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Original Article

Can a 15-sec FLAIR replace conventional FLAIR sequence in stroke MR protocols?

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ABSTRACT

Background and purpose. – Triage imaging facilitates the timely recognition of acute stroke with prognostic implications. Improvement in MR acquisition speed is needed given the extreme time constraints before treatment. We compared an ultrafast Echo-Planar FLAIR sequence (EPI-FLAIR) and a conventional FLAIR sequence (cFLAIR) for their diagnostic performances and ability to estimate the age of infarction.
Material and methods. – Between June and August 2014, 125 consecutive patients (age 69 ± 18 years, 48% men) admitted for a suspicion of acute (≤ 48-hrs) stroke were explored by both FLAIR sequences at 1.5-Tesla. EPI-FLAIR (15-sec) and cFLAIR (2-min and 15-sec) were compared by two readers, blinded to clinical data.
Results. – EPI-FLAIR was less prone to kinetic artefacts than cFLAIR (2–3% vs. 23–49% depending on the reader, $P < 0.001$). Diagnostic concordance was excellent for both readers ($\kappa > 0.9$). Amongst 8 hemorrhages, one subarachnoid hemorrhage presenting as a sudden deficit was missed on EPI-FLAIR sequence. Amongst 60 infarctions, cFLAIR and EPI-FLAIR were concordant in 50 (83%), while signal changes were visible on cFLAIR only in the remaining 10 (17%) cases. Amongst the 43 patients with known onset time ($n = 17$ within 4.5 hrs), FLAIR-DWI mismatch identified < 4.5-hrs infarction with the same sensitivity (65%) using cFLAIR and EPI-FLAIR, but the positive predictive value (PPV) was higher for cFLAIR than for EPI-FLAIR (73% vs. 50%, $P = 0.008$).
Conclusion. – EPI-FLAIR allows a drastic reduction of acquisition time devoted to FLAIR sequence and minimizes motion artifacts. Compared with cFLAIR, it is however associated with increased risk of undiagnosed stroke mimics and lower PPV for identifying < 4.5-hrs infarctions.

Introduction

Brain magnetic resonance imaging (MRI) can distinguish between acute ischemic stroke (AIS) and stroke mimics [1] and estimate stroke onset time [2]. Most stroke MR protocols include a fluid-attenuated inversion recovery (FLAIR) sequence. FLAIR is used to rule out stroke mimics or hemorrhages, including subarachnoid hemorrhages [3] that may occasionally present as stroke mimics. It is also used to evaluate the extent of white matter hyperintensities (WMH) and estimate the age of infarction [2] in patients with unknown onset time.

In routine practice, using acute stroke MR protocols is hindered by the time constraint of treatment decision [4], the limited availability of MR units with busy schedules and the duration of MR acquisition in restless, unstable, or uncooperative patients [5]. Ultrafast MR protocols have been proposed as a first-line

Abbreviations: AIS, acute ischemic stroke; cFLAIR, conventional FLAIR; CT, computerized tomography; DWI, diffusion-weighted imaging; EPI, echo-planar imaging; FLAIR, Fluid-Attenuated Inversion Recovery; IQR, interquartile range; MRI, magnetic resonance imaging; NIHSS, National Institute of Health Stroke Score; TIA, transient ischemic attack; WMH, white matter hyperintensities.

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screening tool before treatment decision [6–8], with scan duration that compete with that of advanced computed-tomography (CT) including CT angiography and CT perfusion. Acquisition time can be shortened with parallel imaging [6] or echo-planar imaging (EPI) techniques. In 52 AIS patients, one study showed that a 52-sec EPI-FLAIR yielded comparable qualitative and quantitative results to a 3-min conventional FLAIR (cFLAIR) [9]. However, there is paucity of data on the ability of the ultrafast FLAIR to detect stroke mimics. Accordingly, we hereby evaluate the diagnostic performances of an ultrafast EPI-FLAIR sequence (15 sec) in patients referred for a suspicion of acute stroke, focusing on the ability to distinguish between AIS and stroke mimics and to estimate the age of infarction.

Material and methods

Patient selection

For a 3-month period of time (June–August 2014), an EPI-FLAIR sequence was added to our standard stroke 1.5-Tesla MRI protocol (comprising a cFLAIR sequence), used as a first-line stroke diagnostic tool. We retrospectively analyzed 243 MR examinations of all consecutive patients referred to our stroke unit for a suspicion of acute stroke ($\leq$ 48 hrs). We excluded 118 patients who did not have an onsite MRI at admission, did not receive the full 1.5-Tesla MR protocol i.e. at least diffusion-weighted imaging (DWI), T2*, cFLAIR and EPI-FLAIR, or were scanned on 3-Tesla MR unit. After exclusion, we analyzed 125 patients (Fig. 1). This single-center retrospective study was approved by the local institutional review board.

