



## Research Paper

# The advantage of the virtual forensic autopsy - A new approach which could benefit forensic expertise



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## ABSTRACT

We aimed to assess the accuracy and advantages of postmortem CT examination and three-dimensional (3D) view of the cadaver with the Sectra Visualization Table compared to the full conventional autopsy of a forensic suicidal case. Our survey concerned unusual case of self-strangulation where a body was found in the stage of mummification with a nylon cable tie around the neck and another around the feet. The case was initially determined as a homicide, but later reconsidered a suicide based on objective scene investigation, virtual autopsy and the positions of knots. Unlike the physical autopsy in case of mummification 3D examination does not alter evidence and can revisit the body for additional investigation.

## 1. Introduction

Traditional autopsy has changed little in the past century, consisting of external examination and evisceration, dissection of the major organs with identification of macroscopic pathologies and injuries, and histopathology if needed.<sup>1</sup> In some forensic cases the conventional autopsy is less accurate than the virtual post-mortem examination and it can destroy key forensic evidence. Post-mortem examination is increasingly assisted by multislice computed tomography (MSCT) and magnetic resonance imaging (MRI).<sup>2–6</sup> Compared with traditional autopsy, MSCT and MRI have numerous advantages: the techniques are non-invasive, and the data can be visualized in situ, stored and fully reinterpreted at any time. The 3D scanning makes autopsies on decomposed bodies noticeable easier.<sup>7</sup> It also determines key findings that are difficult to discover in a traditional autopsy, such as entry angles of a knife or a bullet, or cases related to medical malpractices. Some groups - notably Jewish and Muslim communities have religious objections to autopsy<sup>8</sup> and demand for a minimally-invasive alternative has increased.<sup>1</sup> This demand was acknowledged in the Coroners and Justice Act 2009.<sup>9</sup> Roberts et al. found that compared with traditional autopsy CT was a more accurate imaging technique than MRI for providing a cause of death in adults.<sup>1</sup> Thayyil et al. indicated that the minimally invasive autopsy has accuracy similar to that of conventional autopsy for

detection of cause of death or major pathological abnormality after death in fetuses, newborns, and infants, but was less accurate in older children.<sup>10</sup> Advances in radiology combined with the advances in computer technology have made the 3D (three-dimensional) representation of anatomic structures easily obtainable using CT and MRI. The data sets resulting from CT and MRI examinations commonly consist of hundreds or thousands of slice images. 3D imaging processes and integrates this image data volume and extracts more meaningful, derivative images via primarily multiplanar reconstruction (MPR), and direct volume rendering.<sup>11,12</sup>

Our survey is associated with an unusual case of self-strangulation where a body was found in the stage of mummification with a nylon cable tie around neck and another around the feet and the application of 3D post-mortem examination as a better diagnostic alternative to conventional autopsy. First of all, the homicidal death must be ruled out in such circumstances. It is necessary to make a detailed examination of death scene, ligature material, its configuration, number of wrappings around the neck, position of its locking mechanisms and autopsy findings deserves a special mention.<sup>13</sup> Each wrong interpretation and destruction of forensic evidence can affect the manner of death.

The self-retaining ligature of nylon cable tie around the neck and feet and the presence of the stage of mummification, deployed in the presence case, are remarkable for its uniqueness.

