Original Article

Doppler ultrasound evaluation of blood flow patterns of the uterine arteries in pre- and postmenopausal women with cervical cancer and controls in Zaria

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Abstract

Background: Cervical cancer remains an important health issue, especially in the developing countries that account for about 85% of the world burden of cervical cancer. Finding a role for Doppler ultrasound in the evaluation of these patients may reduce the cost and improve access to management.

Aim: The study aimed at evaluating the Doppler flow parameters in pre- and postmenopausal patients with cervical cancer when compared to normal controls in a teaching hospital in Nigeria.

Methodology: This is a prospective case–control observational study conducted over a period of 7 months (August 2016–February 2017) in Ahmadu Bello University Teaching Hospital, Zaria, Nigeria. Eighty-one patients with cervical cancer and 81 age-matched controls had a transabdominal Doppler ultrasound examination of the main uterine arteries. The data were analyzed using SPSS version 20.0, Chicago, Illinois, USA. Statistical differences in the uterine artery indices between two groups were tested, and $P < 0.05$ was considered as statistically significant.

Results: The mean resistive index (RI) and pulsatility index (PI) of the patients were 0.64 ± 0.12 and 1.26 ± 0.31, respectively, and of controls were 0.88 ± 0.08 and 2.60 ± 0.56, respectively. These showed significantly lower values in patients than the controls ($P < 0.0001$). The mean end-diastolic velocity (EDV) was significantly higher in patients than the controls ($P < 0.0001$). There was, however, no significant difference in the mean peak systolic velocity (PSV) in patients and controls ($P = 0.97$). Both premenopausal patients and controls had significantly lower RI and PI and significantly higher PSV and EDV compared to their postmenopausal counterpart.

Conclusion: The findings showed that significant differences exist in the uterine artery Doppler flow parameters in patients with cervical cancer compared to the healthy controls and that these parameters are influenced by menopausal status of the women and the size of the cervical mass. Hence, Doppler helps in staging, prognosticating, and posttreatment evaluation of patients with cervical cancer.

Keywords: Cervical cancer, Doppler scan, patients, uterine arteries

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INTRODUCTION

Cancer of the cervix is a malignant disease of the uterine cervix. The most common histologic types of cervical cancer are squamous cell carcinoma (69%) and adenocarcinoma (25%).[1] Squamous cancer is preceded by a premalignant phase that usually lasts for about 10 years. With regular, frequent screening, most are detected at the premalignant phase and can be treated readily.

In women, cervical cancer is the fourth most common malignancy worldwide.[1] The frequency varies considerably between developed and developing countries. It is the second most common cancer in developing countries but only the tenth most common in developed countries.[2] Worldwide, more than 528,000 women were diagnosed with cervical cancer in 2012, whereas more than 266,000 women are estimated to have died from cervical cancer in the same year, 85% of which occur in the developing countries.[2]

Human papillomavirus (HPV) infection is central to the development of cervical neoplasia and can be detected in 99.7% of cervical cancers.[3] In most Western countries, the availability of screening tests and vaccine against HPV infections has led to a 75% decrease in the incidence and mortality from cervical cancer over the past 50 years in these countries.[4,5] In Nigeria, it is the most common gynecological cancer,[5-7] with a national incidence of 250/100,000 women.[8,9]

Angiogenesis has been regarded as an essential event for tumor growth and progression.[10] The newly formed vessels are structurally different from the normal ones. Arteriovenous shunts and the absence of a muscular layer, both typical features of neoangiogenesis, result in a high flow velocity and low resistance, respectively.[11] Angiogenesis in cervical cancer has been found to be an independent prognostic factor,[12,13] as well as a predictor of disease recurrence.[14,15]

Traditionally, angiogenesis in tumoral tissue is assessed by immunohistochemical staining, but with the application of ultrasound Doppler imaging, tumor vascularity and therefore the process of angiogenesis can be observed *in vivo*.[16] In addition, these can be achieved by Doppler ultrasound several modes such as pulsed Doppler, color Doppler, and power Doppler modes.[17]

Uterine artery Doppler ultrasonography may be performed through the transvaginal or transabdominal route. Transvaginal route allows the use of high-frequency transducer but may, however, elicit bleeding in patients with exophytic cervical tumor. For the purpose of this study, the transabdominal route was utilized.

Imaging techniques are increasingly used in the pretreatment workup of cervical cancer.[18] The use of magnetic resonance imaging for local extent of disease evaluation and positron emission tomography – scan for distant disease assessment are considered as first-line techniques[19,20] in high-resource countries where these imaging modalities are readily available and affordable. The use of both gray and Doppler ultrasound in the evaluation of cervical cancer patients is an attractive modality because it is cheap, readily available, and can be repeated severally without exposing the patients to any risk of ionizing radiation.

Therefore, this study aimed at evaluating the blood flow pattern in the uterine artery in patients with cervical cancer when compared to normal controls using Doppler ultrasound.

