Post-mortem computed tomography (PMCT) imaging of the lungs: pitfalls and potential misdiagnosis.

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Learning objectives

The learning objectives of this exhibit are:

- To illustrate **PMCT imaging of post-mortal changes of the lungs.**

- To show **PMCT imaging of pathological lungs in:**
  a. thoracic trauma cases
  b. non-thoracic trauma cases
  c. non-trauma cases

- To outline **potential pitfalls in interpretation of PMCT imaging of the lungs.**

- To suggest **how to avoid misinterpretations.**
Background

The lungs are one of the most complex organs of the human body in terms of structural layout, being constituted by three compartments (airways, interstitium and vascular system), and in terms of functioning, cooperating with the other components of the respiratory system, namely upper airways, central nervous system, chest wall, and the pulmonary circulation, to a multitude of vital functions, first the respiratory.

In clinical radiology the knowledge of the imaging appearance of normal lung anatomy is a main issue, so that abnormal features can be distinguished, when they are present.

As well as in diagnostic imaging, also in virtual autopsy, the recognition and right interpretation of imaging abnormalities have an extreme importance in the assessment of diagnostic conclusions. This is even truer for the lungs, that, because of their particular and complex structure, represent one of the organs most submitted to post-mortal changes, also in the early post-mortal period.
1. PMCT IMAGING OF POST-MORTAL CHANGES OF THE LUNGS

The most characteristic appearances of post-mortem changes of the lungs are constituted by an attenuation gradient of ground glass opacities (GGO) with an increase of density values in the dependent lung regions [Fig. 1] (1).

These pulmonary PMCT findings can be attributed both to "physiological" factors, coinciding with those affecting lung imaging in living persons, particularly in expiratory scan, and "post-mortal" factors, acting in addition and related to post mortem changes.

- "PHYSIOLOGICAL" FACTORS:

Depend on regional differences in vascular distension and gas volume distribution due to:

- gravity,
- pleural pressures,
- tension forces of respiratory muscles.

During the life, the respiratory function is performed thanks to a complex mechanism involving not only the lungs, but also other structures, among those the thoracic cage.

For consequence, after ceasing of the life, the lungs, non pathological and in intact thoracic cage, no more submitted to respiratory muscles contractions, tend to assume a balance state, which can be interpreted as being the resting expiratory level. In this condition, gravity, pleural pressure and tension forces of respiratory muscles causes a certain attenuation gradient of GGO as the effect of vascular distension and poor ventilation of the dependent lung (2-9).

- POST-MORTAL FACTORS:

Accentuation of regional differences in vascular distention and gas volume distribution, due to:

- hypostasis: increase with the time since death (TSD),
- cessation of tension forces of respiratory muscles,
- pushing action of diaphragm: increase with the TSD (putrefaction).
After the cessation of the circulation, particularly in cases without the occurrence of massive haemorrhage, the blood, settled in the capillaries of the dependent lung regions, confers an increased opacity to these zones. This phenomenon corresponds to internal hypostasis (1). As well as hypostasis in the skin, this increase of density related to the blood congestion and stagnation is dependent on the position of the body after death and on the time since death. With the passage of the time since death, an increase of this phenomenon is a common finding due to accentuation of blood stagnation and an increased pushing action of the diaphragm related to intrabdominal organ putrefaction [Fig. 2]. Moreover, if the post-mortal scanning in the supine position is executed after the period requested for the fixation of the hypostasis on a body lied in not supine position, the areas of greater attenuation will correspond to the dependent regions of the original position [Fig. 3].

2. PMCT IMAGING OF PATHOLOGICAL LUNGS

PMCT imaging of the lungs is represented by an attenuation gradient of (GGO) with the most dense regions in dependent lungs.

The recognition, identification and isolation of pulmonary HRCT findings specific for post-mortal changes is possible with an high level of certainness often only in absence of thoracic injuries, and of other damage, directly or indirectly occurred to the pulmonary parenchyma.

In these last conditions, in fact, the same findings described as related to post-mortal changes may be masked or even be made no more recognizable, because of the presence of greater abnormalities.

FACTORS INFLUENCING POST-MORTAL CHANGES:

A. FACTORS ACTING DIRECTLY ON THE LUNGS:

- **Lung injuries due to thoracic trauma** (contusions, lacerations, retrograde blood aspiration, hemo- and/or pneumo-thorax) [Fig. 4] (10)
- **Pneumonia, Lung cancer** [Fig. 5]
- **Other lung pathologies**

B. FACTORS ACTING INDIRECTLY ON THE LUNGS:

- **Trauma cases with massive haemorrhage** [Fig. 6]
- **Aspiration** (blood, water, gastric content, ext.) [Fig. 6-7] (11)
- **Acute heart failure** [Fig. 7]
• **Pulmonary embolism** (thrombo-embolism, fat embolism, amniotic fluid embolism) (12)
1. PMCT IMAGING OF POST-MORTAL CHANGES:

**Attenuation gradient of Ground Glass Opacity (GGO)**

with areas of greater opacity in dependent regions and with greater extent in basal regions

Fig. 1: Non-enhanced CT axial images of the thorax performed 10 hours after death in a body lied in the supine position: An attenuation gradient with areas of greater opacity localized in dependent regions is recognizable in posterior regions bilaterally (a-b); the gradient densities show lower extent in superior lobes (a) than in inferior lobes (b).

