GOBrain in Acute Neurological Emergencies: Diagnostic Accuracy and Impact on Patient Management

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Introduction

Even though computed tomography (CT) of the head is the primary imaging modality used in the majority of institutions to rule out intracranial pathologies in acute neurological emergencies, magnetic resonance imaging (MRI) remains the imaging reference standard for the detection and differential diagnosis of intracranial lesions. However, the use of MRI in the acute setting is still limited by long acquisition times for multi-sequence protocols. This drawback may now be overcome by a novel ultra-fast brain MRI protocol, which allows for the acquisition of five standard sequences in just 04:33 min (GOBrain, Siemens Healthcare, Erlangen, Germany, optimized for use in our institution, including sagittal T1-weighted gradient echo (GRE), axial T2-weighted turbo spin echo (TSE), axial T2-weighted TSE fluid-attenuated inversion recovery (FLAIR), axial diffusion-weighted (DWI) single-shot echo-planar imaging (EPI), axial T2*-weighted EPI-GRE). To validate the GOBrain protocol for use in the emergency setting, we hypothesized that

a. image quality and diagnostic performance of GOBrain for the detection of intracranial pathologies are non-inferior to the standard-length brain MRI protocol,
b. GOBrain leads to a change in patient management compared to CT alone.

Sequences		Image Quality						GWM Differentiation			
		Scores						Scores			
		1	2	3	4	5	Median	0	1	2	Median
T1-weighted	Conventional	0	0	1	58	0	4	0	6	53	2
	GOBrain	0	0	0	59	0	4	0	7	52	2
T2-weighted	Conventional	0	0	3	54	2	4	0	34	25	1
	GOBrain	0	0	2	57	0	4	0	39	20	1
FLAIR	Conventional	0	0	2	56	1	4	0	32	27	1
	GOBrain	0	0	1	58	0	4	0	31	28	1
DWI	Conventional	0	0	0	59	0	4	NA	NA	NA	NA
	GOBrain	0	0	0	59	0	4	NA	NA	NA	NA
T2*	Conventional	0	0	6	53	0	4	NA	NA	NA	NA
	GOBrain	0	2	56	1	0	3	NA	NA	NA	NA

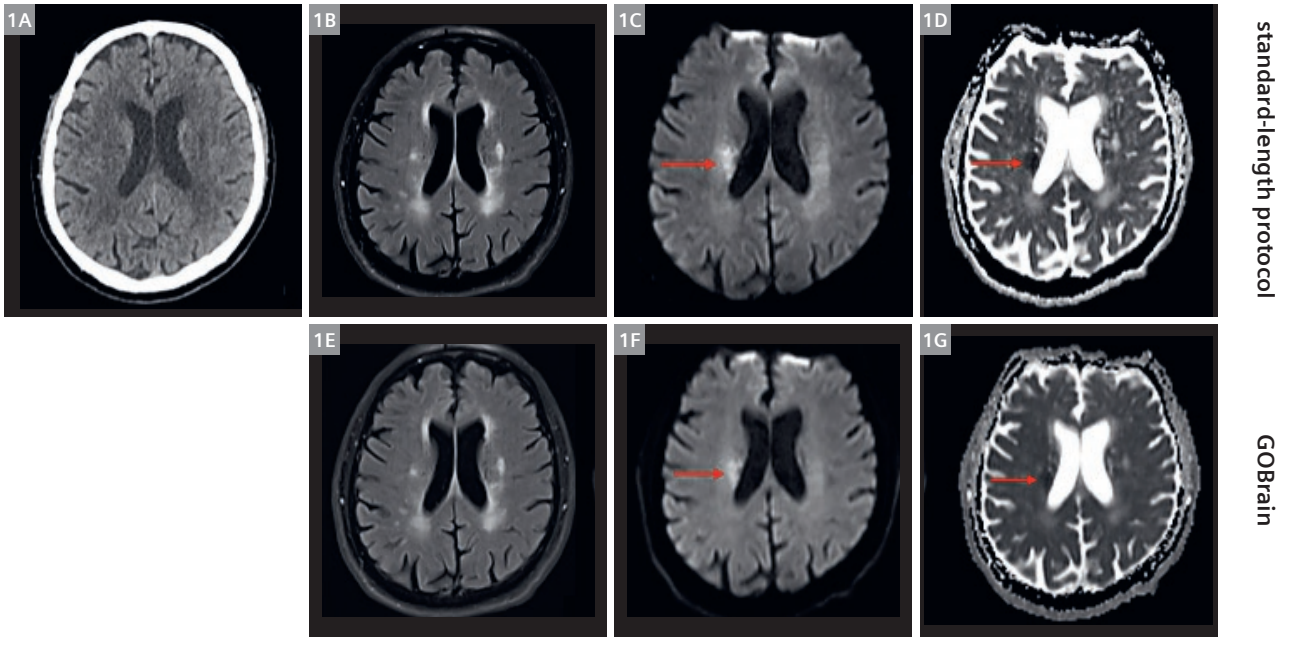
Table 1: Image quality assessments (consensus reading). NA = not applicable; GWM = gray-white matter.

