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RESEARCH ARTICLE

Cranial Magnetic Resonance Imaging Findings in Kwashiorkor

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ABSTRACT

Protein energy malnutrition (PEM) is an important public health problem in the developing countries, although it is becoming uncommon in South West Nigeria. Cerebral changes have been associated with severe PEM. This study evaluated the neurological changes using Magnetic Resonance Imaging (MRI) in Ibadan south west Nigeria. The 5 children evaluated had a median age of 16 months and all the children had brain changes compatible with cerebral atrophy. In addition two of the children had periventricular white matter changes, while one these two had mega cisterna magna in addition. Though this study did not re-evaluate the brains of these children after nutritional rehabilitation, it is possible that changes are reversible as demonstrated in earlier studies

KEYWORDS: magnetic resonance imaging, protein energy malnutrition

INTRODUCTION

Severe forms of childhood malnutrition are common in many developing countries (Bamgboye & Familusi, 1990; Oyedeji, 1984) though there appears to be a significant reduction in incidence of kwashiorkor in the South-western Nigeria probably due to fewer cases of severe measles consequent on widespread immunization against measles and better management of diarrhea with oral rehydration therapy and nutrition. (Oyelami & Ogunlesi, 2007). The brain of the child is one of the most vulnerable organs affected during growth with potential morphological changes, which are detectable at autopsy and/or with neuroimaging technology which are now available in several developing countries. Previous cranial imaging studies of the brain of patients with protein energy malnutrition (PEM) showed that cerebral atrophy and ventricular dilatation are common findings (Akinyinka, Adeyinka, & Falade, 1995; Gunston, Burkimsher, Malan, & Sive, 1992; Househam & de Villiers, 1987; Odabaş et al., 2005) though reversible after nutritional rehabilitation (Akinyinka et al., 1995; Gunston et al., 1992). The present study seeks to describe the morphological changes in the brain of Nigerian children suffering from kwashiorkor using magnetic resonance imaging (MRI).

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METHODOLOGY

Five consecutive children suffering from kwashiorkor seen over a 12-month period at the University College Hospital, Ibadan, Nigeria were studied. The diagnosis of kwashiorkor was based on the Wellcome classification (1970), which is calculated as when the weight for age is less than 80% of the expected for normal children and the patient also has associated oedema. All the 5 children had complete blood counts, creatinine, electrolytes and urea, and albumin evaluation. T1 and T2 weighted sagittal, and axial MRI images were acquired as well as fluid attenuation recovery sequences using Siemens Magnetom Concerto 0.2 T MRI machine.

RESULTS

The 5 children comprised 3 males and 2 females with age range between 7 and 52 months and a median of

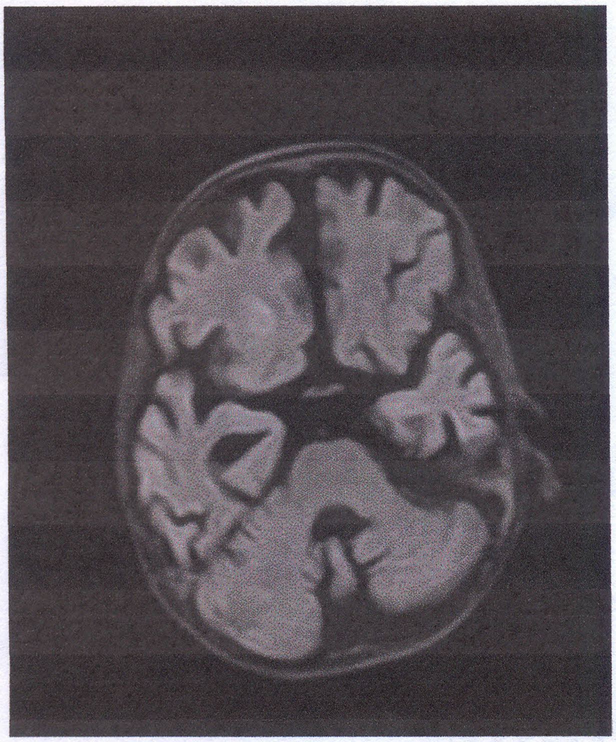

FIGURE 1. Axial dark fluid sequence showing prominent basal cisterns, widened sulci, and interhemispheric fissure.

16 months. Table 1 shows the weight for age (%), associated intercurrent illnesses, and the MRI findings. All the 5 children had marked cerebral atrophy, dilated ventricles, prominent Sylvian fissures, and basal cisterns (Figure 1) as well as normal myelination for age as defined by Barkovich (2005), Figure 2. Two of the five children had periventricular white matter changes (Figures 3 and 4), and in addition, one of the two had large cisterna magna (Figure 5).

