Short Communication

Local staging of rectal cancer using fused high resolution diffusion weighted imaging and modified MR rectography

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Abstract: Rectal cancer (RC) is a common malignant tumor with high mortality. MR imaging plays an important role in treatment decision making of RC. Unfortunately, the contents (gas and feces) in the rectum often induce artifacts and thus negatively affect the depicting and staging of RC. We developed a new protocol for MR rectography using oral administration of iso-osmotic mannitol to distend lumen after bowel cleansing preparation. Fused MR rectography and high resolution diffusion weighted imaging (DWI) is then performed to facilitate detection and staging of RC. Our present technique can eliminate the effect of gas and feces on image quality, especially on DWI, and can achieve satisfactory bowel distention, lesion depicture and visualization of surgical planes. Fused high resolution DWI and MR rectography can be a promising technique to improve the accuracy of RC local staging.

Keywords: Rectal cancer (RC); MR imaging; rectography; high resolution diffusion weighted imaging (DWI); fusion

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Introduction

Rectal cancer (RC) is a common cancer with high mortality (1,2). Local staging of RC, including the status of circumferential resection margin (CRM), depth of tumor spread and adjacent lymph node involvement, is one of the factors influencing the patients' survival (2). Accurate staging using advanced imaging technique can facilitate clinicians for the patients' treatment decision making and improve the patients' outcomes (3-6). MR imaging has been proved to be the first-line imaging modality to stage and assess the response of neoadjuvant radiotherapy and chemotherapy (6). Unfortunately, rectum is a luminal organ, which is often filled with gas and feces or is at the status of collapse. The gas and feces can not only influence the visualization of the lesions, but also introduce susceptibility artifact due to gas-tissue interface effect. Furthermore, collapse of lumen may prevent demarcating the lesion from normal tissue clearly. MR colonography or rectography were developed using bright-lumen (a gadolinium chelate-spiked enema) or dark-lumen (gas) techniques to distend colorectum (7,8). Both techniques have some limitations. Bright-lumen technique may influence assessing tumor enhancement, and the dark-lumen technique may introduce susceptibility artifacts. Ultrasonographic gel has been introduced to distend colorectum lumen and proved to be an effective method to facilitate lesion depiction within the wall and its extension estimation (9-12). The injection pressure can result in over distention of rectum, which may alter the distance between the tumor and surgical planes (13). This distance has a crucial role on assessing the involvement of the mesorectal fascia (MRF) by tumors. The distance of less than 1 mm is regarded as an involvement of MRF, and not suitable for total mesorectal excision. The introduction of ultrasonographic gel needs to insert a rectal tube on the MR examination bed. Therefore, it will increase patients'

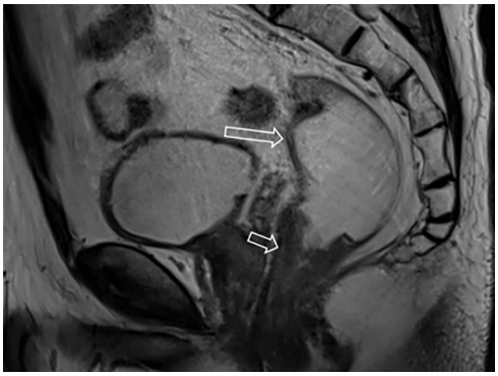

Figure 1 A 64-year-old man with low RC. Sagittal MR rectography shows satisfactory distention of the upstream rectal lumen (long arrow) and the tumor (short arrow). RC, rectal cancer.

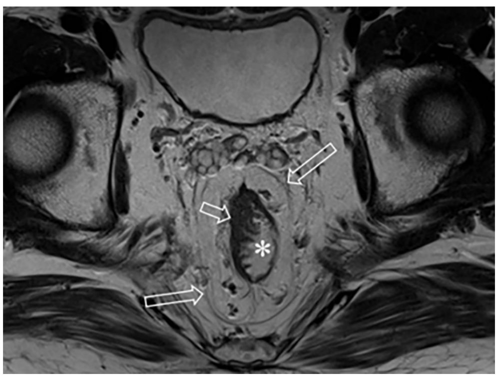

Figure 2 A 67-year-old man with low RC. Axial MR rectography shows excellent distention of rectal lumen (asterisk), clear mesenteric fascia (long arrows) and the stage T2 tumor (short arrow). RC, rectal cancer.

examination room time, and the effect of feces can't be eradicated completely. We developed a novel method to perform MR rectography through oral administration of isosmotic mannitol after bowel cleansing preparation; and fusion of high resolution diffusion weighted imaging (DWI) and MR rectography was carried out to improve local staging of RC.

