Original Article

Noninvasive postmortem investigation of cases refusing autopsy using computed tomography

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Abstract

Background: CT is a well-known tool to assess several conditions in living patients. The post-mortem CT (PMCT) has been introduced to determine the cause of death in dead subjects. CT is also the imaging modality of choice for the analysis of autopsy findings including fracture, hematoma, gas collection and gross tumor injury. The rate of standard autopsy is continuing to decline and there are several reasons for refusing autopsy.

Objective: The current research endeavor is investigate the usefulness of computed tomography (CT) in cases refusing autopsy.

Materials and Methods: In this study, the PMCT were evaluated in 150 subjects in different contexts of death. The causes of death were classified into four categories which include a definite cause of death, a possible cause of death, a minor pathological finding and no fatal findings. For the definite cause of death and the possible cause of death, the specific lesions are described in detail.

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Results: The definite cause of death was detected in 48 (32%) of the subjects. The possible cause of death was detected in 18 (12%) of the subjects. The remaining 84 subjects were classified into minor pathological findings and no fatal findings in 46 (30.7%) and 38 (25.3%) of the patients, respectively. The fatal lesions of PMCT were found in 93 lesions (48 subjects) that were demonstrated by anatomical locations into the traumatic bone, intracranial, spine, thoracic, heart leak and abdominal lesions. We found definite causes of death in 6 subjects, which had no history of trauma and malignancy and were mentioned about a cardiopulmonary failure as a cause of death at first.

Conclusion: The PMCT is a useful tool for identifying the cause of death in many cases that have limitations for conventional autopsy. The morphological change such as intracranial hemorrhage is easily diagnosed with PMCT. The PMCT appears to be an alternative tool to assess the cause of death in any reason of objections.

Keywords: Cause of death, Postmortem CT, Refusing autopsy case, Virtual autopsy.

Introduction

To investigate the cause of death, an autopsy is the reference standard for postmortem evaluation in a modern clinical practice. In recent years, the autopsy rate has declined in most developed countries [1]. Computed tomography (CT) and magnetic resonance imaging (MRI) is a well-known imaging tool to investigate the internal organs of living patients. Several studies have reported the use of these imaging tools to identify postmortem causes of death. Robert et al.[2] reported that whole body CT is more accurate than MRI to investigate the cause of death in adults. Takahashi et al.[3] demonstrates that postmortem CT (PMCT) is a feasible tool to detect the morphological cause of death in non-traumatic cases in the emergency department. Le Blanc-Louvry et al.[4] compares the PMCT with standard autopsy in different contexts of death. They found that PMCT is an

effective tool as a standard autopsy in determining the cause of death. Wichmann et al.[5] reported that advanced radiographic techniques provide an alternative approach for postmortem evaluation. Yukihiro et al. reported PMCT in the investigation of non-traumatic death in infants and children.

Although the conventional autopsy is a standard tool to determine the cause of death in all contexts of death, several reasons to object conventional autopsy are found. CT is an advanced radiographic imaging tool to evaluate the morphological change of internal organs. CT provides a better spatial resolution than MRI and less scan time. CT is also a useful tool for showing fractures and internal hemorrhage. CT is more widely available in most of hospitals particularly in rural areas.

In this study, we evaluate the usefulness of the PMCT to diagnose possible causes of death in cases refusing conventional autopsy.

Materials and methods

This study is a retrospective review and approved by the institutional review board (No.147/2564). The study subjects were unnatural death bodies of any age who were sent to the Institute of Forensic Medicine, Police General Hospital, Thailand between 31 October 2017 and 30 September 2018 with the conventional autopsy not performed due to the refusal of conventional autopsy. The informed consent was waived due to retrospective review. The exclusion criteria were failure to perform PMCT imaging.

All PMCT images were performed on a 16-slice multidetector row CT scanner (Alexion, Canon Medical Systems; Toshiba Medical Systems). The acquisitions were obtained with contiguous axial slices with spiral mode from the vertex to the pelvis with 5 mm slice thickness.

