An investigation into the differentiation of hepatic hydatid and simple cysts via diffusion-weighted MRI

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Abstract

Background and objective: As opposed to simple hepatic cysts (SHC) that are benign, hydatid hepatic cysts are associated with serious complications such as bacterial infection, anaphylactic shock, and spread of new cysts. However, both simple and hydatid cysts are asymptomatic and diagnosed accidentally. The present study was carried out in order to investigate the capacity of diffusion-weighted magnetic resonance imaging (DW-MRI) in differentiating hepatic hydatid and simple cysts among patients who referred to Azadi Teaching Hospital in Duhok, the Kurdistan Region of Iraq from October 2017 to April 2018.

Materials and methods: Performing DW-MRI on 60 patients led to diagnosis of 108 cysts (16 completely liquid (CL) hydatid cysts, 14 cystic echinococcosis CE1, 10 CE2, 17 CE3, 15 CE4, and 36 simple hepatic cysts), and apparent diffusion coefficients (ADCs) were measured. A comparison between the signal intensity on the cysts and the liver was carried out by employing a 3-point scale (0=hypointense, 1= isointense, & 2=hyperintense). The results of the diagnosis were supported by surgery and/or ELISA test. Mean and standard deviation of different types of cysts using DW-MRI (b=0, 400, and 800) were calculated using SPSS 22.0, and the results were presented in tables and diagrams.

Results: According to the results of DW-MRI (b=0, 400, and 800), most of the cysts were hyperintense. Moreover, the results of comparing mean DW cyst at b0, b400, and b800 among types of hepatic cysts showed that CE2 and CE4 had the highest prevalence. Also, comparing mean DW cyst to parenchyma ratio at b0, b400, and b800 among types of hepatic cysts revealed that the highest prevalence belonged to CE3 and CE4. Moreover, comparison of mean ADC cyst at b0 and b800 among types of hepatic cysts showed the highest prevalence for CE3 and CL. Finally, comparing mean ADC cyst to parenchyma ratio at b0 and b800 among types of hepatic cysts revealed the highest prevalence for CL and SHC.

Conclusion: According to the results of the present study, it can be stated that DW-MRI may have the capacity to differentiate between hepatic hydatid and simple cysts.

Key words: hepatic hydatid cysts, hepatic simple cysts, diffusion-weighted MRI, apparent diffusion coefficient

Table 1: Classification of hydatid cysts based on Gharbi and WHO-Informal Working Group of Echinococcosis (WHO-IWGE)

Gharbi	WHO	Ultrasonography characteristics
-	CL	Unilocular cyst, anechoic, no wall depicted
Type I	CE1	CL characteristics + wall + mobile internal echogenicities
Type II	CE2	Multivesicular, multiseptated cyst, daughter cysts, honeycomb pattern
Type III	CE3	Detached-floating membrane (water-lily sign)
Type IV	CE4	Heterogeneous hypo/hyperechoic cyst, no daughter cyst
Type V	CE5	Cyst with a partial or complete wall calcification

Introduction and Background

The general prevalence of hepatic cysts, as indicated by research, is about 5% all over the world, which rises with age, particularly after the age of 80 [1,2]. Cystic lesions involving the liver may be classified into developmental, neoplastic, inflammatory, and miscellaneous lesions. Because the clinical presentations and management strategies of cystic liver lesions differ significantly according to their causes, the need to differentiate non-invasively different types of cysts is extremely important [3,4]. It should also be noted that hydatid cysts cause serious complications such as bacterial infection, anaphylactic shock, and spread of new cysts [5].

As a zoonotic infection caused by the larvae of cestodes of the genus Echinococcus, hydatid cysts usually afflict the lungs and liver and can cause chronic disease and death if they are not diagnosed early and managed efficiently [6].

Based on their sonographical characteristics, hydatid cysts are classified into 5 groups (See Table 1) [7, 8]. According to this classification, 25 to 40% of hydatid cysts fall into type 1 which are almost indistinguishable from simple cysts because they have sonographic similarity [9].

Since both types of cysts are asymptomatic, they are mostly diagnosed incidentally through imaging technologies including computed tomography (CT) scan, ultrasound (US), and magnetic resonance imaging (MRI) [8]. US has been introduced as the gold standard method to diagnose and determine the number, placement, and size of cysts [7]. However, this method cannot detect cysts until they form their wall and become completely solid, which practically restricts its capacity to detect cysts in their early stage because cysts are liquid in initial stages [11]. Therefore, the results of US depend on the maturity of the cysts [9].

