Endorectal ultrasonography has become important part of preoperative staging of rectal cancer, providing adequate information for clinical decision-making in many cases. However, with the currently available ultrasonographic equipment and techniques, a good deal of relevant information may remain hidden. The advent of high-resolution three-dimensional endoluminal ultrasound, constructed from a synthesis of standard two-dimensional cross-sectional images, and of "Volume Render Mode," a technique to analyze information inside a three-dimensional volume, promises to improve the accuracy of rectal cancer staging. The anatomic structures in the pelvis, the axial and longitudinal extension of the tumor, the presence of slight or massive submucosal invasion in early rectal cancer may be imaged in greater detail. This additional information will bring an improvement for both planning and conduct of surgical procedures.

Key words: endorectal ultrasound, rectal cancer, staging, three-dimensional ultrasound

INTRODUCTION

Assessment of cancer invasion through the bowel wall (T stage) remains the primary and most important factor in treatment of patients with rectal cancer. Lesions confined to the wall may be resected by transanal excision or low anterior resection. Lesions involving, or in close proximity to, the anus might need abdominoperineal resection. Patients with locoregionally-advanced lesions (extension onto the perirectal fat and/or perirectal or pelvic adenopathy) should be considered for neoadjuvant chemoradiotherapy. Neoadjuvant therapy has been shown to reduce local recurrence and permit an increased likelihood of a sphincter-sparing operation, with less toxicity compared with postoperative regimes. Thus, unlike more proximal colon cancers, the optimal method of management of rectal carcinoma is critically dependent on accurate preoperative staging of the disease.

Endorectal ultrasound (ERUS) is a safe diagnostic method that allows both tumor invasion and lymph node metastatic involvement to be staged, and it contributes significantly to the selection of an adequate surgical strategy in patients with rectal cancer. This article describes the technique and reviews the current literature on the usefulness of three-dimensional (3D) ERUS in the staging of rectal cancer.

TECHNIQUE

Dedicated transducers (radial probes - mechanical or electronic - with a 360° field of view, frequency range: 6-16 MHz and focal length: 2-5cm) have been developed for optimal imaging of the anal canal, the rectal wall and the adjacent structures. In routine clinical scanning, the operator works with conventional two-dimensional (2D) systems. Recently 3D probes (2050 and 2052 types, BK Medical A/S, Mileparken 34, DK-2730 Herlev, Denmark) have been introduced. These transducers allow high-resolution 3D automatic acquisition, constructed from a synthesis of a series of closely spaced, standard 2D, cross-sectional images. The advantages of 3D imaging is that the 3D volume can be freely rotated, rendered, tilted and sliced to allow the operator to infinitely vary the different section parameters and visualize the lesion at different angles and in different planes (coronal, longitudinal, axial) to get the most information from the data. The data can be saved, exported, reviewed and manipulated to derive comprehensive images of the study area. Multiplanar reconstruction (MPR) is an useful mean of displaying the structures. In addition the 3D dataset can be manipulated to render images with enhanced surface features (surface render mode) as well as depth features (volume render mode, a technique to analyze information inside a 3D volume by digitally enhancing.
individual voxels). By use of the different postprocessing display parameters, the volume-rendered image provides better visualization performance when there are not large differences in the signal levels of pathologic structures compared with surrounding tissues.

ERUS is usually performed with the patient positioned in the left lateral decubitus. The transducer is covered by a latex balloon that is held in place over a transducer collar by two round rubber rings. Inflating the balloon with degassed water during the procedure (at varying volumes, due to different diameters of rectal ampulla) allows acoustic coupling between the transducer and the rectal wall. When using blind rectal probe, it is mandatory to introduce the transducer through a dedicated proctoscope, inserted into the rectum to pass the proximal border of the rectal mass. Reusable metal sigmoidoscopes or disposable proctoscope (A.4522, Sapimed, Alessandria, Italy) are available.

For a correct examination, the entire tumor should be scanned because depth of infiltration could vary at different points of the tumor itself. Higher frequencies provide better resolution of the sphincter muscles and the rectal wall layer, whereas pararectal tissues and lymph nodes are more accurately assessed using lower frequencies.

