Autopsy and Religion: Aiding Forensics, Medicine, and Families with the Virtual Autopsy

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Abstract

Death presents in four forms: natural, homicidal, suicidal or accidental. An unexpected death often results in medico-legal processes, which often include an invasive autopsy to determine the cause of death. Family members and loved ones of the deceased may have a difficult time dealing with the thought of an invasive autopsy due to religious, emotional, or cultural beliefs. The purpose of this study is to investigate the virtual autopsy, a minimally invasive autopsy that takes less time to perform and can provide answers to the cause of death without an anatomical dissection.

Keywords: virtual autopsy, virtopsy, religion, medico-legal, computed tomography (CT), magnetic resonance imaging (MRI), multi-slice computer tomography (MSCT), nuclear magnetic resonance spectroscopy (NMR), magnetic resonance spectroscopy (MRS), noninvasive, forensic pathology, positron emission tomography (PET)

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Introduction

Death comes in the manner of four forms: natural, accidental, homicidal, or suicidal. Death is the end of life, but no matter the cause of death, human dignity does not disappear after life (Charlier et al., 2012). Whether death is expected or unexpected, families and loved ones all have different grieving processes that they must go through during the difficult time. For unexpected deaths medico-legal processes are to be conducted to determine the cause of death. These medico-legal processes can add more grief for the families involved. Sudden, violent, or unexplained deaths are investigated in most western countries through the medico-legal process. Removing the body for invasive autopsy can disrupt traditional religious and cultural grieving practices (Carpenter, Tait, & Quadrelli, 2014). For example, Islamic and Jewish deaths require that their deceased need to be buried within 24 hours. The invasive autopsy can and often delay this process. Another problem is that in some religions; such as, Judaism, it is completely prohibited to permit an invasive autopsy on the dead (Rai et al., 2017). Attitudes towards invasive autopsy are usually based on emotional, cultural, and/or religious views which often strongly oppose invasiveness associated with autopsy an anatomical dissection (Burton & Underwood, 2007). The availability of an alternative autopsy option can help resolve emotional, cultural, and/or religious views. This study investigates the new techniques of the virtual autopsy, a minimally invasive procedure that takes less time to perform, and can provide answers to the cause of death without invasive post mortem surgical procedures.

While the X-ray was discovered in 1895 by Wilhelm Conrad Roentgen, and in 1896 Arthur Schuster used X-rays to view lead bullets in the head of a deceased person (Kumar et al., 2015), little applied new technology has advanced alternative methods in autopsy procedures, and not every medical examiner’s office possesses the X-ray machine in the United States. There is so much more technology that can further advance autopsy protocols. It would be advantageous and prudent for the area of forensic pathology to research for possible implementations of new technology appropriate to meet legal and societal demands. It is unfortunate that forensic pathology for the most part still relies on century old evidence-based methods surrounding the dissection of corpses, and a description with written documentation of the findings, later aided with photography in the past few decades (Bollinger & Thali, 2015). With adaptations of advancements in medicine and new technologies, forensic pathology will incorporate highly sensitive and specific techniques as alternative modalities as alternatives to recognized procedures into the discipline.

What is virtual autopsy or ‘virtopsy’? Virtopsy combines the words “virtual” and “autopsy” (Vadivel, 2016). It is a virtual (non-invasive) dissection of the human body allowing a medical examiner to visualize and analyze the internal aspects of the body through imaging to discover the factors contributing to the leading cause of death (Vadivel, 2016). The virtual autopsy is usually aided by Computerized Tomography (CT) or Magnetic Resonance Imaging (MRI). A computer-assisted system that uses postmortem CT datasets can easily look into the body in real time and capture screen shots that can be used for documentation purposes. A 3D view can facilitate the understanding of the topography of pathologic findings which would be most appreciated in jury trial courtroom presentations (Ebert et al., 2015). The average medical examiner’s office does not possess such technology, instead medical examiners rely on the invasive autopsy methods.

The virtual autopsy can demonstrate details of a mummified corpse that has been dead for thousands of years. In 2006, approximately 2,000 CT scan images were taken of King Tut’s mummified body (Greenspan, 2014). Scientists concluded that King Tut developed a deadly infection in his left leg after fracturing it, which caused the untimely pharaoh’s demise. It was originally believed that King Tut died while riding a chariot, but the
virtual autopsy contradicted this assertion (Wilson, 2016). Scientists also concluded that King Tut wasn’t as flattering in features that history books normally portray. King Tut had a club foot, overbite and female structured hips; he also couldn’t walk unaided due to his club foot (Greenspan, 2014). The virtual autopsy was able to give us a more precise picture of what King Tut might have looked like during his reign.

