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REVIEW ARTICLE

The Value of Color and Power Doppler in the Diagnosis of Ectopic Pregnancy

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ABSTRACT

Implantation of the zygote outside the uterine cavity occurs in 2% of all pregnancies. The rate of ectopic pregnancies has increased from 0.5% in 1970 to 2% today. The prevalence of ectopic pregnancy in all women presenting to an emergency department with first-trimester bleeding, lower abdominal pain or a combination of the two is between 6 and 16%. When diagnosis is made early, the product of conception can be removed safely by laparoscopic surgery and be submitted for histological examination. Tubal rupture is a complication of late diagnosed tubal pregnancy which is more difficult to treat conservatively and often indicates tubectomy or segmental resection. In 5 to 15% of treated ectopic pregnancy cases, remnant conception product parts are diagnosed and may require a final methotrexate (MTX) injection. Rare sites of ectopic pregnancy include interstitial, cervical, abdominal and cesarean scar pregnancies. Our manuscript reviews and illustrates the use of novel sonographic methods such as three-dimensional ultrasound, multiplanar view, in combination with color and power Doppler ultrasound, for early detection of ectopic tubal pregnancy and of other, rare locations of ectopic pregnancy.

Keywords: Ectopic pregnancy, Rare forms of ectopic pregnancy, Neoangiogenesis, Pulsed Doppler, Color Doppler, Power Doppler, Three-dimensional ultrasound, Transvaginal ultrasound.

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INTRODUCTION

Usually, oocyte and sperm meet in the ampullary part of the fallopian tube, where impregnation takes place. The growing morula moves slowly toward the uterus cavity while differentiating into the embryoblast and trophoblast. Implantation in the uterine cavity usually takes place after 6 or 7 days. Implantation of the zygote outside the uterine cavity occurs in about 2% of all pregnancies. At present, an ectopic product of conception and its surroundings can be removed safely in more than 90% of cases by laparoscopic surgery and submitted for histological examination. The rate of ectopic pregnancies has increased from 0.5% in 1970 to 2% today. Although the incidence is low, the prevalence of ectopic pregnancy in all women presenting with first-trimester bleeding, lower abdominal pain or a combination of both, to an emergency department is between 6 and 16%.[1]

The majority of ectopic pregnancies are located in the fallopian tube (approximately 97%): ampulla, isthmus, fimbria in descending order. This might be explained by the narrowing of the tubal diameter from the ampullary to the isthmic region, and the fact that fertilization begins in the ampulla. On the other hand the ampullary region is the most distal place where ascending infections can cause phimosis and therefore either infertility or an increased risk for motility disorder may manifest here. One must, however, be aware of more rare and unusual sites of ectopic pregnancies. About 3% are located in the rudimental uterine horn, ovary, abdominal cavity, broad ligament, cervix and vagina, or are simultaneously intra- and extrauterine.[2]

Two hundred years ago, the mortality rate of ectopic pregnancies was over 60%. Today, it has decreased to 9% of pregnancy-related mortality and less than 1% of overall mortality in women. Despite a 5-fold increase in the incidence of ectopic pregnancy from 1970 to 1992, its mortality could be reduced by more than 90%. Until 1970, over 80% of ectopic pregnancies were not diagnosed before rupture, leading to a high rate of morbidity and mortality. Owing to the advances made in transvaginal ultrasound (TVU) and radio immunoassays for serum β-human chorionic gonadotropin (β-hCG) levels, and because of increased vigilance of clinicians with more experience in diagnostic laparoscopy, more than 80% of ectopic pregnancies are now diagnosed intact. This allows a more conservative management and is responsible for the decline from 35.5 deaths to 3.8 per 1,000 ectopics. The decrease of mortality is due to early diagnosis before the occurrence of hemoperitoneum and/or hypovolemic shock.[1-4]

Despite all diagnostic and therapeutical progress and the decline in the invasiveness of laparoscopic procedures, in 50% of all women with ectopic pregnancy presenting to an emergency department, the condition is not detected at the initial medical assessment.[1,5]

DISCUSSION

Etiology and Risk Factors of Ectopic Pregnancy

The incidence of ectopic pregnancies is independent of maternal age and ethnic origin. Theoretically, anything that impedes migration of the conceptus to the uterine cavity may predispose woman to develop an ectopic gestation.

