Endoscopic Ultrasonography versus Submucosal Enhancing Strip as Contrast Material Enhanced MRI in Rectal Lesions

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ABSTRACT
Background: The incidence of rectal cancer has risen. In addition, about 60% of rectal cancer cases are in the advanced stages of diagnosis. The goals of colorectal cancer (CRC) screening are early diagnosis of cancer in the preclinical state and increasing survival.
Objective: To evaluate endoscopic ultrasonography versus submucosal enhancing strip as contrast material enhanced MRI in colorectal lesions. **Patients and Methods:** Thirty-three patients with colorectal lesions who were admitted to Kobry Elkoba Military Hospital were included, diagnosed by colonoscopy followed by histopathological examination. Submucosal enhanced stripe MRI and endoscopic ultrasound were done for all patients.
Results: Nineteen patients who underwent either endoscopic submucosal dissection or surgical intervention with T1 and T4 were confirmed by pathological examination. Submucosal enhancing stripe (SES) MRI accuracy in T staging was 89.47% while in N staging was 94.74%. EUS accuracy in T staging was 100% while in N staging was 94.74%. The difference in accuracy in T staging was in T3 and T4 only because the main target of SES MRI is differentiating T1 from T2. In T1 and T2 no significant difference was reported between SES MRI and EUS. Regarding lymph node infiltration no significant difference was reported. **Conclusion:** SES MRI and EUS are comparable imaging techniques for the local and lymph node staging of rectal cancer.
Keywords: Colorectal cancer, Rectal cancer, Endoscopic ultrasound.

INTRODUCTION

The occurrence of rectal cancer has seen an increase, and notably, approximately 60% of these cases are identified at an advanced stage [1]. It is essential to precisely determine the stage of rectal cancer (RC) to select the most effective combination of treatments [2].

The selection of treatment and the outlook for the patient are influenced by the T and N stages of the disease at diagnosis [3]. Endoscopic ultrasound (EUS) and magnetic resonance imaging (MRI) have become the leading methods for assessing the stage of rectal adenocarcinoma [4]. Initially introduced in 1980 for assessing pancreatic cancer, endoscopic ultrasound (EUS) combines endoscopy with ultrasound technology. This innovation allows for detailed imaging of the gastrointestinal mucosa and provides insights into the depth and adjacent structures of the tract wall [3].

EUS proves valuable for evaluating the impact on anal sphincters by lower rectal tumors and for staging anal squamous-cell carcinomas. The approach to treating anal cancer is significantly influenced by whether the sphincter is affected [5]. MRI is commonly employed for the pre-surgical assessment of rectal cancer, offering precise evaluations of the tumor and the nearby mesorectal fascia. Its reliability extends to determining the scope of local and regional disease, devising radiation therapy plans, monitoring changes after surgery, and detecting recurrences in the pelvic area [6].

Precisely distinguishing between stage T0-T1 and stage T2 rectal tumors is key for choosing the correct surgical approach. Although MRI is favored for local staging, its effectiveness in differentiating between T1 and T2 tumors is limited. Independent imaging characteristics such as the presence of a submucosal enhancing stripe (SES) in contrast-enhanced MRI, the status of the muscularis propria (SMP) in T2-weighted images, and the shape of the tumor, are critical for identifying differences between stage T0-T1 and stage T2 rectal tumors [7].

Contrast-enhanced MRI with SES provides a superior visualization of the rectal wall's intricate layers compared to non-contrast MRI, due to the varied MRI signal characteristics of the mucosa, submucosa, and muscularis propria. This enhancement facilitates the assessment of the tumor's invasion depth into the rectal wall and aids in distinguishing between the early T stages of the tumor [8].

The literature has yet to thoroughly examine the comparison between SES MRI and EUS for rectal cancer staging, which this study aims to address.

This study aims to compare the effectiveness of endoscopic ultrasonography with that of submucosal enhancing stripe MRI, which uses contrast material for the evaluation of rectal lesions.

PATIENTS AND METHODS

Study Type: This research was a comparative, prospective study carried out at Kobry Elkoba Military Hospital from January 2023 to December 2023.