Not only does the virtual autopsy provide a glimpse of historical mummified corpses that have been dead for thousands of years, the rise of the virtual autopsy has introduced a new era in forensic pathology. With the development of new techniques, such as CT and MRI, both soft tissue and hard impact injuries can be readily assessed (Sibte, 2016). Pathologist sometimes encounter challenging obstacles due to a severely decomposed body, the CT and MRI could tackle this challenge. Virtual autopsies are locating fractures and hemorrhages that were not discovered during conventional invasive autopsies. Radiologists can demonstrate the presence of discrete abnormalities and inform forensic scientists to their findings (Thadeusz, 2013). These types of examinations are well defined thus gaining more acceptability in courtroom proceedings (Sibte, 2016). MRI, CT scan, and X-ray technology all produce anatomic images that support medical diagnosis. There is little controversy about the reliability in the courtroom presentation (Moriarty, Langleben, & Provenzale, 2013).

CT and MRI can answer forensic questions without autopsy. These techniques allow three-dimensional view of the analyzed cadaver (Rai, et al., 2017), opening a new pathway for forensic pathology. According to Leth (2013), the virtual autopsy is much better in identifying the cause of accidental and traumatic deaths. Scientists can match weapons and other objects by using 3D photogrammetry, to fatal injuries sustained in murder and accident cases. Swiss courts already utilize 3D photogrammetry and surface scanning in cases where invasive autopsy risk offending cultural sensibilities (Honigsbaum, 2013). As an alternative to the standard autopsy, the virtual autopsy is less time consuming, supports definitive diagnosis, and renders respect to religious sentiments (Tejaswi, & Aarte Hari Periya, 2013). Many countries such as Switzerland, Sweden, and Japan routinely use CT in their mortuary (Kaplan, 2016). In 2010 the Japanese Ministry of Health, Labor and Welfare made plans to distribute CT and MRI scanners to establish a national autopsy imaging service (Rutty & Morgan, 2013). Other countries embrace CT and MRI technologies for their postmortem cases, but the United States rarely utilizes these technologies.

Review of Literature on Religious Viewpoint

In a review of literature, certain faiths strongly oppose an invasive autopsy because of burial delay (Burton and Underwood, 2017). Minimally invasive and non-invasive autopsies are considered when there are strong emotional, cultural, or religious objections. However, addressing the issue is problematic. Studies concluded that 82% of clinicians had received no sensitivity training on religious and cultural issues surrounding autopsy (Burton & Underwood, 2017).

In another review of literature, a conclusion was reached that no religion expressly condemns the practice of an invasive autopsy, a contradiction of the work of the Burton and Underwood study (Atanda, et al., 2016). Further many uninformed families show a reluctance towards autopsy (Atanda, et al., 2016). However, in agreement with Burton and Underwood, room exists for improvement concerning training on religious and cultural issues. Experienced professionals who have some knowledge of religious and cultural beliefs should communicate with families concerning the procedure of the invasive autopsy and the potential benefits. Through compassion, professionals can show families that their concerns are understood, offer compliance if changing the protocol, and timing of autopsy as needed (Atanda, et al., 2016).
Table 1 below provides an overview of the world’s foremost 20 religions and a summary of their beliefs. In the form presented, it serves a quick reference that relates religion membership population density to belief and as such could easily serve as a guide for medical examiners and other professionals available when addressing sensitive issues and concerns with families from certain faiths.

