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ORIGINAL ARTICLE

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# Sensitivity and specificity of color flow mapping and pulsed doppler waveform studies in differentiating between benign and malignant ovarian cysts

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**OBJECTIVE(S) :** To assess the usefulness of ultrasound color flow mapping and pulsed doppler waveform in differentiating benign and malignant ovarian tumors.

**METHOD(S):** Clinically diagnosed ovarian cysts in 50 women were evaluated by sonography (only transvaginal in cysts <10 cm and both abdominal and transvaginal in cysts > 10 cm), color flow mapping and pulsed dopper wave form studies. On the basis of these findings they were classified into simple cysts, complex cysts, complex cysts with solid areas and solid cysts. These were correlated with subsequent laparotomy and histopathological findings.

**RESULTS:** For identifying malignancy color flow mapping showed 100% specificity, and 87.5% negative predictive value in simple cysts while 100% sensitivity and 100% positive predictive valve in solid cysts. Whereas its sesitivity, specificity, positive predictive value and negative predictive value were 33%, 78.5%, 25% and 84.6% respectively in complex cysts and 100%, 81.8%, 60% and 100% respectively in complex cysts with solid areas. For detecting malignancy pulsed doppler waveform had a sensitivity, specificity, positive predictive value and negative predictive value of 100%, 92.8%, 66.6%, and 100% respectively in simple cysts, 100%, 92.5%, 75% and 100% respectively in complex cysts and 66.6%, 90.9%, 66.6% and 90.9% respectively in complex cysts with solid areas; whereas its sensitivity and positive predictive value were 100% in solid cysts.

**CONCLUSION(S):** Both color flow mapping and pulsed doppler waveform studies are helpful in predicting malignancy in ovarian cysts.

**Key words :** ovarian masses, color flow mapping, neovascularization, pulsed doppler waveform, resistance index

## Introduction

Evaluation of adnexal masses is of particular importance in gynecological practice firstly to differentiate benign and malignant masses and secondly for the choice of appropriate surgical treatment, as in many centers the type of surgery performed (laparoscopy versus laparotomy) depends on the probability of malignancy. Majority of adnexal masses are nonneoplastic cysts but 25% are malignant [1].

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The optimal ultrasound technique and diagnostic criteria for characterizing a suspected ovarian neoplasm are controversial. Papillary formations on the inside of the cystwall and hyperechoic solid component are the most statistically significant predictors of a malignant ovarian mass. Ultrasound and morphologic parameters have a sensitivity of 80% and specificity of 93% that make this examination a standard for ovarian mass diagnosis [2].

Doppler flow measurement and assessment of tumor vascularity by doppler energy increased the confidence with which a correct diagnosis can be made. Color and pulsed doppler sonography depicts the vascularity of the pelvic organs and can be used for assessment of angiogenesis in tumor masses producing insights in tumor histology. So a prospective study was undertaken to assess the usefulness

of ultrasound scanning, color flow mapping and pulsed doppler waveform in differentiating between benign and malignant ovarian tumors.

## Methods

Fifty women with clinically detected ovarian cysts underwent ultrasound scanning, color flow mapping and pulsed doppler waveform analysis. For ovarian masses less than 10 cm transvaginal scanning was performed and for those larger than 10 cm both transabdominal and transvaginal scanning were done. The size and structural features of the ovarian cysts were noted and classified into four categories based on these ultrasound features.

1. Simple cysts - Unilocular without septa and solid areas
2. Complex cysts - Multiloculated without solid areas
3. Complex cysts with solid areas - Solid areas occupying less than 50% of the cyst
4. Solid cysts - Solid areas occupying more than 50% of the cyst

All cases also had color flow mapping and pulsed doppler ultrasound waveform study. Subsequently all the 50 women underwent laparotomy and histopathological examination of the ovarian cysts.

## Results

Eleven malignant and 39 benign cysts were identified on histopathological examination of the ovarian masses removed at laparotomy.