The pulsatility index (PI) and resistive index (RI) provide information on downstream vascular resistance. High resistance in the distal vessels produces low diastolic flow in the supplying artery and results in a high value for these indices; a low resistance results in a low value as there is high diastolic flow.[21]

The PI shows a linear correlation with vascular resistance as opposed to RI, which shows a parabolic relationship with increasing vascular resistance.[22]

The relationship between these indices and the downstream vascular resistance is used as a diagnostic tool, for example, in obstetrics where umbilical artery Doppler waveforms are used to provide an indicator of placental resistance to flow.[23]

The study aimed at evaluating the Doppler flow parameters in pre- and postmenopausal patients with cervical cancer when compared to normal controls in a teaching hospital in Nigeria.

METHODOLOGY

This prospective study was carried out in the Department of Radiology, Ahmadu Bello University Teaching Hospital (ABUTH), located in Zaria, Kaduna state, Nigeria. Zaria has a population of about 975,153.[24] The study was conducted over a period of 7 months (from August 2016 to February 2017) following an approval from the Research and Ethics Committee of ABUTH, Zaria, Nigeria.

The study population was patients with histological diagnosis of cervical cancer attending the gynecological oncology and radio-oncology clinic before receiving treatment. The controls were healthy adult women, matched for age recruited from the hospital, university, and the host communities.

Inclusion criteria (cervical cancer patients) were newly diagnosed women with histological diagnosis of cervical cancer, with or without vaginal bleeding.

Inclusion criteria (controls) were consenting normal adult women within the age range of the cervical cancer patients.

Exclusion criteria (controls) included nonconsenting individuals, pregnant women, gynecological masses such as fibroids or other tumors (teratomas or ovarian), dysfunctional uterine bleeding, diabetic patients, peripheral vascular disease, women who have had previous hysterectomy, and patients with hemodynamic instability.

Exclusion criteria (patients) included other gynecological tumors other than cervical cancer, prior treatment of cervical cancer, pregnant women, diabetic patients, peripheral vascular disease, patients with previous hysterectomy, and patients with hemodynamic instability.

Sample size determination

Estimation of the sample size for this study was based on the Fisher's statistical formula:[25] $N = Z^2Pq/d^2$, where N = minimum sample size, Z = percentage of the standard normal distribution curve which defines 95% confidence interval and equal to 1.96, and P = prevalence rate from a previous study. Based on the study of Durowade *et al*.,[26] the prevalence of positive cervical cytology was 5%. A total of 81 patients were recruited for the study.

Procedure

This was first explained to the participants in clear terms. They were made to understand that the procedure is painless and may be of benefit to them, as any incidental finding would be communicated to the doctor managing them, which may add some value to their management.

After obtaining informed consent, participants were asked to fill their bladder by drinking one or more liter of water and by not urinating for at least 1 hour before the examination. Those who already had full bladder were exempted from taking the fluid. The participants laid supine, hands by the side and the head supported with a pillow. A clean piece of drape was spread on the participants to cover her from the pubic symphysis to the knee and the abdomen exposed to the umbilicus. Coupling gel was applied to the probe and the ultrasound machine settings optimized for the examination. The probe was moved across the lower abdomen and the pelvic organs assessed on two-dimensional (2D) grayscale for any mass. The cervical mass was then evaluated on a grayscale, and a 3D measurement of the mass was obtained in sagittal and transverse views using an electronic caliper, as shown in Figure 1. To visualize the uterine artery, along sagittal section of the uterus was obtained and the cervical canal was identified. The probe was then moved laterally until the paracervical vascular plexus was seen, the color Doppler was then turned on, and the uterine artery was identified as it is seen crossing the external iliac vessels, as shown in Figure 1. Pulsed wave Doppler was then turned on and the Doppler gate was placed and adjusted to cover the entire cross-sectional area of the vessel just distal to the point of crossing. The pulsed wave Doppler was then activated and the measurement was taken after optimization of the Doppler settings. The same process was repeated on the contralateral side if the vessel was not identified clearly on one side. The parameters – PI, RI, peak systolic velocity (PSV), and end-diastolic velocity (EDV) – were automatically calculated by the machine. An average of two regular consecutive cycles of equal heights was used for the calculation, as depicted in Figure 2. The Doppler measurement was optimized as follows: Angle of insonation of <60° was used. Complete alignment of the Doppler gate with the blood flow was ensured. The size of the color box was kept as small as possible to include only the studied area.[27] The Doppler gate was adjusted to ensure the recording of maximum velocities and also ensure that only measurement from the vessel of interest is recorded. The velocity scale or pulse repetition frequency was appropriately adjusted to prevent aliasing.[3]

Method of data analysis

The results and data generated for cervical cancer patients and the control group were first entered into the Excel

