CASE REPORT

# The Potential of Transvaginal Three-dimensional Color/Power Doppler Ultrasound in Detection of Colorectal Cancer

[1]Ulrich Honemeyer, [2]Asim Kurjak, [3]Jawahar Mathias, [4]Prosper Aduh

[1]Specialist, Department of Obstetrics and Gynecology, Welcare Hospital EHL, Dubai, UAE

[2]Professor, Department of Obstetrics and Gynecology, Medical School University of Zagreb, Croatia

[3]Specialist, Department of Surgery, Welcare Hospital EHL, Dubai, UAE

[4]Specialist, Department of Radiology, Welcare Hospital EHL, Dubai, UAE

**Correspondence:** Ulrich Honemeyer, Welcare Hospital EHL Dubai, Department Mother and Child, DBX 31500, UAE email: ulrich@welcarehospital.com

**ABSTRACT**

Colorectal cancer (CRC) is the fourth most common cancer in men and the third most common cancer in women worldwide. The recent decline of CRC in the USA has been attributed to successful development of screening programs. In the last 20 years, endorectal ultrasound (ERUS) has become the primary method for locoregional staging of rectal cancer. Transvaginal sonography (TVS), with a high-frequency probe, obtains excellent image resolution of deep pelvic organs. TVS not only enables diagnosis and treatment in gynecology, infertility, and early pregnancy but also has the potential to detect other structural abnormalities within its reach, such as neoplasm of the rectosigmoid. Three-dimensional power Doppler ultrasound (3D PD) can depict the morphology of the vessel tree of tumors, and thus help to discriminate between benign and malignant neoplasm. In this case of a 42-year-old patient, an adnexal mass was diagnosed by TVS. Three-dimensional ultrasound gave topographic evidence of sigmoid colon tumor. Spectral Doppler and 3D PD diagnostic criteria of tumor vasculature, demonstrated in this neoplasm, were highly suspicious of malignancy. TVS diagnosis initiated endoscopic histological verification of adenocarcinoma of the sigma and timely surgical intervention.

**Keywords:** Colorectal cancer, Transvaginal ultrasound, 3D power Doppler, Tumor neoangiogenesis.

## INTRODUCTION

Tumor neoangiogenesis, as described in 1971 by J Folkman,[1] is associated with improper vascular architecture. When A Kurjak in 1987 introduced color Doppler for transvaginal sonography (TVS), it suddenly became possible to apply this knowledge about architectonics of tumor vasculature in clinical practice. Soon it was obvious that color Doppler was a useful adjunct to grayscale transvaginal sonography.[2] Color Doppler evaluation of the presence or absence of flow, the distribution of flow, and of the flow velocity waveforms proved to be supportive in distinguishing benign from malignant ovarian lesions. Another milestone in the development of transvaginal sonography was the addition of three-dimensional ultrasound to TVS in the preoperative assessment of pelvic tumors.[3] We present this case of sigmoid colon carcinoma diagnosed by TVS as one more example of the clinical usefulness of transvaginal color Doppler, and will demonstrate the benefit of the addition of 3D imaging to TVS in the diagnosis of nongynecological pelvic tumors.

## CASE

A 42-year-old patient, mother of three children with family history of colon cancer, came to gynecological primary care with complaints of left lower abdominal discomfort. Five months earlier she had consulted a gastroenterologist with similar complaints, however without consecutive radiologic or endoscopic testing. Gynecological findings per speculum were normal. Digital vaginal examination revealed resistance in left parametrium. Transvaginal ultrasound showed uterus of normal size, position and echo texture with copper IUD *in situ*. Both ovaries appeared normal. There was a left adnexal mass 5 cm in diameter with smooth convex surface and complete posterior shadowing. To rule out stools as cause of these findings, the patient received medication for bowel cleansing and was advised to present herself afterwards for TVS follow-up. Meanwhile, stool testing for occult blood was positive. Transvaginal ultrasound one week later, after bowel preparation, showed the same left pelvic mass. Further evaluation by means of transvaginal 3D power Doppler presented tumor-typical vasculature within the mass, with irregular branching, micro-aneurysms, stenosis, and lacunae. Resistance to flow in this area was low with resistance index (RI) 0.40, another feature indicative of malignancy. After immediate surgical consultation, colonoscopy was arranged and performed four days later (Fig. 1). A suspicious "Apple core" type lesion was seen at about 40 cm from the anus in sigmoid colon, and multiple biopsies were taken. Normal endoscopic findings were observed proximal to the lesion upto flexura hepatica. Colonoscopy was followed the same day by CT scan of abdomen and pelvis, and

