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Original Article

MRI quantitative T2* mapping on thrombus to predict recanalization after endovascular treatment for acute anterior ischemic stroke

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ABSTRACT

Background. – In anterior acute ischemic stroke (AAIS) treated with endovascular treatment (EVT), the susceptibility vessel sign (SVS+ or SVS−) is related to recanalization results (TICI 2b/3) and clinical outcome. However, a binary qualitative assessment of thrombus using SVS does not reflect its complex composition. Our aim was to assess whether a quantitative MRI marker, Thrombus-T2* relaxation time, may be assessable in clinical routine and may to predict early successful recanalization after EVT, defined as a TICI 2b/3 recanalization obtained in 2 attempts or less.
Material and methods. – Thrombus-T2* relaxation time was prospectively obtained from consecutive AAIS patients treated by EVT (concomitant aspiration and stent retriever). Quantitative values were compared between early recanalization and late or unsuccessful recanalization.
Results. – Thirty patients with AAIS were included and Thrombus-T2* relaxation time was obtained in all patients. Earlier TICI 2b/3 recanalization were obtained in 22 patients (73%) and was significantly associated with SVS+ (1/8 vs. 16/22, $P=0.01$) and a shorter Thombus-T2* relaxation time (mean SD, range: 257, 18–50 ms vs. 45 9, 35–60 ms, $P<0.001$).
Conclusion. – A new quantitative MRI biomarker, the Thrombus-T2* relaxation time is assessable in clinical routine. In a preliminary study of 30 patients, a shorter Thombus-T2* relaxation time is related to earlier recanalization after EVT using combination of stent retriever and aspiration.

Introduction

Large randomized control trials have shown benefits of endovascular thrombectomy (EVT) associated with IV tPa compared to IV tPa alone in acute anterior ischemic stroke (AAIS) [1]. Nevertheless, EVT fails to reopen the occluded artery in almost 30% of cases [1]. Thrombus composition may be a key factor to address in order to decrease the recanalization failure rate [2–5].

The susceptibility vessel sign (SVS) on MRI GRE sequence is related to the thrombus composition and appears in red blood cell predominant thrombi [6,7]. Retrospective and monocentric studies have shown that the qualitative evaluation of the SVS could help predict recanalization and functional outcome after EVT [8–12]. However, this binary assessment of thrombus composition (either SVS+ or SVS−) may not reflect the more complex nature of thrombi [2,13,14]. Moreover, SVS+ defined as the presence of a hypo-intense signal exceeding the diameter of the artery in GRE sequence can be difficult to determine in clinical practice, since some thrombi may show a hypo-intense signal with a diameter equal or slightly above the contralateral artery contours [6].

Abbreviations: AAIS, acute anterior ischemic stroke; EVT, endovascular treatment; SVS, susceptibility vessel sign; ICA, internal carotid artery; MCA, middle cerebral artery; Thrombus-T2* RT, mean T2* MRI relaxation time.

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T2* maps are commonly used to assess the cardiac and liver iron load in thalassemic patients [15,16]. Measuring Thrombus-T2* value might provide more quantitative insight into thrombus composition than simple qualitative evaluation using SVS. In AAIS, it has been shown that after two EVT attempts using stent retrievers, the likelihood of successful recanalization [17,18] and favorable outcome [18–20] significantly decreases.

Our aim was to assess whether measurement of Thrombus-T2* RT within the thrombus may help predict early (in 2 or less attempts) TICI 2b/3 recanalization.

Materials and methods

A single-center, retrospective, analysis of consecutive patients was performed according to the protocol of stroke treatment at our center. In accordance with the French legislation, Institutional or Ethics Committee approval was not required for this study because it only utilized anonymized data collected as part of routine clinical care.

Patients

Consecutive patients treated by EVT between June 2015 and July 2016 for AAIS in our center were included. To ensure a reliable analysis of the clot interaction with thrombectomy devices, we excluded patients for whom distal access to the intracranial vasculature with the intermediate aspiration catheter was unsuccessful. For each patient, age, baseline NIHSS, time between onset and groin puncture and the administration of IV tPA before EVT was recorded.

MR imaging protocol

MR imaging was performed on a 1.5 T magnet (Magnetom Aera; Siemens, Erlangen, Germany) with a phased array head coil. Our Stroke imaging protocol included at least a GRE imaging (TR, 966 ms; TE, 30 ms; section thickness, 5 mm; intersection gap, 0 mm; FOV, 200 × 250 mm; flip angle, 20°, 2.50 min) and a T2* quantification sequence (TR, 700 ms; 16 different TE: 2.78; 5.11; 7.44; 9.77; 12.1; 14.43; 16.76; 19.09; 21.42; 23.75; 26.08; 28.41; 30.74; 35.4; 37.73 ms; section thickness, 5 mm; intersection gap, 0.5 mm; FOV, 244 × 300 mm; flip angle, 20°, 2.33 min). DWI, FLAIR and TOF MRA of the circle of Willis sequences were systematically performed.