ULTRASOUND RECTAL CANCER STAGING

Endosonographically, the bowel wall is seen as five alternating hyper- and hypoechoic layers (Figure 1), as a result of differences in acoustic impedance, corresponding to histological layers. The first (hyperechoic) layer is the interface between the mucosa and the water-filled balloon; the second (hypoechoic) layer represents the mucosa and muscularis mucosae; the third (hyperechoic) layer denotes the submucosa; the fourth (hypoechoic) layer represents the muscularis propria; and the fifth (hyperechoic) layer is the interface between the muscularis propria and perirectal fat/serosa.

Carcinomas are hypoechoic, and the degree to which they disrupt and penetrate the rectal wall layers suggests the local stage. Ultrasonographic staging of tumor depth is denoted by the prefix "u" and corresponds to the TNM classification. A uT0 lesion (villous adenoma) does not penetrate the submucosa (Figure 2). Carcinoma in situ (pTis) is included in this group because it cannot be differentiated from benign adenoma by ultrasound imaging alone. A uT1 tumor is invading the submucosal layer but does not penetrate the muscularis propria. ERUS criteria to determine the depth of submucosal invasion are as follows: slightly irregularity of the submucosa: uT1-slight; massive irregularity of the submucosa: uT1-massive. A uT2 tumor penetrates the muscularis propria. The surrounding hyperechoic layer corresponding to the submucosa and thickening of the hyperechoic layer representing the muscularis propria layer corresponding to the submucosa and thickening of the hyperechoic layer representing the muscularis propria.

Contiguous organs are not involved. ERUS, however, cannot reliably visualize the mesorectal fascia and thus cannot indicate whether the planned surgical circumferential resection margin will be successful. A uT4 tumor infiltrates surrounding organs such as bladder, uterus, cervix, vagina, prostate and seminal vesicles. Sonographically there is a loss of the normal hyperechoic interface between the tumor and the adjacent organ.

The sonographic criteria for identifying involved lymph nodes (Stage uN1) consist of size greater than 5 mm, mixed signal intensity, irregular margins, and spherical rather than ovoid or flat shape (Figure 5). Undetectable or benign appearing lymph nodes are classified as uN0. Inflamed lymph nodes appear hypoechoic, with ill defined
borders. Most of the sound energy is reflected because the lymphatic tissue has not changed.

**DISCUSSION**

ERUS is currently the most widely used and effective staging modality in the local assessment of rectal cancer. Indications for ERUS in rectal cancer are as follows:

1) to choose endoscopic mucosal resection or transanal excision in case of a large polyp (lesion uT0) or early invasive rectal cancer (lesion is uT1);
2) to determine whether preoperative chemotheraphy and radiation is needed (lesion uT3-T4 or N1); and
3) surveillance after surgery for rectal cancer.

Its accuracy in numerous trials ranges from 80 to 95% for T-staging and 70 to 75% for N-staging. The accuracy of ERUS has been assessed in many studies and the main evidence emerged has been that T-staging accuracy varies relative to tumor stage. ERUS tends to be less accurate in staging T2 rectal cancers that are often overstaged. A recent meta-analysis of 11 studies reported that the sensitivity of ERUS in correctly staging T1, T2, T3, T4 rectal cancers was 84%, 76%, 88%, 87%, respectively. Another meta-analysis of 31 studies reported that ERUS sensitivity in correctly staging T1, T2, T3, T4 was 76%, 75%, 88% and 87%, respectively.

3D-ERUS offers a significant advantage over conventional 2D-ERUS for the accurate evaluation of rectal cancer. In a preliminary study, Kim et al. showed that the accuracy of 3D-ERUS was 90.9% for pT2 whereas that of 2D-ERUS was 84.8%. Santoro et al. assessed 142 consecutive patients with clinically possible pT1 rectal cancers using high resolution 3D-ERUS and volume rendering. Histologically, adenomas were found in 75 patients and tumor invasion was found in 44 lesions (24 pT1-slight, 16 pT1-massive, 4 pT2). The depth of invasion was correctly determined in 87.2% of both pT1-slight and pT1-massive lesions. Considering the complete series, the accuracy of this modality in selecting appropriate management was 95.2%.

