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FULL PAPER

Contrast-enhanced ultrasonography vs MRI for evaluation of local invasion by cervical cancer

¹WEI ZHENG, MD, ²KAI CHEN, MD, PhD, ¹CHUAN PENG, MD, ³SHAO-HAN YIN, MD, ⁴YONG-YING PAN, MD, ¹MIN LIU, MD, ¹SHI-YANG LIN and ¹XIAO-QING PEI, MD, PhD

¹Department of Ultrasound, Sun Yat-Sen University Cancer Center, State Key Laboratory of Oncology in South China, Collaborative Innovation Center of Cancer Medicine, Guangzhou, China

²Department of Radiotherapy, Sun Yat-Sen University Cancer Center, State Key Laboratory of Oncology in South China, Collaborative Innovation Center of Cancer Medicine, Guangzhou, China

³Department of Radiology, Sun Yat-Sen University Cancer Center, State Key Laboratory of Oncology in South China, Collaborative Innovation Center of Cancer Medicine, Guangzhou, China

⁴Department of Anesthesiology, Guangzhou Women and Children's Medical Center, Guangzhou Medical University, Guangzhou, China

Address correspondence to: Mrs Xiao-Qing Pei

E-mail: peixq@sysucc.org.cn

The authors Wei Zheng and Kai Chen contributed equally to the work.

Objective: The purpose of this study is to compare contrast-enhanced ultrasound (CEUS) to MRI for evaluation of local invasion of cervical cancer.

Methods: A total of 108 patients with cervical cancer were included in this study. All the enrolled patients were Stage IIA2–IVB according to the International Federation of Obstetrics and Gynecology and treated with volumetric modulated arc therapy. Tumour size in different dimensions was compared between MRI and CEUS. The correlation coefficients (r) between MRI and CEUS for diagnosing local invasion, parametrial extension, and invasion to vagina, uterine corpus and adjacent organs were assessed.

Results: Measurements by MRI and CEUS were strongly correlated in the three dimensions: left-right $r = 0.84$, craniocaudal $r = 0.86$ and anteroposterior $r = 0.88$. Vaginal and parametrial invasion were detected by both MRI and CEUS with moderate concordance, and invasion of uterine corpus, bladder and rectum with good concordance.

Conclusion: CEUS is comparable to MRI for measuring tumour size, with good concordance for evaluating invasion of cervical cancer.

Advances in knowledge: CEUS is a less expensive non-invasive modality for assessment of tumour size and invasion of cervical cancer.

INTRODUCTION

According to the World Health Organization, there were 520,800 new cases of cervical cancer in 2012, of which 85% were in developing countries.¹ Cervical cancer remains the only gynaecologic tumour staged mainly by clinical examination according to the International Federation of Obstetrics and Gynecology (FIGO) staging system with limited radiological or endoscopic findings, such as biopsy with colposcopy, chest and bone radiography, cystoscopy, sigmoidoscopy, intravenous excretory urography and barium enema.^{2,3} However, considering clinical convenience and cost, the proportion of clinicians strictly adhering to these diagnostic procedures is lower than expected.^{2,3} Detection by clinical examination depends strongly on physician experience, and diagnostic accuracy can be reduced by concomitant conditions such as obesity, chronic pelvic inflammatory disease and endometriosis.

A large discrepancy between the diagnostic tests recommended by FIGO and the actual tests used for cervical cancer staging was reported in the ultrasound,^{3–5} with an error rate up to 32% in patients with Stage IB disease and up to 65% of patients with Stage III disease.⁴ Based on extensive literature review, Innocenti et al⁶ estimated inaccuracy rates of 20%–32% in Stage I, 44%–75% in Stage II and 50%–94% in Stage III.

