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ARAŞTIRMA / RESEARCH

The comparison of the efficacy of the single shot spin echo, Fiesta, and Propeller T2-weighted MRI sequences in the detection of focal liver lesions

Fokal karaciğer lezyonlarının saptanmasında single shot fast spin echo, Fiesta ve Propeller T2A MR sekanslarının etkinliklerinin karşılaştırılması

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Abstract

Purpose: The purpose of this study is to compare the signal characteristics of liver lesions and the difference between interpreters in magnetic resonance imaging (MRI) T2-PROPELLER, T2-FIESTA, and T2-SSFSE sequences.

Materials and Methods: This study was performed with upper abdominal MR images examined between January 2014-July 2016 at Adana Numune Training and Research Hospital were included in the study. Liver lesions with a diameter of 5 mm or more were taken into consideration, there was no upper limit on lesion size. Up to 4 lesions were evaluated in patients with more than one liver lesion. Focal liver lesions were categorized into 5 groups according to signal properties. The interpreters blindly evaluated the sequences, without priorly knowing if the patients had liver lesions or not.

Results: 301 lesions were included in the study. 63 (36%) of the patients were males, while 110 (64%) were females. The ages of the patients varied between 19 and 90 years. 40 (13.3%) of the lesions were malignant, while 261 (86.7%) were benign. Of the 301 lesions, 148 (49.2%) were hemangiomas, 90 (29.9%) were cysts, and 32 (10.6%) were metastases. In comparison of signal characteristics of lesions, the intraclass correlation coefficient of the repeated measurement analysis was found to be 0.962.

Conclusion: There was no significant difference in characterizing the signal characteristic of the lesions between the sequences.

Keywords:. Liver lesions, MRI, T2W, PROPELLER, FIESTA, SSFSE

Öz

Amaç: Bu çalışmanın amacı, karaciğer lezyonlarının manyetik rezonans görüntüleme (MRG) T2-PROPELLER, T2-FIESTA ve T2-SSFSE sekanslarında sinyal özelliklerinin ve değerlendiriciler arasındaki farkın karşılaştırılmasıdır.

Gereç ve Yöntem: Bu çalışma, Adana Numune Eğitim ve Araştırma Hastanesinde Ocak 2014-Temmuz 2016 tarihleri arasında çekimi yapılmış üst abdomen MR görüntüleriyle yapılmıştır. 5 mm ve daha büyük karaciğer lezyonları değerlendirilmiş, lezyon boyutunda üst sınır belirlenmemiştir. Birden fazla karaciğer lezyonu olan hastalarda en fazla 4 lezyon değerlendirmeye alınmıştır. Karaciğer fokal lezyonları sinyal özelliklerine göre 5 kategoride sınıflandırılmıştır. Değerlendiriciler, hastaların karaciğer lezyonu olup olmadığından habersiz olarak sekansları incelemiştir.

Bulgular: Çalışmaya 301 lezyon dahil edildi. Hastaların 63'ü (%36) erkek, 110'u (%64) kadındı. Hastaların yaşları 19 ile 90 yıl arasında değişmekteydi. Lezyonların 40'ı (%13,3) malign ve 261'i (%86,7) benign lezyonlardı. 301 lezyondan 148'i (%49,2) hemanjiom, 90'ı (%29,9) kist ve 32'si (%10,6) metastaz olarak saptandı. Lezyonların sinyal özelliklerinin karşılaştırılmasında, tekrarlı ölçümler analizinde sınıf içi korelasyon katsayısı 0,962 olarak bulundu.

Sonuç: Sekanslar arasında lezyonların sinyal özelliğini karakterize etmede anlamlı fark saptanmamıştır.

Anahtar kelimeler: Karaciğer lezyonları, MRG, T2A, PROPELLER, FIESTA, SSFSE

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INTRODUCTION

Benign and malignant lesions of the liver may well be imaged with ultrasonography (US) and computed tomography (CT), but MR imaging of liver lesions is a preferred modality of choice due to the superiority of MR in demonstrating a wide spectrum of signal properties originating from various lesions. Also, the lack of ionizing radiation and its superb contrast resolution, are the other superiorities of MRI[1,2]. Another advantage of MRI is that the contrast agents used in MR imaging possess much less toxic effects in comparison to the iodinated contrast media utilized in CT. Routine liver imaging with MR provides the characterization of focal liver lesions with a very high accuracy rate, thanks to the superior advantages of various sequences such as the T1W, T2W, and fat-suppressed sequences, and also the contrast-enhanced imaging technique[3].

