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Characterization of brain lesions using Magnetic Resonance Spectroscopy

Negwa Gasim Mahgoub Ahmed[1], Asma Aamin[1], Sara Khalifa[1,2], Sawsan Mohammed Elhassan[1,2], Meaad Albashir[2], Mona Ahmed[1], Nada Alomairy[2]

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Author Affiliation:
[1]Sudan University of Sciences and Technology, College of Medical Radiological Sciences, Khartoum, Sudan
[2]Diagnostic Radiology Department, Faculty of Applied Medical Sciences, Jazan University, Kingdom of Saudi Arabia

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ABSTRACT

Nowadays MRS is considered one of the essential imaging modalities to assess the different brain lesions. This retrospective study was done in Khartoum state, Sudan to evaluate brain lesions using MRS. The data were collected from PACS of Royal care hospital after taken an ethical approval from the department of radiology. Total of 100 patients {54 male and 46 females} were examined. After collection, data was then analysed using statistical package for social sciences version 23, frequency and percentage used for categorical variable, cross tabulation using Chi square test to correlate between study variables, p value significant if ≤ 0.05. The study found that the most frequent location of brain lesion in MRI is cerebrum 59%. The most common brain lesion described by MRS are low grade glioma is 18%, high grade glioma is 12%, gliomatosiscerebri5%, focal encephalitis 3%, TB granuloma 4%. The Cho/Cr is done and show that the minimum ratio [1.10] in non-neoplastic lesion, maximum ratio {8} in high grade tumour. Most (86%) of these brain lesions yield low NAA, the lipid/lactate may be moderate or mildly elevated in 33% of cases, respectively. Significant correlation found between lesion type suggesting on MRS and metabolites values ($p < 0.01$) as lipid lactate producing sky high peak on different types of non-neoplastic eg.granuloma, normal peak in all cases of meningioma. The study concluded that MRS complementary to MRI in characterization of brain lesions, it can assess the lesion type and helping in grading of brain tumours.

Keywords: MRS (Magnetic Resonance Spectroscopy), lesions, Cho/Cr ratio, Lipid lactate, NAA (N-acetylasparate) and Cho (Choline)

1. INTRODUCTION

MRS is an important modality for the evaluation of brain tumours it can determine the type and grade (Shokry, 2012). The brain tumours produced markedly different spectra from normal brain tissue. Most of brain tumours caused decreased in N-acetyl aspartate (NAA) and increased levels of Choline (Cho), leading to increased Cho/NAA ratios. The decrease in NAA is widely interpreted as the loss or dysfunction of normal neuronal tissue since NAA is believed to be primarily of neuronal and axonal origin. The 'Cho' signal

increased in brain tumours due to increased membrane turnover. Other metabolic changes in human brain tumours are elevated lactate and lipid and increased levels of myo-inositol (mI) in short echo time (TE) spectra. The increase in lactate is most likely the result of anaerobic glycolysis or may be due to insufficient blood flow leading to ischemia, or possibly also due to necrosis. The observation of elevated lipid levels is believed to be associated with necrosis and membrane breakdown. Increased levels of mI are due to reflect increased numbers of glial cells, which have been reported to contain high levels of mI, and have been reported to be high in grade II gliomas It has also been reported that patients with gliomatosiscerebri may exhibit elevated inositol levels, even in the absence of increased Cho (Horska & Baker, 2010)

2. MATERIALS AND METHODS

A retrospective study performed in Khartoum state, Sudan in the period from 2017-2019. This study was approved in August 1, 2019 by Sudan University of science and technology –medical radiological science, college of post graduate studies, Khartoum state ministry of health research department (ethical approval code: MH/KS/PMI/44/A/2). Written consent was obtained from Royal care international hospital and Amoalem medical city. The sampling includes 54 males and 46 females with brain lesions the data collected from MRI PACS, MRI and MRS performed using Toshiba Excel art Vantage 1.5 Tesla MRI machine. All the patients were investigated by MRI and MRS and the results were reported by experienced radiologists, the MRS done to characterize and evaluate the lesion using metabolites' values and assess the types, NAA and Cho\Cr ratio and lipid lactate results determined.