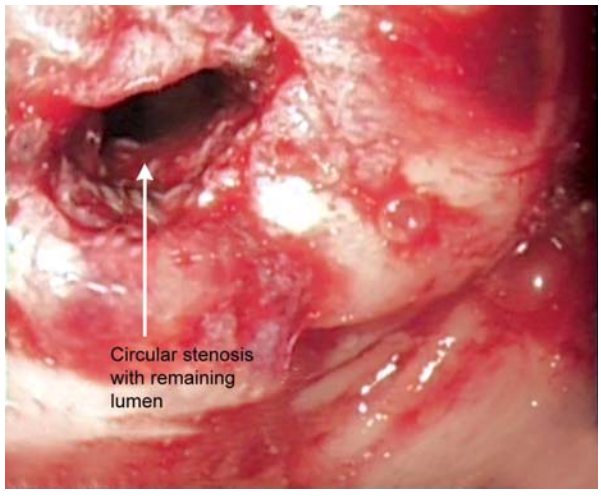



**Fig. 1:** Colonoscopic view of the annular, "Apple Core" lesion in colon sigmoideum

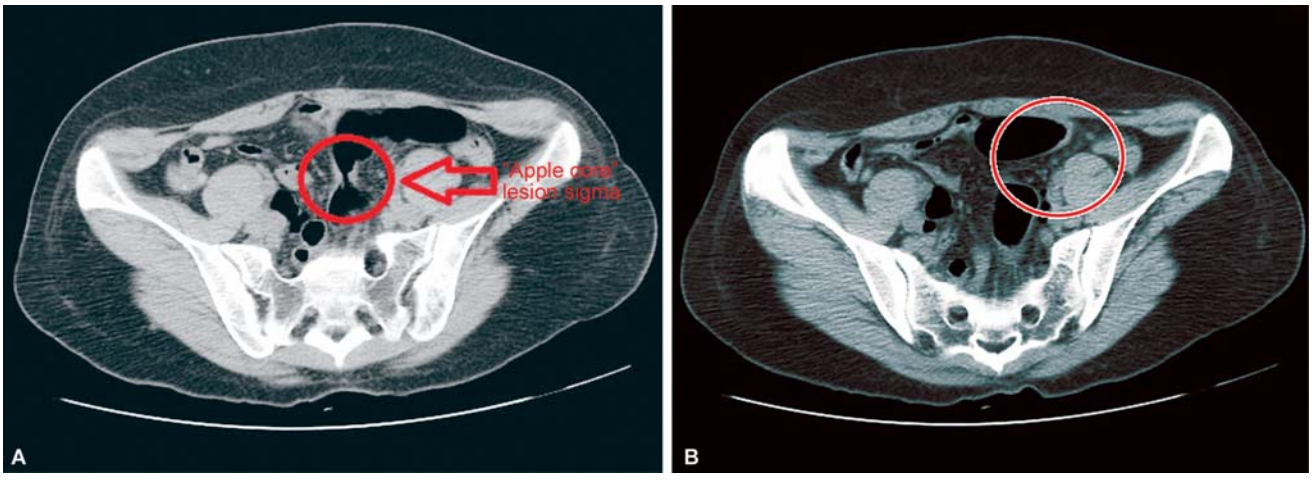
posterioanterior thorax with findings of an annular constrictive mass of the sigmoid colon, suspicious of carcinoma with pericolic lymph nodes were noted at the site of the lesion. Abdomen and thorax were free of metastases (Figs 2A and B).

The histology of the endoscopic biopsies revealed adenocarcinoma. Hence, after another four days, the patient underwent laparotomy. A complete sigma tumor resection with end-to-end anastomosis and routine appendectomy was performed (Figs 3A and B). The postoperative course was uncomplicated.

