Tissue Block Ultrasound and Ovarian Cancer—A Pictorial Presentation of Findings

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Abstract

Malignancy has classically been described, as having vessels "seemingly deployed without purpose.'' In other words, vascularity that does not have tree like in branching with orderly distal tapering is abnormal. 3D imaging can create a virtual cast of vessels, to be "cut into" and "manipulated" on a computer monitor. This can be thought of as a most valuable "Tissue Block" of data, unlike any other imaging test, and I believe, holds the key to a more accurate diagnosis of ovarian cancer.

Keywords: Ovarian cancer, ovarian vascularity, 3D ovarian imaging, tissue block ultrasound, benign vs malignant ovarian mass, Doppler of ovarian masses.

INTRODUCTION

Many women have ovarian masses, but only a very small percentage has malignancy. Once a mass is discovered either by palpation, or by serendipitous imaging, the general gynecologist is faced with a dilemma. Choices include watching and waiting when the mass is thought to be benign and physiologic, surgery with the gynecologist, or surgery with an oncology surgeon when the risk of cancer is thought to be significant. In 2009 this decision is aided by interpretation of 2D ultrasound images and Ca125 values, both often reliably inconclusive.[1,2]

Although in use for decades, the criteria for 2D ultrasound are not universally agreed upon, but any degree of complexity, having septations and or nodules can be suspect for malignancy, depending upon expert opinion and experience. Matrix and scoring of 2D images is a complex and daunting task usually ending in a possible "can not rule out" diagnosis, for virtually every mass other than a smooth walled cyst. Despite now decades of observations and improved imaging technology, 2D images results in many surgeries for benign masses predicted to be cancer (PPV varying from 40-96 %).[3-6]

The original description of "tumor vascularity" is credited to Strickland (1959). In his study of bone tumors, Strickland described a tumor vessel as one that was "deployed seemingly without purpose, and keeps to no set course and shows no progressive diminution in caliber."[7]

Taylor's 1988 Radiology report was the first to correlate Doppler findings with pathologic vascular findings for a variety of neoplasms but not ovarian. He discovered that neoplasms frequently had abnormally elevated velocities, presumed to be related to arterial venous shunting, and/or little systolic to diastolic variation due to correlated "prominent vascular spaces", or "sacculations".[8]

In an effort to improve the diagnostic accuracy of ultrasound, transvaginal color and pulsed Doppler sonography were added, and pioneered by the work of Kurjak[9] and Mikhaleva.[10] Unfortunately, the results and techniques of others were inconsistent, and many instances obvious corpus luteum were "Dopplered" into a suspect category, even ovarian arteries were sampled, adding confusion to the debate, but relief to many general radiologists who routinely added "can not exclude ovarian cancer" to every pelvic study.

As the technology improved with 3D imaging technique, investigators have reported more consistently higher accuracy by examination and comparing individual vessels as well as the total percentage of vascularity, cancer having "chaotic" flow patterns and commonly with more flow than benign masses.[11-16]

Of noteworthy review Alcazar fully utilizing new 3D technology and identified that malignancy had more total vascularity as measured by volume data vs. benign masses, especially if advanced stage or metastatic vs. early stage. 3D color Doppler vascularization data closely matched microvessel density observations in his pioneering research laying the foundation for understanding vascular volume findings.[11,12]

In a well-crafted multicenter review of 1,233 adnexal masses, Timmerman and colleagues reported that finding blood flow in a papillary projection had a positive predictive value of 67 %, and a sensitivity of 82 %, but a high false positive rate of 35 %, for malignancy.[13] Just seeing flow is not enough.

Sladkevicius landmark study reported a highly successful use of qualitative assessment of vascularity, identifying caliber changes, bridging between vessels, tortuosity for example in a 360 degree rotating 3D images of the vessel tree of the tumor, but had a 10 % false positive in a group that included 77 benign tumors and 27 malignancies. Unique to this report is that the 2D data was excluded from the interpretation.[14]

Unlike these reports, we have not limited the Doppler imaging to Power Doppler, but also carefully study the direction of flow and intraluminal flow by using traditional color Doppler 3D images.