MRS Techniques

MRS is similar to MRI brain done in supine position with head within the head coil, the head is adjusted so that the IPL is parallel to the couch and the head is straight. The patient is positioned so that the longitudinal alignment light lies in the midline, and the horizontal alignment light passes through the nasion. Straps, foam pad used for immobilization. MRS requires a standard radiofrequency {RF} coil and dedicated software package like point-resolved surface coil spectroscopy {PRESS} technique. Spectroscopy images were performed through single- voxel technique {SVS}. Initially localization methods used to localize the voxel from MR image in a clinical proton MR spectroscopy include point-resolved surface coil spectroscopy (PRESS) to give voxel size ranging between 2cc to 8cc, then voxel was placed on volume of interest and suppression of water signal done by use chemical shift selective expiation (CHESS) while suppression of fat done to avoid the area of tumour contain fat. Analysis of the differences in metabolite resonance frequency can only be performed in the presence of highly homogenous magnetic field. A heterogeneous magnetic field leads to resonance frequency dispersion, spreading out the peaks or even causing them to disappear into the background noise. Prior to any MRS acquisition, the magnetic field is homogenized (shimming) in the region of interest. The bigger region, the harder it is to homogenize the zones magnetic field throughout. Close to the bone, calcifications or haemorrhage, MR spectroscopic studies are obtained using a localized single volume (PRESS) however, using chemical-shift imaging it is possible to obtain one or two-dimensional data sets that display metabolites from adjacent compartments encompassing a large tissue volume and to give imaging as mapping explaining the concentration of metabolites in MRS image. In MR spectroscopy are capable of echo times (TEs) as short as 20 milliseconds adequate allow for identify the signal from most metabolites have short time of echo and obtained TEs as long as 136 milliseconds to allow for identify the signal from metabolites in the brain have long TE. MR spectra obtained multiple some in tumour area and one in the normal brain during 10 to 15 minutes.

Statistical analysis

After the data collected it was analysed using SPSS version 23. Frequency and percentage are estimated for categorical variables. The Chi square tests were done to assess the relationship of metabolites results and type of lesion suggestive on MRS, p value significant if less than 0.01 or 0.05 respectively.

3. RESULTS

The study clarified that the brain tumours occur more commonly in male 54%, the most affected age group in this study is 39-59 years 37% followed by 18-38 years 27%, the rate of occurrence is lower in children 10%, as shown in table (1).

Concerning the evaluation of the tumours by MRI, in 59% stated that it was cerebral lesion, followed by 9% is cerebellar lesion, 6% brain stem lesion, 6% cerebral GBM, 4% cerebral glioma, extra axial lesion, thalamus lesion respectively, as shown in figure (1).

Concerning the evaluation of those tumours in MRS, 86% of tumours showed reduced in NAA, while 10% had normal NAA and in 4% is absent, 33% of the lesion causes moderate and mild elevation of lipid lactate respectively, while in 20 % the lipid lactate is normal and in 9% there is sky high peak lipid lactate, as shown in table (2).

Table 1 frequency distribution of gender and age

Variables		Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Female	46	46.0	46.0	46.0
	Male	54	54.0	54.0	100.0
Age group	2-17	10	10.0	10.0	10.0
	18-38	27	27.0	27.0	37.0
	39-59	37	37.0	37.0	74.0
	60-80	21	21.0	21.0	95.0
	more than 80	5	5.0	5.0	100.0