Inclusion Criteria: Participants aged 18 and above (including adults and seniors) of any sex were eligible. Eligible participants were those newly diagnosed with rectal cancer through lower GI endoscopy, with their diagnosis confirmed by histopathology, prior to being

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referred for endoscopic ultrasonography (EUS) for staging purposes.

Exclusion Criteria: Individuals not suitable for deep sedation due to propofol injection, those with distant metastases, and those with a known sensitivity to contrast materials were excluded from the study.

Every patient underwent a comprehensive history review, along with general and specific physical examinations and laboratory tests.

Rectal Examination: This included checks for rectal bleeding, the presence of a rectal mass, sentinel piles, etc.

Colonoscopy: A colonoscopy was performed using the Olympus EVIS EXERA II CF-Q180AL colonoscope (Olympus America, Medical). This allowed for the observation of the macroscopic characteristics of rectal carcinoma, such as masses, ulcers, stenosis, etc., with multiple samples taken for histopathological examination. Each identified rectal lesion was assessed based on its size, location (measured as the distance from the anal verge), and surface pattern.

Imaging Techniques:

Submucosal enhanced stripe MRI: The SES MRI was conducted using a Philips MR Ingenia Elition 3.0T machine. The MRI report included detailed descriptions of various factors, such as: The primary tumor's morphology, noting if it was annular, ulcerating, polypoidal, villous, eroding, mucinous, or signet-ring, or if these characteristics could not be assessed. The invading edge of the tumor, described in terms of its position (e.g., from x o'clock to y o'clock). The distance of the tumor's distal edge from the anal verge and from the puborectalis sling. The longitudinal extent of the tumor. The tumor's relation to the peritoneal reflection, noting whether it is above or below, with an approximate distance.

The classification of tumor stages is outlined as follows: Tx signifies the primary tumor is unassessable, T0 denotes the absence of a primary tumor, and Tis indicates carcinoma in situ, which may involve intraepithelial presence or invasion into the lamina propria. T1 describes a tumor penetrating the submucosa, T2 involves the tumor breaching the muscularis propria layer, and T3 outlines the tumor's progression through the muscularis propria into either the subserosa or into areas surrounding the rectum that are not enveloped by peritoneum, without impacting the mesorectal fascia or nearby organs.

During EUS procedures, a Pentax EG-3870UTK linear array echoendoscope, paired with a Hitachi Avius ultrasound device under propofol sedation, facilitated the ultrasonic categorization (uT staging) to ascertain the depth of infiltration by rectal cancer. The uT1 stage indicates that the tumor is confined to the mucosa or submucosa, evidenced by a strong echo across the entire second layer. In stage uT2, the tumor extends into the muscularis propria but is contained within the rectal wall, showing partial disruption, and thickening of the layer. Stage uT3 is marked by the tumor invading completely through the wall, affecting fibrous and fatty tissues around the rectum with noticeable destruction and jagged protrusions. Stage uT4 reveals the tumor's spread to nearby organs or tissues, characterized by the disappearance of the strong echo zone that typically delineates organ boundaries.

Lymph node involvement is determined by the detection of low-echo structures and the size of lymph nodes, with uN0 representing no metastasis for nodes under 5 mm, and lymph node metastasis presumed for nodes 5 mm or larger (uNx). This is further divided into uN1 for the involvement of one to three lymph nodes, and uN2 for involvement of more than four lymph nodes [7] **(Figure 1 and 2)**.

Patients undergoing rectal surgery or endoscopic submucosal dissection (ESD) were monitored, with the examination of their outcomes conducted through histopathological methods.

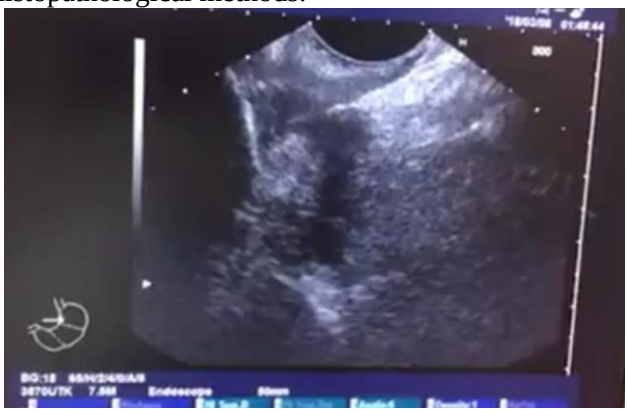

Figure 1: Rectal polyp.