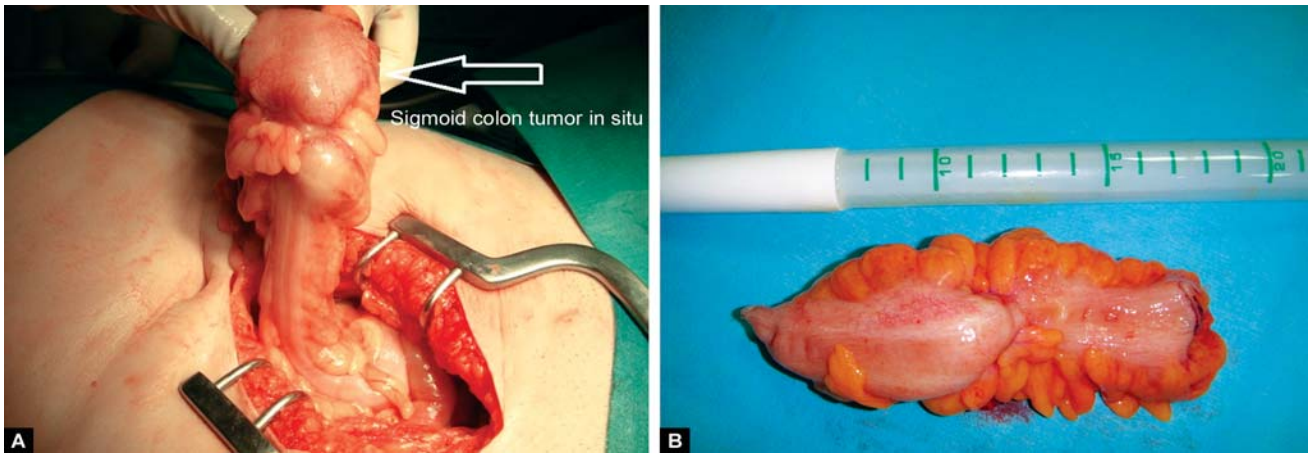
**Postoperative histology and tumor staging**: Moderately differentiated colonic adenocarcinoma invading through muscularis propria into the subserosa (pT3). Tumor size 3.5×3.0×1.5 cm. Metastatic carcinoma in one of 33 lymph nodes (N 1/33). Oncological consultation resulted in recommendation of 12 cycles of Oxaliplatin, 5 Fluorouracil, and Leucovorin.

## DISCUSSION

The three most commonly diagnosed types of cancer among women in 2010 in the USA will be cancers of the breast, lung and bronchus, and colorectum, accounting for 52% of estimated cancer cases in women.103, 000 new cases of colorectal cancer (CRC) with almost 60,000 deaths per year are expected in 2010 in the USA. Worldwide, CRC is the fourth most common cancer in men and the third most common cancer in women.[4] Site distribution: 55 % of CRCs occur in the rectosigmoid with the rectum accounting for 29%, the rectosigmoid junction for 7%, and the sigmoid colon for 18% (Fig. 4).[5]




**Figs 2A and B:** (A) CT image of an annular constrictive mass of the sigmoid colon, (B) Pericolic lymph nodes at the site of the lesion




**Figs 3A and B:** (A) Intraoperative aspect of the sigma carcinoma *in situ*, (B) Resected section of tumorous sigmoid colon

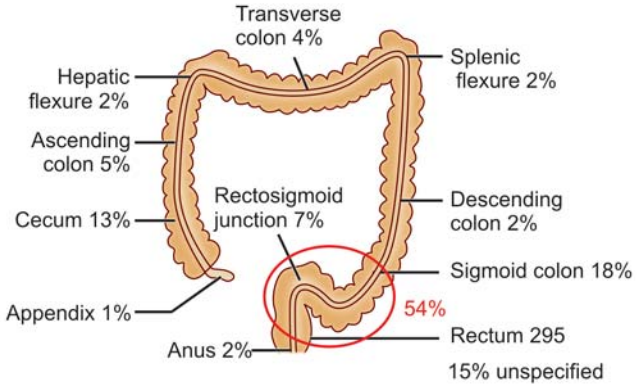



**Fig. 4:** Distribution percentage of CRC by site.
*Toms JR (ed). CancerStats Monograph 2004. Cancer Research UK: London 2004.*

