Virtual Autopsy Software for Smaller Rural Hospitals

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Abstract

Virtual autopsies using computed tomography (CT) imaging are not new technology as they have been used in UK since the mid 1990's (Bisset, Thomas, Turnbull & Lee, 2002). However, virtual autopsies remain underutilized (Thali, Yen, Schweitzer, Vock, Ozdoba, & Dirnhofer, 2003) especially in small rural hospitals where budgets are small, and numbers of healthcare workers are even smaller. In this paper, a solution for accessibility to virtual autopsy software for small rural hospitals is proposed. Implications for this proposed solution are also discussed.

Key Words: Autopsy, Virtual, Software, Healthcare, Accessibility, Rural

Introduction

The healthcare industry is an interesting field in terms of innovation and discoveries. On one hand there are medical breakthroughs that seem to happen overnight then there is the flipside where healthcare professionals are still using tools and techniques that date back hundreds of years. The field of pathology and more specifically autopsies tends to fall in the latter category. The definition of an autopsy is an examination of a body postmortem in order to ascertain the cause of death or progression of disease, this is typically done through the dissection of major organs, intense scrutiny for macropathologies and the evaluation of histopathology (Roberts, Benamore, Benbow, Lee, Harris, Jackson, ... & Traill, 2012). Autopsies are typically ordered for three main reasons: unknown cause of death under non-suspicious circumstances; death under suspicious circumstances; or an autopsy that is requested by the deceased family (Burton & Kitsanta, 2020).

Traditional autopsy is considered by most within forensic and healthcare realms to be the gold standard for determining cause of death. However, autopsy rates have been falling worldwide (Hoyert, 2011). There also needs to be a great effort of preparation and perception skills for an autopsy to be successful (Thali, Dirnhofer & Vock, 2009). There are many who believe that non-invasive techniques like the virtual autopsy should be utilized more heavily. A virtual autopsy can be defined as minimally invasive form of a traditional autopsy where images by MRI or CT are taken postmortem in order to help determine the cause of death (Roberts et al., 2012). This form of minimally to non-invasive autopsy can look more appealing to grieving families who do not want their loved ones "hacked up" or if they protest traditional autopsies due to ethnic or religious reasons as the body remains intact during a virtual autopsy.

The virtual autopsy has shown in past research that it can be just as effective as traditional autopsies when used in traumatic death cases (Cirielli, Cima, Bortolotti, Narayanasamy, Scarpelli, Danzi, ... & Tagliaro, 2018). However, within the same Cirielli et al.,

(2018) study, results showed that CT and MRI autopsies are not as sensitive at detecting non-traumatic deaths such as heart attacks, severe burns, and drowning. Integrity of the body is also an issue with virtual autopsies as with severe decomposition there is a breakdown of internal tissue as well as a large build up of gasses that can make accurate imaging difficult. An argument can be made in the cases for heart attacks that correct lab work taken from the body would be able to quickly diagnose the likelihood of heart attack. However, this may only work in certain cases where the body is fresh and not decomposing. Virtual autopsy has a difficult time diagnosing heart disease and heart attacks as there is no beating heart or working lungs that are able to distribute the contrast dye the CT needs to read the blood vessels throughout the body. A possible solution is to use a heart-lung machine that can pump the contrast throughout the body, but these are expensive machines that smaller rural hospitals may not have access to. There are many instances in which virtual autopsy could produce findings that may not be picked up in a traditional autopsy such as foreign bodies, gaseous areas, or even the path a bullet takes within the body.

There are definite tradeoffs that should be mentioned whenever virtual autopsy is discussed. These include losing much of the external cues and indicators that can be found during a traditional autopsy like touch, smell, and even taste. One of the largest problems that had been found when trying to integrate virtual autopsies with traditional autopsy techniques is that it is difficult to determine which bodies need a traditional autopsy and the extent to how invasive it needs to be (Burton & Kitsanta, 2020).

Virtual autopsies can be done using CT, MRI or a combination of both machines. These machines specialize in different types of images so it is difficult to say that one is definitely better than the other (Grätzel von Grätz, 2020). CT scans can be better at visualizing bones and bone fractures so in cases of motor vehicle accidents or traumatic deaths, a CT might provide the best images. A CT scan can also prove helpful if you need to visualize air within the body, an example could be a body in a strong state of decomposition or possibly a case where air was introduced into the blood stream and caused death. MRI machines are powerful and can be better if you need to visualize anything with soft tissue (Grätzel von Grätz, 2020). MRIs are able to pick up on minute differences within soft tissue and can be particularly useful for imaging the brain. Cases where an MRI may be useful would be for non-traumatic deaths, infants, or cases where disease progression may need to be noted for research.