DISCUSSION

The hospital-based incidence of severe PEM in Nigeria ranged from 3.18% to 4.5% of all admissions (Bamgboye & Familusi, 1990; Oyedeji, 1984), however there has been a significant 70.6% reduction in kwashiorkor over a 20-year period in the same geographical and socio-cultural environment where this study was conducted (Oyelami & Ogunlesi, 2007) which may explain the limitation in the number of cases seen. Several neuropathological studies of the brain have shown that PEM may have adverse impact on the number of neurons and synapses, degree of myelination, and total cerebral lipid content of the developing brain (Levitsky & Strupp, 1995).

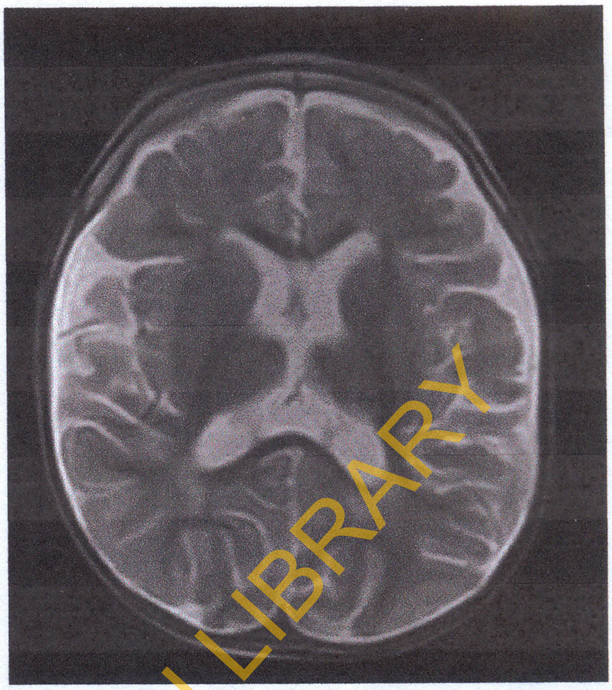

FIGURE 2. T2 weighted axial images showing normal myelination for a 15-month-old child.

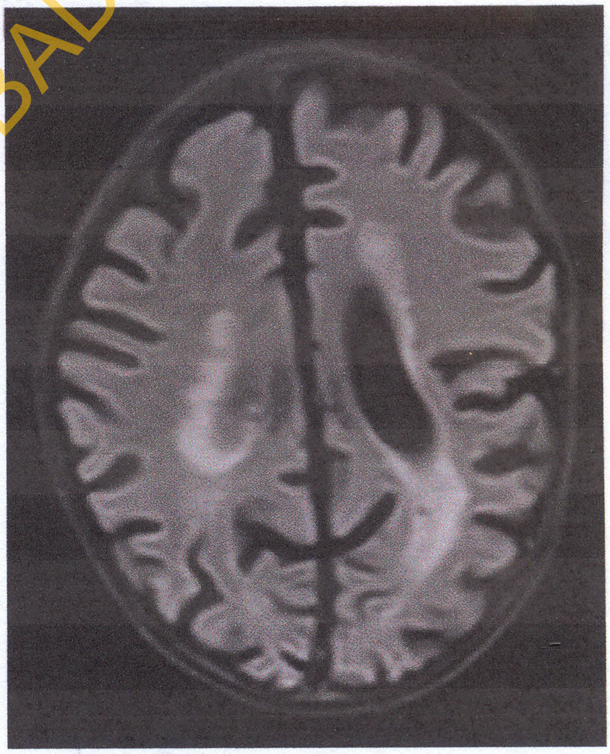

FIGURE 3. Axial dark fluid sequence showing periventricular leukodystrophy.

TABLE 1. The demographic and MRI findings in Kwashiorkor

				MRI findings					
Gender	Age (Months)	Weight for age (%)	Intercurrent illness	Myelination	Dilated ventricles	Dilated cisterns	PVWM changes	Atrophy	Other findings
M	16	62	Septicaemia	Normal	All	Yes	Yes	Yes	None
F	16	66	Disseminated tuberculosis	Normal	All	Yes	Nil	Yes	None
M	15	75.2	None	Normal	All	Yes	Nil	Yes	None
F	7	67.5	Ventricular septal defect pulmonary tuberculosis	Normal	All	Yes	Nil	Yes	None
M	52	72	Dilated cardiomyopathy disseminated tuberculosis, septicaemia	Normal	All	Yes	Yes	Yes	Large cisterna magna

Note: PVWM = periventricular white matter.