Typical symptoms are unexplained ranging from pain in the abdomen or rectum, change of normal bowel habits to diarrhea or constipation, blood in stools, anemia, weight loss to extreme fatigue. Risk factors for colorectal cancer include obesity, a diet low in fruits and vegetables and rich in saturated fat, physical inactivity, smoking, and a family history of CRC.[6-8] The disease was predominant in developed countries whose populations typically exhibit these risk factors.[9] However, in recent years, high colorectal cancer rates have been reported in newly developed countries around the globe where the risk was once low, supposedly due to "westernization" of environmental or lifestyle factors. The consumption of red and processed meats has been linked to an increased risk of CRC whereas dairy products have been associated with a decreased risk. Energy intake from burgers increased 30% between 1977 and 1978 and 1994 and 1996 whereas energy intake from milk decreased 42% during the same time period. Since 1970s, fast-food consumption has increased by a factor of five in young children and tripled in adults. The overall incidence rate of CRC has been increasing since 1992 among adults aging 20 to 49 years; by 1.5% per year in men and 1.6% per year in women.[10]

Global incidence rates per 100,000 among males in the time period 1998 to 2002 differ markedly worldwide ranging from 4.1 in India (Karunagappally) to 59.1 in the Czech Republic. Among females, these rates range from 3.6 in India (Karunagappally) to 39.5 in New Zealand. The majority of cancer registries with the highest incidence rates of colorectal cancer are located in Europe, North America and Oceania. In contrast, the lowest rates are observed from registries in Asia, Africa and South America. The lower rates observed among females compared with males may be related to differences in risk behaviors associated with colorectal cancer, such as smoking, and the differing effect of obesity in men and women. In many countries, the regular uptake of smoking among women lags 20 to 30 years behind that of men.[10]

In the United Arab Emirates, Abu Dhabi, a total of 50 adults per year are diagnosed with colorectal cancer, making CRC the third most common type of cancer found in men and the fourth most common cancer in women in the capital of the UAE.[11]

Screening for CRC has been cited as one of the most important factors responsible for the recent decline in colorectal cancer rates in the United States.[12]

Internationally, the chosen modality of colorectal cancer screening varies, and it is likely that the cost and availability of diagnostic resources are the leading factors influencing CRC screening program design. Although colonoscopy may be considered the gold standard for colorectal cancer screening, it requires a skilled examiner, involves greater cost, and is less convenient to the patient. As such, a population-based colorectal cancer screening program based on colonoscopy is more resource intensive and less feasible in the most countries, and not at all practical in low-resource countries. Therefore, the fecal occult blood test (FOBT), inexpensive and easy to perform, is a more feasible colorectal cancer screening option in many areas of the world, although it is less sensitive than structural examinations.

In the United States, current screening recommendations for the detection of adenomatous polyps and colorectal cancer in adults with average risk (those aged 50 years and older), include either annual stool testing with a high-sensitivity guaiac- or immunochemical-based test, periodic stool DNA testing, flexible sigmoidoscopy every five years, colonoscopy every 10 years, double-contrast barium enema every five years, or computed tomographic colonography every five years.[13] Preoperative computed tomography (CT) of abdomen and pelvis in cases of CRC can demonstrate regional tumor extension, regional lymphatic and distant metastases, and tumor-related complications, such as obstruction, perforation and fistula formation.[14] The sensitivity for detection of distant metastasis is higher (upto 87%) than the sensitivity for detection of nodal involvement (upto 73%) or depth of transmural invasion (upto 50%).[15] Standard practice in the USA is that all patients with stadium 2, 3 or 4 of CRC undergo CT, either prior to or after tumor resection.[16]

## THE ROLE OF ULTRASOUND IN DIAGNOSIS OF CRC

In the last 20 years, endorectal ultrasound (ERUS) has become the primary method for locoregional staging of rectal cancer. ERUS is the most accurate modality for assessing local depth of invasion of rectal carcinoma into the rectal wall layers (T stage). ERUS is not as good for predicting nodal metastases (N stage) as it is for tumor depth.[17,18]

The clinical value of transrectal ultrasound in the diagnosis of suspected neoplasia in the small pelvis was acknowledged by a group of urologists from the University Hospital of Ulm, Germany, mainly because of the option of transrectal ultrasound (TRUS)-guided biopsy: One case of extended node metastasis in prostate cancer, one paravesical manifestation of recurrent cervical cancer, one metastasis of a paravesically infiltrating colon cancer, two cases of paravesical metastases of a gastric cancer, and one case of extragenital endometriosis, could be diagnosed successfully.[19]

