Postmortem CT in emergency depaartment: Influence of cardiopulmonary resuscitation

Poster No.: C-1440
Congress: ECR 2012
Type: Educational Exhibit
Authors: T. Murakami¹, M. Uetani², K. Ikematsu²; ¹Ngasaki/JP, ²Nagasaki/JP
Keywords: Forensics, Diagnostic procedure, CT, Forensic / Necropsy studies
DOI: 10.1594/ecr2012/C-1440

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

The purpose of this exhibit is to describe CT findings of basic postmortem changes and additional findings modified by cardiopulmonary resuscitation (CPR), which can be misinterpreted as causes of death.
Background

Recently in Japan, postmortem CT (PMCT) is performed not only in forensic medicine but also in the emergency department. In about 80% of major emergency departments, PMCT is performed to identify the cause of death in patients with cardiopulmonary arrest [1-3].

The findings of PMCT in emergency department are influenced by the effect of CPR, which include cardiovascular gas, intravascular gas of the abdominal organs (commonly in the liver), dilatation of the alimentary tract by air, and rib fracture. These additional findings should be differentiated from postmortem changes or causes of death. In this presentation, we describe these peculiar PMCT findings in emergency department.
Imaging findings OR Procedure details

(1) Postmortem changes

Hypostasis (See Fig. 1-5.)

Hemoconcentration from postmortem hypostasis results in increased attenuation of the affected organs, vasculature, and tissues on PMCT. This finding is easily observed in large caliber arteries and veins as well as the cardiac chambers. Blood in these vessels separates into serum and red blood cells owing to gravity differences soon after the cessation of blood circulation [4]. Hypostasis is most commonly identified in the lung, usually as ground-glass opacity occupying the dorsal lung parenchyma with horizontal demarcation line to the ventral non-affected lung like an air-fluid level. It is sometimes difficult to differentiate between hypostasis of the lung from aspiration or contusion, which show a more focal pattern of air-space disease. Areas of intravascular hyperattenuation within the posterior dural sinuses of the cranium, cardiac chambers, and great vessels are also seen due to hemoconcentration, which should not be mistaken for thrombosis unless there are additional supportive findings that would suggest acute thrombosis [5].

Hyperattenuating aortic wall (See Fig. 2.)

The cause of hyperattenuating aortic wall of PMCT are considered to be due to contraction of the aortic wall, lack of a motion artifact, and decreased attenuation of the lumen after massive infusion at resuscitation or sedimentation of blood away from the aorta [6].

Dilatation of the right atrium (See Fig. 1.)

The right atrium is often dilated on PMCT possibly due to the blood congestion in the right heart system during death except for the cases with exsanguination. Superior and inferior vena cava are also dilated with the same mechanism [7].

Brain edema (See Fig. 6.)

Immediately after death, the cerebral parenchyma remains normal or becomes mildly edematous with subtle loss of distinction between gray and white matter without swelling [8]. Apparent brain edema with brain swelling can be seen in late stage, but hypotenuated area in the brain parenchyma is relatively mild compared to the cerebral infarct in the living patients.
(2) Changes associated with CPR

Cardiovascular gas (See Fig. 1.) & Intravascular gas of the abdominal organs (See Fig. 7-8.)

The main cause of cardiovascular gas in non-traumatic postmortem CT performed soon after death is possibly due to CPR and three factors can be associated for its origin [9].

1. Inflow of air accompanying venous catheterization

2. Pneumatization of dissolved gas in the blood caused by cardiac massage

3. Pulmonary parenchymal injury due to CPR

Cardiovascular gas is distributed not only in the cardiac chambers but also in the veins (e.g. the superior and inferior vena cava, the brachiocephalic veins, the subclavian veins, the hepatic veins). During CPR procedures, the gas bubbles entering these veins can ascend or descend retrogradely to the organs (e.g. brain, liver) against the blood flow. In patients for whom CPR is unsuccessful, antegrade venous flow does not occur and the gas is not carried away from these veins.

Dilatation of the alimentary tract by air retention (See Fig. 9.)

Gastrointestinal distension is a major complication of CPR; artificial respiration with an AMBU bag sends air to both the trachea and esophagus, thus the gastrointestinal tract is distended after artificial respiration [10].

