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Evaluating the effect of rectal distension on prostate multiparametric MRI image quality

Iztok Caglic[a,*], Nienke L. Hansen[b,c], Rhys A. Slough[a], Andrew J. Patterson[a], Tristan Barrett[a,c]

[a] Department of Radiology, Addenbrooke's Hospital and University of Cambridge, Cambridge, UK
[b] Department of Diagnostic and Interventional Radiology, University Hospital Cologne, Cologne, Germany
[c] CamPARI Clinic, Addenbrooke's Hospital and University of Cambridge, Cambridge, UK

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ABSTRACT

Purpose: To evaluate the effect of rectal distension on the quality of anatomical and functional prostate multiparametric (mp) MRI.
Materials and methods: Multiparametric (mp) 3T-MRI images of 173 patients were independently evaluated by two radiologists in this retrospective study. Planimetry rectal volumes were derived and a subjective assessment of rectal distension was made using a 5-point Likert scale (1 = no stool/gas, 5 = large amount of stool/gas). Image quality of diffusion-weighted imaging (DWI) was evaluated using a 5-point Likert scale. DWI was further scored for distortion and artefact. T2W images were evaluated for image sharpness and the presence of motion artefact. The stability of the dynamic contrast-enhancement acquisition was assessed by recording the number of corrupt data points during the wash-out phase.
Results: There was a strong correlation between subjective scoring of rectal loading and objectively measured rectal volume ($r = 0.82$), $p < 0.001$. A significant correlation was shown between increased rectal distension and both reduced DW image quality ($r = -0.628$, $p < 0.001$), and increased DW image distortion ($r = 0.814$, $p < 0.001$). There was also a significant trend for rectal distension to increase artefact at DWI ($r = 0.154$, $p = 0.042$). Increased rectal distension led to increased motion artefact on T2 ($p = 0.0096$), but did not have a significant effect on T2-sharpness ($p = 0.0638$). There was no relationship between rectal distension and DCE image quality ($p = 0.693$). 63 patients underwent lesion-targeted biopsy post MRI, there was a trend to higher positive predictive values in patients with minor rectal distension (34/38, 89.5%) compared to those with moderate/marked distension (18/25, 72%), $p = 0.09$.
Conclusion: Rectal distension has a significant negative effect on the quality of both T2W and DW images. Consideration should therefore be given to bowel preparation prior to prostate mpMRI to optimise image quality.

1. Introduction

Multiparametric magnetic resonance imaging (mpMRI) incorporating T2W, DWI and DCE sequences has now become established in the work-up of prostate cancer [1].

Increasingly, mpMRI is being performed on 3T scanners to provide a superior signal-to-noise ratio, allowing the use of a surface body coil instead of an endorectal coil (ERC), which is better tolerated by patients, and reduces the time and cost of the examination [2]. Although an ERC is known to induce motion via rectal spasm [3], it may also serve as a mechanical barrier to movement of the rectum and prostate, similar to the effects of endorectal balloon placement for prostatic radiotherapy [4]. Previous studies assessing the effect of rectal loading are lacking, aside from positional differences in relation to radiotherapy planning. Rectal distension has been shown to correlate to increased rectal movement [5], thus in the absence of an endorectal coil, T2W, DWI and DCE images may be degraded by motion artefact. Additionally, the absence of an ERC allows for rectal loading and distension with air/faeces and may induce susceptibility artefact, particularly on diffusion weighted images (DWI), similar to that described with neuroimaging and liver MRI [6], which may be further magnified at 3T [6–8].

* Corresponding author at: Department of Radiology, Addenbrooke's Hospital and University of Cambridge, Cambridge, CB2 0QQ, UK.
E-mail address: iztokcaglic@gmail.com (I. Caglic).

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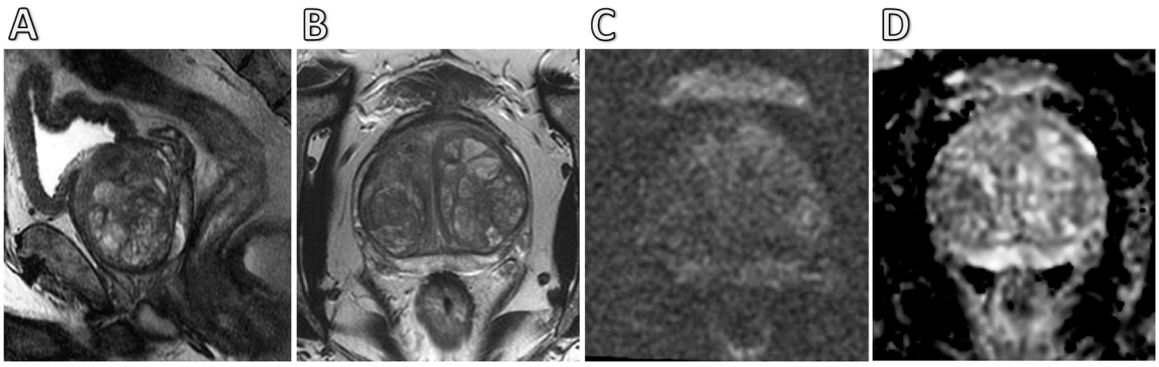

Fig. 1. Mild rectal loading, no distortion or artefact.
61 year old, PSA 8.1 ng/ml, MRI performed pre-biopsy. A: Subjective scores of mild rectal loading, overall rectal volume 23.2 cm^3. B: No motion on T2-weighted axial imaging. C, D: Diffusion-weighted imaging scored as no distortion or artefact.