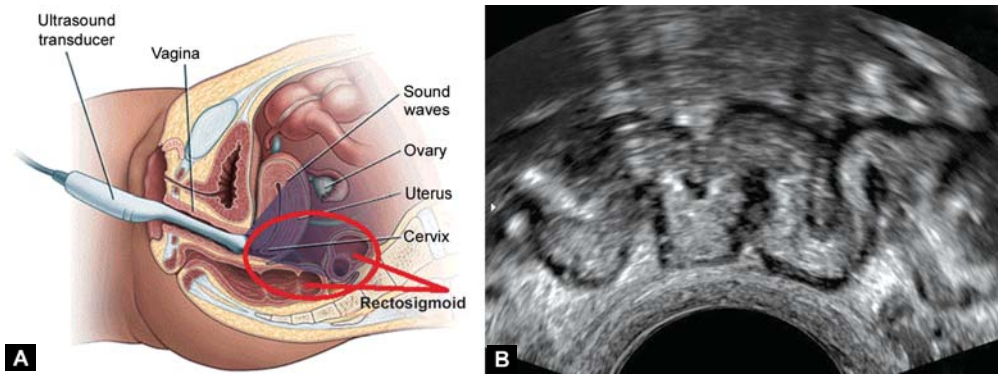
Not much literature exists regarding transvaginal sonographic assessment of colorectal cancer. To the best of our knowledge, there is no previous documentation of a case of transvaginal 3D power Doppler diagnosis and evaluation of a sigmoid colon carcinoma. Water enema transvaginal ultrasound (TVS) for local staging of stenotic rectal carcinoma was considered by an Italian team as potentially valuable technique for defining the local extension of severely stenotic rectal tumors in women.[20]

*Transvaginal sonography (TVS)*, with a high-frequency probe, obtains excellent image resolution of deep pelvic organs. In gynecology, TVS examination has emerged as the cheapest, fastest, and the most conclusive diagnostic tool in the diagnostic evaluation of adnexal masses. The challenge is ever the same: Ovarian cancer is mostly diagnosed in advanced stages, a fact which has not changed in the last decades.[21]

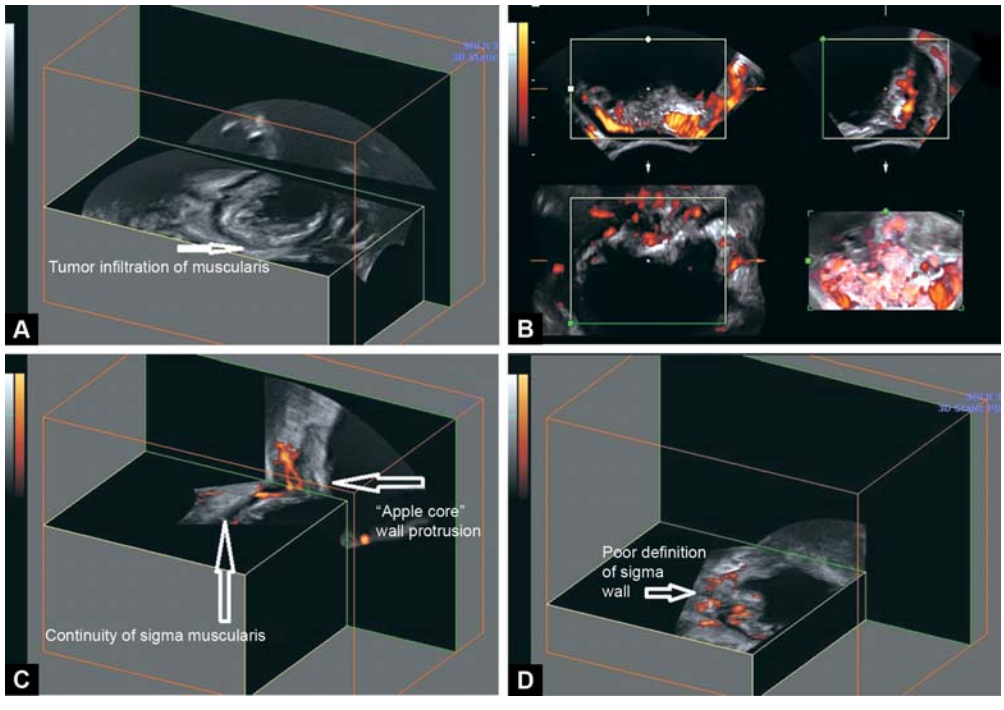
However, differential diagnosis of adnexal masses has to take into account all other anatomic structures in the pelvis, such as rectosigmoid. According to site distribution of CRC, up to 50% of the disease develops in the pelvis within the reach of TVS (Figs 5A and B).