Gastrointestinal distension caused by CPR should not be diagnosed as pathological process (e.g. ileus, bowel ischemia or necrosis).

Rib fracture (See Fig. 10-11.)

Chest compression for CPR may cause the fractures of ribs or sternum, which may eventually lead to rupture of liver or spleen, pneumothorax, hemothorax, pulmonary contusion, and mediastinal hematoma. These additional findings should be differentiated from traumatic change that might be considered as the cause of death.

(3) Findings related to the causes of death that should be differentiated from postmortem changes or changes associated with CPR

PMCT can demonstrate the specific findings, which indicate the cause of death, however, nonspecific postmortem changes or changes that occur after CPR may overlap in the same patient. We present some illustrative cases, in which the causes of death mimic postmortem change or changes after CPR on PMCT.
Traumatic death (See Fig. 12.)

In cases with traumatic death, the causes related to death can be easily identified with PMCT based on the hemorrhagic lesions due to trauma. However, as already mentioned, rib fractures and/or hemopneumothorax can occur as the result of cardiac massage, which may be difficult to be differentiated from the traumatic lesions.

Aortic dissection (See Fig. 13-14.)

Increased attenuation of aortic wall and contraction of aorta are frequency observed as postmortem change on PMCT. These postmortem changes may be mistaken for aortic dissection, because false lumen is usually observed as high attenuation on non-contrast CT.

Rupture of thoracic aortic aneurysm (See Fig. 15.)

Intrathoracic hematoma due to rupture of thoracic aortic aneurysm may be misdiagnosed as the influence of rib fractures associated by CPR. Collapsed aortic aneurysm can be easily misinterpreted as the contracted normal aorta.

Pulmonary edema (See Fig. 16)

Pulmonary edema is a nonspecific finding on PMCT and can be associated with various disorders related to the death.

Intracranial hemorrhage (See Fig. 17)

Intravascular high attenuation from postmortem hypostasis is frequency observed in the dural venous sinuses of the cranial fossae. The small amount of intracranial hemorrhage on PMCT should not be mistaken for intravascular hyperattenuation within the dural sinuses unless there are additional supportive findings that would suggest another cause of death.
Fig. 1: 82-year-old man who died of intracranial hemorrhage. CPR was performed during transport and in our emergency department by artificial respiration with bag valve masking and intratracheal intubation, continuous chest compression, and infusion. A: Antemortem CT performed 16 hours before death on admission. B: PMCT performed 15 minutes after death. PMCT (B) shows high attenuation hemoconcentration (arrows) in the dependent portions of the right and left atriums, which form fluid-fluid levels, and dilatation of the right atrium compared to that on antemortem CT (A). PMCT (B) also shows air bubbles associated with CPR in the right atrium and ventricle.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Nagasaki/JP

Fig. 2: Same patient as shown in Fig.1. Compared to antemortem CT (A), PMCT (B) shows high attenuation hemoconcentration (circle) in the dependent portion of the ascending aorta, which form a fluid-fluid level. PMCT shows decreased size of the ascending aorta with dense aortic wall compared to that on antemortem CT (A).
**Fig. 3:** Same patient as shown in Fig. 1. PMCT (B) reveals ground-glass opacities in the dependent portions of the lungs, reflecting the effect of hypostasis.

**Fig. 4:** 47-year-old man who died of subarachnoid hemorrhage. PMCT performed 5 hours after death reveals homogenous ground-glass opacity occupying the dorsal lung parenchyma with horizontal demarcation line to the ventral non-affected lung (arrows), reflecting the effect of hypostasis.
Fig. 5: 72-year-old man who died of head injury. PMCT performed 13.5 hours after death reveals ground-glass opacity spreading diffusely in the lungs with horizontal demarcation (arrows), reflecting the effect of hypostasis.
Fig. 6: 68-year-old man who died of drowning. A and A': PMCT of the head performed soon after death. B and B': PMCT (performed 8 hours after death) of the head of the same patient. In B and B', the cortico-medullary contrast becomes slightly indistinct compared to that on immediate PMCT (A and A'), reflecting mild edematous change of the brain. But, narrowing of the cerebral fissures and the ventricles are inconspicuous. The left parietal chronic subdural hematoma remains unchanged (arrows).