My experience in ultrasound has increasingly come to rely upon the vascular signatures of pelvic masses and have even identified tumors prior to having a mass formation solely based upon the nature and complexity of the vascularity, even reporting this prior to the advent of 3D ultrasound technology.[17] Using 3D Doppler and the software of the Voluson 730 Expert (Milwaukee, USA) I now have had extensive experience looking at specific details of benign vs "chaotic" or "abnormal" flow. Routinely, several volumes of data are stored and analyzed by all the available options. Conceptually, I treat the saved volumes as a "Tissue Block" of data, and use the "magic cut" feature to cut away various portions or the "rendered" image to expose the true course of vessels and to "open up" the lumen of suspect vessels so as to closely examine the internal flow patterns.[18]

We also take advantage of "TUI" and "Sectional plane" features to trace individual arteries and veins much as an angiographer does on injection studies. This exposes areas of vascular dilatation or "sacculation", narrowing and bridging and thus loss of tree like architecture.

Using the Render feature, we routinely evaluate the nature of the peripheral flow, being sure that several volumes obtained include the borders. We then carefully evaluate the nature of the peripheral vessels, both for abundance, "crowding" as well as having abnormal patterns as categorized abnormal findings as noted below.

With benign masses vascularity appearances are characterized by straight arteries and veins with tree like branching, arteries and veins running in tandem and arteries and veins not crowded (Figs 1 and 2).

The following are the criteria that we have developed that suggest malignancy.

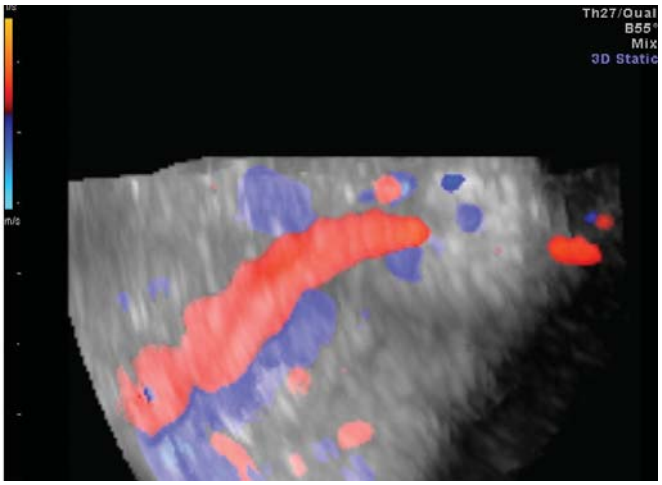


Fig. 1: Normal appearances of a benign artery paired with a vein, having a straight tapering course

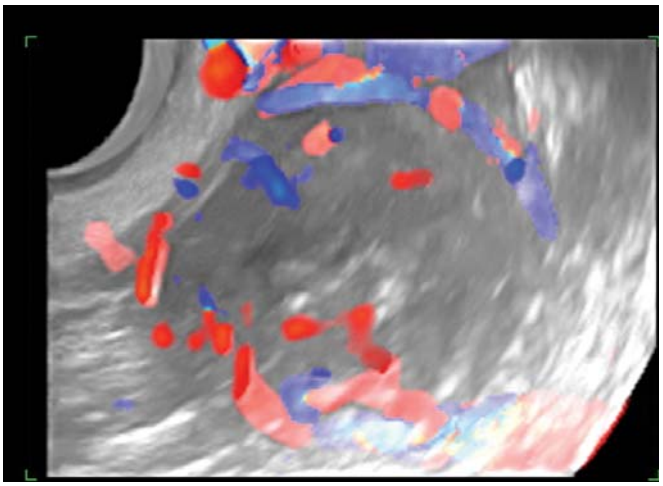


Fig. 2: Straight uncrowded peripheral vascularity of a benign solid mass as demonstrated on rendered 3D view