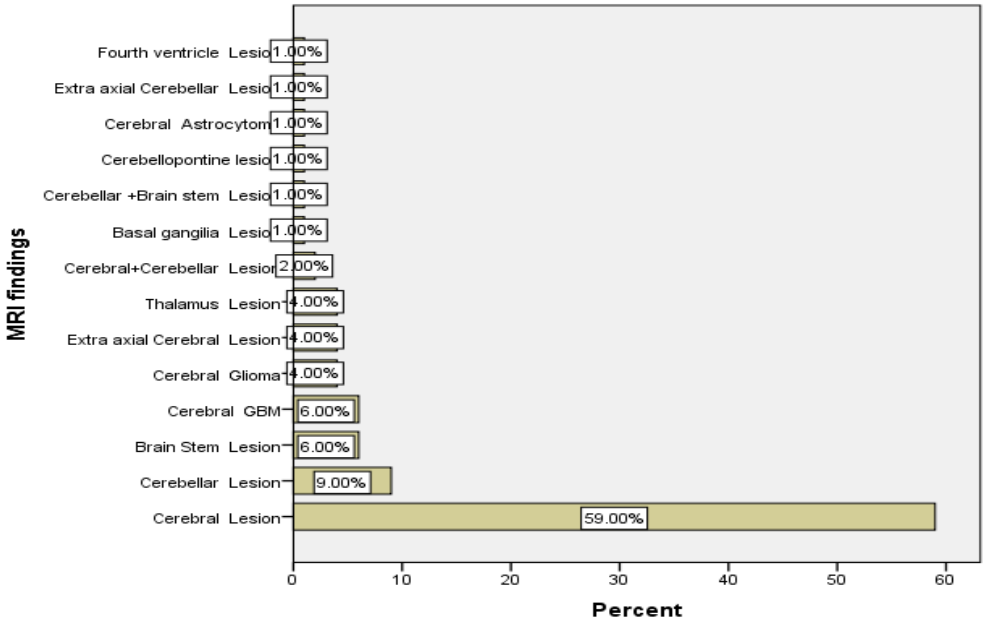

Figure 1 Frequency distribution of MRI finding

Table 2 MRS features of tumours

MRS features		Frequency	Percent	Valid Percent	Cumulative Percent
NAA	Reduced	86	86.0	86.0	86.0
	Normal	10	10.0	10.0	96.0
	Absent	4	4.0	4.0	100.0
Lipid lactate	Moderate Elevation	33	33.0	33.0	33.0
	Mild Elevation	33	33.0	33.0	66.0
	Normal	20	20.0	20.0	86.0
	Sky high peak	9	9.0	9.0	95.0

There is significant correlation between lipid lactate and MRS finding as it is sky high peak in granuloma, TB granuloma or abscess, normal lipid lactate and alanine peak seen in cases of meningioma, while focal encephalitis may show moderate elevation, and in tumours may be normal or mildly and moderate elevation, p value < 0.01, as shown in table (3)

Table 3 Cross tabulation lipid lactate and MRS finding

MRS finding	Lipid lactate					Total
	Mild Elevation	Moderate Elevation	Normal	Normal +Alanine peak	Sky high peak	
Low grade glioma	11	2	5	0	0	18
High grade glioma	3	6	3	0	0	12
GBM	4	4	0	0	0	8
Glioma	1	2	1	0	0	4
Gliomatosiscerebri	0	4	1	0	0	5
Granuloma	1	0	1	0	3	5
Granuloma or Neurological cyst	1	0	0	0	0	1
Granuloma, Infection or abscess	0	0	0	0	1	1
High grade astrocytoma	1	1	0	0	0	2
High grade tumour	0	0	1	0	0	1
Focal encephalitis	0	3	0	0	0	3
Inflammatory	1	0	0	0	0	1
Inflammatory process likely abscess	0	1	0	0	0	1
Intermediate grade glioma	1	0	0	0	0	1
Low grade ependymoma	0	0	2	0	0	2
Low grade glioma DENT	1	0	3	0	0	4
Low grade glioma or Lymphoma	1	0	0	0	0	1
Low grade tumour	3	0	0	0	0	3
Lymphoma	0	1	0	0	0	1
Malignant neoplastic mass	1	0	0	0	0	1
Meningioma	0	0	0	5	0	5
Metastasis	1	4	0	0	0	5
Metastasis or lymphoma	0	3	0	0	0	3
Neoplastic process	1	1	0	0	0	2
Non neoplastic lesion	0	0	1	0	0	1
Oligodendroglioma	1	0	0	0	0	1
Recurrence high grade Astrocytoma	0	0	1	0	0	1
Recurrence tumour	0	0	1	0	0	1
TB Granuloma	0	1	0	0	4	5
TB Granuloma or Abscess	0	0	0	0	1	1
Total	33	33	20	5	9	100
P value <0.001**						

The present study showed that also there is significant correlation between NAA and MRS findings p <0.01. It was reduced in most of brain lesion, absent in most case of meningioma, normal in some low grade tumours, as shown in table (4).

