NOWOTWORY Journal of Oncology • 2002 • volume 52
Number 4 • 305–308

Magnetic resonance imaging (MRI) in cervical carcinoma – assessment of diagnostic value of tumour volume

Małgorzata Tacikowska[1], Urszula Grzesiakowska[1]
Piotr Sobiczewski[2], Tadeusz Tacikowski[3]

MR imaging plays a key role in the diagnosis of cervical carcinoma, especially in the determination of tumour volume.
The aim of the present study included: 1) evaluation of correlation of tumour volume as obtained in MRI and during post-surgical histological examination; 2) evaluation of correlation between the volume and the greatest dimension of the tumour (as assessed in MRI) with the following parameters: a) tumour stage according to FIGO classification, b) parametrium infiltration, c) presence of lymph node metastases.
Material and method. Pelvic MRI results (Elscint T2 unit) of 21 patients with cervical carcinoma. Patient age: 37-73 years. Fifteen patients underwent hysterectomy after MRI, in the remaining cases diagnosis was based on biopsy. In 10 patients treated surgically we compared the MRI-assessed tumour volume with histopathological data. In 16 patients we assessed the correlation between tumour volume, FIGO tumour stage, parametrium infiltration and lymph node enlargement.
Results and conclusions. 1) evident correlation was found between MRI and histological examination in the measurements of tumour volume (p=0.764); 2) in patients with cervical carcinoma the sensitivity and specificity of MRI with tumour volume determination was 100% in differentiation of stage I from the remaining stages; 3) tumour volume correlated best with stage I and II FIG0 when compared with the determination of the greatest dimension of the lesion; 4) correlations between tumour volume and parametrial infiltration were found; 5) no correlation was found between tumour volume and metastases to lymph nodes.

Badanie metodą rezonansu magnetycznego raka szyjki macicy – ocena wartości diagnostycznej objętości guza

Badanie metodą rezonansu magnetycznego (MR) odgrywa kluczową rolę w diagnostyce raka szyjki macicy. Jedną z ważnych części badania MR jest pomiar objętości guza.
Cel. 1) ocena zgodności pomiaru objętości w badaniu MR z pooperacyjnym badaniem histopatologicznym; 2) ocena korelacji objętości i największego wymiaru raka szyjki macicy (ocenianych w badaniu MR) z następującymi parametrami: a) stopniem zaawansowania według klasyfikacji FIGO; b) naciekaniem przymacicza; c) przerzutami do węzłów chłonnych.
Materiał i metoda. Materiał stanowią badania MR miednicy, wykonane aparatem firmy Elscint 2T, u 21 chorych na raka szyjki macicy. Wiek chorych od 37 do 73 lat. U 15 pacjentek po badaniu MR przeprowadzono operację usunięcia macicy, w pozostałych przypadkach rozpoznanie postawiono na podstawie biopsji. U 10 chorych operowanych dokonano oceny porównawczej objętości guza, ocenianej w badaniach MR i histopatologicznym. U 16 chorych analizowano korelację objętości guza ze stopniem zaawansowania, naciekaniem przymacicza i powiększeniem węzłów chłonnych.
Wnioski. 1) stwierdzono wysoką zgodność badania MR i histopatologicznego (po operacji) w pomiarze objętości guza, p=0.764; 2) badanie MR z pomiarem objętości guza u chorych z rakiem szyjki macicy odznacza się 100% czułością i specyficznością w rozgraniczeniu stopnia I od pozostałych; 3) ocena objętości guza lepiej koreluje ze stopniem zaawansowania I i II wg FIGO niż ocena największego wymiaru zmiany; 4) stwierdzono korelację pomiędzy objętością guza i naciekaniem przymacicza; 4) nie stwierdzono korelacji objętości guza z przerzutami do węzłów chłonnych.