These may be intrinsic anatomic defects in the tubal epithelium, hormonal factors that interfere with normal transport of the conceptus, or pathologic conditions that affect normal tubal function. The hormonal interference is explained by the different effects which estrogen and progesterone have on growth and motility of the epithelial cilia. Another maternal reason can be a dysfunction of the epithelial cilia caused by smoking.[4,6,7]

Ectopic Pregnancy and Neoangiogenesis

The primary function of the corpus luteum is secretion of progesterone for maintenance of pregnancy. The development and function of the corpus luteum from residual follicular granulosa and theca cells after ovulation is induced by the midcyclic peak of luteinizing hormone (LH) secretion and followed by further pulsatile LH release. Due to this stimulation, follicular granulosa and theca cells are converted to large and small luteinized cells with high proliferation rate. During this process vascular endothelial growth factor (VEGF) plays a major role as a potent stimulator of neoangiogenesis. Formation of new blood vessels is essential to ensure supply of LDL-cholesterol as substrate for steroid production. If pregnancy does not occur, the corpus luteum must regress to initiate another cycle.[8] Luteal regression seems to be initiated by prostaglandin F2 (PGF2) alpha which is secreted from the uterus. PGF2 alpha reduces luteal blood flow and progesterone synthesis. Furthermore, it is a potent inducer of apoptosis. If pregnancy occurs, sustained secretion of progesterone and other substances like estradiol and relaxin are required to provide an appropriate uterine environment for maintenance of pregnancy. In that case the corpus luteum is further stimulated by hCG secreted by the blastocyst and the trophoblast cells until 8/9 weeks of gestational age, when synthesis and secretion of steroids is taken over by the placenta.[8]

The major difference between uterine implantation and tubal gestation is that the endosalpingeal stroma usually fails to undergo decidualization. The chorionic villi of the tubal implantation may then invade the tubal wall and mesentery (mesosalpinx) more directly and rapidly. The vascularization within the ectopic pregnancy develops analog to placenta increta.[9]

In such situations, the cytotrophoblast may invade the contiguous artery and vein of mesosalpinx with destruction of the wall of these vessels, and thus may induce a local arteriovenous malformation. Possibly, the secretion of angiogenic factors (by trophoblast) and the increasing afterload of an arteriovenous shunt existing in the tubal gestation, might induce the rapid development of a small pre-existing congenital arteriovenous shunt into a major arteriovenous malformation. Interestingly, two unusual cases of adnexal arteriovenous malformations associated with 'vanishing' ectopic gestation where congenital etiology seemed unlikely, have also been reported.[10,48]

B-mode ultrasound, three-dimensional ultrasound (3D-US), and color/power Doppler can provide valuable diagnostic information on hemodynamics of the vascular tumor and lead to the diagnosis of an arteriovenous malformation. 3D color/power angiography can further improve understanding of the complex vascular local anatomy and refine the diagnosis (Figs 1A to E).[48]