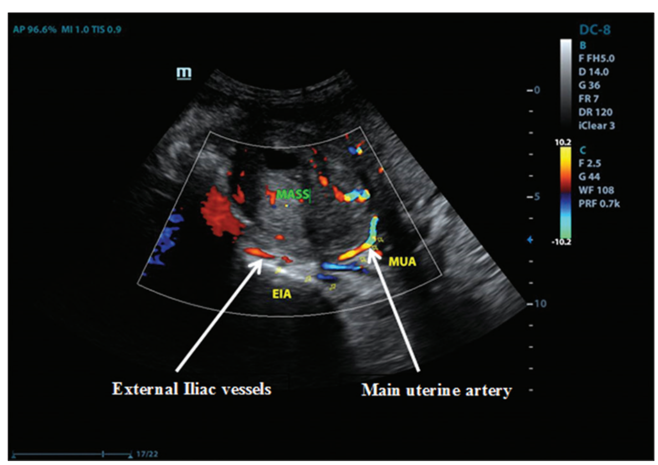

Figure 1: Color Doppler image of the uterine artery and the external iliac vessels in a patient with Stage IIIB cervical cancer

datasheet before being analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0, Chicago, Illinois, USA.

Statistical analysis of the Doppler parameters (PI, RI, PSV, and EDV) and clinical and demographic variables was performed. Means and standard deviation of the variables were computed and the result was presented in appropriate tables, graphs, and charts. The difference in PSV, EDV, RI, and PI measurements of patients with cervical cancer and the control group was tested using Student's *t*-test, with $P < 0.05$ considered as statistically significant. The relationship between the PSV, EDV, RI, and PI and the estimated tumor volume was also evaluated using Pearson correlation.

RESULTS

One hundred and sixty-two women were enrolled in the study comprising 81 cervical cancer patients and 81 normal controls. Majority of the patients were between the ages of 41 and 50 years, as shown in Table 1. However, that of controls showed between the ages of 41 and 50 years, as shown in Table 2. The mean age of the patients was 51.80 ± 6.69 (range, 33–75) years, whereas the mean age of the controls was 49.94 ± 7.01 (range, 31–73) years. There was no statistically significant difference in the mean age of the two groups ($P = 0.087$).

Most of the patients (91.3%) were in their 5th and 6th decades of life (40–59 years), with the highest frequency (50.6%) occurring in the age group of 50–59 years. The lowest incidence was among the age group of >60 years, as shown in Table 1. Similarly, most of the controls (90.1%) were in their 5th–6th decade of life, with the age group of 40–49 years having the highest frequency, as shown in Table 2.

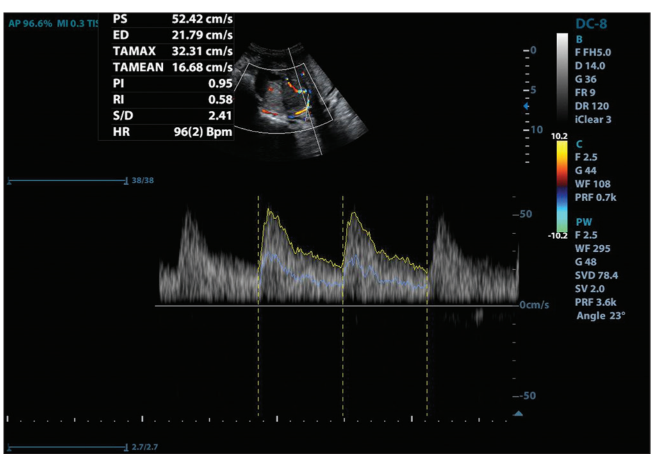

Figure 2: Pulsed Doppler examination of the uterine artery in a 56-year-old woman with International Federation of Gynecology and Obstetrics Stage IIIB cervical cancer, with high end-diastolic velocity = 21.79 cm/s, low resistive index = 0.58, and pulsatility index = 0.95

Based on the International Federation of Gynecology and Obstetrics (FIGO) staging, most of the patients (92.6%) presented with advanced stage disease (IIB–IVA). Stage IIIB was the most common (40.7%) form of presentation, as depicted in Table 3.

Most of the patients presented to the hospital between 7 months and 18 months of onset of symptoms, as shown in Figure 3.

Seventy-one of the patients (87.6%) with cervical cancer had squamous cell histology, whereas the remaining ten (12.4%) patients had columnar histology, as shown in Figure 4.

The premenopausal control group had significantly higher mean PSV and EDV and significantly lower mean RI and PI compared to the postmenopausal control group, as shown in Table 4. A similar observation was made but to a lesser degree among the pre- and postmenopausal patients with cervical cancer, as depicted in Table 5.