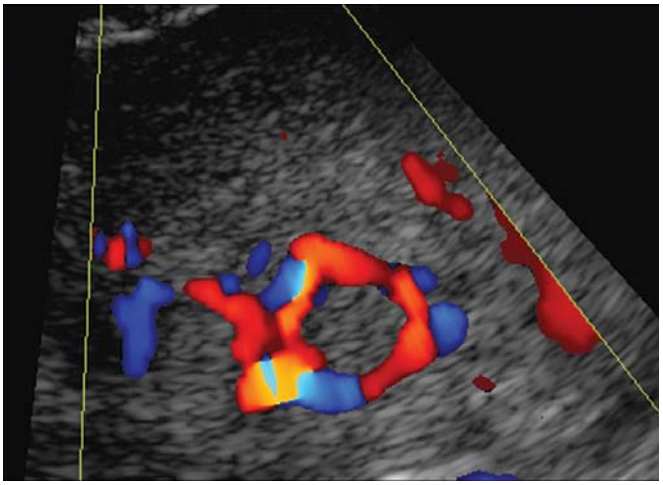


Fig. 3A: Non tree like vascularity demonstrated for this artery, which appears in this view to make a circle

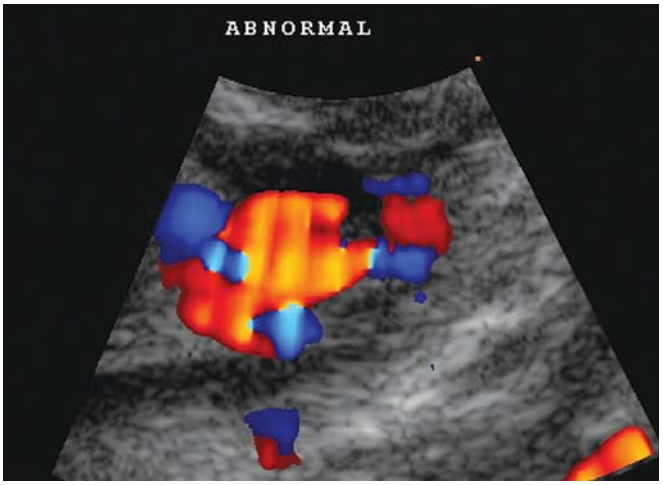


Fig. 3B: Non tree like vascularity example in another ovarian malignancy

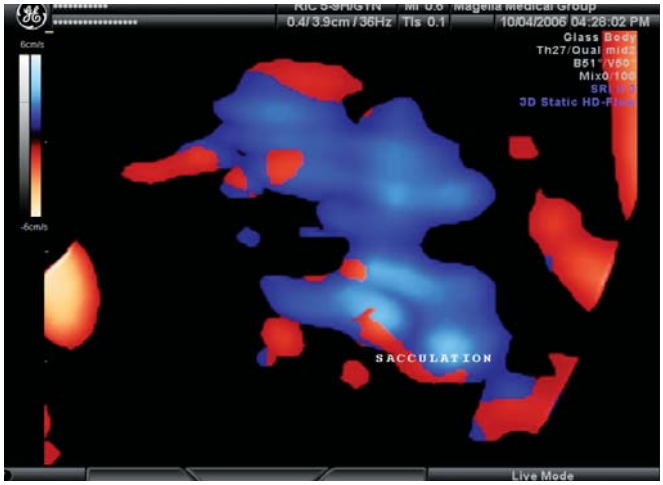


Fig. 4: Sacculation or focal widening

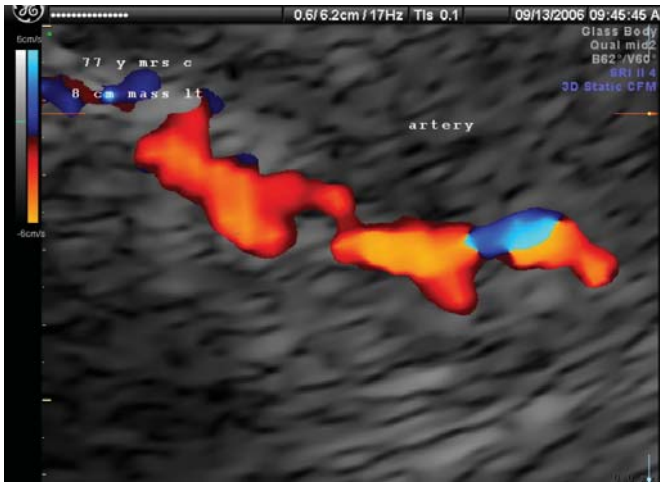


Fig. 5A: "Focal narrowing" finding in a patient having a solid ovarian malignancy

