Comparison between “In-bore” MRI guided prostate biopsy and standard ultrasound guided biopsy in the patient with suspicious prostate cancer: Preliminary results

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SUMMARY

Objectives: To evaluate the detection rate of prostate cancer (PCA) in patients who underwent to “in-bore” Magnetic Resonance Imaging -guided prostate (MRI-GB) biopsy compared to the standard transrectal ultrasound guided prostate biopsy (TRUS-GB).

Materials and methods: Between January 2017 and March 2015, a cohort of 39 consecutive patients was prospectively enrolled. All the patients underwent an “in-bore” guided MRI prostate biopsy and subsequently ultrasound-guided standard prostate biopsy.

Results: Median age of patients was 65.5 years (SD ± 6.6), median total PSA serum level was 6.6 ng/ml (SD ± 4.1), median prostate total volume was 51.1 cc (SD ± 26.7). Thirty of 39 (76.9%) were biopsy-naive patients while 7/39 (17.9%) had at least one previous negative random TRUS-GB; 2/39 (5.1%) patients were already diagnosed as PCa and were on active surveillance.

In 18/39 (33.8%) men PCA was diagnosed; as regards the MRI-GB results related to the PI-RADS score, biopsies of PI-RADS 3 lesions were positive in 5/18 cases (27.8%), while the number of positive cases of PI-RADS 4 and 5 lesions was 7/11 (63.6%) and 6/10 (60%) respectively. At the histological examination, 4/39 (10.3%) had a PCA ISUP grade group 1, 11/39 (28.2%) had a ISUP 2, 6/39 (15.4%) had a ISUP grade group 3 and 2/39 (5.1%) had a ISUP 4-5.

Conclusions: MRI-GB represents a promising technique that may offer some of advantages compared to standard systematic TRUS-GB. Our preliminary experience in MRI-GB resulted safe and feasible and represents a viable procedure for the diagnosis and characterization of PCA.

KEY WORDS: Prostate cancer; MRI guided biopsy; Ultrasound guided biopsy.

Submitted 27 March 2019, Accepted 29 April 2019

INTRODUCTION

Prostate Cancer (PCA) represents the most common neoplasm diagnosed in men and the second cause of death after lung cancer (1). Digital rectal examination, serum PSA assay and ultrasound-guided biopsy (TRUS-GB) are common methods for prostate cancer diagnosis (2) although not devoid of some limitations and questionable validity. In fact, during prostate ultrasound, the yield of cancer detection remains very low, ranging between 20 and 30% for patients with a serum PSA value between 2 and 4 ng/ml (3, 4); moreover, in a non-negligible percentage of cases (25-30%), PCAs may arise from the anterior part of the gland (anterior horn of peripheral gland, central/transitional zones and fibromuscular stroma). For these reasons, “random” TRUS-GB has a false negative rate of up to 40-50% (5, 6) and clinically significant tumors can often be undetected, especially in larger glands. A higher number of cores can improve the rate of tumors identified but, at the same time, increases the risk of diagnosis of indolent diseases: an aggressive management of these overdiagnosed cases will inevitably lead to an overtreatment, thereby negatively affecting the patients’ quality of life. Magnetic Resonance Imaging (MRI) is a tool of growing importance in PCA diagnosis; furthermore, with the introduction of multiparametric MRI (mpMRI) the accuracy for characterization of prostate lesion is significantly improved. mpMRI, performed before the biopsy, can improve the detection of occult tumors in the areas of prostate generally undersampled during random TRUS-GB. A growing body of evidences suggest that an accurate tumor identification and sampling can improve risk classification and should reduce false-negative rates and the necessity of repeat biopsies both in biopsy-naive patients and in patients with prior negative-biopsy (7-10). However, the increasingly widespread use of the mpMRI for the detection of clinically significant PCAs has involved the need for targeted biopsy reducing the sampling in non-suspicious areas. The techniques for targeted biopsy include visual estimation TRUS-GB, software co-registered MRI ultrasound fusion and in-bore MRI-guided biopsy (MRI-GB); the latter provides the great advantage of direct visualization of the targeted lesion with the same system. Thus, the aim this study was to evaluate the detection rate of prostate cancer in patients underwent to “in-bore” MRI-guided prostate biopsy compared to the standard ultrasound guided prostate biopsy; for secondary endpoint we evaluated the morbility and the complications of both procedures.