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The PMCT was interpreted by the consensus of one radiologist and one forensic doctor. The clinical history was given to the radiologist and forensic doctor during the imaging interpretation. The CT images were visualized in axial images on computer workstation with DICOM viewing software. For better image visualization, the coronal and sagittal images were reconstructed during the imaging interpretation. All abnormalities were noted in the case record form. To define the cause of death, the CT findings are classified in four categories: definite causes of death, possible causes of death, minor pathological findings and no fatal findings. For the definite causes of death and possible causes of death, the specific lesions are described in detail.

The demographic data including ages, genders and clinical data were collected. The PMCT findings were presented in non-contiguous variables.

Results

Out of the total of 153 decedents enrolled in the study, three were excluded because the PMCT was not available (data loss). The remaining 150 decedents were employed in the study. The demographic data of the subjects were males and females in 123 and 27, respectively. The average age of the subject is 42.6 years old (Table 1). The definite causes of death were detected in 48 (32%) of the subjects. The possible causes of death were detected in 18 (12%) of the subjects. The remaining 84 subjects were classified into minor pathological findings and no fatal findings in 46 (30.7%) and 38 (25.3%) of the patients, respectively (Table 2).

Table 1. *Patient characteristic.*

No of cases	150
Male	123
Female	27
Age (years)	42.6 years (range 1-96)

Table 2. *Classification of causes of death by post mortem CT.*

	No of cases
Definite cause of death	48 (32%)
Possible cause of death	18 (12%)
Minor pathological finding	46 (30.7%)
No fatal finding	38 (25.3%)
Total	150

The fatal lesions of PMCT in definite causes of death were found in 93 lesions (48 subjects) that were demonstrated by anatomical locations into traumatic bones (Figure 1), intracranium, and spine (Figure 2), thoracic, heart leak and abdominal lesions. In the definite causes of death, two most common lesions are subarachnoid hemorrhage and skull fractures (Table 3). The traumatic bone and intracranial lesions are also the most common anatomical locations for the fatal lesions.

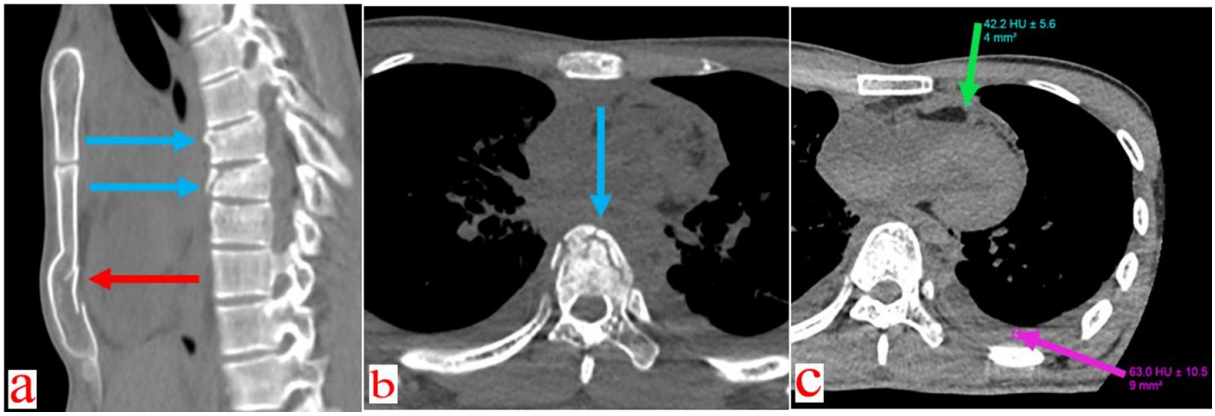

Figure 1. *A 24-year-old male who fell from height. PMCT in the bone windowed in (a and b) sagittal and axial views found a fracture at sternum (red arrow) and a fracture in vertebral bodies at T6-7 levels (arrow head). (c) axial image soft tissue windowed showed hemopericardium (green arrow) and hemothorax (pink arrow).*