Table 1: The age-frequency distribution of the patients with cervical cancer

Age group	Frequency (%)
30-39	3 (3.7)
40-49	33 (40.7)
50-59	41 (50.6)
60-69	3 (3.7)
>69	1 (1.2)
Total	81 (100)

Table 2: The age-frequency distribution of the control group

Age group	Frequency (%)
30-39	2 (2.5)
40-49	40 (49.4)
50-59	33 (40.7)
60-69	5 (6.2)
>69	1 (1.2)
Total	81 (100)

Table 3: The distribution of the patients by clinical (International Federation of Gynecology and Obstetrics) staging

FIGO stage	Frequency (%)
IA	0 (0)
IB	2 (2.5)
IIA	4 (4.9)
IIB	19 (23.5)
IIIA	8 (9.9)
IIIB	33 (40.7)
IVA	15 (18.5)
IVB	0 (0)
Total	81 (100)

FIGO – International Federation of Gynecology and Obstetrics

It was also found that patients with cervical cancer were divided into two groups, i.e., less advanced Stage I/II and more advanced Stage III/IV disease based on FIGO staging, and it was observed that significant lower RI and higher PSV parameters among patients with more advanced stage of the disease (Stage III/IV) were noted compared to those with less advanced stage (Stage I/II disease). However, no statistically significant difference was observed in the EDV and PI between the two groups, as depicted in Table 6.

The relationship between PSV, EDV, RI, and PI and the estimated tumor volume was tested using Pearson correlation. Positive correlation was observed between the estimated tumor volume and PSV ($r = 0.417$, $P < 0.0001$) and the estimated tumor volume and EDV ($r = 0.449$, $P < 0.0001$). A negative correlation was also observed between the estimated tumor volume and RI ($r = -0.505$, $P < .0001$) and the estimated tumor volume and PI ($r = -0.481$, $P < 0.0001$).

The premenopausal control group had significantly higher mean PSV and EDV and significantly lower mean RI and PI compared to the postmenopausal control group [Table 3]. A similar observation was made but to a lesser degree among the cervical cancer patients [Table 4].

Forty-two (51.9%) of the patients were postmenopausal, whereas thirty-seven (45.7%) of the controls were postmenopausal [Table 5].

The patients with cervical cancer were further sub-divided into two groups for ease of comparison into Stage I/II as early case and Stage III/IV as advanced case based on

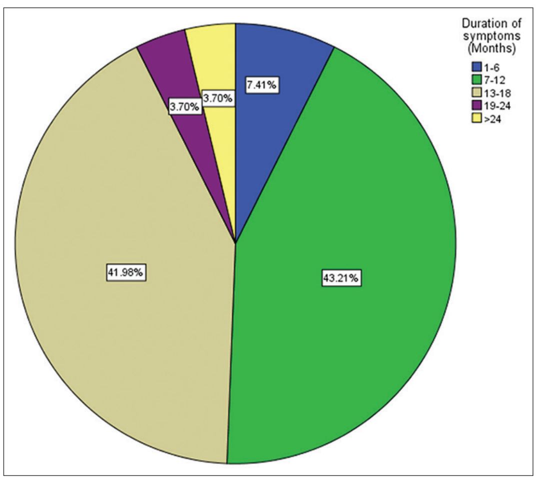

Figure 3: The distribution of the cervical cancer patients by duration of presenting symptoms

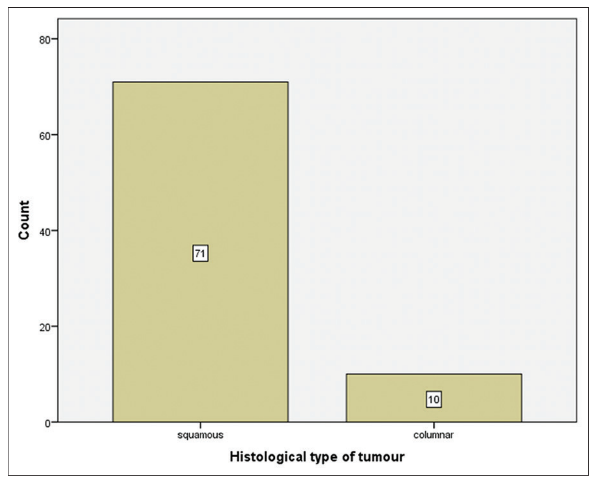

Figure 4: The distribution of the cervical cancer patients by histological type

Table 4: Mean±standard deviation of the uterine artery peak systolic velocity, end-diastolic velocity, resistance index, and pulsatility index of pre- and postmenopausal control groups

Doppler measurement	Mean±SD		*P*	Significance
	Postmenopausal	Premenopausal		
PSV	45.78±6.18	51.64±4.25	<0.0001	Significant
EDV	6.20±6.08	8.65±2.42	<0.0001	Significant
Resistance index	0.88±0.08	0.82±0.06	<0.0001	Significant
PI	2.60±0.56	2.05±0.39	<0.0001	Significant
n	37	44		

