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SPECIAL SECTION: PROSTATE CANCER UPDATE

Tips to start an MR-US fusion biopsy program

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Abstract
There is growing evidence that MRI-ultrasound (MR-US)-targeted biopsy (TB) has high detection rates of clinically significant prostate cancer (PCa) compared to standard transrectal ultrasound (TRUS)-guided biopsy. A radiologist plays a significant role in MR-US fusion biopsy planning. Here, we discuss six simple steps that can help set up a successful MR-US fusion biopsy program in collaboration with the urologist.

Keywords MRI-US fusion biopsy · MRI targeted prostate biopsy · Prostate MRI · Prostate Cancer

Introduction

The utilization of prostate MRI has increased dramatically in the last several years due in part to international efforts to standardize the acquisition and reporting of prostate MRIs between centers [1, 2]. The primary goals of prostate multiparametric MRI (mpMRI) with targeted biopsy are twofold: (1) to detect clinically significant prostate cancer (PCa), and (2) to avoid over-diagnosis and subsequent over treatment of non-clinically significant PCa.

There is now a growing body of high-quality evidence that MRI-ultrasound (MR-US)-targeted biopsy (TB) has high detection rates of clinically significant PCa compared to standard transrectal ultrasound (TRUS)-guided biopsy [3, 4]. The American Urologic Association (AUA) and the Society of Abdominal Radiology (SAR) have issued a Joint Statement recommending prostate MRI and subsequent biopsy for men with suspicion of prostate cancer who have a negative prior systematic standard biopsy [5]. The National Comprehensive Cancer Network (NCCN) currently recommends consideration of mpMRI followed by a targeted biopsy based on the MRI results in a patient with high clinical suspicion of prostate cancer with a prior negative prostate biopsy [6]. NCCN guidelines V2.2019 on prostate cancer early detection also allows for a provider to consider MRI-targeted biopsy instead of standard 12-core TRUS biopsies at baseline evaluation in centers with experience and expertise in MR interpretation and targeting [7].

MRI-targeted biopsy methods include cognitive fusion biopsy (CFB), software-based fusion biopsy and In-bore MR targeted biopsy.

Radiologists have an increasingly important role to assist in MRI-targeted biopsy and to work closely with urologists. Here, we describe six steps to establish a successful MR-US fusion biopsy program, focusing on software-based fusion. Step 1: identify and evaluate an MR-US fusion biopsy system that works between Urology and Radiology. Step 2: develop a multidisciplinary approach to patient scheduling for prostate MRI by radiology and subsequent biopsy with urology. Step 3: implement a standardized mpMRI protocol and PI-RADS version 2.1 MRI reporting template. Step 4: work closely with the urologist to ensure appropriate post-processing and review of cases prior to biopsy. Step 5: create a database of MR-US fusion biopsy cases that allows for follow-up of targeted lesion pathology. Step 6: implement a quality improvement process for evaluation of mpMRI image quality and reporting by radiology as well as MRI-US fusion biopsy results by urology. These steps are discussed in more detail below and summarized in an example case (Figs. 1, 2, and 3).