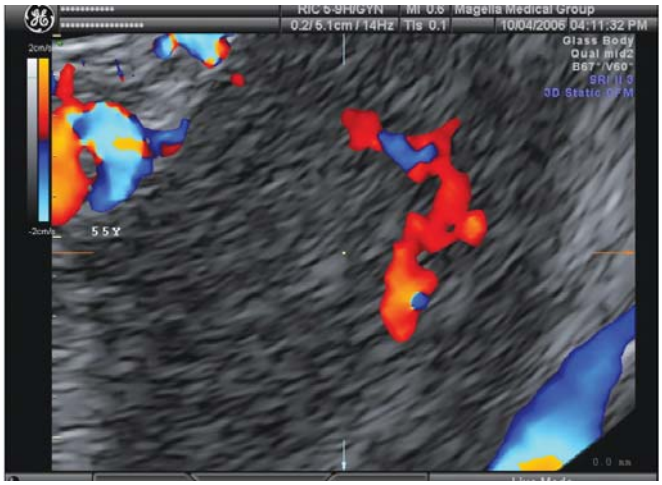


Fig. 5B: Another example of "focal narrowing" in other solid ovarian malignancy

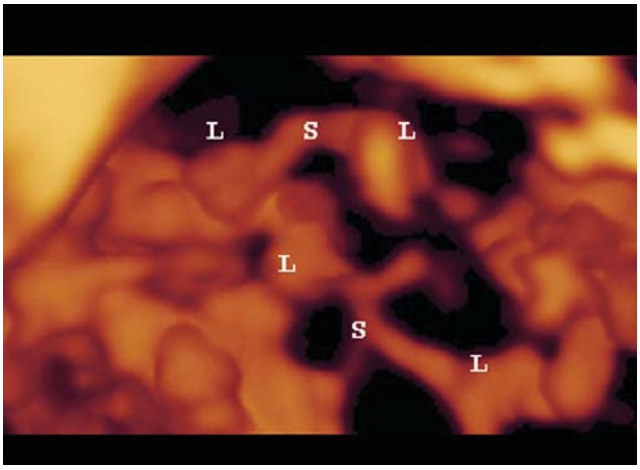


Fig. 5 C: Power Doppler display of an ovarian malignancy that shows focal larger (L) and smaller (S) regions, not expected to be seen in benign tree like vessels

1. Loss of "Tree like" branching of vessels (Figs 3A and B).
2. Sacculation of arteries and veins (Fig. 4).
3. Focal narrowing of arteries (Figs 5A to C).
4. Internal shifts in velocity within arterial lumen (Fig. 6).
5. "Beach Ball" finding of abnormally increased and disorganized peripheral flow. By using the render technique, we can see the surface of tumor masses. A "beach ball" pattern of abnormal flow (criteria 1-4 above) along with a crowded haphazard interwoven matrix of arteries and veins strongly suggests malignancy vs an occasional artery and vein running in tandem as seen with benign tumors. (Figs 7A to C) (see Fig. 1B for benign comparison).
6. Increased flow to a center of a solid region (Figs 8A and B). Care must be used to distinguish the occasional