On the other hand, due to high contrast resolution on images obtained from conventional MRI, it is introduced as a helpful method to differentiate different types of hydatid cysts particularly CE1, CE2, and CE3; however, liquid hydatid cysts and simple cysts are difficult to distinguish from each other through this method [12]. Recently, diffusion-weighted magnetic resonance imaging (DW-MRI) has been introduced to be useful in distinguishing simple cysts from liquid hydatid cysts because it can measure intracellular water molecules and extracellular and intravascular movements [13]. Through ADC values calculated based on the images obtained from DW-MRI using different b factors (the gradient strength and time), it is possible to carry out quantitative analysis of the images of the cysts [14].

The present study was an experiment to check the capacity of DW-MRI in differentiating hepatic hydatid and simple cysts among patients who referred to Azadi Teaching Hospital in Duhok, the Kurdistan Region of Iraq from October 2017 to April 2018.

Materials and Methods

The present cross-sectional study was carried out on 60 patients (23 men and 37 women) who had referred to the radiology department of the Hospital in Duhok, the Kurdistan Region of Iraq from October 2017 to April 2018. Following relevant examinations, a total of 108 cysts (36 simple cysts and 72 hydatid cysts except for CE5) were included.

In the beginning and before the initiation of the examinations, written informed consent was taken from each patient, and those patients who had contraindications to MRI (due to claustrophobia) or had undergone treatment or surgery for hydatid disease were excluded from the study. Other exclusion criteria were solid liver lesions, type-5 hydatid cyst (CE5) due to the effect of it calcific content on DWI, and cyst diameter less than 1 cm.

First, ultrasound was carried out for all of the patients, and the detected hydatid cysts were classified based on their radiological characteristics according to the WHO-IWGE classification presented in Table 1 above. Afterwards, DW-MRI was conducted with a 1.5 tesla MR unit (Achieva, Philips medical systems).

For DW-MRI, axial non-breath holding (NBH) spin echo planar EPI DW images were obtained with sensitivity encoding SENSE at three different b values (0, 400 and 800 s/mm²). Afterwards, those images were utilized to generate ADC maps. In addition, a comparison between the signal intensity on the cysts and the liver was carried out by employing a 3-point scale (0=hypointense, 1= isointense, & 2=hyperintense).

In order to analyze the collected data, a region of interest (ROI) was generated and placed in the center of the cysts in order to measure the signal intensities of the cysts for

each b factor (i.e. 0, 400, and 800 s/mm2). Afterwards, ADC maps were created, and the mean ADC values were measured. The statistical analysis was carried out through SPSS 22.0. In so doing, different groups were compared regarding the ratio of cysts signal intensity and cyst/parenchyma signal intensity and the ratio of cyst ADC and cyst/parenchyma ADC. Mean ± standard deviation was employed to present the DW trace and ADC values.

Afterwards, Kruskal Wallis variance and the Mann-Whitney U test were utilized to analyze the differences of DW cysts signal intensity, cyst/parenchyma signal intensity ratio, cyst ADC and cyst/parenchyma ADC ratio. The level of statistical significance was set at $p<0.05$.

Results

The present study was carried out on 62 patients (23 men and 37 women) with hydatid cysts and simple hepatic cysts. The patients were aged from 10 to 64 years. A total number of 108 cysts were included in the study. According to the results, the median number of cysts per each patient was 1, with a range from 1 to 9 cysts per patient. The results revealed 16 completely liquid (CL) hydatid cysts, 14 cases of cystic echinococcosis CE1, 10 cases of CE2, 17 cases of CE3, 15 cases of CE4, and 36 simple hepatic cysts. The results also showed that 88% of the lesions were seen in the right lobe of liver, 18% in the left lobe, and 2% in the caudate lobe. It was also observed that the smallest and largest diameters were 1.3 and 11 cm, respectively (See Table 2).

Comparing the signal intensities on the cysts and the liver using DW quality b0 showed that 100% of the signals of the cysts were hyperintense. According to DW quality b400, it was seen that 2, 11, and 87% of the signals of the cysts were respectively hypointense, isointense, and hyperintense. Also, based on analysis using DW quality b800, 25, 5, and 70% of the signals of the cysts were respectively hypointense, isointense, and hyperintense (See Table 1).

