The role of 3D volumetric MR sequences in diagnosing intraventricular neurocysticercosis

Preliminar results

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ABSTRACT

Objective: The purpose of this paper was to investigate the role of two three-dimensional magnetic resonance (MRI) sequences: enhanced spoiled gradient recalled echo (SPGR), and fast imaging employing steady-state acquisition (FIESTA) in the evaluation of intraventricular neurocysticercosis cysts and scolices. **Method:** Seven neurocysticercosis patients suspected of presenting intraventricular lesions were evaluated by magnetic resonance imaging using enhanced SPGR, and FIESTA. **Results:** Enhanced SPGR detected eight cystic lesions, with scolices in four. Contrast enhancement was observed in three cysts. FIESTA also detected eight cystic lesions with the presence of scolices in seven of those cystic lesions. Four patients presented parenchymal involvement, while the remaining three presented the racemose form. **Conclusion:** FIESTA and SPGR are sequences that can detect intraventricular cysts of neurocysticercosis, and FIESTA also is good for the detection of the scolex. Considering this information we suggest that FIESTA and SPGR should be included in the MRI protocol for the investigation of intraventricular neurocysticercosis.

Key words: intraventricular neurocysticercosis, magnetic resonance imaging, FIESTA, SPGR.

Papel das sequencias volumétricas 3D de RM no diagnóstico da neurocisticercose intraventricular: resultados preliminares

RESUMO

Objetivo: O objetivo deste trabalho foi investigar o papel de duas sequências de ressonância magnética (RM) volumétricas tridimensionais: *spoiled gradient recalled echo* (SPGR) pós-contraste e *fast imaging employing steady-state acquisition* (FIESTA) na avaliação de cistos e escólex na neurocisticercose intraventricular. **Método:** Sete pacientes suspeitos de neurocisticercose intraventricular foram avaliados pela ressonância magnética com SPGR pós-contraste e FIESTA. **Resultados:** SPGR pós-contraste evidenciou oito lesões císticas com presença de escólex em quatro. Realce foi observado em três destes cistos. FIESTA também detectou oito lesões císticas, com presença de escólex em sete destas lesões. Envolvimento do parênquima cerebral foi observado em quatro pacientes e forma racemosa em três. **Conclusão:** FIESTA e SPGR são sequências que permitem a detecção de cistos intraventriculares de neurocisticercose e FIESTA é uma boa sequência para a detecção de escólex. Considerando estes achados nós sugerimos que estas sequências (FIESTA e SPGR) devam ser incluídas no protocolo de RM na investigação de neurocisticercose intraventricular.

Palavras-chave: neurocisticercose intraventricular, ressonância magnética, FIESTA, SPGR.

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Neurocysticercosis (NCC) is one of the most common parasitic diseases of the central nervous system (CNS) in humans. Neurocysticercosis is an infection caused by the encysted larval stage of the tapeworm *Taenia solium*. Humans and pigs can develop cysticerci by ingesting eggs from adult tapeworms via fecal-oral contamination. After ingestion of the eggs, the larvae can lodge in the CNS, muscles and other soft tissues[1]. In the CNS, the larvae is found mainly in brain parenchyma, subarachnoid space, ventricular system, spinal cord (rarely), or even a combination of the above. Intraventricular cysts are unusual and very difficult to diagnose[1-4]. Intraventricular lesions are difficult to detect via computed tomography (CT) and magnetic resonance imaging (MRI). Cysts usually have an attenuation and signal intensity similar to those of the cerebrospinal fluid (CSF), and the cystic wall is very thin[5,6]. MRI is more accurate than CT for detecting uncalcified neurocysticercal lesions[6]. However, conventional MR sequences such as T1, T2-weighted, and fluid attenuated inversion recovery (FLAIR) images can miss intraventricular NCC cysts[7]. Cystic lesions can present a mural nodule that corresponds to the scolex, i.e., the "hole with a dot sign"[8].

The optimal MR protocol for the detection of intraventricular NCC cysts and scolices is controversial. Some authors have suggested that three-dimensional (3D) very heavily T2-weighted MR sequences, such as constructive interference in steady state (CISS) or fast imaging employing steady-state acquisition (FIESTA), are very good sequences in evaluating intraventricular NCC cysts[2,9] because these sequences have a high spatial resolution and signal-to-noise rate. Both CISS and FIESTA are fast steady state acquisition sequences that provide T2/T1 contrast.

Other authors have suggested that the 3D spoiled gradient recalled echo sequence (SPGR) is more accurate than spin echo T1, T2-weighted, and FLAIR images for detecting cysts and scolices in the case of intraventricular NCC[10]. SPGR is also a fast steady state acquisition, but this sequence gives T1 information.

