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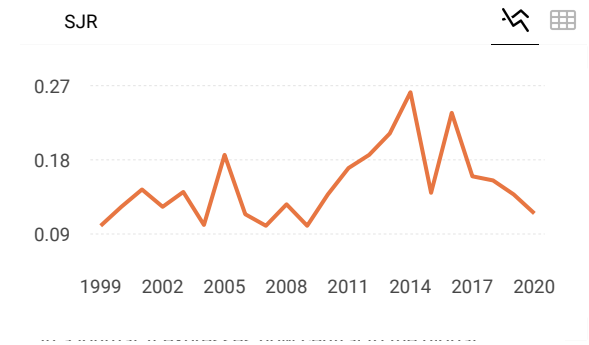

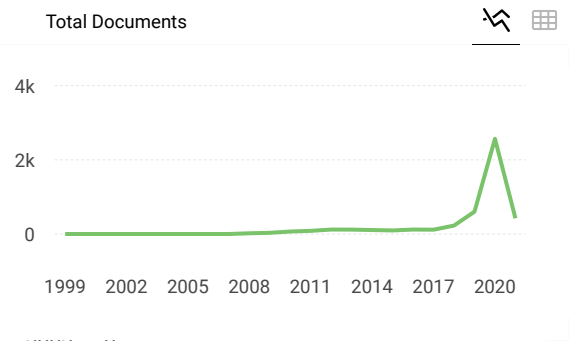

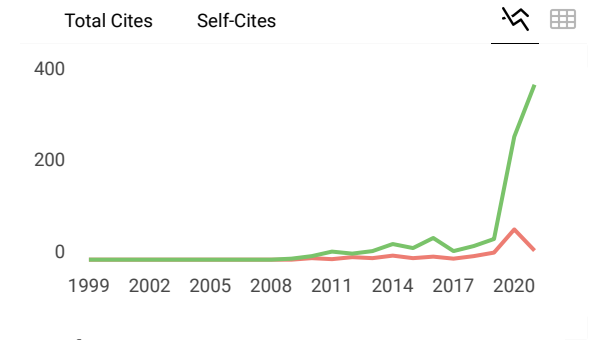

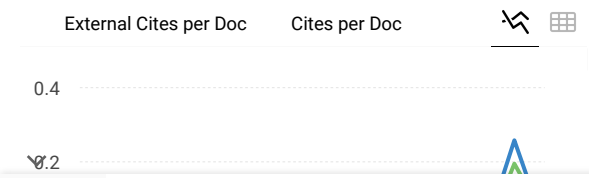

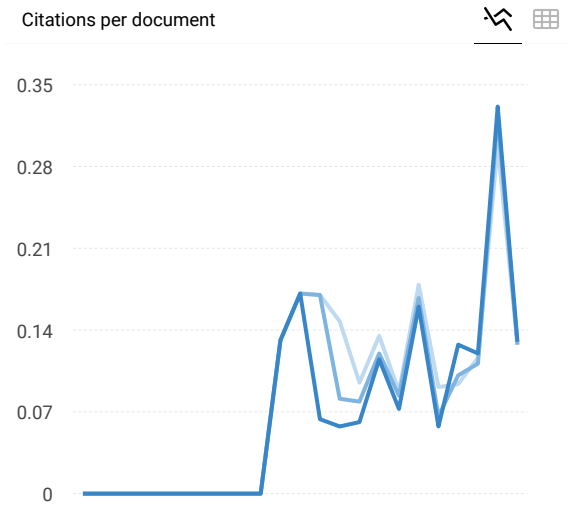

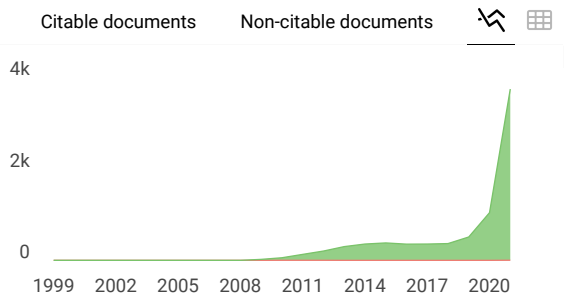

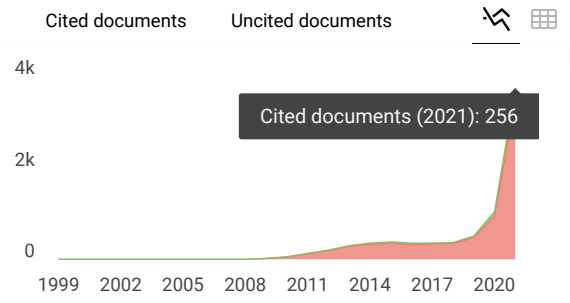

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The Role of Chemical Shift Magnetic Resonance Imaging (SCMRI) to Differentiate Benign and Malignant Vertebral Lesions

