of 50 years; the reasons behind this selection were the fact that

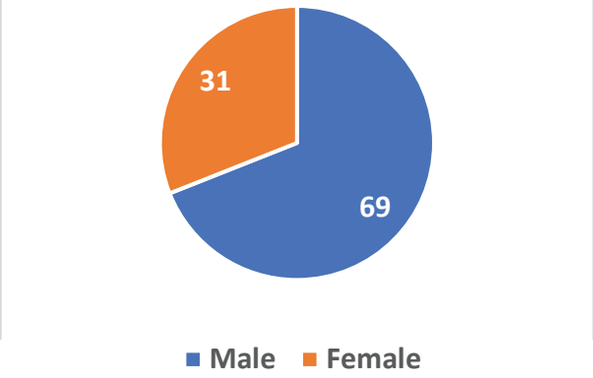

Figure 4- *Distribution of Virtopsy according to gender.*

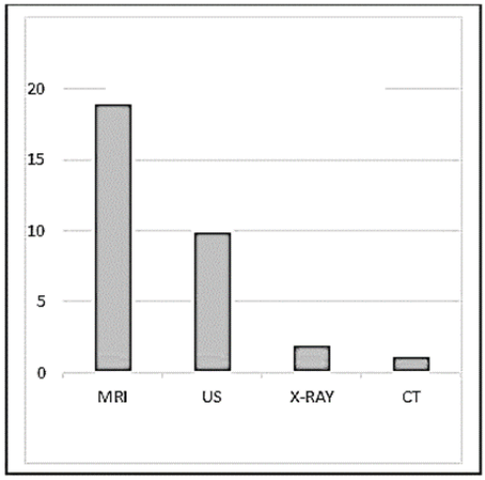

Figure 5- *Number of Cases according to the imaging modalities*

most of the deaths due to COVID-19 occurred in the older age group and the associated comorbidities are present at the old age population which, contributes to higher mortality rates [13-16].

6. 2 Country-wise distribution of COVID-19 patients who underwent virtopsy

Thirty-two deceased who underwent virtopsy were distributed among 4 countries, which were Belgium, Brazil, the USA, and France. Their distribution is shown in Figure-3.

In our selected four virtopsy studies, Belgium was at the top in performing virtopsy in covid-19 deaths constituting about 59% of the reviewed cases. While some countries had more covid-19 spread, their focus went toward the clinical part of the disease. On the other hand, Belgium was the least in Covid-19 cases of the 4 countries, which gave them ample time to conduct virtopsy and study its efficacy [13].

6. 3 Gender-based distribution of COVID-19 patients who underwent virtopsy

The presence of gender differences among the deceased who underwent virtopsy could raise many questions. Virtopsy was predominantly performed more in males (n=22) than females (n=10), Figure-4. This considerable variation in the gender distribution is attributed to the cultural and religious factors that favours virtopsy more in males than females. Different cultures and religions refuse to do an autopsy or virtopsy in female subjects.

6. 4 Imaging modalities used in performing virtopsy in COVID-19 patients

There are several types of imaging modalities available in the medical field, but only 4 imaging modalities were used in the reviewed virtopsy studies. The imaging modalities searched in the present review included ultrasound, computed tomography (CT), X-ray, and magnetic resonance imaging (MRI). In a total of 32 participants who underwent imaging, the most used imaging modality was MRI followed by the ultrasound, x-ray and the CT. The number of cases per imaging modality is shown in Figure-5.

6.5 Combination of autopsy and virtopsy in COVID-19 patients

As a part of postmortem investigation, virtopsy was either performed solely using a concurrent

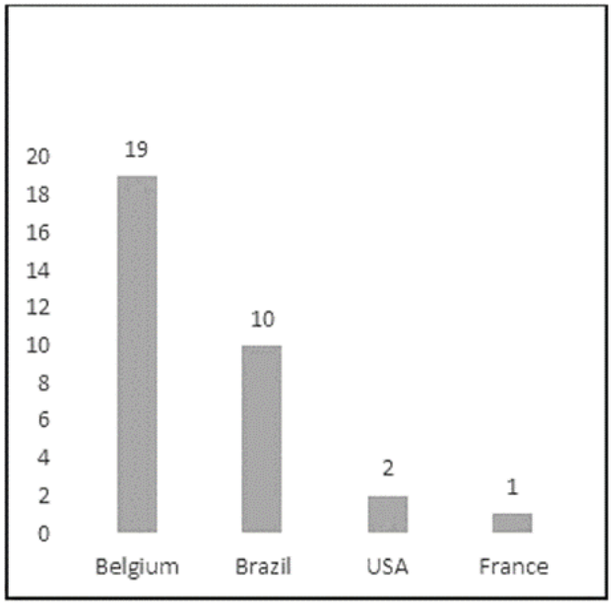

Figure 6- *Distribution of Virtopsy performed on worldwide bases during Covid-19 pandemic.*

conventional autopsy or in combination with virtual autopsy (virtopsy). Virtopsy combined with a traditional autopsy was performed in three out of the four studies. On the other hand, Virtopsy alone was conducted in only one study.

