Prediction of myometrial invasion in patients with endometrial carcinoma: Comparison of magnetic resonance imaging, transvaginal ultrasonography, and gross visual inspection

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Summary

This study evaluated the accuracy of magnetic resonance imaging (MRI) and transvaginal ultrasonography (TVUS) in preoperative detection of myometrial invasion by endometrial cancer. We also evaluated the results of gross visual inspection (GVI) of surgical specimens compared with histopathological diagnosis. One hundred and seventy-seven women underwent preoperative pelvic MRI, TVUS, and intraoperative GVI. Myometrial tumor invasion was evaluated histologically and classified as absent (depth a), superficial (depth b: $\leq 50\%$ invasion), or deep (depth c: $> 50\%$ invasion). The accuracy of MRI, TVUS, and GVI were 64.0, 66.9, and 63.8%, respectively. The positive predictive values of of each modality for depth a were 52.6, 51.4, and 52.2%, respectively. The accuracy of each in detecting deep myometrial invasion (depth c) were 84.0, 86.9, 83.1%. Although evaluation of depth a was limited with all modalities, MRI and TVUS were shown to be reliable for preoperative evaluation of deep myometrial invasion. The high accuracy of these three methods suggests that they are useful either interchangeably or in combination.

Key words: Endometrial cancer; Myometrial invasion; Magnetic resonance imaging; Transvaginal ultrasonography; Gross visual inspection.

Introduction

Endometrial cancer is one of the most common gynecologic malignancies in females. Prognosis and treatment of endometrial cancer are mainly based on three factors: histologic tumor grade, the presence of nodal metastasis, and the depth of myometrial invasion [1, 2]. The depth of myometrial invasion is correlated with the risk of lymph node metastasis and 5-year survival [1, 2]. In most institutions, patients with more than 50% myometrial invasion are considered for further surgical staging, including pelvic and paraaortic lymphadenectomy. Preoperative and intraoperative procedures such as ultrasonography [3, 4], computed tomography (CT) [5, 6], magnetic resonance imaging (MRI) [6, 7], frozen section acquisition [8], and intraoperative gross visual inspection (GVI) of surgical specimens [9, 10] have been used to assess the depth of myometrial invasion. This study aimed to evaluate the accuracy of MRI, transvaginal ultrasonography (TVUS), and GVI in the detection of myometrial invasion of endometrial cancer.

Materials and Methods

One hundred and seventy-seven patients with histopathological diagnoses of endometrial cancer were referred for MRI and TVUS examination between January 1995 and April 2004. All were submitted to abdominal hysterectomy and bilateral salpingo-oophorectomy, and GVI of surgical specimens was evalu-

ated. Imaging was conducted with a 1.5-T superconducting MRI unit (Siemens, Germany) within two weeks prior to surgery. Axial T1-weighted and fast spin-echo (SE) T2-weighted images were obtained in all patients. Sagittal and axial SE T1-weighted images were obtained immediately after intravenous administration of gadolinium-diethylene triamine pentaacetic acid (Gd-DTPA). Myometrial invasion was evaluated according to previously published criteria [11]. The thickness of the endometrium (major axis) was measured as the tumoral thickness. TVUS was conducted using a 7.5 Mhz transvaginal probe within a week prior to surgery. Irregularity of the endometrium was evaluated as myometrial invasion in TVUS. Surgical specimens of the uterus were examined immediately after surgical resection. The invading myometrial thickness was compared with the total myometrial thickness.

Myometrial tumor invasion was evaluated histologically and classified as absent (depth a), superficial (depth b: $\leq 50\%$ invasion), or deep (depth c: $> 50\%$ invasion). Histopathological diagnosis was considered the gold standard. The accuracy, sensitivity, specificity, and positive and negative predictive values of MRI, TVUS, and GVI in assessing depth of myometrial invasion were calculated with histologic results as the gold standard.

Results

Patient characteristics are shown in Table 1. On pathological examination 58 of the 177 patients (33%) showed deep myometrial invasion, 39 (22%) showed no invasion and 80 (45%) showed superficial invasion. The depth of myometrial invasion was classified into three categories in the first analysis: 1) no invasion (depth a); 2) $\leq 50\%$ invasion (depth b); and 3) $> 50\%$ invasion (depth c). FIGO Stages Ia and Ib were often placed in the same

Table 1. — *Patient characteristics.*

Characteristics		No. of patients	%
Menopause			
premenopausal		56	32
postmenopausal		121	68
Myometrial invasion			
depth a		39	22
depth b		80	45
depth c		58	33
Tumor grade			
G1		110	62
G2		48	27
G3		19	11
Characteristics		No. of patients	%
FIGO stage			
Ia	34 ⎤		
Ib	58 ⎬	116	66
Ic	24 ⎦		
IIa	5 ⎤		
IIb	6 ⎦	11	6
IIIa	26 ⎤		
IIIb	1 ⎬	50	28
IIIc	23 ⎦		

group because of the similar prognostic implications, and therefore, invasion was classified into two categories in the second analysis: 1) ≤ 50% invasion (depths a and b); and 2) > 50% invasion (depth c).