Materials and methods

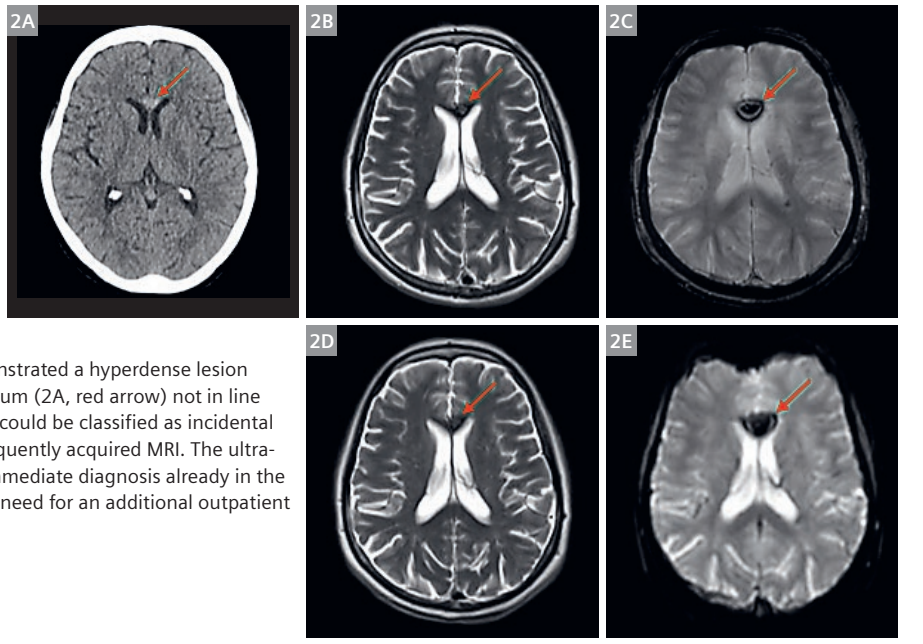
A total of 449 consecutive patients presenting to our emergency department with acute non-traumatic neurological symptoms were evaluated [1]. Of these, 238 patients underwent a head CT scan to exclude an intracranial pathology. In case of a negative head CT scan, patients were included in this prospective single-center trial and were transferred to the 3T MRI suite (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany). A total of 60 patients (30 female, 30 male; mean age 61 years) were successfully included. The MRI examinations were performed using a 20-channel receiver head coil. Two brain MRI protocols (GOBrain and a standard-length protocol serving as reference standard) including the following five non-contrast standard sequences were acquired in randomized order:

1. **Sagittal T1-weighted GRE**
   (GOBrain 00:41 min; standard-length: 01:34 min)
2. **Axial T2-weighted TSE**
   (GOBrain 01:02 min; standard-length: 03:45 min)
3. **Axial T2-weighted TSE FLAIR**
   (GOBrain 01:52 min; standard-length: 04:02 min)
4. **Axial T2*-weighted EPI-GRE**
   (GOBrain 00:06 min; standard-length: 04:44 min)
5. **Axial DWI SS-EPI**
   (GOBrain 00:38 min; standard-length: 01:06 min)

Total acquisition times: GOBrain 04:19 min, standard-length protocol 15:11 min, localizer 00:14 min (same for both protocols). Two blinded board-certified neuroradiologists independently analyzed the image datasets with regard to overall image quality (5-point Likert scale: 1 – non-diagnostic, 2 – substantial artifacts, 3 – satisfactory, 4 – minor artifacts, 5 – no artifacts) and gray-white matter differentiation as a surrogate of image quality (T1-weighted, T2-weighted, and FLAIR images; 0 = no visible gray-white matter differentiation, 1 = unclear but recognizable borders, 2 = clear differentiation) [2]. In case of divergent results, a consensus reading was performed by a third reader. To calculate the parameters of diagnostic accuracy for the GOBrain protocol, image datasets were read regarding six defined intracranial pathology categories: acute ischemia, chronic infarction, intracranial hemorrhage/microbleeds, edema, white matter lesion, and miscellaneous. A consensus reading was performed in case of divergent reading results. Due to severe motion artifacts, one patient was excluded and 59 patients were successfully included in the statistical analysis.