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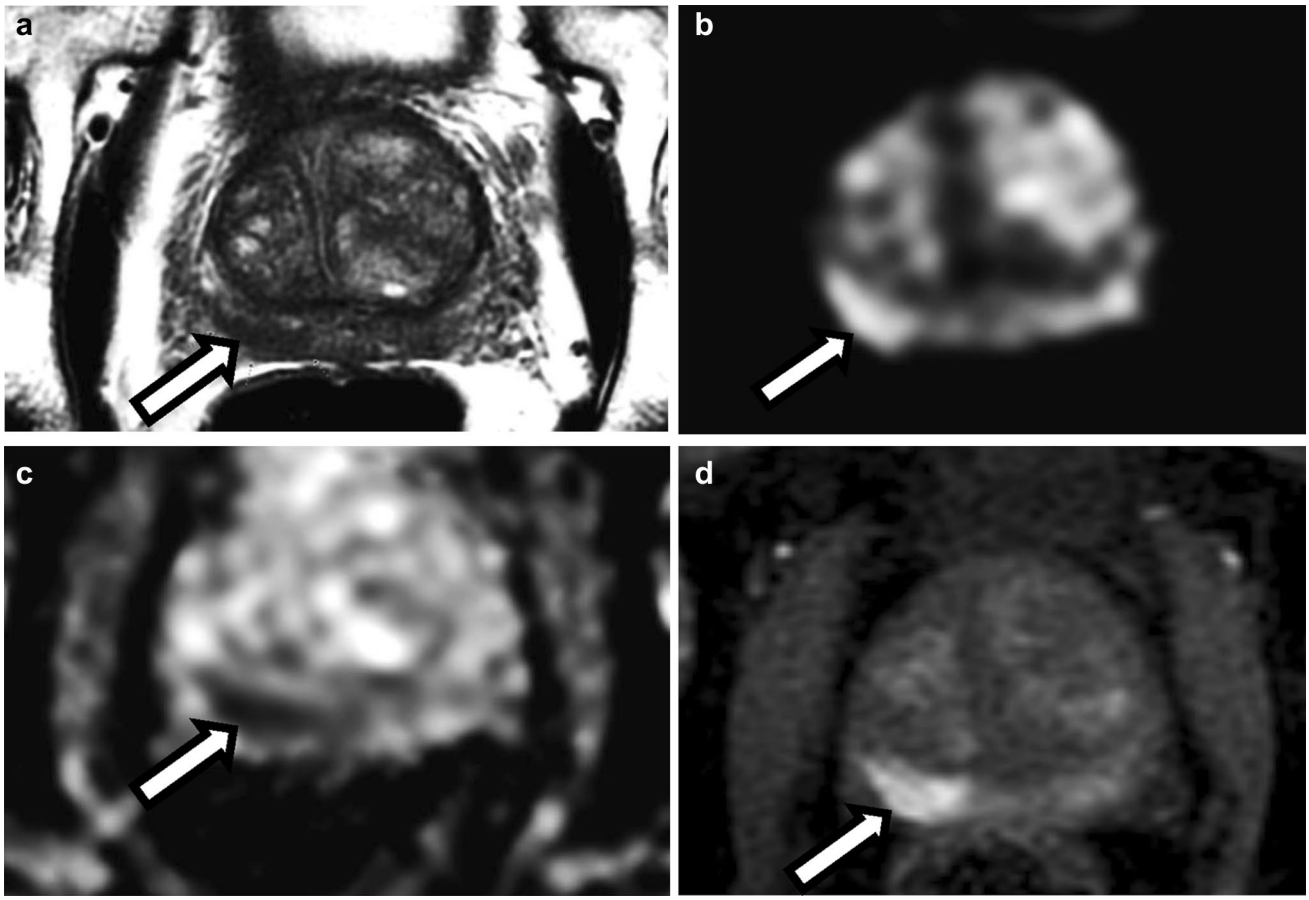

Fig. 1 A 69-year-old with PSA of 10 ng/ml and TRUS Biopsy showing Gleason 3 + 4 = 7 cancer on the right. Multi-parametric MRI (mpMRI) was performed due to rising PSA. mpMRI demonstrates a PI-RADS 5 lesion in the right posterior peripheral zone in the base of the gland (arrow) on axial T2-weighted small FOV (**a**), Diffusion-weighted image with *b* value of 1400 (**b**) with apparent diffusion coefficient map (**c**), and dynamic contrast-enhanced T1-weighted sequences (**d**)

