Thai Journal of Obstetrics and Gynaecology
January 2015, Vol. 23, pp. 52-58

## GYNAECOLOGY

# The Predictive Value of Transvaginal Color and Pulsed Doppler in Evaluation of Adnexal Masses

Ahmed Mohamed Abbas, MBBCh, MSc, MD.

*Woman's Health Center, Assiut University, Assiut, Egypt*

**ABSTRACT**

**Objective:** To evaluate the role of transvaginal color Doppler assessment of amount of blood flow and the areas of vessels distribution within the adnexal masses, besides the accuracy of pulsed Doppler vascular indices in differentiation between benign and malignant adnexal masses.

**Materials and Methods:** Two Hundred and thirty one women with adnexal masses underwent Doppler sonography at Woman's Health Center, Assiut University, Egypt between August 2013 and July 2014. Resistance index, pulsatility index, color score and area of vessels distribution were detected and assessed for their significance. A definitive histopathological diagnosis was obtained in every case and used as a gold standard.

**Results:** Out of 189 benign masses, color Doppler study could diagnose 184 cases as benign, while out of 42 malignant masses, 36 masses were diagnosed as malignant. Our study showed a sensitivity of 85.7% and specificity 97.4%. In addition, peripheral localization of vessels was observed in benign masses (71.4%), while septal or central vessel localization (42.9% and 38.1%) was observed in malignant masses. Our cut-off PI value of ≤ 1.0, gave a sensitivity and specificity of 88.1% and 95.8%, respectively. Considering RI value ≤ 0.42 as the cut-off point, the sensitivity and specificity were 52.4% and 97.9% respectively. P-value was < 0.001 for both RI and PI between both groups, being of significant value in prediction of malignancy.

**Conclusions:** Application of Doppler sonography is important in differential diagnosis of adnexal masses. Evaluation of blood vessels location using color Doppler is the most sensitive parameter in diagnosis of malignancy. In addition, using RI cut-off value ≤ 0.50 and PI cut-off value ≤ 1.0 has a higher sensitivity in detection of adnexal malignancy.

**Keywords:** Adnexal mass – color Doppler – ovarian cancer- pulsed wave Doppler.

## Introduction

An adnexal mass is defined as an enlarged structure in the region of uterine adnexa weather it was palpated on bimanual pelvic examination or visualized by imaging modalities[1].

The differential diagnosis of adnexal masses still represents a challenge despite of the marvelous efforts that have been made to improve the sonographically based diagnosis. Good preoperative differentiation between benign and malignant adnexal masses may results in more patients being accurately referred for gynecologic oncology care[2].

Ultrasound and Doppler wave's analysis are the main diagnostic modalities for diagnosis of adnexal

masses. Recent studies have shown that transvaginal ultrasound plus color Doppler can differentiate benign from malignant adnexal masses with a sensitivity of 99.1% and a specificity of 85.9%[3].

Malignant masses can be detected by their abnormal vascularity, as shown with color Doppler. This can be assessed by the pattern of arrangement and vessel density of the vascular network within the mass. In addition, neovascularization of malignant masses usually shows a penetrating pattern, with extension of vessels into the center of the mass[4].

Therefore, the purpose of the current study was to show the value of assessment of amount of blood flow and the areas of vessels distribution within the masses in differentiating them. In addition to determine the accuracy of vascular indices; pulsatility index (PI) and resistance index (RI) in discrimination of benign and malignant adnexal masses.

## Materials and Methods

Between August 2013 and July 2014, 231 patients were admitted to Woman's Health Center, Assiut University, Egypt, with preliminary diagnosis of an adnexal mass detected either clinically or diagnosed by ultrasonography elsewhere, and scheduled for elective surgery.

Patients required urgent surgical intervention and patients with known diagnosis of nature of mass by previous biopsy or ovarian malignancy scheduled for second look operation were excluded from the study. All of those patients were counseled and invited to join the study after obtaining written informed consent approved by the Ethical Review Board of the faculty of medicine, Assiut University.