Clinical data

Demographic data (sex, age) and stroke characteristics (National Institute of Health Stroke Score [NIHSS] at admission, stroke onset time) as well as onset-to-MRI time were collected from medical charts. Administration of thrombolytic treatment and final diagnosis at discharge were recorded. Transient ischemic attack (TIA) was defined as transient symptomatology (< 24 hrs) without brain infarction on admission or on a 24-hrs follow-up MRI [10–12].

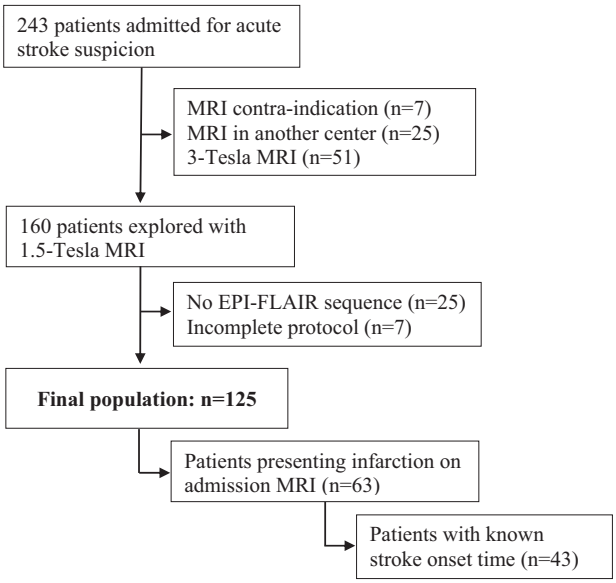

Fig. 1. Flow chart for patient inclusion.

Image acquisition

All MRI were done on a 1.5 T MRI unit (GE Healthcare, Madison, Wis), using a gradient strength of 33 mT/m and an eight-channel head coil. The imaging protocol included DWI, cFLAIR, EPI-FLAIR, T2* and intracranial MR angiography. cFLAIR was acquired in spin-echo mode with the following parameters: 8377/157/2093 (repetition time ms/echo time ms/inversion time ms), 24 × 24 cm field of view, 256 × 192 matrix, one signal acquired, 24 sections, 6-mm slice sections, no gap. EPI-FLAIR images were acquired in echo-planar mode with the following parameters: 10,000/88/2000 (repetition time ms/echo time ms/inversion time ms), 128 × 128 matrix; all other parameters were identical to those of cFLAIR. Acquisition duration was 2-min and 15-sec for cFLAIR, and 15-sec for EPI-FLAIR. Total acquisition time was less than 10 minutes. Patients were scheduled for a 24-hrs MR follow-up for etiological work-up (cervical MR angiography) that also included a DWI sequence focused on the brain.

Image analysis

All MRIs were reviewed by two independent readers (two residents with 1-year and 4-year experience), trained with the Wake-Up Radiology Trainer set [13], and blinded to clinical data. Two reading sessions were scheduled two months apart. For the first reading session, all sequences except for the cFLAIR were available for readers. For the second reading session, all sequences except for the EPI-FLAIR were available for readers. Discordances were solved in a separate session by a senior (20 years of experience) neuroradiologist. A 4-scale imaging score was used to evaluate image quality: 1/poor, not interpretable; 2/impaired with significant artifacts; 3/good with minimal artifacts; 4/excellent. Readers assessed the presence or absence of kinetic artifacts, and quoted the extent of the periventricular WMH of presumed vascular origin according to Fazekas scoring system [14] on cFLAIR and EPI-FLAIR. Readers had to assign each patient to one of the following diagnostic categories: brain infarction, intracranial hemorrhage, stroke mimic or unremarkable MRI. In order to estimate the age of infarction, when present on DWI, each reader determined if the lesion was visible on cFLAIR and/or EPI-FLAIR. Each patient was then classed to the FLAIR-DWI mismatch or non-mismatch group [2,15]. As for the WAKE-UP study [16], patients with WMH in the area corresponding to the acute DWI lesion that prevented the analysis of the FLAIR parenchymal changes were considered as not assessable. In patients with infarction, one of the readers also determined the arterial territory (anterior cerebral artery, middle cerebral artery, posterior cerebral artery, posterior fossa, watershed or multiple territories), side, whether the infarction was extended (> 1/3 of MCA territory or > 1/2 of other territories), and determined if hyperintense vessel sign resulting from slow flows [17] were present on cFLAIR and/or EPI-FLAIR.

Statistical analysis

Values were expressed as means ± standard deviation or median and InterQuartile Range (IQR) as appropriate. A *t*-test was used to compare ages between included and excluded patients. Wilcoxon's test was used to compare NIHSS between included and excluded patients. McNemar's test was used to compare the proportion of kinetic artifacts and FLAIR vascular hyperintensities between the two sequences. A weighted-κ statistic was used to evaluate the inter-sequence (cFLAIR vs. EPI-FLAIR) agreement for WMH. A κ statistic was used to evaluate the inter-reader and inter-sequence agreement for diagnosis. For patients presenting with infarction of known stroke onset time, the performances of EPI-FLAIR and cFLAIR-DWI mismatch for the identification of