Key words: cervical carcinoma, MRI, tumour volume
Słowa kluczowe: rak szyjki macicy, MR, objętość guza

[1] Department of Radiology
[2] Department of Gynecological Oncology
The Maria Sklodowska-Curie Memorial Cancer Center
and Institute of Oncology, Warsaw, Poland
[3] Clinic of Metabolic Diseases and Gastroenterology
National Institute of Food and Nutritions, Warsaw, Poland

In the diagnosis of cervical carcinoma magnetic resonance imaging (MRI) plays a key role, correlating well with the results of histological examinations in the assessment of parimetrial infiltration (94%), and slightly lower in the evaluation of metastases to lymph nodes (86%). MRI correlation for establishing tumour stage is 76.5% [1].

A important element of MRI is the measurement of tumour volume.

In the present study we present the preliminary results of the analysis of correlations between tumour stage in FIGO classification, parametrium infiltration and presence of lymph node involvement.

The aim of the study was to evaluate:

1. Correlation of tumour volume measurements in MRI and in histological examination after the operation.
2. Correlation between the volume and greatest dimension of cervical carcinoma assessed with the following parameters:
   a) tumour stage (FIGO classification),
   b) parametrial infiltration,
   c) metastases to lymph nodes.

Material and method

The material comprised pelvic MRI carried out with Elscint 2T unit in 21 patients with cervical carcinoma aged between 37 and 73 years. Fifteen patients underwent hysterectomy after MRI, in the remaining cases the diagnosis was based on biopsy.

The protocol of pelvic MRI:

SET1 sequences in axial projection with large field of vision:

– study parameters: TR=950ms, TE=18ms, FOV 34x42cm, matrix 252x306, layers 5mm, gap 20%;

FSE sequences with fat saturation, axial projection with large field of vision:

– study parameters: TR=7200ms, TE=126ms, FOV 37x42cm, matrix 252x306, 5mm layers, gap 20%;

SET1 sequences in sagittal projection, FSE T2 in axial, sagittal and frontal projections with small field of vision:

– study parameters SE sequences: TR=500ms, TE=18ms; FSE sequences: TR=7300ms, TE=126ms, FOV 21x21cm, matrix 252x296, 4mm layers, gap 20%;

SE T1 sequences in axial frontal and sagittal projections after Gd-DTPA i.v. administration (0.1-0.2 mmol/kg body weight) with small field of vision, parameters as above.

In SE T1 sequences with large field of vision the pelvis was examined with reference to lymph nodes and small pelvis organs. The limit value in the evaluation of lymph nodes involvement was over 15 mm longitudinal dimension.

In the remaining sequences the genital organs were assessed in detail with particular reference to cervical lesions, changes in uterine corpus, vagina, parametrium. The tumour was measured in the cervix in sagittal, frontal and transverse planes. Then 3D MRI reconstruction was carried out and the tumour was outlined in each layer. Using a special computer programme the outlined areas were added and tumour volume was calculated. In histological examinations tumour volume was calculated on the basis of three dimensions of the lesion using the formula for ellipsoid volume:

$$V = \frac{4}{3} \text{ x } 3.14 \text{ x } \frac{a \text{ x } b \text{ x } c}{2}$$

where a, b and c are the lengths of ellipsoid axes.

Before measurements the specimens were set in formaldehyde for 1-3 days.

In 10 patients the results of the measurements of tumour volume in MR and on histological examination after the operation were compared. Standard deviations of mean value of volume differed statistically, due to which the Student's T-test for non-parametric variance distribution was used.

On the basis of MRI results the calculated volumes and greatest dimensions in each group (10 patients operated on and 6 patients treated conservatively) were compared with FIGO tumour stage, parametrial invasion and the presence of metastases in lymph nodes.

Results

In the study group of 21 patients 3 cases demonstrated *in situ* carcinoma foci on histological examination, in 1 case (patient operated on after radiotherapy) histological examination found no cancer cells. In these cases MR examination was negative. In 1 case of stage Ia MRI result was also negative, while on histological examination a flat infiltration (10 mm long and 0.4 mm deep) was revealed. Preinvasive carcinoma (stage 0) and invasive in stage Ia are recognized exclusively in microscopic examination.

Comparative evaluation of tumour volume in MRI and in histological examination based on Student's T-test showed a high level of correlation of these two methods in the 10 patients treated surgically. In MRI the mean value of the volume was 51.303cm^3 ± 44.65, in histological examination 54.41cm^3 ± 39.14, p=0.764.