When the depth of myometrial invasion was classified into three categories (depths a, b, and c), the accuracy of MRI, TVUS, and GVI was 64.0, 66.9, and 63.8%, respectively. The positive predictive values of MRI, TVUS, and GVI for depth a were 52.6, 51.4, and 52.2%, respectively (Table 2). When the depth of myometrial invasion was classified into two categories, superficial (depths a+b) and deep invasion (depth c), the accuracy of each modality was 84.0, 86.9, and 83.1%, respectively. Indexes of accuracy for correct determination of deep myometrial invasion (depth c) are shown in Table 3. MRI showed the highest sensitivity and TVUS showed the highest specificity. The best accuracy (87.4%) was obtained when myometrial invasion was assessed with a combination of all three modalities.

The influence of tumor grade, menopausal status, endometrial thickness (indirect measurement of tumoral thickness), and presence of fibromyoma or adenomyosis on the assessment of myometrial invasion were analyzed. As shown in Table 4, univariate analysis revealed that endometrial thickness was significantly correlated with the erroneous diagnosis of deep myometrial invasion by MRI (p = 0.03). The average tumoral thickness was 26.7 mm in cases of erroneous MRI diagnosis whereas it was 19.9 mm in cases of correct MRI diagnosis. The presence of fibromyoma or adenomyosis marginally reduced the accuracy of TVUS (91.9% (absence) versus 80.4% (presence); p = 0.08). Tumor grade and menopausal status did not show any correlation with erroneous diagnosis with each modality.

Discussion

In this study, we retrospectively compared the results of MRI, TVUS, and GVI in determining myometrial invasion in a large series of endometrial cancer patients. When myometrial invasion was divided into three categories (depths a, b, and c), the accuracy of these three modalities were between 63.8 and 66.9%, with no significant differences. Positive predictive values for detecting depth a (no myometrial invasion) with MRI, TVUS, and GVI were unsatisfactory, and thus evaluation of depth a is limited with all modalities. The accuracy of MRI, TVUS, and GVI in detecting deep myometrial invasion was 84.0, 86.9, and 83.1%, respectively. MRI showed the highest sensitivity whereas TVUS showed the highest specificity for detection of deep myometrial invasion. The best accuracy (87.4%) was obtained when myometrial invasion was assessed with a combination of all three methods, though the difference between the accuracy by single modality was not significant.

We analyzed the influence of tumor grade, menopausal status, endometrial thickness (indirect measurement of tumoral thickness), and the presence of fibromyoma or adenomyosis on the assessment of myometrial invasion with each modality. The presence of fibromyoma or ade-

Table 2. — *Assessment of myometrial invasion with MRI, TVUS, and GVI.*

Modality	Myometrial invasion (histopathology)	n	TP n (%)	Accuracy n (%)	Underestimation n (%)	Overestimation n (%)
MRI	depth a	57	30 (52.6) ⎤		27 (47.4)	–
	depth b	63	40 (63.5) ⎬	112 (64.0)	14 (22.2)	9 (14.3)
	depth c	55	42 (76.4) ⎦		–	13 (23.6)
		175			41 (34.2)	22 (18.6)
TVUS	depth a	74	38 (51.4) ⎤		36 (48.6)	
	depth b	62	43 (69.4) ⎬	117 (66.9)	18 (29.0)	1 (1.6)
	depth c	39	36 (92.3) ⎦		–	3 (7.7)
		175			54 (39.7)	4 (4.0)
GVI	depth a	67	35 (52.2) ⎤		32 (47.8)	–
	depth b	64	41 (64.1) ⎬	113 (63.8)	19 (29.7)	4 (6.3)
	depth c	46	37 (80.4) ⎦		–	9 (19.6)
		177			51 (38.9)	13 (10.9)

depth a: no myometrial invasion; depth b: invasion ≤ 50% of myometrial thickness; depth c: invasion > 50% of myometrial thickness; n: number of patients; TP: true positive.

Table 3. — *Indexes of the accuracy for correct determination of deep myometrial invasion.*

Modality	Accuracy (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
MRI	84.0	73.7	89.0	76.4	87.5
TVUS	86.9	64.3	97.5	92.3	85.3
GVI	83.1	63.8	92.4	80.4	84.0
Triple	87.4	71.9	94.9	87.2	87.5

MRI: magnetic resonance imaging; TVUS: transvaginal ultrasonography; GVI: gross visual inspection; PPV: positive predictive value; NPV: negative predictive value.

Table 4. — *Univariative analysis for each factor affecting the assessment of deep myometrial invasion.*

Modality	Tumor grade	Menopause	Endometrial thickness	Presence of myoma or adeomyosis
MRI	0.46	0.21	0.03	0.12
TVUS	0.47	0.51	0.40	0.08
GVI	0.60	0.28	0.42	0.80

p value
MRI: magnetic resonance imaging; TVUS: transvaginal ultrasonography; GVI: gross visual inspection.

nomyosis marginally reduced the accuracy of TVUS, and a thickened endometrium led to an erroneous MRI diagnosis. Thus, we have to be more careful when there is a space-occupying lesion within the uterus such as a fibromyoma or adenomyosis, and when the endometrium is thick due to a tumor of large size.

Though evaluation of depth a was limited with all modalities, MRI and TVUS were shown to be reliable methods for preoperative evaluation of deep myometrial invasion. The high accuracy achieved with MRI, TVUS, and GVI suggests that they are useful either interchangeably or in combination as a diagnostic adjunct for clinical treatment planning.

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