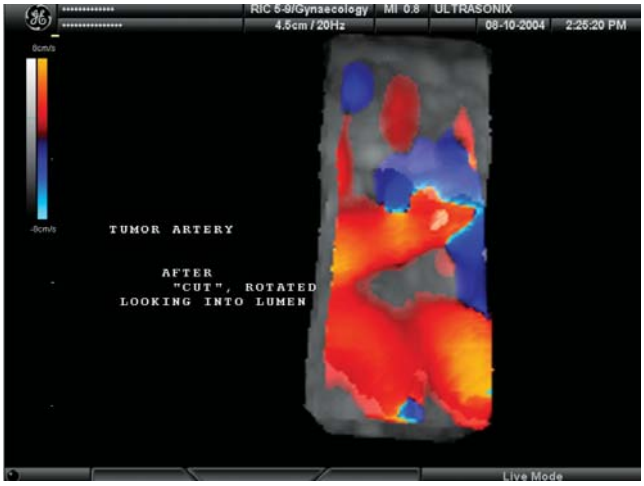
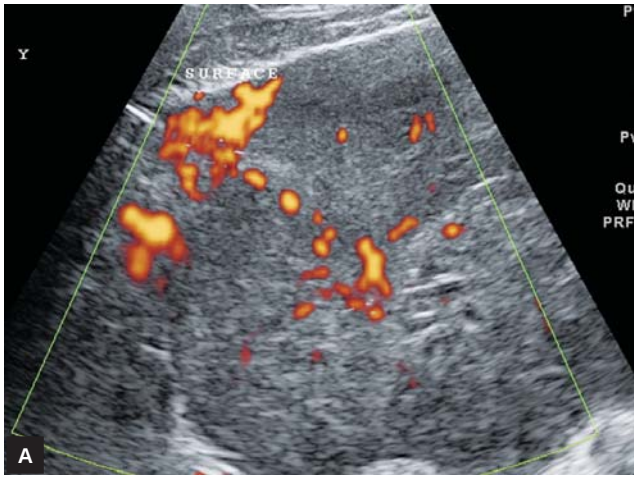
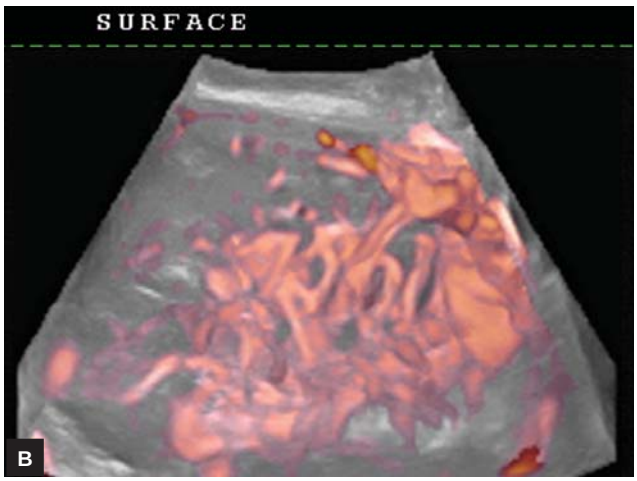


Fig. 6: This picture shows an artery "open" by using magic cut, and displaying a jet of flow distal to an area of narrowing. A similar jet or "orange" shift can be seen in 5A using sectional plane software for another patient





Figs 7A and B: The "beach ball" sign is noted when the 3D volume captures the vascular peripheral borders of many malignancies. Note the increased flow suggested on the Power Doppler 2D image, in contrast the 3D rendered image displays the whole mass and demonstrates the florid flow surrounding the surface