SD – Standard deviation; PSV – Peak systolic velocity; EDV – End-diastolic velocity; PI – Pulsatility index

Table 5: The mean±standard deviation of the uterine artery peak systolic velocity, end-diastolic velocity, resistance index, and pulsatility index of pre- and postmenopausal cervical cancer patient

Doppler measurement	Mean±SD		*P*	Significance
	Postmenopausal	Premenopausal		
PSV	47.75±0.59	53.85±4.83	<0.0001	Significant
EDV	14.88±4.48	20.33±6.33	<0.0001	Significant
Resistance index	0.64±0.12	0.59±0.11	0.015	Significant
PI	1.26±0.31	1.08±0.36	0.008	significant
n	42	39		

SD – Standard deviations; PSV – Peak systolic velocity; EDV – End-diastolic velocity; PI – Pulsatility index

Table 6: The mean±standard deviation of the uterine artery peak systolic velocity, end-diastolic velocity, resistance index, and pulsatility index of International Federation of Gynecology and Obstetrics stage I/II and Stage III/IV cervical cancer patients

Doppler measurement	Mean±SD		*P*	Significance
	Stage I/II	Stage III/IV		
PSV	48.00±6.68	51.89±5.60	0.008	Significant
EDV	15.85±5.08	18.25±6.08	0.076	Not significant
Resistance index	0.65±0.08	0.60±0.12	0.028	Significant
PI	1.27±0.29	1.14±0.36	0.12	Not significant
n	25	56		

SD – Standard deviation; PSV – Peak systolic velocity; EDV – End-diastolic velocity; PI – Pulsatility index; FIGO – International Federation of Gynecology and Obstetrics

the FIGO staging, it was found that a significantly lower RI, and higher PSV among patients with Stage III/IV disease compared to those with Stage I/II disease, but no significant difference was observed in the EDV and PI between the two groups [Table 6].

The relationship between PSV, EDV, RI, and PI and the estimated tumor volume was tested using Pearson correlation. Positive correlation was observed between the estimated tumor volume and PSV ($r = 0.417$, $P < 0.0001$) and the estimated tumor volume and EDV ($r = 0.449$, $P < 0.0001$). A negative correlation was also observed between the estimated tumor volume and RI ($r = -0.505$, $P < .0001$) and the estimated tumor volume and PI ($r = -0.481$, $P < 0.0001$).

DISCUSSION

Out of the total 81 cervical cancer patients enrolled in the study, 90.8% were in the age group of 40–59 years, with a mean age of 51.8 ± 6.69 years. This is higher than the findings of Sule and Shehu[28] who reported the mean age of 47.61 ± 11.55 years among cervical cancer patients in Zaria but lower than the findings of Ijaiya *et al.*[29] who reported a higher mean age of 54.7 years in Ilorin.

Majority (81.5%) had advanced disease (IIB–IVB) at presentation, with Stage IIIB being the most common (40.7%) form of presentation. Sule and Shehu[28] in their study reported similar findings where 79.71% presented with advanced disease. Anorlu *et al.*[30] observed that late presentation of cervical cancer patients at Lagos University Teaching Hospital, Nigeria, was largely due to patients' delay in seeking health-care and care providers' delay in referring patients to a tertiary hospital.

Squamous cell carcinoma was the most common histological type constituting 87.7%. Similar findings were reported by Abdul *et al.*[31] in Zaria (89.2%) and Ijaiya *et al.*[29] in Ilorin (85.2%). Egbang *et al.* in Cameroon observed that squamous cell carcinoma was the most common histological type accounting for 81.5%.[32] Pérez-Gómez *et al.*[33] in a 15-year review in Spain observed that squamous carcinoma accounted for 73% of the histological types, less than what was observed in this study.

This study which to the best of our knowledge happened to be the first in this our environment (Zaria, Northern Nigeria), using Doppler parameters of PSV, EDV, RI, and PI, to evaluate the flow in the uterine artery of patients with cervical cancer. However, it was observed that patients with cervical cancer showed significantly lower mean RI and PI and significantly higher mean EDV compared to healthy controls. The mean PSV of the patients with cervical cancer was also higher than that of the controls, but the difference was not statistically significant.

The above observation signifies a reduction in the uterine artery vascular bed resistance in patients with cervical cancer. Previous studies in the past have observed that the vascularity of malignant tumors was entirely different from that of the normal tissue.[11] The tumoral blood vessels are abnormal with respect to cellular composition and basement membrane, resulting in increased vascular permeability, fragility, aneurysm formation as well as arteriovenous fistulas,[34,35] which may result in the reduction of the vascular bed resistance of the uterine artery in cervical cancer. Findings in this study are consistent with the study reported by Liyanage *et al.*[20] They reported a significantly lower RI and PI in the descending uterine artery among patients with cervical cancer compared to the control group. They also similarly observed no significant difference in the PSV between the two groups. The mean RI and mean PI among the cervical cancer patients in their study were, however, higher than the values obtained in this study. The transvaginal route of examination and the choice of the descending uterine artery adopted by the authors may have accounted for the relatively lower values observed. Choi *et al.*[19] and Di Vagno *et al.*[36] also reported similar findings using the RI and PI. Greco *et al.*,[37] however, reported findings that differed from those observed in this study. They found no significant difference in the PI, RI, and mean systolic flow velocity (MSFV) between 23 patients with cervical cancer and 20 healthy controls. The small sample size in their study may have affected the outcome of their results.