However, in imaging with the conventional T2W sequence, patients are asked to hold breath for a while, but it creates serious problems in patients who cannot perform the task. Recently, some new T2W sequences have been developed to deal with such problems[2]. The purpose of our study is to compare the signal properties of focal liver lesions imaged with the various T2-weighted sequences assigned to the study plan, and look for any statistically significant differences among these sequences. These T2-weighted (T2W) sequences are the T2-PROPELLER, FIESTA, and SSFSE sequences. This will lead to an opinion on which T2W sequence is more effective and beneficial to use in liver imaging protocols. There are a limited number of studies on this subject in the literature, some of which are not up-to-date. We think that our study, which has been carried out with an up-to-date point of view with developing MRI techniques, will contribute to the literature.

MATERIALS AND METHODS

This retrospective study was performed with upper abdominal MR images which examined between January 2014-July 2016 at Adana Numune Training and Research Hospital. This hospital, where the study was conducted, was a Training and Research hospital, which has been providing specialty training in medicine for many years. Oral informed consent was obtained from the patients whose images were used. A document dated 02.12.2016 and numbered 59 was obtained from the Ethics Committee of Cukurova University Faculty of Medicine for the study. The planning of this study was based on the Helsinki Declaration, and an ethical committee approvement was obtained prior to the execution of the study.

Sample

During this study, images obtained from 637 upper abdominal dynamic MRI examinations were examined between January 2014 and July 2016. 301 lesions of 173 patients were evaluated in the study. Exclusion criteria in the images examined were poor image quality and incomplete diagnosis of the lesion.

MR Imaging

MR imaging of the patients were performed in a 1.5 Tesla scanner (General Electric Optima 360, Milwaukee – USA, 2014), by utilizing 16-channel phase array coils. The sequences used in the MR examinations and the imaging parameters are outlined in Table 1.

Table 1. Technical parameters used in the MR examinations

Parameters	**SSFSE T2W Coronal**	**PROPELLER FSE T2W Axial**	**FIESTA T2W Axial**
Obtained by	Breath - Hold	Free Inspiration	Breath - Hold
Fat Suppression	-	+/-	+/-
TR (ms)	657	7500	3
TE (ms)	70	112	1
b-value (s/mm²)	-	-	-
Slice thickness (mm)	5	5	5
Slice interval	1	1	1
Field of view (mm)	360-480	360-480	360-480
Matrix	288x192	288x224	288x192

SSFSE: Single shot fast spin echo, T2W: T2 Weighted, FIESTA: Fast imaging with steady state acquisition, TR: Time of repetition, TE: Time of echo

The images obtained from the MR examinations were evaluated by two radiologists and one senior radiology resident. The interpreters scored the focal liver lesions they detected in the liver, on a scale of from 1 to 5. This scoring was done on the basis of the signal characteristics of the lesions in comparison to that of the liver parenchyma, and it was structured as follows: (1) hypointense lesions, (2) isointense lesions, (3) slightly hyperintense lesions, (4) mildly hyperintense lesions whose brightness are less than those of the cerebrospinal fluid (CSF) and gallbladder, and (5) conspicuously hyperintense lesions whose brightness are equal to those of the CSF and gallbladder.

Statistical analysis

The IBM SPSS Statistics Version 20.0 Pocket Program was used for the statistical analysis of the data. Categorical measurements were defined as numbers and percentages, while numerical measurements were put as mean and standard deviation values (as the median and minimum – maximum values, when needed). The Shapiro Wilk Test was utilized in order to evaluate if the numerical measurements complied with the normal distribution assumption. The T Test was used for the comparison of the numerical measurements among the groups. The agreement between the two interpreters in every T2W sequence was evaluated by the Kappa statistics. The agreement among all of the interpreters in every T2W sequence, together with the agreement among all of the interpreters in all T2W seqences, were evaluated with the correlation coefficient (Intraclass Correlation Coefficient). The statistical significance level was set as 0.05 in all tests.

SPSS reference: IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.