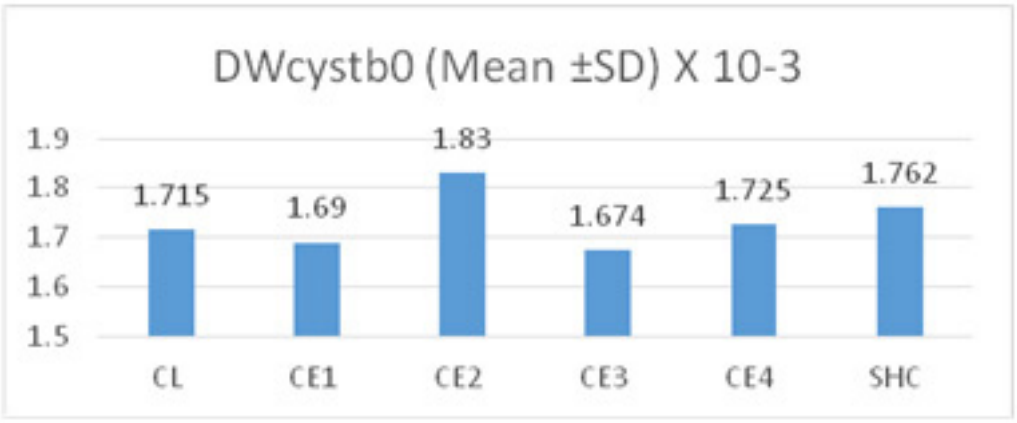
The quantitative results of the present study indicated that mean DW signal intensities of liver parenchyma at b0, b400, and b800 s/mm² were respectively $0.617\pm0.203\ X10^{-3}$, $0.290\pm0.156\ X10^{-3}$, and $0.175\pm0.061\ X10^{-3}$. Moreover, the mean ADC signal intensities of liver parenchyma at b0 and b800 s/mm² were respectively $1.334\pm0.421\ X10^{-3}$ and $0.358\pm0.259\ X10^{-3}$ (See Table 2).

Table 2: Demographic characteristics

Characteristic	Value
Number of patients	60
Number of cysts	108
Age	(10-64)
Gender (Male /Female)	23 / 37
Number of Cyst/ patients (Median) (range)	1 (1-9)
Cyst type	
Completely liquid (CL) hydatid cyst	16
Cystic echinococcosis CE1	14
CE2	10
CE3	17
CE4	15
Simple hepatic cyst	36
Site Rt lobe/Lt lobe/ caudate	88/ 18/ 2
Size (minimum diameter) cm	1.3
Size (maximum diameter) cm	11
DW quality b0 (hypo/iso/hyper)	0/0/100
DW quality b400 (hypo/iso/hyper)	2/11/87
DW quality b800 (hypo/iso/hyper)	25/5/70
DW P b0 (Mean ±SD) X 10^{-3}	0.617 ±0.203
DW P b400 (Mean ±SD) X 10^{-3}	0.290 ±0.156
DW P b800 (Mean ±SD) X 10^{-3}	0.175 ±0.061
ADC P b0 (Mean ±SD) X 10^{-3}	1.334 ±0.421
ADC P b800 (Mean ±SD) X 10^{-3}	0.358 ±0.259

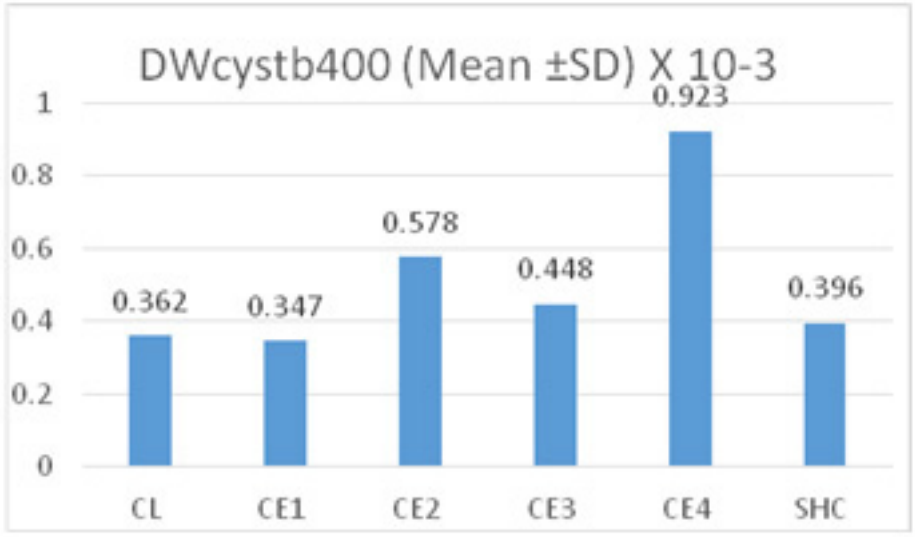
Figures 1 to 10 present the results of comparing mean DW and ADC signal intensities. Moreover, Kruskal Wallis test was run to carry out the overall comparisons. Also, Mann Whitney U test was used to compare two types of cysts. Comparing mean DW cyst signal intensities at b0 s/mm² factor showed that there was no significant difference between types of cyst (p>0.05) (See Figure 1).