Currently, many institutions evaluate cervical cancer by sectional imaging modalities such as MRI, CT, transrectal ultrasound and positron emission tomography/CT (PET/CT).^{7,8} It is still controversial whether imaging is more accurate than clinical examination for cervical cancer diagnosis.^{6,9,10} Since 2009, imaging in addition to physical examination has been encouraged by the revised FIGO staging system.^{11,12} Given the good soft tissue resolution

from axial, sagittal and coronal planes, MRI is advantageous for the assessment of prognostic factors such as tumour size, parametrial and pelvic side wall invasion, adjacent organ invasion and lymph node metastases.¹³ A large-scale meta-analysis by Woo *et al*¹⁴ concluded that MRI shows good performance for detection of parametrial invasion in cervical cancer patients based on studies published between 2012 and 2016.

Radiotherapy with or without cisplatin is the standard treatment for locally advanced cervical cancer, which is defined as tumour size larger than 4 cm or tumour with parametrial invasion.¹⁵ In patients receiving concurrent chemoradiotherapy as the primary treatment, surgical staging is unavailable as a reference for clinical staging. MRI before treatment can provide important information for these cases.¹⁶ Brachytherapy is an essential component of treatment for locally advanced cervical cancer,¹⁵ and MRI is considered the best method for image-guided brachytherapy. However, imaging must be performed more than once, which may be unaffordable for many patients or institutions.¹⁷ Further, females with metal implants such as intrauterine devices may be unsuitable for MR scanning, so this modality is contraindicated in many cases.

Ultrasound and MRI had similar sensitivity and specificity with regard to the presence, size, and extent of invasive cervical cancers.^{18–20} As an alternative to MRI, ultrasound is faster, less invasive, more broadly applicable, and lower cost. Contrast-enhanced ultrasound (CEUS), a real-time and non-ionising imaging technique, can assess the spatial and temporal variations in tumour microcirculation and provide a non-invasive method to obtain perfusion related histopathological information.^{21–23} The CEUS enhancement patterns of lesions can be studied during all vascular phases (arterial phase, venous phase) in a fashion similar to contrast-enhanced CT and contrast-enhanced MRI, yet the CEUS with pure blood pool agents can be used to investigate tumour microcirculation angiogenesis, and tumours with massive enhancement are those with high perfusion.^{24,25} It was reported that CEUS revealed a better definition of the margins of the cervical cancer.²¹ To date, however, few studies have directly compared the efficacy of CEUS with MRI for the evaluation of cervical cancer. The aim of our studies is to compare CEUS to MRI for evaluating local invasion of cervical cancer.

METHODS AND MATERIALS

Patients

From June 2013 to September 2016, 108 patients with biopsy-confirmed cervical cancer were enrolled in this study and their clinical data retrospectively reviewed. The inclusion criteria were (1) staged as IIA2–IVB according to the FIGO system, (2) received volumetric modulated arc therapy (VMAT) without surgery (including conization of the cervix), (3) MRI and CEUS scans were performed at diagnosis, before concurrent chemoradiotherapy and brachytherapy, and (4) the interval between MRI and CEUS was less than a week and no chemotherapy or radiotherapy was applied. Patients with recurrent disease were excluded.

Table 1. General characteristics of patients and tumours

	N = 108
Age (years)	55.3 ± 9.9 (30–75)
FIGO stages	
IIA2	2
IIB	46
IIIA	12
IIIB	46
IVB	2
Histological type	
Squamous carcinoma	102
Adenocarcinoma	4
Adenosquamous carcinoma	2
Grading of differentiation	
II	78
III	28
Unknown	2

FIGO, International Federation of Obstetrics and Gynecology;

Concurrent chemoradiotherapy was established as the primary treatment while surgery was deemed unsuitable after multidisciplinary consultation among a radiologist, gynaecologist and oncologist at our institution. All enrolled patients received VMAT at 45 Gy/25 f with a concurrent boost of 10–15 Gy to enlarged lymph nodes suspected of metastasis. The concurrent chemotherapy regimen of cisplatin was administered at 40 mg m⁻² per week. Following chemoradiotherapy, four sessions of brachytherapy at 7 Gy twice a week were prescribed to the high-risk clinical target volume according to recommendations from the Groupe Européen de Curiethérapie-European Society for Therapeutic Radiology and Oncology working group.²