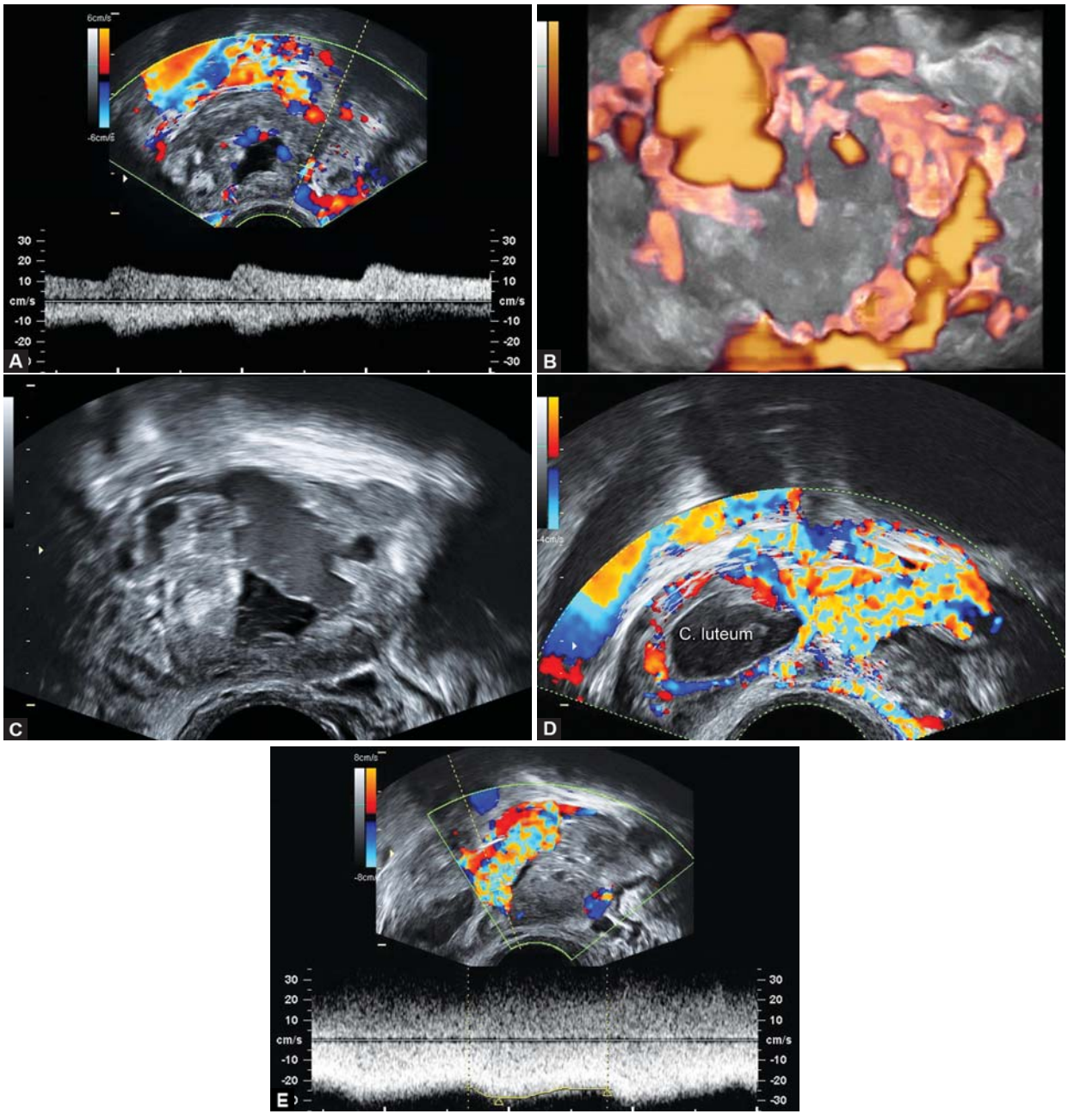
Diagnostic Methods and Preoperative Assessment

After a positive pregnancy test, additional unspecific parameters are a normal or slightly enlarged uterus, vaginal bleeding or spotting, pelvic pain triggered by manipulation of the cervix, and/or a palpable adnexal mass. Apart from mimicking the symptoms of other gynecological and even nongynecological diseases, ectopic pregnancies appear in many variations, often without causing pain during vaginal examination. Anyway, lower abdominal pain can also be experienced in a normal pregnancy.[11]

Usually the earliest appearance of symptoms occurs in the 6th week after the last period. Patients with ectopic pregnancy can show all symptoms of a normal early pregnancy, such as interruption of the normal menstrual period, nausea, vomiting, breast fullness and fatigue. Beyond that, typical symptoms of an ectopic pregnancy are lower abdominal pain and abnormal uterine bleeding, ranging from spotting to severe bleeding. Clinical examination may demonstrate muscular defense and peritonism which are indicators for intraperitoneal blood collection. There may be tenderness on cervical motion. The uterus may be enlarged, with soft consistency. In some cases, an adnexal mass can be palpated.[1] Usually the pain is alternating and spasmodic, followed by intervals free of complaints.[4]

Another leading symptom is uterine bleeding. An extra-uterine gravidity can be associated with complete amenorrhea, recurrent or persistent uterine bleeding, or even a normal menstrual cycle. As most extrauterine gravidities produce only suboptimal hCG levels, the uterus is not able to maintain the decidual transformation of the endometrium. Therefore, often breakthrough bleedings appearing as spotting are the consequence.[4]

The first diagnostic step is the determination of an existing pregnancy which can be detected by an increased β-hCG serum level about 10 days following ovulation. hCG starts with secretion on day 5 to day 8. A serum array detects