MATERIALS AND METHODS

Study methodology and population

Between January 2017 and March 2015 a cohort of 39 patients...
Consecutive patients was prospectively enrolled. The study was conducted with the approval of the institutional review board and all the procedures and reporting were in accordance with the Helsinki protocol. Patients were informed and a subsequent written consent was acquired. All patients had a suspicion for PCa – raised Prostate Specific Antigen (PSA) serum level and/or abnormal digital rectal examination (DRE) – and showed at the mp-MRI, the intervention to their suspicion and the correct position. After manual calibration adjustments to the target lesion, the gadolinium-filled needle guide was properly tracked and the proper direction of the needle guide to the target; reconfirmation of the needle track were repeated until proper alignment was obtained. Once the patient was taken from the scanner, biopsy was performed with a median of 2 (range 1-2) cores taken from each target lesion. If targeting was not certain, due to lesion size or subjective judgement of the operator, subsequent axial and sagittal T2w images with the needle in place were obtained to detect needle position and be able to make adjustments for the next core. Total table time was appreciatively 15 to 30 minutes per patient. After the procedure, patients were observed for 1 hour and were re-evaluated by outpatient visit after 7-10 days in order to record any potential complication. Specimens were processed by routine histopathological fixation with formalin solution and evaluated by a single dedicated uro-pathologist with 20 years of experience.

**Conduct of ultrasound guided prostate biopsy**

The standard biopsy was performed by transrectal approach; the examination was typically 12 cores collected in a sextant template of biopsies from the medial and lateral area of the apical, mid and the base of prostate, on the left and right lobe. During the TRUS guided biopsy the mpMRI data target was not available. Total table time was appreciatively 15 to 30 minutes per patient. After the procedure, patients were observed for 1 hour and were re-evaluated by outpatient visit after 7-10 days in order to record any potential complication. Antibiotic prophylaxis was continued by patients for seven days after the procedure. Specimens were processed by routine histopathological fixation with formalin solution and evaluated by a single dedicated uro-pathologist with 20 years of experience.

**Statistical analysis**

Simple descriptive statistical techniques were used to analyze data, in particular median with interquartile range (IQR) and mean ± standard deviation (SD) were used to report continuous variables, whereas frequencies with percentages were used to describe categorical ones. One-way ANOVA and Kruskal-Wallis k-samples were used to...
compare means and medians between three groups. Pearson’s Chi-Square test and Mc-Nemar test were used to compare the association between clinical and pathologic variables. Two-tailed P values less than 0.05 were considered statistically significant. Statistical analyses were conducted using SPSS® version 21.0 for Macintosh® (IBM Corp, Armonk, NY).

RESULTS

Patient characteristics: Median age of patients was 65.5 years (SD ± 6.6), median total PSA serum level was 6.6 ng/ml (SD ± 4.1), median prostate total volume was 51.1 cc (SD ± 26.7). Thirty of 39 (76.9%) were biopsy-naive patients while 7/39 (17.9%) had at least one previous negative random TRUS-GB; 2/39 (5.1%) patients were already diagnosed with aPCa on active surveillance.

Detection rate All patients enrolled in the study underwent both the MRI-GB and the TRUS-GB. The majority of suspected lesions identified with mpMRI were located in the posterior zone of the prostate (69% of cases). The mean number of biopsic cores taken from patients who underwent “in-bore” biopsy was 12 in MRI-GB and 13 in TRUS-GB (range 12-14). As reported in table 5, about overall detection rate (DR) of patients who underwent “in-bore” MRI-GB and TRUS-GB, 32/39 (82%) men with PCa was diagnosed; as regards the MRI-GB results related to the PI-RADS score, number of positive cases of PI-RADS 4 and 5 lesions was 7/11 (63.6%) and 4/10 (40%) respectively. Analyzing the results of MRI-GB, globally 17/39 (43.5%) patients presented a clinically significant PCa (ISUP group ≥ 2), while the DR for clinically significant PCa in TRUS-GB was 15/39 patients (38.4%). In the series of “biopsy naïve” patient we observed 14/30 (46.7%) cases of PCa detected by MRI-GB and 13/30 (43.3%) cases in the series of TRUS-GB. In patients with previous negative biopsies we observed PCa in 2/7 (28.6%) cases both in MRI-GB and TRUS-GB. In the “active surveillance” group we detected 2/2 (100%) men with PCa in MRI-GB series and 1/2 (50%) in TRUS-GB.