Table 1
World’s 20 Largest Religions

<table>
<thead>
<tr>
<th>Religion or Culture</th>
<th>Population*</th>
<th>Beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>African traditional and Diasporic</td>
<td>100 million</td>
<td>Each sector has their own history and beliefs.</td>
</tr>
<tr>
<td>Bahá’í</td>
<td>7 million</td>
<td>Fresh ideas are fairly assessed and, if appropriate, quickly assimilated into Bahá’i ideology.</td>
</tr>
<tr>
<td>Buddhism</td>
<td>376 million</td>
<td>Treatment of deceased may impact the quality of their next rebirth, and deceased be neither touched nor moved in the immediate postmortem period.</td>
</tr>
<tr>
<td>Cao Dai</td>
<td>4 million</td>
<td>Unite with God and being released from the birth/death cycle.</td>
</tr>
<tr>
<td>Chinese traditional religion</td>
<td>394 million</td>
<td>Relatives and friends shave the head, wash the body, and clip the nails of the deceased (Traditional, 2017).</td>
</tr>
<tr>
<td>Christianity</td>
<td>2.3 billion</td>
<td>Different denominations may have certain provisos.</td>
</tr>
<tr>
<td>Hinduism</td>
<td>1.1 billion</td>
<td>Object to non-Hindus touching a dead body, and rarely agree to an autopsy even though no specific religious prohibition.</td>
</tr>
<tr>
<td>Jainism</td>
<td>4.2 million</td>
<td>Every being should be treated with equal respect, hurting no one.</td>
</tr>
<tr>
<td>Juche</td>
<td>19 million</td>
<td>North Korean ideology. Man is the master of everything and decides everything (Jong-il, 1982).</td>
</tr>
<tr>
<td>Judaism</td>
<td>14 million</td>
<td>Jewish parliament permits autopsy but with strict provisos.</td>
</tr>
<tr>
<td>Muslim</td>
<td>1.8 billion</td>
<td>Body belongs to God, burial should occur within 24 hours of death, and dead perceive pain.</td>
</tr>
<tr>
<td>Neo-Paganism</td>
<td>1 million</td>
<td>“They are dead; leave them in peace.” High Priest Alex Sanders</td>
</tr>
<tr>
<td>Nonreligious</td>
<td>1.1 billion</td>
<td>Secular/Agnostic/Atheist</td>
</tr>
<tr>
<td>Primal-indigenous</td>
<td>300 million</td>
<td>All things are spiritual in nature.</td>
</tr>
<tr>
<td>Shinto</td>
<td>4 million</td>
<td>Emphasizes man’s essential goodness.</td>
</tr>
<tr>
<td>Sikhism</td>
<td>23 million</td>
<td>The body is an empty shell. Body and organ donation are permitted.</td>
</tr>
<tr>
<td>Spiritism</td>
<td>15 million</td>
<td>Value scientific research.</td>
</tr>
</tbody>
</table>
**Case Scenarios**

**Scenario I**

A healthy 52-year-old male dies suddenly in his home with his wife beside him. No foul play is suspected, but because of his age the medical examiner requests an autopsy by law. The wife wants to know what caused her husband’s death but struggles with thought of autopsy, owing to the fact that her husband was of Buddhist faith. Buddhists believe that the treatment of the deceased person may impact on the quality of their next rebirth (Carpenter et al., 2011). Despite her conflicting emotions, she agrees to the autopsy. It is later determined that her husband died of myocardial infarction as a result of cardiovascular disease.

The majority of natural deaths are caused by cardiac insufficiency (Dirnhofer et al., 2006). A natural death, such as the scenario mentioned above, could have been discovered by virtual autopsy intervention in contrast to traditional autopsy technique. In cases of myocardial infarction, the virtual autopsy can detect damage to the heart muscles (Virtual Autopsy Solutions, 2018). If the virtual autopsy option was available, the man’s wife would not have struggled with the decision to do an autopsy on her late husband. The virtual autopsy leaves the body intact, so it would not add to the grief of loved ones left behind (Virtual Autopsy Solutions, 2018).

**Scenario II**

An attempt was made to identify the cause of death of an elderly woman, that was thought to be of suicide or homicide, by using the method of virtual autopsy. Multi-slice computed tomography (MSCT) was performed on her maxillofacial area. It was discovered that there was foreign body in her endotracheal area (Aquila, et al., 2013). The woman’s death was determined accidental as she died from hypoxia caused by obstruction of the upper respiratory tract by food materials (Aquila, et al., 2013). Consequently, a death originally thought to be of suicide or homicide, actually turned out to be accidental. The cause of death can seem quite clear, but the mechanism of death is not (Ebert, 1987). In this case, the virtual autopsy was able to determine the mechanism of death was accidental. The virtual autopsy provides visual feedback which can identify small radiopaque foreign bodies that may have been missed in a traditional autopsy (Ebert et al., 2015).