A major drawback for virtual autopsies is the cost associated with them. Barriers that are affecting the widespread adoption of virtual autopsies are the large cost for equipment and software, access to CT and MRI machines, and the overall limitations of the technology available (Scientific American, 2012) (Thali et al., 2003). Current products on the market and available to the healthcare and forensic community for virtual autopsies are few and far between. Virtual autopsy options include robotic-assistance for imaging and needle-core biopsies and virtual autopsy tables that allow for dissection layer by layer via hand movements. The problem with these options, is that they are incredibly expensive. Robotic assistance equipment and accompanying software can cost upwards of hundreds of thousands of dollars. The price points of these virtual autopsy solutions place accessibility for rural hospitals almost impossible. This is the topic of the current paper. The author proposes a new solution that would allow rural hospitals to access and perform virtual autopsies without needing to buy costly new equipment.

Proposal of New Solution

The proposed new solution aims to utilize the equipment that hospitals already have such as CT, MRI, and image viewing systems like PACS. PACS stands for picture archiving and communication system and most hospitals use a form of PACS within the radiology department. This system allows hospitals and other healthcare facilities to communicate and "push" images between each other to help facilitate patient care. The virtual autopsy software would work hand-in-hand with the hospital's existing PACS system as a sort of "add-on" feature. The software would be sold not to hospitals but to PACS systems to be integrated into the packages and software they already offer which would enable smaller rural hospitals access to perform, store, retrieve, and interpret virtual autopsies using the facilities, workers, and software they already have. For smaller rural hospitals who do not have the funds or access to multi-slice computed tomography (MSCT) scanners, this software would allow these hospitals to harness the power of a virtual autopsy without the need to buy equipment or software that costs hundreds of thousands of dollars.

The name of the proposed new software is PACStopsy which is an amalgamation of the words *PACS* and *autopsy*. PACStopsy would include all the portals and tools that a radiologist or pathologist would need to perform and interpret a virtual autopsy. Some PACStopsy specific features would be computer aided 3D imaging of the body that allows for in depth examination of the internal organs of the body to aid in determining cause of death. This feature would be especially important for hospitals that do not own an MRI machine and therefore rely on CT scans for most of their advanced imaging. This 3D feature would take the 2D images from the CT-scan and convert them into 3D images that a radiologist or pathologist could examine view by view. The 3D direct rendering feature would also be able to be used as a reconstruction tool and would be helpful in cases where the body is severely decomposed or merely bones. PACStopsy could serve as a powerful tool if the medical examiner or pathologist is ever needed to testify in court for possible murder trials.

Other features that would be included in PACStopsy would be dictation and transcription capabilities that would act much like the already popular Dragon voice recognition dictation system. This would allow for reports, toxicology results and diagnoses to be located in one central system which gives medical examiners better organization of cases.

One problem seen in traditional autopsies are the limitations that the reporting presents. These limitations could include only reporting what those present are seeing "you only know what you know", incomplete and messy archiving of autopsies, and unique interpretations by the medical examiner or pathologist (Thali et al., 2009). These limitations would be addressed with the PACStopsy software as it would allow for sharing of the images and interpretations between healthcare professionals, and all reporting would be done in one concise and easily available space within the software.

PACStopsy is software that allows for all virtual autopsy reporting to be completed in one place. PACStopsy would also offer remote access through an app. This web application would allow pathologists, radiologists, or medical examiners to access files or images remotely and in real time which could mean that they technically determine cause of death without needing to leave the comfort of their home.

The potential users of PACStopsy are broad and would include radiologists, pathologists, x-ray technicians, lab personnel, and office assistants. Radiologists and pathologists would be interpreting the images using the PACStopsy portal, while x-ray techs, lab personnel and office assistants may use the portal to view images and "push" the images and findings to other hospitals.

The current proposal of PACStopsy focuses on virtual autopsies, but future designs and features for PACStopsy would be to include a fully integrated pathology dashboard that includes all aspects of pathology such as images from specimen grossing, whole slide imaging, pathology report capabilities. PACStopsy could be a fully functioning pathology and medical examiner software that allows for efficient, secure, and innovative ways to create, store, and share pathology and autopsy material.

Overview of Features in PACStopsy

PACStopsy is designed to work with equipment that hospitals already own like PACS, CT, and MRI machines. Specific features of PACStopsy include transcription and dictation, report filing and storage, ability to share images and reports between facilities without the need to print and fax. *Please see Figure 1 and Figure 2 located in the Appendix*.

Applications of Virtual Autopsy for Cause of Death

There are many different applications of virtual autopsy and PACStopsy when attempting to determine the cause of death.

