Power Doppler ultrasound: a potentially useful alternative in diagnosing pelvic pathologic conditions

A. PAPADIMITRIOU - D. KALOGIROU - G. ANTONIOU - N. PETRIDIS (*)
O. KALOGIROU - A. KALOVIDOURIS (**)

Summary: *Introduction* - To evaluate the efficacy of power Doppler sonography in depicting soft-tissue hyperemia in endometriosis and other pelvic inflammatory conditions thirty-one patients with predominantly pelvic inflammatory symptoms were evaluated.

Materials and Methods - Power Doppler sonography at 5 MHz and a pulse repetition frequency of 800 Hz was used. All the women underwent laparoscopy after 10 days.

Results - Soft-tissue hyperemia was seen on power Doppler sonograms in 22 of the symptomatic patients. In these women Doppler demonstrated a diffused "blush" of almost or the entire symptomatic sites. Specificity was 52.4%, sensitivity 47.1% and the positive predictive value was 53.2%.

Conclusion - Power Doppler sonography showed hyperperfusion in many cases associated with pelvic inflammatory pathology. It is a potentially useful adjunct to standard color Doppler imaging in depiction of vascular flow.

Key words: Pelvic blood supply; Color Doppler sonography; Power Doppler; Ultrasound diagnosis; Pelvic infection; Endometriosis.

INTRODUCTION

Color Doppler sonography is a well-known diagnostic tool. It is well-suited for evaluating high-velocity flow, particularly in large vessels, but less effective in detecting low-velocity blood flow at the microvascular level. A new technique, described by Rubin *et al.*, may be more sensitive than color Doppler sonography in depicting vascular flow ([1]). The new method is called power Doppler sonography and effectively extends the dynamic range over that of conventional color Doppler imaging.

Recently, radiologists have used power Doppler to illuminate an inflamed area such as the thyroid area or the entire cortex of a kidney ([2]). Other groups are employing the technique in inflammatory processes of the musculoskeletal system ([3]). It is also being used to reveal signs of congenital heart disease in the fetus in the first trimester ([4]).

Received June 10, 1996 from the
2nd Department of Obstetrics and Gynecology, University of Athens,
Areteion Hospital, Athens, Greece
(**) Department of Radiology, University of Athens, Areteion Hospital, Athens, Greece
(*) 2nd Division of Gynecology, University of Athens, "Alexandra" Maternity Hospital, Athens, Greece
Revised manuscript accepted for publication July 27, 1996.

The aim of our study was to evaluate the efficacy of power Doppler sonography (PDS) in depicting soft-tissue hyperemia in pelvic inflammatory conditions, such as endometriosis and pelvic inflammatory diseases.

MATERIALS AND METHODS

Thirty-one patients, 20-36 years old, were included in this investigation. All the women presented with one or more symptoms such as: lower quadrant pain, dysmenorrhea, tenderness, purulent vaginal discharge and leucocytosis. All patients underwent laparoscopy 10 days after. A sonographic examination was performed with a Diasonics Spectra unit, modified by the manufacturer to color encode the power in the Doppler signal, and a 5-MHz linear transducer. Scanning was performed by one examiner (A.K.). Initially, real-time, gray-scale sonography was performed. Then, power Doppler sonography was perfomed with the technique previously described by Rubin *et al.* A thin gel pad was used to improve near-field visualization. Pulse repetition frequency was maintained at 800 Hz in most cases. The color gain was manipulated until "color noise" first became apparent at the predetermined pelvic depths in the image background of color Doppler scans and until it first began to exceed the homogeneous single-color background of the electronic noise of power Doppler scans. In cases of fluid collection an increase in vessel number in the tissue immediately surrounding the abnormality was considered pathologic.

A comparison was made with the laparoscopy findings.

Statistical analysis was performed using Student t-test for paired and unpaired data.

RESULTS

Power Doppler Imaging showed diffused hyperemia in 22 of the symptomatic women examined. Flow patterns ranged from an increased number of visible small vessels to soft-tissue "Blush", which we presume consists of various small vessels.