All patients underwent Doppler examination by the same sonographer (level II experience), who had no clinical information about the patients, using a SonoAce X8 machine (Medison, Korea) with transvaginal volumetric probe with 4-8 MHz frequency (using an average 6.5 MHz). After activation of color Doppler gate to assess tumor vascularization. A subjective semi quantitative assessment of the amount of blood flow within the examined mass (color score) was made according to the IOTA protocol[5].

The amount of blood flow within the mass was scored as follows: a score of 1 was given when there is no blood flow detected; a score of 2 was given when only minimal flow could be detected; a score of 3 was given when moderate flow was present, and a score of 4 was given when the pelvic mass appeared highly vascularized with marked blood flow. A color score ≥3 was considered suggestive of malignancy.

The area distribution of visualized vessels in the adnexal masses was also recorded and classified as in center of the mass, in the septum, in the papillae, at tumor wall or peri-tumor areas. Malignancy was suspected also in the presence of penetrating vessels within papillary projections, solid areas, or central areas of a solid tumor.

Spectral pulsed wave Doppler analysis was done after that, RI and PI were calculated for each mass, Doppler waves application were applied on the most evident and apparent vessels in the mass. When no blood flow was detectable within the tumor, a signal was recorded from peripheral areas or the adnexal branch of the uterine artery.

The formulas used for PI and RI were PI = (S-D)/mean and RI = (S-D)/S respectively, when S is the peak Doppler frequency shift and D is the minimum. The Doppler variables used for predicting malignancy in adnexal masses was RI ≤ 0.42 or PI ≤ 1.0. The final diagnosis used as gold standard was based on histopathological findings.

The sensitivity and specificity of cut-off levels of PI and RI were calculated. All data were analyzed using SPSS software Chicago, IL, USA, version 21. Qualitative data were expressed as frequency and percentage. Fisher's exact test was used to examine the relation between qualitative variables. Quantitative data were presented in terms of, mean and standard deviation. For quantitative data, comparison between two groups was done using Student's T-test. Level of significance "P" value was evaluated, where $p < 0.05$ is considered of significant value.

## Results

In the designated study period, 231 patients

initially diagnosed as having adnexal masses were included in the study. The mean age of the patients was 30.2 ± 12.7 years (range 12-70 years). One-hundred ninety eight patients (85.7%) were in the reproductive age, 26 were postmenopausal (11.3%), and 7 of them (3%) were in the premenarche period. Ninety-five patients (41.1%) were nulliparous.

Histopathological examinations revealed 189 (81.8%) benign masses and 42 (18.2%) malignant masses. Table 1. summarizes the type of adnexal masses in the study.

**Table 1.** Distribution of the final histopathological diagnosis of the adnexal masses.

| Diagnosis | n | % |
|---|---|---|
| **Benign masses** | | |
| Endometriotic cyst | 52 | 22.5 |
| Simple serous cyst | 37 | 16.0 |
| Dermoid cyst | 32 | 13.9 |
| Hemorrhagic corpus luteum cyst | 22 | 9.5 |
| Mucinous cystadenoma | 14 | 6.1 |
| Tuboovarian abscess | 10 | 4.3 |
| Fibroma/thecoma | 9 | 3.9 |
| Serous cystadenoma | 7 | 3.0 |
| Others | 6 | 2.6 |
| **Malignant masses** | | |
| Mucinous cystadenocarcinoma | 13 | 5.6 |
| Serous cystadenocarcinoma | 9 | 3.9 |
| Granulosa cell tumor | 6 | 2.6 |
| Metastatic adenocarcinoma | 4 | 1.7 |
| Immature teratoma | 3 | 1.3 |
| Struma ovarii | 2 | 0.9 |
| Endodermal sinus tumor | 2 | 0.9 |
| Dysgerminoma | 2 | 0.9 |
| Endometrioid adenocarcinoma | 1 | 0.4 |
| **Total** | **231** | **100** |

Of the 231 cases, the mean PI values of tumor arteries were 1.66 ± 0.56 and 0.82 ± 0.28 for benign and malignant masses respectively. The mean PI in the benign and malignant group was significantly different (Student's T-test, $p < 0.001$) being much lower in malignant masses.

The mean RI values were 0.79 ± 0.18 and 0.50 ± 0.20 for benign and malignant masses respectively. In addition, the mean RI in the benign and malignant group was significantly different (Student's T-test, $p < 0.001$) being much lower in malignant masses.