Table 4 Cross tabulation NAA and MRS finding

MRS finding	NAA			Total
	Absent	Normal	Reduced	
Low grade glioma	0	1	17	18
High grade glioma	0	0	12	12
GBM	0	0	8	8
Glioma	0	0	4	4
Gliomatosiscerebri	0	0	5	5
Granuloma	0	3	2	5
Granuloma or Neurological cyst	0	1	0	1
Granuloma, Infection or abscess	0	0	1	1
High grade astrocytoma	1	0	1	2
High grade tumour	0	0	1	1
Focal encephalitis	0	0	3	3
Inflammatory	0	0	1	1
Inflammatory process likely abscess	0	0	1	1
Intermediate grade glioma	0	0	1	1
Low grade ependymoma	0	1	1	2
Low grade glioma DENT	0	1	3	4
Low grade glioma or Lymphoma	0	0	1	1
Low grade tumour	0	1	2	3
Lymphoma	0	0	1	1
Malignant neoplastic mass	0	0	1	1
Meningioma	2	1	2	5
Metastasis	0	0	5	5
Metastasis or lymphoma	0	0	3	3
Neoplastic process	1	0	1	2
Non neoplastic lesion	0	1	0	1
Oligodendroglioma	0	0	1	1
Recurrence high grade Astrocytoma	0	0	1	1
Recurrence tumour	0	0	1	1
TB Granuloma	0	0	5	5
TB Granuloma or Abscess	0	0	1	1
Total	4	10	86	100
P value< 0.01**				

4. DISCUSSION

MRS complements the MRI for characterization of lesion. While the MRI uses signals from hydrogen protons to form anatomic images, the proton MRS uses this information to determine the quantity of brain metabolites such as N-acetyl aspartate (NAA), choline (Cho), Creatine (Cr), and lactate. Brain lesion can caused reduced, markedly reduced or absent N-acetylasparate (NAA) with increased choline (Cho), elevated lactate (LAC) and lipid peaks (Byrd et al., 1996; Shetty et al., 2014). In this study the most brain lesion diagnosed through value of metabolites ratio are low grade and high grade glioma both of them produced low amount of NAA and high Cho, the choline\ creatine ratio is more in high grade than low grade tumours most of them showed moderate or mildly elevated of lipid lactate peak, in suspected cases of meningioma there is normal lipid lactate and presence of alanine peak, this results similar to Byrd et al., whom stated that brain tumours produced markedly elevation on choline with markedly decreased or absent N-acetylasparate, elevated lactate and lipid peaks and in meningioma, there was also an elevated alanine peak (Byrd et al., 1996; Poptani et al., 1995).

In this study MRS finding as it is sky peak lipid lactate in granuloma, TB granuloma or abscess in addition to reduce NAA. The previous studies stated that in MRS of brain tuberculoma peaks of lipids are usually seen due to large lipid fractions in tuberculosis bacillus and also produced increased choline levels and decreased NAA and Cr. The choline/creatine ratio was greater than 1 in all tuberculoma. MRS identifies tuberculoma and aid in early treatment (Seth et al., 2010; Gutch et al., 2012). Poptani et al. (1995) found that in high-grade gliomas high choline and low or absent N-acetyl-L-aspartate and creatine, lipid and/or lactate are present, whereas in low-grade gliomas reduced of N-acetyl-aspartate and creatine, increased choline and presence of only lactate. Choline/creatine ratio was significantly higher in high-grade gliomas than in low-grade gliomas. Metastasis showed lipid and lactate, whereas choline was visible in only four cases. In the infective masses, pyogenic abscesses demonstrate resonances only from cytosolic amino acids, lactate, alanine, and acetate; and tuberculoma showed only lipid resonances (Poptani et al., 1995).

MR spectroscopy metabolites value adding important information to conventional MRI to aid in diagnosis and differentiation of different type of brain lesion as in high and low grade tumours there is increased in cho\cr ratio, reduced or absent of NAA and elevation of lipid lactate peak, in inflammatory lesion such as tuberculoma and abscess there is sky peak lipid lactate, and in meningioma there is normal lipid lactate peak with resonate of alanine.