Technique and protocol of MR rectography

This study was approved by institutional review board and obtained informed consent from all the patients. Patients undergoing MR rectography were asked to take compound polyethylene glycol electrolyte orally as laxative on the night prior to the exam to clear the colorectum. The examinations were scheduled in the morning. About 1,500 mL of isosmotic mannitol was continuously taken orally in 90 to 120 min before examination. MR rectography was performed when the patients had the feeling of bowel movement again after 2 or 3 excretions. To ensure the completeness of the examination, the patients were permitted to have two or three bowel movements before the beginning of examination. All the preparation was performed outside the examination room. Therefore, it did not increase examination time and did not influence the patient flow. MR rectography was performed at rectal axial, coronal and sagittal high resolution T2 weighted imaging at 3.0T MR system (Magnetom Skyra, Siemens Healthcare, Erlangen, Germany) using parameters as follows: repetition time (TR), 3,000–4,200 ms; echo time (TE), 83–101 ms; slice thickness, 3 mm; field-of-view, 220–280 mm; matrix, 381–435×448–512. Besides the regular dynamic contrast enhanced MR imaging, high resolution DWI was obtained using the techniques of readout segmentation of long variable echo trains (RESOLVE) at transverse and sagittal planes with the following parameters: TR, 5,800–7,030 ms; TE,61 ms; slice thickness,3 mm; field-of-view, 220–230 mm; matrix, 116×116; and b values, 0 and 1,000 s/mm^2. Fusion of high b value DWI onto T2WI was conducted by using an image processing workstation (Syngo Via, Siemens Healthcare, Erlangen, Germany) at both axial and sagittal planes respectively.

Results and discussion

After the cleansing preparation, effect of feces on the lesion depicture of CRC can be eradicated completely. Intention of bowel movement shows that the contrast material has reached the rectum. Therefore, luminal distention can be obtained also, which can improve tumor visualization (*Figure 1*). With high resolution T2 weighted images on axial, coronal, and sagittal planes, this technique also showed its advantage in displaying the relationship of tumor to surgical planes, such as CRM and anal sphincter (*Figures 2-4*).

DWI has been proved to a valuable tool for tumor detection and characterization staging, prognosis evaluation, assessing response to treatment and recurrence of RC. Due to high cellularity and heterogeneity, RC appears as high signal lesion on high b value DWI. Unfortunately, gas in non-preparation bowel can induce susceptibility artifact to distort the images (*Figure 5*). In present protocol, oral isosmotic mannitol after bowel cleansing preparation can

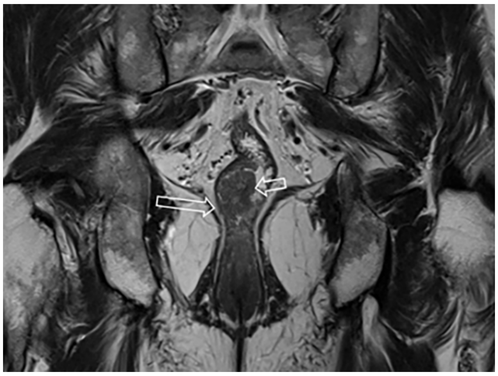

Figure 3 A 59-year-old man with low RC. Coronal MR rectography shows the tumor (short arrow) and clear anal sphincter space (long arrow). RC, rectal cancer.