Blood flow velocity waveforms within the tumors were detected in all cases of the malignant group and in 148 out of 189 cases of the benign one. In the remaining 41 patients, blood flow was detected only in either the ovarian artery or adnexal branch of the uterine artery.

Subjective assessment of the amount of blood flow within the examined masses revealed that 85.7%

of malignant masses attained a color score ≥ 3, while 97.4% of benign masses scored ≤ 2. The results of pulsed and color Doppler evaluation of the masses are summarized in Table 2.

**Table 2.** Doppler findings of the benign and malignant adnexal masses

| | Benign masses (n=189) | Malignant masses (n=42) | P |
|---|---|---|---|
| PI (Mean ± SD) | 1.66 ± 0.56 | 0.82 ± 0.28 | < 0.001* |
| - Range | (0.46 – 2.93) | (0.41 – 1.64) | |
| - > 1.5 | 145 (76.7%) | 1 (2.4%) | |
| - 1 - 1.5 | 36 (19.1%) | 4 (9.5%) | |
| - < 1 | 8 (4.2%) | 37 (88.1%) | |
| RI (Mean ± SD) | 0.79 ± 0.18 | 0.50 ± 0.20 | < 0.001* |
| - Range | (0.36 – 1.00) | (0.29 – 1.00) | |
| - > 0.42 | 185 (97.9%) | 20 (47.6%) | |
| - < 0.42 | 4 (2.1%) | 22 (52.4%) | |
| Color score | | | < 0.001† |
| - Score 1 | 41 (21.7%) | 0 | |
| - Score 2 | 143 (75.7%) | 6 (14.3%) | |
| - Score 3 | 5 (2.6%) | 28 (66.7%) | |
| - Score 4 | 0 | 8 (19%) | |
| Vessel Localization | | | < 0.001† |
| - Central | 10 (5.3%) | 16 (38.1%) | |
| - In the wall | 135 (71.4%) | 3 (7.1%) | |
| - In Septae | 3 (1.6%) | 18 (42.9%) | |
| - In Papillae | 0 | 5 (11.9%) | |
| - Peritumor | 41 (21.7%) | 0 | |

RI, Resistance index; PI, Pulsatility index; * Student t-test was used to compare the mean difference between groups; † Fisher's exact test was used to compare the difference in proportions.

The sensitivity, specificity, postive and negative predictive values of each parameter in color and pulsed-wave Doppler for detection of malignancy in the evaluated adnexal masses are shown in Table 3.

**Table 3.** The diagnostic performance of different Doppler parameters in the evaluation of adnexal masses.

| Parameter | Sensitivity | Specificity | PPV | NPV |
|---|---|---|---|---|
| Vessel location by CD | 92.9% | 93.1% | 75.0% | 98.3% |
| Color score by CD | 85.7% | 97.4% | 87.7% | 96.8% |
| PI ≤ 1.0 | 88.1% | 95.8% | 82.2% | 97.3% |
| PI ≤ 1.5 | 97.6% | 76.6% | 48.2% | 99.3% |
| RI ≤ 0.50 | 81.0% | 95.2% | 79.1% | 95.7% |
| RI ≤ 0.42 | 52.4% | 97.9% | 84.6% | 90.2% |

CD: color Doppler; RI, Resistance index; PI, Pulsatility index;

## Discussion

Even though histopathological examination of the adnexal lesion is the gold standard for the final diagnosis or exclusion of malignancy, clinical evaluation, 2DUS, 3DUS, Doppler studies in addition to tumor markers are reasonably accurate, helpful and non-invasive tools for assessment of adnexal masses particularly distinguishing benign from malignant ovarian tumors.

Folkman et al first described the importance of angiogenesis for tumor growth[6]. In our study, we support the hypothesis that sonographic evaluation of tumor angiogenesis might help to improve differentiation between benign and malignant adnexal masses, as stated by Carmeliet and Jain[7].

In spite of presence of different opinions about cut-off values of Doppler vascular indices for the differentiation between benign and malignant adnexal masses, all authors have the same opinion that recognition of angiogenesis as a reference point denoting malignant changes within the ovary is a highly sensitive parameter[8].

