Three-dimensional power doppler angiography characteristic in validating the preoperative accuracy of myometrial and cervical involvement in women with endometrial cancer*

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ABSTRACT

Background: The *Lead Vessel* and *Infitrating Vessels* are findings in endometrial cancer that are well visualized by three-dimensional power Doppler angiography. Vessel diameter and length may be utilized as markers for deep myometrial and or cervical involvement.

Objective: To determine the accuracy of *Lead vessel* and *Infiltrating vessel* dimensions in assessing the depth of myometrial invasion in endometrial cancer and its cervical involvement.

Participants and Methods: All women histopathologically diagnosed with endometrial cancer, undergoing surgical staging, with informed consent were included. Sonography using GE Voluson S8 system for describing the uterus and endometrial thickness were followed by a 3D power Doppler Angiography to analyze the depth of myometrial invasion and presence or absence of cervical involvement. Vessel diameter and length in transverse and sagittal plane were measured by calipers. Predictive values and operating characteristics (sensitivity, specificity, positive and negative predictive values) were computed.

Results: A total of eleven cases (superficial n=5; deep=6) were identified. The cut-off for *Lead vessel* and *Infiltrating vessel* in the sagittal view was (diameter > 0.28; length >0.47) and for the transverse view was (diameter >0.36, length >0.5). Among the four measurements, the sagittal diameter (98.3%), sagittal length (100%) and the transverse length (100%) measurements of the *Lead and Infiltrating vessel* gives the highest predictive accuracy.

Conclusion: Three-dimensional power Doppler angiography measurement of the *Lead and Infiltrating vessels* are associated with improved accuracy and reliability in predicting deep myometrial invasion.

Keywords: 3D-PDA, Lead Vessel, Infiltrating Vessel, Endometrial CA

INTRODUCTION

Endometrial cancer is the sixth most commonly diagnosed cancer among women worldwide with an estimated 319, 600 new cases occurring in 2012. Most cases were diagnosed at an early stage with a presenting symptom of an abnormal uterine bleeding in 90% of cases.

Surgery is the primary treatment for this disease depending on the stage, extent and histological type. Numerous imaging modalities emerge to help in selecting the ideal treatment. 2D Transvaginal ultrasound, Computed tomography scan, and Magnetic Resonance Imaging have been used as diagnostics to assess the myometrial invasion and cervical involvement in endometrial cancer. Endometrial thickness has been used as a parameter to discriminate between benign and malignant uterus.

The 3D-PDA is based on three-dimensional reconstruction of vessels image, received from Power Doppler System. With the advent of this in gynecological oncology, studies have been shown to have favorable outcomes in assessing depth of invasion. This modality enables to acquire sonographic volume of the entire corpus and cervix in which the vasculature could be examined thoroughly. Estimation of the volume is achieved better in 3D-PDA. It allows the evaluation of the total blood flow in the corpus by the analysis of the power Doppler signal.

Angiogenesis is the development of new microvasculature and is the key step in the formation of new tissues in hyperplastic and neoplastic growths. It is the process of generating new capillary blood vessels, leading to neovascularization.[2] It has an essential role in the tumor growth and spread in the development of endometrial cancer. 3D-PDA could be applied clinically which will be focused in assessing the characteristics of the angiogenesis in uterus with cancer and its association with tumor qualities. Vessel distribution, arrangement and

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measurements will be included and will be studied. In this method, the sensitivity and specificity will be enhanced in distinguishing the extent of endometrial carcinoma.

In review of other researches, there is no existing conclusive study in characterizing the vessel in determining the extent of the myometrial invasion and cervical involvement in endometrial cancer. In utilizing the 3D-PDA, we perceived in cases of superficial metastases to the myometrium a main peripheral vessel that penetrates with a tree-shaped appearance called a *"Lead vessel"* similar to the observance of *A.C. Testa, et.al* in their study entitled *"The Lead vessel: A vascular feature of metastasis to the ovary."* Through this study, it encouraged us to further study this kind of vessel in cases of endometrial cancer. As we go through, we discover another kind of vessel in which we called it as *"Infiltrating vessel,"* these are group of scattered vessels that flows within the endometrial mass penetrating the myometrial wall. These vessels are seen in deep myometrial invasion.

