Computer Aided Quantitative Analysis of T2-Weighted prostate MR Images

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TARGET AUDIENCE

Radiologist and Physicist who are interested in computer-aided diagnosis (CAD) and MR imaging of prostate cancer

PURPOSE

To evaluate the quantitative features extracted from T2 weighted images of prostate cancer (Pca) and non-cancer by CAD, within the central gland (CG) and peripheral zone (PZ) of the prostate, respectively.

METHODS

Subjects: Between December 2008 and January 2010, 71 consecutive patients who were suspected of PCa by urologist in the prostate MR database were selected into our retrospective study, with Clinical Trial Ethic Committee permission. Among them, 35 patients were confirmed to be prostate cancer by biopsy, the other 36 patients had not been detected of cancer by serial biopsy and long-term follow-up (12 to 59 months, mean 32 months). Inclusion criteria for the study were as follows: (1) there were complete prostate data, combined T2WI, and at least two functional MRI techniques (DWI, DCE and MRS); (2) the clinical information contained age, tPSA, fPSA/tPSA, US and DRE; (3) subsequent ultrasound guided biopsy was performed within 3 months after MRI scan; (4) all the patients were underwent a long-term follow-up.

	PZ	CG	Whole Gland
PCa	92	52	144
Non PCa	146	136	282
Total	238	188	426

Table 1. The distribution of ROIs in the peripheral zone and central gland

MRI Acquisition: MR examinations were carried out on a 1.5 Tesla MR scanner (Signa TM; GE Medical Systems, Milwaukee, WI), using a pelvic phased-array coil. All routine prostate MR examinations followed standardized protocols. T2 weighted turbo-spin-echo images were obtained in the axial plane without fat suppression. Parameters were as follows: TR: 3500 ms; TE:85 ms; FOV: 240 × 240 mm; matrix: 320 × 256; slice thickness: 4 mm with no gap; Number of signals acquired: 4.

ROIs Selection: ROIs with 8×8 pixels were manually sketched from the cancerous regions and randomly selected from the normal regions in the T2w images of CG and PZ. Cancerous region was defined as the most suspected region at T2WI within a sextant that was positive at biopsy, which was identified by two experienced radiologists (7 and 9 years of prostate MR experience) in interpreting prostate MRI at the time of this study. Totally, the distribution of ROIs selected from the T2WI was summarized in Table 1.

Computer-Extracted Features: Before analysis, T2WI were standardized to correct for background and nonlinearity of the MR image intensity scale. Totally, 12 features were extracted from the T2-weighted images. Quantified features in this study were grouped into 3 types: general features (mean value, minimum value, standard deviation, coefficient of variation, 10th percentile), features derived from gray-level histogram (skewness, kurtosis), and features derived from co-occurrence matrix (GLCM) (contrast, correlation, energy, homogeneity, entropy). Then at last, sequential forward selection (SFS) was performed and prediction error was used as a selection criterion.

RESULTS

The Summary of the performance for features extracted from T2WI was shown in table 2. It seems that the most of the features (10/12) have significant difference (P<0.01) between PCa and non PCa in the PZ, while only 5 features (sum average, minimum value, SD, 10th Percentile and entropy) have significant difference in CG. These 5 features have significant difference in both PZ and CG.

The feature weights were shown in figure 1, 2. For PZ, sum average seems to contribute the largest part in distinguishing prostate cancer, while for CG, SD comes to be the most important feature.