- Motor Vehicle Accidents
- Pediatrics
- Suicides
- Homicide
- Falls from heights
- Infants
- Suspected Drowning
- House Fires

These are all possible instances that a smaller rural hospital may encounter and could use virtual autopsy and PACStopsy to aid in determining cause of death.

Impact of Product

PACStopsy has the potential to make a large impact on rural healthcare as it opens up new possibilities in terms of options for families who do not want a traditional autopsy performed. This software would also help the medical examiner and pathologist as they are often the same person in smaller rural areas. PACStopsy could help pathologist workflow and the medical examiner's turn around time for death certificate cause of death. PACStopsy could also reduce the number of traditional autopsies ordered by a medical examiner which could save the county money as traditional autopsies can cost anywhere from $2000-$5000 dollars. A

traditional autopsy could also take hours to complete when compared to a virtual autopsy which can be completed in a matter of minutes.

There are many stakeholders that PACStopsy would impact. Medical device manufacturers, hospitals, families, pathologists and pathology assistants, radiologists, and technicians. An increase of virtual autopsies through the adaptation of PACStopsy could help alleviate autopsy-related injuries such as needle sticks, cuts, and exposure to pathogens (McKenna, 2012). PACStopsy would allow smaller rural hospitals who do not have a pathology department the opportunity to perform virtual autopsies. PACStopsy would allow these smaller hospitals to perform the imaging necessary for the autopsy (CT, MRI or both) and then upload the images to the software which could then been viewed remotely by a pathologist or radiologist.

PACStopsy may impact the market and cause changes that not all would view as positive. PACStopsy and virtual autopsies may help lighten the workload of medical examiners and pathologists but increase the workload for radiologists. Many in the medical community, especially in smaller rural areas may not trust results that come from non-traditional autopsies. However, the research shows that virtual autopsy in some cases can be just as diagnostic as traditional (Burton & Kitsanta, 2020). PACStopsy will allow small rural hospitals a non-invasive autopsy option for cases where receiving consent from families may be difficult (e.g. infants, children). However, there are situations where invasive techniques may still need to be performed even if the virtual autopsy has determined a cause of death. These situations could include: cases that will be going to court; cases where tissue samples need to be collected from the internal organs; cases where the brain needs to be excised for research or pathology.

Conclusion

General practitioners and hospitalists only accurately certify 31-75% of deaths (Bisset, Thomas, Turnbull, & Lee, 2002). This number may be even lower in rural hospitals. PACStopsy and virtual autopsies could make a major impact on healthcare within these small rural areas. The goal of PACStopsy is not to replace but rather compliment the traditional autopsy. The main goals of performing a virtual autopsy are identifying gender, age, individual features, discovering and documenting foreign bodies, and the cause or manner of death (Pomara, Fineschi, Scalzo & Guglielmi, 2009). With PACStopsy, hospitals and medical examiners also have the opportunity to store virtual autopsies to later be used in education, research and furthering the science of virtual autopsies.

PACStopsy is designed to allow smaller rural hospitals provide autopsy solutions using equipment they already have. There are significant drawbacks to virtual autopsies as discussed in this paper. Nevertheless, greater acceptance of the virtual autopsies within the medical community and the public are dependent on evolving technology and making the technology accessible for smaller rural hospitals. The big idea behind PACStopsy is that software should adapt and integrate within its space not healthcare adapting and integrating to the software. PACStopsy would be a step in the right direction to accessible autopsy solutions for rural healthcare facilities.