The present study aimed to validate the accuracy of 3D-PDA in detecting the occurrence of deep invasion and predicting cervical metastasis preoperatively through these *"Lead vessel" and "Infiltrating vessel"* in women with endometrial cancer in a tertiary hospital. We would like to define the volume and endometrial blood flow calculated by 3D-PDA, if these parameters will be useful in staging before surgery in conjunction with the final histopathology result postoperatively.

Specifically, it is aimed to describe the characteristic and determine the diameter and length of the vessel to determine the depth of myometrial invasion and cervical involvement; determine the accuracy of 3D-PDA for preoperative assessment of single-stage myometrial invasion in relation to final histopathological result; assess the prediction of deep myometrial invasion, sensitivity, specificity, PPV and NPV of 3D-PDA and identify the accuracy of 3D-PDA in assessing cervical involvement in relation to final histopathological result.

PATIENTS AND METHODS

This is a cross-sectional study validating the accuracy of Three-dimensional power Doppler angiography in preoperative evaluation of myometrial and cervical involvement in women with endometrial cancer.

We included those women who were able to understand the study procedure and agreed to participate in the study by giving written informed consent; those who are histologically diagnosed as endometrial cancer who will undergo surgical treatment and those will undergo complete surgical staging.

We excluded those found to have non-uterine source on histopathology; with inconclusive sonographic results; with vagueness in the histopathological diagnosis in relation to the extent of myometrial invasion by the carcinoma; those who did not undergo surgery and those subjects who had neoadjuvant therapy.

All patients who meet the inclusion criteria were invited in private to participate in the study. Informed consent were likewise obtained in a private room of the hospital after a thorough explanation of the purpose and procedures of the study.

Each participant was asked to fill-up a self-administered survey form. Questions will include information regarding demographics, medical, personal, past medical, family and social history, menstrual and obstetric history.

Patients who were diagnosed to have endometrial carcinoma by biopsy and were scheduled to undergo surgery were admitted to the study. All these women who gave their consent to participate in the study signed the informed consent form as approved by the ethics board committee of the institution. Ultrasound was done to each patient who were deemed qualified in the research before the proposed surgical treatment.

Sonography was done by a single operator who is the head of the ultrasound section and supervising investigator of this research who underwent training in gynecological ultrasound oncology with 3 year experience in performing the said imaging study. The expert specialist used a Voluson S8 system (GE Healthcare Ultrasound) with GE RIC5-9-RS 3D/4D transvaginal probe. The procedure started with 2D imaging using two orthogonal views where the uterus was examined in sagittal section which clearly delineated the endometrial thickness. Any lesions from endometrium extending to the myometrium and cervix were carefully analyzed and recorded. Probe was turned 90 degrees to a transverse position to assess the whole corpus up to the cervix.

After 2D imaging of the uterus, a 3D power Doppler was used to analyze the depth of myometrial invasion and presence or absence of cervical involvement. The specified power Doppler settings was used: Power Doppler Gain: -2.2 dB, Dynamic range: Wide Range, WMF (Wall Motion Filter): low 1, PRF (Pulse Repetition Frequency. 0.3-0.6, Angle: 146°, B-view: -5°, Dynamic contrast: -4, Focal Zone: 1, Frequency: Normal, Mix: 96/4, Power Doppler Flow 30. The patient was asked to hold her breath while getting the volume datasets. Highest quality of the volume was established. Two orthogonal views were used and standardized namely sagittal and axial planes to carefully scrutinize the uterus and cervix. Each volume acquisition was set to 20-25 minutes with 2 quality images saved.

In analyzing the depth of myometrial invasion, we described the characteristics if there is a presence of *"Lead vessel"* or *"Infiltrating vessel".* The expert used calipers in measuring the diameter and length of these

vessels which gives strong color flow. It is measured primarily from the endometrial mass to the depth of its myometrial invasion. Subsequently, we categorize the endometrial mass in the following manner using the 2009 FIGO Staging of Endometrial Cancer: (1) T*umor confined to the corpus* (2) *<50% of the myometrial invasion* (3) *>50% of the myometrial invasion* (4) i*nvasion beyond the uterine serosa*. Cervical involvement will be also categorized as (1) *present* (the endocervical canal is invaded with volume and chaotic characteristic of vessels) (2) *absent* (endocervical border were intact from internal os to external os).

After the ultrasound was done, patient underwent the appropriate surgery and ultrasound result was compared to the final histopathological report.

