

The importance of Post Mortem Computed Tomography (PMCT) in the reconstruction of the bullet trajectory

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Abstract

Introduction. Post Mortem Computed Tomography (PMCT) and 3D reconstruction provide a powerful tool in the evaluation of the causes of death, distinguishing between those findings related to traumas and those related to post mortal changes. It has proven to be extremely useful in case of violent deaths as a support to the traditional autopsy.

Aim of the study. The aim of the study is to prove the essential role of PMCT in the determination of the cause of death. For this purpose, we present a case of homicide where CT scans were performed before the autopsy, thus bringing to the resolution of an otherwise controversial death.

Case presentation. A 17 years old male died from a gunshot fired by a policeman during a chase. There were some controversies in this case that brought it to the national mediatic attention. PMCT reconstructed images showed the entry point and the ballistic trajectory of the bullet, moreover, PMCT high sensitivity in the evaluation of bone lesions, made the technique diriment in the clarification of the sequence of events that brought to the death of the subject, resolving the controversies of the case. In fact, it showed that the trajectory of the bullet could have not been compatible with the victim's family thesis. *Clin Ter 2019; 170(2):e129-133. doi: 10.7417/CT.2019.2122*

Key words: Gunshot injuries, PMCT, virtopsy, ballistics, forensic pathology, legal medicine

Introduction

Virtual Autopsy is the use of medical imaging technologies in forensic sciences. It is based on the use of Post Mortem Computed Tomography (PMCT) and 3D reconstruction. Those techniques can be used as an objective, observer-independent documentation of evidences. Multislice CT provides the best instrument in order to perform virtual autopsies, since it provides 3D data with higher resolution and better image quality than other imaging instruments. Using this means, the radiologist has to evaluate the causes of death, distinguishing between those findings that can be caused by lethal trauma and those caused by post mortem

changes. PMCT can be used in order to improve forensic investigations with a complete, non-destructive way of collecting findings, even preserving the body in a virtual form and ensuring its future accessibility. This technique has several advantages when the direction of an impact has to be determined and when bone evaluation has to be done in order to find complex traumas (1-4).

PMCT is extremely useful whenever we want to obtain information about the path of a bullet through the body, helping us in the reconstruction of an event. This tool has proved to be very useful in the detection and quantification of pneumothorax, otherwise extremely difficult to evaluate with a traditional autoptic examination. This can be of crucial importance in the evaluation of a ballistic trauma (5).

In this study we present a case of homicide in which PMCT scans were performed before the autopsy, proving essential in the determination of the cause of death, thus bringing to the resolution of an otherwise controversial death.

The aim of this study is to evaluate what advantages this technique can bring to the field of forensic ballistic.

Case presentation

A 17 years old male died from a gunshot fired by a policeman during a chase. There were some controversies in this case that brought it to the national mediatic attention. In fact, while the policeman claimed to have fired accidentally after stumbling on a step, the family of the victim claimed that the shot was fired intentionally, accusing the policeman of intentional manslaughter. This thesis was sustained through several testimonies.

Post mortem investigation on the corpse included a preliminary full body PMCT. The acquired scans were rendered using the open source software OsiriX on a Mac OS X computer in order to obtain a 3D reconstruction of the body surfaces. The crime scene reconstruction was performed using the software Poser Debut on a Mac OS X computer.

PMCT reconstructed images showed the entry point and the ballistic trajectory of the bullet, as a result, we were able to precisely identify the trajectory of the bullet, thus leading

to the reconstruction of the dynamic of the event. The entry point was identifiable as a discontinuity of the soft tissues in the left pectoral region. The interruption was quite deep, involving all the muscle layers. The subsequent track was determined analyzing the involvement of several anatomic structures. The thorax was involved on the frontal side, as well as the left visceral pleura, while the lung parenchyma was interested at the level of the dorsal-apical and upper lingular segments of the upper lobe, and the upper, middle, lateral and lower segments of the lower lobe. A large hemothorax was detected on the dorsal side of the left hemithorax. In front of it, there was evidence of a fluid hydrothorax layer associated with a small air-fluid level near the frontal arches of the thoracic ribs (Fig. 1).

The exit point was identified with the bullet hole found at the level of the eight dorsal vertebra. It extended from the anterolateral side of the vertebral body to the contralateral isthmus, showing evidence of a comminuted fracture of the spinous process of the same vertebra. On the sagittal and axial projections, there was evidence of a small subcutaneous emphysema in the soft tissues located on the back side of the eight dorsal vertebra, that corresponded to the exit point of the bullet.

