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WORD COUNT 4441
TIME SUBMITTED 09-OCT-2022 05:37PM
PAPER ID 91365438

Name of Journal: *World Journal of Radiology*
Manuscript NO: 78598
Manuscript Type: ORIGINAL ARTICLE

Retrospective Study

Diagnostic Efficacy of Diffusion, Semiquantitative and Quantitative Dynamic Contrast-Enhanced Magnetic Resonance Imaging in Salivary Gland Tumors

Diagnostic Efficacy Diffusion, Semiquantitative and Quantitative DCE MRI in SGTs

Abstract

BACKGROUND

Increasing use of functional magnetic resonance imaging (MRI) methods such as diffusion-weighted imaging (DWI) and dynamic contrast-enhanced (DCE) MRI consisting of sequential contrast series, which allow us to have more information about the microstructure, cellularity, interstitial distance and vascularity of tumors, have increased the discrimination power for benign and malignant salivary gland tumors (SGTs). In the last few years, quantitative DCE MRI data containing T1 perfusion parameters (K_{trans}, $K_{ep,}$ and V_e), which were reported to contribute to the differentiation of benign or malignant subtypes in SGTs, have been reported.

AIM

In the present study, diagnostic efficacies of DWI, semiquantitative and quantitative perfusion MRI parameters were evaluated in SGTs.

METHODS

Diffusion MRI (Apparent diffusion coefficient - ADC value) with a 1.5 T MR machine, semiquantitative perfusion MRI (Time intensity curve - TIC pattern) and perfusion MRI examinations (K_{trans}, $K_{ep,}$ and V_e) of 73 tumors of 67 patients with histopathological

diagnosis performed in 2017-2021 period were retrospectively evaluated. In ADC value and semiquantitative perfusion MRI measurements, cystic components of the tumors were not considered, and the region of interest (ROI) was manually placed through the widest axial section of the tumor. TIC patterns were divided into four groups: type A = T_{peak} > 120 s; type B = T_{peak} ≤ 120 s, washout ratio (WR) ≥ 30%; type C = T_{peak} ≤ 120 s, WR < 30%; and type D = flat TIC. For the quantitative perfusion MRI analysis, 3D ROI was placed in the largest solid component of the tumour, and the K_{trans}, $K_{ep,}$ and V_e values were automatically generated.

RESULTS

Majority of the SGTs were located in parotid glands (86.3%). Of all SGTs, 68.5% were benign and 31.5% were malignant. Significant differences were found for ADC values among pleomorphic adenomas (PMAs), Warthin's tumors (WTs) and malignant tumors (MT) (P < 0.001). PMAs had type A and WTs had type B TIC pattern while the vast majority of MTs and other benign tumors (OBTs) (54.5 and 45.5%, respectively) displayed type C TIC pattern. PMAs showed no washout, while the highest mean WR was observed in WTs (59% ± 11). K_{trans} values of PMAs, WTs, OBTs and MTs were not significantly different. K_{ep} value of PMAs and WTs were significantly different from those of OBTs and MTs. Mean V_e values of WTs were significantly different from those of PMAs, OBTs and MTs (P < 0.001).

CONCLUSION

The use of quantitative DCE parameters along with diffusion MRI and semiquantitative contrast-enhanced MRI in SGTs could improve the diagnostic accuracy.

Key Words: Diffusion-weighted imaging; Dynamic contrast-enhanced imaging; Magnetic resonance imaging; Perfusion imaging; Salivary gland tumor; Tumor

Gökçe E, Beyhan M. Diagnostic Efficacy of Diffusion, Semiquantitative and Quantitative Dynamic Contrast-Enhanced Magnetic Resonance Imaging in Salivary Gland Tumors. *World J Radiol* 2022; In press

Core Tip: In this study, diagnostic features of DWI and semiquantitative and quantitative perfusion MRI parameters were evaluated in salivary gland tumors (SGTs). The ADC values of pleomorphic adenomas (PMAs) were significantly higher than the ADCs of Warthin's tumors (WTs), other benign tumors (OBTs) and malignant tumors (MTs). On semiquantitative MRI, PMAs were distinguished from all other tumors by their long T_{peak} times and lack of washout. WTs had the shortest T_{peak} and highest washout ratio values. For quantitative perfusion MRI parameters, K_{ep} value of WTs was significantly higher than other tumors. For V_e value, WTs and OBTs differed significantly from PMAs and MTs.