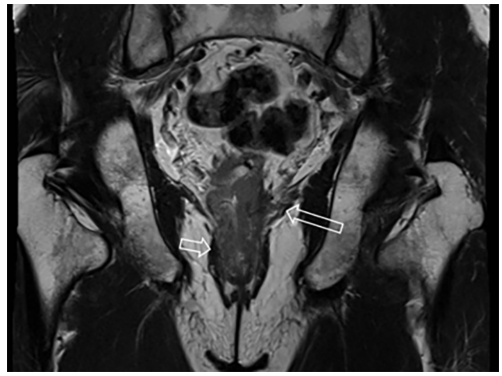

Figure 4 A 60-year-old man with low RC. Coronal MR rectography shows that external anal sphincter (short arrow) and levator ani muscle (long arrow) are invaded. RC, rectal cancer.

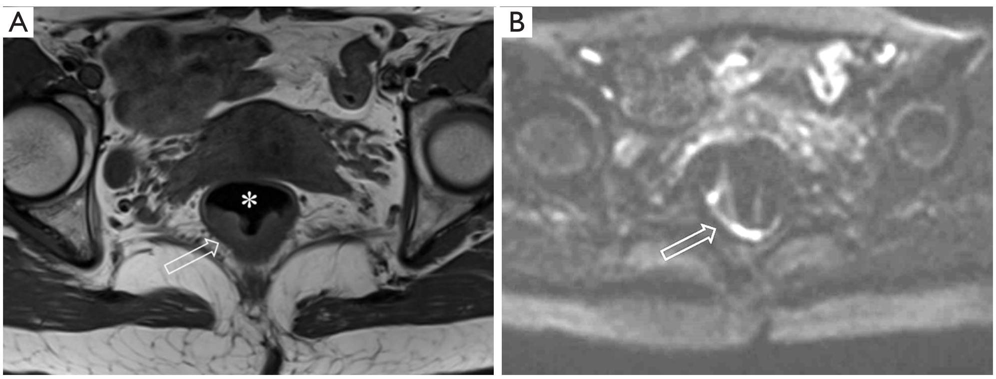

Figure 5 A 51-year-old woman with low RC. (A) Axial MR rectography shows the tumor (short arrow) and the air in the rectum (asterisk) at the T2WI; (B) axial DWI shows the tumor (arrow) is distorted due to air-tissue interface susceptibility artifact. RC, rectal cancer; DWI, diffusion weighted imaging.

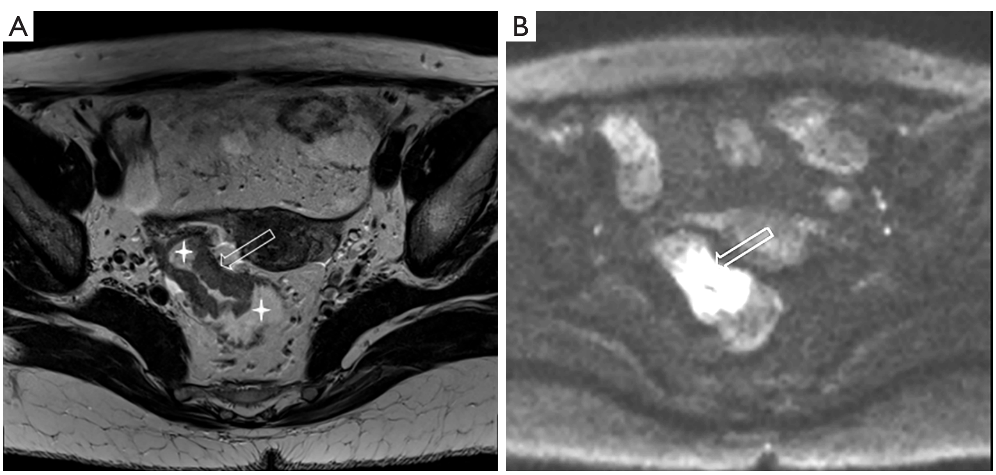

Figure 6 A 54-year-old man with high RC. (A) Axial MR rectography shows the tumor (arrow) and the well filled rectum (asterisk); (B) axial DWI demonstrates the tumor (arrow) with clarity. RC, rectal cancer; DWI, diffusion weighted imaging.

