Diagnostic and Interventional Imaging (2016) **97**, 331—335

ELSEVIER MASSON

ORIGINAL ARTICLE / *Neuroradiology*

Usefulness of multidetector-row computerized tomographic angiography for the surgical planning in stereoelectroencephalography

V. Gilard [a,*], **F. Proust** [b], **E. Gerardin** [c], **A. Lebas** [d], **N. Chastan** [d], **P. Fréger** [a], **D. Parain** [d], **S. Derrey** [a]

[a] *Department of Neurosurgery, Rouen University Hospital, hôpital Charles-Nicolle, 1, rue de Germont, 76000 Rouen, France*
[b] *Department of Neurosurgery, Strasbourg University Hospital, Strasbourg, France*
[c] *Department of Radiology, Rouen University Hospital, Charles-Nicolle Hospital, 1, rue de Germont, Rouen, France*
[d] *Department of Physiology, Rouen University Hospital, Charles-Nicolle Hospital, 1, rue de Germont, Rouen, France*

KEYWORDS
Stereoelectroencephalography;
Epilepsy;
Multidetector-row computerized tomographic angiography;
Surgical planning

Abstract
Purpose: Surgical planning of depth electrode implantation in stereo-electro-encephalography (SEEG) routinely uses magnetic resonance imaging (MRI) alone. Accurate visualization of arteries and veins in the vicinity of the electrode is essential to plan a safe trajectory to presumably reduce the risk of intracranial bleeding. The goal of this study was to compare multidetector row computerized tomographic angiography (MDCTA) with MRI for the visualization of vessels along each planned trajectory in patients who undergo SEEG.
Materials and methods: Ten consecutive patients who were scheduled to undergo SEEG procedure were included. T1-weighted gadolinium-chelate enhanced MR sequence, stereotactic MDCT and MDCTA were performed after fixation of Leksell's frame. For each of the 106 planned stereotactic trajectories, the number of vessels in a 4.0 mm diameter circle around the trajectory from the dura mater to the target that were visible on MDCTA were compared to that of visible vessels in the same areas on MRI.
Results: Ten vessels (10/106; 9.4%) were seen on MRI and 66 (66/106; 62.3%) on MDCTA ($P < 0.0001$). All vessels visible on MRI were visible on MDCTA. The difference in number of visible vessels between the two techniques remained significant for the different lobes (i.e., frontal lobe, temporal lobe and parieto-occipital lobe).

* Corresponding author.
E-mail address: vianney.gilard@chu-rouen.fr (V. Gilard).

http://dx.doi.org/10.1016/j.diii.2015.10.001

Conclusion: MDCTA enabled visualization of more vessels than MRI based SEEG. MDCTA may help neurosurgeons better define the trajectory of the electrode and reduce the risk of intracranial bleeding.

The use of subdural grids or stereoelectroencephalography (SEEG) procedure is still required to localize causative areas in patients with intractable epilepsy. These procedures are indicated solely when non-invasive techniques have failed to identify epileptic circuits with the aim of proposing cortectomy as a reasonable therapeutic option. To verify this hypothesis, the accurate implantation of depth electrodes within cortical targets is needed. Thus, the definition of each target is crucial but the determination of the best trajectory also needs careful analysis. Procedural morbidity is mainly dominated by intracranial bleeding. The prevalence of the latter was reported between 0.5 and 4.2% [1—5] and global mortality ranged from 0% [6—8] to 1.4% [2]. Telemetric two-dimensional stereoscopic angiography (TDSA) remains the gold standard [9] for vessel visualization, but magnetic resonance imaging (MRI) is being used increasingly. To reduce the risk of intracranial bleeding, we added multidetector row computerized tomographic angiography (MDCTA) to MRI sequence.

The goal of this study was to compare MDCTA and MRI for the vizualisation of vessels along each planned trajectory in patients who have SEEG.

Patients and methods

Population

Ten consecutive patients who were referred to the neurosurgery department of our tertiary care center for intractable epilepsy were included in the study. They were three men and seven women with a mean age of 19.6 years ± 7.8 (standard deviation [SD]) (range: 7—31 years). Prior to SEEG, the case of each patient was discussed in a national meeting convening several other French centers all experts in epileptic surgery. Information on the goal and risk of SEEG procedure was given to family members and caregivers with special focus on the possible occurrence of intracranial hematoma. Informed patient consent was sought and obtained. SEEG procedures aimed to investigate mesial temporal ($n = 5$), frontal ($n = 4$) and parieto-occipital ($n = 1$) epilepsies. Exploration was unilateral in five patients (right hemisphere $n = 3$; left hemisphere $n = 2$) and bilateral in the other five patients.

Technique of SEEG electrode implantation

Under general anesthesia and after placement of a Leksell frame, patients had MRI examination of the brain using three-dimensional (3D) T1-weighted gadolinium-chelate (Gadoteric acid; Dotarem®, Laboratoire Guerbet, Roissy-Charles de Gaulle, France) enhanced sequence (Magneton Symphony 1.5 Tesla, Siemens, Erlangen, Germany), stereotactic MDCT and MDCTA (LightSpeed 16, General Electric Healthcare, Milwaukee, WI, USA). MR images were acquired in the transverse plane (matrix size, 256 × 25; FOV, 256 × 256 mm; section thickness, 1 mm; spatial resolution, 1 × 1 × 1 mm^3). MDCTA was acquired in the transverse plane with: 512 × 512 matrix, FOV 270 × 270 mm, section thickness of 0.625 mm and 0.4-mm reconstruction interval. The injection rate was 3.5 mL/s. Fifty mL of iodinated contrast material (Xenetix 350®, Laboratoire Guerbet) was pulsed by 50 mL of saline. The start of MDCTA acquisition was made using the bolus tracking technique with a region of interest placed on the aortic arch. Volumes of interest were displayed on both arterial and venous opacification. The data were loaded in the stereotactic planning software (Framelink^R 5.0, Stealth-Station^R, Medtronic, MN). For each electrode, using MRI and MDCTA data, a trajectory (orthogonal or double obliquity) was planned avoiding sulci and cortical vessels. The rest of the procedure has been previously described [10,11].

Comparison of MRI and MDCTA data for vessel vizualization

To compare the number of vessels observed with MRI and those with MDCTA, a 4.0 mm diameter circle was built around the trajectory with Framelink^R 5.0 (Fig. 1). Then, from the dura-mater entry point to the target, the number of vessels found within this 4.0 diameter circle was counted. For the 106 trajectories planned, the count was successively performed on MRI and MDCTA datasets by two observers. Vessels were localized throughout the predefined 4-mm diameter acquired volume by increments of 1 mm, using cortical sulci as surface markers on stereotactic planning software (Framelink^R 5.0, Stealth-Station^R, Medtronic, MN) using specific windowing for MRI and MDCTA.

Determination of target accuracy

For each target, the authors calculated the 3D-euclidian distance error that exists between the expected and the actual target. With the stereotactic coordinates, this distance was calculated by the formula: $\sqrt{((x_e - x_r)^2 + (y_e - y_r)^2 + (z_e - z_r)^2)}$ with x_e, y_e and z_e for