Multi Phase Post-Mortem CT Angiography: Is an Interventional Radiological Approach Possible to combine with classical approach?

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Aims and objectives

Multi-phase post-mortem CT angiography (MPMCTA) is a recent technique, used for forensic and scientific purposes [1]. Its usefulness and performance are now well known but study is continuing in several centers [2, 3]. One of its promising advantages is good detection of vascular and solid organ lesions [4]. Our institution has been performing this technique as well as conventional autopsies since 2012. The standard procedure involves cannula insertion using surgical devices (Maquet GmbH & Co. KG, Rastatt, Germany). This requires surgical dissection of the inguinal and/or cervical anatomical regions.

In March 2013 we began trials of a new vascular access, avoiding the inguinal incision approach and using ultrasound-guided punctures. Our study concerns eight MPMCTA cases performed between March and July 2013 using this interventional vascular approach. We aimed to assess the feasibility of sheath insertion instead of surgical cannula insertion for MPMCTA.

Methods and materials

Materials

The protocol was carried out on eight corpses in the medico-legal unit of our center. Circumstances of death are shown in the Table n°1. Medico-legal autopsy was ordered by the public prosecutor in charge of investigation for seven cases (cases 1 to 4 and 6 to 8). A scientific autopsy was performed for case 5.

Methods

The procedure was the same in all cases.

The first step was vascular puncture under ultrasound guidance. Sheaths with a diameter of 14 French (Check-Flo Performer® Introducer, Cook Medical, Bloomington, Indiana, USA) were inserted in both arterial and venous vessels. We first attempted to introduce sheaths in femoral vessels (Fig. 1). If this was difficult, we used the jugular vein or the carotid artery. This step was performed by a radiologist experienced in this technique. There was always very little bleeding from these access sites and it was difficult to collect peripheral venous blood. For this reason, blind subclavian venous puncture was performed each time.

The second step consisted of conventional MPMCTA, as described by Grabherr et al. [5, 6]. Each sheath (arterial and venous) was connected to the corresponding tubule of a Virtangio™ machine (Fumedica AG, Muri, Switzerland). The contrast agent (Angiofil®) injections were performed with the same pressure data as with conventional cannulas [4].
The examinations were performed with a 16-detector CT scanner (Sensation 16, Siemens, Erlangen, Germany).

Cases in which a lower limbs examination were executed (cases N°3, 6, 7 and 8), lower limbs vascular opacification has been also studied.

The results were studied by two radiologists (FZM and FD), then submitted to forensic experts before carrying out autopsy.

Radiology reports precised the different lesions found using MPMCTA, but they also studied the injection quality for all the cases.

Quality injection was considered as optimal when all vascular compartments (arterial and venous) were filled with the contrast agent.

Images for this section:

Fig. 1: Case 1. Left femoral venous and right femoral arterial accesses
Results

Vascular opacification was optimal in all eight cases and was comparable to that obtained with conventional cannulas (Table 1).

<table>
<thead>
<tr>
<th>Case</th>
<th>Death circumstances</th>
<th>Type of investigation</th>
<th>Arterial cannula</th>
<th>Venous cannula</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Location</td>
<td>Opacification quality</td>
</tr>
<tr>
<td>1</td>
<td>81 M Gunshot suicide</td>
<td>Forensic</td>
<td>Left femoral</td>
<td>good</td>
</tr>
<tr>
<td>2</td>
<td>30 M Undetermined sudden death</td>
<td>Forensic</td>
<td>Right femoral</td>
<td>good</td>
</tr>
<tr>
<td>3</td>
<td>73 M Fall</td>
<td>Forensic</td>
<td>Right femoral</td>
<td>good</td>
</tr>
<tr>
<td>4</td>
<td>62 M Fall</td>
<td>Forensic</td>
<td>Left carotid</td>
<td>good</td>
</tr>
<tr>
<td>5</td>
<td>27 M Death in ICU</td>
<td>scientific</td>
<td>Left carotid</td>
<td>good</td>
</tr>
<tr>
<td>6</td>
<td>28 F suicide</td>
<td>Forensic</td>
<td>Right femoral</td>
<td>good</td>
</tr>
<tr>
<td>7</td>
<td>M Arme blanche</td>
<td>Forensic</td>
<td>Right carotid</td>
<td>good</td>
</tr>
<tr>
<td>8</td>
<td>M Fall</td>
<td>Forensic</td>
<td>Right femoral</td>
<td>good</td>
</tr>
</tbody>
</table>

Table 1: Summary of eight cases using ultra-sound guided sheath insertion for vascular access in multi-phase post-mortem computed tomography angiography

Abbreviations: M male, F female, yr years, ICU intensive care unit

References: Service de radiologie, CHU rangueil - Toulouse/FR Injection quality was good for the three vascular phases: arterial, venous and dynamic (Figures 6, 7 and
8) The venous and arterial vessels of all body regions (head, thorax and abdomen) were optimally filled (figures from 2 to 8).