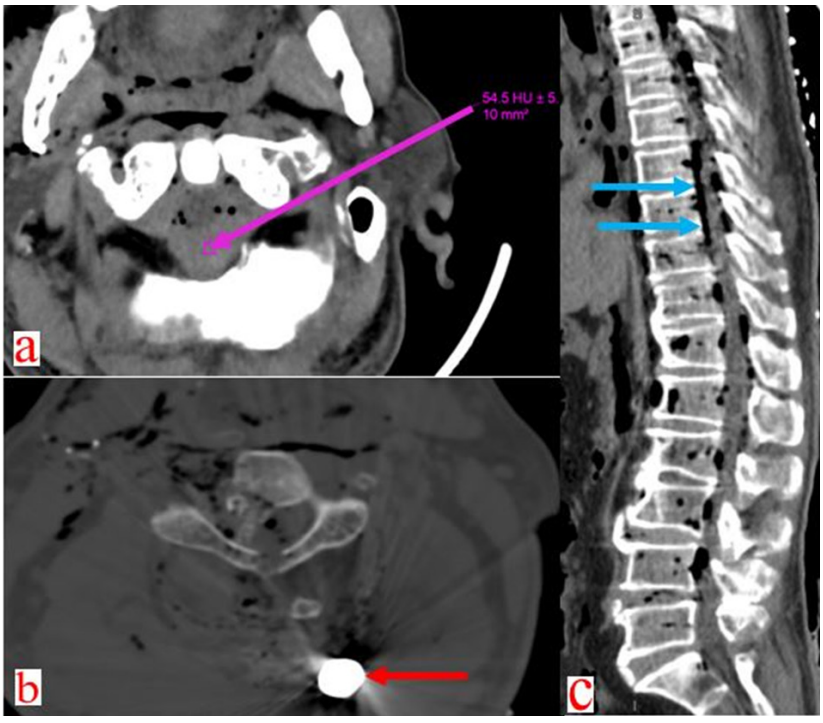

Figure 2. *A 70-year-old male with multiple gunshot wounds at the right shoulder. PMCT showed (a) hemorrhage in the spinal canal (pink arrow) in the bone windowed (b) found multiple fractures along bony vertebrae with retained bullet (arrow-head). (c) Sagittal image showed pneumorrhachis along the spinal canal (blue arrow).*

Table 3. *Post-mortem CT findings in definite causes of death and possible causes of death by the specific lesion.*

Category	Lesion	No. of lesion
Definite causes of death	Traumatic bone lesions	
	- skull fractures	12
	-Facial fractures	1
	-Vertebral fractures	9
	-Pelvic fractures	5
	Intracranial lesions	
	-Pneumocephalus	1
	-Intracranial hemorrhage	5
	-Subarachnoid hemorrhage	14
	-Epidural hematoma	1
	-Subdural hematoma	2
	-Intraventricular hemorrhage	8
	-Cerebral contusion	2
	-Cerebral edema	1
	Spines lesions	
	-Intraspinal hemorrhage	1
	Neck lesions	
	-Neck injury	1
	Thoracic lesions	
	-Pulmonary congestion	1
	-Pleural fluids	1
	-Pneumothorax	9
	-Hemothorax	9
	-Thoracic cancer	2
	Heart leakage lesions	
	-Hemopericardium	5
	Abdominal lesions	
	-Hemoperitoneum	3
	-Abdominal cancer	1
Possible causes of death	Thoracic lesions	
	-Pulmonary infiltration	4
	-Pulmonary mass	4
	-Pulmonary edema(drowning)	1
	-Pleural effusion	4
	-Pulmonary congestion	1
	-Hemopneumothorax	3
	Cardiac lesions	
	-Markedly cardiomegaly	2
	Abdominal lesions	
	-Kidney atrophy(ESRD)	1
	-Ascites fluid	2

We found definite causes of death in 6 subjects, which had no history of trauma and malignancy and were mentioned about the cardiopulmonary failure for the cause of death at first (Table 4, Figure 3-5).

