Diagnostic and Interventional Imaging (2016) **97**, 657—665

ORIGINAL ARTICLE /*Legal medicine*

Multiphase whole-body CT angiography before multiorgan retrieval in clinically brain dead patients: Role and influence on clinical practice

A. Tache[a], **N. Badet**[a], **A. Azizi**[a], **J. Behr**[a], **S. Verdy**[b], **E. Delabrousse**[a,*]

[a] *Service de radiologie viscérale, hôpital Jean-Minjoz, CHRU de Besançon, 3, boulevard Fleming, 25030 Besançon, France*
[b] *Service de coordination hospitalière des prélèvements et des tissus, hôpital Jean-Minjoz, CHRU de Besançon, 3, boulevard Fleming, 25030 Besançon, France*

KEYWORDS
Multiorgan harvesting;
Brain death;
Multiphase whole-body CT angiography

Abstract
Goals: To evaluate the contribution of multiphase whole-body CT angiography (CTA) for identifying the contra-indications to multiorgan retrieval (MOR) and improving the preoperative organ harvesting strategy.
Patients and methods: One hundred and eleven consecutive patients who were clinically brain dead underwent multiphase whole-body CTA to confirm the diagnosis of brain death and for assessment of MOR. The CTA protocol included volumetric acquisitions of the brain and abdominopelvic cavity without IV administration of iodinated contrast material, then images of the thorax-abdomen-pelvis 25 s after IV contrast administration, of the brain at 60 s and finally an abdominopelvic CT acquisition at 90 s. The diagnosis of brain death was based on well-established criteria. The assessment of thorax, abdomen and pelvis was based on a systematic checklist. Post-processing imaging techniques were used in all patients.
Results: No organs were retrieved from 21 patients due to patient refusal (19%). Twenty-two potential MOR were denied because of general contra-indications including 12/22 (54%) based on CTA criteria alone. Finally, 68 patients were eligible for MOR and 160 organs were harvested. The exclusion of specific organs was based on CTA alone for 2/16 livers, 4/70 kidneys and 5/55 lungs. Fifty hearts and 58 pancreases were not harvested, none based on CTA results alone. Hepatic abnormalities and vascular anatomical variants were identified in 10% of patients. At least one renal artery variant was found in 28% of patients, 13% presented with a double renal vein and 8% with a hepato-mesenteric artery.

* Corresponding author.
E-mail address: edelabrousse@chu-besancon.fr (E. Delabrousse).

http://dx.doi.org/10.1016/j.diii.2015.06.024

Conclusion: Multiphase whole-body CTA for MOR is based on the simultaneous association of cerebral CTA to determine brain death with CTA of the thorax, abdomen and pelvis. This rapid, standardized and easily accessible procedure has no harmful effects on harvested kidneys. It makes it possible to select the donors and the organs to be harvested and allows the retrieving surgeon to identify and anticipate technical difficulties.

Because of legal obligations, the source of grafts in France is mainly based on patients who are brain dead [1]. For many years the diagnosis of brain death (BD) was based on clinical criteria and either an associated conventional cerebral angiography or two electroencephalograms (EEG) [2]. In 2003, following a French study showing that cerebral computed tomography angiography (CTA) for the diagnosis of BD was as effective as conventional cerebral angiography, a conference of experts including the French Society of Intensive Care Specialists (*Société française de réanimation de langue française*), the French Society of Anesthesiology and Intensive Care (*Société française d'anesthésie et de réanimation*) and the French Biomedical Agency (*Agence de biomédecine*) decided to modify its practices by recommending the use of cerebral CTA as a complementary examination to confirm BD, then in 2005 it recommended performing CTA of the thorax, abdomen and pelvis (TAP) during the same session as the assessment for BD to evaluate the organs for potential multiorgan retrieval (MOR) [3,4]. Although in a few years, and based on these recommendations, cerebral CTA has become the reference diagnostic examination for BD [5,6], whole-body CTA does not seem to be as extensively used. Thus, the first study on this topic was only published in 2010 by Frégeville et al. [7] based on a small series of 27 brain dead patients who were potential donors and underwent whole-body CTA. In this study, two abnormalities that were discovered incidentally during whole-body CTA finally resulted in a contra-indication to MOR for the two patients in question. In the same study, vascular anatomical variants were identified, resulting in a change in the surgical procedure for organ harvesting [7].

The goal of this study was to evaluate the contribution of multiphase whole-body CTA in a single-center series of 111 consecutive patients for the diagnosis of BD and in identifying contra-indication to MOR during an evaluation for MOR as well as its influence on clinical practice, in particular in improving preoperatively organ retrieval strategy.

Patients and methods

From January 2010 to January 2014, 111 consecutive patients (57 men and 54 women) with a mean age of 55 years (range: 6—85 years) who were diagnosed with clinical BD in the intensive care unit were included in this retrospective study. Criteria for the clinical diagnosis of BD were uniformly well-admitted criteria. They included lack of motor activity, abolition of brain stem reflexes, and no spontaneous breathing. All of the included patients underwent exploratory multiphase whole-body CTA both for the paraclinical diagnosis of BD and assessment for MOR. TAP CTA was performed during the same session as the diagnosis of BD in 98/111 patients (88%).

Imaging technique

Cerebral CTA for the diagnosis of BD was performed according to the French Neuroradiological Society (*Société française de neuroradiologie*) guidelines [5,8], or at least 6 hours after the clinical diagnosis of BD, after confirming satisfactory hemodynamic stability (PAM MAP > 65 mmHg, CVP = 6—8 mmHg, diuresis $\geq$ 100 ml/h), using a large peripheral venous catheter for intravenous administration of 2 ml/kg of iodinated contrast material (Iomeron 400, Bracco, Milan, Italy) at a flow rate of 3 ml/s. Well-established criteria were used to determine cerebral vascular lack of opacification score for each patient [5,6]. All CTA were performed with a 64-section multidetector system (Brilliance 64, Philips, the Netherlands and Somatom Definition AS 64, Siemens Healthcare, Germany).

Our multiphase whole-body CTA protocol (Table 1) included a non-enhanced volumetric CTA of the brain, abdominal and pelvis, then volumetric CTA of the TAP, brain and abdomen and pelvis 25 s, 60 s and 90 s respectively following intravenous administration of iodinated contrast material.

The goal of unenhanced images of the abdomen and pelvis was to detect stones, vascular calcifications and to measure spontaneous attenuation values of organs. Arterial phase TAP acquisition (25 s) allowed analysis of the arterial vessels and depiction, if any, of anatomical variants, to identify hyperarterialized lesions and presence of active bleeding resulting in extravasation of iodinated contrast material. Late portal phase acquisition (90 s) provided optimal visualization of the digestive tract and solid organs as well as venous vascularization and its variants. Finally, delayed-phase abdominopelvic acquisitions were obtained depending on the results of the images during the previous phases.

For efficacy but especially to avoid having to move the patient twice and to perform a second intravenous injection of iodinated contrast material, exploratory TAP CTA was performed during the same session as the diagnosis of BD.