Table 1.
Clinical and radiologic features of patients who underwent “in-bore” biopsy.

| Overall (n = 39) | Biopsy naïve (n = 30) | Previous negative biopsy (n = 7) | Active surveillance (n = 2) | p value |
|-----------------|-----------------------|---------------------------------|-----------------------------|---------|
| Age, years Mean ± SD | 65.5 ± 6.6 | 65.3 ± 6.8 | 66.6 ± 7.1 | 63.5 ± 2.1 | 0.8 |
| PSA, ng/ml Mean ± SD | 6.6 ± 4.1 | 11.7 ± 4.9 | 10.9 ± 7.4 | 6.2 ± 1 | 0.007 |
| PSA density, ng/ml/cc Mean ± SD | 0.14 ± 0.09 | 0.14 ± 0.09 | 0.15 ± 0.05 | 0.13 ± 0.04 | 0.95 |
| Prostate volume, cc Mean ± SD | 51.1 ± 26.7 | 46.7 ± 22.2 | 70.4 ± 38.1 | 52 ± 8.5 | 0.1 |
| Diameter mpMRI area, mm Mean ± SD | 11.9 ± 5.1 | 11.7 ± 4.9 | 13.1 ± 6.5 | 10 ± 5.7 | 0.7 |
| Area location mpMRI+, n (%) | | | | | |
| Posterior | 27 (69.2) | 21 (70) | 4 (57.1) | 2 (100) | 0.5 |
| Anterior | 12 (30.8) | 9 (30) | 8 (11.4) | 0 (0) | 0 |
| PI-RADS-v2, n (%) | | | | | |
| 3/5 | 16 (42.6) | 14 (46.7) | 2 (28.6) | 2 (100) | 0.5 |
| 4/5 | 11 (28.2) | 8 (26.7) | 3 (42.9) | 0 (0) | 0 |
| 5/5 | 10 (25.6) | 8 (26.7) | 2 (28.6) | 0 (0) | 0 |

Table 2.
Overall and stratified according to clinical status “in-bore” results.

| Overall | Biopsy naïve | Previous negative biopsy | Active surveillance | p value |
|---------|--------------|---------------------------|---------------------|---------|
| Detection rate PCa, n (%) | 17/39 (43.5) | 14/30 (46.7) | 2/7 (28.6) | 2/2 (100) | 0.2 |
| Detection rate csPCa, n (%) | 14/30 (46.7) | 2/7 (28.6) | 1/2 (50) | 0.1 |
| csPCa/overall PCa rate, % | 17/18 (94.4) | 14/14 (100) | 2/7 (28.6) | 1/2 (50) | 0.2 |
| ISUP group, n (%) | | | | | |
| Negative | 21 (53.8) | 16 (53.3) | 5 (71.4) | 0 (0) | 0.1 |
| 1 | 1 (2.5) | 1 (5.5) | 0 (0) | 1 (50) | |
| 2 | 10 (25.6) | 10 (33.3) | 0 (0) | 0 (0) | |
| 3 | 4 (10.3) | 2 (6.6) | 1 (14.3) | 0.5 |
| 4-5 | 3 (7.6) | 2 (6.6) | 1 (14.2) | 0 (0) | |

Table 3.
“In-bore” biopsy results stratified according to PI-RADS Score.