RESULTS

The total number of lesions included in the study was 301. 63 (36 %) of the patients were males, while 110 (64 %) were females. The age range of the patients was 19-90 years (mean age being 52.9 years). 40 (13.3 %) of the patients had malignant, while 261 (86.7 %) had benign, lesions. Lesion diameters varied between 5 mm and 170 mm, the mean diameter value being 22.7 mm.

The distribution of the liver localizations of the lesions and their percentages are given in Tables 2 and 3, respectively.

The evaluation of the mean signal brightnesses of the lesions in respect to the sequences, done with the Student T – Test analysis, is given in Table 4.

The intraclass correlation coefficients obtained by the repeated measurements analysis done at the lesions evaluated by the three sequences are shown in Tables 5, 6, and 7. As can be seen from these tables, a high level of agreement was found among the interpreters.

The intraclass correlation coefficient obtained by the repeated measurements analysis done in this study, which was focused on the comparison of the signal properties of the T2 – PROPELLER, FIESTA, and SSFSE sequences in focal liver lesions, was found to be 0.962. As a result, no statistically significant difference was found among these 3 sequences, and all the 3 sequences showed a high level of agreement (Table 8).

Table 2. The distribution of focal liver lesions into the segments of the liver

		Number	Percentage (%)
Segment	2	39	13.0
	3	7	2.3
	4	29	9.6
	5	11	3.7
	6	76	25.2
	7	74	24.6
	8	65	21.6
	Sum	301	100.0

Table 3. The distribution of the varieties of the liver lesions according to their diagnoses

		Number	Percentage (%)
Diagnosis	Cyst	90	29.9
	Hemangioma	148	49.2
	Metastasis	32	10.6
	HCC	8	2.7
	Hydatid cyst	15	5.0
	FNH	5	1.7
	Abscess	1	0.3
	Adenoma	1	0.3
	Dysplastic nodule	1	0.3
	Sum	301	100.0

Table 4. The signal brightness mean values of the liver lesions on the 3 T2W sequences

	Malignancy - Benignity	Number	Mean	Standard Deviation
FIESTA	Benign	261	4.06	0.715
	Malignant	40	2.80	0.564
SSFSE	Benign	261	4.14	0.688
	Malignant	40	2.73	0.716
T2 TSE	Benign	261	4.11	0.692
	Malignant	40	2.78	0.698
Matrix	288x192		288x224	288x192

FIESTA: Fast imaging with steady state acquisition, SSFSE: Single shot fast spin echo, TSE: Turbo spin echo

Table 5. The agreement among the interpreters at the FIESTA sequence

Intraclass Correlation Coefficient	Intraclass Correlation	95 % Confidence Interval	
		Lower Limit	Upper Limit
Single Measurement	0.693	0.648	0.735
Mean Measurement	0.900	0.880	0.917

FIESTA: Fast imaging with steady state acquisition

Table 6. The agreement among the interpreters at the Coronal T2 - SSFSE sequence

Intraclass Correlation Coefficient	Intraclass Correlation	95 % Confidence Interval	
		Lower Limit	Upper Limit
Single Measurement	0.677	0.631	0.721
Mean Measurement	0.893	0.872	0.912

SSFSE: Single shot fast spin echo

Table 7. The agreement among the interpreters at the T2 - PROPELLER sequence

Intraclass Correlation Coefficient	Intraclass Correlation	95 % Confidence Interval	
		Lower Limit	Upper Limit
Single Measurement	0.688	0.643	0.731

Table 8. The agreement among the interpreters at the T2 – PROPELLER, FIESTA, and SSFSE sequences

Intraclass Correlation Coefficient	Intraclass Correlation	95% Confidence Interval	
		Lower Limit	Upper Limit
Single measurement	0.680	0.642	0.717
Mean measurement	0.962	0.956	0.968

FIESTA: Fast imaging with steady state acquisition

DISCUSSION

MRI is a very valuable tool in the imaging of liver lesions. The T1-weighted (T1W) sequences are more sensitive in depicting the anatomic detail, while the T2W sequences are better in differentiating pathologic signals from normal ones[4,5].