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Abstract

The objective of this study was to assess the role of chemical shift magnetic resonance imaging (CSMRI) in differentiating benign and malignant vertebral lesions by comparing signal intensity characteristics, signal intensity value in opposed phase and inphase, and signal intensity ratio (SIR). The clinical data retrieved taken from patients medical records and imaging data of 3T MRI examinations that used chemical shift imaging sequence. Opposed phase signal intensity value, inphase signal intensity value and SIR were significantly different between healthy vertebrates and abnormal vertebrates (both benign and malignant) with $p<0.001$, $p=0.006$ and $p<0.001$, respectively. Our data suggested the signal intensity values in opposed phase was significantly higher in patients with malignant lesion compared to benign vertebrate lesions, 195.77 (±62.03) and 128.17 (±80.66), respectively with $p=0.043$. Similarly, SIR in vertebrate with malignant lesions was significantly higher (1.13±0.097) compared to vertebrate lesions due to benign processes (0.95 ±0.085), with $p<0.001$. In conclusion, SCMRI potentially be used to differentiate between benign and malignant lesions in vertebrates and therefore could help for diagnosis and management of patients with vertebrate lesions. However, further studies are warrant to validate the findings of this study.

Keywords*: Vertebral lesion, signal intensity ratio (SIR), opposed phase, in phase, chemical shift imaging (CSI)*

Introduction

Vertebral morphology and bone marrow changes in vertebrae occur due to benign process such as infection or malignant process, in which both have significantly different in management.[1] Magnetic resonance imaging (MRI) is an excellent imaging modality to evaluate vertebral abnormalities because of its high sensitivity in detecting changes of fat and water components of the bone medulla, intervertebral discs, spinal cord and surrounding tissues.[2] Chemical shift MRI (CSMRI) is a non-invasive, does not require contrast which could harm to the kidney function, specific in assessing bone marrow, can be done after image formation (post processing), and is able to determine the proportion of water and fat content in tissue voxels at the molecular level.[3]

The proportion shift of fat and fluid will affect the signal intensity of bone marrow in the CSMRI sequence, where this change will be assessed using the signal intensity ratio (SIR) obtained by comparing signal intensity (SI) in the opposed phase compared to inphase. If the opposed phase does not show the signal drop image as in normal bone, it will increase the SIR value. In benign process, there will be an incomplete bone marrow change and thus increasing of SIR value is

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lower compared due to malignancy process.[4]

This sequence has been studied quite extensively in distinguishing benign and malignant processes with a fairly good level of sensitivity and specificity, and has been used in many educational centers in many countries. However, this is still rare in Indonesia. The aim of this study was to assess the role of CSMRI to differentiate between benign and malignant vertebral lesions that could be important to be used as an additional information for proper diagnosis and management of the patients with vertebrate lesions.

Materials and Methods

Study setting and the data

This study was a retrospective study in which clinical and imaging data were retrieved from patients' medical records and MRI examination from 3T MRI of Dr. Soetomo Hospital that used the CSMRI imaging sequence. The data were collected between March and September 2020. A total of 23 samples for the malignant group were included and consisted of patients with varied types of malignancy with vertebrate metastatic from cervical cancer (n=1), lung cancer (n=1), pancreatic cancer (n=1), sinonasal cancer (n=2), thyroid cancer (n=1), and breast cancer (n=5), kidney cancer (n=2), thymus cancer (n=3), and primary non-Hodgkin's malignant lymphoma (n=7). All patients were diagnosed based on history of histopathological examination and/or MRI. In benign group, 23 patients were included due infection (n=22) and haemangiomas (n=1), which were diagnosed using conventional MR with contrast and advance. Normal MRI images were used as control.

Instrument and MRI protocol

All examination were performed using 3 Tesla IMR, Siemens Magnetom Skyra. MRI protocol consisted of sagittal, coronal and axial planes of T1W, T2W and short tau inversion recovery (STIR) sequences. This sequence examinations were obtained using a sagittal plane with following parameters on 3T: inphase TR / TE 120 / 2.52, opposed phase TR / TE 120 / 1.3, slice thickness 4 mm, gap 1 mm, flip angle 0 degrees, field of view (FOV) 450 mm^2.