**Fig. 7:** Case 4. Coronal maximum intensity projection (MIP) reconstruction of the arterial phase (4a) and venous phase (4b). 4a (left): good arterial opacification, with complete visualization of the aorta (black star). 4b (right): good venous opacification, with visualization of the superior (black dotted star) and inferior cava veins (white star), associated to opacification of right atrium (black full star). Hepatic vessels are also seen with the middle hepatic vein (black arrow).

**References:** Service de radiologie, CHU rangueil - Toulouse/FR

Vascular opacification was optimal. The coronary arteries were optimally opacified in all eight cases. Contrast extravasations were identified at multiple sites: disc space due to vertebral fracture (case 3), intraperitoneal space due to multiple hepatic and splenic fractures (case 4), and peri-cerebral space due to multiple skull bone fractures (case 1).

We also obtained good vascular opacification of the lower limbs ipsilateral to the sheath insertion site. This important point is in contradiction with results obtained using surgical cannulas. Surgical cannulas in fact always cause obstruction in the ipsilateral limb (Fig. 9a, b).

These findings were all confirmed at autopsy.
The main finding was the feasibility of sheath insertion for the purpose of MPMCTA. We were able to replace the surgical cannulas by the radiological sheaths in all eight cases. We obtained good vascular opacification, and interpretation of the lesions was optimal in all cases. Although this micro-invasive approach has already been used in post-mortem CT angiography, the sheaths used were of lesser diameter and were introduced only in arterial vessels [7].

We observed some limitations. Firstly, operators require experience in interventional vascular techniques. Only trained radiologists can perform this ultra-sound guided approach, and even so, we had difficulty obtaining vascular access in two cases. Secondly, the sheaths are costly. Finally, we experienced some pressure problems with sheaths used more than once.

However, several advantages were enhanced. This change of technique allowed a micro-invasive approach instead of the mini-invasive approach when surgical cannulas are used [8]. This is a major advantage as femoral or cervical incisions are avoided and the body remains intact. An additional positive feature was the opacification of the lower limb in which the sheath was inserted. With the conventional MPMCTA procedure, the cannula causes vascular obstruction that makes opacification impossible. This can be a major drawback especially in cases of multiple trauma (Fig. 9). Furthermore, this micro-invasive technique presents the same advantages as conventional MPMCTA, as the same machine presets, such as volume and pressure, are maintained.

Images for this section:
**Fig. 2:** case 7. Coronal thick maximum intensity projection (MIP) reconstruction of the cephalic extremity. Arterial brain vascularization is correctly seen: anterior cerebral arteries (white arrow), middle cerebral arteries (black arrows) and basilar artery (black star).
**Fig. 3:** case 7. axial thick maximum intensity projection (MIP) reconstruction of the cephalic extremity at the dynamic phase. Arterial brain vascularization is correctly seen (black stars), as well as venous one (black arrow and arrowhead).
Fig. 4: case 7. Sagittal thick maximum intensity projection (MIP) reconstruction of the cephalic extremity at the dynamic phase. Arterial brain vascularization is correctly seen: arteries seen are anterior cerebral arteries corresponding to the anterior part of Willis polygon (black star). Veins are also seen: torcula (black arrowhead) and superior sagittal sinus (black arrow).
**Fig. 5:** case 2. Axial thick maximum intensity projection (MIP) reconstruction of the thorax at the dynamic phase. Left heart structures are opacified: left ventricle (black dotted star) and descending aorta (black arrow), but also right heart structures: right atrium (black star) and pulmonary arteries (white dotted circle).
**Fig. 6:** Case 2. Coronal maximum intensity projection (MIP) reconstruction of the arterial phase (2a) and venous phase (2b). 2a (left): good arterial opacification, with aortic visualization of the aorta and opacification of the small arteries. 2b (right): good venous opacification, with visualization of the superior and inferior cava veins, and opacification of veins of the small organs.
**Fig. 8:** Case 4. Coronal maximum intensity projection (MIP) reconstruction of the dynamic phase. Radiological cannulas are seen: arterial cannula in the right femoral site (black arrow) and venous cannula in the left femoral site (black dotted arrow). Vascular under diaphragmatic structures are optimally opacified: aorta (black dotted star) and inferior veina cava (black star).

**Fig. 9:** Case 3. Sagittal oblique reconstructions in MIP mode (9a, right) and volume rendering technique (VRT) mode (9b, left). Visualization of the arterial sheath (white arrows), inserted into the right femoral artery. Good opacification of the ipsilateral femoral and popliteal artery (white dotted arrows).
Conclusion

Use of MPMCTA is now common, and it could be further extended by introducing the interventional radiological approach for cannula insertion. Image quality was as good as that obtained using conventional surgical cannulas. Thanks to this change in technique, the approach was micro-invasive rather than mini-invasive. This could well make the procedure more acceptable to families. Also, lower limb opacification was optimal, especially of the limb ipsilateral to the puncture site. This indication could be extended to child cadavers after specific experimentation on animal models in order to adapt the various parameters of protocol implementation, such as volume and pressure.

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