At the external examination, on the left subclavian region, 4,5 cm beneath the left clavicle and 14 cm left of the anterior midline, a round shaped wound of entrance was detected. It was 0,9 cm in diameter, showing inward skin tears. Surrounding the lesion, a red-brown colored eccentric abraded margin was found. It showed an area of increased thickness located on the upper right. The wound course went from left to right, front to back and downward (Fig. 2-3).

On the right dorsal level, 2 cm from the midline, 40 cm under theinion, the exit wound was found. It was 0,4 cm in diameter, being evident as a skin laceration that went outwards. The wound didn't show an abrasion ring.

At the autoptic examination, on the left emithorax, at the level of the third intercostal space, a round-shaped wound measuring 1,1 cm was found. It was quite deep, as it penetrated in the pleural space.

A pulmonary atelectasis was also detected. The lacerative lesions of the lung parenchyma and of the branches of the left pulmonary artery resulted in a severe hemothorax that amounted to 2100 cc of fluid and partially clotted blood.

Moreover, a complete fracture of the vertebral body of the eight dorsal vertebra was found on the left antero-lateral side. The right lamina of the same vertebra was also fractured (Fig. 4).

Discussion

Among those innovative approaches (6), whose application is increasingly common in forensic practice, Computed tomography (CT) is the most widely used method in modern forensic radiology (7,8).

PMCTA has become an established method due to numerous studies that have documented the undeniable advantages in terms of acquisition times, costs and possibility to review the data acquired at any time (9,10,11). It has become an increasingly helpful tool in the study of fine anatomical features and anatomical relationships. For these reasons, PMCT examination should always be performed in case of violent deaths as a support to the traditional autopsy

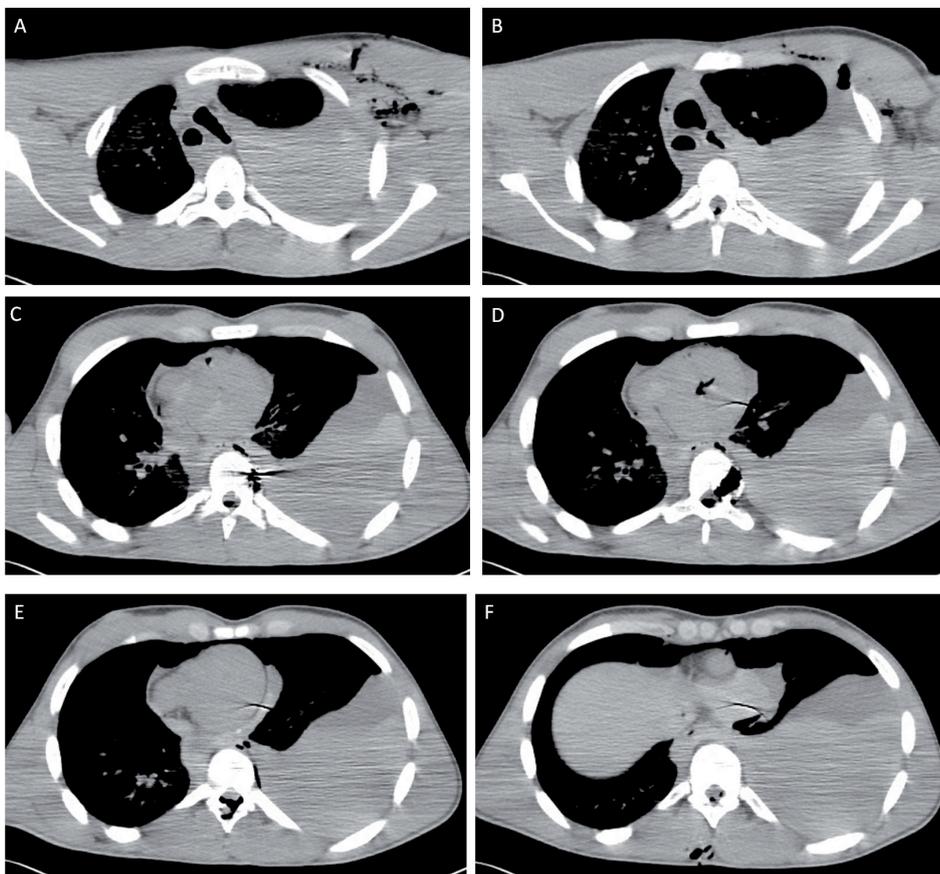


Fig.1. PMCT coronal images. A large hemothorax is clearly detectable on the dorsal side of the left hemithorax. Near the frontal arches of the thoracic ribs there is evidence of a fluid hydrothorax layer associated with a small air-fluid level.