Magnetic resonance imaging

MRI was performed using a 3.0 T unit (GE Discovery MR750 3.0; GE Healthcare, Milwaukee, WI-, USA) with a combined 32-channel phased-array surface coil. The protocol were obtained for each patient: unenhanced T_2 weighted images (T_2 WI) in the sagittal and axial planes, unenhanced T_1 weighted images (T_1 WI) in the axial plane, diffusion-weighted images (DWI) in the axial plane repeated for two motion-probing gradient values ($b = 0$ and 800 s mm⁻²), and contrast-enhanced scanning in the axial, sagittal and coronal planes. The parameters of these sequences are listed in Table 1. For contrast enhancement, a 0.1 mmol kg⁻¹ body weight bolus injection of gadopentate dimeglumine (Magnevist, Schering, Berlin, Germany) was administered. Axial and coronal planes were acquired obliquely, orientated to the plane of the cervical canal. This allowed for a more precise evaluation of tumour borders and parametrial invasion. The signs of parametrial invasion on T_2 weighted sequences included the disruption of the cervical stromal ring, spiculated tumour invasion and encasement of the periuterine vessels.^{9,14,17}

Images were reviewed on a picture archiving and communication system workstation monitor (Centricity Radiology RA1000 Workstation V.3.0; GE Healthcare, Barrington, IL, USA) by Dr Y. with more than 5 years' experience in the gynaecological imaging, who was blind to the patients' physical examination and ultrasonography results.

Tumour size was measured in different planes by T_2 WI. Vaginal invasion was defined when the low signal of normal vaginal wall was replaced by high signal of tumour tissue and further increased by contrast-enhanced scanning. Parametrial invasion was defined when the low signal of cervical stroma was discontinuous, the margin was coarse, and tumour signal protruded beyond the margin of the cervix. Pelvic invasion was defined when the tumour signal reached the pelvic muscle or vessels. Invasion of corpus uterus was defined when the tumour signal protruded beyond the isthmus and extended to the myometrial wall. Bladder or rectum invasion was defined when the fatty interspace between the cervical tumour and bladder or rectum disappeared, the bladder or rectum was discontinuous or increased by contrast-enhanced scanning.

Contrast-enhanced ultrasonography

The patients drank 0.5 l of fluid approximately 1 h before the examination to keep the bladder full. CEUS was only done through trans-abdominal route by Dr P. or Dr Z. with more than 5 years' experience on CEUS. They were examined using a Sequoia scanner (Siemens-Acuson, Mountain View, CA, USA) with a curved 4C1 transducer (between 1.0 MHz and 4.0 MHz) and Cadence Contrast Pulse Sequencing software. The morphological characteristics of the tumours were recorded and the optimum sagittal section for tumour visualisation in the cervix was determined during greyscale evaluation. An intravenous bolus injection of 1.0 ml SonoVue (Bracco, Italy) was used for enhancement, followed by a 5 ml saline flush. Real-time CEUS scanning using low mechanical index (between 0.17 and 0.19) was initiated as soon as the contrast agent was injected and terminated when the contrast agent disappeared (approximately 4–6 min post-injection). The probe was kept stable to maintain the lesion in the plane of examination throughout the first 40 s post-injection.

All ultrasound scanning videos were reviewed by Dr P. and Dr Z., who were blind to the patients' physical examination and MRI results. The Cronbach's α test was used to evaluate the consistency between the two doctors. When they disagreed with the interpretation, they would reviewed the videos again to reach a consensus. Tumour size was measured in arterial phase as maximal craniocaudal (C-C) dimension, anteroposterior (A-P) dimension and left-right (L-R) dimension. Vaginal invasion was defined when the vaginal wall was hyperenhanced consistent with the cervical tumour in arterial phase and hypoenhanced in venous phase. Parametrial invasion was defined when the cervical serosa was discontinuous and hyperenhanced tissue appeared beyond the serosa in arterial phase. Parametrial invasion to the pelvic wall was defined when the enhanced tumour reached the pelvic muscle and vessels. Invasion of uterine corpus

was defined when the tumour extended beyond the isthmus uteri. Invasion of bladder or rectum was defined when the interspace between cervix and bladder or rectum, which was mildly hyperenhanced in arterial phase, disappeared and was replaced by tissue simultaneously enhanced with the cervical tumour.