Belitsos *et al.*[38] using 3D power Doppler indices of vascular index (VI), flow index (FI), and vascular FI (VFI) observed that all the indices were significantly higher in the cervical cancer group and the precancerous group than in the control group. The power Doppler indices employed by Belitsos *et al*. being a more sensitive measure of flow and vascularization within an organ and hence its ability to measure more precisely the differences in the cervical vascularity of patients with cervical cancer and healthy controls may support the findings in our study.

In this study, when the patients were divided into two groups of Stage I/II and Stage III/IV disease based on FIGO staging, significantly lower RI and higher PSV were observed among patients with Stage III/IV disease compared to those with Stage I/II disease but no significant difference in the EDV and PI between the two groups. Testa *et al*.[39] observed that the PSV was significantly higher among patients with FIGO Stage III/IV disease compared to those with Stage I/II disease but found no difference in the RI with respect to the FIGO staging and histological type. In this study, the finding is not in total agreement with that of Testa *et al*. above. Clinical staging (FIGO staging) has been found to underestimate or overestimate the actual disease extent in significant number of cases,[40,41] and this may have accounted for the difference in this study and that of Testa *et al*. The index study found no significant difference in the flow parameters with respect to histological types, similar to the findings of Testa *et al*.[39]

In this study, a significant positive correlation between PSV, EDV, and estimated tumor volume and a significant negative correlation between RI, PI, and estimated tumor volume were found. These findings may suggest a progressive lowering of the resistance in the vascular bed distal to the point of measurement of the Doppler parameters in the uterine artery. These may be explained by the previous studies which found that growth and expansion of cervical cancer is dependent on the degree of angiogenesis[11] and that angiogenesis results in the formation of abnormal blood vessels. Testa *et al*.[39] in the Doppler evaluation of the intratumoral blood vessels in cervical cancer patients reported findings that are consistent with that of this study. They found that significantly lower RI and PSV (the only parameters measured in their study) were associated with tumor size >4 cm compared to smaller tumor. Bolla *et al*.,[40] however, in their study, reported findings which were not in total agreement with that of the index study. They found a significant positive correlation between the EDV, PSV, and the tumor size but found no relationship between RI, PI, and the tumor size. In our study, we used 3D measurement to estimate the tumor volume which may give a better estimate of the extent of the tumor size than a single measurement of maximum tumor diameter employed by Bolla *et al*. They also conducted the study on a small sample size consisting of 25 cervical cancer patients. These may have contributed to the differences in the findings in this study and that of Liyanage *et al*. Belitsos *et al*.,[38] using 3D power Doppler indices of VI, FI, and VFI, observed a significant positive correlation between the cervical volume and all the power Doppler indices in the cervical cancer patients. These findings, though used different parameters, may support the suggestion of a progressive change in the vascularity of the tumor with size.

When we divided the patients into premenopausal and postmenopausal groups, a significant difference was observed in all the Doppler parameters (PSV, EDV, RI, and PI) between the two groups. A significant difference in all the Doppler parameters evaluated was also observed between the premenopausal and postmenopausal controls. This finding is consistent with that of Luzi *et al*.[41] who also reported a significant difference in the uterine artery PI (the only index assessed) between healthy pre- and postmenopausal women. The differences may be due to the hormonal changes that accompany postmenopausal state which has the tendency to predispose them to increased arteriosclerosis and hence increased peripheral vascular resistance. The relative smaller difference in the mean RI and PI observed between the post- and premenopausal patients compared to the controls may be attributed to the decrease of the cervical vascular bed resistance produced by cervical cancer which may have reversed the increased vascular resistance associated with postmenopausal state. Cheng *et al*.[42] reported finding which was not consistent with that of this study. They found no significant difference in the intratumoral RI (the only index measured) between premenopausal and postmenopausal cervical cancer patients. However, in a study by Belitsos *et al*.[38] using 3D power Doppler indices of VI, FI, and VFI which are indices that measure vascularization and flow within an organ, they observed a significant difference in all the indices between premenopausal and postmenopausal cervical cancer patients.

Limitation

Bowel gas shadows in patients who find it difficult to maintain a full bladder were one of the limitations; this was overcome in most patients by graded compression which successfully displaced the bowel gas in most instances.