As is the situation in various other anatomical regions of the body, in the MR imaging of the liver and liver lesions, too, the basic MR sequences are the T1W and T2W ones. But supplemental sequences such as FIESTA, SSFSE, and T2-PROPELLER, may well be added to the protocol in order to enhance the effectivity of MR imaging. These sequences have proved to be very effective in the evaluation of many benign and malignant liver lesions, but it must not be forgotten that they, alone, are not always sufficient to detect and evaluate liver lesions.

In our study, we had the purpose of delineating the lesion characterization capabilities of these sequences and also comparing their efficacies. A study done by Christoph et al. revealed that both the SSFSE and FIESTA techniques had high diagnostic value both in the detection and characterization of liver lesions. Our study demonstrated that, although statistically not significant, the SSFSE sequence had some advantages over FIESTA, in terms of characterization of hemangiomas[6]. But still it was not possible to justify, on the sole basis of these data, that the SSFSE sequence is superior to FIESTA, in the process of characterization of focal liver lesions.

MR is a very reliable means of detecting and characterizing focal liver lesions. The T2W series have always been known to be sequences of high reliability and effectivity, both in the detection and characterization of liver lesions. In this aspect, the exceptional speed of SSFSE comes out as a big advantage[7,8].

A technique named Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction (PROPELLER) has been developed in order to prevent motion artefacts during MR examinations of the upper abdomen[9]. In this technique, colliding and overlapping images are reconstructed to create new images[10]. High resolution capability, absence of ghost artefacts, and the clear-cut sharp contour images of the liver are the supreme properties of the PROPELLER sequence over the other T2W sequences[11]. On the other hand, its rather long duration of imaging is its disadvantage. In our study, no statistically significant difference was found among the T2-PROPELLER, FIESTA, and SSFSE sequences, and a high level agreement was found among these techniques, in terms of characterization of focal liver lesions. In a study done bu Mc Farland et al, too, no statistically significant differences were found among these sequences, in the process of characterizing these lesions[12]. The SSFSE and FIESTA sequences may be preferred to the T2-PROPELLER sequence in order to shorten scan times, but on the other hand, PROPELLER may be the choice in patients having difficulty in breath holding.

Studies have shown that the SSFSE sequence is at least equal to or even better than the T2W-FSE sequence in terms of lesion detection[13,14]. Besides, studies show that SSFSE makes very good delineation of cystic versus solid liver lesions[15]. It has been demonstrated in various studies that SSFSE is superior to T2W-FSE in terms of anatomic resolution and lesion discrimination[16]. On the other hand, there are studies indicating that SSFSE sequence shows poor performance in detecting solid hepatic lesions.[17] When compared to other studies done, no superiorities of any one of the sequences studied, over another, was found in our study. Thus, it must be kept in mind that these results may be due to various technical parameters. While the TE value was chosen as 70 ms in our SSFSE sequence, some other studies have this value as 60, 80, and 120 ms[6,16,18].

Various studies in the literature have put out that both the SSFSE and FIESTA sequences are successful in the detection of benign liver lesions, but they are not as good in malignant lesions. Again, it has been shown in various studies, that the FIESTA sequence is less sensitive than the SSFSE sequence in terms of malignant lesion detection, even though this difference was not found to be statistically significant. This finding has been attributed to the rather weak character of T2W in the FIESTA sequence. Thus, the use of FIESTA instead of SSFSE has not been suggested[6]. In our study, no statistically significant differences were found among the FIESTA, SSFSE, and T2-PROPELLER, sequences, in terms of demonstration of lesion signal intensities in malignant liver lesions.

The relatively low number of malignant lesions, the fact that the FIESTA sequence was utilized with fat suppression in some patients while it was run without fat suppression in some others, and the utilization of

the SSFSE sequence in the coronal plane, may be listed as the restrictive factors of our study.

In this study, we compared the signal properties of the T2-PROPELLER, FIESTA, and SSFSE sequences. As a result, no statistically significant differences were found among the three sequences in this aspect, and no dominancy of any one of these sequences over another was found in terms of characterization of the signal properties of the lesions. But it must be noted that the FIESTA and SSFSE sequences may be substituted for the T2-PROPELLER sequence in order to shorten scan times.

There is not an enough number of studies in the literature in which all of the three sequences of FIESTA, SSFSE, and T2-PROPELLER are compared against each other in terms of evaluation of focal liver lesions. Thus, we conclude that further studies are needed to support our findings.

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