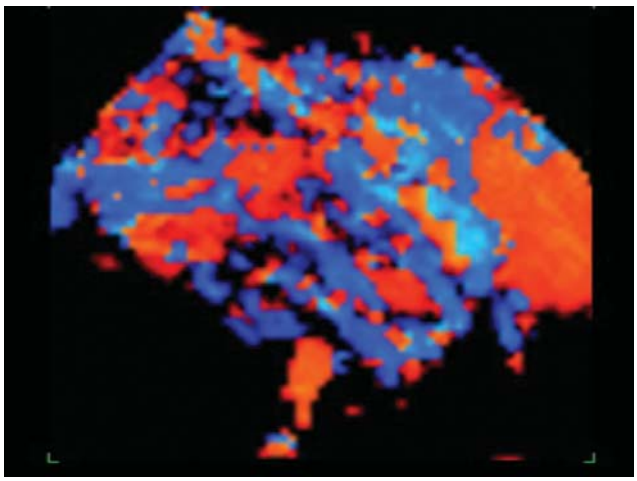
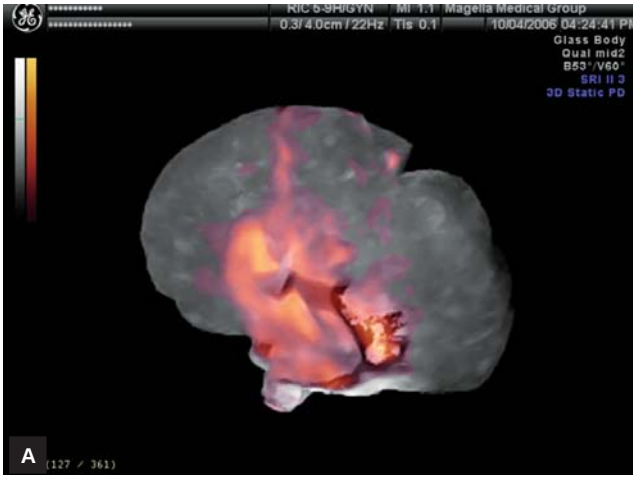
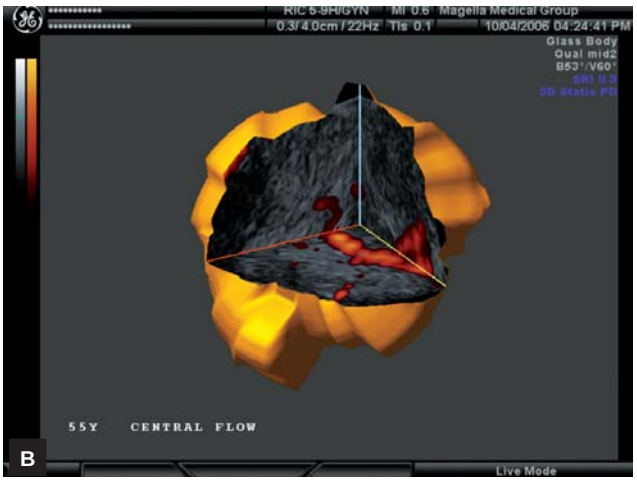


Fig. 7C: This picture shows the complexity of the peripheral vascularity in a malignancy as compared to a benign mass as shown in Figure 2





Figs 8A and B: Increased central flow may be an indication of malignancy, and can be eloquently demonstrated by 3D imaging

