3D- Cube sequence in preoperative loco- regional staging in rectal cancer: is a one- shot diagnosis possible?

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Purpose

Pelvic MRI is part of a diagnostic framework in rectal cancer, and plays a fundamental role in preoperative staging. However, this kind of examination is not the first step in rectal cancer diagnosis: rectal cancer must be histologically proven and radiologist must be aware about tumor location (1, 2, 3).
Standard acquisition protocol requires 2D FSE sequence acquired on the three planes; Cube is a single slab 3D FSE sequence that allows the acquisition of a volume in a single short acquisition and gives the possibility to process dataset with multiplanar and curved planar reconstructions along the rectal centerline.
Aim of the paper is to compare 2D T2w sequences and 3D Cube in the loco-regional staging of rectal cancer.

Images for this section:

Fig. 12: Preoperative MRI examination in a 29 years old man with multiple polyps (star) and sigma cancer (arrow). Sagittal 2D FSE T2w images show multiple polyps (star) in low rectum.
Methods and Materials

On March 2011, a 3T MRI scanner (Discovery 750, General Electric, Milwaukee, Wisconsin, USA) has been installed in our Institution.

From April to December 2011, 32 MRI have been performed in patients with rectal cancer diagnosis; all patients underwent neoadjuvant therapy (chemo and radiotherapy). Until December 2011, 11 patients ended therapy and underwent surgery; all of them received a total mesorectal excision (TME). No one of them had hepatic or pulmonary metastasis at CT preoperative staging.

TECHNIQUE
Despite several studies denied the utility of a luminal distention, a rectal enema with water solution is usually performed in our Institution. Rectal distention allows a good mucosal evaluation and lesion conspicuity is easily evaluated. After water solution introduction, the probe is removed and patient is positioned in a supine position; a phased array coil is disposed. Localizer on three planes and calibration is obtained; then, a T2 weighted FSE on a sagittal plane is acquired. This first sequence allows a first evaluation about lesion location, and is a guide to choose planes for the other sequences. Axial T2w FSE with a large FOV is obtained; then oblique axial is tilted in order to be perpendicular to rectal lumen at the level of the tumor with thin slice thickness (3mm). Coronal T2w FSE is acquired parallel to anal canal, in order to evaluate levator muscle anatomy and eventually their neoplastic involvement; this sequence is useful in low third rectum cancer, in order to evaluate also sphincter complex and intersphincteric plane. Finally, a 3D FSE Cube sequence is performed on a sagittal plane. The standard acquisition protocol usually required 15 minutes; 3D Cube is performed within 6 minutes.

Two experienced radiologists independently assessed T and N parameters respectively on 2D dataset and on 3D images; then, the distance form distal lesion border to pubo-rectal muscle insertion was calculated. 3D cube datasets can be processed with multiplanar and curved planar reconstructions along the rectal centerline, so rectal lumen can be "unrolled". Histopathological specimen was considered the gold standard; because of muscles were never involved, distance from distal lesion border to puborectal muscle was compared with the distance measured from surgeon with endoscope. Linear Cohen k values were calculated to quantify agreement between images and histopathological/ surgical data. Furthermore, image quality was evaluated using a linear qualitative scale (very poor/poor/acceptable/good/very good).

Images for this section:
**Fig. 10:** Preoperative MRI examination in a 69 years old woman with medium rectal cancer. Oblique coronal 2D FSE (a) and 3D Cube image (b) processed on the same plane show a substenotic rectal lesion involving anterior and left lateral wall; distance from lesion to mesorectal fascia is inferior than 1mm. 3D cube acquired on sagittal plane (c) and processed with curved planar reconstructions along the rectal centerline shows "unrolled" rectal lumen (d); distance from lesion border to pubo-rectal muscle insertion can be measured (d).
Fig. 11: Preoperative MRI examination in a 69 years old woman with medium rectal cancer. Oblique coronal 2D FSE (a) and 3D Cube image (b) processed on the same plane show a substenotic rectal lesion involving anterior and left lateral wall; distance from lesion to mesorectal fascia is inferior than 1mm. 3D cube acquired on sagittal plane (c) and processed with curved planar reconstructions along the rectal centerline shows "unrolled" rectal lumen (d); distance from lesion border to pubo-rectal muscle insertion can be measured (d).
Results