	PZ			CG		
Feature	**PCa**	**Non PCa**	***P***	**PCa**	**Non PCa**	***P***
Sum Average	370.6±160.5	661.5±244.5	<0.01*	355.5±112.0	463.4±154.8	<0.01*
Minimun Value	298.6±142.8	508.5±216.5	<0.01*	289.3±89.88	373.6±123.6	<0.01*
Standard Deviation	35.74±15.56	68.14±34.79	<0.01*	33.85±16.81	46.37±21.65	<0.01*
Coefficient of Variation	11.18±4.30	11.19±4.98	0.982	11.84±4.350	11.04±3.513	0.194
10th Percentile	323.9±148.5	570.2±227.8	<0.01*	313.4±98.05	404.9±135.1	<0.01*
Skewness	0.126±0.509	-0.189±0.697	<0.01*	0.256±0.447	0.212±0.591	0.627
Kurtosis	2.736±0.699	3.019±1.366	0.067	2.742±0.812	2.912±1.045	0.291
Contrast	1.077±0.439	0.842±0.379	<0.01*	1.351±0.517	1.292±0.545	0.496
Correlation	0.810±0.096	0.859±0.072	<0.01*	0.770±0.088	0.776±0.098	0.683
Energy	0.075±0.022	0.087±0.039	<0.01*	0.065±0.018	0.072±0.023	0.076
Homogeneity	0.675±0.060	0.711±0.068	<0.01*	0.637±0.060	0.651±0.063	0.154
Entropy	5.454±0.248	5.615±0.161	<0.01*	5.446±0.229	5.535±0.200	<0.01*

**P* values calculated by two-sample t-test were used to indicate the significance of the difference between features obtained in normal ROIs and cancerous ROIs. Data are mean±SD.

Table 2. The means and SDs of features extracted from T2-weighted images in PZ and CG

DISCUSSION

T2WI is one of the most important sequences in prostate MR. Quantitative features extraction is the major difficulty affecting image processing and analysis. By CAD, doctors' understanding of T2 weighted images can be presented by 12 features. Viswanath[1] indicated that CG and PZ prostate cancers and non-cancers have significantly different quantitative and texture features on T2w endorectal in vivo MRI. So we analyze the features in CG and PZ separately.

In PZ, 11 of the 13 features can distinguish Pca from non Pca. But as for CG, the number is only 5. For the sum average and the minimum, prostate cancer both in the CG and PZ appears as an area of low signal intensity on T2w images. It is easily differentiated from high-signal-intensity normal PZ tissue, but often with some difficulty in the CG region. But he low signal intensity is always homogeneous in the cancer region, both in CG and PZ[2,3]. That means the standard deviation in cancer region is lower than that of non-cancer, which is consistent with our clinical experience. All the six features derived from co-occurrence matrix were significant different between Pca and non-Pca in PZ, but only entropy was significant different between Pca and non Pca in CG. The underlying mechanism could be that the healthy prostate peripheral zone consists of complicated tissue structures with normal glandular morphology, whose complex architectures contribute to higher roughness features on the T2w images.

The biggest feature weight is not the same between PZ and CG. PCa in the PZ appears as an area of low signal intensity that is always easily differentiated from high-signal-intensity normal tissue. A homogeneous low-signal-intensity region is very important findings supporting the diagnosis of a tumor in CG[2].So the uniformity of signal, standard deviation in CAD, is very important in the CG cancer diagnosis. The sum average is also very considerable for CG.

CONCLUSION

With computer-aided analysis of T2w images, many characteristic features can be extracted and analyzed. The outcome is convictive and consistent with our clinical experience, which could be widely used in the near future.

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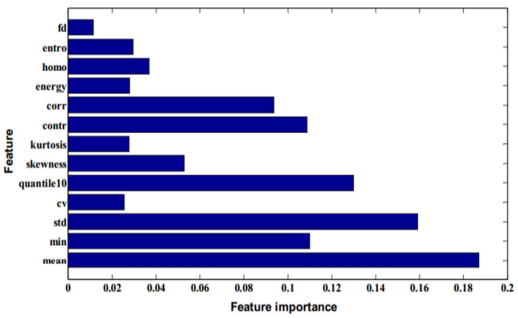

Figure 1: Feature weights of PZ

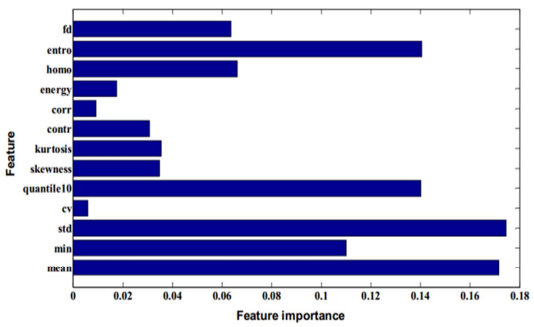

Figure 2: Feature weights of CG