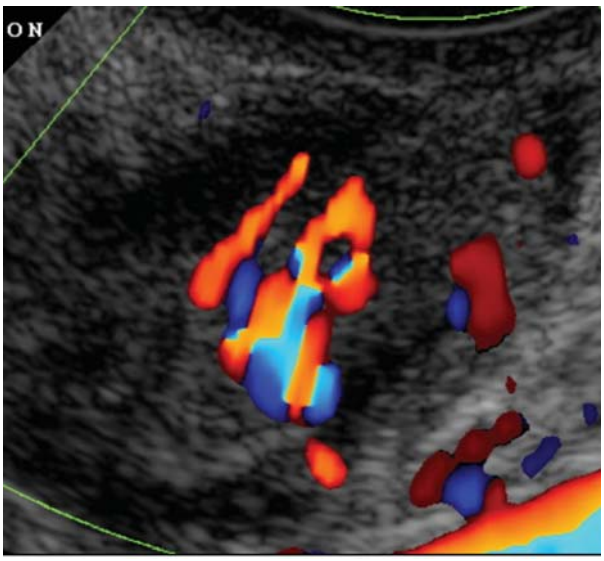
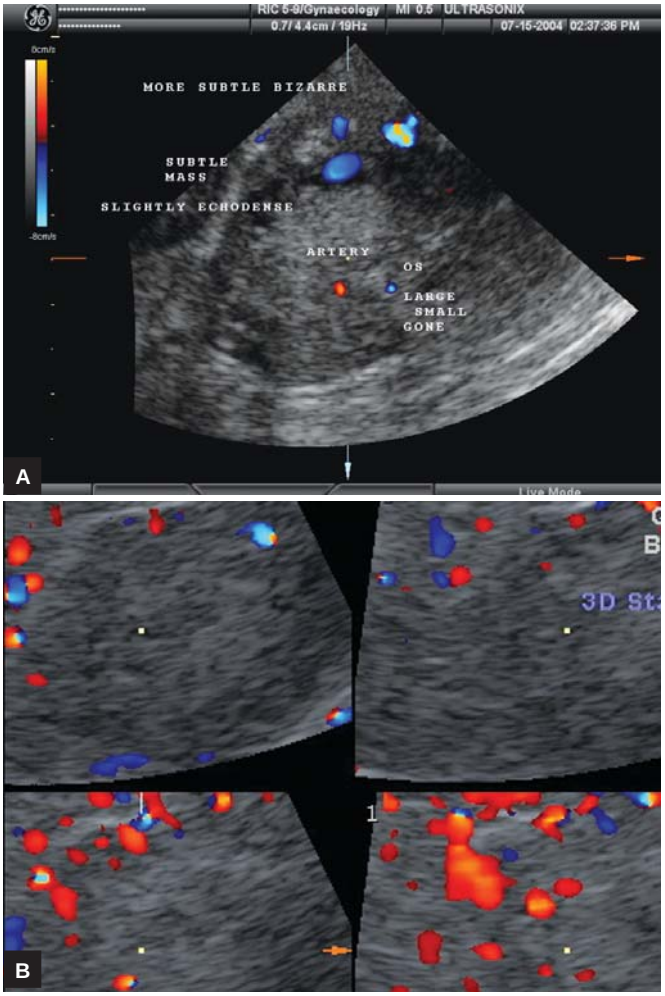


Fig. 9: Crowded vascularity: This subtle solid mass was given away as a cancer when the crowding of vessels was discovered in the central region of an ovary, for this postmenopausal patient

minor flow into a resolving solid central portions corpus luteum, which resolve upon follow-up study.

7. Crowding of vascularity (Fig. 9).
8. Start and Stop Arteries. The most subtle indication of abnormality occurs when the arteries appear to "start and stop" within a mass in a disjointed fashion, thus losing the tree like expected appearance of a benign mass. This is usually associated with increased peripheral flow, in my experience. It may be due to the relative lack of oxygen centrally in fast growing tumors, and therefore they are probable remnants of more prominent tumor vessels[10] (Figs 10A and B).



Figs 10 A and B: Subtle findings of arteries that appear to start and stop may indicate a malignancy. These findings may be associated with increased peripheral flow patterns

CASE ILLUSTRATION

A. There was a subtle solid region with medium density but no cystic elements and no nodules within the right ovary for a premenopausal patient, without pain. Due to suspect increased vascularity and especially elements of bridging, focal narrowing and internal vascular shifts, monitoring by ultrasound done with similar results one month later. A granulosa cell tumor was discovered at surgery (Fig. 11).

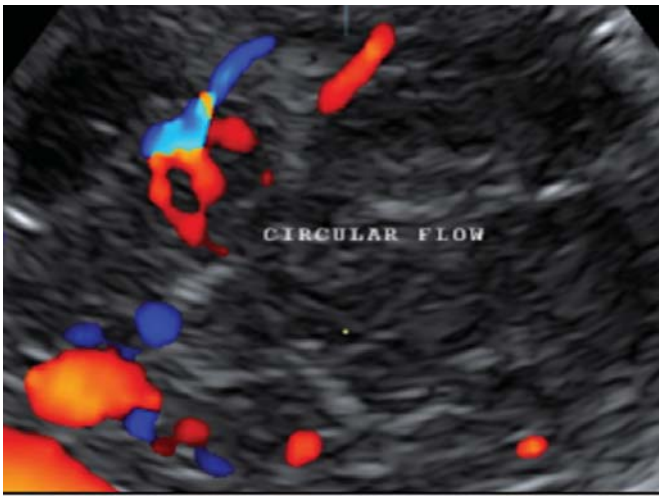


Fig. 11: Solid lobulated ovarian mass had abnormal vascularity including this artery with branches connecting in a circular manner upon itself leading to an early diagnosis of a granulosa cell malignancy