Analysis of the results of tumour stage, volume, greatest dimension of the lesion, parametrial infiltration and involvement of lymph nodes is presented in Tables I and II. In surgically treated cases the tumour stage established on the basis of the results of histological examinations, in the conservatively treated group this grade was established on the basis of clinical examination and imaging results tranvaginal ultrasonography, CT.

Discussion

MRI is the method of choice in tumour volume assessment. According to literature a comparative analysis of the results of tumour volume measurements in MRI and in transvaginal ultrasonographic examinations have shown MRI to be a better measurement method [2]. According to the authors of comparative analyses of tumour volume measured in MRI or in postoperative specimens the results of both methods correlate well (p=0.983) [2-4]. We

Table I. Tumour stage according to FIGO, volume, greatest dimension of the tumour, parametrium infiltration and involvement of lymph nodes in 10 surgically treated patients

No.	Tumour stage	Volume (cm^3)	Greatest dimension (mm)	Parametrium infiltration	Lymph nodes involvement
1	IB	0.02	12	no	no
2	IB	3.70	22	no	no
3	IB	6.80	42	no	no
4	IB	32.70	34	no	no
5	IB	45.70	70	no	no
6	IIA	53.10	48	yes	yes
7	IIA	58.40	70	no	yes
8	IIA	70.30	55	yes	no
9	IIB	85.70	61	yes	no
10	IIB	156.60	95	yes	yes

Table II. FIGO tumour stage, volume, greatest dimension, parametrium infiltration, lymph nodes enlargement in 6 patients treated conservatively

No.	Tumour stage	Volume (cm^3)	Greatest dimension (mm)	Parametrium infiltration	Lymph nodes involvement
1	IB	31.5	44	no	no
2	IIB	50.3	55	yes	no
3	IIB	58.4	58	yes	no
4	IIB	96.0	79	yes	no
5	IVA	158.9	73	yes	no
6	IVA	221.7	89	yes	no

confirmed this, obtaining high correlation of the measurements ($p=0.764$).

In the light of own results it was found that in all 10 cases with tumour size exceeding 50 cm^3 the tumour stage was always higher than Ib. In all 6 cases with stage Ib tumour volume was below 46 cm^3.

In 1995 amendments were introduced to the FIGO classification of tumour stage. The range between tumour dimensions in grade Ib was too high, therefore it was divided into grades Ib and Ib2, with 40 mm of tumour size as the cut-off point [2]. This arose directly from the studies on the prognostic values of various parameters of tumour evaluation, including volume. As stated by the authors of these analyses, tumour volume correlated poorly with Ib clinical stage, in which tumours of big volume were found [4]. In own material similar relationships were found, with the range of tumour volume in Ib stage varying from 0.02 cm^3 to 45.7 cm^3.

Comparing the results of greatest tumour dimension measurements in patients with Ib tumour stage in the present material it was found that in one case this dimension was 12 mm, while in the other cases the greatest dimension did not exceed 70 mm.

In the group of patients with stage IIa and IIb the tumour volumes ranged from 50.3 cm^3 to 96 cm^3, in one case the volume was 156.6 cm^3, while tumour dimensions were in the range of 48 mm to 79 mm, in one case 95 mm. In 2 patients with tumour stage IVa the tumour volume was 158.9 cm^3 and 221.7 cm^3, while the greatest dimension was 73 mm and 89 mm, respectively.

On the basis of the obtained results it may be said that in cervical carcinoma patients the assessment of tumour volume correlates better with FIGO stages I and II, than with the greatest tumour dimension. The sensitivity and specificity of MRI with tumour volume were 100% in the differentiation of stage Ib from higher stages. Similar observations were reported by Ishikawa [5]. In the reports of other authors no statistically significant differences were found between tumour volume and tumour dimension ($p=0.01$) in tumour stage assessment [6].