Table 4. *Post-mortem CT findings with definite causes of death in six subjects, which were mentioned about the cardiopulmonary failure for the cause of death at first.*

Case	History	Cause of death from CT
1	Male 57 years, unconsciousness	Massive left hemothorax
2	Male 61 years, unconsciousness	Hemopericardium
3	Male 62 years, unconsciousness	Subarachnoid hemorrhage
4	Female 65 years, unconsciousness	Subarachnoid hemorrhage
5	Male 50 years, unconsciousness	Subarachnoid hemorrhage, intraventricular hemorrhage
6	Male 40 years, unconsciousness	Intraventricular hemorrhage, intracerebral hemorrhage

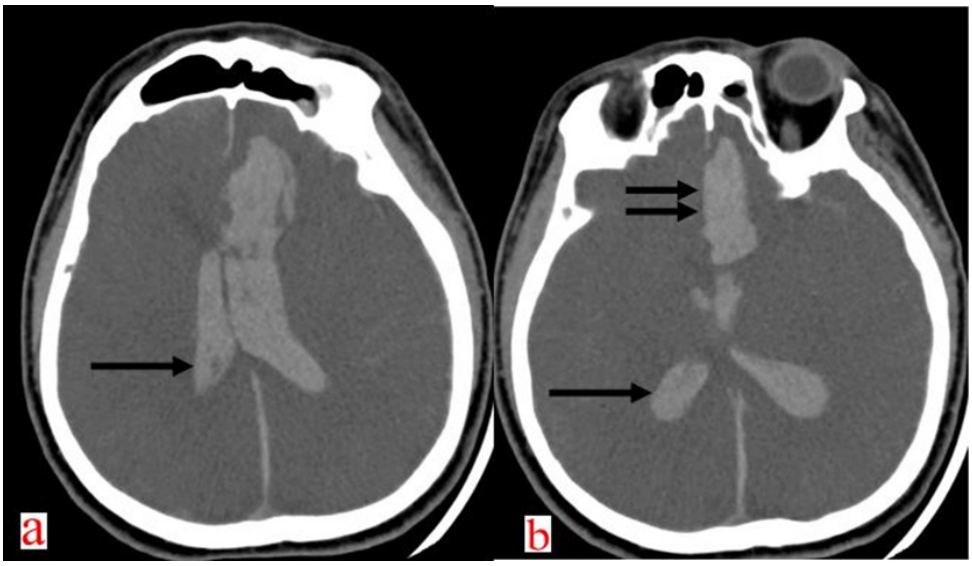

Figure 3. *A 61-year-old male with unconsciousness and PMCT showed (a and b) intraventricular hemorrhage (arrow) and intracerebral hemorrhage (double arrow).*

