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Comparison between Gradient-Echo Images and b0 Images Obtained from Diffusion-Weighted Echo-Planar Sequences in Detection of Blood Products in Cerebral Hemorrhagic Vascular Accidents

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Abstract

Purpose: Our aim was to evaluate the clinical utility of b0EPI images obtained from diffusion sequence versus GRE images for the detection of the intra-axial hemorrhagic lesions, especially acute intracerebral bleeds thereby shorten the scan time particularly in the critical acute cases of stroke thus altering the plan of treatment.

Material and Methods: A retrospective study over a year duration with patients' admitted to the emergency department with clinical presentation stroke who were subjected to MR examination with DWI and GRE images to evaluate the most sensitive sequence for depiction of blood in acute vascular insults (intra-axial hematoma, hemorrhagic venous infarct and hemorrhagic transformation of cerebral infarct).

Results: Forty-six patients were included in this studywith a variety of pathogeneses in various locations. All of these lesions were hemorrhagic (hypointense) on the GRE sequences, whereas 40 (87%) were characterized as hemorrhagic on b0EPI images, and 6 (13%) were not detected. The overall difference in hemorrhage conspicuity/diagnostic certainty between GRE and b0EPI sequences was statistically significant ($p<0.05$).

Conclusion: GRE is superior to B0 used in detection of blood products in stroke patients.

Key Words: *GRE – B0-blood products – Cerebral – Vascular – Accidents.*

Introduction

THE intracranial blood appearance on MRI is complicated, depending on its evolution over time and its location **[1-12]**.

Although the sensitivity and efficacy of MRI for detection of acute intracranial hemorrhage have been evaluated to an extent **[2-7]**, its precise ability to depict the presence of hyperacute hemorrhage (within the first 6 hours) has been less well studied **[13]**.

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Multimodal magnetic resonance imaging (MRI), with diffusion-weighted imaging (DWI), has excellent ability to detect the presence, size, location, and extent of hyperacute ischemia **[14]** but it is not proven to be reliable in identifying early parenchymal hemorrhage. The advent of thrombolytic therapy and other interventional therapies for acute ischemic stroke, has led to increasing importanceto use MRI for selectionof candidates for treatments **[15]**.

In routine clinical DWI, four sets of spin-echo EPI images are acquired. Three DWI sets (obtained with orthogonally applied diffusion gradients) are combined to produce an isotropic DWI scan, and a B0 set is acquired without diffusion gradients **[16]**. Since EPI is intrinsically sensitive to magnetic field heterogeneity, paramagnetic blood breakdown products produce signalloss similar to that in T2* weighted GRE sequence **[16]**.

As for the accuracy of conventional MR sequences in the evaluation of acute intracranial blood has been questioned in thepast, but some authors have indicated that gradient-echo(GRE) and fluid-attenuated inversion-recovery (FLAIR) sequences significantly increase the sensitivity of MR imaging ascompared with other MR sequences and CT **[17]**.

But nowadays, many stroke centers still perform both CT and MRI in the initial evaluation of stroke patients. Using both modalities is time consuming and costly **[15]**.

The aim of this study isto evaluate the clinical utility of b0EPI images obtained from diffusionsequence versus GRE images for the detection of the intracranial hemorrhagic lesions, especially acute intracerebral bleeds thereby shorten the scan time particularly in the critical acute cases of stroke thus altering the plan of treatment.

Material and Methods

A retrospective study over a year duration for patients clinically suspected for acute stroke less than 4 days old who were subjected to MR examination with DWI and GRE images to evaluate the most sensitive sequence for depiction of blood in acute vascular insults (intra-axial hematoma, hemorrhagic venous infarct and hemorrhagic transformation of cerebral infarct). Patientswith underlying brain tumors, vascular anomaly, trauma were excluded. The institutional review board allowed retrospective review of patient data sets.

Forty-six patients were included in this study (26 females and 20 males) fulfilled these criteria and constituted our study group. They range inage from 18 to 83 years (mean 50.2 years). The clinical manifestations of the patients include: Symptoms due to cerebral vascular disease (n=13), hypertension (n= 12), blood disease (n=16) and complication of treatment (n=5).

All patients underwent MR examination in the Radiology Department Faculty of Medicine, Cairo University during the period Jan. 2012 – Jan. 2013.