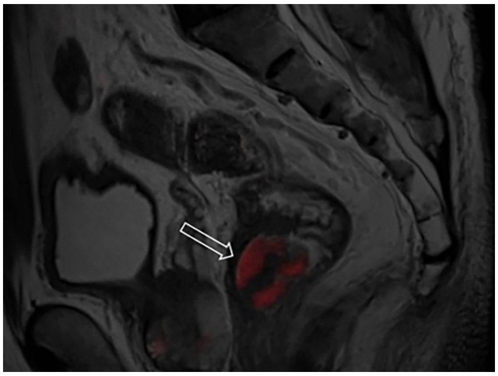

Figure 7 A 60-year-old man with low RC. Fused sagittal MR rectography and DWI shows the tumor with restricted diffusion in red color (arrow) without breaking through the outer membrane of the rectum. RC, rectal cancer; DWI, diffusion weighted imaging.

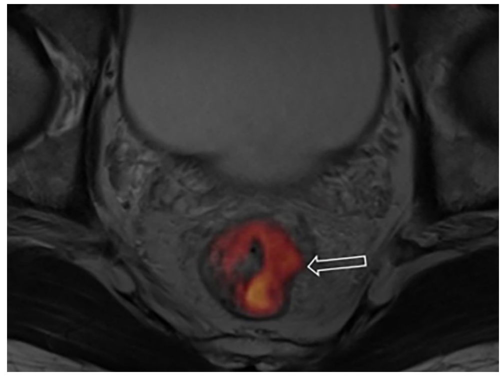

Figure 8 A 55-year-old man with low RC. Fused axial MR rectography and DWI shows a stage T3a tumor (arrow) in hot color which has broken through the outer membrane of the rectum. RC, rectal cancer; DWI, diffusion weighted imaging.

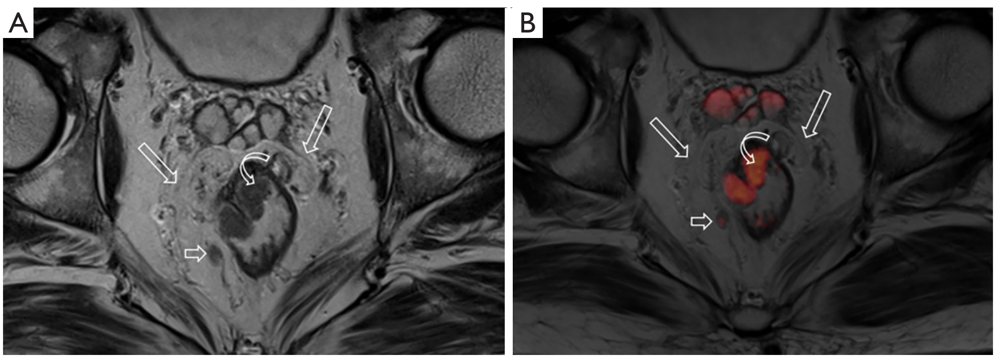

Figure 9 A 59-year-old man with low RC. (A) Axial MR rectography shows the tumor (curve arrow), enlarged lymph nodes (short arrows) and clear mesenteric fascia (long arrows); (B) fused axial MR rectography and DWI visualizes the tumor (curve arrow) and enlarged lymph nodes (short arrows) with restricted diffusion in color. The clear mesenteric fascia (long arrows) can be also identified. RC, rectal cancer; DWI, diffusion weighted imaging.

eliminate gas inducing artifact on DWI (*Figure 6*). To overcome lower spatial resolution, RESOLVE technique and fusion of DWI and MR rectography were used to improve spatial resolution of DWI and to combine advantages of DWI in visualization of lesions and high spatial resolution of T2WI (*Figure 7*). This technique could not only improve the assessment of the tumor's position and the local invasion (*Figure 8*), but also facilitate evaluation of adjacent lymph nodes, for metastatic nodes of which often exhibit significant diffusion restriction (*Figure 9*).

In conclusion, we described a new protocol for MR rectography, which uses isosmotic mannitol instead of gas to distend the bowel lumen after bowel cleansing. This was shown to be a practical method to improve image quality and lesion depicture of RC through eliminating effect of gas and feces. Another advantage is that our method can eliminate susceptibility artifact induced by gas interface so that it is very suitable for diffusion weighted sequence. Fusion of high resolution DWI and MR rectography, which combines the advantages of these two sequences, is a promising technique to improve the accuracy of RC local staging.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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