The purpose of this study was to investigate the role of 3D MR sequences (FIESTA and enhanced SPGR) in the detection of cystic lesions and scolices in cases of intraventricular NCC.

METHOD

We prospectively evaluated, from March 2007 to February 2008, seven consecutive patients having focal or diffuse ventricular dilatation and suspected of intraventricular NCC. All patients had a previous diagnosis of NCC by means of CSF analysis or previous examinations (CT or MR showing the presence of a cystic lesion with a scolex[8]. Four females and three males, aged 39±10 years, were evaluated. All of the cases presented ventricular enlargement (focal or diffuse) despite the fact that four of them had a ventricular shunt.

Patients presenting with parenchymal lesions projecting into the ventricular system were excluded from the analysis.

All of the patients had MRI examinations in a 1.5-T MR unit (GE, LX Horizon; Milwaukee, USA). Two imaging protocols were used: FIESTA (TR=4.5 ms, TE=1.5 ms, field of view=220 mm, matrix=512x512, slice thickness=0.8 mm, and interspacing=0.4 mm) and enhanced axial SPGR (TR=8 ms, TE=1.7 ms, field of view=240 mm, matrix=512×512, slice thickness=1.6 mm, and interspacing=0.8 mm). Before gadolinium administration, we also acquired axial FLAIR (fluid attenuated inversion recovery: TR=10002 ms, TE=109 ms, slice thickness=5 mm, gap=2 mm) and axial T1-weighted (TR=500 ms, TE=9 ms, slice thickness=5 mm, gap=2 mm) images. The gadolinium dose (DOTAREM®, Guerbet, France) was 0.1 mmol/kg.

FLAIR images were used to evaluate ventricular dilatation and to detect parenchymal or subarachnoid NCC lesions with or without a scolex. Axial unenhanced T1 was used to confirm the presence or absence of enhancement.

Two neuroradiologists (16 years and 1 year of experience) evaluated by consensus all of the images. All 3D images were reconstructed in the three planes (axial, sagittal, and coronal). First, we evaluated all of the enhanced SPGR images from the patients, and we then evaluated all of the FIESTA images from all of the patients. FIESTA and enhanced SPGR were used to evaluate the presence and number of intraventricular cysts, their location, and the presence or absence of the scolex in the intraventricular cysts. Using enhanced SPGR, the presence or absence of enhancement of the intraventricular cysts was also evaluated. This protocol was approved by the Internal Review Board from our hospital (IRB), and all of the patients provided written informed consent.

RESULTS

In all cases, intraventricular cysts were detected. In three cases, racemose NCC was also identified in the subarachnoid space. In the remaining four patients, parenchymal lesions were detected; three presented at least one parenchymal cyst with a scolex. In only one patient, there were parenchymal lesions without scolices, but in this case, MR imaging with FIESTA and enhanced SPGR identified intraventricular cystic lesions with a scolex, which enabled the confirmation by imaging of neurocysticercosis.

We identified eight intraventricular cystic lesions in three different locations: four in the IV ventricle, two in the III ventricle, and two in the lateral ventricles. In one of these patients, there were intraventricular cysts in both the III and IV ventricles (Table).

Table. Evaluation of intraventricular lesions via FIESTA and enhanced SPGR.

	1	2	3	4	5	6	7
FIESTA	One cyst with a scolex	One cyst with a scolex	Two cysts and one scolex	One cyst with a scolex	One cyst with a scolex	One cyst with a scolex	One cyst with a scolex
Enhanced SPGR	One cyst	One cyst	Two cysts	One cyst with a scolex	One cyst with a scolex	One cyst with a scolex	One cyst with a scolex
Location	LLV	III V	III and IV V	IV V	LLV	IV V	IV V
Enhancement	No	No	Yes	Yes	No	No	No

III V: third ventricle; IV V: fourth ventricle; LLV: left lateral ventricle; RLV: right lateral ventricle.

