Review Article

Optimization of Prostate Biopsy: the Role of Magnetic Resonance Imaging Targeted Biopsy in Detection, Localization and Risk Assessment

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Abbreviations and Acronyms

ADC = apparent diffusion coefficient
BPH = benign prostatic hyperplasia
CDR = cancer detection rate
DCE = dynamic contrast enhanced
DW = diffusion weighted
DWI = diffusion weighted imaging
GS = Gleason score
mp = multiparametric
MR = magnetic resonance
MRGB = magnetic resonance guided biopsy
MRI = magnetic resonance imaging
PCa = prostate cancer
PSA = prostate specific antigen
T2WI = T2-weighted imaging
TRUS = transrectal ultrasound
US = ultrasound

Purpose: Optimization of prostate biopsy requires addressing the shortcomings of standard systematic transrectal ultrasound guided biopsy, including false-negative rates, incorrect risk stratification, detection of clinically insignificant disease and the need for repeat biopsy. Magnetic resonance imaging is an evolving noninvasive imaging modality that increases the accurate localization of prostate cancer at the time of biopsy, and thereby enhances clinical risk assessment and improves the ability to appropriately counsel patients regarding therapy. In this review we 1) summarize the various sequences that comprise a prostate multiparametric magnetic resonance imaging examination along with its performance characteristics in cancer detection, localization and reporting standards; 2) evaluate potential applications of magnetic resonance imaging targeting in prostate biopsy among men with no previous biopsy, a negative previous biopsy and those with low stage cancer; and 3) describe the techniques of magnetic resonance imaging targeted biopsy and comparative study outcomes.

Materials and Methods: A bibliographic search covering the period up to October 2013 was conducted using MEDLINE®/PubMed®. Articles were reviewed and categorized based on which of the 3 objectives of this review was addressed. Data were extracted, analyzed and summarized.

Results: Multiparametric magnetic resonance imaging consists of anatomical T2-weighted imaging coupled with at least 2 functional imaging techniques. It has demonstrated improved prostate cancer detection sensitivity up to 80% in the peripheral zone and 81% in the transition zone. A prostate cancer magnetic resonance imaging suspicion score has been developed, and is depicted using the Likert or PI-RADS (Prostate Imaging Reporting and Data System) scale for better standardization of magnetic resonance imaging interpretation and reporting. Among men with no previous biopsy, magnetic resonance imaging

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increases the frequency of significant cancer detection to 50% in low risk and 71% in high risk patients. In low risk men the negative predictive value of a combination of negative magnetic resonance imaging with prostate volume parameters is nearly 98%, suggesting a potential role in avoiding biopsy and reducing over detection/overtreatment. Among men with a previous negative biopsy 72% to 87% of cancers detected by magnetic resonance imaging guidance are clinically significant. Among men with a known low risk cancer, repeat biopsy using magnetic resonance targeting demonstrates a high likelihood of confirming low risk disease in low suspicion score lesions and of upgrading in high suspicion score lesions. Techniques of magnetic resonance imaging targeted biopsy include visual estimation transrectal ultrasound guided biopsy; software co-registered magnetic resonance imaging-ultrasound, transrectal ultrasound guided biopsy; and in-bore magnetic resonance imaging guided biopsy. Although the improvement in accuracy and efficiency of visual estimation biopsy compared to systematic appears limited, co-registered magnetic resonance imaging-ultrasound biopsy as well as in-bore magnetic resonance imaging guided biopsy appear to increase cancer detection rates in conjunction with increasing suspicion score.

Conclusions: Use of magnetic resonance imaging for targeting prostate biopsies has the potential to reduce the sampling error associated with conventional biopsy by providing better disease localization and sampling. More accurate risk stratification through improved cancer sampling may impact therapeutic decision making. Optimal clinical application of magnetic resonance imaging targeted biopsy remains under investigation.

Key Words: prostate, image-guided biopsy, magnetic resonance imaging, prostatic neoplasms, risk assessment

Approximately 1 million prostate biopsies are performed annually in the United States. An increased PSA most frequently triggers an extended 12-core systematic TRUS guided biopsy, which is endorsed by the American Urological Association as the optimal biopsy method.[1] As the designation of systematic sites on biopsy is largely operator dependent, this strategy relies on random sampling for cancer detection. This biopsy strategy is subject to sampling error and provides poor localization of disease. The primary limitations of the 12-core random systematic biopsy include failure to detect clinically significant cancer (according to Epstein criteria); imprecise tumor risk stratification (high risk cancers are improperly classified as low risk); and detection of small, low risk clinically insignificant cancers. This diagnostic uncertainty can lead to repeat biopsy, delayed detection of significant disease and disease overtreatment.

With the increasing challenge to preferentially detect higher grade PCa while avoiding lower grade tumors, noninvasive imaging may offer a means of selective disease localization. The use of MRI in evaluating the necessity of prostate biopsy and the guidance of biopsy location have gained considerable momentum due to improvements in the ability of multiparametric MRI to localize and noninvasively assess risk.[2] The ability to improve the detection and localization of PCa using modern MRI techniques has prompted the development of MRI targeted biopsy strategies by visual estimation MRI targeting, in-bore MRI guidance and MRI-US fusion targeting.

MATERIALS AND METHODS

We searched MEDLINE/PubMed for English language articles published up to October 2013 using combinations of the terms MRI, multiparametric, MRI-guided, MRI-targeted, image-guided, MRI-ultrasound fusion, cognitive, prostate, prostate cancer, prostate neoplasm, biopsy, detection, localization, risk assessment, risk stratification, cancer detection and visual estimation. Supplemental articles were identified through hand searches. Non-English articles were excluded from analysis. Relevant studies were then screened by 3 authors (MAB, XM, JLN), and data were extracted, analyzed and summarized.

LIMITATIONS OF CONTEMPORARY SYSTEMATIC BIOPSY TECHNIQUE

False-Negative Biopsy (under sampling)

The contemporary, random, systematic biopsy strategy relies on sampling efficiency for cancer detection and, thus, is subject to sampling error (fig. 1). Under sampling occurs in up to 30% of cases with clinically significant tumors being missed on initial biopsy.[3] Cancers are often small, intermingled with benign stroma and not uniformly distributed in the gland. As a result, clinically significant cancers frequently go undetected. Due to the random nature of systematic sampling, larger glands are subject to a greater risk of missed cancer.[3] This risk is not greatly improved by increasing the core number to more than 12.[1]

Incorrect Risk Stratification (under sampling)

Under sampling of the prostate during ultrasound guided biopsy also leads to incorrect risk