CONCLUSION

This study had demonstrated that a significant difference exists in the uterine artery Doppler parameters between patients with cervical cancer and healthy women. The different parameters were also influenced by the menopausal state of the women and the size of the cervical mass. This can buttress the role of Doppler in staging, prognosticating and posttreatment evaluation of women with cervical cancer.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. World Health Organization. Comprehensive Cervical Cancer Control. Available from: http://www.who.int/reproductivehealth/publications/cancers/cervicalcancer-guide/en/. [Last assessed on 2015 Oct 25].
2. Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM. Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. Int J Cancer 2010;127:2893-917.
3. Walboomers JM, Jacobs MV, Manos MM, Bosch FX, Kummer JA, Shah KV, *et al.* Human papillomavirus is a necessary cause of invasive cervical cancer worldwide. J Pathol 1999;189:12-9.
4. World Health Organization ICO. Information Centre of Human Papilloma Virus and Cervical Cancer: Human papilloma virus and related cancers in the world. Summary Report. World Health Organization ICO; 2010. Available from: http://www.who.int/hpvcentre/en. [Last accessed on 2015 Jun 20].
5. Willoughby BJ, Faulkner K, Stamp EC, Whitaker CJ. A descriptive study of the decline in cervical screening coverage rates in the North East and Yorkshire and the Humber regions of the UK from 1995 to 2005. J Public Health (Oxf) 2006;28:355-60.
6. Kyari O, Nggada H, Mairiga A. Malignant tumours of female genital tract in North Eastern Nigeria. East Afr Med J 2004;81:142-5.
7. Uzoigwe SA, Seleye-Fubara D. Cancer of the uterine cervix in Port Harcourt, rivers state: A clinic-pathological review. Niger J Med 2004;13:110-3.
8. Yakasai IA, Ugwa EA, Otubu J. Gynaecological malignancies in Aminu Kano teaching hospital Kano: A 3 year review. Niger J Clin Pract 2013;16:63-6.
9. Adewole IF, Edozien LC, Babarinsa IA, Akang EE. Invasive and *in situ* carcinoma of the cervix in young Nigerians: A clinico-pathologic study of 27 cases. Afr J Med Med Sci 1997;26:191-3.
10. Folkman J, Watson K, Ingler D, Hanahan D. Introduction of angiogenesis during the transition from hyperplasia to neoplasia. Nature 1989;339:58-61.
11. Kidron D, Bernheim J, Aviram R, Cohen I, Fishman A, Beyth Y, *et al.* Resistance to blood flow in ovarian tumors: Correlation between resistance index and histological pattern of vascularization. Ultrasound Obstet Gynecol 1999;13:425-30.
12. Kaku T, Hirakawa T, Kamura T, Amada S, Kinukawa N, Kobayashi H, *et al.* Angiogenesis in adenocarcinoma of the uterine cervix. Cancer 1998;83:1384-90.
13. Abulafia O, Sherer DM. Angiogenesis in the uterine cervix. Int J Gynecol Cancer 2000;10:349-57.
14. Obermair A, Wanner C, Bilgi S, Speiser P, Kaider A, Reinthaller A. Tumour angiogenesis in stage 1B cervical cancer: Correllation of microvessel density with survival. AM J Obstet Gynaecol 1998;178:314-9.
15. Dinh TV, Hannigan EV, Smith ER, Hove MJ, Chopra V, To T. Tumour angiogenesis as predictor of recurrence in stage 1b squamous cell carcinoma of the cervix. Gynecol Oncol 1996;87:751-4.
16. Taylor KJ, Ramos I, Carter D, Morse SS, Snower D, Fortune K. Correlation of Doppler US tumor signals with neovascular morphologic features. Radiology 1988;166:57-62.
17. Maulik D, Ivica Z. Doppler in Obstetrics and Gynaecology. 2nd ed. New York-USA: Springer-Verlage; 2005. p. 227-42.
18. Follen M, Levenback CF, Lyer RB, Grisgsby PW, Boss EA, Delpassand ES, *et al.* Imaging in cervical cancer. Cancer 2003;98:2028-38.
19. Choi HJ, Ju W, Myung SK, Kim Y. Diagnostic performance of computer tomography, magnetic resonance imaging, and positron emission tomography or positron emission tomography/computer tomography for detection of metastatic lymph nodes in patients with cervical cancer: Meta-analysis. Cancer Sci 2010;101:1471-9.
20. Liyanage SH, Roberts CA, Rockall AG. MRI and PET scans for primary staging and detection of cervical cancer recurrence. Womens Health (Lond) 2010;6:251-67.
21. McDicken WN, Hoskins PR. Physics: Principle, practice and artifacts. In: Pozniak AM, Allan PL, editors. Clinical Doppler Ultrasound. 3rd ed. London, UK: Churchill Livinstone; 2014. p. 1-25.
22. Ochi H, Suginami H, Matsubara K, Taniguchi H, Yano J, Matsuura S. Micro-bead embolization of uterine spiral arteries and changes in uterine arterial flow velocity waveforms in the pregnant ewe. Ultrasound Obstet Gynecol 1995;6:272-6.
23. Maulik D, Mundy D, Heitmann E, Maulik D. Evidence-based approach to umbilical artery Doppler fetal surveillance in high-risk pregnancies: An update. Clin Obstet Gynecol 2010;53:869-78.
24. National Population Commission. National Demographic Survey. National Population Commission; 2006. Available from: http://www.population.gov.ng. [Last assessed on 2015 Jun 04].
25. Araoye MO. Research Methodology with Statistics for Health and Social Scieces. Ilorin-Nigeria: Nathadex Publishers; 2003. p. 115-22.
26. Durowade KA, Osagbemi GK, Salaudeen AG, Musa OI, Akande TM, Babatunde OA, *et al.* Prevalence and risk factors of cervical cancer among women in an urban community of Kwara State, North central Nigeria. J Prev Med Hyg 2012;53:213-9.
27. Bhide A, Acharya G, Bilardo CM, Brezinka C, Cafici D, Hernandez-Andrade E, *et al.* ISUOG practice guidelines: Use of Doppler ultrasonography in obstetrics. Ultrasound Obstet Gynecol 2013;41:233-39.
28. Sule ST, Shehu MS. Cervical cancer management in Zaria, Nigeria. Afr J Health Sci 2007;14:149-53.
29. Ijaiya MA, Aboyeji PA, Buhari MO. Cancer of the cervix in Ilorin, Nigeria. West Afr J Med 2004;23:319-22.
30. Anorlu RI, Orakwue CO, Oyeneyin L, Abudu OO. Late presentation of patients with cervical cancer to a tertiary hospital in Lagos: What is responsible? Eur J Gynaecol Oncol 2004;25:729-32.
31. Abdul MA, Shittu SO, Mohammed A, Mayun A. Non-squamous cell carcinoma of the cervix in Zaria, Northern Nigeria: A clinicopathological analysis. Ann Afr Med 2006;5:118-21.
32. Egbang NJ, Tchente NC, Owona ML, Simo G, Essam SJ, Elono FA, *et al.* Epidemiological and histological profile of cervical cancer in Cameroon: About 2078 cases. Open J Obstet Gynecol 2016;6:232-9.
33. Pérez-Gómez B, Martínez C, Navarro C, Franch P, Galceran J, Marcos-Gragera R, *et al.* The moderate decrease in invasive cervical cancer incidence rates in Spain (1980-2004): Limited success of opportunistic screening? Ann Oncol 2010;21 Suppl 3:iii61-8.
34. Blood CH, Zetter BR. Tumor interactions with the vasculature: Angiogenesis and tumor metastasis. Biochim Biophys Acta

