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"Virtopsy" Virtual Alternative for Post-Mortem Investigation in Pandemic Era of Covid-19: Diagnostic Approach to Reduce the Menace of Contagion:- A Review

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Abstract:- Due to the strong infectivity of COVID-19 and lack of familiarity for performing autopsy in suspected or infectious disease induced death, this pandemic created certain challenges for forensic investigators. Virtopsy which is contactless and minimally invasive technique utilizing advanced radiological imaging methods may serve to be an appropriate and important tool to prevent cross infection and health hazards for forensic personnel/experts. The purpose of this article is to review about the importance of Virtopsy as a post mortem procedure in covid-19 suspected or infected cases. This technique decreases the threat of contagion for the operators that have to perform specific examinations/investigation during the time of emergencies.

Keywords:- *Virtopsy, Autopsy, Covid -19, Forensic Science, Pandemic.*

I. INTRODUCTION

Today, the entire world is under the direct threat of new hidden nemesis –the noval corona virus (COVID-19) disease which has become pandemic since December 2019. During, this time where mankind is being affected emotionally, physically as well as mentally of fear for getting infected with novel corona virus, it has created more challenges for forensic practitioners. Medico-legal autopsy in Covid-19 deaths is a high-risk procedure and should be avoided where possible. In present scenario of covid 19 plague, the method in which the medical and forensic field engrosses itself with the process of death, is significantly imperative, not only in the pathological aspect but also in the social and cultural aspect for appropriate identification of deceased for medico-legal purposes as well as for proper burial too.

Unidentified human remains with unknown medical history tend to pose biological threat to forensic experts. Post mortem procedure is an invasive surgical technique, making it mandatory for the forensic personnel and its team to be in close contact with the suspected or infected dead body, thereby increasing the probabilities of cross contamination (highly contraindicated in this covid-19 era). To reduce the exposure of such a potentially dangerous health risk, it is indeed the need of hour to inculcate a new, redefined and advanced "touch free" post mortem technique to minimize the risk of mortality as well to break the chain of transmission. Covid-19 seems to be re-defining post mortem technique too. The technical progress by introduction of newer and advanced imaging modalities in the field of forensic has lead to the development of objective, non-invasive and non-destructive methods, the concept of "virtopsy," [1,2]. In this review article, we sketch about that how adapting "Virtopsy" can have many benefits to infectious disease prevention or control, public health and communities worldwide, especially in this Covid -19 pandemic era. The article also boosts to encourage multi-disciplinary Virtopsy as developing improved protocols and safety measures in this pandemic of novel corona virus.

II. SARs-CoV-2 AND FORENSICS

The end of year 2019 was marked by the occurrence of new public health crises threatening the world with its blowout, the novel coronavirus/ Covid 19 or the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The virus originated in Wuhan, Hubei province, China in bats and was transmitted to humans. According to WHO data the total affected countries in the world are 219, infecting about 761,071,826 people with the death toll of 6,879,677 worldwide. The disease is transmitted by inhalation or contact with droplets and close contact with the infected person , incubation period ranges about 14 to 24 days The symptoms ranges from mild like fever, cough, sore throat, breathlessness, fatigue and malaise but may progress to severe like pneumonia, acute respiratory distress syndrome and multi organ dysfunction in immune-deficient patients . The case fatality rate is estimated to range from 2 to 3%. Diagnosis is mainly done by special molecular tests for the presence of virus in respiratory secretions, laboratory findings are normal or low white cell counts with elevated C-reactive protein (CRP)[3]. The CT chest scan is shows ground-glass opacities and lung consolidation even in patients with no symptoms or mild disease[4,5]. Treatment is basically supportive, role of antiviral drugs is yet to be recognized and vaccines are still in use. Prevention necessitates home isolation and strict infection control measures at hospitals that include contact and droplet

precautions. It is highly contagious and spreads rapidly from person to others.

Forensic science refers to the application of scientific methods and techniques to criminal and civil laws for investigation by a court of law and includes various experts to help in decision making to solve a crime or to manage emergencies or crises but, this highly contagious plague has created challenges for forensic experts too, making it significant to increase protection awareness and collect knowledge for medico-legal death investigation of infectious diseases among them[6]. Carrying out autopsy is considered to be as gold standard in forensic investigation which has become even more challenging during this pandemic due to contagious nature of pandemic, limitation of resources and proper working conditions. Therefore, a reasonable alternative should be established with proper protocols with in forensic departments.[7]

III. IMPENDING RISK DURING AUTOPSY

Autopsy is invasive and aggressive and requires close contact with the deceased thereby posing risk of infectious disease like Covid- 19 to the one performing it[1] As death investigation requires processing as soon as possible and the working forensic expert may not be aware of deceased accurate health condition, travel history or close contact with infected person or environment poses greater risk to them.[8] Studies have shown that covid-19 has strong survival ability and significant resistance toward cold[9]. Due to which, the novel corona virus can endure in a cadaver for a longer duration of time even after death, thus patients infected or suspected patients of corona virus may harbor large amount of the virus. Cryopreservation further prolongs the perseverance of the virus within body[10].It is well known fact that this infection spreads through aerosol or directly by cuts and puncture wounds and hence hazardous to forensic experts while performing autopsy procedure. Post-mortem investigations in SARS-CoV-2 suspected or positive patients have to be considered as high risk contagious autopsies. Numerous publications and recommendations from various institutions (such as the Robert-Koch-Institute in Berlin for Germany) have spawned a debate about pondering risks and benefits of autopsies during this COVID-19 era [11,12,13] .