Twelve of the tumors showed neovascularization (positive colour flow mapping) whereas 38 had negative color flows (Table 1). The overall sensitivity and specificity of color flow mapping in identifying malignant ovarian tumors was 63.6% and 87% respectively (Table 2). In 13 cases the pulsed doppler resistance index (RI) was found to be less than 0.4 (positive RI) whereas 37 cases had higher values (negative RI) (Table 3). The overall sensitivity and specificity of pulsed doppler wave form studies with an RI <0.4 in identifying malignant ovarian tumors was 90.9% and 92.3% respectively (Table 4).

**Table1. Correlation of histopathology results with color flow mapping.**

| Color flow mapping | Number (n=50) | Histopathology | |
|---|---|---|---|
| | | Malignant (n=11) | Benign (n=39) |
| Neovascularisation present | 12 | 7 | 5 |
| Neovascularisation absent | 38 | 4 | 34 |

Sixteen of the ovarian tumors were simple cysts and all were found to be negative for color flow mapping (Table 5), but later two malignances were detected in them giving a false negative rate of 12.5% (2/16) and sensitivity of

**Table 2.Diagnostic indices of color flow mapping alone in identification of malignancy in ovarian cysts.**

| Type of cyst | Sensitivity | Specificity | False positive | False negative | Positive predictive value | Negative predictive value |
|---|---|---|---|---|---|---|
| Simple | 0% | 100% | NV in none | 12.5% | NV in none | 87.5% |
| Complex | 33% | 78.5% | 75% | 15.3% | 25% | 84.6% |
| Complex with solid areas | 100% | 81.8% | 40% | 0% | 60% | 100% |
| Solid | 100% | NV in all | 0% | NV in all | 100% | NV in all |
| Overall | 63.6% | 87% | 41.6% | 10.5% | 58.3% | 89.4% |

NV - Neovascularisation.

**Table 3. Correlation of histopathology results with pulsed doppler waveform**

| Pulsed dopper waveform (Resistivity Index) | Number of cases (n=50) | Histopathology | |
|---|---|---|---|
| | | Malignant (n=11) | Benign (n=39) |
| <0.4 | 13 | 10 | 3 |
| >0.4 | 37 | 1 | 36 |

**Table 4. Diagnostic indices of pulsed doppler waveform (RI<0.4) in detection of malignancy in ovarian cysts.**

| Type of ovarian cyst | Sensitivity | Specificity | False positive | False negative | Positive predictive value | Negative predictive value |
|---|---|---|---|---|---|---|
| Simple | 100% | 92.8% | 33.3% | 0% | 66.6% | 100% |
| Complex | 100% | 92.8% | 25% | 0% | 75% | 100% |
| Complex with solid areas | 66.6% | 90.9% | 33.3% | 9% | 66.6% | 90.9% |
| Solid | 100% | - | - | 0% | 100% | - |
| Overall | 90.9% | 92.3% | 27.2% | 2% | 76.9% | 97.2% |

**Table 5. Correlation of color flow mapping and histopathological examination in different categories of ovarian cysts.**

| Type of ovarian cyst | Number of cases | Color flow mapping | Histopathology | | | |
|---|---|---|---|---|---|---|
| | | | Benign (n=11) | Malignant (n=39) | Type of malignancy | |
| Simple | 16 | All Negative | 14 | 2 | Granulosa cell carcinoma | 1 |
| | | | | | Cystadenoma of borderline malignancy | 1 |
| Complex | 17 | 4 positive | 3 | 1 | Cystadenocarcinoma | 1 |
| | | | | | Poorly differentiated adenocarcinoma | 1 |
| | | | | | Ademocarcinoma | 1 |
| | | 13 Negative | 11 | 2 | Ademocarcinoma | 3 |
| Complex with olid areas | 14 | 5 Positive | 2 | 3 | | |
| | | 9 Negative | 9 | - | | |
| Solid | 3 | 3 Positive | - | 3 | Adenocarcinoma | 3 |

Positive implies presence of neovascularization on color flow mapping

**Table 6. Details of correlation of doppler waveform (RI<0.4) and histopathological examination in different categories of ovarian cysts.**

| Type of cyst | No. of cases | RI | Histopathology | |
|---|---|---|---|---|
| | | | Malignant | Benign |
| Simple | 16 | 3 Positive | 2 | 1 |
| | | 13 Negative | - | 13 |
| Complex | 17 | 4 Positive | 3 | 1 |
| | | 13 Negative | - | 13 |
| Complex with solid areas | 14 | 3 Positive | 2 | 1 |
| | | 11 Negative | 1 | 10 |
| Solid | 3 | 3 Positive | 3 | - |