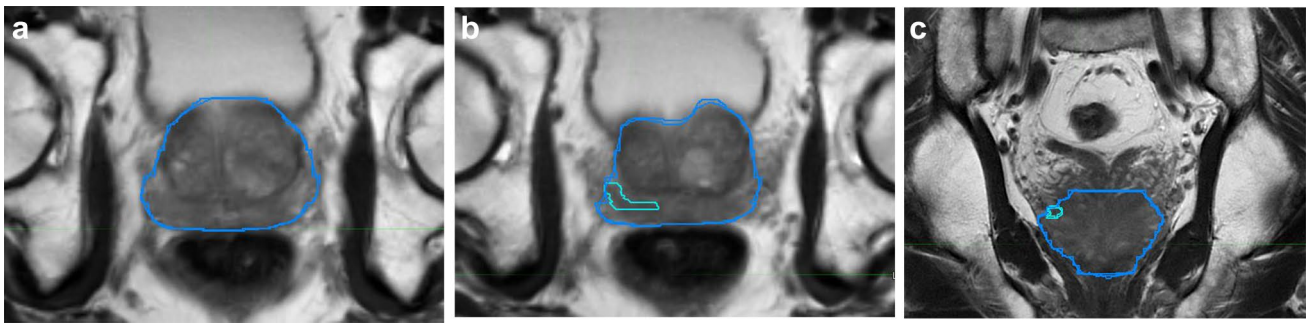

Fig. 2 Shows segmentation of the prostate gland (**a**) and segmentation of a PI-RADS 5 lesion in the right posterior peripheral zone in the base of the gland in axial (**b**) and coronal (**c**) planes on T2-weighted sequences using MIM Symphony Dx™ commercially available software for targeted MR-US fusion biopsy planning

Step 1: MR-US fusion biopsy system selection

A targeted biopsy can be performed with or without specialized fusion software [8, 9]. *Cognitive fusion* is performed by the urologist who reviews MR images then directs targeted biopsies to zones deemed suspicious by mpMRI using ultrasound guidance. *Software-based MR-US fusion* is performed with the aid of specialized software that digitally superimposes segmented

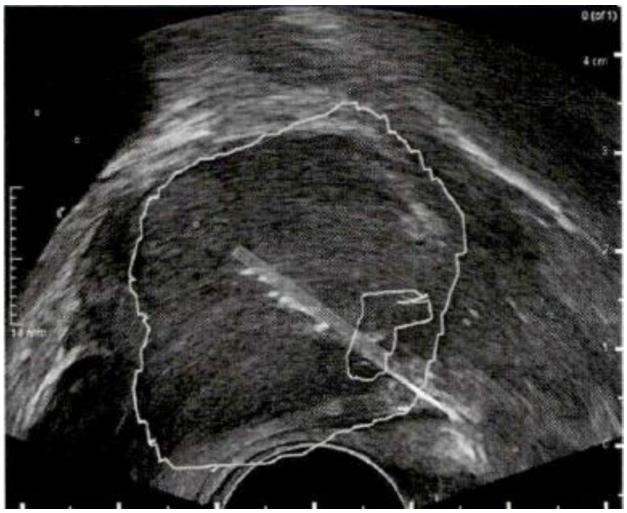

Fig. 3 Shows a MR-TRUS fusion image obtained at the time of targeted biopsy of the segmented right posterior peripheral zone lesion. Pathology of the targeted biopsy specimen showed Gleason score 9 = 4 + 5 cancer

lesions from the MRI onto real-time ultrasound data at the time of biopsy. There are several commercially available MR-US imaging fusion systems for targeted prostate biopsy: including Uronav, Artemis, Urostation, Biojet, MIM, Logiq 9, Fusion Bx [10]. Each software package pairs with specific biopsy hardware and is vendor-specific. The selection of an MR-US fusion biopsy system should be done in consensus with radiology and urology departments. Several factors can influence the decision including cost, compatibility of the software with current ultrasound-guided biopsy machines in urology and specific preferences related to post-processing software and ultrasound- guided biopsy device use.

Step 2: coordinated patient scheduling in radiology and urology

Through coordinated efforts, it is possible to set up a program that allows for image acquisition, rapid reporting, and processing of the mpMRI followed by biopsy the same day.

Current reimbursement for 3D post-processing is possible using the ICD 10 CPT/HCPCS codes 76376 and 76377, group 1 R93.49 (Abnormal radiologic findings on diagnostic imaging of other urinary organs). It is important to note that medical necessity must be documented on the MRI examination request by provider and post-processing by radiologist must be done on the day of interpretation, prior to finalization of the report.

Step 3: standardized mpMRI protocol and MRI reporting

High quality mpMRI of the prostate and correct reporting of MRI findings are key components of an MRI-targeted biopsy program. PI-RADSv2 guidelines [2] help standardize the mpMRI protocol for prostate and aid radiologists with quality control among various MRI scanners within and across different institutions.

Inter-observer variability in PI-RADS assessment has been reported even among experienced abdominal radiologists [11, 12]. There is a learning curve with interpretation of prostate MRI, therefore, we suggest all reading radiologists be trained with PI-RADS guidelines and assessment categories to minimize variability in MRI interpretation.