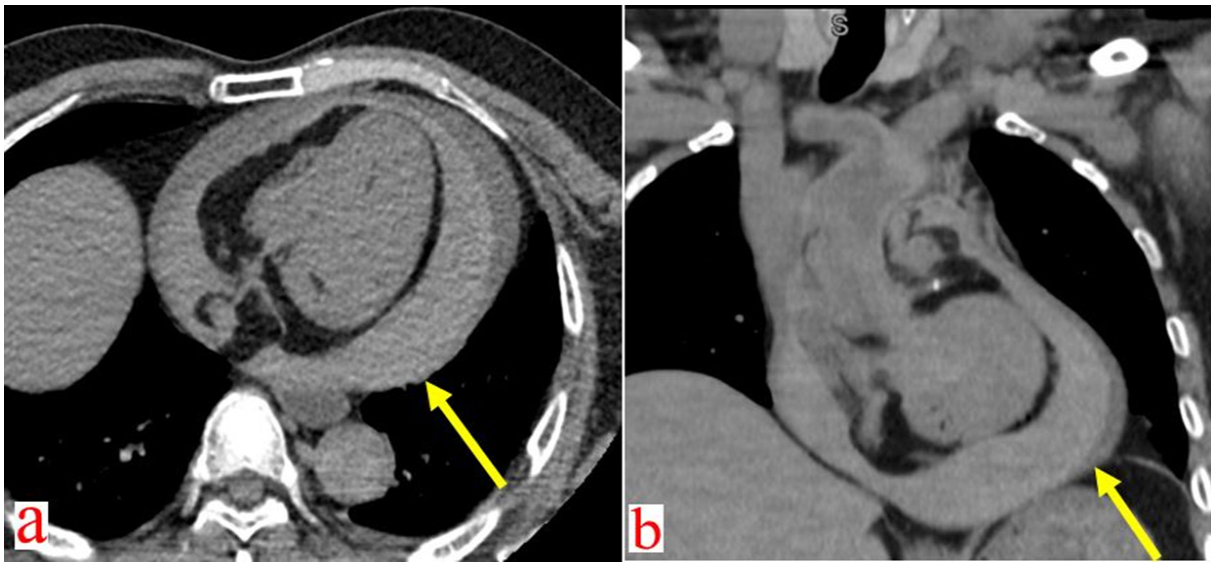

Figure 4. *A 62-year-old male with unconsciousness and PMCT axial and coronal views (a and b) showed hemopericardium (arrow).*

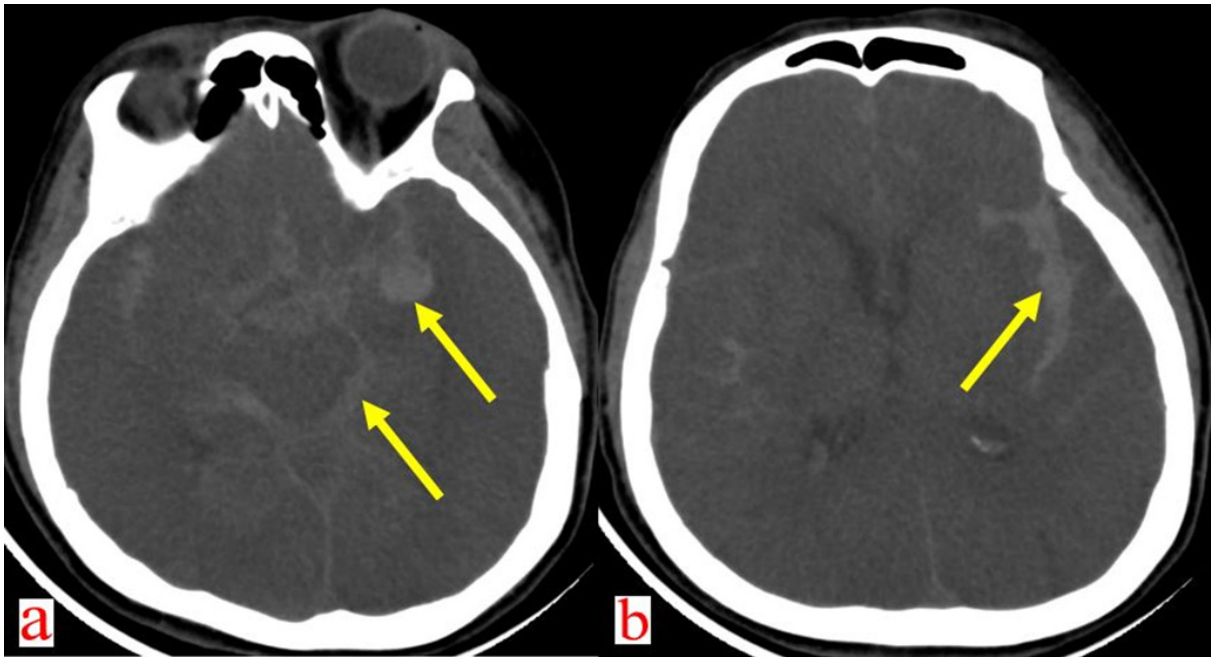

Figure 5. *A 65-year-old female with unconsciousness and PMCT brain axial view (a and b) showed subarachnoid hemorrhage (arrow).*