Positive RI <0.4 Negative RI >0.4

**Table 7. Comparison of the present study with other studies showing the diagnostic indices of color flow mapping in detecting malignancy in ovarian masses.**

| Study | No. of cases with ovarian masses | Color flow mapping | Histopathology | | Sensitivity | Specificity | Positive predictive value | Negative predictive value |
|---|---|---|---|---|---|---|---|---|
| | | | Malignant | Benign | | | | |
| Hata et al (1989)[4] | 16 | 12 Positive | 8 | 4 | 100% | 50% | 66.6% | 100% |
| | | 4 Negative | - | 4 | | | | |
| Weiner | 53 | 16 Positive | 16 | - | 94.1% | 100% | 100% | 94.1% |
| et al (1992)[5] | | 17 Negative | 1 | 16 | | | | |
| Kawai | 24 | 11 Positive | 8 | 3 | 88.8% | 80% | 72.7% | 92.3% |
| et al (1992)[6] | | 13 Negative | 1 | 12 | | | | |
| Kurjak | 147 | 25 Positive | 23 | 2 | 100% | 50% | 66.6% | 100% |
| et al (1992)[7] | | 122 Negative | - | 122 | | | | |
| Present study | 50 | 12 Positive | 7 | 5 | 63.6% | 87% | 58.3% | 89.4% |
| (1992) | | 38 Negative | 4 | 34 | | | | |

0% (Table 2). When pulse doppler studies were done in these cases, 3 cases were found to be positive (RI<0.4) and 13 negative (RI>0.4). Out of the 3 positive cases, 2 were malignant and 1 benign whereas all the 13 negative cases were benign (Table 6). This method gave the false negative rate of 0% and sensitivity of 100% (Table 4).

Seventeen complex cysts without solid areas were identified in which 4 were positive for color flow mapping and 13 negative. Out of the 4 positive cases only 1 was found to be malignant and in addition 2 out of the 13 cases reported negative on color flow mapping were found malignant (Table 5). This gave a sensitivity and specificity of 33% and 78.5% respectively (Table 2). Four cases in this group showed RI<0.4 (positive) out of which 3 were found to be malignant, whereas all the 13 cases with negative RI indices were found to be benign (Table 6) giving a sensitivity and specificity of 100% and 92.8% respectively (Table 4).

Complex cysts with solid areas were seen in 14 cases out of which 5 showed positive color flow mapping and 9 negative. Out of 5 positive cases, 3 were found to be malignant whereas all the 9 negative cases were benign (Table 5).The sensitivity and specificity of color flow mapping in detecting malignancy in this category were 100% and 81.8% respectively (Table 2). The RI values of 3 cases were positive out of which 2 malignances were detected and in the 11 negative cases 1 malignancy was detected giving a sensitivity and specificity of 66.6% and 99.9% respectively (Table 4).

Three women presented with solid cysts and all were found to have positive color flow mapping (Table 5) and RI values of <0.4 (Table 6). All these masses were later confirmed malignant on histology giving a sensitivity of 100% for both the methods (Tables 2 and 4).

**Discussion**

Tumor angiogenesis factors are important in rapid formation of new capillaries (neovascularization) in malignant tumors [3]. Color flow mapping and pulsed doppler ultrasound detect blood flow changes in these low resistance vessels. These appear as continuously fluctuating color rather than the pulsatile color seen with normal arteries. Color blood flow imaging and doppler waveform analysis have been used as diagnostic tools to differentiate between benign and malignant ovarian masses by many workers [4-7].

In the present study the use of color flow mapping in preoperative identification of malignancy in cystic ovarian masses had an overall sensitivity and specificity of 63.6% and 87% respectively with a negative predictive value of 89.4% and positive predictive value of 58.3% (Table 2).