Interpretation of post processing of images was conducted by two musculoskeletal expert radiologists with more than 5 years of experience and was performed blindly. To reduce bias, placement of the region of interest (ROI) was applied to the abnormal area at a sagittal section that was a round or oval 20-50 mm^2 ROI, was copied and placed in the bone marrow change compared to normal bone marrow at the same point in both the inphase and the opposed phase. Three ROIs were manually selected for each segment examined. ROI placement was compared with sequences of T1W, T2W DWI, ADC, or with contrast enhancement to avoid areas of necrosis and normal tissue around the tumor.

Data Analysis

The normality of the data was assessed using that is Shapiro–Wilk test. Since Shapiro–Wilk test indicated that the data was non-normal distribution, non-parametric tests were employed. To compare the signal intensity value in opposed phase and inphase, and SIR between the abnormal patient's group (benign and malignant) and the control group, Kruskal-Wallis test was used. The Mann Whitney U test was employed to compare between the benign and malignant patients.

Results

A total of 46 samples were included, 23 benign samples and 23 malignant samples. In addition, 20 control samples were also included as comparisons. Morphological characteristics of MRI vertebrate imaging of both groups (benign and malignant) are presented in **Table 1**. MRI imaging of patients from benign group characterized by multiple segment (48%), rim contrast enhancement (46%), paraspinal abscess (46%), and involvement of disc space (43%). The malignant group were dominated by involvement of pedicle and posterior column (48%), heterogenous contrast enhancement (41%), skip lesion (41%), and of multiple segment (41%). Involvement of pedicle and posterior column was more prevalent in malignant compared to benign vertebrate lesions.

Signal intensity in T1W, opposed phase and inphase in benign and malignant group were compared. Signal intensity on T1W, inphase and in opposed phase were normal from all patients from control group (**Table 2).**

In T1W, both of the benign and malignant groups had similar signal dominance, 39% and 30% hypointense, respectively. In opposed phase, there was difference in dominance between benign and malignant in which in benign group 43% was slight hyperintense while 41% was hyperintense signals in the malignant group. In phase, 30% and 37% of samples from benign and malignant group was hypointense, respectively; 17% and 33% were slightly hypointense, respectively (**Table 2**).

Table 1. Distribution data of morphological characteristics in conventional MRI

MRI morphology	Benign	Malignant
Gibbus deformity	12 (26%)	0 (0%)
Involvement of disc space	20 (43%)	0 (0%)
Paraspinal abscess	21 (46%)	0 (0%)
Multiple segment	22 (48%)	19 (41%)
Skip lesion	5 (11%)	19 (41%)
Epidural space	18 (39%)	11 (24%)
Convex posterior border	0 (0%)	14 (30%)
Involvement of pedicle and posterior column	0 (0%)	22 (48%)
Paraspinal soft tissue mass	0 (0%)	18 (39%)
Rim contrast enhancement	21 (46%)	0 (0%)
Heterogenous contrast enhancement	0 (0%)	19 (41%)

Kruskal-Wallis analysis suggested that the opposed phase signal intensity value and SIR were significantly higher in abnormal groups (benign and malignant) compared to control group ($p<0.001$ for both comparations). However, in phase signal intensity value was significantly higher in normal group compared to abnormal groups ($p=0.006$). The Mann-Whitney test was conducted to compare between benign and malignant groups and our data suggested that both signal intensity value of opposed phase (195.77 *vs.* 128.17) and SIR (1.13 *vs.* 0.95) were significantly higher in malignant lesions compared to benign lesions with $p=0.043$ and $p<0.001$ (**Table 2**).

Discussion

MRI examination is considered good modality to evaluate bone marrow and to distinguish benign and malignant lesions compared to biopsy. A study found that the accuracy of MRI was approximately 75% when compared to biopsy of about 80-90%.[5] However, due to difficulty in accessibility of the lesions during biopsy, MRI sometime is preferred. In the present study, the role of CSMRI was assessed as an alternative examination to diagnose benign and malignant lesions in vertebrate. Our data suggested that the opposed phase signal intensity value and SIR of CSMRI were different between benign and malignant vertebral lesions.

Both benign and malignant groups showed almost the same signal changes in T1W and inphase, while in the opposed phase it was seen a difference in dominance where the benign group was more present with slight hyperintense while the malignant group was more dominant with hyperintense signals (**Figure 1**).