INTRODUCTION

Salivary gland tumors (SGTs) account for about 2.0-6.5% of all head and neck tumors. Approximately 70% of them originate from parotid glands, but a smaller part is of submandibular, sublingual and minor salivary gland origins. While the majority of tumors from parotid glands are benign, malignancies are more common in those caused by other glands. Preoperative characterization of SGTs is important for treatment planning. The choice of surgery method for SGTs is closely associated with the histology of the tumor. Diagnosis is mostly based on combined evaluation of clinical features and findings from physical examinations, imaging and cytological observations. Fine-needle aspiration biopsy (FNAB) is most commonly used method for cytological examinations but complex pathologies can result in false positives and false negatives in malignant tumors (MTs)[1,2]. Conventional magnetic resonance imaging (MRI) is very useful for identifying the tumor location, morphology, extension, and its association with the nerves and inner structure[1-3]. However, diagnosing the MTs and benign tumors (BTs) with conventional MRI could be difficult due to overlapping

findings[1,2,4]. In recent years, an increase has been reported in diagnostic accuracy in SGTs for distinguishing between MTs and BTs with the use of diffusion-weighted imaging (DWI) and dynamic contrast-enhanced (DCE) MRI techniques[1,5-9]. DCE MRI is used to track an exogenous, paramagnetic contrast agent in tissues and has been a powerful tool in the characterization of tumor hemodynamics[1,3,10,11]. As a semiquantitative method in DCE MRI, patterns have been established by measuring time to peak (T_{peak}) and washout ratio (WR) on the time intensity curve (TIC)[1,3]. T_{peak} is closely related to microvessel count while WR reflects the stromal cellularity grade. On quantitative DCE MRI, on the other hand, perfusion parameters such as K_{trans} [volume transfer constant between blood plasma and extracellular extravascular space (EES)], K_{ep} (flux rate constant between the EES and plasma) and V_e (EES fractional volume) are used[1,3]. Although there are many studies dealings with diffusion and semiquantitative DCE MRIs in SGTs, number of quantitative MRI studies is limited[12-15]. In the present study, diagnostic value of diffusion MRI and semiquantitative and quantitative perfusion MRI parameters were evaluated in SGTs.

MATERIALS AND METHODS

Patients

The study was retrospectively conducted after the approval of the local ethics committee (20-KAEK-105). A total of 67 patients with tumors originating from or involving salivary glands were included. The study included the patients who had applied with swelling on the face or in salivary glands, who were subjected to MRI, diffusion MRI and perfusion MRI examinations in our hospital between April 2017 and February 2021 and who were diagnosed histopathologically after FNAB, tru-cut biopsy or surgical removal. For the study, patients whose neck and maxillofacial MRI examination reports included the description of mass in the salivary glands were surveyed in PACS. A total of 33 patients were excluded: two patients with intra-lesion hemorrhage due to FNAB before the MRI examination, 16 patients who had contrast-enhanced MRI but did not have perfusion MRI series and 15 patients whose diagnosis

were not confirmed histopathologically. Thus, a total of 73 MTs and BTs, which originated from major and minor salivary glands in 67 patients, were included in the study (Figure 1).