Different aspects of local invasion, including tumour size, parametrial extension, and invasion to vagina, uterine corpus and adjacent organs were evaluated on CEUS. As the patients received VMAT without surgery, pathological results were unavailable image modalities were compared without a pathological gold-standard regardless of the clinical stage. Lymph node evaluation was not included in this study.

Statistics

Tumour dimensions were compared using a linear regression model and Pearson's test with $\alpha = 0.05$ as the confidence level. All values were calculated using SPSS19 for Windows v. 21. Bland–Altman analysis was also used to calculate the difference between the two methods. Interobserver agreement was evaluated with Cohen's κ , the concordances between MRI and CEUS for diagnosing local invasion, parametrial extension and invasion to vagina, uterine corpus and adjacent organs were assessed by Cohen's κ . κ values of 0.81 to 1.0 indicated excellent agreement, 0.61 to 0.80 good agreement, 0.41 to 0.60 moderate agreement, and ≤ 0.40 poor agreement.¹⁷ Considering MRI as the standard reference, the sensitivity (SEN), specificity (SPE), positive predictive value (PPV), negative predictive value (NPV) and accuracy (ACC) of CEUS for identifying invasion of uterine corpus and adjacent organs were determined.

RESULTS

The general characteristics of the patients are summarized in [Table 1](#). The majority of patients were in advanced stages IIB to III, , , including 72.22% (78/108) in stage II and 25.93% (28/108) in stage III (FIGO stage IIB: cancer spread to upper third of vagina or neighboring tissue, not to pelvic wall, with parametrial invasion; FIGO stage III: Cancer extension to pelvic wall or distal/lower third of vagina, or Hydronephrosis). It showed very good consistency of the interpretation on CEUS between Dr P. and Dr Z. ($\kappa > 0.8$). The majority of tumours were squamous carcinoma (94.44%, 102/108).

Tumour L-R and A-P dimensions were comparable as measured by MRI and CEUS, while the C-C dimension was significantly greater as measured by MRI (mean difference of about 3.5 mm). In the vast majority of patients, however, the difference between modalities was ≤ 10 mm (L-R: 83.3%, 90/108; CC: 85.2%, 92/108; A-P: 92.6%, 100/108), while in only a few cases was the difference ≥ 20 mm (L-R: 5.6%, 6/108, maximum 23 mm; CC: 1.9%, 2/108, maximum 27 mm; A-P: 1.9%, 2/108, maximum 20 mm). Indeed, measurements were strongly correlated in all three dimensions (L-R: $r = 0.84$; C-C: 0.86; A-P: 0.88) ([Figure 1](#)). The 95% confidence intervals of agreement between the two methods by Bland–Altman analysis are shown in [Table 2](#).

Vaginal invasion was detected by both MRI and CEUS in 84 patients (77.78%) ([Table 3](#)) 3). However, 12 cases detected by

Figure 1. Images of a 45-year-old female patient with invasive cervical carcinoma. (A) A hyperintense mass in the cervix was found by sagittal T_2 weighted MRI (short arrows) with maximum C-C $\times$ A-P $\times$ left-right (L-R) dimensions of 39 $\times$ 38 $\times$ 36 mm. (B) The cervical mass was heterogeneously enhanced on T_1 weighted MR images. (C, D) The hypointense cervical mass with heterogeneous enhancement (short arrows) filling the endocervix as revealed by axial T_1 weighted and contrast-enhanced T_1 weighted MR images with fat saturation. (E) A smaller hypoechoic mass was found by B-mode ultrasonography, with C-C $\times$ A-P $\times$ L-R dimensions of 44 $\times$ 35 $\times$ 36 mm (short arrows). (F-H) A well-defined cervical mass (short arrows) with hyperenhancement relative to adjacent normal myometrium was revealed in arterial phase (F) and a hypoenhanced cervical mass in venous phase appeared on both sagittal CEUS (G) and axial CEUS (H). AP, anteroposterior; CC, craniocaudal; CEUS, contrast-enhanced ultrasonography; LR, left-right.