Figs 1A to E: Arteriovenous malformation of right adnexal mass after ectopic pregnancy. Serum β-hCG became negative after MTX therapy, but color Doppler signal intensity increased during follow-up, and patient kept complaining of right lower abdominal pain. (A) Adnexal mass with positive β-hCG, MTX therapy, (B) power Doppler glass body of right ectopic tubal pregnancy shows 'ring of fire', (C) B-mode image. 7 weeks later, serum hCG was negative. Arteriovenous malformation: note varicose formation right tube, (D) color Doppler demonstrates dense confluent color signals, partially with aliasing, next to luteal 'ring of fire', (E) pulsed wave Doppler. Note high diastolic flow with faint pulsatility, typical for AV-malformation

levels as low as 5 mIU/ml while the detection limit in urine is 20 to 50 mIU/ml. The β-hCG level doubles every 1.5 days in the first 5 weeks of a regular gestation. After 7 weeks the sequence for doubling of titers is 3.5 days. In comparison, only 30% of ectopic pregnancies show a normal β-hCG course. In 70% of ectopic pregnancies the β-hCG levels rise more slowly and reach a plateau or even show a decrease in serum levels. An abnormal β-hCG pattern is highly suspicious for ectopic gestation, or a gestation which is no longer intact. Ectopic pregnancies can be differentiated from a spontaneous abortion by a slower decrease of the β-hCG serum titer, and by an abnormal rise of the β-hCG levels compared to a normal pregnancy.[7,12-14]

Vaginal Probe with Color/Power Doppler and Pulsed Wave Ultrasound

Color Doppler, power Doppler, and HD flow represent sonographic techniques to visualize (blood) flow. While color Doppler allows differentiation of flow direction, power Doppler does not provide this information, however, is able

to detect slow flow in smaller blood vessels, and proves valuable in depicting neoangiogenesis with low resistance indices. HD flow refers to a recently introduced combination of color and power Doppler, by adding the information of flow direction to the advantages of power Doppler. Ultrasound machines with vaginal probe for color and power Doppler are excellent tools when searching for atypical blood flow signals within the pelvis. In comparison to transabdominal approach, TVU produces much better images of the morphological features in the pelvis due to higher frequencies and a probe location in the middle of the examined area. Sensitivity of transvaginal sonography was found to be 96%, the specificity reached 88%, the positive predictive value 89% and the negative predictive value 95%.[15]

An intrauterine gestational sac (GS) surrounded by double ring, containing a clear embryonic echo is considered to be strong evidence against ectopic pregnancy because heterotopic pregnancy (intrauterine and ectopic), coincide rarely, but should not be so easily ignored, especially in the patients undergoing some of the methods of assisted reproduction.[16,46]

Intrauterine sonographic findings in women with ectopic pregnancy are variable. They include:

1. Empty uterus, with or without increased endometrial thickness.
2. Central hypoechoic area, or sac like structure in uterine cavity—so called pseudogestational sac.[16]

The color/power Doppler flow pattern associated with ectopic pregnancy is variable. It usually exhibits randomly dispersed multiple small vessels within the adnexa (Fig. 2), showing high velocity and low impedance signals (RI = 0.36-0.45). In case of tubal ectopic pregnancy, these signals will be clearly separated from the ovarian tissue and corpus luteum (Figs 3A to C). The sensitivity of transvaginal color/power and pulsed Doppler in diagnosis of ectopic pregnancy has been analyzed in several studies, and ranges from 73 to 96%, with a specificity of 87 to 100%.[17-20]

Visualization of ipsilateral corpus luteum blood flow is one important feature of tubal ectopic pregnancy and may aid in diagnosis of ectopic pregnancy (Fig. 4). The resistance index (RI) of luteal flow in the cases of ectopic pregnancy