MRI technique:

The study was performed on 1.5-T MR scanner (Gyroscan Intera, Philips medical systems) using standard imaging head coil. Images were acquired with the patient on supine positionwith a placed head support pillow to minimize the patient's movement. MRI study included A- Axial and sagittal T1WI 427/12ms [TR/TE]; 16 slices; slice thickness, 7.0mm; 0.7mm interslice gap; 1 average. B-Axial FLAIR 5496/100ms [TR/TE], inversion time, 6.4mm; 1.3mm interslice gap; 2 averages, matrix size, 256x256. C- Axial T2WI (2014/100 ms [TR/TE]; 19 slices; slice thickness, 7.0mm; 0.7mm interslice gap; 1 average; matrix size, 256x256) and D- Axial GRE (2666/23ms [TR/TE], GRE matrixis 265x192). Single-shot echo-planar spin-echo (SE) planar imaging DWI sequences were obtained by applying diffusion gradients in three orthogonal directions at eachslice with two diffusion weighting (p-value=0 and 1000s/mm^2), the parameters of DWI were matrix is 192x68, 1200/140ms [TR/TE]. The scan time was about 5 1s for the DWI sequence, 13 5 s minutes for GRE, 180s for T1W, 120s for FLAIR and 90s for T2W images.

Image analysis:

The study was analyzed retrospectively by an experienced radiologist blinded to the clinical data. The b0EPI and GRE images were examined for the presence or absence of hemorrhage at separate sessions randomly. Subsequently, the b0EPI and GRE images were analyzed side-by-side, in conjunction with the DWI scans, for conspicuity of hemorrhage and diagnostic certainty. Patients showing multiple lesions, each lesion was reviewed separately. The presence or absence of hemorrhages in each sequence was recorded, and the images were classified as either negativeor positive. Hemorrhages were diagnosed as present when there were areas of abnormally low signal intensity. When ahemorrhagic lesion was identified, it was further characterized by its age, anatomic location and pathogenesis. The degree of visualization of hemorrhage with b0EPI and GRE was rated as easily identified, hardly identified and unidentified. The accuracy of detection of hemorrhage by b0EPI was assessed. The results were compared to the presence of low signalintensity on GRE sequences and/or the presence of high-attenuationlesion on CT scan performed within 2 days. Computer software package SPSS 15 was used in the analysis. Chi-square and Fisher-exact tests were used to determine whether the difference in hemorrhage detection using b0EPI and GRE was statistically significant. A p-value less than 0.05 was considered statistically significant.

Results

There were 46 hemorrhagic lesions with a variety of pathogeneses in various locations, including cerebral microbleeds, parenchymal hematomas and hemorrhagic infarct including venous infarcts (Table 1).

Side-by-side analysis of GRE and b0 images revealed that hemorrhages were invariably more conspicuous on the GRE sequences (Tables 2,3). All of these lesions were of low signal on the GRE sequences, whereas 40 (87%) were characterizedas hemorrhagic (low signal) on b0 images, and 6 (13%) were not detected (Figs. 1-3). The differencein lesion conspicuity/diagnostic certainty between GRE and b0EPI scans was statistically significant ($p<0.05$).

Hyperacute bleeds were detected in one case. They were easily recognized on the T2*-GRE images and it was missed on b0 images.

There were 32 cases of acute hematomas in all locations.

All were identified on GRE sequence. Twenty-nine (90.6%) were identified as hemorrhage on b0 images whereas 3 (9.4%) lesionswere not detected. With regard to subacute bleeds, GRE image detected all 4 lesions, whereas 3 (75%) lesions were identified on b0 images. Among the cases included in our study, 9 were incidental chronic hematomas (microbleeds and intraparenchymal) all depicted as areas of low signal on GRE sequence. Seven (77.7%) of these hemorrhages were detected on b0 scans. Hemorrhagic infarctions were detected in 14 patients. Blood products were depicted on the GRE sequences onall cases and were more pronounced compared with b0 sequences. b0 images missed the diagnosis of hemorrhage in one case, and hardly detected hemorrhage in three cases. The difference in sensitivity for detecting hemorrhagic infarction was statistically significant (p<0.05). The GRE sequence was superior to the b0 sequence in 19 cases of small punctate hemorrhages <10mm in diameter (microbleeds). They were seen on 19 GRE studies, but onlyon 14 of the b0 images. This difference in sensitivity was statistically significant (p<.05).