**Scenario III**

A utility worker discovers a badly charred body alongside of the woods near a utility pole. A visual examination makes it difficult to identify the victim. In a case such as this, the virtual autopsy becomes a quick
reliable approach for retrieving postmortem records (Do Rosário Junior, et al., 2013). Because the victim is badly charred, the mandible area is ideal for examination. If an identifier is present on bridgework obtained from the victim, this may serve to link the missing person dental records which can be compared with the unknown victim for possible identification. Retrieving the victim’s postmortem dental records can help establish the identity of the victim. In virtual autopsy, 3D imaging in postmortem victim’s mandible area can help determine identification based on shape of pulp chambers, root arrangement, and periodontal work (Rosário Junior, et al., 2012). By utilizing 3D imaging of a postmortem victim as evidence in a court room, this evidence can spare the jury from having to visualize gruesome details (sometimes necessary to deliver greater impact in court proceedings). A CT 3D image can be more palatable for a jury to view (Kaplan, 2016). A homicide case, that would have been difficult to identify the victim and time consuming, can obviously benefit from a time sensitive and reliable virtual autopsy approach. Because the virtual autopsy is less time consuming, victims are able to be identified and the cause of death established; thus, giving the family of the deceased closure and aiding a possible homicide case in a reduced time frame that would otherwise not be possible with traditional invasive procedures. A summary of case scenario discussion are summarized in the table below.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Age</th>
<th>Environment</th>
<th>Invasive autopsy required?</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>52</td>
<td>Home</td>
<td>Yes</td>
</tr>
<tr>
<td>II</td>
<td>Elderly</td>
<td>Home</td>
<td>Yes</td>
</tr>
<tr>
<td>III</td>
<td>Unknown</td>
<td>Dwelling</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Advantages and Disadvantages**

The virtual autopsy has many advantages. CT and MRI techniques can obtain a more accurate and sensitive approach than the conventional invasive autopsy; for example, CT is a great diagnostic tool in identifying entry and exit pattern of wounds (Thali, 2013). CT is also a better for evaluating bones, while MRI is a better for evaluating soft tissue (Center, 2019). Another technique used in the virtual autopsy is magnetic resonance spectroscopy (MRS) which helps determine the post mortem status of metabolic concentrations in tissue and in turn, helps to establish an estimated time of death (Thali, 2013). A listing of exemplary techniques used in medicine are finding their way into the forensic pathology arena are provided in Table 3. Here, magnetic imaging techniques, both standard and enhanced, are listed as to their potential for virtual autopsy applications.

**Table 3**

**Magnetic Imaging Techniques and Potential for Use in Virtual Autopsy**

<table>
<thead>
<tr>
<th>Technique</th>
<th>Medicine</th>
<th>Forensics</th>
<th>Forensic Examples</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI</td>
<td>X</td>
<td>X</td>
<td>Muscle, skin, internal organs, bone, anatomic structures</td>
<td>Visualization of soft tissues</td>
</tr>
<tr>
<td>Technique</td>
<td>Imaging Characteristics</td>
<td>Future Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-T Magnetic Resonance Imaging (3T-MRI) + USG</td>
<td>Forensic age estimation; Cardiac / myocardial infarction; Visualization of Sudden Cardiac Death</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D - PMCT+ PMMR</td>
<td>Internal organs, soft tissue; brain; edema, hemorrhage; strangulation; traumatic injury;</td>
<td>Visualization of bullet, trajectory, and trauma injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td>Dental; gender; bone morphology; prosthetics; prior injuries; pathologies;</td>
<td>Cause of Death in infants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optical Coherence Tomography (OCR)</td>
<td>Vascular finger print;</td>
<td>Doppler effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positron Emission Tomography (PET)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-detector computed tomography (MDCT)</td>
<td>Multi-sectional tissue slicing</td>
<td>Futuristic application to forensic pathology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

References: (Haederle, 2015), (Ekizoglu, et al., 2016), (Flach, et al., 2016), (Beck, 2011), (Jackowski, et al., 2013), (Murakami, et al.), (Steele, 2010), and (Liu & Chen, 2013).