| Overall | PI-RADS score 3 | PI-RADS score 4 | PI-RADS score 5 | p value |
|---------|-----------------|-----------------|-----------------|---------|
| Number of Pts, % | 39 | 18 (46.2) | 11 (28.2) | 10 (25.6) | - |
| Detection rate PCa, n (%) | 18/39 (43.5) | 5/18 (27.8) | 7/11 (63.6) | 6/10 (60) | 0.3 |
| Detection rate csPCa, n (%) | 17/39 (43.5) | 3/18 (16.7) | 5/11 (45.5) | 5/10 (50) | 0.1 |
| Detection rate csPCa/PCa, % | 17/18 (94.4) | 14/14 (100) | 9/11 (81.8) | 5/6 (83.3) | 0.7 |
| ISUP group, n (%) | | | | | |
| Negative | 21 (53.8) | 13 (72.2) | 4 (36.5) | 4 (40) | 0.1 |
| 1 | 1 (2.5) | 1 (5.5) | 0 (0) | 0 (0) | |
| 2 | 10 (25.6) | 3 (16.6) | 5 (45.4) | 2 (20) | |
| 3 | 4 (10.3) | 1 (5.5) | 1 (9.1) | 2 (20) | |
| 4-5 | 3 (7.6) | 0 (0) | 1 (9.1) | 0 (0) | |

Table 4.
Number of biopsic cores taken from patients who underwent in-bore and random biopsies.

| Number of cores | Overall (n = 39) | Biopsy naïve (n = 30) | Previous negative biopsy (n = 7) | Active surveillance (n = 2) | p value |
|-----------------|-----------------|-----------------------|---------------------------------|-----------------------------|---------|
| Total | 13 (13-14) | 13 (13-14) | 13 (13-15) | 13 (13-13) | 0.5 |
| In bore biopsy | 1 (1-2) | 1 (1-2) | 1 (1-2) | 1 (1-1) | 0.5 |
| Random biopsy | 12 (12-12) | 12 (12-12) | 12 (12-12) | 12 (12-12) | 0.5 |
series. The details of results are reported in table 2-8. As far as the secondary endpoint is concerned, we have not observed any complications related to procedures.

**DISCUSSION**

TRUS-GB represents the “gold-standard” technique of histological diagnosis of prostate cancer. Aim of this study was to investigate the real diagnostic accuracy of a novel prostate biopsy technique MRI guided compared to the standard TRUS-guided biopsy (11). During the recent years, there was an increasing use of mpMRI in stadiation of prostate cancer e in order to improve quality of surgery during radical prostatectomy (12).

Other important application of mpMRI is the guide to prostate biopsy in order to improve PCa diagnosis with the aim to refine PCa risk classification (13) and, simultaneously, to overcome the limitations of contemporary standard TRUS-GB: low-risk patients could be spared from biopsies reducing overdetection of low-risk cancer while a lower number of cores could be required in men with suspicious MRI findings reducing also potential complications related to the procedure and all the consequence on quality of life (14-16).

Targeted MRI-GB has become an alternative approach to TRUS-GB and several MRI-GB methods have been proposed for the diagnosis of PCa. In the “cognitive” technique, TRUS-GB is planned on the basis of MR images; in spite of reduced costs, this method has a long learning curve and the sampling of suspicious lesions may not be guaranteed. The MRI-US “fusion” biopsy is simply described as a way to align a pre-registered MRI to an intraprocedural US in order to identify and target suspected lesions within the gland through a dedicated hardware platform targeting areas found during mpMRI and not clearly visible during US scan; the advantages are the high reproducibility and the real time feedback though counterbalanced by the high up-front cost of the device. The “in bore” technique consists in the execution of the biopsies directly inside the MRI scanner with dedicate non-magnetic biopsy devices. Despite a longer operative time and higher costs, this method has real-time feedback in needle placement, fewer sampled cores and a low likeli-

### Tables

**Table 5.** Overall “detection rates” and “pathologic results” of patients who underwent “in-bore” biopsies and random biopsies.

| Number of cores | Overall (n = 39) | In-bore biopsy | Random biopsy | p value |
|-----------------|------------------|----------------|---------------|---------|
| Detection rate PCa, n (%) | 23/39 (59% ) | 18/39 (46.2% ) | 15/39 (38.4% ) | 0.7 |
| Detection rate csPCa, n (%) | 20/39 (51.3% ) | 17/39 (43.5% ) | 15/39 (38.4% ) | 0.7 |
| csPCa/PCa detection rate, % | 20/23 (87% ) | 17/18 (94.4% ) | 15/18 (83.3% ) | 0.8 |
| ISUP grade group, n (%) | | | | |
| Negative | 16 (41% ) | 21 (53.8% ) | 21 (53.8% ) | 0.6 |
| 1 | 4 (10.3% ) | 1 (2.5% ) | 5 (12.8% ) |
| 2 | 11 (28.2% ) | 10 (25.6% ) | 7 (17.9% ) |
| 3 | 6 (15.4% ) | 4 (10.3% ) | 5 (12.8% ) |
| 4-5 | 2 (5.1% ) | 3 (7.6% ) | 1 (2.6% ) |