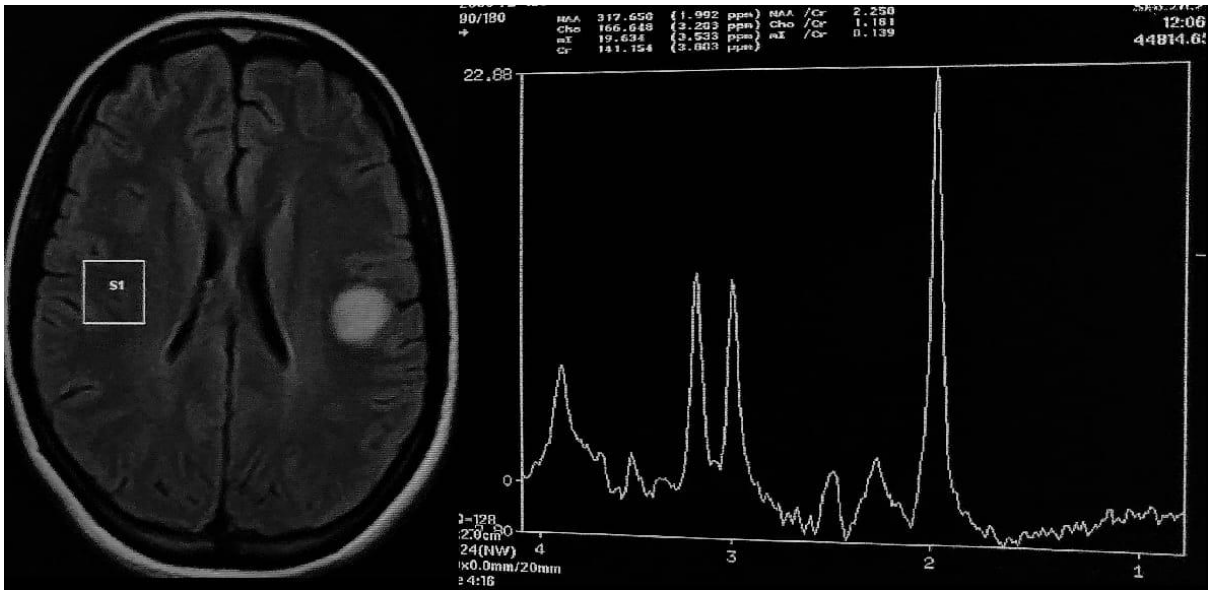

Figure 2 Female 18 years show Normal carve

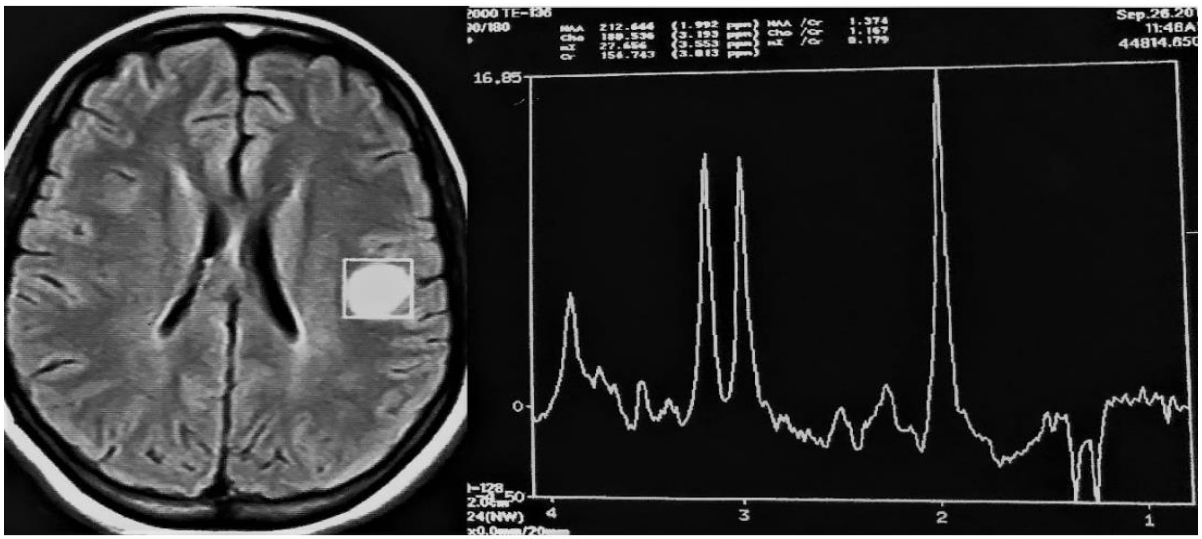

Figure 3 Same patient show Low grade glioma DNET... Ch/cr1.5.. Reduced NAA... Mild elevation lipid-lactate