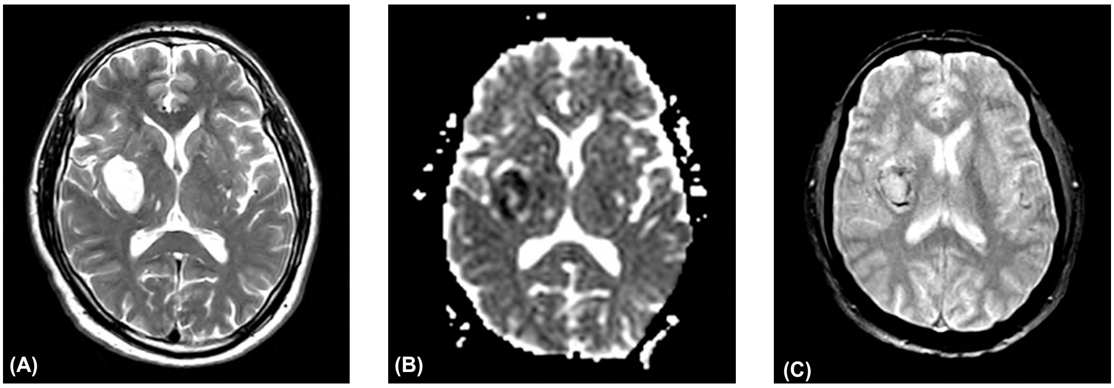

Fig. (1): A- Axial T2WI, B- b0EPI, C- GRE images, showing hypertensive parenchymal hematoma in the right temporal region. The hypointenserim suggestive of blood products are more conspicuous on GRE image.

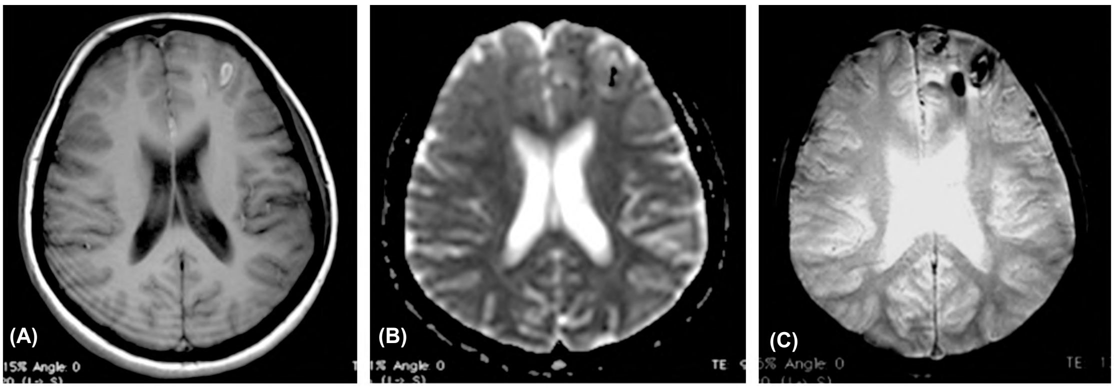

Fig. (2): A- Axial T 1 WI, B- b0EPI, C- GRE images, showing left frontal venous infarct due to cortical vein thrombosis with small areas of faintly bright signal on T1, being hardly seen on b0EPI and susceptibility clearly noted on GRE images.

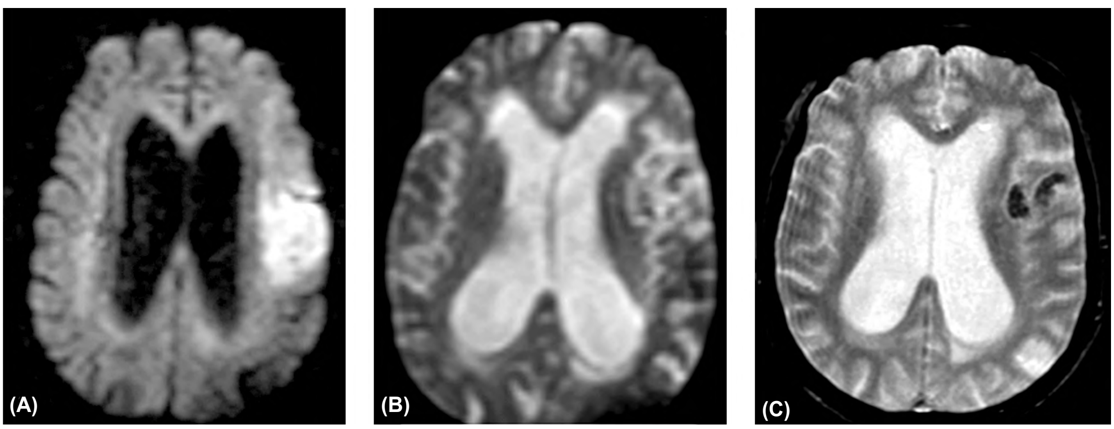

Fig. (3): A- Axial DWI (b=1000), B- b0EPI and C- GRE images showing left parietal acute hemorrhagic infarct. It shows restricted DWI, with central foci of low signal denoting blood products being better depicted on GRE (C) better than b0EPI (B).