In order to estimate the sensitivity of Three dimensional power Doppler angiography of 99% as evidenced by *S. Jantarasaengaran, et.al*, the minimum number of subjects required to reject the null hypothesis (sensitivity: 80%) is 36. An additional 20% of the computed sample was added to adjust for potential dropouts. This sample size wass calculated with a minimum type 1 error of 5% (α is 0.05) and type 2 error of 20% (β is 0.20). The sample size was calculated using MEDCALC (Chicago, USA, with license). The study had eleven subjects.

The present study was granted approval by the hospital's Ethical Review Board. All study procedures conformed to the Declaration of Helsinki' governing principles in the utilization of human subjects for clinical experiments. All procedures conformed to the WHO Manual of Good Research Medical Practice. Patient anonymity and confidentiality was preserved at all times. All provisions for patient care were embodied in the informed consent.

RESULTS AND ANALYSIS

A total of 43 cases were screened and scanned. However, 26 patients failed to undergo surgery because of lack of funds and some did not comply with the requirements given by the surgeons. Two (2) patients had neoadjuvant chemotherapy. Only 15 patients who completed the surgery were included in the study. Among the 15, one had incomplete staging and 3 have incompatible histopathology results. Hence, a total of 11 cases were analyzed. Of this, five were determined to have superficial infiltration and six had deep *infiltration* containing the 2 vessels observed by the authors namely *Lead vessel* and *Infiltrating vessel* respectively. (Table 1) The mean age was 46 years (± 12), with nulligravida accounting for 45.5%, primigravida (27.3%) and multigravida (27.3%). (Table 2) Four cases were diabetic (36.4%) and obese (72.7%). One case was a smoker (9.1%), while four (36.4%) had a family history of cancer. Six patients (54.5%) had taken oral contraceptive pills.

Table 1. Comparison of the ultrasound result to histopathological result 2017

Characteristic	No.
Total number of subjects (N=15)	15
Incomplete staging	1
Incompatible ultrasound result with histopathology result	3
Compatible ultrasound result with histopathology result Superficial Infiltration (5) Deep Infiltration (6) No cervical involvement (5) With cervical involvement (6)	11

Table 2. Profile of cases of endometrial cancer 2017

Characteristic	No.	%
Age (Mean ± SD)	46 ± 12	--
Gravidity		
Nulligravida	5	45.5
Primigravida	3	27.3
Multigravida	3	27.3
Diabetes mellitus		
Yes	4	36.4
No	7	63.6
Obesity		
Yes	8	72.7
No	3	27.3
Smoker		
Yes	1	9.1
No	10	90.9
Family history of cancer		
Yes	4	36.4
No	7	63.6
Hormonal treatment		
None	5	45.5
OCPs	6	54.5

Five cases were assessed to have superficial tumor infiltration and six cases with deep tumor infiltration based on the myometrial depth, 3D PDA Characteristic and final histopathology reports. The individual and average *Lead vessel* measurements in both sagittal and transverse views for this category are presented.

LEAD VESSEL

The range of the *Lead vessel* (Fig-1) diameter on sagittal view was between 0.25 to 0.28 cm (mean = 0.26, ± 0.011) while the transverse view was between 0.24 to 0.36 cm (mean = 0.27± 0.05). The range of Lead vessel length in the sagittal view was 0.34 to 0.47 cm (mean = 0.41 ± 0.05) while in the transverse view it was 0.39 to 0.5 (mean = 0.45 ± 0.05). (Table 3)

In Superficial infiltration, the average distance of the endometrial mass to the internal cervical os was 1.62 ±

0.33. Two patients in this category had an intact cervix which is a normal finding and free of infiltration (> 1.0 cm). (Table 4)

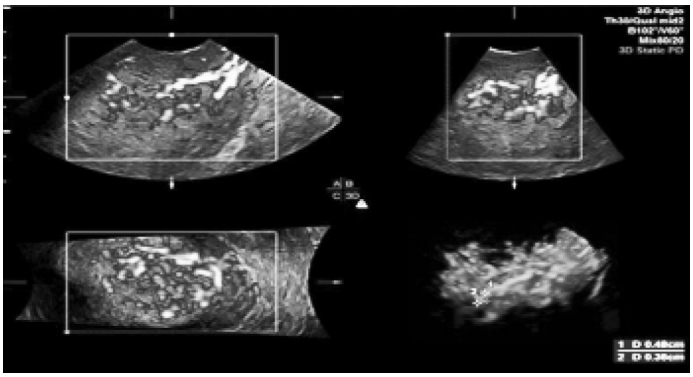

Figure 1. Lead vessel in superficial Myometrial Infiltration

Table 3. Diameter and Length Measurements of the Lead Vessel on 3D-PDA in Superficial Tumor Infiltration, Five (5) Cases, 2017