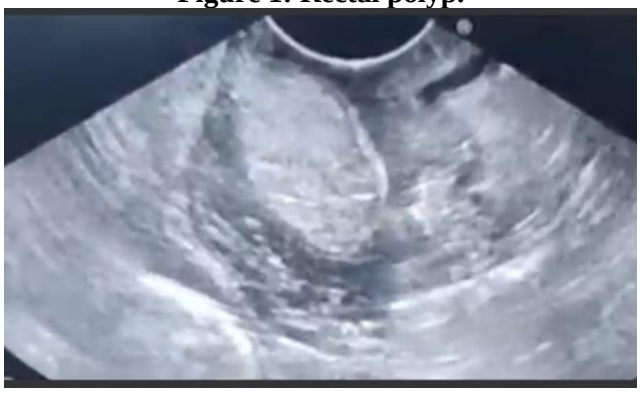

Figure 2: Rectal mass.

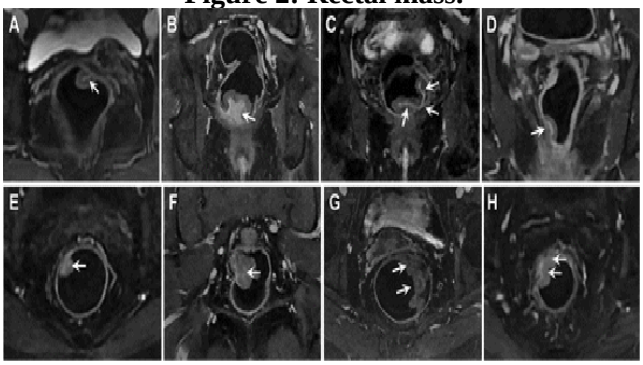

Figure 3: Contrast material–enhanced T1-weighted MRI scans show submucosal enhancing stripe (SES).

Ethical considerations:

The study was done after being accepted by the Research Ethics Committee, Benha University and Kobry Elkoba Military Hospital. All patients provided written informed consents prior to the enrolment. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The data collected were systematically organized and statistically analyzed. Statistical processing and data management were carried out with SPSS software, version (IBM, Armonk, New York, USA). Quantitative data were depicted by means with standard deviations, medians, and ranges. Furthermore, categorical data were expressed in terms of frequencies and percentages. All statistical determinations were made with a bidirectional approach, and P values below 0.05 were considered to indicate a significant difference.

Results:

Demographic and clinical data are shown in **Table 1**.

Table 1: Demographic and clinical data of studied patients

Demographic data	**Age (years)**	**Mean±SD**	66.42 ±10.16
		Median	67.00
		Range	35.00-84.00
	Sex Count (%)	**Female**	8 (24.2%)
		Male	25 (75.8%)
	Residency Count (%)	**Urban**	32 (97.0%)
		Rural	1 (3.0%)
	Smoking Count (%)	**Yes**	15 (45.5%)
		No	18 (54.5%)
Comorbidities	**Hypertension** Count (%)	**Yes**	24 (72.7%)
		No	9 (27.3%)
	Diabetes mellitus Count (%)	**Yes**	13 (39.4%)
		No	20 (60.6%)
Previous history	**Operations** Count (%)	**Yes**	19 (57.6%)
		No	14 (42.4%)

SES MRI revealed annular shaped tumor in 14 (42.4%) patients. SES MRI revealed N1 in 7 (21.2%) patients. T2 was the most common stage in 13 (39.4%) patients **(Table 2)**.