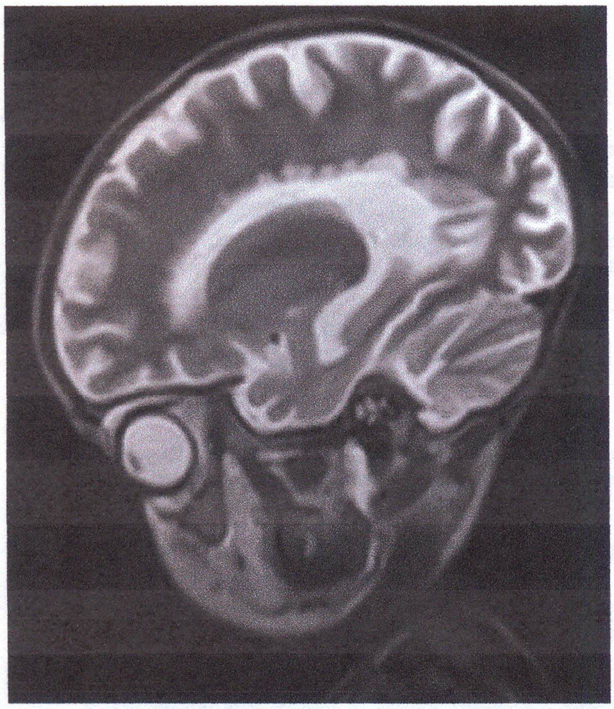

FIGURE 4. Sagital T2 image showing irregularity of the ventricular wall.

FIGURE 5. Sagittal T2 weighted image showing in addition to widened sulci, enlarged ventricles, and large cisterna magna with normal cerebella.

In the present study as in previous studies using computed tomography (Akinyinka et al., 1995) and MRI (Househam & de Villiers, 1987), cerebral atrophy and dilated ventricles were the commonest images seen in the children suffering from kwashiorkor. In an earlier CT study of the brain of patients suffering from kwashiorkor in the same locality, Akinyinka et al. (1995) demonstrated cerebral atrophy and ventricular dilatation in 10 of 14 cases of kwashiorkor and 11 of 12 cases of marasmic-kwashiorkor while Gunston et al. (1992) demonstrated brain shrinkage in all the 12 children evaluated using MRI. These specific morphological changes in the brains of these children can be attributable to kwashiorkor in the absence of the other causes of cerebral atrophy such as intrathecal chemotherapy for acute lymphocytic leukaemia (Prassopoulos et al., 1996) or chronic renal failure (Steinberg, Efrat, Pomeranz, & Drukker, 1985) which were not present in these patients.

The present study as in earlier studies (Gunston et al., 1992; Hazin, Alves, & Rodrigues Falbo, 2007) demonstrated that all the patients with oedematous malnutrition had normal cerebral myelination for their ages (Barkovich, 2005) but occasionally myelination may be delayed as demonstrated in 1 of the 15 patients studied by Odabas et al. (2005) and in 2 of 11 children with severe stunting (El-Tatawy, Badrawi, & El Bishlawy, 1983).

The present study as in others (Akinyinka et al., 1995; Gunston et al., 1992; Odabaş et al., 2005) demonstrated widening of the Sylvian fissures and sulci, prominence of the basal cisterns, and dilation of the ventricules indicating severe cerebral atrophy. The authors are unaware of previous documented leukodystrophic changes seen in PEM, however the present study demonstrated leukodystrophic changes in 2 of the children, one of which had septicaemia while the second patient had tuberculosis with dilated cardiomyopathy in addition to large a cisterna magna but the cerebellum was normal. The role(s) of these intercurrent illnesses in the development of periventricular white matter (PVWM) changes as well as inherited enzyme deficiencies that can result in abnormal formation, destruction, or turnover of myelin or even destruction of intrinsically normal myelin remains conjectural in these patients.

Although these patients were not followed up on long-term basis, which is a limitation of this study as well as the limited number of cases studied because of the declining incidence of kwashiorkor, earlier studies have shown complete resolution of the morphological changes documented after nutritional rehabilitation (Househam & de Villiers, 1987; Oyelami & Ogunlesi, 2007). Associated diseases are not uncommon in PEM as demonstrated in the children in this study (Berkowitz, 1983; Shimeles & Lulseged, 1994).

CONCLUSION

Cerebral atrophy and ventricular dilation are common findings in the brains of children suffering from kwashiorkor, while PVWMC was present in nearly half of the children. However the brain myelination process was normal indicating that no significant delay in the myelination process could be attributable to the nutritional status of the children.