Table 2. Tumour dimensions measured by MRI and CEUS

	L-R (M ± SD mm)	C-C (M ± SD mm)	A-P (M ± SD mm)
MRI	51.93 ± 14.78	42.96 ± 13.31	37.37 ± 11.47
CEUS	49.68 ± 13.89	39.48 ± 12.94	37.74 ± 11.71
Mean difference	2.24 ± 8.24	3.48 ± 7.03	-0.37 ± 5.80
Bland-Altman 95% limits of agreement	-13.91-18.39	-10.29-17.26	-11.74-11.00
r^a	0.836	0.857	0.875
P	0.053	0.001 ^b	0.064

AP, anteroposterior; CC, cranio caudal; CEUS, contrast-enhanced ultrasonography; LR, left-right.

^aCorrelation coefficient.

^bDifference in craniocaudal diameter was significant ($p < 0.05$).

Table 3. Detection of vaginal invasion by MRI and CEUS

	CEUS			Total
	Negative	Upper 2/3	Lower 1/3	
Negative	0	2	0	2
Upper 2/3	12	68	2	82
Lower 1/3	0	8	16	24
Total	12	78	18	108

CEUS, contrast-enhanced ultrasonography;

MRI were deemed negative by CEUS and 2 cases detected by CEUS were deemed negative by MRI, for an overall moderate concordance of $\kappa = 0.461$.

Parametrial invasion was detected by MRI in 82 of the 108 cases (75.92%), while parametrial invasion was deemed negative by CEUS in 20 of these cases (Table 4). Moreover, six cases with pelvic wall invasion were detected by MRI but none by CEUS. The κ value was 0.469, indicating moderate concordance.

Invasion of the uterine corpus was detected by both modalities in 40 cases (37.04%). MRI detected 6 cases that were negative according to CEUS, and CEUS detected 12 cases negative by MRI (Table 5). The κ value (0.665) indicated good concordance. CEUS detected uterine corpus invasions with a SEN of 85.96%,

Table 4. Detection of parametrial and pelvic wall invasion by MRI and CEUS

MRI	CEUS			Total
	Negative	Parametrium	Pelvic wall	
Negative	20	0	0	20
Parametrium	20	62	0	82
Pelvic wall	0	6	0	6
Total	40	68	0	108

CEUS, contrast-enhanced ultrasonography;

Table 5. Detection of invasion of uterine corpus by MRI and CEUS

MRI	CEUS		Total
	-	+	
-	50	12	62
+	6	40	46
Total	56	52	108

CEUS, contrast-enhanced ultrasonography;

SPE of 80.65, PPV of 79.92%, NPV of 89.29% and ACC of 83.33% compared to MRI. A high NPV was demonstrated by CEUS.

16 cases of bladder invasion were detected by both MRI and CEUS (Figure 2), while MRI detected 6 cases not found by CEUS, and CEUS detected 8 cases missed by MRI (Table 6). The κ value was 0.613, indicating good accordance. CEUS detected bladder invasion with a SEN of 72.73%, SPE of 90.70%, PPV of 66.67%, NPV of 92.86% and ACC of 87.03% compared to MRI. CEUS provided a high SPE and NPV for detecting bladder invasion.

There were 10 cases of rectal invasion detected by both MRI and CEUS. However, MRI detected six cases not found by CEUS and CEUS detected two cases deemed negative by MRI (Figure 2) (Table 7). Overall, the κ -value of 0.673 indicated good accordance. CEUS detected rectal invasion with SEN of 62.50%, SPE of 97.83%, PPV of 83.33%, NPV of 93.75% and ACC of 92.59% compared to MRI. The SPE, NPV and ACC of CEUS for identifying rectal invasion were outstanding.