In our material a correlation was found between tumour volume and parametrial infiltration. In the group of 9 patients with parametrial involvement tumour volume ranged between 50.3 cm^3 and 156.6 cm^3, only in 1 out of 9 patients (with volume 58.4 cm^3) parametrial infiltration wasn't found. In 6 of 7 cases without parametrial involvement tumour volume ranged between 0.02 cm^3 and 45.7 cm^3 and in 1 patient tumour volume was 58.4 cm^3. Tumour dimensions in the group with parametrial involvement ranged between 55 and 95 mm, in those without involvement they were within a range of 48 to 55 mm. According to reports of studies on numerous cases tumour volume was found to correlate with parametrial involvement, but not with involvement of lymph nodes [6]. In own material we found no correlation between tumour volume and lymph node metastases.

According to literature tumour volume is of prognostic importance in the prediction of treatment effects [3, 7--9]. The initial tumour volume before treatment shows a better correlation with the therapeutic response than clinical examination, stage in FIGO classification or the grade of histological malignancy [10]. The 5-year survival rate is between 91% in cases of tumour volume below 2.5 cm^3 and 70% in those with 10-50 cm^3 volume. The survival rate of cases with tumour volume over 50 cm^3 is 48% after 5 years [10]. Determination of tumour volume is of prognostic significance in foreseeing survival without disease progression [6].

In view of a short observation time these preliminary results cannot be interpreted as related to the 5-year survival rate nor to therapeutic response. However the study will be continued.

Conclusions

1. Correlation was found between MRI and post-surgical histological examination regarding tumour volume measurements, p=0.764.
2. In cervical carcinoma patients the sensitivity and specificity of MRI for tumour volume determination were 100% in the differentiation of cases with stage Ib from other ones.
3. In cervical carcinoma patients the assessment of tumour volume correlates better with stages I and II acc. to FIGO classification than to the measurement of the greatest dimension of the tumour.
4. Correlation between tumour volume and parametrial invasion was found.
5. No correlation was found between tumour volume and metastases to lymph nodes.

Małgorzata Tacikowska M.D., Ph.D.
ul. Żabińskiego 10 m 61, 02-793 Warszawa
Poland

References

1. Sheu MH, Chang CY, Wang JH et al. Cervical carcinoma: assessment of parametrial invasion and lymph node metastasis with magnetic resonance imaging. *Chung Hua I Hsueh Tsa Chih* 2000; 63: 634-40.
2. Hawnnaur JM, Johnson RJ, Carrington BM et al. Predictive value of clinical examination, transrectal ultrasound and magnetic resonance imaging prior to radiotherapy in carcinoma of the cervix. *The British Journal of Radiology* 1998; 71: 819-27.
3. Peppercorn P D, Jeyarajah AR, Woolas R et al. Role of MR imaging in the selection of patients with early cervical carcinoma for fertility-preserving surgery: initial experience. *Radiology* 1999; 212: 395-9.
4. Hofmann HM, Rbner F, Haas J et al. Magnetic resonance imaging in clinical cervical cancer: pretherapeutic tumour volumetry. *Baillieres Clin Obstet Gynaeco*l 1988; 2: 789-802.
5. Ishikawa H, Nakanishi T, Inoue T et al., Prognostic factors of adenocarcinoma of the uterine cervix. *Gynecol Oncol* 1999; 73: 42-46.
6. Wagenaar HC, Trimbos JB, Postema S et al. Tumor diameter and volume assessed by magnetic resonance imaging in the prediction of outcome for invasive cervical cancer. *Gynecol Oncol* 2001; 82: 474-82.
7. Togashi K, Morikawa K, Kataoka M et al. Cervical cancer. *J Magn Reson Imaging* 1998; 8: 391-7.
8. Nicolet V, Carignan L, Bourdon F et al. MR imaging of cervical carcinoma: a practical staging approach. *Radiographics* 2000; 20:1539-49.
9. Boss EA, Barentsz JO, Massuger LF et al. The role of MR imaging in invasive cervical carcinoma. *Eur Radiol* 2000; 10: 256-70.
10. Burghardt E, Baltzer J, Tulusan AH et al. Results of surgical treatment of 1028 cervical cancers studied volumetry. *Cancer* 1992; 70: 648-55.

Paper received: 2 October 2001
Accepted: 12 July 2002