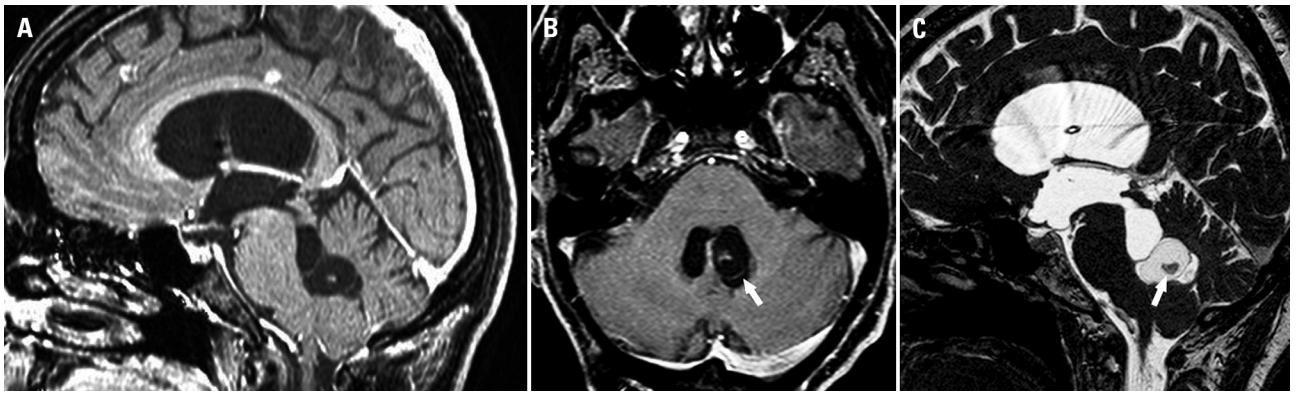

Fig 1. Case 4. Sagittal [A] and axial [B] enhanced SPGR images [A] show an intraventricular cystic lesion with a mural nodule. Also note the peripheral enhancement (arrow). The sagittal FIESTA image [C] also demonstrates the lesion in the fourth ventricle with a scolex (arrow).

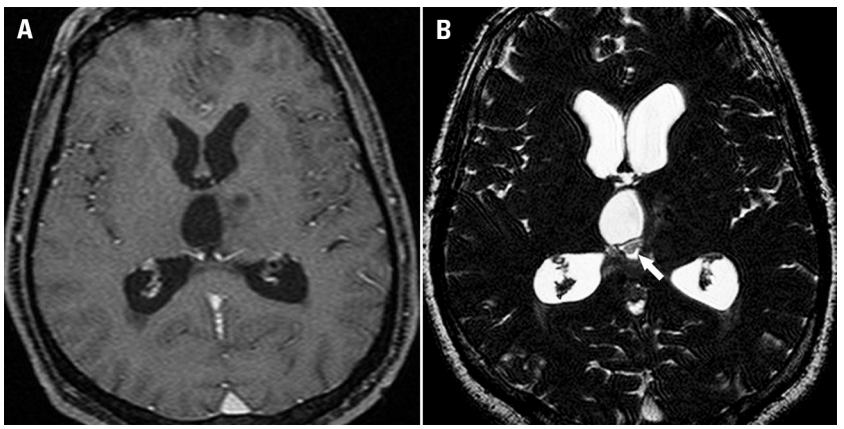

Fig 2. Case 2. Axial enhanced SPGR [A] demonstrates a cystic lesion in the third ventricle. Axial FIESTA [B] shows the presence of a scolex inside this cystic lesion (arrow).

FIESTA and enhanced SPGR identified eight intraventricular cysts in seven patients (Fig 1).

In these eight cysts detected by FIESTA, the scolex was identified in seven (Table), while enhanced SPGR identified four scolices. Three of the cystic lesions presented enhancement; two presented peripheral enhancement around the cystic lesion, and one presented a nodular enhancement in the cystic wall.

Only FIESTA detected scolices in the intraventricular cysts in three patients; in these patients SPGR was able to detect only cystic lesions without scolices (Fig 2).

In all cases, the cystic wall presented an intermediated signal intensity in FIESTA and an intermediate to hyperintense signal in enhanced SPGR.

DISCUSSION

Infection caused by *Taenia solium* is endemic in developing countries in Latin America, Asia, and Africa, but the number of cases is increasing in developed countries, which is probably due to immigration from developing areas. Humans are the intermediate host as they ingest the larval stage due to fecal-oral contamination[1,11,12].

The central nervous system has different presentations of NCC, with involvement of the parenchyma, subarachnoid space, ventricles, and spinal canal.

The presentation of intraventricular NCC is described as one or more cystic lesions, with a scolex (*Cysticercus cellulosae*) or without a scolex (*Cysticercus racemosus*).

Ventricular cysts can be mobile inside the ventricular cavities, and rarely calcify[3,4].

In pathology studies, viable cysts have a translucent membrane through which the scolex is visible as a small 2- to 3-mm nodule in the case of *Cysticercus cellulosae*. When the parenchymal cyst starts to degenerate, the vesicular fluid becomes opaque and dense, and the edges of the cyst become irregular and shrink[10].

The intraventricular form of NCC is more difficult to detect than the parenchymal form because the attenuation and signal intensity of the cyst's content is similar to those of CSF, and the cystic wall is usually very thin. If the scolex is identified, then NCC may be confidently diagnosed[9].