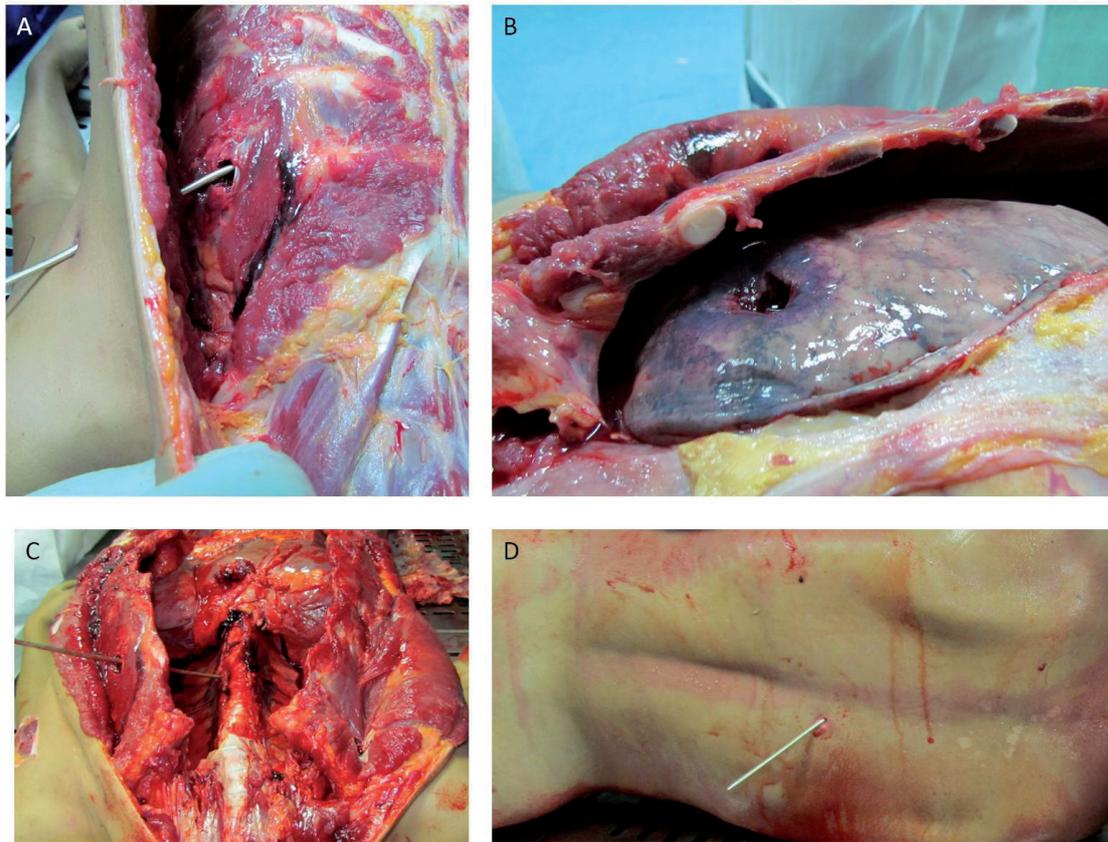


Fig. 2. Autopsic reconstruction of the bullet trajectory. The entrance wound was located 4,5 cm beneath the left clavicle and 14 cm left of the anterior midline. The wound course went from left to right, front to back and downward, and the exit wound was found on the right dorsal level, 2 cm from the midline, 40 cm under the inion.