Table (1): Number and types of hemorrhagic lesions.

	Hyperacute	Acute	Subacute	Chronic	Total
Petichealhge	–	12	1	6	19
Hemorrhagic infarction	1	11	2	–	14
Parenchymal hematoma	–	9	1	3	13

Table (2): Lesion conspicuity and diagnostic certainty with b0EPI.

B0	Un-identified	Hardly identified	Easily identified	Total
Petichealhge	5	7	7	19
Hemorrhagic infarction	1	4	9	14
Parenchymal hematoma	–	5	8	13

Table (3): Lesion conspicuity and diagnostic certainty with GRE.

GRE	Un-identified	Hardly identified	Easily identified	Total
Petichealhge	–	–	19	19
Hemorrhagic infarction	–	1	13	14
Parenchymal hematoma	–	–	13	13

Discussion

Despite the frequent use of conventional MR imaging to evaluate the appearance and underlying biophysical basis of evolving ICH over the past few years, diffusion-weighted MR imaging (DWI) has only recently been identified as a valuable investigative resource [18].

The detection of a hemorrhage in an acute stroke is crucial in determining the appropriate type of treatment for the patient. Thrombolytic therapy has to be started within the first few hours after the insult and is contraindicated in patients with intracerebral hemorrahages. A quick establishment of acute strokeand the exclusion of an intracerebral bleed is therefore important for clinical management [19].

A series of studies now consider GRE sequences the most sensitive of the MR sequences for detecting intracerebral hemorrhage being even superior to CT [13,20,21].

But GRE sequence is lengthy, and intracranial hemorrhage patients are critical, requiring quick therapeutic decision making [22].

DWI with an echo planar imaging (EPI) technique is a fast sequence and is needed to assess irritable and uncooperative patients presenting with acute strokes [18]. In additionto detection of ischemic insults, it might also beused to detect the inhomogeneity of the magnetic field due to the presence of blood products [18].

In this study, the clinical utility of b0 images obtained from diffusion was evaluated in the detection of intracerebral hemorrhage. b0 images from DWI were less sensitive than GRE sequences in the detection of hemorrhages. Blood products were more conspicuous and readily detected by GRE sequences compared to b0EPI sequences. The difference in lesion conspicuity / diagnostic-certainty between GRE and b0EPI scans was statistically significant ($p<.05$). Due to lower spatial resolution of b0EPI compared to GRE sequence (EPI matrix is 192.68, GRE matrixis 265.192) some cases of hemorrhage were not clearly recognized on b0EPI due to small size of the lesions and difficult characterization of their internal structure.

In this study, GRE sequence yielded better results in revealing acute hemorrhage, especially in cases of acute infarction.

The results were in agreement with Lin et al., [17] who reported that GRE sequence was more sensitive than b0EPI for identify ingacute hemorrhage at 1.5 T. They stated that GRE is an important sequence in MR protocol for acute stroke particularly when thrombolytic therapy is planned.

However, authors stated that, there was nosignificant difference in the sensitivity between GRE and b0EPI for acute hemorrhage detection at 3T. They found that b0 images can fast detect as many hemorrhagic lesionsas GRE. Therefore, evaluation of acute stroke patients with a 3.0T scanner should not routinely include GRE; GRE can be performed for equivocal lesion on b0EPI [22]. The reasonfor better results of b0EPI images in their study could be attributed to increased magnetic susceptibility at higher magnetic field [23], therefore it becomes more sensitive to deoxy hemoglobin.

Also, one of the limitations of their study is that they compared the EPI images with fast GRE and not conventional GRE, which should have longer TE and thus, a stronger susceptibility effect.

In detection of microbleeds, b0EPI was also less sensitive than GRE sequence. They were less conspicuous on b0EPI images, most likely as a result of limited spatial resolution.

These findings were in agreement with the study by Lam et al., [18]. They are noted in 12-20% of MRI-examined stroke patients [24,25]. Although these microbleeds are not relatedto patient's acute clinical presentation, they suggest the presence of vascular fragility and a risk factor for intracranial hemorrhage later on [26]. Therefore, its detection is of clinical significance and caution for the possibility of intracerebral hemorrhage when administering thrombolysis or anticoagulant therapy is planned [18].

In conclusion, the b0EPI sequence, although shorter inacquisition time, was inferior to GRE imaging in the detection of acute and chronic intracerebral hemorrhage. It is suggested that, when there is time limit, or in case of clinically irritable, or uncooperative patients, an ultrafast b0EPI sequence maybe useful in reducing scan time and may be informative for treatment planning.

Conflict of interest:

The author declares no conflict of interest.

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