Hyperemia was found in all the cases with deep endometriosis and in two ovarian endometriomas. Laparoscopy results are shown in table 1. In the patients with pelvic inflammatory disease, color Doppler sonography depicted many intraovarian blood vessels but did not depict diffused ovarian blush in any examination. Depiction of ovarian blush appeared to be depth-dependent. The blush decreased with increasing distance from the transducer. Table 2 presents the diagnosis of the 22 patients that showed diffused hyperemia.

Table 1. — *Laparoscopic findings in all symptomatic patients.*

Diagnosis	No. of patients
Endometrioma	5
Endometriosis	
1) Superficial	2
2) Deep	6
Chronic P.I.D.	5
Acute P.I.D.	7
Salpingitis	1
Abscess	1
Hemorrhagic corpus luteum	1
Torsion of adnexa	1
Endometritis	1
Acute appendicitis	1
Total	31

Subjective comparison of color Doppler sonography with power Doppler sonography showed that power Doppler scan demonstrated more vessels over longer courses than color Doppler sonography. Vasculature with both techniques appeared to be depth-dependent. The blush decrea-

Table 2. — *Diagnosis of women who showed hyperemia with Power Doppler Sonography.*

Diagnosis	No. of patients
Deep endometriosis	6
Tubo-ovarian abscess	1
Pelvic inflammatory disease	8
Hemorrhagic corpus luteum	1
Acute salpingitis	1
Endometrioma	5
Total	22

sed with increasing distance from the transducer.

In a patient with hemorrhagic corpus luteum, flow was less pronounced than in the other cases although it remained more prominent than on the contralateral, asymptomatic side. In two patients periovarian vessels on power Doppler sonograms were unusually large and prominent when compared with the contralateral side without an increase in vessel number of vascular blush. This pattern was seen in a woman with acute salpingitis and in a case with chronic pelvic inflammatory disease. With laparoscopy, a tubo-ovarian abscess was diagnosed in one patient. Power Doppler sonograms of the ovary showed marked hyperemia with vascular blush around the ovary and fluid-filled subuterus space. The subovarian space was distended with hypoechoic material. With Power Doppler Imaging specificity was 52.4%, sensitivity 47.1% and the positive predictive values was 53.2%.

DISCUSSION

In our investigation, we were consistently able to show hyperemia at the symptomatic site of the pelvis. Hyperemia was associated with a variety of gray-scale abnormalities in several conditions including those of inflammatory and infectious origins. Limitations of this study include the heterogeneous population of patients. Also, no direct quantitative parameter, such as resistive index, was applicable to this technique.

Although power Doppler (P.D.I.) is a niched product that is being used in only about 5% of cases, it promises to have a considerable effect on ultrasound in the future, both in terms of cost and clinical effectiveness ([5]). Endometriosis causes some bleeding on the surface of the ovary or elsewhere in the pelvis, which provokes an inflammatory response. Doppler energy reveals the sites of endometriosis as islands of light. This new technique should help in deciding if endometriosis is present, how active it is biologically, and how well treatment may be working.

Tumor evaluation is another potential area of importance for power Doppler. The increased sensitivity to blood flow may more clearly demarcate the differences between malignant and benign tumors. In addition, power Doppler may sort out the particulates in the cystic fluid of some tumors ([6]). It is our opinion that by pressing on the cyst and using the energy Doppler we can detect the motion of the particulates inside. The more information available on flow to a mass, the better the patient can be managed.

Where conventional color Doppler depicted only tiny pinpoints of light in areas of ovarian blood flow, power Doppler shows an entire vein or artery curled on itself. Blood flow in septations, which is difficult to achieve with conventional color Doppler, can be detected with power Doppler ([7]). There is some controversy about the use of imaging to detect ovarian carcinoma in its early stages. Nevertheless, power Doppler, in addition to color Doppler, may be beneficial in screening women at high risk for ovarian cancer. In particular, the technique will help determine when immediate surgery may be needed.