B. Postmenopausal patient with "routine" fibroids, found to have an area of "abnormal vascularity" and focally increased flow, associated with the lateral border of the fibroid. Despite normal CA 125, surgery followed with a tubal cancer found applied to the surface of the fibroid. (Fig. 12).

On average if a mass is discovered, we take about 20 minutes to obtain the images and volumes and after the patient has left the room, review the data within 15 minutes.

In a formalized review of 66 patients with pelvic masses, with 10 malignancies, we have had a 100 % PPV and a 95 %

Fig. 12 A: Rendered 3D image contrasts the orderly vascularity of the fibroid to the right, and the crowded disorganized vascularity of a subtle solid mass applied to the surface of the fibroid at surgery, to the left in the image, and found to be a tubal cancer

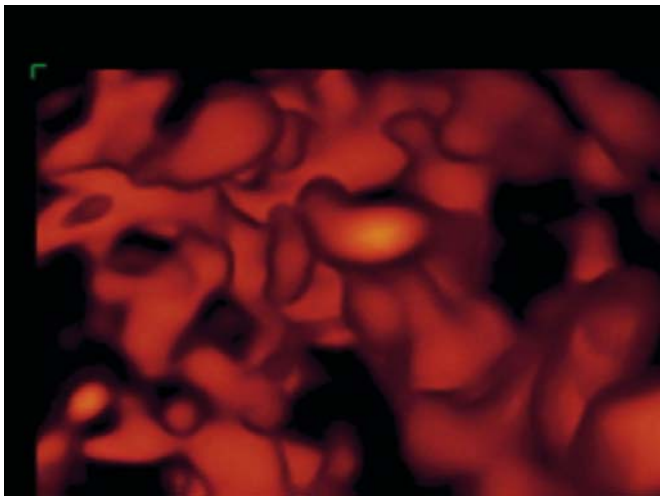


Fig. 12 B: Power Doppler of the rendered malignancy shows the complexity of this tumor

NPV.[19] All the cancer and none of the benign masses had loss of "Tree like" branching. All but one cancer had increased flow, 6 had focal narrowing and 9 had vascular shifts –perhaps indicating unseen narrowings– on magic cut study. Sacculations were discovered in 8 cancers. None of the benign masses had any of the abnormal criteria.

Our experience and criteria are similar to that reported by Sladkevicius,[14] but add in the concept of "start and stop" arteries, as well the "magic cut" technique to qualitatively analyze the shift in velocities of individual vessels. We also include the separate categories of narrowing and sacculation, rather than "caliber changes." We also emphasize the evaluation of the borders by 3D imaging, looking for the aggressive "beach ball" finding of malignancy.

The limitations of the technique include those malignant tumors that are so large as to necrotic and avascular. Some metastatic breast metastasis may not have increased vascularity. One case seen was an unusual and focal intraovarian abscess showing a complex mass and "abnormal" vascularity, without tubal inflammation. Endometriosis can cause vascular nodularity when "decidualized" by pregnancy.[20]

With continued experience, however, these and other rare problems usually can be identified or at least suspected. Tissue Block ultrasound evaluation adds confidence to ovarian diagnosis, sometimes in support of strong 2D indications of malignancy but at times, without.

In conclusion, the 3D "Tissue Block" should be thought of as a virtual cast of vascularity which can be manipulated, cut into, rotated and defined. Individual arteries and veins and their relationships can be studied and provide significant information, helping to sort out those patients needing surgery for cancers from those with benign masses. Specific appearances have been presented thus expanding upon the concepts of "chaotic flow".

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