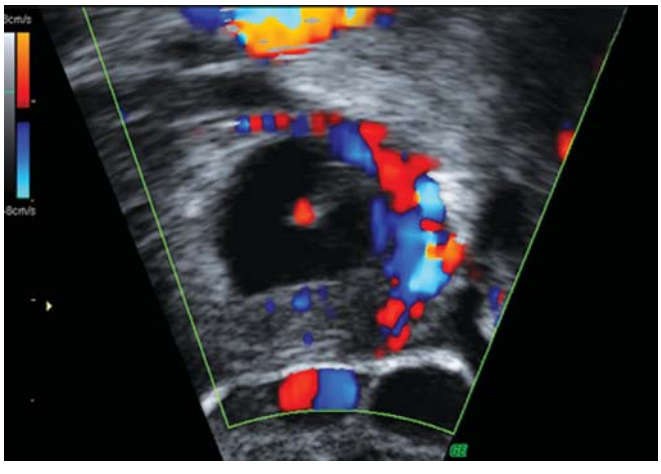
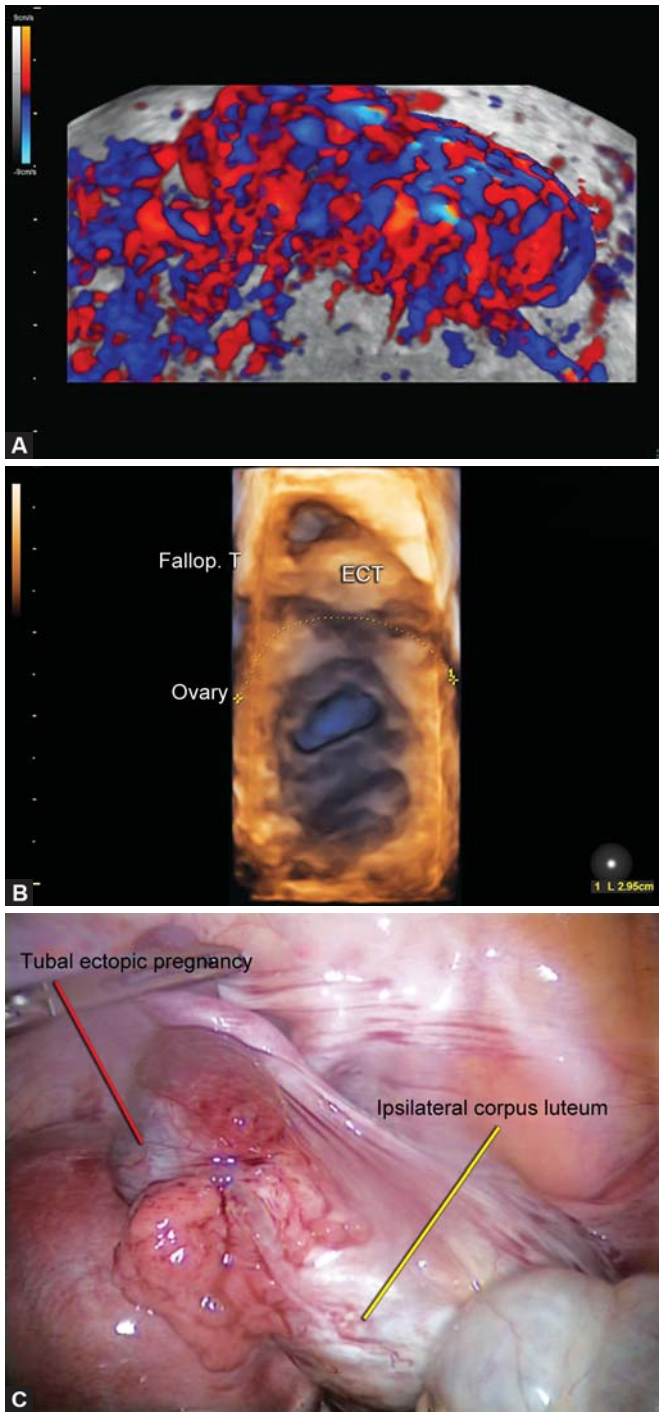


Fig. 2: Viable tubal ectopic pregnancy, color Doppler shows randomly dispersed color signals



Figs 3A to C: Analysis of spatial relation between suspected tubal ectopic pregnancy and ovary: (A) HD flow of tubal ectopic next to ipsilateral corpus luteum. Note intense neovascularization, (B) 3D surface rendered image with spatial differentiation of ovary and affected tube, (C) Tubal ectopic pregnancy with ipsilateral corpus luteum, laparoscopic image

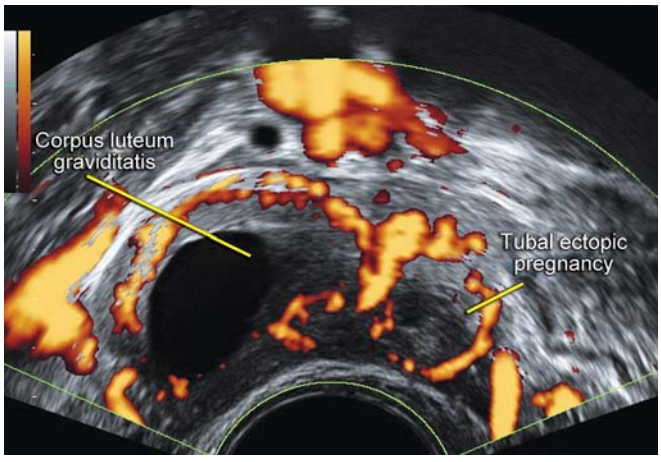


Fig. 4: Ectopic tubal pregnancy and ipsilateral corpus luteum with double 'ring of fire'

has been reported to be 0.48 ± 0.07, which is between the values of the nonpregnant women (0.53 ± 0.09) and those with normal early intrauterine pregnancy (0.42 ± 0.12).[21]

In the majority of patients with proven ectopic pregnancy, luteal flow is detected on the same side as the ectopic pregnancy. This observation could be used as a guide in searching for ectopic gestation.