In our case, in the presence of a left adnexal mass, uterus and both ovaries showed no sonographic abnormalities. After bowel preparation, it was possible to "scan along" the colon sigmoideum into the mass suggesting the mass being part of the sigmoid. To confirm this assumption, "NICHE" aspect of three-dimensional ultrasound was used, which is known to be an excellent technique for sonographic spatial evaluation of tubular structures, such as fallopian tube or bowel, enabling assessment of continuity of muscularis and visualization of intratumoral structures in selected sections of the sigmoid[22] (Figs 6A to D).

*Frequency-based color Doppler* imaging provides information about blood flow by analyzing the changes in Doppler shift proportional to velocity changes. Tumor blood vessels have a lack of a media muscularis, which is normally part of the vessel




**Figs 5A and B:** (A) Transvaginal ultrasound of pelvic organs, (B) Normal colon sigmoideum in TVS




**Figs 6A to D:** (A) NICHE aspect sigma tumor grayscale, (B) Multiplanar 3D power Doppler, (C) NICHE 3D PD, (D) NICHE mode power Doppler: Continuity of muscularis, tumor vasculature

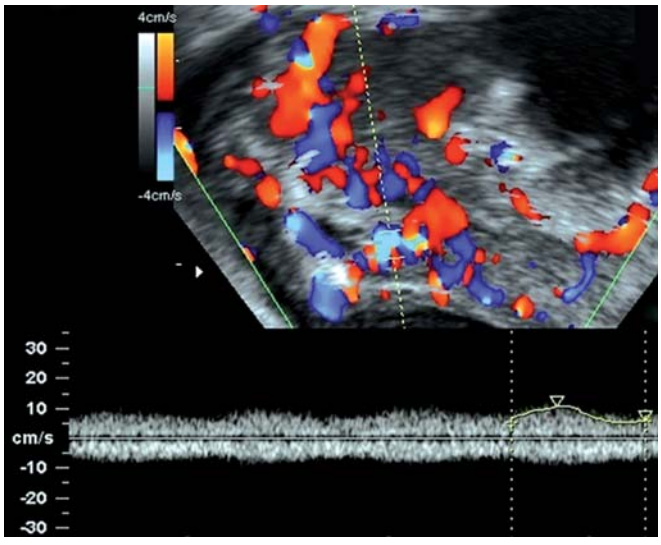



**Fig. 7:** Low resistance index of tumor vasculature in sigma carcinoma

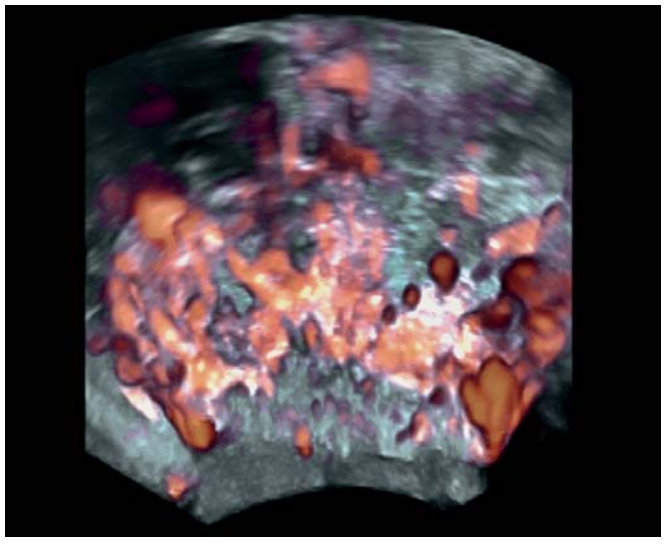


**Fig. 9:** Tumor vasculature in 3D power Doppler

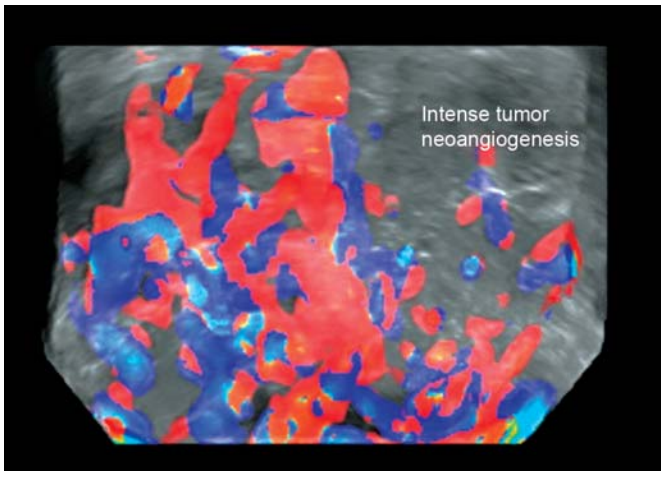



**Fig. 8:** Tumor vasculature sigma carcinoma in 3D color Doppler

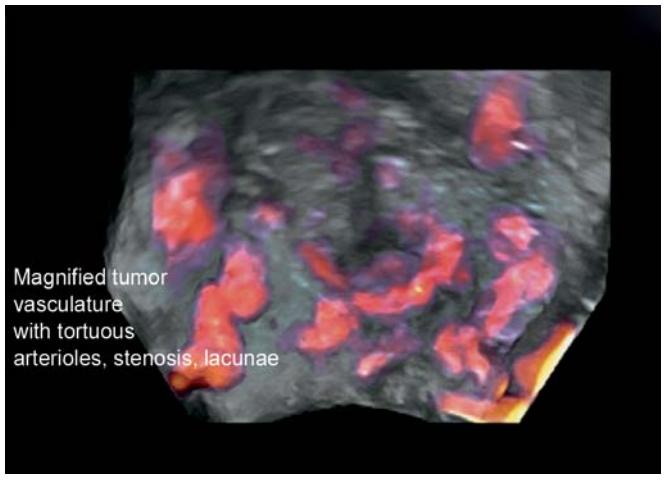



**Fig. 10:** Tumor vasculature magnified 3D PD glass body

wall, and hence are more distensible. This property, combined with arteriovenous shunts typically seen in the tumor vascular network, results in low resistance-to-flow, measured as resistance index around 0.40 (RI) (Fig. 7).