MRI scanning and measurements

MRI was performed on a 1.5 T superconducting MRI system (GE Signa Explorer SV 25; GE Healthcare, Milwaukee, WI, United States, 2016) with head and neck array coils. Routine MRI sequences included axial T1-weighted (TR/TE, 456 ms/8.1 ms), in phase axial T2-weighted (TR/TE, 3711 ms/82.8 ms), sagittal T2-weighted (TR/TE, 4499 ms/88.2 ms) and coronal T2-weighted (TR/TE, 4380 ms/84.6 ms). DCE MRI was performed with a T1-weighted 3D fast spoiled gradient echo sequence (TR/TE/TI, 3.8 ms/1.3 ms/15 ms; flip angle 20°). The contrast agent Gd-DTPA (Dotarem, Guerbet, France) was injected after fourth dynamic sequence acquisition at a rate of 2.0 mL/s *via* the right antecubital vein. The contrast agent was administered at a rate of 0.2 mmol/kg body weight. Right after the injection of contrast agent, a 20 mL saline flush was performed at the same injection rate. In total, between 18 and 21 dynamic sequence acquisitions with 30 dynamic images per sequence were performed with total scanning times ranging from 3 minutes and 11 s to 5 minutes and 24 s. The location, morphology and internal structure of the tumor were evaluated with conventional MRI (Figures 2-5 A, Figures 3-5 B).

DWI was performed using a multislice echo-planar single-shot spin-echo sequence, on the axial plane (TR/TE = 5476 ms/95.4 ms, FOV = 26 cm, matrix = 96 × 128, section thickness = 4-5 mm and interslice gap = 4 mm). Three diffusion gradients were applied sequentially in the x, y, and z directions with b values of 0 and 1000 s/mm^2 (Figure 2 B). The acquisition time varied from 60 to 120 s. The apparent diffusion coefficient (ADC) maps were generated automatically.

"GE Advantage Windows Workstation 4.7" was used to determine ADC values in diffusion MRI and to perform measurements in semiquantitative and quantitative perfusion MRI. Image analysis and region of interest (ROI) measurements were carried

out on a consensus basis by two neuroradiologists (EG and MB with more than 12 and 7 years of work experience, respectively) who were not aware of clinical status of the patients. On ADC value measurements, cystic components of the tumors were not considered, the ROI was manually placed through the widest axial section of the tumor, and the ADC value was determined as mm^2/s (Figures 2-5 C). Semiquantitative analysis of DCE MRI was based on TIC (Figures 2-5 D, E). T_{peak} was measured as the time from the point where the lesion began to contrast enhancement to the point with the highest level of contrast enhancement. TICs were evaluated in four different categories based on Yabuuchi *et al*[10]: type A= T_{peak} > 120 s; type B= T_{peak} ≤ 120 s, WR ≥30%; type C= T_{peak} ≤120 s, WR < 30%; and type D= flat TIC. To confirm the accuracy of TIC and perfusion biomarker analyses, ROIs were drawn in a way to avoid the vascular and cystic parts of the tumors. Quantitative perfusion DCE MRI parameters were measured using the Tofts kinetic model[16]. For quantitative perfusion MRI analysis, 3D ROI was placed in the largest solid component of tumor, and the K_{trans}, K_{ep} and V_e values were generated automatically (Figures 2-5 F, G, H).

Statistical analyses

Statistical analyses were performed using SPSS 18.0 software (IBM, Chicago) and MedCalc statistical software version 20.009 (MedCalc software bvba, Ostend, Belgium). For each parameter, the conformity of the groups to the normal distribution was evaluated with the Shapiro-Wilk test and the Levene test was used to evaluate the homogeneity of variances. Data were expressed as mean ± standard deviation or frequency and percent. One-way ANOVA test was used for the groups with normal distribution in the comparison of the groups, and Bonferroni correction was applied in multiple comparisons. The Kruskal-Wallis test was used to compare the groups that did not fit the normal distribution, and Bonferroni correction was applied in multiple comparisons. AUC (Area Under Curve), sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and cut-off values of diagnostic

parameters were calculated for each tumor group by performing receiver operating characteristic curve (ROC) analysis.