As MRI is used for lesion detection, staging, and biopsy-targeting, the importance of good quality imaging without significant artefact and distortion is essential. The lack of evidence to inform patient preparation prior to MRI has been highlighted in the recently updated Prostate Imaging-Reporting and Data System (PI-RADS) guidelines, which are aimed at standardizing MRI acquisition and interpretation [9]. One reason for this deficit in the literature may relate to the formerly widespread use of endorectal coils, with subsequent expulsion of rectal contents. Current practice reflects a shift to 3T MRI with no endorectal coil, making rectal loading a potential issue, and artefact may even be exacerbated by the higher field strength employed.

To date, no study has directly evaluated the correlation between rectal distension and the degree of artefact at mpMRI, with only one study assessing the effects on image quality of intervention with a cleansing enema [10]. The purpose of this study was therefore to determine the effect of rectal distension on the quality of T2W, DWI and DCE sequences of prostate mpMRI.

2. Methods

2.1. Study population

This single-institution retrospective study was approved as part of a prostate MRI service evaluation, with the need for informed consent for data analysis waived by the local ethics committee (study registration CUH/5126). The study included 173 patients undergoing prostate 3T-MRI for any indication during a 12 month window, which ended in February 2016. Exclusion criteria included presence of pelvic metalwork and any previous treatment for prostate cancer.

2.2. Magnetic resonance imaging

Patients underwent MRI at 3T (MR750, GE Healthcare) using a 32 channel phased array cardiac coil. Sequences included axial T1 weighted FSE (fast spin echo) pelvic images and high resolution T2 weighted fast recovery FSE images of the prostate in the axial, sagittal, and coronal planes. T1 weighted parameters: TR/TE 561/11 ms, FOV 24 × 24 cm, resolution 1.1 × 1.0 mm. T2 weighted parameters: TR/TE 4273/102 ms, FOV 22 × 22 cm, resolution 0.8 × 0.7 mm, 1.5 signal averages. Axial diffusion-weighted imaging (DWI) was performed using a dual spin-echo planar pulse sequence: TR/TE 3775/70 ms, FOV 28 × 28 cm, resolution 2.2 × 2.2 mm, with 6 signal averages; b-values of 150, 750, 1400 and 2000 s/mm^2, with automated ADC maps. Axial 3D dynamic contrast-enhanced (DCE) images were acquired using a fast-spoiled gradient echo sequence (TR/TE 4.088/1.788 ms; FOV 24 × 24 cm) with a temporal resolution of 7s. After 28 s a bolus of Gadobutrol (Gadovist, Schering AG) was injected via a power injector at 3 mL/s (dose 0.1 mmol/kg) followed by a 25 mL saline flush at 3 mL/s. The axial T2-w, DWI and DCE sequences were spatially matched, with a 3 mm thickness and 0-mm gap.

2.3. Image analysis

Images were reviewed for image quality by two radiologists, blind to the clinical details, with 7 years (**XX**) and 2 years experience (**XX**) in prostate MRI reporting. Planimetry rectal volumes were derived using maximal axial and sagittal dimensions (anal canal to peritoneal reflection), and a subjective assessment of rectal distension was made using a 5-point Likert scale: 1 = no stool/gas, 2 = minimal, 3 = small amount, 4 = moderate, 5 = large amount of stool/gas (Figs. 1 and 2). T2-weighted imaging was qualitatively assessed for image sharpness (based on the sharpness of the neurovascular bundle, seminal vesicles, and prostatic capsule compared to periprostatic fat) and motion artefact (ghosting or movement). DW image quality was scored on the highest b-value imaging (b = 2000 s/mm^2) using a 5-point scale: poor = 1, suboptimal = 2, adequate = 3, above average = 4, excellent = 5. DWI was also assessed for artefact and distortion using 4-point scales; artefact: none = 1, mild, not/mildly impacting diagnosis = 2, artefact moderately impacting diagnosis = 3, marked artefact/non-diagnostic = 4; distortion: none = 1, <5 mm mismatch to T2WI = 2, ≥5 mm mismatch to T2WI *or* mild warping = 3, significant warping = 4 [11]; Figs. 3 and 4. DCE images were assessed based on the number of corrupt data points, using a region-of-interest of ≥0.2 cm^3 in normal appearing peripheral zone, and recording the number of corrupted data points from the contrast curve (defined as any >10%, between-point, signal intensity changes during the wash-out phase) [10].

2.4. Statistics

Wilcoxon signed ranked tests were performed to assess differences between binary criteria (T2 motion and sharpness) and the ordinal image quality scales. Fisher's exact test was used to compare targeted biopsy outcomes between groups of patients with differing rectal distension. Spearman's correlation was performed to assess the relationship between ordinal variables. A p-value <0.05 was defined as statistically significant. Weighted Cohen's Kappa was performed to assess inter-rater agreement using the following rules of thumb (0–0.20 = slight, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 substantial, and 0.81–1 almost perfect agreement) [12]. The statistical analysis was performed using R (version 3.1.1, The R Foundation for Statistical Computing, Vienna, Austria).