*Three-dimensional power Doppler (3D PD)* for visualization of tumor vasculature is based on "tissue block" technique, where several volumes of a certain region of interest (ROI) in the adnexal mass containing vascular patterns picked up by color or power Doppler, are stored away and rendered (without physical presence of the patient ) by means of a selection of software features like "magic cut", tomographic ultrasound imaging (TUI), "glass body" or NICHE-mode. With this technique, a number of distinct criteria have been developed to define vascularity appearance suggesting malignancy:

1. Loss of tree-like branching of vessels
2. Sacculation of arteries and veins
3. Focal narrowing of arteries
4. Internal shifts in velocity within arterial lumen
5. "Beach Ball"—finding of increased and disorganized peripheral flow surrounding the surface of a malignancy, thus forming a ball-like power Doppler image of vascular signals
6. Increased flow to a center of a solid region
7. Crowding of vascularity
8. "Start and Stop" arteries showing arteries that stop abruptly within the tumor without developing the tree-like branching and how it would be normally seen in a benign mass[23,24] (Figs 8 to 10).

## SUMMARY

This case illustrates the potential of transvaginal ultrasound in detection and structural analysis of nongynecological malignancies in the female pelvis such as CRC. In symptomatic patients with suspicious history and/or positive risk factor assessment for CRC, stool testing for occult blood is mandatory. In addition, TVS can make a valuable contribution to diagnosis and staging of CRC in the hands of an experienced sonographer. Spectral Doppler and newly developed tools like 3D color and power Doppler technique, together with postprocessing options

"glass body" and NICHE mode, do not only enable spatial tumor assessment, but also *in vivo* visualization of tumor vasculature as an outstanding diagnostic marker of malignancy. Hence, as described by a number of authors for ERUS – we consider TVS useful in diagnosis and preoperative T-staging of CRC. The possible role of TVS in screening for CRC needs further evaluation.