**Table 6.** Overall “detection rates” and “pathologic results” of biopsy naïve patients who underwent “in-bore” biopsies and Random biopsies.

| Overall (n = 30) | In-bore biopsy | Random biopsy | p value |
|-----------------|----------------|---------------|---------|
| Detection rate PCa, n (%) | 16/30 (53.3% ) | 14/30 (46.7% ) | 1/30 (33.3% ) | 0.8 |
| Detection rate csPCa, n (%) | 15/30 (50% ) | 14/30 (46.7% ) | 13/30 (43.3% ) | 0.8 |
| csPCa/PCa detection rate, % | 1/16 (6.2% ) | 14/14 (100% ) | 13/13 (100% ) | 0.5 |
| ISUP grade group, n (%) | | | | |
| Negative | 14 (46.7% ) | 16 (53.3% ) | 17 (56.7% ) | 0.7 |
| 1 | 1 (3.3% ) | 0 (0% ) | 0 (0% ) |
| 2 | 9 (30% ) | 10 (33.3% ) | 8 (26.7% ) |
| 3 | 5 (16.7% ) | 2 (6.6% ) | 4 (13.3% ) |
| 4-5 | 1 (3.3% ) | 2 (6.6% ) | 1 (3.3% ) |

**Table 7.** Overall “detection rates” and “pathologic results” of patients with previous negative biopsies who underwent “in-bore” biopsies and random biopsies.

| Overall (n = 7) | In-bore biopsy | Random biopsy | p value |
|-----------------|----------------|---------------|---------|
| Detection rate PCa, n (%) | 4/7 (57.1% ) | 2/7 (28.6% ) | 2/7 (28.6% ) | 0.3 |
| Detection rate csPCa, n (%) | 2/7 (28.6% ) | 2/7 (28.6% ) | 1/7 (14.3% ) | 0.1 |
| csPCa/PCa detection rate, % | 2/4 (50% ) | 2/7 (28.6% ) | - - |
| ISUP grade group, n (%) | | | | |
| Negative | 1 (14.3% ) | 5 (71.4% ) | 5 (71.2% ) | 0.2 |
| 1 | 4 (57.1% ) | 0 (0% ) | 2 (28.6% ) |
| 2 | 0 (0% ) | 0 (0% ) | 0 (0% ) |
| 3 | 1 (14.3% ) | 1 (14.2% ) | 0 (0% ) |
| 4-5 | 1 (14.3% ) | 1 (14.2% ) | 0 (0% ) |

**Table 8.** Overall “detection rates” and “pathologic results” of patients in Active Surveillance who underwent “in-bore” biopsies and random biopsies.