WHO has recommended special safety measures necessary to be taken while performing autopsies for the forensic experts to prevent the spread of infection. Recently, medico-legal autopsies have drastically decreased by 70% [16], due to the impact of Covid-19 breakout. For reasons related to several variables like mainly lack of personal protective equipment, inadequacy of forensic autopsy rooms with sufficient negative pressure or other fundamental prerequisites for the protection of environmental and operator health. Full medico-legal autopsies are not being performed except for extreme circumstances, and frequently with limited dissection only to the extent necessary [14,15].

Virtual autopsy based on advance imaging technology could play a noteworthy role in carrying out autopsy of infectious diseases. PmCT scan of the deceased can be performed prior to autopsy could provide an initial evaluation of a possible cause of death and avoid the forensic expert from coming directly in contact of an infected or suspected body. Thus, a preliminary assessment could be made by the forensic expert to take suitable protective measures during autopsy.

➢ *What is Virtopsy* -

Virtopsy requires a Virtobot to perform and generate 3-dimensional body scan followed by post mortem CT or MRI scans that can be studied for detailed description of different body parts to know the cause of death without cutting or mutilating the corpse resulting in bloodless, contactless and minimally invasive procedure.

The first step in performing a virtopsy is to prepare the corpse for imaging which is accomplished by placing small disks along the exterior of the body, so that the surface scan and the interior scans could easily be aligned for which Virtobots or robotic machines are used, making it more standardized and accurate.

The markers are used by the computer processors to calibrate the exterior scan of the corpse and match with internal imaging processes. 3D color model of the corpse is created. The scan utilizes stereoscopic cameras to capture the color image; this procedure is called 3D photogrammetry[3].

After the surface scan, the body is brought for CT and MRI , covered in double layered blue bag through which X-rays can pass and acquires up to 25,000 sliced images in time span of 15-20seconds. The information gained is fed to computers where in data are combined via computer-aided drafting programs and ultra-powerful graphics processors. In a short span, detailed images of bone and tissue are reconstructed by computers, from the data representing thin X-ray slices of the body are rendered into a 3D visualization of different colors and opacities. The computer can assign the density differences of any color, but this is often standardized as blue for air pockets, beige for soft tissues, red for blood vessels, and white for bones. The images obtained are interpreted and studied .At the same time, images can be manipulated up and down and rotated at various angles. Biopsy can also be performed if internal body samples are needed. Magnetic resonance spectroscopy is another technique in virtopsy which helps in determining the metabolic concentrations in the tissues, thus helping in estimating the time of death[2].

➢ *Uses of Virtopsy*

- For personal identification in forensics
- To know about the Timing of death
- To know about the cause of death ,examples-burns, strangulation , road-traffic accidents , drug abuse ,gun-shot injuries, mass disasters
- For toxicological examination
- To determine age and sex of a person
- In forensic odontology - Dental identification procedures often embrace evaluation and comparison of post-mortem and ante-mortem data. Virtopsy can become a quick, reliable way for getting postmortem records.

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Fig 1 Virtospy: Virtual Autopsy Tools for Scanning

Table 1 Some of the Main Differences between Autopsy and Virtual Alternative are as Follows –

Autopsy	Virtopsy
Requires dissection and mutilation of body	Preservation of body by virtual scanning via PmCT & MRI
Observer dependent	Observer independent
Close contact with cadaver increases chances for contamination	Contamination free examination
Data is not reproducible	Data obtained is reproducible
Blood and fluid contamination are part of general surgical examination	Bloodless field
Cost effective	Expensive
Physiological smell, texture and color are well observed	Lacks the physiological smell, texture and color as their no contact with the cadaver

IV. VIRTOPSY IN TIMES OF PANDEMIC COVID - 19 EPOCH FOR FORENSIC INVESTIGATIONS

We live in a time where forensic science in most societies is perceived as of utmost significance for the justice and protection of human rights. As already discussed ,autopsy plays a major role in forensic science but during this point of pandemic covid-19 breakout where everyone has chance of getting infected to this current life threatening communicable disease with various studies in recent time showing persistence of virus in corpse even after several hours of death, makes it more important to require necessary precautions for the protection of forensic personnel. It becomes our moral duty to prevent as well as limit the spread of infection by implementing procedure that may substitute autopsy but at same time should be reliable too[16]. Accordingly, this 'touch free'' digital autopsy or Virtopsy may prove to be a substitute to an autopsy procedure and play a vital role in forensic investigations. Latest guidelines from many countries are also stressing on minimum, partial or no dissection or non-surgery techniques which may be the future of the forensic jurisprudence[17,18,19,20].