To provide consistency in MRI reporting and to improve communication of abnormal MRI findings to referring providers, we utilize a standardized PI-RADS version 2.1 reporting structure which allows for documentation of peripheral zone and transition zone lesion characteristics on T2-weighted, DWI/ADC, and post-dynamic-contrast images as well as image number for lesion location on T2 and ADC series with an overall PI-RADS category assignment. This allows for improved comparison between prior scans, standardization of reporting style, as well as contouring of prostatic lesions. In addition, this facilitates referring provider identification of abnormalities and lesions from the MRI reports. Also, saving relevant MRI images with markups can greatly aid the performance of cognitive fusion biopsy. Finally direct communication and review of the MRI findings with the urologist may be necessary in complex cases to select the targets for fusion biopsy.

Step 4: post-processing for MRI-TRUS fusion biopsy planning

In order to minimize workflow interruptions and to expedite post-processing, MR-US fusion software should be loaded directly onto radiology workstations and all radiologists reading prostate MRI ideally should be trained on how to use biopsy fusion software for post-processing and exporting of MRI data to urology. In our practice, the interpreting radiologist performs the post-processing at the time of MRI reporting. The radiologist contours the prostate gland and lesions with PI-RADS category > 2 using vendor-specific segmentation software. Typically, segmentation is done utilizing T2 weighted images. Several systems also allow for fusion of T2 weighted images and ADC maps to improve accuracy of lesion contouring. In addition, we find marking a fiduciary target like the membranous urethra can aid in fusion alignment for the urologist.

It is also important to communicate directly with the urologist performing the biopsy in complex cases to select

the sites and number of the targets for fusion biopsy. This includes a review of post-processed images with urologists to verify lesion location on MRI and segmented lesions on software fused images, as well as discussion of other findings on the MRI such as extracapsular extension, seminal vesicle invasion or equivocal lesions, especially lesions in the transition zone.

From a urology perspective, at the time of biopsy, the MRI data are fused to the TRUS imaging data to align the MRI and TRUS prostate segmentations. Real-time fusion of MRI data to TRUS images are vendor specific and achieved via electromagnetic positioning devices on the TRUS probe, an articulated semi-automated robotic arm that tracks the motion of the ultrasound probe relative to the MRI, or a handheld 3D ultrasound probe for targeted biopsy.

MR-US biopsy system error is dependent in part on MRI-US image registration error and irregular tumor shape and is estimated to be approximately 3 mm [13–15]. Based on multiple studies, it is recommended to obtain at least two cores from each MRI target, especially, if the lesion is large or irregular [5, 16–18]. However, the clinical yield may vary by biopsy technique [19, 20]. To maximize clinically significant cancer detection, a standard 10 or 12-core systematic biopsy is generally also performed, although the data supporting this are mixed [21, 22]. There is a learning curve in MR-US fusion targeted biopsy procedure, improvements in accuracy can be achieved with greater experience [23].

Step 5: MRI-US fusion biopsy database

Separate labeling of systematic and MRI-targeted cores for pathologic analysis during the biopsy allows for tracking of pathologic data obtained following targeted biopsy as well as procedural and MRI interpretation quality control. Some vendors provide add-ons to aid in lesion tracking. These databases supply an excellent resource for research projects, image interpretation feedback, and assessment of the MR-US fusion technique.

Step 6: multidisciplinary review

Finally, a multidisciplinary review group should be established to discuss clinically significant disease identified only on concurrent systematic biopsy and for discordant PI-RADS 4 or 5 lesions with benign pathology to determine appropriate clinical follow-up or repeat biopsy in these cases.

These sessions are important for image interpretation feedback and improvement in the MRI-US fusion biopsy technique. Also, they provide a forum for discussion of discordant cases, the determination of appropriate follow-up and ways to monitor the MR-US fusion biopsy program.