| Overall (n = 2) | In-bore biopsy | Random biopsy | p value |
|-----------------|----------------|---------------|---------|
| Detection rate PCa, n (%) | 2/2 (100% ) | 2/2 (100% ) | 1/2 (50% ) | 0.5 |
| Detection rate csPCa, n (%) | 2/2 (100% ) | 1/2 (50% ) | 1/2 (50% ) | 1 |
| csPCa/PCa detection rate, % | 2/2 (100% ) | 1/2 (50% ) | 1/1 (100% ) | 0.5 |
| ISUP grade group, n (%) | | | | |
| Negative | 0 (0% ) | 0 (0% ) | 1 (50% ) | 0.3 |
| 1 | 0 (0% ) | 1 (50% ) | 0 (0% ) |
| 2 | 1 (50% ) | 0 (0% ) | 1 (50% ) |
| 3 | 1 (50% ) | 1 (50% ) | 0 (0% ) |
| 4-5 | 0 (0% ) | 0 (0% ) | 0 (0% ) |
hood of missed target. Therefore, the use of “in bore” MRI-GB has the potential to reduce the sampling error associated with unselective standard biopsy scheme by providing better disease localization; moreover, accurate risk stratification through improved cancer sampling may impact therapeutic decision making (13, 17). In our experience the overall detection rate of MRI-GB and TRUS-GB are similar; in particular, in the series of MRI-GB, we observed a slightly higher PCa diagnosis of clinically significant disease (43.5% vs 33.3%), although this result was not statistically significant. A recent systematic review showed that MRI-GB improved significant PCa detection compared to standard TRUS-GB (relative sensitivity 1.26, 95% CI 1.08-1.46) (18). In their preliminary experience with in-bore technique, Panebianco et al. (19) showed a DR for the diagnosis of PCa of 80% and 90% of PCa cases had intermediate grade aggressiveness. Whereas there was currently not enough evidence to recommend mpMRI before a first set of prostate biopsies (2), the use of targeted biopsy often achieved significantly higher cancer DR in the repeat biopsy setting. In patients with prior negative biopsy, MRI-GB showed a median DR of 42%, significantly higher than those reported in repeating systematic biopsy (20). Our preliminary experience in MRI-GB confirmed the feasibility and the reproducibility of an “in-bore” strategy on a 1.5 T MR scanner using a 32-channel coil. Engelhard et al. (21) reported a DR of 38% in 37 consecutive men with elevated PSA levels and negative prostate biopsies underwent a MRI-GB in a 1.5-T scanner in the supine position; in similar but larger cohorts, Roethke et al. (22) and Hoeks et al. (10) found a DR of 52% (52/100) and 41% (14/37), respectively. In our cohort, analyzing the series of patients with previous negative biopsies, the overall DR of MRI-GB was higher than TRUS-GB (57.1% vs 28.6%), particularly in the clinically significant disease (28.5% vs 14.2%). Our preliminary results highlighted the excellent correlation between the PI-RADS score at mpMRI and the ISUP grade groups in MRI-GB cores: this data allows us to infer, on one hand, a high capability of the mpMRI to predict the biological aggressiveness of neoplastic lesions and, on the other hand, the good performance of the MRI-GB procedure. Moreover, the mpMRI procedure with this setting and patients in the prone position has been well tolerated and feasible to perform. Given an initial learning curve, we believe that the time needed for the procedure can be further reduced optimizing the setting and the positioning of the needle guide. Finally, Jung et al. (23) found that the rate of positive MRI-GB resulted as a function of target size and level of suspicious. It could be argued that obvious that larger target with higher level of suspicious were most likely to yield a positive biopsy; however, the authors concluded that this finding could be helpful when deciding whether to perform a MRI-GB. Engelhard et al. (21) concluded that suspicious lesions with a diameter > 10 mm could be successfully punctured using this device. In spite of reliable feasibility and the preliminary promising results with an acceptable DR, some limitations of the present study have to be kept in mind. First, the number of patients was small and, as a part of study design, the patients analyzed were only men with positive findings at mpMRI: this selected patient population from a single institution series may have a positive influence on the number of tumors detected; however, the study was thought as an initial experience to compare the MRI-GB technique and standard TRUS-GB in order to evaluate its feasibility. Consequently, the preliminary results are far from being meaningful and have to be interpreted carefully. Second, the study lacks follow up data and no prostate specimen histology can confirm the results of a negative MRI-GB; further series with radical prostatectomy specimen as reference standards are required in order to corroborate the benefit of a MRI-GB procedure. Finally, it is important to highlight that initially MRI-GB can represent a time-consuming and expensive procedure but, as reported by other authors (24), initial costs could be written off by reducing treatment related costs and improving risk tumor evaluation and quality of life preventing unnecessary radical treatment of insignificant tumors.

**CONCLUSIONS**

MRI-GB represents a promising technique that may offer some of these advantages compared to standard systematic TRUS-GB. Our preliminary experience in MRI-GB resulted safe and feasible and represents a viable procedure for the diagnosis and characterization of PCa especially in a subgroup of patient with clinically significant disease. Further investigations are needed in order to identify who should undergone prostate biopsy and the technique that should be used with the aim of detecting significant PCa and reducing the burden of biopsies.

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