DISCUSSION

Pre-treatment tumour volume is a predictor of survival in patients with cervical cancer.²⁶⁻²⁸ Hawnaur et al²⁶ reported MRI had an advantage over transrectal ultrasound to assess the full extent of bulky tumours and identify patients with a poor prognosis in 1998. The measurement accuracy of ultrasound would be limited relative to current systems in early comparative studies. In recent years, ultrasound and MRI both showed acceptable accuracy for detecting tumour presence. Epstein et al¹⁹ reported better agreement of ultrasound for detecting residual tumour and measuring tumour size in the early stages of cervical cancer compared to MRI using pathologic findings as the reference

Figure 2. Images of bulk invasive cervical carcinoma in a 62-year-old female. (A) An isointense bulk cervical mass extending to the uterus and upper 2/3 of the vagina (shortarrows) was found by sagittal T_2 weighted MRI. (B) The cervical mass with invasion of uterine corpus was heterogeneously enhanced on sagittal T_1 weighted MR images with fat saturation. The boundary of the mass was indistinct and the fatty interspace between the cervical tumour and bladder was absent (thin arrow). (C, D) The cervical mass was indistinct on axial T_2 weighted MR images and axial T_1 weighted MR images with fat saturation. The bladder wall with low signal was discontinuous (thin arrow). (E, F) A hypoechoic ill-defined bulk cervical mass extending to the uterine corpus was demonstrated by B-mode ultrasound. The fatty interspace between cervix and bladder was absent. (G, H) The cervical mass was hyperenhanced in arterial phase and hypoenhanced in venous phase on CEUS (short arrows). The fatty interspace between cervix and bladder appeared hyperenhanced coincident with the cervical tumour in the arterial phase (thin arrows). The tumour protruded beyond the cervix, with local discontinuous corpus (white heavy arrows). CEUS, contrast-enhanced ultrasonography.

Table 7. Detection of rectal invasion by MRI and CEUS

MRI	CEUS		Total
	–	+	
–	90	2	92
+	6	10	16
Total	96	12	108

CEUS, contrast-enhanced ultrasonography;

standard. Furthermore, it was reported that tumour volume as measured by transrectal ultrasound was more strongly correlated with pathological findings than MRI in locally advanced cervical cancer recently.⁸

CEUS is utilised for the characterisation of sonographically detected lesions on livers, pancreases, and so on.^{22,23} It led to an improvement of ultrasound in the diagnosis of gynaecologic disease.^{21,23} For the evaluation of cervical cancer, CEUS revealed a better definition of the margins of the neoplastic lesions.²¹ Alternatively, the present results showed moderate correlations between CEUS and MRI, indicating that CEUS can provide comparable measures of tumour size at generally lower cost with repeatability. In our study, MRI trended to obtain a larger diameter in each dimension than CEUS. Edematous tissue around the tumour with a high T_2 -signal may have led to overestimation of tumour size by MRI; in contrast, CEUS may obtain information more consistent with histopathological results.

The evaluation of parametrial invasion at diagnosis is critical for subsequent treatment decisions, as patients without extension to the parametrium can be scheduled for surgery. In earlier studies, clinical examination alone underestimated parametrial invasion in one-third of all patients.^{29,30} In the study by Stenstedt et al,¹³ the treatment plan was altered in about 8% of cervical cancer FIGO Stage Ia–IIa cases and in about 20% of more advanced cases after pre-treatment MRI. Epstein et al²⁰ reported better agreement of ultrasound with histology than MRI for assessing parametrial invasion (κ 0.75 vs 0.45). Patients in our study, however, had more advanced disease (IIA2–IVB), with 81.48% (88/108) deemed invasion-positive (including parametrial and pelvic wall invasion) by MRI and 57.41% (62/108) by CEUS, proportions much higher than in previous studies. False-positive parametrial invasion due to high T_2 -signals on MRI may be related to oedema or inflammatory reactions around the tumour. Alternatively, false-positive parametrial invasion according to CEUS may be related to large tumours in which the irregular border of the cervix was incorrectly interpreted as parametrial invasion, parametrial endometriosis, and (or) fibrous change of the parametrium.¹² Our previous study demonstrated that CEUS was an effective non-invasive strategy for detecting perfusion and angiogenic status of cervical cancer.²⁵ An inherent advantage of CEUS is the opportunity to assess the contrast enhancement patterns in real time, with higher temporal resolution than other imaging modalities, so that the enhancement dynamics of tumour invasion consistent with the cervical cancer can be discerned, even though, this surmise cannot be confirmed due to lack of pathological confirmation as the reference standard.