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Discussion

The PMCT is a non-invasive method to visualize the internal organ after death. Recently, several studies have proposed the use of PMCT to determine the cause of death [1-10]. The PMCT is considered the most feasible imaging modality because it is widely available. In our study, we demonstrate the usefulness of PMCT to determine the cause of death in cases refusing autopsy. We can determine the definite and possible causes of deaths in 66 (44%) subjects. The remaining are minor pathological and no fatal findings. The anatomical change of the internal organ can be detected in PMCT. Conventional CT is a well-known diagnostic tool to access the internal organ. The most common fatal anatomical locations in PMCT are traumatic bones and intracranial lesions. The traumatic bone lesions are skull, facial, vertebral and pelvic fractures. The intracranial lesions are pneumocephalus, intracranial hemorrhage, subarachnoid hemorrhage, epidural hematoma, subdural hematoma, intraventricular hemorrhage, cerebral contusion and cerebral edema. The most common lesion of traumatic bone lesions is skull fractures, which is in concordance with the previous study [4]. The PMCT is more frequently detected for facial and vertebral fractures than conventional autopsy because these areas are not in routine dissection [4]. The intracranial lesions are well-demonstrated in PMCT. The hyperattenuation of blood clot or hematoma can be easily visualized in conventional methods and PMCT. Elkhateeb et al. [7] reported that PMCT was as valuable as autopsy for detecting the direction of firing and internal bleeding of gunshot injuries.

In 86 subjected who were diagnosed with the cardiopulmonary failure from only an external body exam, we found definite causes of death from PMCT in six subjects. Four of them had intracranial hemorrhage and two of them had intrathoracic hemorrhage. This is about 7% in cases of a diagnosed cardiopulmonary failure.

PMCT is less sensitive than autopsy in vascular injury because of no contrast enhancement in vessels. The direct evidence of blood leakage is demonstrated as an isoattenuation on CT images. If leakage is small, it is difficult to be detected in

PMCT. However, the indirect evidence of blood leakage is perivascular hematoma, which is slightly hyperattenuation of lesion adjacent to the vessel. In this study, no direct evidence of perivascular hematoma is detected in all subjects. The hemopericardium is indirect evidence of ascending aortic or heart rupture that is frequently found in autopsy observation [6]. In this study, we can detect hemopercardium in five subjects. The acute coronary syndrome is one of the commonest causes of death worldwide. The absence of post mortem coronary angiography may lead to underdiagnosis of an acute coronary syndrome [6]. The Agatston score measured in non-contrast CT more than 400 may indicate the likely presence of the significant coronary artery disease but it is not a definite diagnosis. Nevertheless, the PMCT is not sufficient in the diagnosis of this sudden death. Pulmonary embolism is also a diagnostic pitfall of PMCT. The pulmonary embolism is one the most common sudden deaths that is presented with cardiovascular collapse. However, the pulmonary embolism is limited for diagnosis in non-contrast PMCT [3, 6].

The PMCT is an effective tool similar to the conventional autopsy in diagnosis of airway, lung and thoracic diseases [6]. The airway obstruction by foreign body or food aspiration may be secondary to a cardiac arrest. The opaque foreign body can be detected in non-contrast PMCT. However, post mortem redistribution of gastric contents into the airways and lungs are commonly misdiagnosed as aspiration in PMCT [6].

The abdominal region is one of the causes of sudden death. The solid organ injuries may be visualized as hyperattenuation hematoma. The gastrointestinal perforation may reveal gas and free air in the abdomen but the perforation site cannot be visualized [6]. The hemoperitoneum or blood leakage in the abdomen may be a possible result of solid organ injury or aortic rupture. In this study, we found hemoperitoneum in three subjects. Takahashi et al. [3] reported the usefulness of PMCT in detecting bowel lesions such as bowel strangulation and ischemic colitis.

The limitation of this study is no confirmation by conventional autopsy. Non-contrast of CT imaging is also a major limitation of vascular lesions. Prospective studies with a larger sample size are required to investigate the additional value of PMCT.

Conclusion

The PMCT is a useful tool for identifying the causes of death in many cases that have limitations in a conventional autopsy. The morphological change such as intracranial hemorrhage is easily diagnosed with PMCT. The PMCT appears to be an alternative tool to assess the causes of death in any reason of objections.

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