Figure 1: Comparison of mean DW cyst at b0 among types of hepatic cysts



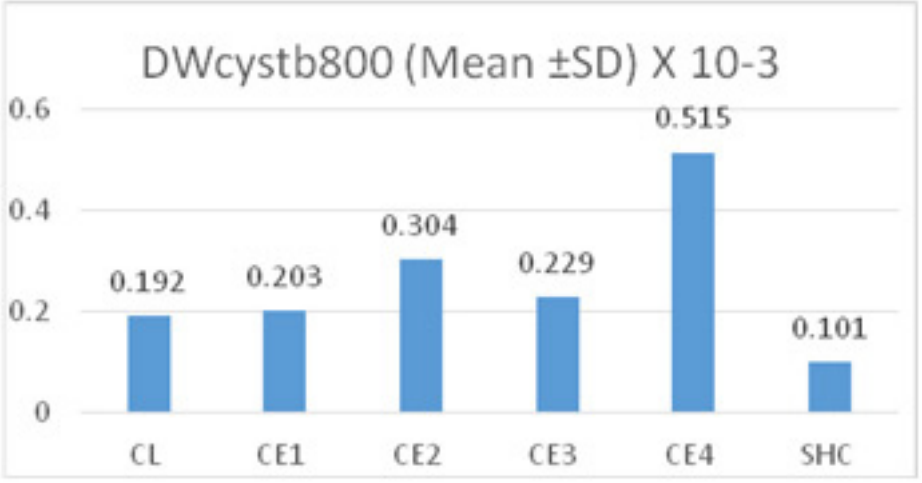
Comparing mean DW signal intensities at 400 s/mm2 was successful in differentiating CE4 and CE2 from other types of hydatid cyst and from simple hepatic cysts (SHC); however, SHC could not be differentiated from CL hydatid cysts (See Figure 2).

Figure 2: Comparison of mean DW cyst at b400 among types of hepatic cysts



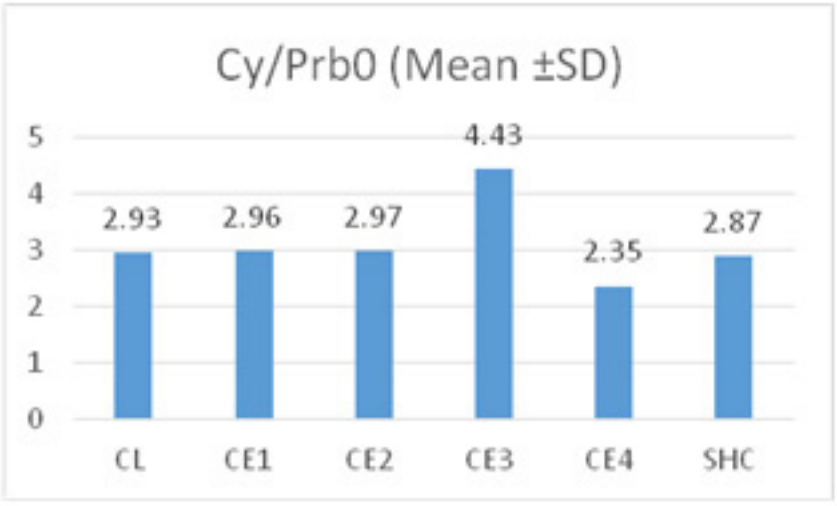
Also, mean intensity of DW signal at b800 s/mm2 could successfully differentiate CE4 and CE2 from other hydatid cysts. However, it failed to differentiate SHC from CL hydatid cyst (See Figure 3).