RESULTS

The age range of the 67 patients (40 male and 27 female) included in the study was 12-93 years (mean age= 56.9 ± 15.8). One patient had three lesions in salivary glands, while four patients had two and the remaining 62 patients had one lesion. Thus, 73 Lesions in 67 patients were evaluated. The majority of the lesions (86.3%) were located in parotid glands, while a small portion (4.1%) originated from minor salivary glands. Locations, numbers and frequencies of SGTs are given in Table 1. About two-thirds of the lesions (68.5%) were benign (Figures 2 and 3), and one-third (31.5%) was malignant (Figures 4 and 5). Warthin's tumors (WTs) (36.0%) were the most common benign tumors, followed by pleomorphic adenomas (PMAs) (28.0%). Of the MTs, squamous cell cancer (47.8%), adenoid cystic cancers (13.0%) and malignant lymphomas (13.0%) were most common. Numbers of benign and malignant SGTs are given in Table 2. The ADC values of PMAs were significantly higher than those of WTs, other benign tumors (OBTs) and MTs ($P < 0.001$). However, there was no significant difference for ADC values of OBTs, WTs and MTs. Significant differences were not found for ADC values of all BTs and MTs. Mean ADC values of SGTs are given in Table 3.

An evaluation of T_{peak} values of semiquantitative perfusion MRI parameters revealed that PMAs reached T_{peak} significantly later (mean T_{peak}= 202.74 ± 21.48 s) than WTs, OBTs and MTs did while the difference between OBTs and MTs for T_{peak} values was not significant. WTs reached T_{peak} significantly earlier than other tumors. When it comes to WR, no washout was observed in PMAs. WTs had the highest mean WR value (59% ± 11), which was significantly different from the mean WR values of MTs and OBTs. PMAs had type A and WTs had type B TIC pattern, while the majority of MTs and OBTs (54.5 and 45.5%, respectively) exhibited type C TIC pattern. Semiquantitative DCE MRI parameters of SGTs are given in Table 4.

For quantitative perfusion MRI parameters, K_{trans} values of PMAs, WTs, OBTs and MTs were not significantly different. K_{ep} value of WTs, on the other hand, was significantly higher than other tumors ($P < 0.001$). For V_e value, WTs and OBTs differed significantly from PMAs and MTs ($P < 0.001$). An evaluation of all BTs and MTs showed significant differences for K_{ep} and V_e values ($P < 0.05$) but not for K_{trans} values. Quantitative DCE MRI parameters of SGTs are given in Table 3.

Results of ROC analysis and cut-off values used for the parameters of DWI, semiquantitative and quantitative MRI of PMAs, WTs and malignant SGTs are given in Table 5.

DISCUSSION

In recent years, diffusion MRI has been an indispensable complement to conventional sequences in the radiological evaluation of SGTs[1,3,6-10,13-15,17,18]. Diffusion MRI allows us to evaluate the cellularity in tissues and the changes that physiological processes create on microstructural features. Since malignant or benign SGTs include a highly heterogeneous group, their ADC values could also be highly variable. In cell-rich tumors such as WT and lymphoma, ADC values are low, but tumors containing heterogeneous components such as PMA have higher ADC values[1,13]. In many DWI studies involving SGTs, ADC values were reported to be useful in distinguishing BTs and MTs[6-8,17,19-21]. However, there are also studies reporting that DWI was not sufficient to make this distinction but ADC values could be useful in distinguishing some subtypes of MTs or BTs[10,22-24]. An evaluation of mean ADC values of all BTs and MTs in the present study showed that ADC values of BTs (0.98×10^{-3} mm²/s ± 0.43) and MTs (0.95×10^{-3} mm²/s ± 0.31) were similar and did not differ significantly. However, when specific tumoral subgroups were evaluated, significant differences were found among the mean ADC values of PMAs, WTs and MTs ($P < 0.001$). In a ROC analysis using an ADC cut-off value of > 1.1×10^{-3} mm²/s for PMA, AUC, sensitivity and specificity were 97.7, 100 and 89.8%, respectively. A ROC analysis for WTs using an ADC cut-off value of ≤ 0.8×10^{-3} mm²/s, on the other hand, resulted in AUC, sensitivity

and specificity values of 74.2, 94.4 and 58.2%, respectively. These values were 54.1, 78.3 and 44.0%, respectively, for MTs with an ADC cut-off value of > 0.7 x 10^{-3} mm^2/s. In the present study, the mean ADC value of malignant lymphomas was 0.56 x 10^{-3} mm^2/s ± 0.05, which was well below the average ADC value of all MTs. This finding meant that diffusion MRI could be more useful in distinguishing the subgroups within both BTs and MTs than contributing to a more general distinguishing between MTs and BTs.