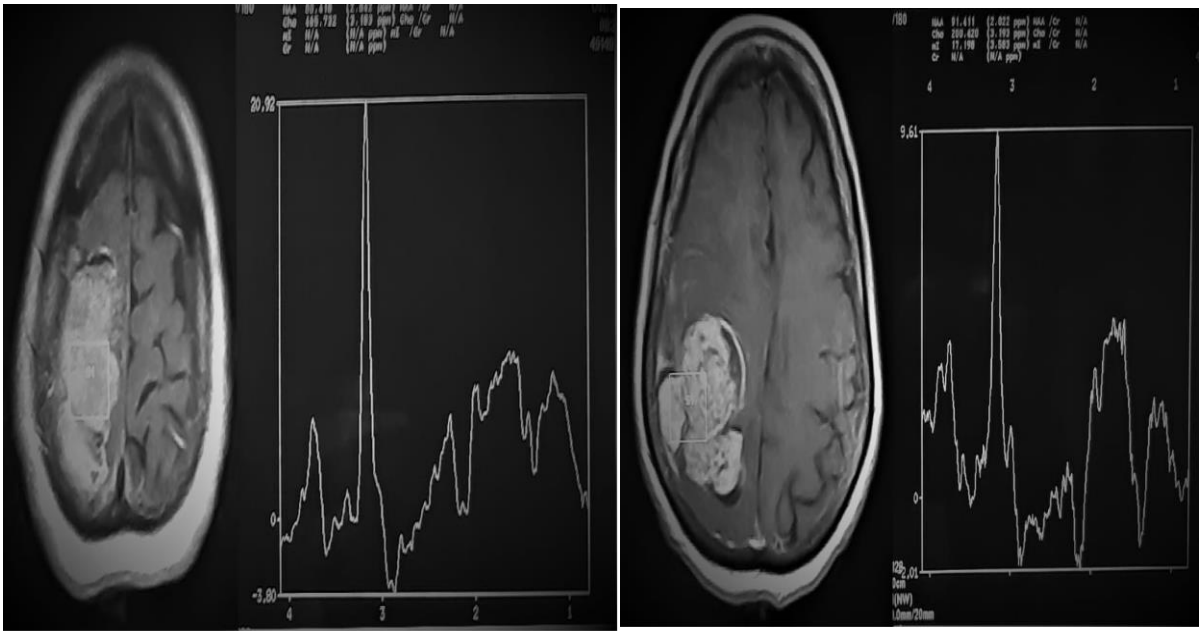

Figure (4-5) Female 65 years show Malignant neoplastic Ch/cr 3.1.....reduced NAA.... Mild elevation lipid-la.

5. CONCLUSION

In conclusion, the study found a high Significant correlation between lesion type using MRS technique as lipid lactate producing sky high peak on different types of non-neoplastic and normal peak in all cases of meningioma. It concluded that MRS characterized different brain lesion furthermore than MRI alone, it can help to determine the lesion types based on metabolites value assessment. Therefore, MRS is complementary study to MRI in characterization of brain lesions, it can assess the lesion type and helping in grading of brain tumours.

Recommendations

Further studies should be done adding biopsy results to assess the accuracy of MRS in differentiation and grading of different brain lesion. Also, more cases have to be added for more accurate result.

Acknowledgement

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Author Contributions

Nagwa Ahmed and Asma Aamin conceived of the presented idea. Nagwa Ahmed, Sarra Khalifa, Sawsan Mohammed Elhassan, Meaad Albashir collected the cases. Mona Ahmed performed the analysis. Nagwa Ahmed and Nada Alomairy wrote the manuscript. All authors discussed the results and contributed to the final manuscript.

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Ethical approval

This study was approved in August 1, 2019 by Sudan University of science and technology –medical radiological science, college of post graduate studies, Khartoum state ministry of health research department (ethical approval code: MH/KS/PMI/44/A/2).

Informed consent

Written consent was obtained from Royal care international hospital and Amoalem medical city. The data collected from PACS in radiology department.

Data and materials availability

All data associated with this study are present in the paper.

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