Conclusion

In summary, there is increasing interest in MR-US fusion targeted biopsy for the diagnosis of clinically significant prostate cancer. Establishing a successful program where radiology works closely with urology optimizes clinical workflow and improves patient access to this important modality.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Kim SP, Karnes RJ, Mwangi R, Van Houten H, Gross CP, Gershman B, Leapman MS, Shah ND. Contemporary Trends in Magnetic Resonance Imaging at the Time of Prostate Biopsy: Results from a Large Private Insurance Database. Eur Urol Focus 2019. https://doi.org/10.1016/j.euf.2019.03.016
2. Weinreb JC, Barentsz JO, Choyke PL, Cornud F, Haider MA, Macura KJ, Margolis D, Schnall MD, Shtern F, Tempany CM, Thoeny HC, Verma S. PI-RADS Prostate Imaging - Reporting and Data System: 2015, Version 2. Eur Urol 2016;69(1):16-40. https://doi.org/10.1016/j.eururo.2015.08.052
3. Siddiqui MM, Rais-Bahrami S, Turkbey B, George AK, Rothwax J, Shakir N, Okoro C, Raskolnikov D, Parnes HL, Linehan WM, Merino MJ, Simon RM, Choyke PL, Wood BJ, Pinto PA. Comparison of MR/ultrasound fusion-guided biopsy with ultrasound-guided biopsy for the diagnosis of prostate cancer. JAMA 2015;313(4):390-397. https://doi.org/10.1001/jama.2014.17942
4. Kasivisvanathan V, Rannikko AS, Borghi M, Panebianco V, Mynderse LA, Vaarala MH, Briganti A, Budaus L, Hellawell G, Hindley RG, Roobol MJ, Eggener S, Ghei M, Villers A, Bladou F, Villeirs GM, Virdi J, Boxler S, Robert G, Singh PB, Venderink W, Hadaschik BA, Ruffion A, Hu JC, Margolis D, Crouzet S, Klotz L, Taneja SS, Pinto P, Gill I, Allen C, Giganti F, Freeman A, Morris S, Punwani S, Williams NR, Brew-Graves C, Deeks J, Takwoingi Y, Emberton M, Moore CM, Collaborators PSG. MRI-Targeted or Standard Biopsy for Prostate-Cancer Diagnosis. N Engl J Med 2018;378(19):1767-1777. https://doi.org/10.1056/nejmoa1801993
5. Rosenkrantz AB, Verma S, Choyke P, Eberhardt SC, Eggener SE, Gaitonde K, Haider MA, Margolis DJ, Marks LS, Pinto P, Sonn GA, Taneja SS. Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR. J Urol 2016;196(6):1613-1618. https://doi.org/10.1016/j.juro.2016.06.079
6. NCCN Guidelines Version 2.2018: Prostate Cancer Early Detection.
7. NCCN Guidelines Version 2.2019: Prostate Cancer Early Detection.
8. Verma S, Choyke PL, Eberhardt SC, Oto A, Tempany CM, Turkbey B, Rosenkrantz AB. The Current State of MR Imaging-targeted Biopsy Techniques for Detection of Prostate Cancer. Radiology 2017;285(2):343-356. https://doi.org/10.1148/radiol.2017161684