In addition to diffusion MRI, the parameters of semiquantitative DCE MRI (TIC patterns) have also been frequently used in recent years for the differential diagnosis of SGTs[9,12,20,25,26]. On DCE MRI, TIC is obtained from signal intensity changes before the contrast matter administering, during the transition of contrast matter from the capillary bed to extravascular-intercellular distance and during the washing of contrast matter from the tissue[1,18]. TIC patterns are correlated with tumor cellularity and vascularity[1,5,18,27]. PMAs have progressive contrast-enhancement due to low microvessel count and cellularity-stromal grade, and their washout patterns are mostly negative and, to a lesser degree, in the form of a plateau[1,27]. In the present study, type A TIC pattern (curve pattern with progression towards the late phases) was observed in all PMAs. T_{peak} values ranged from 161.80 to 251.70 s. The average T_{peak} value of PMAs (202.74 s ± 21.48) was significantly longer compared to the T_{peak} values of all other SGTs. In ROC analysis of PMAs using a cut-off value of T_{peak} > 120 s, AUC, sensitivity, specificity, PPV and NPV were 94.7, 100, 89.8, 70.0 and 100%, respectively. WTs feature rapid contrast enhancement and washout due to their high microvessel count and cellularity-stromal grade. In the present study, type B TIC pattern (T_{peak} ≤ 120 s, WR ≥ 30%) was observed in all WTs. T_{peak} values ranging from 10.80 to 46.40 s, while WR varied from 31 to 75%. The mean T_{peak} of WTs (20.26 s ± 11.72) was significantly shorter than other parotid lesions. The average WR value of WTs (59.33% ± 10.99) was significantly higher than any other tumors. In ROC analysis of WTs using a cut-off value of WR > 43%, AUC, specificity and PPV were quite high (98.1, 94.4 and 90.9%, respectively). Due to their high microvessel count and lower cellularity-stromal grade, MTs have rapid enhancement but their washouts tend to be slower than those of

WTs[1,27]. In the present study, the mean T_{peak} value of MTs (60.60 s ± 55.78) was significantly shorter than the T_{peak} value of only PMAs. Mean WR value of MTs (18.48% ± 18.38) was significantly lower than those of WTs, but was not different from mean WR value of OBTs. In ROC analysis of MTs with cut-off values of T_{peak} ≤ 120 s and WR ≤ 49%, sensitivities were quite high (91.3 and 100%, respectively) but specificities were quite low (36.0 and 30.0%, respectively). A survey of semiquantitative DCE MRI studies in the literature showed that PMAs generally had type A pattern, while WTs had type B and MTs had type C TIC patterns[4,5,26]. TIC patterns are considered to have a higher diagnostic accuracy in the distinguishing of subgroups in SGTs compared to their power to distinguish all BTs from MTs. However, it was mentioned that TIC patterns had higher specificity especially in PMAs and WTs while their specificity in MTs was lower[4,18,25,26]. In their study with all SGTs, Lam *et al*[26] showed that all malignant tumors except lymphomas showed type C TIC pattern (T_{peak} < 150 s and WR < 30%), while 70% of lymphomas had type B TIC pattern (T_{peak} < 150 s and WR ≥ 30%). Similar to the findings of Lam *et al*[26], 66.7% of lymphomas in the present study showed type B TIC pattern. However, unlike their findings, some of other MTs showed type A, B and D TIC patterns. There are also studies in the literature reporting that all WTs had type B TIC pattern[4,10,12]. In accordance with their findings, 100% of WTs in the present study featured type B TIC pattern. Subtypes of SGTs in the present study generally had similar TIC patterns to those reported in the literature.