Out of the 16 simple cysts, color flow mapping missed 2 malignancies giving a false negative rate of 12.5%. Since, malignancy is less suspected in simple cysts, color flow mapping alone appears unreliable in this situation where it is probably needed the most. When color flow mapping was performed on 17 complex cysts without solid areas, 2 out of the 3 malignancies (66.6%) were missed by color flow mapping. Out of the 14 complex cysts with solid areas 3 were malignant and all of them showed positive color flow mapping. Similarly, 3 solid ovarian cysts showed positive color flow mapping and all of them were found to be malignant on histopathological examination. Therefore, color flow mapping alone may not be very reliable in differentiating between benign and malignant ovarian masses especially in simple and complex cysts without solid areas. To improve the detection rates of color flow mapping we used pulse doppler waveform studies to measure the impedance to blood flow to differentiate between benign and malignant ovarian masses. The parameter we used was the resistance index (RI) which has been found to be the most sensitive reliable indicator of malignancy in ovarian cysts especially using the cut off value of RI <0.4. Taking this parameter and cut off value, the overall sensitivity, specificity, positive predictive value and negative predictive value in detecting malignancy were 90.9%, 92.3%, 76.9% and 97.2% respectively which are much superior to 66.6%, 87%, 58.3% and 89.4% respectively obtained for color flow mapping (Tables 2 and 4).

Kurjak et al [7] conducted a study on 14000 patients with ovarian masses and found 56 malignancies. All but two showed abnormal color flow patterns with RI <0.4. The reported sensitivity, specificity and positive predictive value in their study were 96.4%, 99.8% and 98.2% respectively [7]. Table 7 compares our findings with those reported by other workers.

Accurate preoperative assessment of ovarian tumors is important as it affects the counseling, preoperative preparation, and intraoperative and postoperative management of the cases. It would also avoid inappropriate laparoscopic excision of malignant ovarian tumors. In our study color flow mapping alone had a high sensitivity of 100% in identifying malignancy in solid ovarian tumors and complex cysts with solid areas. But it failed to identify 66.6% of malignancies in complex cysts without solid areas and all the malignancies in simple cysts.

Our study further showed that the addition of pulse doppler waveform studies using RI <0.4 as cut off increased the sensitivity, specificity and positive predictive value in detecting malignancies in all types of ovarian masses and specially in simple cysts and complex cysts without solid

areas where color flow mapping alone showed poor results.

Recently 3 D power doppler qualitative analysis of tumor angiogenesis has shown promising results in accurate detection of ovarian malignancy. At present higher equipment costs and need for more sophisticated operator skills make 3D ultrasound technology limited to only few centers. But routine 2D ultrasonography and color doppler studies are still valuable screening modalities. Workers are also exploring the use of microbubbles as an ultrasound contrast agent to improve color flow mapping. Sonicated albumin microbubbles used in the field of cardiology have shown to improve pulsed doppler signals and color flow imaging.

## Conclusion

Color flow mapping and pulsed doppler waveform studies have high sensitivity and specificity in the diagnosis of malignant ovarian cysts.

**References**


1. Koonings PP, Campbell K, Mishell DR. Relative frequency of primary ovarian neoplasms; a ten year review. Obstet Gynecol 1989;74:921-6.
2. Marret H. Doppler ultrasonography in diagnosis of ovarian cysts; indications, pertinence and diagnostic criteria. J Gynecol Obstet Biol Reprod 2001;30:20-33.
3. Folkman J, Merler E, Abernathy C et al. Isolation of a tumor factor responsible for angiogenesis. J Exp Med 1971;133:275-88.
4. Hata T, Hata K, Senoh D et al. Doppler ultrasound assessment of tumor vascularity in gynecologic disorders. J Ultrasound Med 1989;8:309-14.
5. Weiner Z, Beck D, Brandes JM et al. Transvaginal sonography, colour flow imaging, computed tomographic screening and CA 125 as a routine follow up examination in women with pelvic tumor: detection of recurrent disease. J Ultrasound Med 1994;13:37-41.
6. Kawai M, Kano T, Kikkawa F et al. Transvaginal doppler ultrasound with color flow imaging in the diagnosis of ovarian cancer. Obstet Gynecol 1992;79:163-7.
7. Kurjak A, Zalud I,Alfirevic Z. Evaluation of adnexal masses with transvaginal color ultrasound. J Ulrasound Med 1991;10:295-7.