Figure 3. Comparison of mean DW cyst at b800 among types of hepatic cysts



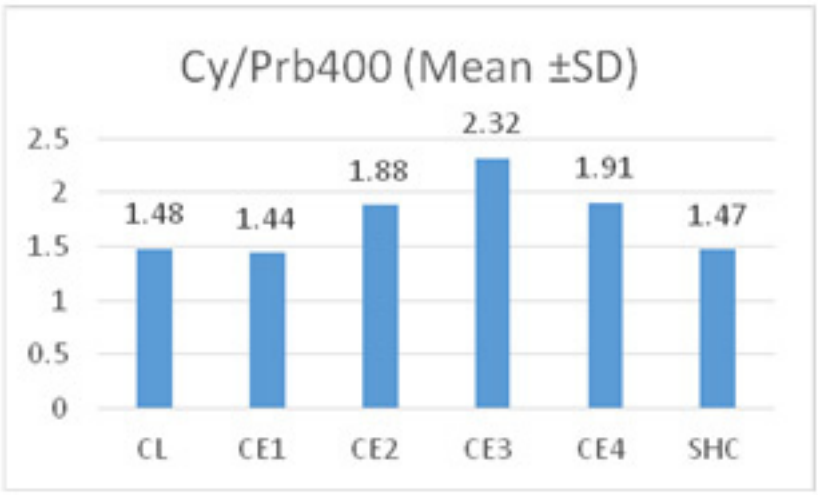
The results also showed that the mean signal intensity cyst/parenchyma ratio and b0 s/mm^2 could only differentiate CE3 from other hydatid cysts types, but it could not differentiate between SHC and CL hydatid cyst (See Figure 4).

Figure 4: Comparison of mean DW cyst to parenchyma ratio at b0 among types of hepatic cysts



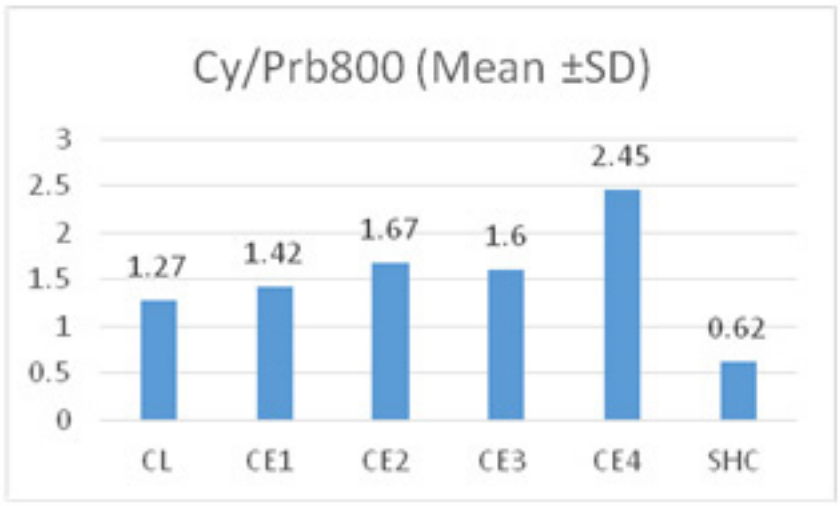
Moreover, CE3, CE2, and CE4 could successfully be differentiated from other types of hydatid cysts through the mean signal intensity cyst/parenchyma ratio and b400 s/mm^2. It failed to differentiate SHC from CL (See Figure 5).

Figure 5: Comparison of mean DW cyst to parenchyma ratio at b400 among types of hepatic cysts



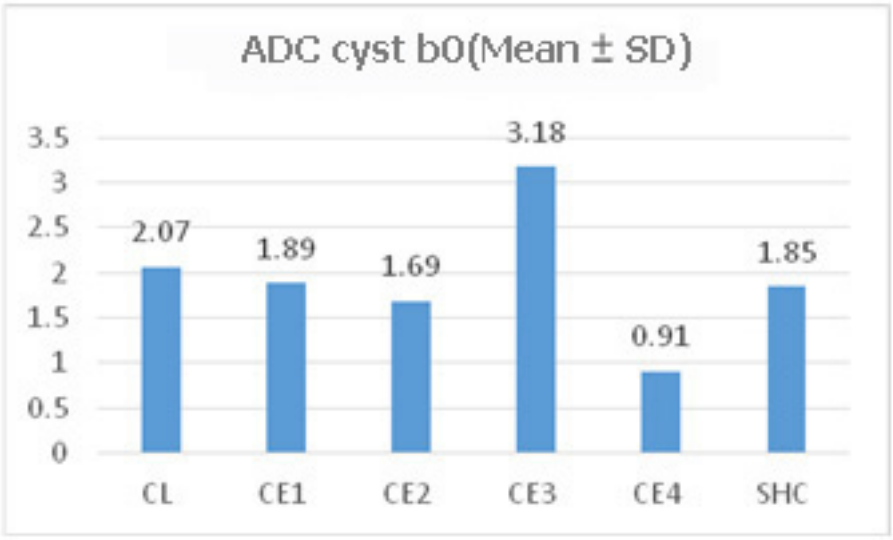
The mean signal intensity cyst/parenchyma ratio and b800 s/mm^2 could successfully differentiate SHC from all other types of hydatid cysts (Figure 6).