1990;1032:89-118.
35. McDonald DM, Choyke PL. Imaging of angiogenesis: From microscope to clinic. Nat Med 2003;9:713-25.
36. Di Vagno G, Cormio G, Vimercati A, Nacci G, Greco P, Lepera A, *et al*. Transvaginal color-Doppler sonography for monitoring the response to neoadjuvant chemotherapy in patients with locally advanced cervical cancer. Minerva Ginecol 1996;48:463-7.
37. Greco P, Cormio G, Vimercati A, Loverro G, Selvaggi L. Transvaginal colour Doppler sonography In predicting the response to chemotherapy in advanced cervical carcinoma. Ultrasound Obstet Gynecol 1997;9:49-52.
38. Belitsos P, Papoutsis D, Rodolakis A, Mesogitis S, Antsaklis A. Three-dimensional power Doppler ultrasound for the study of cervical cancer and precancerous lesions. Ultrasound Obstet Gynecol 2012;40:576-81.
39. Testa AC, Ferrandina G, Distefano M, Fruscella E, Mansueto D, Basso D, *et al*. Color Doppler velocimetry and three-dimensional color power angiography of cervical carcinoma. Ultrasound Obstet Gynecol 2004;24:445-52.
40. Bolla D, In-Albon S, Papadia A, Di Naro E, Gasparri ML, Mueller MM, *et al*. Doppler ultrasound flow evaluation of the uterine arteries significantly correlates with tumor size in cervical cancer patients. Ann Surg Oncol 2015;22 Suppl 3:S959-63.
41. Luzi G, Coata G, Cucchia GC, Cosmi EV, Di Renzo GC. Doppler studies of uterine arteries in spontaneous and artificially induced menopausal women. Ultrasound Obstet Gynecol 1993;3:354-6.
42. Cheng WF, Lee CN, Chu JS, Chen CA, Chen TM, Shau WY, *et al*. Vascularity index as a novel parameter for the *in vivo* assessment of angiogenesis in patients with cervical carcinoma. Cancer 1999;85:651-7.