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## 2. Methods

We used the Sectra Visualization Table as a basic piece of equipment in order to explore 3D human body images. Data from a CT or MR scan is used to render 3D representations of a patient (or a death body). By providing natural-size 3D views of anatomy of a death body, the visualization table helps forensic medical teams to localize vital anatomy (e.g. fragments of bones, variable positions of anatomic structures, the position of foreign bodies, presence of collection of air into tissues – pneumothorax, air embolisms or subcutaneous emphysema) before starting an autopsy. The Sectra Visualization Table is a large, multi-touch medical display with software that facilitates interaction with 3D images of the human body created by modern computer tomography (CT) or magnetic resonance (MR) cameras. To achieve good images quality in 3D rendering one prerequisite is to have thin slices (< 1 mm), and a second one is to use correct protocols in the CT or MR scanner to be able to study the specific tissues, organs and pathology. The users are able to intuitively zoom in, rotate or cut into the visualized body without using a scalpel or destroying the subject. This means that the same image can be used repeatedly, which is a valuable aspect in teaching younger colleagues. The idea of interacting with virtual patients is to provide a better understanding for the body's anatomy and functions, which in turn will contribute to better educated medical personnel and thus higher efficiency and safety in healthcare in the long-term. A unique feature in the visualization table is that it can be connected to the radiology PACS to retrieve patient data, as a clinicians workstation, but here also providing an advanced 3D rendering and intuitive interface for multiple users.<sup>12</sup>

In brief, the virtopsy approach has the following advantages: gives observer-independent and objective data archiving, nondestructive, minimally invasive, provides actual-size documentation, is in 3D, it is not necessary to touch the forensic evidence, non-destructive for the forensic evidence, provides 3D geometry that is correct in xyz-axis or space documented, real data based, the basis for sound scientific reconstruction, provides an alternative or additional examination tool for “difficult body area autopsy” (e.g., face, neck, pelvis), could be used in cultures and situations where autopsy is not tolerated by religion or rejected by family members (e.g., psychological reasons), provides ability to examine bodies contaminated by infection, toxic substances, radionuclides, or other biohazards (i.e., bioterrorism), provides 2D and 3D postprocessing for visualizing the findings by people not present during the examination, gives greater understandability in court or supports the process of quality improvement by digital archives (database for teaching, learning, education).<sup>14</sup>

## 3. Case report

Our case involved the badly decomposed, mummified and partial skeletonized remains of a male. The body was found in a locked wood-house near a neighborhood where a 50-year-old mentally retarded male had disappeared 6 months earlier. There were a nylon cable tie completely encircling the neck and another around the feet. Both fixed locking mechanisms had frontal positions (Figs. 1 and 2). Upon removal of the ligature material, a complete horizontal mark was found around the upper third of the neck above the laryngeal prominence corresponding to the size and pattern of the ligature, measuring 27 cm with maximum width 1 cm. The nylon cable tie measured 50 cm in length and a noose had been made with a circumference of 27 cm to completely encircle the neck, while the circumference of the neck was also 35 cm. According to the shrinkage of all tissues due to dehydration, the circumference of the noose had been less than the circumference of the neck irrespective to the same sizes detecting during the external examination of the body.

Based on the fact that the mummified skin and underlying tissues were dark, dry and leathery, the dissection of the neck in this case could alter key findings (ligature mark, laryngo-hyoid fractures) compared to



Fig. 1. In-situ ligature material at the neck.



Fig. 2. In-situ ligature material around the feet.

the use of post-mortem CT examination and three-dimensional view of the cadaver with the Sectra Visualization Table (SVT) (Fig. 3). The patterned injury on the skin can give clues to the strangulation tool. There was a superficial patterned injuries on the neck. The injuries on the neck of the body and nylon cable tie were digitized with the SVT. The match analysis concluded that the width of the noose could fit the patterned injuries. The laryngo-hyoid structures were intact. No evidence of any defense injury or any other mark of violence was detected. Further investigations revealed that the deceased was suffering from mental disorder and had attempted suicide previously.