Differences in sonographers' experience, different sensitivity in ultrasound machines and the lack of standardization of Doppler measurements can be reasonable factors for the conflicting information in the literature about the definite cut-off values of Doppler indices[9].

In the present study, RI and PI values were calculated for each mass. Our cut-off PI value of ≤1.0, gave a sensitivity and specificity of 88.1% and 95.8%, respectively. Considering RI value ≤ 0.42 as the cut-off point, the sensitivity and specificity were 52.4 % and 97.9% respectively. P-value was < 0.001 for both RI and PI between both groups, being of significant value in predicting malignancy of adnexal masses.

In the previous studies, some authors suggested the existence of clear cut-off values for RI and PI of benign and malignant tumors; Kurjak et aland Takac suggested 0.4 for the RI value[10-11], others like Alcazar and Jurado preferred 0.45[12], while Chou et al preferred 0.50[13].

In our study, if 0.42 had been chosen as a cut-off value for RI, only 52.4% of malignant masses would have been accurately diagnosed, but if we used 0.50 (the mean value for malignant group) as a cut-off value; 81% of malignant masses could be detected. Medeiros et al results that showed that Doppler can better detect malignant masses when the RI was < 0.50[14]. Our results coincided with their conclusions that the best results obtained when we used a cut-off value ≤ 0.50. Sengoku et al., reported sensitivity and specificity of 81.3% and 91.7% respectively when the cut-off value of PI < 1.5 was used[15]. Ueland et al reported sensitivity and specificity of 52.8% and 77.6% respectively using cut-off value of PI < 1[16]. Tongsong et al had chosen a cut-off PI value of 1.24, giving a sensitivity and specificity of 95.1% and 88.3% respectively[8]. In our study, using cut-off value ≤ 1.5 for PI was associated with high sensitivity in detecting malignancy (97.6%) but specificity was low (76.6%) and this contradict the results published by Sengoku et al[15].

In general, both indices tended to be lower in malignant masses than in benign masses which are in agreement with histological features of malignant tumor blood vessel anastomoses, shunts, and sinuosity[17].

Out of 189 benign masses, color Doppler study using color score could diagnose 184 cases as benign but labeled five cases as malignant that were actually benign, while out of 42 malignant masses, 36 masses were diagnosed as malignant. Our study showed a sensitivity of 85.7% and specificity 97.4%. These results were better than those published by Timmerman et al of the IOTA study that show a sensitivity and specificity of 80% and 66.6% respectively[18].

Our results showed predominantly peripheral localization of vessels in benign masses (71.4%) and predominantly septal or central vessel localization (42.9% and 38.1%) was observed in malignant masses. There were 41 benign masses showed absence of blood flow (21.7%), on the other hand all malignant masses showed vascularity. Therefore, we can conclude that any mass without detectable blood flow is very unlikely to be malignant.

This keeps with the results of Gramellini et al who found that 54% of benign masses showed

peripheral vessels while 66.6% of malignant masses showed central vessels. Absence of blood flow was present in 34% of benign masses versus 6.6% of malignant masses[19]. Also, in Jokubkiene et al series, 57% of benign masses showed peripheral vascularization versus 70% of malignant masses showed central vascularization[20].

In conclusion, Application of Doppler waves, either pulsed wave or color Doppler examination is considered of significant value in differential diagnosis of adnexal masses. According to our results, pulsatility and resistance indices of transvaginal pulsed Doppler sonography has high sensitivity and specificity in differentiating benign from malignant adnexal masses when cut-off values 0.50 for resistance index and 1.0 for pulsatility index used. Evaluation of blood vessels location using color Doppler is the most sensitive parameter in detection of adnexal malignancy followed by evaluation of color score of the mass.

## Conflict of Interest

The author declare that he has no conflict of interest.


## Acknowledgement

I would like to thank all members of "Ultrasound Unit" in Woman's Health Center.