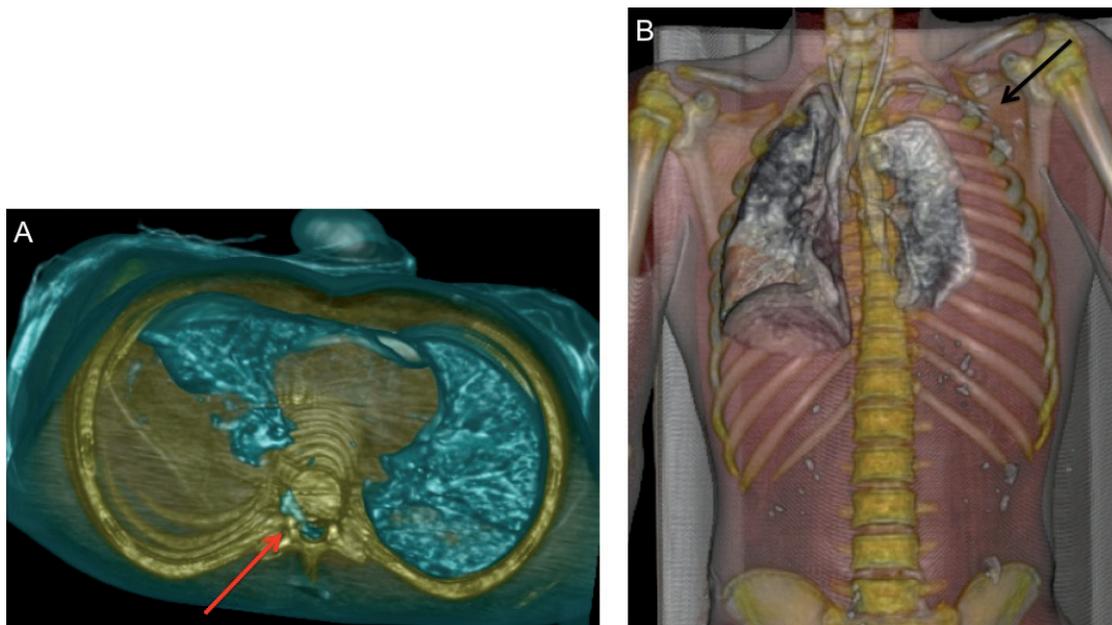


Fig. 3. Axial (A) and coronal (B) CT 3D reconstructions. These images show anatomical relationships among bone structures, lungs, airways and vessels. Black and red arrows point, respectively, entrance wound and exit wound.

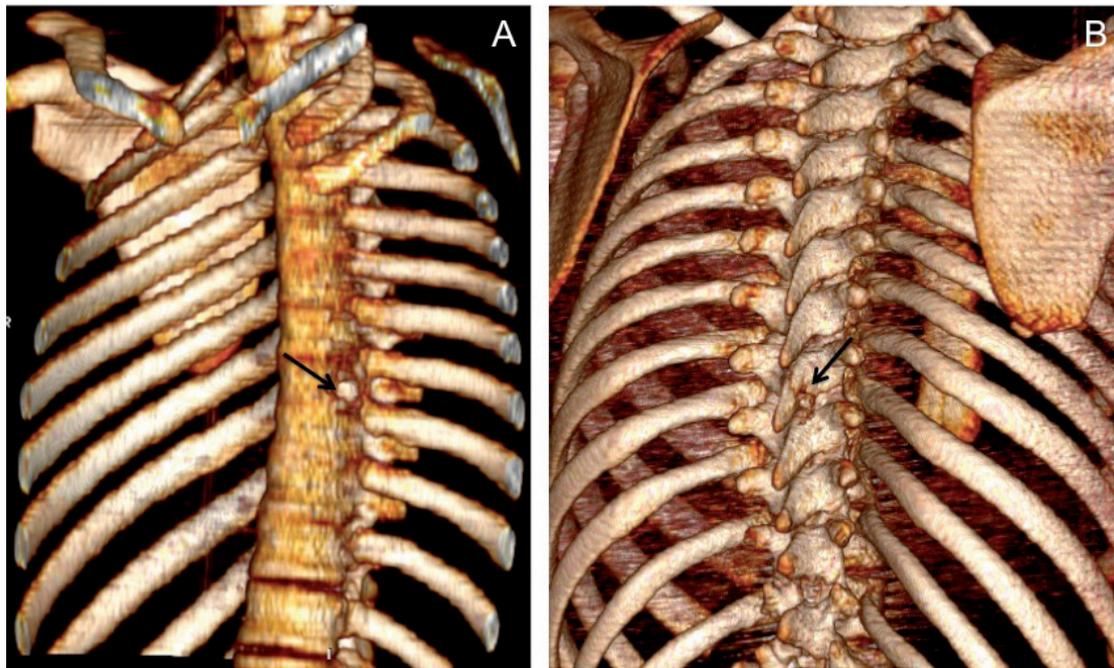


Fig.4 – PMCT 3D reconstruction: A) complete fracture of the vertebral body of the eight dorsal vertebra on the left antero-lateral side. B) fracture of the right lamina of the same vertebra

(12,13). In fact, PMCT has proven to be useful in many different cases of violent death, such as gunshots, asphyxia, carbonization etc.