Based on the detailed death scene investigation, autopsy findings, information on the history of psychiatric illness (previous suicide attempt), the manner of death was determined as suicidal irrespective of the presence of an additional ligature encircling the legs.<sup>15</sup>

## 4. Discussion

Self-strangulation is an uncommon method of suicide. Ligature strangulation is mostly homicidal and suicidal ligature is relatively rare. It is difficult to differentiate self-strangulation case from homicide, and there is no particular characteristic feature to distinguish them.<sup>15–17</sup> Thus each case of self-strangulation may be misinterpreted as homicide because self-compression of the neck with constricting force being other than body weight is usually considered unlikely.<sup>11</sup> The majority of the suicidal ligature strangulation cases in forensic literature reports

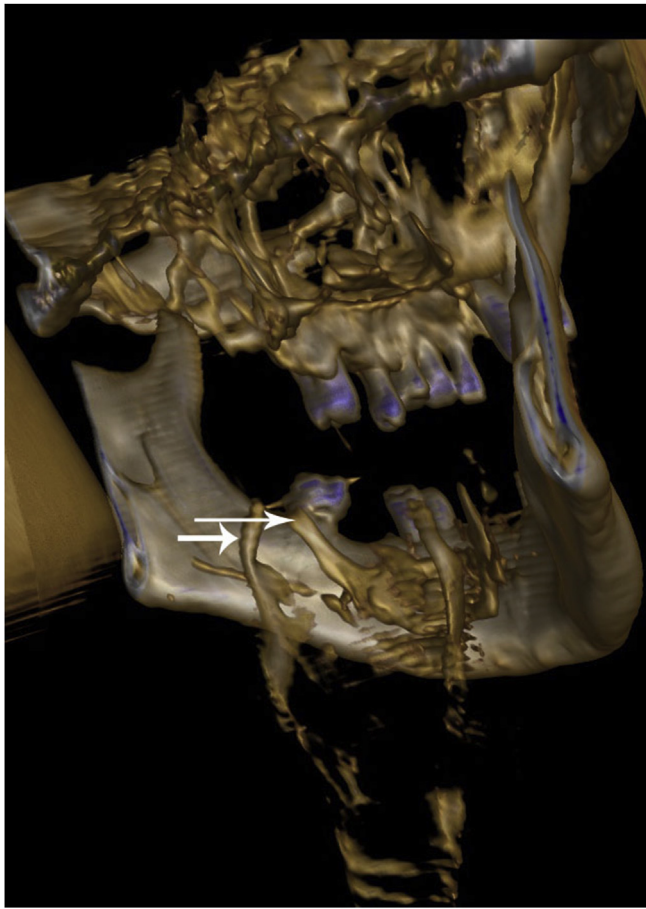


Fig. 3. 3D reconstruction of the neck structure (arrows show the hyoid bone and thyroid cartilage).

ligature marks which are mostly horizontal and complete and its knot or another locking mechanism is presence at the anterior region of the neck.<sup>12,15,16</sup> The fact that a mere tension of 2 kg would be sufficient enough to block the jugular veins, while the force required to occlude the trachea is 15 kg, counteracts the myth that self-strangulation is impossible.<sup>18</sup> Moreover, the absence of fractures of the thyroid cartilage and hyoid bone does not avoid suspicions of constriction of the neck. Lebreton-Chakour et al. reported that the fracture of hyoid bone was occurred at mean force of 30.55 N and it was dependent on a large number of variables such as age, weight and height of the subject, anteroposterior length and angle of the bone.<sup>19</sup> Laryngo-hyoid fractures and other neck injuries are extremely uncommon in cases on suicidal ligature strangulation.<sup>20</sup>

Another point worth mentioning is the advantage of modern medical technologies, including CT scanning and three-dimensional reconstruction of the body with the Sectra Visualization Table compared to the conventional forensic autopsy on a decomposed body. The virtual technology represents a significant advance on traditional “hands-on” forensic pathology techniques that were previously limited to the invasive dissection of the body as part of an autopsy.<sup>21,22</sup> In this case related to the examination of a mummified body the usage of traditional autopsy methods could destroy key findings mentioned above.

The manner of death was initially investigated as homicidal. However, crime scene examination, autopsy findings and investigation

into the past history of the deceased confirmed it as a suicidal death by self-strangulation. The case is reported for its rarity and the unusual method adopted by the victim to commit suicide by self-strangulation.

### Conflicts of interest

The authors declare that they have no conflict of interest.

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