Figure 6: Comparison of mean DW cyst to parenchyma ratio at b800 among types of hepatic cysts



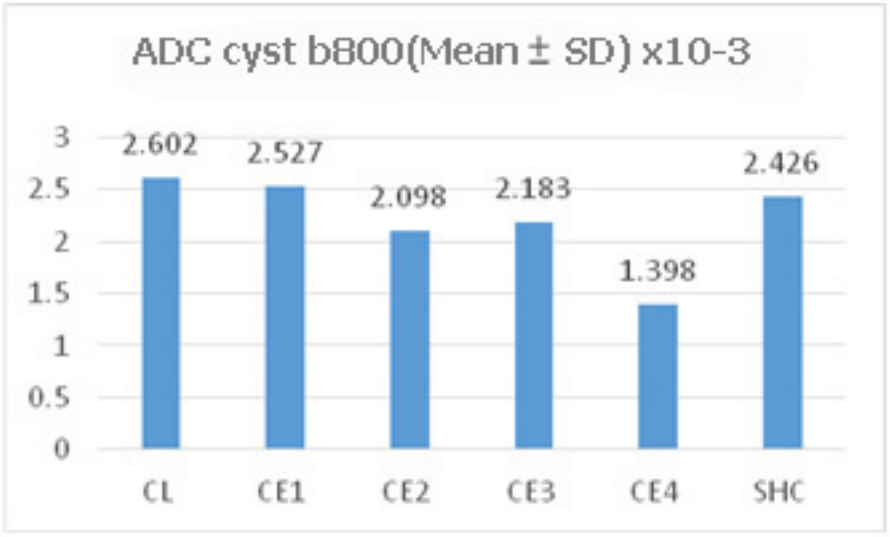
The results also indicated that at b0 s/mm^2 mean ADC signal intensity of cysts and cyst/parenchyma ADC ratio could successfully differentiate CE3 and CE4 from other hydatid cyst types but failed to differentiate SHC from CL (See Figure 7).

Figure 7: Comparison of mean ADC cyst at b0 among types of hepatic cysts



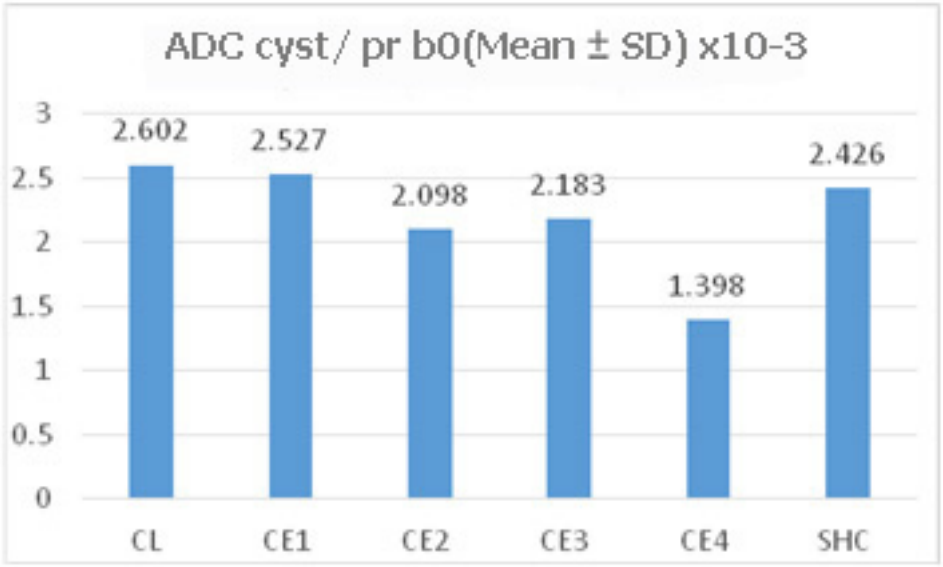
Moreover, mean ADC signal intensity at b800 s/mm^2 factor was successful in differentiating CE4 from other hydatid cysts and CL hydatid cyst from SHC (See Figure 8).