Sagittal View	No.	%	Mean	SD
Diameter (cm)				
0.25	1	20	0.26	0.011
0.26	1	20		
0.27	2	40		
0.28	1	20		
Length (cm)				
0.34	1	20	0.41	0.05
0.38	1	20		
0.40	1	20		
0.45	1	20		
0.47	1	20		
Transverse View	**No.**	**%**	**Mean**	**SD**
Diameter (cm)				
0.24	1	20	0.27	0.05
0.25	1	20		
0.27	2	40		
0.36	1	20		
Length (cm)				
0.39	1	20	0.45	0.05
0.40	1	20		
0.48	2	40		
0.50	1	20		

INFILTRATING VESSEL

The range of the deep *infiltrating vessel* (Fig. 2) diameter on sagittal view was between 0.28 to 0.74 cm (mean = 0.46, ± 0.20) while the transverse view was between 0.25 to 0.39 cm (mean = 0.32 ± 0.05). The range of infiltrating vessel length in the sagittal view was 0.58 to 1.43 cm (mean = 0.89 ± 0.32) while in the transverse view it was 0.65 to 1.31 (mean = 0.92 ± 0.27). (Table 5)

In deep myometrial infiltration, the average distance of the endometrial mass to the internal cervical os was 0.53 ± 0.23 (range 0.32-0.93). (Table 6)

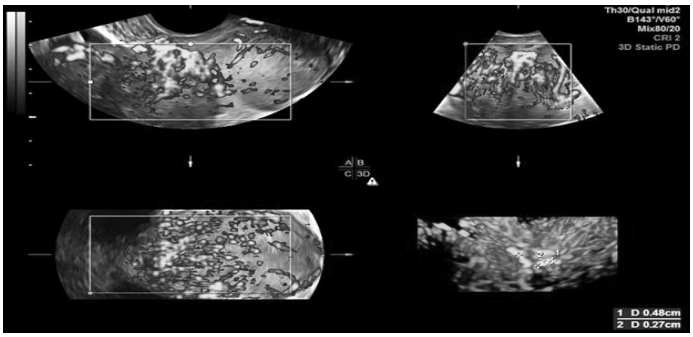

Figure 2. Infiltrating vessel in deep myometrial infiltration

Table 4. Distance of endometrial mass to the internal cervical Os

Stage	Postoperative Therapy
IA: grade 1/2 IB: grade 1/2	No further therapy
IA: grade 3 IB: grade 3 IC: grade 1/2 IIA: grade 1-3[a]	<u>Vaginal cuff brachytherapy</u> Low-dose-rate 6,500 cGy RSD or High-dose-rate 700 cGy at 0.5 cmx3
IC: grade 3 IIA: grade 1-3[b] IIB: grade 3 IIIA: grade 1-3[c] IIIB: grade 1-3[d] IIIC: grade 1-3[e] IVA: grade 1-3	<u>External pelvic irradiation plus vaginal cuff brachytherapy</u> 5,040 cGy)(180 cGy/d) 4-field whole pelvis (4,800 cGy at 160 cGy/d if > 70 yr); Low-dose-rate 3,500 cGy RSD; 4,500 cGy for + LVS; or High-dose-rate 200 cGy at 0.5 cm x 6 (250 cGy for + LVS, 300 cGy for positive/ close margins)
IVB: grade 1-3 (intra-abdominal) Any stage papillary serous or clear cell histology	<u>Whole-abdominal irradiation, pelvic boost, and vaginal cuff brachytherapy</u> 3,000 cGy (150 cGy/d) whole abdomen with 5 HVL posteroanterior kidney blocks Additional 1,980 four-field whole pelvis Additional 1,500 cGy para-aortic dose if positive para-aortic lymph nodes Low-dose-rate 3,500 cGy RSD; 4,500 cGy for + LVS; 5,000 cGy for positive/close margins: or High-dose-rate 200 cGy at 0.5 cm x 6 (250 cGy for + LVS, 300 cGy for positive/ close margins)

[a] With less than 50% myometrial invasion.
[b] With greater than 50% myometrial invasion.
[c] With positive cytology, whole-abdominal irradiation, in addition to pelvic irradiation and vaginal cuff brachytherapy
[d] Groin irradiation is added if the disease involves the distal one-third of the vagina.
[e] Para-aortic irradiation is added if the para-aortic lymph nodes are positive.
HVL = half-value layer; +LVS = lymphovascular space involvementl; RDSD = rad surface dose.