CT, MRI, and MRS are not the only techniques used in a virtual autopsy. A research team in Switzerland examined 40 forensic cases through multi-slice CT (MSCT)/NMR and conventional invasive autopsy. Of these forensic cases 55% causes of death were discovered through imagistic methods (Dumbrava, et al., 2013). MSCT and NMR were superior in trauma cases, pneumothorax, air embolism, and subcutaneous emphysema. In addition, there are psychological and cultural advantages to individuals of certain religious communities who do not necessarily accept the idea of an invasive autopsy (Dumbrava, et al., 2013).

Disadvantages of the virtual autopsy are noted. The virtual autopsy exhibits problems in detecting organic diseases such as, hemorrhage and fat embolism (Dumbrava, et al., 2013). Vascular and metabolic modifications cannot be identified attributed to the fact that a contrast substance cannot be injected in the cadaver (Dumbrava, et al., 2013). However, there is hope for post-mortem MRI methods, the University of New Mexico Center for Forensic Imaging is leading a project to improve post-mortem tissue imaging (Center, 2019). One other disadvantage is the financial aspect of the virtual autopsy cost of operations, initial startup costs associated with instrument and their ongoing maintenance, and trained specialists in the application of the technique. An MRI machine can cost anywhere from $150,000 to $1.2 million and the most advance MRI machine the 3 Tesla MRI cost $3 million. The CT can cost $65,000 for a refurbished one that only produces small images, but a new CT scanner that produces larger images can cost up to $2.5 million (Glover, 2014).

Future Research

In order for continued advancement in the utilization of virtual autopsy, future research is required. Technology has seen great improvements since the discovery of the first X-ray in 1895. Positron emission tomography (PET) scan can detect a variety of conditions such as cancers, heart disease, and brain disorders and imbalances in the living by using a radioactive drug (Mayo, 2018). In order for PET scan to work the heart must be pumping, which is not possible in a deceased individual. Future research can help discover a contrast to be used in a cadaver that could possibly highlight and enhance specific areas in question, or perhaps a pump
that can be used to distribute the radioactive contrast material in the dead state to highlight the areas in question. Nevertheless, new technologies are answering cause-of-death questions that traditional autopsy has not been able to answer and help sidestep the religious or cultural objections (McKenna, 2012). For example, New Mexico Office of the Medical Investigator (OMI) handles all autopsies in the state of New Mexico. The OMI stands out from all medical examiner’s office in the United States because they have both MRI and CT scanners. The OMI research team is exploring ways to enhance the MRI of human corpses (Haederle, 2015). More research is needed in the area of post-mortem forensics. It is unfortunate that there is only one facility in the United States that has, and is leading research of post-mortem MRI studies.

Conclusion

European countries and the New Mexico Office of the Medical Investigator appreciate the benefits of the virtual autopsy and already utilize the process. Visibility and access to technology associated with this autopsy option is lacking in many North American medicolegal establishments. Whether medical examiners are not aware of what the virtual autopsy has to offer or there exists lacking of appropriate funding eventually medical examiners offices in the near future need to address this option. Many medicolegal facilities train medical students on rotation and technology especially virtual could find homes within accredited medical school curricula. The presence of medical imaging protocols involving advanced technology within forensic rotational sites would lead to cutting edge educational offerings to clinical, anatomic and forensic pathologists trained at their sites. It is important to make medical examiners aware of the benefits the virtual autopsy has to offer. Having these instruments on site could assist in the determining cause, manner and mechanism of death associated in the most difficult cases that would not otherwise be solved through invasive autopsy alone. Though the virtual autopsy has not been widely adopted yet, dissemination of the critical information associated with applications in the forensic arena are required. A general review of current literature supports the notion that more applications associated with mechanism of death via virtual platforms are on the horizon. Still more research needs to be done on the virtual autopsy, preferably showing the benefits of the virtual approach, and overcoming what obstacles the virtual autopsy may present. Perhaps the creation of a check list of ideal cases to utilize the virtual autopsy will lead to a better acceptance by medical examiners in practice. The more this concept receives attention, the increasing likelihood of the virtual autopsy being utilized more widely in North American medical examiner’s facilities. However, in cases involving pediatric forensic autopsy pathology, greater accuracy in establishing cause of death may be achieved by comparative findings incorporating invasive procedures, clinical findings and virtual platforms (Murakami, T., et al). It is the goal that all autopsy outcomes can be achieved solely by virtual imaging technology thus becoming a ‘gold standard’ of autopsy approaches.

In memory of Thomas K. Rizzo
References


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