The impact of tumor level on ERUS accuracy is controversial. Sailer et al. have suggested impaired visualization of tumors located in both the proximal and distal rectum. In their study, 162 tumors were divided into three groups based on tumor location. Reduced accuracy in the staging of low rectal tumors has been attributed to the anatomy of the rectum, which makes it difficult to maintain uniform acoustic contact and proper orientation of the probe. Santoro et al. performed a prospective study to determine whether tumor site and tumor position would influence the accuracy of 3D-ERUS staging. Using multiplanar reconstruction, ERUS correctly predicted the depth
of invasion in 95.3% of lower rectal tumors, 96.1% of middle rectal tumors and 90.3% of upper rectal tumors. These data confirm that using 3D-ERUS, there is no difference in staging rectal cancer regardless of its different positions in the rectal ampulla.

Ultrasonographic criteria for distinguishing malignant from inflammatory lymph nodes are a source of controversy. The criteria of echogenicity and border characteristics are subjective, although at least one study has shown that as many as 72% of nodes with hypoechoic patterns are metastatic. In a recent meta-analysis by Puli et al., the sensitivity of ERUS in diagnosing nodal involvement was 73.2% and specificity was of 75.8%. The use of 3D-ERUS promises to improve the diagnostic accuracy. Kim et al. reported that lymph node metastases were accurately predicted by 3D-ERUS in 84.8% of patients, whereas 2D-ERUS predicted the disorder in 66.7%. Although their findings did not show 3D-ERUS to have a statistically significant advantage over 2D-ERUS, stereoscopic visualization provided easier and more complete understanding of lymph nodes. The accuracy of 3D-ERUS for lymph node metastases, assessed in 142 patients by Santoro et al., was 95.6% for lower rectal tumors, 93.8% for middle rectal tumors and 90.3% for upper rectal tumors.

A number of comparative studies have been performed to assess the efficacy of ERUS, CT and MRI. Some studies have shown clear supremacy of ERUS, whereas other have shown little difference. MRI as with CT, is 95.6% accurate in assessing the relationship of tumor to the wall, invasion of contiguous structures, spread to regional lymph nodes or distant metastases. In a meta-analysis by Bipat et al., ERUS was found to be the most accurate staging modality when compared to CT and MRI imaging for evaluation of local invasion of rectal cancer. For lymph node involvement, the results were comparable, with low sensitivity values. ERUS was used to evaluate only perirectal or mesorectal lymph nodes, whereas CT and MRI were also used to evaluate iliac and mesenteric or retroperitoneal lymph nodes.

In conclusion, ERUS is currently the best modality for the preoperative staging of rectal cancer. It is not alternative, but rather complementary to high-resolution MRI. With the addition of 3D to conventional 2D-ERUS imaging, spatial resolution has increased and anatomic definition improved.

SUMMARY

PREOPERATIVNI STEJDŽING KARCINOMA REKTUMA: ULOGA 3D ENDOREKTALNOG ULTRAZVUKA

Sažetak: Endorektalni ultrazvuk je postao bitan deo preoperativnog stejdžinga karcinoma rektuma na osnovu koga se mogu dobiti adekvatne informacije za donošenje odluka u daljoj kliničkoj praksi i pristupu lečenju kod velikog broja pacijenata. Ipak, sa trenutno dostupnom opremom i tehnikama veliki broj relevantnih informacija može ostati prikriven. Prednosti visokorezolucinone, trodimenzionalne endoluminalne ultrasonografije (konstruisane sintezom dvodimenzionalnim transekcionim imidžingom i "Volume Render Mode" tehnikom koja analizira informacije u trodimenzionalnom prostoru) obećavaju poboljšanje egzaktnosti stejdžinga karcinoma rektuma. Anatomske strukture karlice, aksijalno i longitudinalno pružanje tumora, prisustvo manje ili masivne submukozne invazije kod ranog karcinoma rektuma se u velikoj meri mogu videti. Ove dodatne informacije u velikoj meri mogu uticati na dalje planiranje i sprovedenje hirurških procedura.

Ključne reči: endorektalni ultrazvuk, karcinom rektuma, stejdžing, trodimenzionalni ultrazvuk

REFERENCES