Although there was poor-moderate agreement between MRI and CEUS in this study (κ = 0.469), the present study suggests CEUS could be a possible application in improving the clinical staging of the cervical cancers.

Few studies have compared vaginal invasion by the two methods. In our study, the agreement between MRI and CEUS was clinically unsatisfying, with a κ -value of 0.484. Byun et al³¹ reported poor sensitivity of both ultrasound and MRI (44.4 and 55.6%, respectively) for detection of vaginal invasion. Furthermore, the accuracy of clinical examination was 77.8% while MRI specificity was poor. In a study by Testa et al¹⁹ ultrasound diagnosed only one of three cases of histologically confirmed vaginal invasion while MRI missed all three. Thus, both modalities appear unreliable for evaluation of vaginal invasion. Palpation and colposcopy are more convincing and easily performed and thus better options.

Evaluation of uterine corpus invasion is important for deciding whether a patient is suitable for treatment by fertility-preserving surgery and for defining the target volume in patients who receive brachytherapy. Van Dyk et al³² reported differences less than 5 mm between MRI and transabdominal ultrasound imaging for measurement of cervix and uterine corpus. In the current study, CEUS and MRI showed good agreement, with a κ -value of 0.665. Evaluation of bladder and rectum between the two methods had better agreement in our study, with κ of 0.613 for bladder and 0.673 for rectum. Biopsy under invasive endoscopy can identify lesions extending to the mucosa of bladder and rectum. However, patients with no invasion on CT and MRI images do not require additional endoscopic examinations considering the high NPV demonstrated by CT and MRI scans.^{33,34} In the present study, CEUS provided high NPVs (89.29, 92.86 and 93.75%) for detecting uterine corpus compared to MRI; therefore, endoscopy should be avoided for patients who present with no uterine invasion on CEUS imaging work-up, similar research had ever been published.³⁵

On the other hand, MRI is recommended as the best modality for image-guided brachytherapy due to its high image resolution and clear target volume definition.³⁶ Our present findings demonstrate good concordance of CEUS with MRI for evaluating tumour size and local invasion of cervical cancer. Thus, CEUS could be performed before brachytherapy to accurately determine the clinic stage, and it has the potential to be an alternative in brachytherapy of cervical cancer.

Table 6. Detection of bladder invasion by MRI and CEUS

MRI	CEUS		Total
	–	+	
–	78	8	86
+	6	16	22
Total	84	24	108

CEUS, contrast-enhanced ultrasonography;

The major limitations of our study as following: (1) All patients received exclusive radiochemotherapy without surgery, so CEUS and MRI results were not compared to pathological findings, which are usually regarded as the golden standard for diagnosis. (2) Lymph node metastasis is a major prognostic factor associated with poor prognosis and it could alter treatment planning, however, lymph node status is exactly ignored to take into evaluated by both methods in our primary trial design, which focused on parametrial involvement. (3) Considering the transabdominal scanning may not always be suitable for visualization in patients especially in those with large body habitus, so the evaluation of local invasion of cervical carcinoma using transabdominal CEUS lost lots of details in those patients, and transvaginal CEUS may be more suitable for visualization.

CONCLUSION

In brief, CEUS shows good concordance with MRI for evaluating local invasion of cervical cancer (parametrial, pelvic wall,

uterine corpse, bladder and rectal), and potential for assessing tumour size. In addition, ultrasound is more convenient and less expensive than MRI. Thus, CEUS as well as convention ultrasound may be suitable alternatives for staging cervical cancer and guiding brachytherapy.

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CONSENT

Written informed consent for the cases to be published (including images, and data) were obtained from the patients for the publication.

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