Table 2. Comparison of signal intensity value of opposed phase, in phase, and SIR for normal and abnormal (benign and malignant) vertebral lesions

Indicator	Phase	Normal (±SD)	Abnormal		P-value	
			Benign (±SD)	Malignant (±SD)	Normal vs. abnormal	Benign vs. Malignant
Signal intensity	T1W	Normal (isointense) 100%	Hypointense 18 (39%)	Hypointense 14 (30%)	NA	NA
	Opposed phase	Normal (hypointense) 100%	Slight hyperintense 20 (43%)	Hyperintense 19 (41%)	NA	NA
	Inphase	Normal (isointense) 100%	Hypointense 14 (30%)	Hypointense 17 (37%)	NA	NA
			Slight hypointense 8 (17%)	Slight hypointense 15 (33%)	NA	NA
Signal intensity value	Opposed phase	73.97 (±47.16)	128.17 (±80.66)	195.77 (±62.03)	<0.001	0.043
	Inphase	221.68 (±110.22)	131.26 (±76.92)	173.96 (±89.97)	0.006	0.550
	SIR	0.37 (±0.15)	0.95 (±0.085)	1.13 (±0.097)	<0.001	<0.001

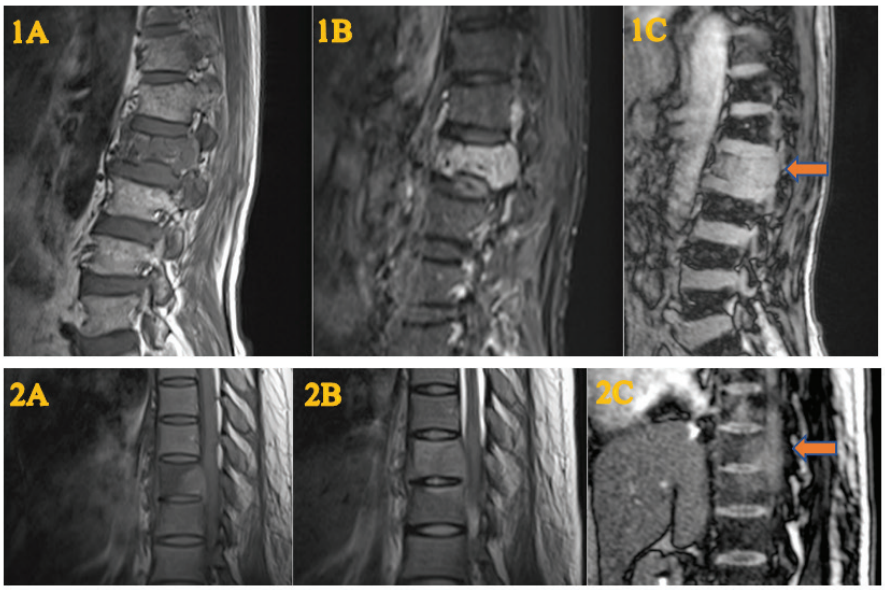

Figure 1. Lumbar MRI examination of malignant group patient (Panel 1) and thoracal MRI examination of benign group patient (Panel 2). (1A) shows hypointense in T1W sequence, (1B) hyperintense in T2 Fat

Sat; and (1C) hyperintense in the opposed phase, intensity of the lesion is similar with the intensity of the intervertebral discs. (2A) shows hypointense in T1W sequence, (2B) hyperintense on T2 Fat Sat; and (2C) slight hyperintense in the opposed phase, intensity of the lesion is slightly lower than the intensity of the intervertebral disc.

Our data suggested that the signal intensity values in opposed phase and SIR were higher in malignant lesion compared to benign vertebrate lesions. These findings are in line with previous studies[3,4,6] with slight variation of the values. The mean SIR value of the benign group in the present study was slightly higher than in the previous studies. This is probably because the variation of benign samples in previous studies was relatively wide compared to our study, including osteoporosis in which only small changes of fat-water imbalance occur.[3,4,6]

This study has some limitations. The number of samples was relatively small. Most of the lesion pathology in benign group were infectious process. A range of the benign processes might be required to increase the applicability of CSMRI in various non-infection benign processes. In addition, not all patients from malignant underwent biopsy due to difficulty in accessibility of the lesions and therefore had no histopathological examination from the vertebrate. However, most the patients were cancer patients with metastatic processes that have been proven by a histopathological biopsy from the primary location of the cancer elsewhere.

Conclusion

Our data suggest that two SCMRI parameters (opposed phase signal intensity values and SIR) are higher in malignant lesions compared to benign lesions in the vertebrates. This suggests that SCMRI is potentially be used to differentiate between benign and malignant lesions in vertebrates that could help for the diagnosis and proper management of patients with vertebrate lesions.

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Ethical Clearance: The protocol of this study was approved Institutional Ethics Committee, Faculty of Medicine, Airlangga University, Surabaya.

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