Proximal occlusion was defined as an occlusion on TOF of the M1 segment of the middle cerebral artery or of the internal carotid artery.

*Mean T2*relaxation time (Thrombus-T2* RT) measurements and SVS classification*

The measurements of Thrombus-T2* RT of the clot were performed with a window ranging from 10 to 100 ms on the PACS Carestream (Thalium window). The region of interest was manually contoured inside the clot determined after coregistration with the other sequences available (TOF, Flair, GRE) to localize the occlusion. On GRE sequence, the SVS was classified as present (SVS+) or absent (SVS−) according strictly to the definition of Rovira et al. [6]. All MR images were analyzed blindly by a junior radiologist (N.B.) and an experienced neuroradiologist (R.B.), and discordance were solved by consensus, with two other experienced radiologists (J.M.S. and H.D.).

Endovascular treatment

All endovascular procedures were performed on a biplane system (IntegrisAllura 20/20; Philips Healthcare, Best, the Netherlands) by experienced interventional neuroradiologists that have each performed more than one hundred procedure of EVT for AAIS (HD, RB, BDD). All three operators strictly performed the procedure in the same manner during the inclusion period.

An 8F Envoy (Codman & Shurtleff, Raynham, Massachusetts) guiding catheter was introduced through a femoral sheath into the concerned carotid artery. Then a 5F or 6F intermediate aspiration catheter (Penumbra Inc., Alameda, CA, or Micro-Vention, Tustin, California) was introduced into the guiding catheter. Navigation into the target vessel was made with a 0.014-inch microguidewire (Traxcess; Micro-Vention, Tustin, California) and a 0.021-inch microcatheter (Rebar; Covidien, Irvine, California). The microguidewire was exchanged with the stent-retriever device. Once the device was deployed, angiography was performed to evaluate its correct placement and expansion. The device was left in place for 2–7 minutes. During the retrieval, the fully deployed device together with the micro catheter were gently pulled back as a single unit and recovered. Before and during this retrieval, aspiration was performed through the hemostatic valve of the intermediate aspiration catheter placed at the contact of the clot. Results were assessed according to the TICI grading scale with successful recanalization defined as TICI 2b/3 [21]. The procedure was repeated for a maximum of 6 attempts until a TICI score of 2b or 3 was obtained. After the sixth attempt, if a TICI score of 2b/3 was not achieved, EVT was stopped. Early successful recanalization was defined as a TICI 2b/3 obtained with 2 or less attempts with the stent-retriever. An experienced neuroradiologist blindly reviewed the final angiographs to determine TICI scores and the number of attempts.

Statistical analysis

Descriptive analysis was used. Qualitative variables were presented with count and percentage (%) and quantitative variables with mean or median, standard deviation (SD), range and interquartile (IQR) range. Correlations between quantitative variables were analyzed with Spearman correlations. Mann Whitney tests were used to compare quantitative variables between groups. Significance level was fixed to 5%. Statistical analysis was performed with IBM SPSS (version 19.0) statistical software.

Results

Baseline characteristics

Thirty-five consecutive patients were admitted between June 2015 and June 2016 for AAIS that underwent an MRI with Thrombus-T2* RT measurement before EVT. Five patients were excluded because of failure to reach optimal positioning in the intracranial vasculature with the intermediate aspiration catheter (or into the cervical carotid artery with the guiding catheter). Excluded patients did not differ from the study population according to baseline demographic criteria (data not shown).

Thirty patients (mean age ± SD, range: 70 ± 16, 23–89) with a median baseline NIHSS of 16 (2–27) and a mean time between onset to groin puncture of 198 min (60–349, SD: 74) were included.

Twenty-five thrombi were located in the first segment of the middle cerebral artery and 5 at the T-terminus of the internal carotid artery. Bridging (i.e. intravenous recombinant tissue plasminogen activator injection plus EVT) was performed in 17 patients (57%), whereas EVT alone was performed in 13 patients (43%).

Among 30 thrombi, 13 were classified SVS−, and 17 SVS+ (Fig. 1). The mean ± SD (range) Thrombus-T2* RT was 30 ± 11 ms (18–60). For the SVS+ group, the mean Thrombus-T2* RT was 24 ± 5 ms (18–40), and 38 ± 12 ms (22–60) for the SVS− group (Fig. 2).