9. Wegelin O, Exterkate L, van der Leest M, Kummer JA, Vreuls W, de Bruin PC, Bosch J, Barentsz JO, Somford DM, van Melick HHE. The FUTURE Trial: A Multicenter Randomised Controlled Trial on Target Biopsy Techniques Based on Magnetic Resonance Imaging in the Diagnosis of Prostate Cancer in Patients with Prior Negative Biopsies. Eur Urol 2019;75(4):582-590. https://doi.org/10.1016/j.eururo.2018.11.040
10. Sadhna Verma, Peter L. Choyke, Steven C. Eberhardt, Aytekin Oto, Clare M. Tempany, Baris Turkbey, Andrew B. Rosenkrantz: The Current State of MR Imaging–targeted Biopsy Techniques for Detection of Prostate Cancer, Radiology 2017; Nov;285(2):343-356. https://doi.org/10.1148/radiol.2017161684
11. Rosenkrantz AB, Ginocchio LA, Cornfeld D, et al. Interobserver Reproducibility of the PI-RADS Version 2 Lexicon: A Multicenter Study of Six Experienced Prostate Radiologists. Radiology. 2016 Sep;280(3):793–804.
12. Patel NU, Lind KE, Garg K, Crawford D, Werahera PN, Pokharel SS. Assessment of PI-RADS v2 categories ≥ 3 for diagnosis of clinically significant prostate cancer. Abdom Radiol (NY). 2019 Feb;44(2):705-712. https://doi.org/10.1007/s00261-018-1751-5.
13. Natarajan S, Marks LS, Margolis DJ, Huang J, Macairan ML, Lieu P, Fenster A. Clinical application of a 3D ultrasound-guided prostate biopsy system. Urol Oncol 2011;29(3):334-342. https://doi.org/10.1016/j.urolonc.2011.02.014
14. Xu S, Kruecker J, Turkbey B, Glossop N, Singh AK, Choyke P, Pinto P, Wood BJ. Real-time MRI-TRUS fusion for guidance of targeted prostate biopsies. Comput Aided Surg 2008;13(5):255-264. https://doi.org/10.3109/10929080802364645
15. Martin PR, Cool DW, Romagnoli C, Fenster A, Ward AD. Magnetic resonance imaging-targeted, 3D transrectal ultrasound-guided fusion biopsy for prostate cancer: Quantifying the impact of needle delivery error on diagnosis. Med Phys 2014;41(7):073504. https://doi.org/10.1118/1.4883838
16. Kuru TH, Roethke MC, Seidenader J, Simpfendorfer T, Boxler S, Alammar K, Rieker P, Popeneciu VI, Roth W, Pahernik S, Schlemmer HP, Hohenfellner M, Hadaschik BA. Critical evaluation of magnetic resonance imaging targeted, transrectal ultrasound guided transperineal fusion biopsy for detection of prostate cancer. J Urol 2013;190(4):1380-1386. https://doi.org/10.1016/j.juro.2013.04.043
17. Sonn GA, Natarajan S, Margolis DJ, MacAiran M, Lieu P, Huang J, Dorey FJ, Marks LS. Targeted biopsy in the detection of prostate cancer using an office based magnetic resonance ultrasound fusion device. J Urol 2013;189(1):86-91. https://doi.org/10.1016/j.juro.2012.08.095
18. Sonn GA, Chang E, Natarajan S, Margolis DJ, Macairan M, Lieu P, Huang J, Dorey FJ, Reiter RE, Marks LS. Value of targeted prostate biopsy using magnetic resonance-ultrasound fusion in men with prior negative biopsy and elevated prostate-specific antigen. Eur Urol 2014;65(4):809-815. https://doi.org/10.1016/j.eururo.2013.03.025
19. Schimmoller L, Quentin M, Blondin D, Dietzel F, Hiester A, Schleich C, Thomas C, Rabenalt R, Gabbert HE, Albers P, Antoch G, Arsov C. Targeted MRI-guided prostate biopsy: are two biopsy cores per MRI-lesion required? Eur Radiol 2016;26(11):3858-3864. https://doi.org/10.1007/s00330-016-4266-x
20. Zhang M, Milot L, Khalvati F, Sugar L, Downes M, Baig SM, Klotz L, Haider MA. Value of Increasing Biopsy Cores per Target with Cognitive MRI-targeted Transrectal US Prostate Biopsy. Radiology 2019;291(1):83-89. https://doi.org/10.1148/radiol.2019180712
21. Salami SS, Ben-Levi E, Yaskiv O, Ryniker L, Turkbey B, Kavoussi LR, Villani R, Rastinehad AR. In patients with a previous negative prostate biopsy and a suspicious lesion on magnetic resonance imaging, is a 12-core biopsy still necessary in addition to a targeted biopsy? BJU Int 2015;115(4):562-570. https://doi.org/10.1111/bju.12938
22. Arsov C, Rabenalt R, Blondin D, Quentin M, Hiester A, Godehardt E, Gabbert HE, Becker N, Antoch G, Albers P, Schimmoller L. Prospective randomized trial comparing magnetic resonance imaging (MRI)-guided in-bore biopsy to MRI-ultrasound fusion and transrectal ultrasound-guided prostate biopsy in patients with prior negative biopsies. Eur Urol 2015;68(4):713-720. https://doi.org/10.1016/j.eururo.2015.06.008
23. Kasabwala K, Patel N, Cricco-Lizza E, Shimpi AA, Weng S, Buchmann RM, Motanagh S, Wu Y, Banerjee S, Khani F, Margolis DJ, Robinson BD, Hu JC. The Learning Curve for Magnetic Resonance Imaging/Ultrasound Fusion-guided Prostate Biopsy. Eur Urol Oncol. 2019 Mar;2(2):135-140. https://doi.org/10.1016/j.euo.2018.07.005. Epub 2018 Aug 17.