The most common intraventricular location is the fourth ventricle and, less commonly, the third and lateral ventricles[3]. Intraventricular NCC cysts can block the circulation of CSF, causing hydrocephalus, as was found in all of our cases. Hydrocephalus is a common finding in intraventricular NCC due to obstruction of the CSF flow; acute hydrocephalus can also ensue and can cause death. In intraventricular NCC, when the cyst starts to degenerate, it causes an inflammation of the ependyma and choroid plexus, and the cysts may show contrast enhancement. The presence of enhancement in intraventricular NCC can suggest ependymitis, which can lead to chronic obstruction of the CSF flow[2]. We chose to use enhanced, instead of unenhanced, SPGR to detect possible degeneration of the intraventricular NCC cysts. Contrast enhancement was detected in three of the eight cysts identified by enhanced SPGR.

The diagnosis of intraventricular NCC cysts can be done by CT with instillation of contrast in the ventricular system. This is a more invasive diagnostic procedure that has been used in the past to delineate intraventricular cysts. Increasingly, MRI has been replacing CT ventriculography for the diagnosis of intraventricular NCC[13,14].

MRI, with its multiplanar capability and excellent depiction of tissue contrast, is an important tool for the non-invasive assessment of NCC. MRI is the most accurate technique available to assess the degree of infection, the location, and the stage of the parasite in brain NCC[11]. Furthermore, the detection of a scolex by CT or MRI within a cystic lesion, which is usually seen in a parenchymal form, is pathognomonic of NCC[9]. In T1-weighted and FLAIR images, when the intraventricular cyst can be identified, the cyst wall and scolex present intermediate to high intensity[7].

Many previous papers have studied the best MRI protocol for the diagnosis of NCC[15-17], but these have focused mainly on parenchymal involvement. Few papers have focused on the application of MR sequences in the diagnosis of intraventricular NCC, despite the fact that this is one of the most severe forms of NCC[7,11,18,19]. Singh et al.[19] found that FLAIR and T1-weighted images demonstrated the scolex in three out of four cases of intraventricular NCC and that T2-weighted images did not demonstrate the cyst or the scolex. All of the cases presented contrast enhancement[19]. Govindappa et al.[7] and Robanni et al.[10] found that 3D MR sequences were better than conventional T1, T2, and FLAIR images for detecting intraventricular NCC. Govindappa et al.[7] used constructive interference in steady state, which is a sequence equivalent to FIESTA, to detect intraventricular cysticercosis. These authors showed that CISS was more accurate than T1 and fast spin echo T2-weighted images for detecting these NCC lesions. Robbani et al.[10] demonstrated that SPGR was more accurate than T1, T2-weighted, and FLAIR images in the demonstration of the intraventricular cyst and the scolex.

In our study all the patients presented ventricular dilatation and intraventricular NCC was a strong possibility. We showed that the quantification of intraventricular lesion burden in NCC was the same using enhanced SPGR or FIESTA. However, FIESTA detected seven scolices, while enhanced SPGR detected only four.

FIESTA is a fast steady state sequence that gives T2 information and is useful to demonstrate structures or lesions with high water content. FIESTA has a good signal to noise ratio that allows evaluation of small structures or lesions. As the scolex is a small structure that has an intermediate signal and the CSF has a hyperintense signal, this sequence showed to be useful to demonstrate the scolex in intraventricular cysts. On the other hand SPGR is a fast steady state sequence that gives T1 information that also has a good signal to noise ratio, but the scolex presents on T1-weighted image isointensity, while the CSF has hypointense signal, making more difficult the detection of such structures inside a cystic lesion. This could explain partially the differences between FIESTA and SPGR in the detection of scolex in intraventricular NCC, but the fact that the smaller slice thickness may influence this finding must be kept in mind.

For the differential diagnosis of cystic intraventricular lesions FIESTA could detect the scolex better than SPGR, making possible the confirmation of NCC diagnosis. If the diagnosis of NCC was already done by other means (laboratory tests or previous CT or MRI) and there is a suspicion of intraventricular cysts, both FIESTA or SPGR were able to detect intraventricular cysts.

One possible limitation of our study is the small sample size; however, intraventricular NCC is not the most common presentation of the disease, so there are not many confirmed cases, even in endemic regions.

To our knowledge, this is the first paper to compare these 3D sequences, FIESTA and enhanced SPGR, in the

detection of intraventricular NCC. Potential future studies could include three-dimensional FLAIR images to detect intraventricular NCC cysts, even though some authors[7,10] have shown that FLAIR can miss NCC cysts.

In conclusion, from our series, FIESTA and SPGR are sequences that can detect intraventricular cysts of neurocysticercosis, and FIESTA also is good for the detection of the scolex. Considering this information we suggest that FIESTA and SPGR should be included in the MRI protocol for the investigation of intraventricular neurocysticercosis.

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