Figure 8: Comparison of mean ADC cyst at b800 among types of hepatic cysts



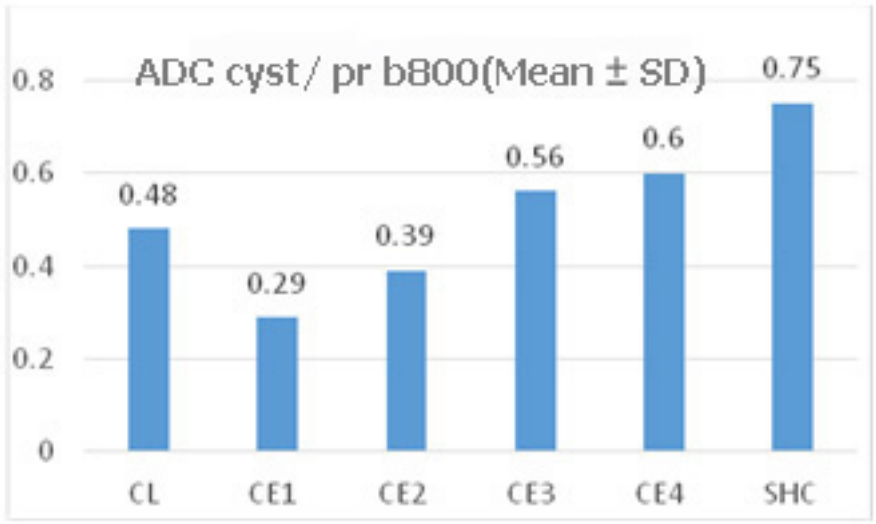
In addition, mean ADC cyst to parenchyma ratio at b0 s/mm^2 factor could CE3 and CE4 from other hydatid cyst types but failed to differentiate SHC from CL (See Figure 9).

Figure 9: Comparison of mean ADC cyst to parenchyma ratio at b0 among types



Finally, mean ADC cyst to parenchyma ratio at b800 s/mm^2 factor could differentiate CE4 from other hydatid cysts and CL hydatid cyst from SHC (See Figure 10).

Figure 10: Comparison of mean ADC cyst to parenchyma ratio at b800 among types of hepatic cysts



In line with the figures presented above, Table 3 (next page) presents the mean and standard deviation of DW and ADC and ratios among all types of cysts.

Table 3: The mean and standard deviation of DW and ADC and ratios among all types of cysts

Parameter	CL	CE1	CE2	CE3	CE4	SHC
DWcystb0 (Mean ±SD) X 10^{-3}	1.715 ±0.417	1.690 ±0.403	1.830 ±0.304	1.674 ±0.566	1.725 ±0.487	1.762 ±0.373
DWcystb400 (Mean ±SD) X 10^{-3}	0.362 ±0.065	0.347 ±0.056	0.578 ±0.420	0.448 ±0.116	0.923 ±0.625	0.396 ±0.144
DWcystb800 (Mean ±SD) X 10^{-3}	0.192 ±0.037	0.203 ±0.034	0.304 ±0.325	0.229 ±0.037	0.515 ±0.298	0.101 ±0.021
Cy/Prb0 (Mean ±SD)	2.93 ±0.78	2.96 ±0.70	2.97 ±0.65	4.43 ±3.98	2.35 ±0.57	2.87 ±0.63
Cy/Prb400 (Mean ±SD)	1.48 ±0.45	1.44 ±0.38	1.88 ±1.12	2.32 ±1.18	1.91 ±0.63	1.47 ±0.49
Cy/Prb800 (Mean ±SD)	1.27 ±0.54	1.42 ±0.37	1.67 ±1.67	1.60 ±0.76	2.45 ±1.22	0.62 ±0.29
ADCcystb0 (Mean ±SD) X 10^{-3}	2.602 ±0.595	2.527 ±0.547	2.098 ±0.806	2.183 ±0.564	1.398 ±0.566	2.426 ±0.525
ADCcystb800 (Mean ±SD) X 10^{-3}	0.157 ±0.178	0.078 ±0.032	0.155 ±0.167	0.137 ±0.115	0.228±0.076	0.220 ±0.086
ADC Rb0 (Mean ±SD)	2.07 ±0.46	1.89 ±0.28	1.69 ±0.87	3.18 ±3.65	0.91 ±0.60	1.85 ±0.59
ADC Rb800 (Mean ±SD)	0.48 ±0.43	0.29 ±0.07	0.39 ±0.37	0.56 ±0.49	0.60 ±0.47	0.75 ±0.19

Figure 1 (below) DW MRI image & Figure 2 (below) corresponding ADC map of a case from this study of a 10-year-old female with hepatic hydatid cyst, shows restricted diffusion. Selection of the ROI for measurement of the signal intensity of the cyst is also shown.