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Appendix

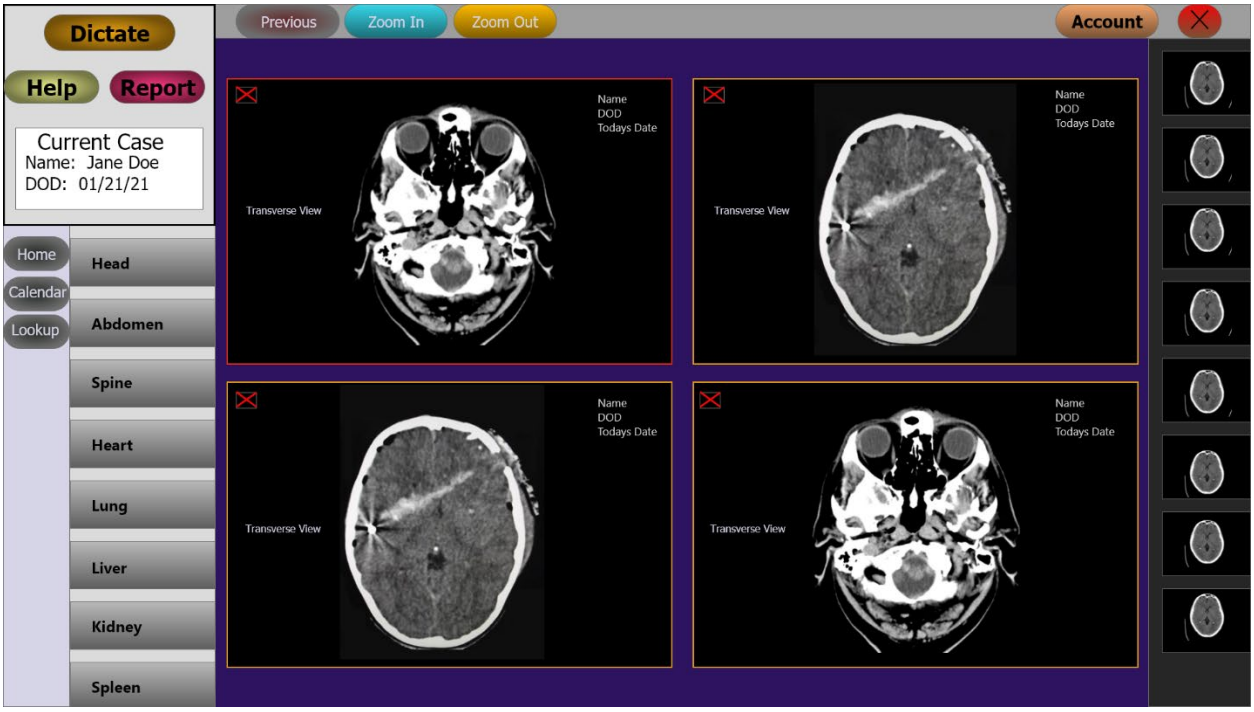

Figure 1. Wireframe of proposed PACStopsy dashboard.

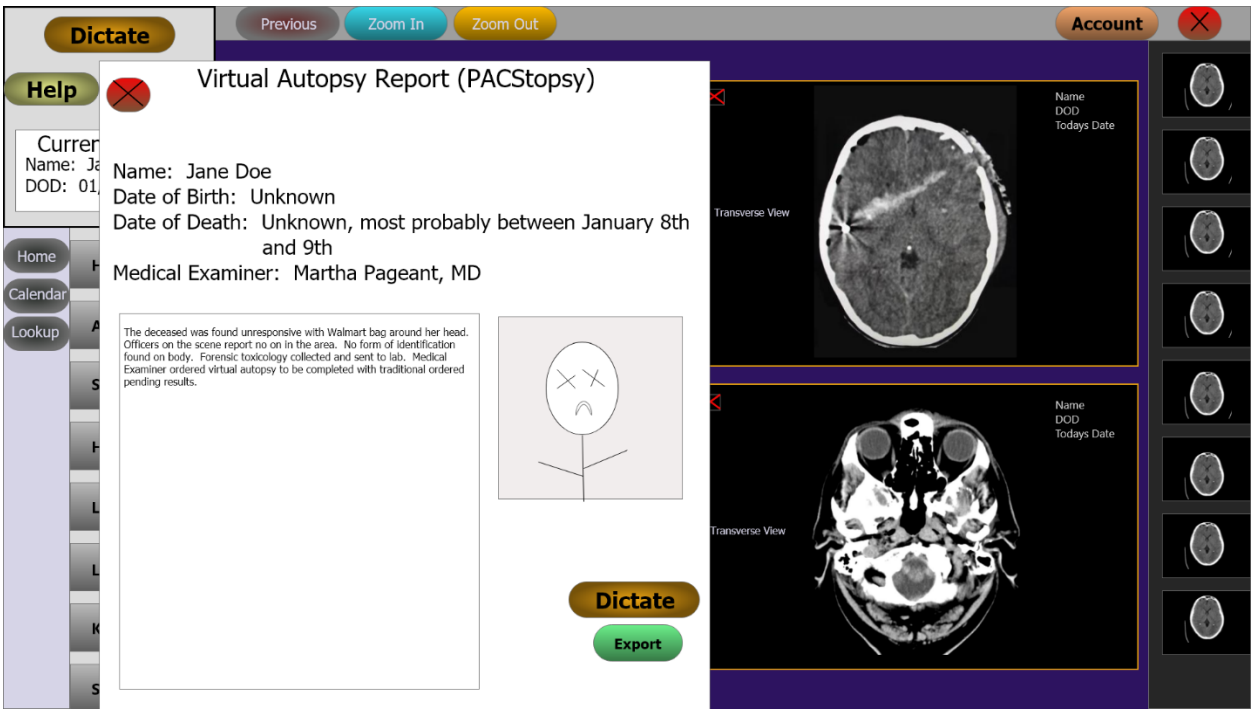

Figure 2. PACStopsy dashboard with dictation and sharing capabilities for autopsy reports.