The literature contains several studies on quantitative DCE perfusion MRI parameters (K_{trans}, K_{ep} and V_e) in SGTs[3,14,15,28]. In these studies, mean K_{trans} values for PMAs ranged from 0.101 ± 0.069 to 0.217 min^{-1} ± 0.036, mean K_{ep} values from 0.245 ± 0.160 to 0.567 min^{-1} ± 0.048 and mean V_e values from 0.360 to 0.590 ± 0.478, while mean K_{trans} values for WTs varied between 0.105 ± 0.064 and 0.464 min^{-1} ± 0.036, mean K_{ep} values between 0.729 ± 0.112 and 2.299 min^{-1} ± 1.312, and mean V_e values between 0.1439 ± 0.093 and 0.272 ± 0.013. For MTs, mean K_{trans} values varied from 0.130 ± 0.035 to 0.327 min^{-1} ± 0.030; mean K_{ep} values from 0.463 ± 0.103 to 0.784 min^{-1} ± 0.064 and mean V_e values from 0.264 ± 0.119 to 0.445 ± 0.025. In all of these studies in the literature, the K_{trans}

values of PMAs were lower than the K_{trans} values of other SGTs[3,14,15,28]. Xu *et al*[3] found that the mean K_{trans} value of PMAs was slightly different from that of WTs (P = 0.05). Yabuuchi *et al*[14] found no significant difference among K_{trans} values of other SGTs. Huang *et al*[15] found that the K_{trans} values of PMAs were significantly lower than the K_{trans} values of other SGTs. Similar to the results of Yabuuchi *et al*[14], in our study, mean K_{trans} value of PMAs was the lowest of all SGTs, but it was not significantly different from mean K_{trans} values of other tumors. In studies of Xu *et al*[3], Yabuuchi *et al*[14] and Huang *et al*[15], the mean K_{ep} value was the lowest in PMAs and highest in WTs. K_{ep} values of PMAs, WTs, and MTs in the studies of both Xu *et al*[3] and Yabuuchi *et al*[14] were significantly different. However, in Huang *et al*[15] study, the K_{ep} value of only WTs was significantly different from other tumors. In another study of Huang *et al*[28], significant differences were found between K_{ep} values of WTs and PMAs, and those of WTs and OBTs. Similar to the results of those studies in the literature, mean K_{ep} value in the present study was the lowest in PMAs and highest in WTs, and K_{ep} values of PMAs and WTs were significantly different from other tumors[3,13,14,28]. Xu *et al*[3], Yabuuchi *et al*[14] and Huang *et al*[15] found that mean V_e values of WTs were significantly lower than the V_e values of other tumors. Similar to the results of their studies the mean V_e value of WTs in the present study was significantly lower than the V_e values of other tumors[3,14]. In another study by Huang *et al*[28], unlike other studies, the V_e value of WTs and the V_e values of PMAs and OBTs were found to be significantly lower. In ROC analysis using a cut-off value of $K_{ep} \geq 2.44$ min^{-1} for WTs, the AUC, sensitivity and specificity were 97.3, 100 and 85.5%, respectively. On the other hand, in ROC analysis using a cut-off value of $V_e \leq 0.17$, quite high AUC, sensitivity and specificity values (95.8, 100 and 90.9%, respectively) were obtained. High K_{ep} and low V_e values in WTs are explained by the limited extravascular and extracellular space of these tumors. As many studies in the literature and the present study revealed, ADC and TIC patterns of WTs could overlap with those of MTs[11]. However, similar to the findings of the studies in the literature, the present study showed that quantitative perfusion MRI parameters K_{ep} and V_e could contribute greatly to the distinguishing of WTs from MTs[3,14,15].

Nevertheless, our findings need to be verified by future quantitative perfusion MRI studies to be performed with larger series.