Figure 1

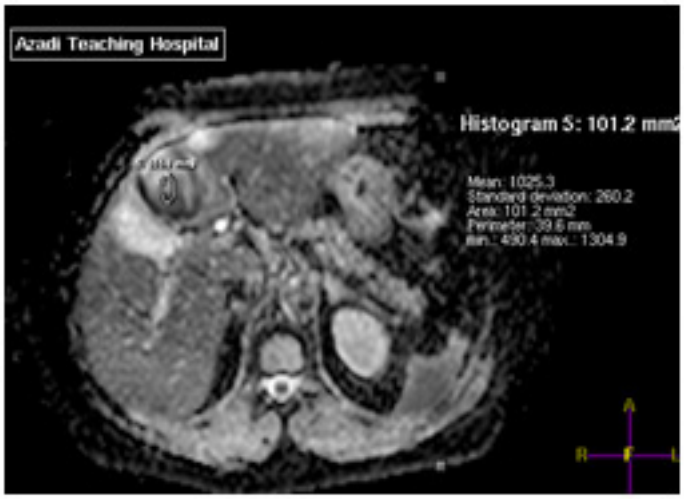
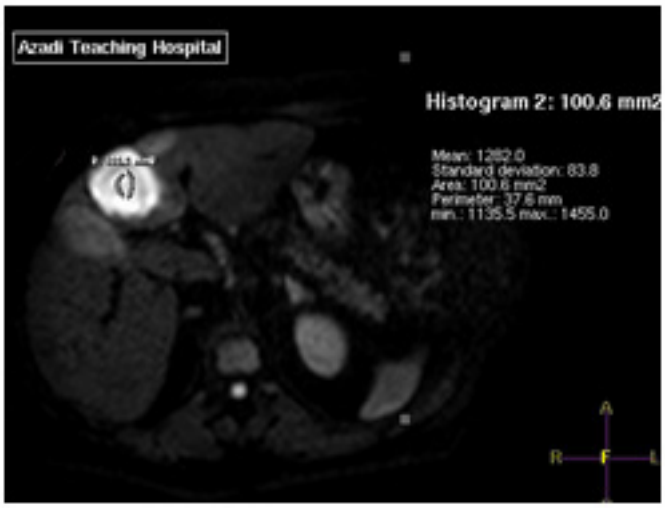


Figure 2



Discussion

According to the results of research studies, cystic echinococcosis (CE) is one of the most important parasitic diseases which threatens human health all over the world. Ultrasound as the gold standard method to detect cysts fails to differentiate different types of CE and completely liquid (CL) hydatid cysts from simple hepatic cysts (SHC) [7]. In these cases conventional MRI and diffusion-weighted MRI come to be quite useful [13]. In this regard, the present study was an attempt to investigate the capacity of diffusion-weighted magnetic resonance imaging (DW-MRI) in differentiating hepatic hydatid and simple cysts.

The results of the present study showed that the average ADC values of normal liver parenchyma at b0 and b800 factors were respectively 1.334±0.421 X10-3 and 0.358±0.259 X10-3, which proved that the ADC values were significantly different at different b factors. This finding proves that ADC values vary with different b factors (especially at minimum and maximum b factors). Similar results were reported by Yamada et al [15].

Moreover the results of the current experiment indicated that the signal intensity of the images obtained from DW-MRI of different types of cysts successfully differentiated types of hydatid cysts from simple hepatic cysts (SHCs) at b800 factor. This finding is in complete agreement with the results of the study carried out by Inan et al [16]. Also, as indicated by the results of the present study, completely liquid (CL) hydatid cysts could successfully be differentiated from simple hepatic cysts (SHC) through ADC values at b800 factor. This finding was in line with those of the studies conducted by Inan et al and Oruç et al [17, 18]. However, as seen above, ADC values could not differentiate between CL hepatic cysts and simple hepatic cysts at b0 and b400 factors, which is in line with previous studies [17, 18].

Study Limitations

The present study had one limitation which was related to using the echo-planar sequence with a higher b value and a lower SNR which might have led to greater image distortion.

Recommendations

In the present study, the echo-planar sequence was utilized, which may have caused anatomic distortion as a result of its susceptibility effects; therefore, future studies are recommended to employ a single-shot spin-echo echo-planar sequence with ECG triggering in order to minimize cardiac pulsation effect. Moreover, in the present study, the ADC values were measured manually, which may include a degree of subjectivity; therefore, utilization of computerized method of ROI demarcation is advised in future studies.

Conclusion

In conclusion, ADC values obtained from DW-MRI images can be helpful to differentiate type-4 hepatic cysts from other cysts and from simple cysts. The can also be utilized to differentiate between completely liquid (CL) hydatid cysts and simple hepatic cysts (SHC).

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