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Paper #: PA51

3D SAP-EPI in Motion-Corrected Fast Susceptibility Weighted Imaging (SWI)

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Purpose: Susceptibility-weighted imaging (SWI) has been utilized as a useful contrast mechanism in MRI. In SWI, the phase images of a T2*-weighted acquisition is used to enhance sources of susceptibility effects such as blood products. The standard acquisition is a 3D GRE sequence, however it suffers from a long scan time and is prone to motion. Here, a 3D short-axis readout propeller (SAP)-EPI trajectory is suggested as an alternative approach to 3D GRE for moving patients. 3D SAP-EPI acquires several low resolution 3D volumes in a PROPELLER-fashion that can be motion corrected and united to form the final image. This makes it a useful alternative to interleaved (i)EPI which also suffers from motion artifacts. Here we show human 3D SAP-EPI motion corrected SWI images.

Methods and Materials: 3D SAP-EPI, 3D iEPI, and 3D GRE images were acquired on moving volunteers using a 3 T GE system and an 8-channel head coil. SAP-EPI and EPI both used a matrix size=256^2, 64 slices in a total scan time=1:48 min (SAP-EPI: brick frame rate=3.5 s, acceleration factor=3; EPI: 32 interleaves); and GRE used a matrix size=512 x 256, 32 slices, in a scan time=5mins. All data were SWI processed as described elsewhere.

Results: Both iEPI and GRE exhibited significant ghosting in moving volunteers, whilst the SAP-EPI was successfully corrected for motion. In the absence of motion the resolution and SNR is highest for the GRE scans, however both iEPI and SAP-EPI images generally depicted darker vessels.

Conclusions: SAP-EPI generated SWI images acquired in less than half the scan time of GRE, and could be 3D motion corrected. Furthermore, the images depicted good contrast between vessels and background tissue. One disadvantage of SAP-EPI (and iEPI) for SWI is the reduced conspicuity of smaller vessels and increased geometric distortion in the base of the brain, however if one is concerned about speed and motion-correction capability this technique may be a useful option for pediatric imaging.

Paper #: PA52

Cranial Magnetic Resonance Imaging Findings in Kwashiorkor

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Purpose: Protein energy malnutrition (PEM) is an important public health problem in the developing countries. Cerebral changes have been associated with severe PEM. This study evaluated the neurological changes using Magnetic Resonance Imaging (MRI) in a developing world.

Methods and Materials: Five consecutive children suffering from kwashiorkor seen over a 12 month period were studied. The diagnosis of kwashiorkor was based on the Wellcome classification of weight for age of<80% and the presence of oedema. (8) All the 5 children had complete blood counts, creatinine, electrolytes and urea and albumin evaluation. T1 and T2 weighted sagittal, and axial MRI images were acquired as well as fluid attenuation recovery sequences using Siemens Magnetum Concerto 0.2 T MRI machine.

Results: All the patients with a mean age of 16 months had brain changes compatible with cerebral atrophy. In addition two of the patients had Periventricular white matter changes, while one these two had mega cisterna magna in addition.

Conclusions: Cerebral atrophy and ventricular dilation are common findings in the brains of children suffering from kwashiorkor, while Periventricular white matter changes (PVWMC) was present in nearly half the children. However the brain myelination process was normal indicating that no significant delay in the myelination process could be attributable to the nutritional status of the children.

Paper #: PA53

T1-Weighted 3D SAP-EPI for Use in Pediatric Imaging

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Purpose: Standard Spoiled Gradient Echo (SPGR) is sensitive to motion resulting in ghosting/motion artifacts in the final image. 3D Short-Axis readout Propeller EPI (SAP-EPI) has been introduced as an alternative to the 3D T1-w SPGR technique commonly used for routine clinical studies. SAP-EPI is a pseudo-EPI technique, which similar to PROPELLER in 2D, acquires several low resolution 3D volumes (a.k.a 'bricks') that can be 3D motion corrected and then united to form a high resolution image. This technique is less distorted than EPI, and is more powerful than PROPELLER for motion correction. The objective of this study was to apply motion-corrected 3D SAP-EPI images on pediatric patients and compare the image quality with 3D SPGR.

Methods and Materials: Images were acquired on a 1.5 T GE system using an 8-channel head coil. 3D SAP-EPI data were acquired on unsedated, moving, pediatric patients with a brick frame rate=3.5 s and a scan time=2:07mins. The post-processing stage is described elsewhere. Resolution/scantime-matched 3D SPGR datasets were also acquired.

Results: 3D SAP-EPI generated images with high gray-white matter contrast similar to that of 3D SPGR, and were additionally corrected for a significant amount of motion. With a brick frame rate of 3.5 s, the acquisition may still suffer from intra-volume motion-however, with the acquisition of a few extra volumes corrupted volumes could be discarded without significantly hampering the final image quality (three extra volumes, for example, will take ~10 s). A limitation of 3D SAP-EPI is the residual blurring in the final image, however improved distortion correction methods can help to mitigate this effect.