1 **CT-occult acute ischemia (right corona radiata).** Axial non-contrast head CT scan **(1A)**, FLAIR **(1B, E)**, DWI **(1C, F)**, ADC map **(1D, H)** from the standard-length protocol (top row) and GOBrain (bottom row) in a 72-year-old man presenting with acute left facial paralysis, dysarthria, and left-body coordination disorder. No evidence of ischemia or hemorrhage on non-contrast CT. MRI revealed an acute ischemia in the right internal capsule and the corona radiata (red arrow). Note the equivalent image quality and lesion conspicuity of both protocols.



2 Incidental cavernoma (genu of the corpus callosum). Axial non-contrast head CT scan **(2A)**, axial T2 TSE **(2B, D)**, axial T2* **(2C, E)** from the standard-length protocol (top row) and GOBrain (bottom row) of a 62-year-old woman reporting temporary visual disturbance in the right eye. No correlation of the symptoms in both imaging modalities. However, non-contrast CT imaging demonstrated a hyperdense lesion in the genu of the corpus callosum (2A, red arrow) not in line with acute hemorrhage, which could be classified as incidental cavernoma based on the subsequently acquired MRI. The ultra-fast MRI protocol enabled an immediate diagnosis already in the emergency setting without the need for an additional outpatient MRI scan a few days later.

Results

Image quality of the GOBrain protocol was equivalent to the standard-length protocol: Results of image quality and gray-white matter differentiation assessments are listed in Table 1. Compared to CT imaging, 93 additional intracranial lesions were detected using the ultra-fast protocol (n = 21 acute ischemia, n = 27 intracranial hemorrhage/microbleeds, n = 2 edema, n = 38 white matter lesion, n = 3 chronic infarction, n = 2 others) while 101 additional intracranial lesions were detected using the standard-length protocol (n = 24 acute ischemia, n = 32 intracranial hemorrhage/microbleeds, n = 2 edema, n = 38 white matter lesion, n = 3 chronic infarction, n = 2 others). GOBrain demonstrated high diagnostic accuracy in detecting intracranial pathologies, with a sensitivity of 0.939 (95% CI: 0.881; 0.972) and a specificity of 1.000 (95% CI: 0.895; 1.000). Figures 1 and 2 demonstrate representative clinical cases in which GOBrain proved to be equivalent to the standard-length protocol reference standard. A change in patient management based on the MRI was noted in 10% (6/59; admission to a dedicated stroke unit in 6/59 patients, initiation of acetyl-salicylic acid treatment in 3/6 stroke unit patients).

Discussion

In this prospective study, we investigated a novel ultra-fast (04:33 min/5 sequences) brain MRI protocol in the neurological emergency setting. Image quality and diagnostic performance of the GOBrain protocol demonstrated to be non-inferior to a standard-length brain MRI protocol. Furthermore, MRI led to a change in patient management in 10% of cases compared to CT imaging alone. Our data provide evidence for the standard use of the ultra-fast GOBrain protocol as a valid alternative to CT imaging for the detection and differential diagnosis of intracranial pathologies in selected acute neurological emergency patients. The ultra-fast MRI protocol may be individualized by adding sequences, such as dedicated brain stem DWI or constructive interference in steady state (CISS) sequences for optimized diagnosis of infratentorial pathologies, a contrast-enhanced T1-weighted sequence for suspected tumor or neuroinflammatory disease, or MR angiography to exclude vascular pathologies.

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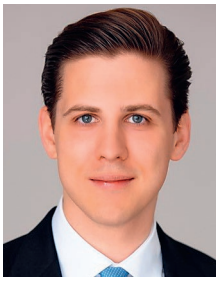

References

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2 Prakkamakul S, Witzel T, Huang S, et al. Ultrafast Brain MRI: Clinical Deployment and Comparison to Coventional Brain MRI at 3T. J Neuroimaging 2016;26:503-510.