## REFERENCES

1. Folkman J. Tumor angiogenesis: Therapeutic implications. N Engl J Med 1971 Nov 18;285(21):1182-86.
2. Kurjak A, Shalan H, Kupesic S, et al. Transvaginal color Doppler sonography in the assessment of pelvic tumor vascularity. Ultrasound Obstet Gynecol 1993;3:173-54.
3. Kurjak A, Kupesic S, Sparac V, Bekavac I. Preoperative evaluation of pelvic tumors by Doppler and three-dimensional sonography. J Ultrasound Med 2001;20:829-40.
4. Jemal A, Siegel R, Xu J, Ward E. American cancer statistics 2010. Available online at: http://cajournal.org and http://cacancerjournal.org.
5. Toms JR (Ed). CancerStats Monograph 2004. Cancer Research UK: London 2004.
6. Giovannucci E, WU K. Cancers of the colon and rectum. In: Schottenfeld D, Fraumeni J. Cancer Epidemiology and Prevention. 3rd ed. New York: Oxford University Press; 2006;809-29.
7. Botteri E, Iodice S, Bagnardi V, et al. Smoking and colorectal cancer: A meta-analysis. JAMA 2008;300:2765-78.
8. Giovannucci E. Modifiable risk factors for colon cancer. Gastroenterol Clin North Am 2002;31:925-43.
9. Popkin BM. The nutrition transition: An overview of world patterns of change. Nutr Rev 2004;62:S140-43.
10. Siegel R, et al. Cancer Epidemiology Biomarkers and Prevention 2009;18:1695-98.
11. Dr. Ehmad Rahmani, chairman of medicine Mafraq Hospital Abu Dhabi, in an interview with Gulf News 23/07/2010.
12. Espey DK, Wu XC, Swan J, et al. Annual report to the nation on the status of cancer, 1975-2004, featuring cancer in American Indians and Alaska Natives. Cancer 2007;110:2119-52.
13. Levin B, Lieberman DA, McFarland B, et al. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: A joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. CA Cancer J Clin 2008;58:130-60.
14. Horton KM, Abrams RA, Fishman EK. Spiral CT of colon cancer: Imaging features and role in management. Radiographics 2000;20:419.
15. Hundt W, Braunschweig R, Reiser M. Evaluation of spiral CT in staging of colon and rectum carcinoma. Eur Radiol 1999;9:78.
16. Ahnen PJ, Macrae FA. Clinical manifestation, diagnosis, and staging of colorectal cancer. UpToDate online, May 2010.
17. Kav T, Bayraktar Y. How useful is rectal endosonography in the staging of rectal cancer? World J Gastroenterol. 2010 Feb 14;16(6):691-97.
18. Nesbakken A, Løvig T, Lunde OC, Nygaard K. Staging of rectal carcinoma with transrectal ultrasonography. Scand J Surg. 2003;92(2):125-29.
19. Rinnab L, Gottfried HW, Schnöller T, Hautmann RE, Kuefer R. Clinical value of transrectal ultrasound in the diagnosis of suspected neoplasia in the small pelvis. Ultraschall Med 2007Apr;28(2):195-200.
20. Scialpi M, Rotondo A, Angelelli G. Water Enema Transvaginal Ultrasound for Local Staging of Stenotic Rectal Carcinoma. January 1998.
21. Honemeyer U. Primary care in Obstetrics and Gynecology: A place for advanced ultrasound? Ian Donald School Journal of Ultrasound in Obstetrics and Gynecology, July-Sept 2009;3(3):61-74.
22. Kurjak A, Kupesic Plavsic S, Honemeyer U. Ultrasonic Characterization of Adnexal Masses. In: Color Doppler and 3D Ultrasound in Gynecology, Infertility and Obstetrics, 2nd edition, Kurjak A and Kupesic Plavsic S, eds. Jaypee Brothers: New Delhi 2010 (in press).
23. Crade M. Tissue block ultrasound and ovarian cancer—a pictorial presentation of findings. Donald School Journal of Ultrasound in Obstetrics and Gynecology 2009;3(1):41-47.
24. Ruey-Feng Chang, Sheng-Fang Huang, Woo Kyung Moon, Yu-Hau Lee, Da-Ren Chen. Solid breast masses: Neural network analysis of vascular features at three-dimensional power Doppler US for benign or malignant classification. Radiology April 2007;243(1).