The in-between-sides difference in tubal artery blood flow was also documented. There was a significant increase in the tubal artery blood flow on the side of tubal gestation. The mean reduction of the RI on the side with the ectopic pregnancy compared to the opposite side was 15.5%. The abnormal implantation and tubal trophoblast invasion of the ectopic pregnancy can cause more marked blood flow changes in the adjacent supplying vessels, than in the main uterine arteries.[18,22]

These changes appear to be due to trophoblastic invasion, and showed no dependence on gestational age. Bright color on the screen while using the pulsed Doppler facility is due to very high speed of the peritrophoblastic blood flow, and low impedance. It should be emphasized that patients with tubal abortion demonstrate a significantly higher vascular impedance of peritrophoblastic flow (RI > 0.60), and less prominent color signals.

The main diagnostic importance of transvaginal color, power and pulsed Doppler consists in the capacity to differentiate the nature of nonspecific adnexal masses. Doppler blood flow indices in the uterine, spiral arteries and luteal arteries in ectopic and intrauterine pregnancies showed that the mean uterine and spiral artery RI decreased with increasing gestational age of the intrauterine pregnancies, but remained constantly high in ectopic pregnancies.[23]

The peak systolic blood flow velocity in the uterine artery increased with increasing gestational age in intrauterine pregnancies, and the values were significantly higher than in ectopic pregnancies.[24]

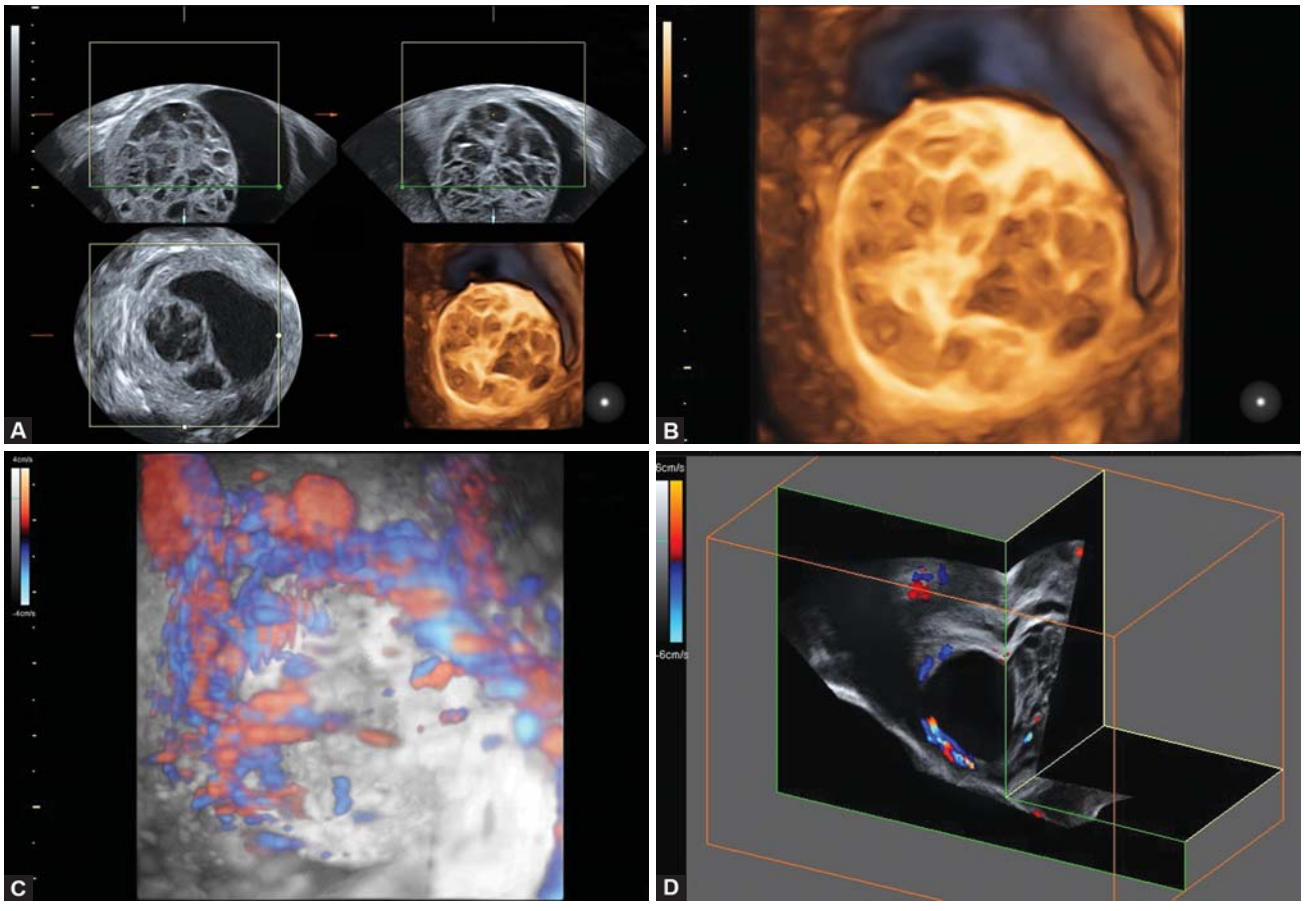
The difference in peak systolic velocity reflects a decreased blood supply to the ectopic pregnancy. Furthermore, the intrauterine GS shows prominent peritrophoblastic vascular signals (RI = 0.44-0.45), while pseudogestational sacs do not demonstrate increased blood flow (RI > 0.55). It has been suggested that velocities below 21 cm/s are diagnostic for a pseudogestational sac and can successfully rule out trophoblastic flow of a normal intrauterine pregnancy.[25]