There are some limitations to this study. First, the parameters (number of dynamic series, acquisition time, *etc.*) varied on perfusion MRI series due to the retrospective nature of the study. Second, most of the tumors in our study were benign SGTs, and the number of MTs in the primary salivary gland was relatively low, which may have resulted in an overestimation of the diagnostic accuracy. Third, the manual definition of ROI might have increased the variability in quantitative measurements. Although the cystic-necrotic components of the lesions were tried to be excluded from the ROI in our study, even the contamination of these areas can lead to significant changes in quantitative values, even if it is small in manual measurements. Fourth, in the measurements of ADC values and semi-quantitative and quantitative DCE perfusion MRI parameters, interobserver agreement could not be evaluated in the study because the measurements were made by two observer with consensus.

CONCLUSION

Combined use of quantitative DCE MRI along with diffusion MRI and semiquantitative DCE MRI could help radiologists in differential diagnosis of different subtypes of SGTs through providing higher diagnostic accuracy.

ARTICLE HIGHLIGHTS

Research background

1

Conventional magnetic resonance imaging (MRI) provides more data than other radiological modalities in determining the extent of tumor spread in salivary gland tumors (SGTs) and assessing its relationship to vascular and neural structures, but falls short of distinguishing subtypes of SGTs. Since SGTs' malignant or benign nature affects the treatment protocol, it is important to differentiate between malignant (MTs) and benign tumors (BTs) noninvasively with high diagnostic accuracy.

Research motivation

In recent years, advanced MRI techniques such as diffusion-weighted imaging (DWI) and semi-quantitative MRI have been increasingly used in the radiological evaluation of SGTs. However, various studies on quantitative dynamic contrast-enhanced (DCE) perfusion MRI parameters (K_{trans}, K_{ep} and V_e) in SGTs are limited. Therefore, in this study, the effectiveness of advanced MRI applications, including all three methods, in the diagnosis of SGTs was evaluated in the light of the literature.

Research objectives

In this study, we aimed to determine the diagnostic efficiency of DWI, DCE (semiquantitative perfusion) MRI and quantitative perfusion MRI parameters in SGTs.

Research methods

Apparent diffusion coefficient (ADC) values of SGTs on DWI were measured with manually inserted ROIs, excluding the cystic components of the tumors. Time intensity curve (TIC) patterns were created for semiquantitative perfusion MRI based on T_{peak} and washout ratios of tumors. On quantitative DCE MRI, perfusion parameters such as K_{trans} [volume transfer constant between blood plasma and extracellular extravascular space (EES)], K_{ep} (flux rate constant between the EES and plasma) and V_e (EES fractional volume) were used.

Research results

The ADC values of pleomorphic adenomas (PMAs) were significantly higher than the ADCs of Warthin's tumors (WTs), other benign tumors (OBTs) and MTs ($P < 0.001$). However, there was no significant difference for ADC values of OBTs, WTs and MTs. PMAs had type A and WTs had type B TIC pattern while the vast majority of MTs and OBTs (54.5 and 45.5%, respectively) displayed type C TIC pattern. PMAs showed no washout, while the highest mean washout ratio was observed in WTs. For quantitative perfusion MRI parameters, K_{ep} value of WTs was significantly higher than other tumors

($P < 0.001$). For V_e value, WTs and OBTs differed significantly from PMAs and MTs ($P < 0.001$). K_{trans} values of PMAs, WTs, OBTs and MTs were not significantly different.

Research conclusions

DWI, semiquantitative and quantitative perfusion MRI which provides more information about the microstructure, cellularity, interstitial distance and vascularity of tumors, have increased the discrimination power of subtypes SGTs.

Research perspectives

Although there is some overlap in the findings of the subtypes of SGTs obtained by advanced MRI methods, the combined use of DWI, semiquantitative and quantitative perfusion MRI will increase the power of distinguishing subtypes of SGTs.

ACKNOWLEDGEMENTS

We thank Demir O and Gürpınar AB for their help with the statistical analyses.

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