Table 5. Diameter and Length Measurements of the *Infiltrating Vessel* on 3D-PDA in Deep *Tumor Infiltration* of Six (6) Cases, 2017

Sagittal View	No.	%	Mean	SD
Diameter (cm)				
0.28	1	16.7	0.46	0.20
0.29	2	33.3		
0.51	1	16.7		
0.65	1	16.7		
0.74	1	16.7		
Length (cm)				
0.58	1	16.7	0.89	0.32
0.62	1	16.7		
0.76	1	16,7		
0.87	1	16.7		
1.12	1	16.7		
1.43	1	16.7		
Transverse View	**No.**	**%**	**Mean**	**SD**
Diameter (cm)				
0.25	1	16.7	0.32	0.05
0.28	1	16.7		
0.29	2	33.4		
0.34	1	16.7		
0.35	1	16.7		
Length (cm)				
0.65	1	16.7	0.92	0.27
0.71	1	16.7		
0.82	1	16,7		
0.83	1	16.7		
1.21	1	16.7		
1.31	1	16.7		

Table 6. Distance of Endometrial Mass to the Internal Cervical Os

Distance of endometrial mass to the internal cervical os (cm)	No.	%	Mean	SD
0.32	1	16.7		
0.36	1	16.7		
0.40	1	16,7	0.53	0.23
0.48	1	16.7		
0.68	1	16.7		
0.93	1	16.7		

Below is a summary of the ultrasound measurements of distance of endometrial mass to the internal cervical os comparing the cervical involvement on histopathology. All patients with distance of > 1 cm displayed cervical involvement on histopathology. However, two patients with a sonographic reading of < 1 cm (deep invasion) reading failed to showed cervical involvement while four had cervical involvement. (Table 7)

Accuracy of the *Infiltrating and Lead Vessel* Measurements in Determining Myometrial Invasion

Based on the upper range cut-off of the sagittal diameter, a sagittal diameter value of above 0.28 detects deep infiltration with a sensitivity of 83.3% and a specificity of 100%. The sagittal length cut-off of above 0.47, gives both a sensitivity and specificity value of 100%. (Table 8)

A transverse diameter cut-off value of above 0.36, detects deep infiltration with a higher specificity (100%) than sensitivity (0%) while the transverse length of above 0.5 cm gives both a sensitivity and specificity value of 100%. (Table 9)

Table 7. Measurements of Distance of Endometrial Mass to the Internal Cervical Os Comparing the Cervical Involvement on Histopathology.

Distance of Endometrial Mass to Internal Cervical os	Cervical Involvement on Histopathology				Total
	Yes		No		
A. Superficial Invasion	No.	%	No.	%	
> 1 cm	5	100	--	--	5
B. Deep invasion					
< 1 cm	4	66.7	2	33.3	6
Total	9		2		11

Table 8. Accuracy of the Sagittal Diameter & Length of the Lead and Infiltrating Vessel in Assessing Myometrial Involvement, Analysis of 11 Cases, 2017

	Histopathology		
Sagittal Diameter*	**Deep Infiltration**	**Superficial Infiltration**	**Accuracy**
> 0.28	5	0	SN=83.33 (35.8-99.6)
<0.28	1	5	SP=100 (47.8-100)
Total	6	5	PPV= 100 (47.8-100) NPV=83.33 (35.8-99.6)

** Based on the highest cut-off value for range*

	Histopathology		
Sagittal Length*	**Deep Infiltration**	**Superficial Infiltration**	**Accuracy**
> 0.47	6	0	SN=100 (54.1-100)
< 0.47	0	5	SP=100 (47.8-100)
Total	6	5	PPV=100 (54.1-100) NPV=100 (47.8-100)

** Based on the lowest cut-off value for range*

Predictive Accuracy of *Lead and Infiltrating Vessel* Measurements

Figure 3 demonstrates the receiver operator curve of the four-*Lead and Infiltrating vessel* measurements on 3D-PDA using the above cut-off values. Among the four measurements, the sagittal diameter (98.3%), sagittal length (100%) and the transverse length (100%) measurements of the *Lead and Infiltrating vessel* gives the highest predictive accuracy.