Intravascular ultrasound contrast agents may have a recognizable effect on clarity of Doppler ultrasonographic findings of the adnexal circulation. They seem to be helpful when the findings in color flow imaging are doubtful. The use of contrast agents may also facilitate the localization of trophoblastic tissue in hemorrhagic adnexal lesions.[26]

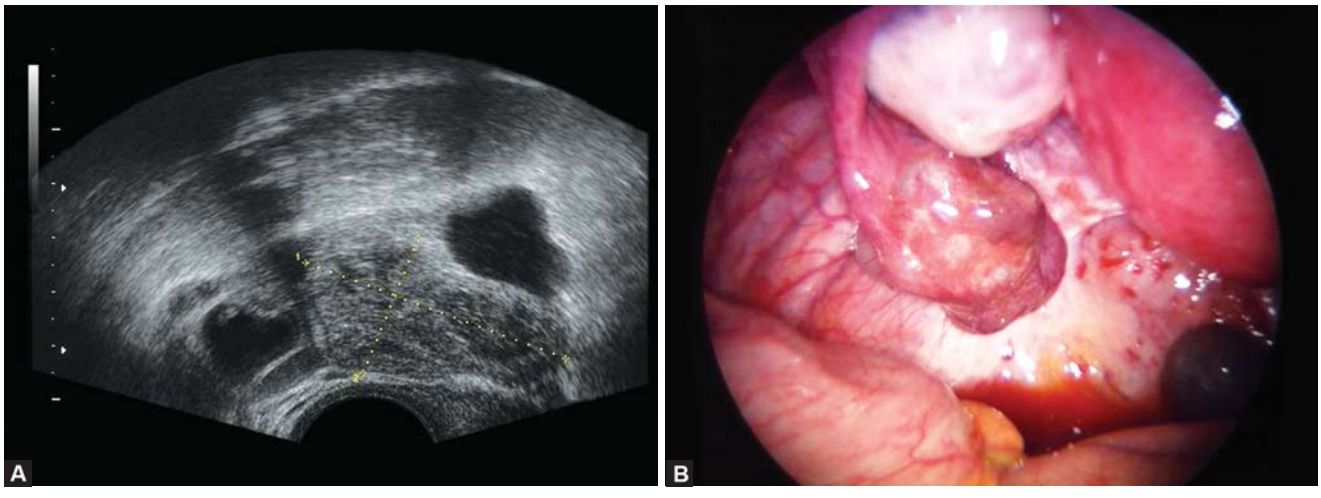
In 5 to 15% of treated ectopic pregnancy cases, remnant parts of conception products are suspected and may require a final MTX injection. To localize such remnant trophoblast material before MTX treatment, use of contrast sonography could be an option and be helpful in follow-up of the lesion, in addition to sequential β-hCG serum level testing.[27,28]