Power Doppler is a signal-processing technique that works on the Doppler signal just as standard color Doppler does. In power Doppler, noise looks like low power. If the gain is high or the threshold is wown to the noise floor, noise becomes an almost uniform low-power background. We think that in cases with very slow flow but with lots of cells in movement, such as in the inferior vena cava, flow is seen better with power than regular Doppler. In power Doppler the gain can be turned all the way up to fill the entire image with noise, and the vascular signal will still shine through.

Power Doppler is also almost totally angle-independent. The technique consequently helps in imaging vessels that are tortuous or perpendicular to the plan of insonation. In addition, power Doppler does not lie, so it elicits more precise pictures with less confluence of colors and the salt-and-pepper appearance of standard color Doppler. The technique has a number of disadvantages as well. It identifies movement within blood vessels but cannot show the direction of the movement. It is extremely motion-sensitive and produces a great deal of flash artifact, particularly when scanning near the beating heart of the diaphragm ([8]).

Power Doppler involves an upgrade to present color Doppler software. As a result, it does not require a major financial investment. Any costs incurred, radiology investigators agree, will be recouped by the ability to increase the certainty of diagnosis. Power Doppler should save money by a avoiding further testing. In many cases, the technique will lead to a definitive diagnosis, confirm inconclusive conventional color Doppler studies, and assure that hyperemia found in borderline cases is not due to artifact or random sampling error.

We believe our most important finding is the diffused blush of the ovary – to variable degrees – seen with power Doppler sonography. Probably, this blush is the visualization of vessels distal to the internal iliac vessels. These vessels are not routinely imaged with color Doppler sonography ([9]) and are so small and numerous that they probably summate to produce he blush and are not depicted as discrete vessels.

This new technique has a number of potential applications. If an infectious origin is suspected, it might aid in localizing appropriate sites. Further examination of the patients with pelvic pathology before and after therapy might elucidate the role of power Doppler imaging in monitoring therapeutic response. In conclusion, power Doppler sonography cannot be characterized as a major breakthrough, but it is a potentially useful adjunct to standard color Doppler imaging. Additional studies are suggested.

REFERENCES

1) Rubin J. M., Bude R. O., Carson P. L., Bree R. L., Adler R. S.: "Power Doppler, a potentially useful alternative to mean-frequency based color Doppler sonography". *Radiology*, 1994, *190*, 853-856.
2) Eggli K. D., Eggli D.: "Color Doppler sonography in pyelonephritis". *Pediatr. Radiol.*, 1992, *22*, 422-425.
3) Mack L. A., Nyberg D. A., Matsen F. A.: "Sonographic evaluation of the rotator cuff". *Radiol. Clin. North Am.*, 1988, *28*, 161-177.
4) Sahn D. J.: "Instrumentation and physical factors related to visualization of stenotic regurgitant jets by Doppler color flow mapping". *J. Am. Coll. Cardiol.*, 1988, *12*, 1354-1365.
5) Jain S. P., Fan P. H., Philpot E. F. *et al.*: "Influence of various instrument setting on the flow information derived from the power mode". *Ultrasound Med. Biol.*, 1991, *17*, 49-54.
6) Newman J. S., Adler R. S., Bude R. O., Rubin J. M.: "Detection of soft-tissue hyperemia: value of power Doppler sonography". *AJR*, 1994, *163*, 385-389.
7) Bude R. O., Rubin J. M., Adler R. S.: "Power versus conventional Color Doppler Sonography: comparison in the depiction of normal intrarenal vasculature". *Radiology*, 1994, *192*, 777-780.
8) Simpson I. A., Valdes-Cruz L. M., Sahn D. J., Mariollo A., Tamora T., Chung K.: "Doppler color flow mapping of simulated in vitro regurgitant jets: evaluation of the effects of orifice size and hemodynamic variables". *J. Am. Coll. Cardiol.*, 1989, *13*, 1195-1207.
9) Dumling S. O., Persson H. W., Hertz C. H.: "Measurement of blood perfusion in tissue using Doppler ultrasound". *Ultrasound Med. Biol.*, 1991, *17*, 433-444.

Address reprint requests to:
ANTONIOU GEORGE
Agiou Meletiou 48, str.
Kipseli 112 57 - Athens, Greece