6.6 Virtopsy findings in COVID-19 patients

Figure-6 shows the distribution of vitropsy performed on worldwide bases during Covid-19 pandemic. In Belgium, 19 decedents underwent brain MRI with four showing abnormalities in brain parenchyma: subcortical macro-, and micro hemorrhages were observed in 2 deceased, MRI showing subcortical oedematous changes suggestive of posterior reversible encephalopathy syndrome (PRES) was discovered in one case while white matter nonspecific changes were seen in one case. Also, within the same study, asymmetric olfactory bulbs were discovered in the MRI of another 4 decedents. On the other hand, brainstem MRI did not show any sign suggestive of brainstem abnormalities [13].

In Brazil, ultrasound (US) image-guided tissue sampling was done for 10 decedents. Ultrasound was used to localize and direct the tissue sampling in multiple organs. The samples obtained from each organ were then sent to pathology for histological and molecular analysis. In the 10 decedents, the following organ samples were obtained under ultrasound guidance: a total of 10 samples from each lung were collected, two samples from the liver, one sample from each kidney, and one sample from the spleen as well as one from the heart. The collected samples were then sent for pathology investigations where the histological and molecular analysis was conducted. The pathology results were of great importance with multiple positive signs, such as pulmonary diffuse alveolar damage, hepatic centrilobular congestion, and cardiomyocyte hypertrophy as well as myocardial fibrosis [14].

In the United States, two covid-19 patients underwent postmortem radiography using chest X-ray imaging modality. In one of the cases involving a 77-year-old male, the postmortem chest X-ray showed diffuse, dense bilateral consolidations with multiple air bronchogram. The 2nd case was of a 42-year-old obese male; the chest X-ray was positive for bilateral pulmonary opacities and multiple bilateral air bronchogram [15].

In France, there was a single COVID-19 case of a 75-year-old male who died and a virtopsy was performed. Whole-body non-enhanced computed tomography (CT) was the imaging modality used in virtopsy. Postmortem CT showed no abnormalities in the brain, cervical and abdominal area. There were no sign of soft tissue or bone trauma. Evaluation of the thorax area revealed a bilateral pleural effusion and ground-glass opacities, perilobular and intralobular reticulations. Fluids were present in the trachea and bronchi; the oesophagus was distended, and mediastinal lymph nodes were positive [16].

6.7 Obstacles in performing virtopsy during COVID-19 pandemic

During the COVID-19 pandemic, health care providers are at high risk of acquiring coronavirus infection. Special and unique measures must be taken to avoid infection spread to a large number of health care providers, and the possible major consequences such as health care system collapse.

Due to the highly contagious property of the virus, there are safety concerns regarding the possibility of health care workers being exposed to the virus throughout the process of virtopsy [17].

In addition, with the large number of infected cases, some hospitals have limited resources to perform virtopsy during the Covid-19 pandemic, and instead, their resources are directed to manage and stabilize patients having Covid-19 infection.

7. Conclusion

Virtopsy is a technique used in forensic medicine involving the use of radiological imaging on cadavers. In combination with traditional autopsy, virtopsy can be very effective in identifying the cause, mode, and the state of health a person was in before he died. However, just by itself, it is less sensitive than traditional autopsy and, therefore, cannot fully replace traditional autopsy. One of the main advantages of virtopsy is that it is a hands-off approach, making it more acceptable for family members of the deceased than traditional autopsy, especially in more religious societies, as in most countries of the Middle East traditional autopsy is disliked, especially when the gender the cadaver is female. Virtopsy is still not a commonly practiced technique for postmortem death investigations in the Middle East because it is relatively expensive and more state-of-the-art equipment is required to put this technique into common practice. Since most of the Arab countries in the Middle East are poor and cannot afford purchasing costly equipment required to perform virtopsy.

During the COVID-19 pandemic, virtopsy emerged as an indispensable tool for postmortem death investigations. Since the safety of health care workers and pathologists performing autopsy is of prime importance, virtopsy is seen as technique of future application playing a fundamental role in the postmortem evaluation of Covid-19 infected deceased.

Conflict of Interest

Authors declare no conflict of interest.

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