After neoadjuvant chemo-radiotherapy, T downstaging resulted in T2 stage (1 patient), T1 (6 patients) and T0 (4 patients).
T staging accuracy was 11% on 2D images, and 28% on 3D images.
N stage was 0 in 7 patients, and 1 in 4 patients; N staging accuracy in 11 patients was 53% on 2D and 50% on 3D images.
Accuracy in evaluating distance from distal lesion border to pubo-rectal muscle insertion in 11 patients was 60% on 2D and 100% on 3D images.

Images for this section:

Fig. 8: Preoperative MRI examination in a 30 years old woman. Please describe the findings.
**Fig. 9:** MRI examination shows a low rectal lesion; 2D FSE T2w images acquired on sagittal, axial and coronal planes (a, b, c) are compared with 3D Cube datasets (d, e) processed on similar planes. Lateral and posterior rectal wall is involved; there is not cleavage between lesion and right levator muscle (red arrow). However, levator muscle does not show signal abnormalities.
Conclusion

3D- FSE Cube is reliable in measuring distance from lesion border to puborectal muscle insertion thanks to the possibility to process dataset with multiplanar and curved planar reconstructions along the rectal centerline (4).
Cube is a single slab 3D FSE sequence that allows the acquisition of a volume in a single short acquisition; because of isotropic voxels, Cube is characterized by a high spatial resolution and gives the possibility to reconstruct images on sagittal, axial, coronal or any oblique orientation. By acquiring a single sequence, examination requires 20 minutes; a standard protocol requires at least 30 minutes. Cube is convenient for patients with less SAR than FSE (5).
However, SNR can be lower on Cube because isotropic voxel used are really small (0.8-1mm) and this parameter can affect the sensitivity in evaluating T stage.
T staging accuracy was not really high in both datasets, and overstaging occurred in all patients; the main difficult in assessing tumor response is distinguishing fibrosis and residual lesion (6,7).
Lymph- nodes involvement was evaluated on the basis of dimensional criteria; short axis was measured, and the number of lymph- nodes was assessed. N staging accuracy resulted similar on 2D and 3D images (8).
Our study has some limitations. Two experienced radiologists independently assessed data on 2D and 3D, but we can reasonable speculate that their capabilities were not perfectly superimposable.
Furthermore, all patients underwent neoadiuvant therapy, and can not be considered the best condition to evaluate the reliability of the sequence.

Images for this section:
Fig. 1: Preoperative MRI examination in a 60 years woman. Please describe the findings.
Fig. 2: Preoperative MRI examination in a 60 years woman. Please describe the findings.
**Fig. 3:** Preoperative MRI examination in a 60 years woman. Please describe the findings.
Fig. 4: Preoperative MRI examination in a 60 years woman. Please describe the findings.
**Fig. 5:** Preoperative MRI examination in a 60 years woman. MRI examination shows T4 middle- high rectal cancer. 2D FSE T2w images (a, c, e) acquired on sagittal, axial and coronal planes are compared with 3D Cube datasets (b, d, f) processed on similar planes. Sigma wall is involved (arrows); lymph- nodes are present (red arrows). Both reviewers predicted this lesion to be a T4 lesion in both data sets.
Fig. 6: Preoperative MRI examination in a 60 years woman. MRI examination shows T4 middle- high rectal cancer. 2D FSE T2w images (a, c, e) acquired on sagittal, axial and coronal planes are compared with 3D Cube datasets (b, d, f) processed on similar planes. Sigma wall is involved (arrows); lymph- nodes are present (red arrows). Both reviewers predicted this lesion to be a T4 lesion in both data sets.
**Fig. 7:** Preoperative MRI examination in a 60 years woman. MRI examination shows T4 middle- high rectal cancer. 2D FSE T2w images (a, c, e) acquired on sagittal, axial and coronal planes are compared with 3D Cube datasets (b, d, f) processed on similar planes. Sigma wall is involved (arrows); lymph- nodes are present (red arrows). Both reviewers predicted this lesion to be a T4 lesion in both data sets.
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