### References


1. Griffin N, Grant LA, Sala E. Adnexal masses: charcaterization and imaging strategies. Semin Ultrasound CT MRI 2010;31:330-46.
2. Yazbek J, Raju SK, Ben-Nagi J, Holland TK, Hillaby K, Jurkovic D. Effect of quality of gynaecological ultrasonography on management of patients with suspected ovarian cancer: a randomised controlled trial. Lancet Oncol 2008;9:124–31.
3. Amor F, Alcazar JL, Vaccaro H, Leon M, Iturra A. GI-RADS reporting system for ultrasound evaluation of adnexal masses in clinical practice: a prospective multicenter study. Ultrasound Obstet Gynecol 2011;38:450-55.
4. Timmerman D, Verguts J, Konstantinovic ML. The pedicle artery sign based on sonography with color Doppler imagining can replace second-stage tests in women with abnormal vaginal bleeding. Ultrasound Obstet Gynecol 2003;22:166-71.
5. Timmerman D, Valentin L, Bourne TH, Collins WP, Verrelst H, Vergote I. International Ovarian Tumor Analysis (IOTA) Group. Terms, definitions and measurements to describe the sonographic features of adnexal tumors: a consensus opinion from the International Ovarian Tumor Analysis (IOTA) Group. Ultrasound Obstet Gynecol 2000;16:500–5.
6. Folkman J, Merler E, Abernathy C, Williams G. Isolation of a tumor factor responsible for angiogenesis. J Exp Med 1971;133:275-88.
7. Carmeliet P, Jain RK. Angiogenesis in cancer and other diseases. Nature 2000;407:249-57.
8. Tongsong T, Wanapirak C, Neeyalavira V, Khunamornpong S, Sukpan K. E-flow Doppler indices for prediction of benign and malignant ovarian tumors. Asian Pac J Cancer Prev 2009;10:139-42.
9. Kurjak A, Kupesic S. Three dimensional ultrasound and power Doppler in assessment of uterine and ovarian angiogenesis: a prospective study. Croat Med J 1999; 40:413-20.
10. Kurjak A, Zalud I, Alfirevic Z. Evaluation of adnexal masses with transvaginal color Doppler. J Ultrasound Med 1991;10:295–7.
11. Takac I. Receiver operating characteristic curves of transvaginal Doppler blood flow measurements in benign and malignant adnexal tumors. J Ultrasound Med 1998; 17:637–42.
12. Alcázar JL, Jurado M. Using a logistic model to predict malignancy of adnexal masses based on menopausal status, ultrasound morphology and color Doppler findings. Gynecol Oncol 1998;69:146–50.
13. Chou CY, Chang CH, Yao BL, Kuo HC. Doppler ultrasonography and serum CA125 in the differentiation of benign from malignant ovarian tumors. J Clin Ultrasound 1994;22:491–96.
14. Medeiros LR, Rosa DD, da Rosa MI, Bozzetti MC. Accuracy of ultrasonography with color Doppler in ovarian tumor: a systematic quantitative review. Int J Gynecol Cancer 2009;19:1214-20.
15. Sengoku K, Satoh T, Saitoh S, Abe M, Ishikawa M. Evaluation of transvaginal color Doppler sonography, transvaginal sonography and CA 125 for prediction of ovarian malignancy. Int J Gynecol Obstet 1994;46:39–44.
16. Ueland FR, DePriest PD, Pavlik EJ. Preoperative differentiation of malignant from benign ovarian tumors: the efficacy of morphology indexing and Doppler flow sonography. Gynecol Oncol 2003;91:46–50.
17. 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.
18. Timmerman D, Testa AC, Bourne T, Ferrazzi E, Ameye L, Konstantinovic ML, et al. International Ovarian Tumor Analysis Group. Logistic regression model to distinguish between the benign and malignant adnexal mass before surgery: a multicenter study by the International Ovarian Tumor Analysis Group. J Clin Oncol 2005;34:8794–801.

19. Gramellini D, Fieni S, Sanapo L, Casilla G, Verrotti C, Nardelli GB. Diagnostic accuracy of IOTA ultrasound morphology in the hands of less experienced sonographers. Aust NZ J Obstet Gynaecol 2008; 48:195-201.

20. Jokubkiene L, Sladkevicius P, Valentin L. Does three dimensional power Doppler ultrasound help in discrimination between benign and malignant ovarian masses? Ultrasound Obstet Gynecol 2007;29:215-25.