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How accurate is multiparametric Magnetic Resonance Imaging in evaluating prostate cancer volume?

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Purpose: To evaluate the accuracy of prostate cancer volume measurement using multiparametric MRI (mp-MRI).

Materials & Methods: 202 consecutive patients who underwent radical prostatectomy in our institution and gave written consent were included in the CLARA-P radio-pathological correlation database. Pre-operative mp-MRIs (T2-weighted (T2w), diffusion-weighted (Dw), and dynamic contrast-enhanced (DCE) sequences) obtained at 1.5T (n=71) or 3T (n=131), with (n=52) or without (n=150) an endorectal coil, were independently interpreted by two radiologists. A 5-level subjective suspicion score (SSS) of malignancy was used to characterize mp-MRI findings. A 0/4 SSS (definitely benign) was reserved to prostate areas strictly normal on all sequences. Focal abnormalities thus received a SSS ranging from 1/4 (probably benign) to 4/4 (definitely malignant). One pathologist noted on prostatectomy whole-mount sections the position and Gleason score of all tumor foci. Then, whole-mount sections were digitized and, after calibration, the volume of all tumors was calculated using dedicated software. MR and histological results were then correlated by the two radiologists and the pathologist. MR focal abnormalities were considered true positives (TPs) only if their position matched that of a histological cancer, and if their diameter was within 50-150% of the diameter of the corresponding histological cancer.

Volumes of mp-MRI TPs and histological cancers were correlated. Four mp-MRI volumes were evaluated for each reader: the volumes measured individually on each MR sequence (T2w, Dw, DCE) and the maximal volume of the three sequences (Vmax).

Results: 414 cancers were seen at pathology. Readers 1 and 2 respectively identified 416 and 363 mp-MRI focal abnormalities, with respectively 241 and 216 TPs. They missed 173 and 198 cancers.

Mean and median mp-MRI TPs volumes were respectively 1.38 and 0.63cc for reader 1 and 1.74 and 0.9cc for reader 2. Corresponding mean and median histological volumes were 2.08 and 1.2cc for reader 1 and 2.26 and 1.3cc for reader 2.

Correlations between mp-MRI and histological volumes of cancers detected at imaging were good for both readers (R=0.76-0.82 for T2w imaging, 0.81 for Dw imaging, 0.80-0.82 for DCE imaging, R=0.82-0.83 for Vmax). All individual mp-MRI sequences significantly underestimated the histological volume (T2w: $p=1.10^{-12}$ - 1.10^{-8} , Dw: $p=2.10^{-16}$ - 2.10^{-19} , DCE: $p=0.01$ - 0.001), while Vmax was not significantly different from the histological volume ($p=0.1$ - 0.06). At univariate analysis, 4 factors significantly influenced the accuracy of histological volume evaluation using Vmax: the Gleason score ($p=3.10^{-5}$ - 4.10^{-5}), the SSS ($p=3.10^{-6}$ - 5.10^{-3}), the localization of the cancer (peripheral vs transition zone; $p=3.10^{-6}$ - 8.10^{-6}) and the histological volume itself ($p=1.10^{-11}$ - 4.10^{-14}), whereas the coils used, the field strength and the histological architecture of the cancer did not. At multivariate analysis, three factors significantly influenced the accuracy of volume estimation: the Gleason score ($p=0.009$ - 0.006), the SSS ($p=0.002$ - 0.03) and the histological volume ($p=0.02$ - 0.03), with more accurate volume estimations when the Gleason score, SSS and histological volume were higher.

Conclusion: The maximal tumor volume measured on the three individual mp-MRI sequences is a good estimator of the histological tumor volume. The accuracy of estimation is significantly better when the Gleason score, the SSS and the histological volume are higher.