The term "Virtopsy" is a virtual alternative to conventional autopsy which is a non- surgical, minimally invasive technique using CT and MRI to detect the reason behind the death of deceased without coming in grip or close contact with the body [2,]. Virtopsy began at the turn of the millennium as a multi-disciplinary research to implement advanced imaging modalities from diagnostic radiology in forensic sciences. Subsequently, this approach has become an emerging if not standard technique in forensic investigations worldwide.

In the current spread of COVID-19, all autopsy procedures, must assume that each one of human remains are potentially infected. A staged postmortem is usually required for more detailed examination. But In widespread infections, limited and minimally invasive postmortem examination can be considered to provide fluid and tissue samples, however, confined and regional infections may be difficult to identify with this method alone, which may be improved by combination with postmortem imaging. In these circumstances, where the risk is more and the significance of autopsies cannot be overlooked ,Virtual autopsy can play a significant role in victim's suspected of infectious diseases. While performing Virtopsy the operating personnel doesn't come in close contact with the patients and with the help of PmCT and MRI different sections of internal body structures' are created and can be examined accordingly to know the cause of death . It is digitally proficient scalpel-free, non-invasive imaging technology in which is there no mutilation of the body, so posing no hazard of infections from the blood or other tissue fluids to the health-care workers from corpse, at same time it is less time consuming, and the body can be released immediately[21]. Virtual scanning is non-destructive

and does not alter forensic evidence and the data provide a near to body match with 3D spatial documentation, which can be used for scientific reconstruction. The approach provides an alternative or additional examination that 'sees' different characteristics of the body, as CT 'sees' with x-rays and MRI 'sees' various chemical distributions[22,23]. Body areas which are challenging to examine via autopsy procedure can also be examined quickly (eg, face, pelvis, spine, neck). By using Virtobot in combination with optical 3D surface scanner provides potentially valuable tool for documentation of case in forensic investigations. In combination with modern cross-sectional imaging techniques such as CT and MRI, internal and external data can be used into a whole body model [2,3,22].

V. PULMONARY & Xtra-PULMONARY MANIFESTATIONS AND VIRTUAL AUTOPSY FINDINGS RELATED TO COVID-19

Typical pulmonary imaging features frequently seen, more specific for COVID-19 pneumonia on the basis of the literature review in the current pandemic include peripheral bilateral ground glass opacities with or without consolidation or crazy-paving pattern, reverse halo sign or other findings related to pneumonia , and multifocal ground glass opcacities of the rounded morphology with or without consolidation or visible intralobular lines[24].Other than lungs, corona virus affects multi organ systems within the body like heart, liver, kidneys, brain, spleen, lymph nodes, gastrointestinal tract[25]. Manifestations include in gastrointestinal tract presence of enlarged fluid-filled small and large bowel loops and surrounding stranding are demonstrated on enhanced CT. In brain hemorrhagic lesions are found, enhanced Ct imaging shows them as an areas of hypo-density [26,27] . Lymh node shows lymphadenopathy or lymph node enlargement that can be potentially detected by CT imaging suggesting expression of the inflammatory response to the infection[28,29] . Disseminated intravascular coagulation, in the later stages of the disease is the leading cause of death during second wave of covid-19. Various studies have suggested that in COVID-19 patients are affected by two types of pathologic coagulation processes. First is microcirculation of the lungs and other organs causing the formation of micro-vascular clots [30] . The second is related to the systemic circulation with the potential development of large-vessel thrombosis and major thromboembolic events, including pulmonary embolism [31,32 s]. PMCT angiography has been introduced in the virtual autopsy as a complementary technique to add important information about the vascular bed in non-decomposed cadavers, enhancing possible applications of the virtual autopsy, particularly in natural deaths[33]. [. Thus, Virtopsy procedure provides important information in ascertained or suspected covid patients and at same time this touch free autopsy decreases risk of contagion too. VIRTOPSY is an autonomous, impartial, and noninvasive method which can improve the quality of autopsy in forensic science without increasing the risk of being contaminated or infected in this Covid -19 pandemic.

Fig 2 Axial PMCT in a SARS-CoV-2 RT-PCR Positive Deceased Person, Showing Typical Findings in CoVID-19 Including GGO and "Crazy Paving" (Arrow)[34]

VI. CONCLUSION

It is essential, to improve the forensic investigation phase even during this pandemic emergency worldwide. Presently, many forensic practitioners lack the occupational protection awareness and experience for infectious disease. It is necessary to establish rules of occupational protection and risk prevention systems. This review allows us, concluding that Virtopsy favors the growth of forensic autopsies, not only as a screening technique but also as a method of post-mortem investigation. Virtual autopsies are able to provide considerable information on a high number of COVID-19 infected people and with a significant reduction of infection for the operators though the specialized knowledge of autopsy is still not completely replaceable by high-technology methods, but an addition to provide more accuracy along with safety in such critical times.

ABBREVIATIONS

SARS-COV-2 -Severe Acute Respiratory Syndrome Coronavirus 2

COVID-19- coronavirus disease 2019

WHO- World Health Organization

PmCT- Post-Mortem Computed Tomography

CT -Computed Tomography

MRI Magnetic Resonance Imaging

3D- 3 Dimensional

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