Table 9. Accuracy of the Transverse Diameter & Length of the Lead & Infiltrating Vessels in Assessing Myometrial Involvement, Analysis of 11 Cases, 2017

	Histopathology		
Transverse Diameter*	**Deep Infiltration**	**Superficial Infiltration**	**Accuracy**
> 0.36	0	0	SN=0 (0.0-45.9) SP=100 (47.82-100) PPV=NC NPV=45.4 (45.4-45.4)
<0.36	6	5	
Total	6	5	

** Based on the highest cut-off value for range, NC-not calculated*

	Histopathology		
Transverse Length*	**Deep Infiltration**	**Superficial Infiltration**	**Accuracy**
> 0.50	6	0	SN=100 (54.1-100) SP=100 (47.8-100) PPV=100 (54.1-100) NPV=100 (47.8-100)
< 0.50	0	5	
Total	6	5	

** Based on the lowest cut-off value for range*

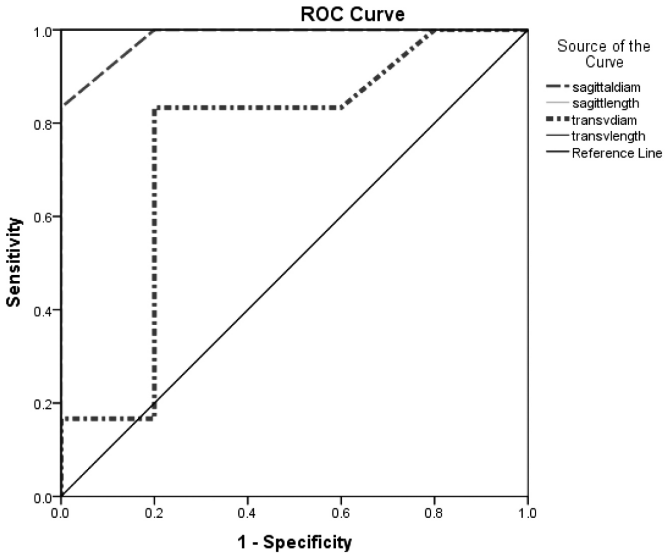

Figure 3. Comparative Accuracy of the Different Infiltrating and Lead Vessel Measurements in Detecting Superficial and Deep Tumor Infiltration (Myometrial Involvement), Analysis of 11 Cases, 2017

Shown below are the comparative accuracies for detecting *deep Infiltrating and superficial Lead vessel* in the 3D-PDA. (Table 10)

As stated above, among the three measurements, both the *Lead vessel and infiltrating vessel's* diameter and length on sagittal view, and the length on transverse view show significant predictive accuracy. The cut-off value for sagittal view- diameter suggestive of significant deep infiltration is above 0.28, while that of sagittal length was above 0.47. The cut-off value for length on transverse view is above 0.5 cm.

Table 10. Receiver Operator Curve Analysis (ROC) for the Four *Lead & Infiltrating Vessel* Measurements on 3D-PDA in the Assessment of Myometrial Involvement, 2017

Area Under the Curve					
Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Sagittal Diameter*	.983	.033	.008	.919	1.000
Sagittal Length*	1.000	.000	.006	1.000	1.000
Transverse Diameter	.72	.180	.23	.35	1.000
Transverse Length*	1.000	.000	.006	1.000	1.000

*significant predictive accuracy

DISCUSSION

This is a pilot study conducted concerning the use of three-dimensional power Doppler angiography (3D-PDA) in the measurement of the *Lead vessel and Infiltrating vessels'* dimensions to predict deep myometrial and cervical involvement.

The sample came from eleven subjects with final histopathologic results documenting the depth of infiltration. The pathologist-reader was unaware of the sonographic reports at the time of evaluation.

The cut-off values set for each dimension was based on the range of values reported and since there are no existing local or international documents indicating the precise cut-off values of the mentioned dimensions.

Of the four reported measurements in this study, three were found to be associated with great accuracy, namely; the sagittal length and diameter as well as the transverse length of the lead vessel. The accuracy ratings for determining deep myometrial invasion were highest for transverse length, sagittal length and sagittal diameter in that order.