Table 2: Radiological findings in the studied patients

			Count	%
SES MRI	**Shape**	**Annular**	14	42.4%
		Polypoidal	11	33.3%
		Thickening	8	24.2%
	Lymphadeno-pathy	**No**	26	78.8%
		N1 (1-3 nodes)	7	21.2%
		N2 (4 or more)	0	0.0%
	Staging	**T0**	0	3.0%
		T1	7	21.2%
		T2	13	39.4%
		T3	12	36.4%
		T4	1	3.0%

EUS revealed N1 in 9 (27.3%) patients and no lymph node infiltration in 24 (72.7%) patients. T3 was reported in 14 (42.4%) patients **(Table 3)**.

Table 3: EUS findings in the studied patients

EUS	**Lymphadeno-pathy**	**No**	24	72.7%
		N1 (1-3 nodes)	9	27.3%
		N2 (4 or more)	0	0.0%
	Staging	**T0**	0	3.0%
		T1	7	21.2%
		T2	11	33.3%
		T3	14	42.4%
		T4	1	3.0%

Pathological examination in studied patients revealed high grade dysplasia in 7 (21.2%) patients and no dysplasia in 20 (60.6%) patients. Malignancy pathology revealed well differentiated tumor in 17 (51.5%) **(Table 4)**.

Table 4: Preoperative pathological examination in the studied patients

		Count	%
Dysplasia pathology	**High grade**	7	21.2%
	Low grade	6	18.2%
	No	20	60.6%
Malignancy pathology	**Undifferentiated**	0	0.0%
	Well differentiated	17	51.5%
	No	16	48.5%

Accuracy of SES MRI in T staging

SES MRI showed 0 % sensitivity in late stages (above T2) while showing 100% sensitivity in early

stages (T1 and T2) and 100% specificity in T staging with 89.47% accuracy in T staging **(Table 5)**.

Table 5: Accuracy of SES MRI in T staging

		Staging Pathology		
		T1	T2	T3
		Count	Count	Count
Staging (SES MRI)	T1	5	1	0
	T2	3	8	2

Statistic	Value	95% CI
Sensitivity in late (above T2)	0.00%	0.00% to 84.19%
Sensitivity in early (T1 and T2)	100.00 %	80.49% to 100.00%
Specificity	100.00 %	80.49% to 100.00%
Negative Predictive Value	89.47%	89.47% to 89.47%
Accuracy	89.47%	66.86% to 98.70%

EUS showed 100% sensitivity and 100 % specificity in T staging with 100% accuracy **(Table 6)**.

Table 6: Comparison between EUS and postoperative pathology and Accuracy of EUS in T staging

		Staging Pathology		
		T1	T2	T3
		Count	Count	Count
Staging EUS	T1	5	1	0
	T2	3	8	0
	T3	0	0	2

Statistic	Value	95% confidence interval
Sensitivity	100.00%	78.20% to 100.00%
Specificity	100.00%	81.47% to 100.00%
Positive Predictive Value	100.00%	78.20% to 100.00%
Negative Predictive Value	100.00%	81.47% to 100.00%
Accuracy	100.00%	89.42% to 100.00%

A significant agreement was reported between T staging using EUS and pathological examination **(Table 7)**.

Table 7: Measure of agreement between EUS and staging pathology in T staging.

	Kappa Value	P value
Measure of Agreement	0.638	0.001

No difference was reported between SES MRI and EUS regarding staging in T1 and T2 and lymph node infiltration **(Table 8)**.

Table 8: Comparison between SES MRI and EUS regarding staging and lymph node infiltration

		SES MRI		EUS	
		Count	%	Count	%
Lymphadenopathy	No	17	89.5 %	17	89.5 %
	N1 (1-3 nodes)	2	10.5 %	2	10.5 %
	N2 (4 or more)	0	0.0 %	0	0.0%
Staging	T0	0	0.0 %	0	0.0%
	T1	8	42.10%	8	24.2 %
	T2	9	47.36%	9	27.27 %
	T3	0	00.00%	2	6%
	T4	0	0%	0	0%

DISCUSSION

This research was designed to compare the effectiveness of endoscopic ultrasonography with that of submucosal enhancing stripe MRI, using contrast material, in the evaluation of rectal lesions. It involved 33 patients who had colorectal lesions and were receiving care at Kobry Elkoba Military Hospital.