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Nagasaki/JP
Fig. 7: 64-year-old woman who died of trauma. She had attempted suicide by leaping from the top of the building. CPR was performed during transport and in our emergency department. PMCT performed soon after death shows intrahepatic gas distributed in the hepatic veins. These findings are considered the influence of CPR.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Ngasaki/JP
Fig. 16: 34-year-old woman who died of acute respiratory distress syndrome following amniotic fluid embolism. PMCT performed 80 minutes after death shows severe pulmonary edema in the lungs. Pulmonary edema associated cause of death should not be misdiagnosed as hypostasis of the lung. Note that all images do not show homogenous ground-glass opacity in the dependent portions of the lungs with a horizontal demarcation like the effect of hypostasis (See Fig. 4-5.).
Fig. 15: Same patient as shown in Fig. 8. PMCT performed 25 minutes after death shows multiple rib fractures (arrows) and massive hematoma in the right pleural space due to the rupture of thoracic aortic aneurysm (circle in A and B) and left pneumothorax (A' and B'). The ruptured thoracic aortic aneurysm can be easily overlooked due to collapsed lumen and intrathoracic hematoma may be misinterpreted as changes after CPR.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Nagasaki/JP
Fig. 14: Coronal PMCT of the chest in the same patient as shown in Fig. 13. The hematoma of false lumen in the ascending aorta and hemorrhagic cardiac effusion (arrows) are observed.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Ngasaki/JP
Fig. 13: 75-year-old woman who died of aortic dissection with cardiac tamponade. PMCT performed soon after death shows intimal flap in the ascending aorta (arrows in A, B and C) and hemorrhagic cardiac effusion (arrows in D). These findings associated with cause of death should not be mistaken as postmortem change or changes after CPR.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Nagasaki/JP
**Fig. 12:** Same patient as shown in Fig. 8. PMCT performed soon after death shows left hemopneumothorax and pneumomediastinum. These findings associated with cause of death should not be diagnosed as changes after cardiac massage.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Nagasaki/JP

**Fig. 11:** 86-year-old woman who died of drowning. PMCT was performed immediately after death. PMCT of the chest (A) shows rib fractures, pneumothorax, and subcutaneous emphysema. PMCT of the abdomen (B) shows slightly high-density fluid collection around the spleen suggesting splenic injury associated with CPR.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Nagasaki/JP

**Fig. 10:** 88-year-old woman who died of brain stem hemorrhage. PMCT performed 24 minutes after death shows multiple rib fractures (arrows) with right hemopneumothorax and subcutaneous emphysema due to CPR.
**Fig. 9:** Same patient as shown in Fig. 1. PMCT (B) shows that bowel dilatation associated with CPR compared to that on antemortem CT (A).

**Fig. 8:** 88-year-old woman who died of rupture of thoracic aortic aneurysm. CPR was performed during transport and in our emergency department. PMCT performed 25 minutes after death shows intrahepatic gas distributed in the hepatic veins. These findings are considered the influence of CPR. PMCT also reveals intrathoracic hematoma (arrows) due to the rupture of thoracic aortic aneurysm.
Fig. 17: Same patient as shown in Fig. 5. A: Sagittal PMCT of the head shows high attenuation hemoconcentration in the superior sagittal sinus and straight sinus. These findings are considered postmortem change reflecting the effect of hypostasis. B: Axial PMCT of the head shows diffuse subarachnoid hemorrhage, acute subdural hematoma and intraventricular hemorrhage due to head injury. Note all images show not only postmortem change but also cause of death.

© Department of Radiological Science, Nagasaki University Graduate School of Biomedical Sciences - Nagasaki/JP
Conclusion

Knowledge of the CT findings that occur after CPR is important when interpreting PMCT because these processes may be mistaken as pathologic process or injury related with the causes of death.
Personal Information

T. Murakami, M. Uetani. Department of Radiological Science, Unit of Translational Medicine, Nagasaki University Graduate School of Biomedical Sciences, 1-7-1 Sakamoto, Nagasaki 852-8501, Japan

Mail to: tomonorimurakami@yahoo.co.jp

K. Ikematsu. Department of forensic pathology and sciences, Nagasaki University Graduate School of Biomedical Sciences, 1-12-4 Sakamoto, Nagasaki 852-8523, Japan
References