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Fig. 2: Non-enhanced CT axial images of the thorax performed 10 hours (a), and 26 hours (b) after death in two healthy young subjects lied in the supine position: The attenuation gradient related to internal hypostasis shows greater extent and density in (b) than in (a).

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1. PMCT IMAGING OF POST-MORTAL CHANGES:

*Attenuation gradient of Ground Glass Opacity (GGO)*

with areas of **greater opacity in dependent regions** (related to the development and fixation of hypostasis)

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**Fig. 3:** Non-enhanced CT axial images at apical level of two bodies lied on the back (a) and on the left side (b): This images shows gradient densities localized in posterior regions in (a) and particularly in the left lung and in lateral position in (b) (bold, arrow). Note in (b) the co-presence of a nodular GGO due to blood aspiration.

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Fig. 4: Non-enhanced CT image of 2 cases of thoracic trauma: The images (a-b) show nodular GGO (long arrow, exemplar), close to lung lacerations (short arrow, exemplar) due to retrograde blood aspiration (a); some peripheral GGO (head arrows exemplar) are due to contusions (a); bilateral pneumo- and hemato-thorax are recognizable (a, b). Note in (b) the diffuse increase of density of ground glass type due to bilateral lung collapse and contusions. In both cases the attenuation gradient of GGO is not recognizable
Fig. 5: Non-enhanced CT image of 2 cases of pneumonia (a) and lung cancer (b): The image (a) shows multiple areas of lung consolidation and GGO. In (b), the presence of lung cancer in the left inferior lobar bronchus caused the collapse of the left inferior lung lobe. In both cases the attenuation gradient of GGO is not recognizable.

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**2. PMCT IMAGING OF PATHOLOGICAL LUNGS:**

**PMCT IMAGING OF NON-TORHACIC TRAUMA CASES:**

*Almost complete absence; Masking of post-mortral changes*

*Non trauma case with massive haemorrhage; Head trauma case*

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**Fig. 6:** Non-enhanced CT image of a case of death due to massive haemorrhage (a) and head trauma (b): The image (a) shows almost complete absence of notable gradient densities, mainly due to the lack of internal livores; note gas embolism in heart ventricles. The image (b) shows multiple nodular GGO, distributed bilaterally, due to blood aspiration; in this case the attenuation gradient of GGO related to post-mortal change is not well recognizable.

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2. PMCT IMAGING OF PATHOLOGICAL LUNGS:

PMCT IMAGING OF NON TRAUMA CASES:

Masking of post-mortem changes

Aspiration (fresh water); Acute heart failure

Fig. 7: Non-enhanced CT image of a case of death by fresh water drowning (a), and due to acute heart failure caused by myocardial infarction (b): The image (a) shows many nodular areas of consolidation (bold arrows, exemplar) and nodular GGO (thin arrows, exemplar), distributed bilaterally, in the entire parenchyma. The image (b) shows multiple areas of lung consolidation and GGO, bilaterally. The attenuation gradient of GGO is not recognizable in both cases.

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Conclusion

The detection of abnormalities in PMCT imaging of the lungs is an almost constant occurrence. Nevertheless, the presence of imaging alterations in scans obtained after death doesn't mean necessarily that the lungs were involved in any process with forensic relevance.

On the other hand, the presence of other lung imaging alterations related to pathologies, and confounding the normal pattern of post-mortal lungs, is really frequent in forensic cases. The lungs are in fact an organ with a really complex structure and crucial functions, and for these reasons, they are involved with direct or indirect mechanism in many processes leading to death.

For these reasons, the consideration and analysis of other elements in the diagnostic process is crucial for a right interpretation of pulmonary imaging abnormalities after death. The recognition of the eventual presence of other pulmonary and thoracic abnormalities, the examination of the whole-body images, the consideration of information about case circumstances and clinical history of the deceased are undoubtedly the fundamental tool to reach the right interpretation of post-mortal pulmonary abnormalities.

The correct interpretation of PMCT pulmonary findings is a main issue for the radiologist or the forensic pathologist who approach forensic cases with the modern PMCT techniques. A straight collaboration between radiologists and forensic pathologists and the consideration and analysis of clinical data and case circumstances is crucial to avoid misleading forensic conclusions.
References


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