The average age of the patients participating in this study was 67 years, with a predominance of male patients. This aligns with projections indicating that individuals aged 65 and older would constitute the majority of new colorectal cancer cases and would represent over two-thirds of the mortality from this disease in the United States by 2023. Furthermore, global trends show a higher incidence of colorectal cancer in men [9].

Among the symptoms reported in this study, constipation (63%) and rectal bleeding (60%) were the most common. This is noteworthy since many individuals with colon cancer initially present without symptoms. When symptoms do manifest, they often include changes in bowel habits, such as increased instances of diarrhea or constipation, and rectal bleeding, highlighting the insidious nature of colon cancer symptoms [10].

In this research, 60.6% of the participants, amounting to 20 patients, exhibited pallor, and the average hemoglobin level was found to be 9.92 ± 1.94 g/dl.**)** It's noted that anemia and pallor frequently occur as extraintestinal signs in individuals diagnosed with colorectal cancer (CRC), as highlighted by **Chardalias *et al.*** [11].

The study also identified that the occurrence of well-differentiated colorectal adenocarcinoma stood at 51.5%. In comparison, a Nationwide Cohort Study reported a lower incidence rate of 30.8% for the same condition. The discrepancy between these findings

could be attributed to differences in sample size and the duration of the study [12].

Regarding surgical interventions, this study observed a prevalence rate of 39.4%. Contrastingly, an analysis of three cohort studies encompassing 1290 patients with colorectal malignancies found that 42.7%, or 552 patients, underwent surgical resection [13].

Furthermore, the accuracy of SES MRI in T staging was determined to be 89.47% in this investigation. This is consistent with findings from **Wan *et al.*** [7], which involved patients with rectal tumors undergoing pre-treatment MRI and subsequent tumor resection. Their study reported a diagnostic accuracy of 87% for SES MRI, affirming that the SES in contrast-enhanced MRI, the condition of the muscularis propria (SMP) in T2-weighted images, and the shape of the tumor are crucial imaging characteristics for distinguishing between stage T0–T1 and stage T2 rectal tumors.

The current study demonstrated a significant correlation between T staging performed by EUS and the results obtained from pathological examinations, with a Kappa value of 0.823 and a P-value less than 0.001, indicating a high level of agreement. EUS achieved 100% sensitivity, specificity, PPV, NPV, and accuracy in T staging.

These results are in line with the findings from **Reginelli *et al.*** [14], which highlighted the exceptional diagnostic efficacy of ERUS in the early detection of rectal cancer (stage T1), despite its challenges in accurately identifying the extent of transmural tumor invasion, often resulting in the overestimation of T2 stages. Furthermore, **Oien *et al.*** [15] observed a tendency for ERUS to classify T1 tumors as T2–T3 in a significant number of cases (16 out of 24). Similarly, **Scheele *et al.*** [16]. found that among 63 patients evaluated with EUS, there was a therapeutic-relevant overestimation of cancer stage into the T3/4 category in 10 (16%) instances.

To the best of our understanding, there have been limited investigations into the utility of the SES as a distinguishing feature for differentiating between stage T0–T1 and T2 rectal tumors. Prior to this research, no studies had been published on the comparative analysis of EUS and SES MRI in assessing colorectal abnormalities.

Our findings suggest that SES MRI and EUS offer similar effectiveness in the staging of rectal cancer, both locally and in evaluating lymph nodes. While EUS is relatively straightforward to administer, its dependency on the operator's skill and its less comprehensive coverage, especially for larger tumors, present notable limitations. Conversely, MRI faces challenges such as the risk of claustrophobia due to the confined space, potential interference with implanted metal devices due to the magnetic field, and adverse reactions to the contrast material used [14].

Healthcare providers should consider the strengths and weaknesses of both techniques and select the most suitable method by considering the accuracy of each diagnostic tool, as well as the practices and constraints of their facility [17].

CONCLUSION

SES MRI and EUS are comparable imaging techniques for the local and lymph node staging of rectal cancer. There is a need for further prospective investigations on a broader scale to assess the effectiveness of endoscopic ultrasonography compared to the use of a submucosal enhancing stripe in contrast-enhanced MRI for the evaluation of rectal lesions.

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