Ultrasound is established as the method of choice for evaluating local extent of endometrial cancer. Measurement of the endometrial *Lead vessel's* dimensions is a novel approach to pre-operative staging. There is a dearth of published studies that focus on the accuracy of these measurements. It is sufficient to note that using 3-D PDA, vascular patterns are particularly well visualized in peripheral nodes using high resolution linear array probes or in the pelvis using high-frequency probes. The presence of peripheral or mixed vascularity or displacement of vessels seems to be the sole criterion in the diagnosis of metastatic or lymphomatous nodes.[7]

In our study, careful measurements of the *Infiltrating*

and Lead vessels' length and diameter in both the transverse and sagittal planes were sought. The accuracy ratings were much better with the sagittal length and diameter as well as the transverse length. This finding supports the study of Saarelainen *et.al.* who observed sonographic and histological data on 100 consecutive cases of endometrial carcinoma. The median endometrial and myometrial vascular indices were higher in the group with deep invasion than in the group without. It was concluded that endometrial flow indices and volume correlate with the depth of myometrial invasion in endometrial carcinoma.[8]

In our study data, 3D-PDA had higher specificity values for the all *Lead and Infiltrating vessel* dimensions. This supports the same author's findings that in detecting deep myometrial invasion, there were no significant differences in the 3D-PDA vascularity indices' specificity between ultrasound or when used with MRI together.[9]

In our study, there was only one eligible board-certified sonographer who measured the *Lead and Infiltrating vessel's* dimensions thrice, with high internal consistency and reproducibility were high. Whether measurements were taken in the sagittal or transverse planes, endometrial and sub-endometrial 3D power Doppler indices have an acceptable reproducibility, significantly higher in detecting tumor invasion. The reliability of measurements does not seem to be significantly influenced by the rotation plane and degrees of rotation.[10]

It is also worth mentioning that the Lead vessel was only observed in cases with superficial infiltration and seems to be absent when myometrial invasion becomes deep. This is an observation similar to Testa *et.al.*[5] who did not offer any explanation for such occurrence. However, the same study concluded that the presence of *Lead vessels* was a main feature of metastatic ovarian cancer than in primary invasive ovarian carcinoma. We have not located any study attempting to explain why the reverse is true in endometrial cancer. It may be justified to perform high resolution imaging (e.g. MRI) to validate the presence of the lead vessel in all stages of endometrial carcinoma. Since *Lead vessel* is only noted in superficial, the authors labeled the sonographic feature of vascular morphology in deep myometrial invasion as *"Infiltrating vessels."* These are group of scattered vessels that flows within the endometrial mass penetrating the myometrial wall.

The technique in *Lead vessel and Infiltrating vessel* measurements were crucial in this study. As cited above, reliability was not influenced by variations in the plane or view as otherwise expected. In general transverse view dimensions for length and diameter were much larger when compared to the sagittal view dimensions. However, in the data presented for deep infiltration, the cut-off data for the mean length of the lead vessel on sagittal view was 0.89 while on transverse view 0.92. The diameter was larger in the sagittal rather than the transverse view (0.46 versus 0.32). The same observations were noted with the superficial infiltration. These slight incongruences may be addressed by standardizing the procedure in determining the dimensions using the caliper.

In itself, 3D-PDA is known to clearly reveal the angio-architecture spatial relationships between vessels and depth of myometrial invasion in endometrial cancer.[10] *Lead and infiltrating vessel* dimension measurements may have a role in further elucidating tumor depth of invasion into the myometrium and cervical involvement as well as shown in this study. Its clinical significance to clinicians is centered on its preoperative management. It helps in counseling and planning of the appropriate treatment for the patient.

This study is not without limitations. The inherently small sample made the confidence intervals wide. Secondly, the absence of standardized cut-off values for the length and diameter measurements of the *Lead and Infiltrating vessels* makes it difficult to draw a conclusion concerning the true depth of myometrial invasion.

CONCLUSION

Three-dimensional power Doppler angiography is associated with improved accuracy and reliability in the determination of superficial and deep myometrial invasion with involvement of cervical extension. *Lead and Infiltrating vessels* are two new sonographic features which may help sonologists on a prompt identification of its invasion to myometrium and cervix.

RECOMMENDATION

The clinical utility of identifying and measuring the Lead and Infiltrating vessel dimensions and its association with myometrial involvement still needs to be improved by reducing variation in the measurements in both sagittal and transverse views and involving more subjects.

It is recommended to determine a cut-off range of values for length and diameter of the Lead and infiltrating vessels using a larger representative sample from all the FIGO stages. Secondly, it may be worthwhile to determine the operating characteristics of lead vessel measurements in addition to vascular and volume indices. ■

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