In asphyxia cases, for example, no specific signs or injuries may be found at the autopsy, while the PMCT with 3D documentation can be very helpful in revealing injuries on the small structures of the neck, which can be difficult to reach with traditional neck dissection, being frequently masked by soft tissues and surrounding bleedings (14,15).

In case of gunshot injuries, instead, PMCT allows an easier localization and retrieval of the bullet and/or its fragment. It permits a preliminary and detailed 3D reconstruction of the ballistic effects, such as accurate determination of the wound track, entrance and exit wounds, bone's fractures and the course of fragments inside the body.

On the other hand, PCMT has showed to be extremely helpful in the determination of the cause of death in cases of natural deaths, with reference to sudden death (16).

The role of PMCT, and most specifically PMCTAngiography in case of sudden cardiac death is giving important clues in order to carry out a thorough autopsy. In particular, this exam can assess an increase in diagnostic sensitivity allowing an accurate detection of coronary arteries and pathological findings (17).

In our experience, PMCT showed to be very useful in the evaluation of an otherwise difficult case. It was crucial to identify the direction and the course of the bullet through the body. PMCT helped us in the evaluation of the trajectory of the bullet, showing us clearly the exit point, identifiable with the hole and the comminuted fracture at the level of the eight dorsal vertebra. The particular position of the exit wound made was difficult to detect and investigate by tradition autoptic techniques. PMCT high sensitivity in the

evaluation of bone lesions, made the technique diriment in the clarification of the sequence of events that brought to the death of the subject, resolving the controversies of the case. PMCT clearly showed that the trajectory of the bullet could have not been compatible with the victim's family thesis, supporting the policeman's version.

PMCT was also extremely important in order to identify pneumothorax in a clear, objective way (Fig.1). Usually in order to identify pneumothorax a specific autoptic technique is used. It consists in the dissection of the skin and the muscles on the side of the chest that we want to analyze. It is of crucial importance in this stage to be careful not to damage the soft tissue between the ribs. A pocket is then obtained through the use of a mean of traction that is applied on the skin and the underlying soft tissue. Then the pocket is filled with water. At that point a scalpel is introduced under the water level through an intercostal space into the costodiaphragmatic sinus. Every time there is air in the pleural cavity, air bubbles appear in the water (18). It is evident that this technique is difficult to perform, and its success relies strongly on the experience of a skilled operator. On the other side, PMCT proved to be a simpler observer-independent, more objective means, being also able to evaluate and quantify the pneumothorax volume, increasing even further its capacity to assess the trajectory of the gunshot (1,19). This kind of quantification would have been otherwise very difficult to achieve only with a simple autoptic examination. Furthermore, acquiring radiological documentation before the autopsy allows the pathologist to choose the right dissecting technique and avoid artifacts or iatrogenic injury to delicate structures.

In our case, postmortem CT was of great help in the identification of the wound course, trajectory of the bullet,

parenchymal injuries, bone's fracture, as well as in the reconstruction of the dynamic of the event. In facts, according to the radiological scans, we were able to reconstruct the dynamics of the event. The subject was hit on the left hemithorax while he was slightly facing forward the gun. The offender was standing in front of, above, and shifted on the left of the victim.

However, thanks to the postmortem CT we were able to clarify the cause of death and the trajectory of the gunshot before the traditional autopsy.

Conclusions

PMCT proved itself determinant in the clarification of the causes and the dynamics of a controversial death.

PMCT proved to be more accurate than a conventional autopsy in the definition of pneumothorax, with a reliability that was higher than that of the common autoptic technique (1,20). Bone lesions are also better characterized through the use of this instrument. This helped us obtaining a precise definition of the bullet exit point. PMCT also proved to be extremely accurate in the definition of the penetration paths of extraneous bodies, being also a useful method in the localization of fragments (4-5,19).

Nowadays, it does not seem possible for post-mortem imaging to ever replace conventional autopsy, but it can be a valid complementary tool with encouraging future perspectives.

According to those considerations, we believe that PMCT should be performed in every case of death from a ballistic trauma, making the technique complementary to the more traditional postmortem examination in forensic investigations. This would enable forensic scientists to obtain as much of information possible in order to put light on the causes and the mechanics of death.

In the reported case, postmortem CT showed multiple advantages: objectivity, reproducibility, easy visualization of the wound paths, easy localization of the bullet and its fragments.

For these reasons, post-mortem imaging has to be considered an aid in the forensic investigations, rather than an alternative to conventional post-mortem procedures.

In conclusion, looking at the objectives of this study, one could argue that the use of instrumental devices represents an important aid to forensic pathology, and could be relevant form the medico-legal point of view (21).

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