As other diagnostic methods, transvaginal color, power and pulsed Doppler studies include both, false-positive and false-negative findings. A false-positive diagnosis arises predominantly from the corpus luteum, also known as the 'great imitator', but in exceptional cases some adnexal lesions may also mimic ectopic pregnancy (Figs 5A to D). A false-negative result may arise from technical inadequacy, lack of experience of the ultrasound operator or patient's noncompliance. The other possibility of fault diagnosis is nonvascularized ectopic gestation (chronic ectopic pregnancy), as these are associated with low or absent β-hCG values. Chronic ectopic pregnancy is not a rare clinical entity and should be considered in differential diagnosis among patients presenting with an adnexal mass and an overt clinical picture. Transvaginal sonography is sensitive in diagnosing chronic ectopic pregnancy, but not specific. In their study of 55 cases of chronic ectopic pregnancy diagnosed intra- or postoperatively, Turan et al (1995) described 30 patients who had color Doppler flow examination, and of whom none had color Doppler flow imaging on the wall of the mass or within the mass. Only the combined use of transvaginal ultrasonography and β-hCG assay could increase diagnostic accuracy. However, it should be kept in mind that a negative β-hCG value does not rule out chronic ectopic pregnancy (Figs 6A and B).[29]

Some authors explained diagnostic failure with improper setting of color flow parameters.[30]



Figs 5A to D: Corpus luteum, the 'Great Imitator': (A) 3D ultrasound: A, B, and C plane, and surface rendered image of corpus luteum, (B) 3D surface rendering, magic cut. Note webbed structures and vacuoles, mimicking neoplasm, (C) glass body power Doppler mode, note outer reticular neovascularization, (D) niche mode color Doppler showing outer, but no inner vascular signals



Figs 6 and B: Chronic ectopic pregnancy with negative serum β-hCG: (A) B-mode left adnexa. Note solid area surrounded by cystic formations, (B) laparoscopic image of left tube and ovary before salpingectomy. Histopathology of tube confirmed 'ghost villi' of chronic ectopic pregnancy

The color velocity scale, color priority, color gain, color sensitivity and color wall filter should be adjusted to optimize color flow information. Technical errors may result in false diagnosis of ovarian torsion, malignancy and ectopic pregnancy.

Doppler Diagnosis and Therapeutic Management

The diagnosis of ectopic pregnancy still remains a challenge to the clinician despite advances in ultrasound and biochemical technology. Frequently the diagnosis remains uncertain until laparoscopy or D&C are performed. With

the increasing tendency toward conservative therapy, the distinction between ectopic pregnancies that will resolve spontaneously and those that will rupture is essential.[31]

Usually patients without acute symptoms and with declining β-hCG values are treated conservatively.[32]

However, secondary ruptures have been reported in patients with low initial β-hCG concentrations.[33]

The differentiation between viable ectopic pregnancies with trophoblastic activity, and dissolving tubal abortions could facilitate the decision to proceed with conservative or operative treatment.

After implantation in the mucosa of the endosalpinx, the lamina propria and then the muscularis of the oviduct, the blastocyst grows mainly between the lumen of the tube and its peritoneal covering.[34]

Growth occurs both parallel to the long axis of the tube and circumferentially around it. As the trophoblast invades surrounding vessels, intensive blood flow and/or intraperitoneal bleeding occur, and the risk for complications increases. The intensive ring of vascular signals could be a criterion for viability of an ectopic pregnancy that can be determined rapidly and easily and seems to be independent of β-hCG values, and may direct decisions on clinical management.[35]

In patients with a viable ectopic pregnancy who demand a conservative treatment, color/power Doppler could provide an aid, in addition to β-hCG values, for supervising the efficacy of treatment, especially in those cases where β-hCG levels come down only slowly. In this way duration of hospitalization could be shortened, the patient's uncertainty reduced, and the costs of treatment kept low. In cases of persisting high β-hCG levels after operative removal of the ectopic trophoblast, color Doppler sonography could provide evidence of remaining viable trophoblast requiring additional therapy. And on the other hand, in asymptomatic patients with hypoperfused and/or avascular ectopic trophoblast and decreased values of β-hCG, management could be expectative.

Color/Power and Pulsed Doppler in Rare Forms of Ectopic Pregnancy

Interstitial or Cornual Pregnancy/Rudimental Uterine Horn

The intramural or interstitial part of the uterus/tube is highly vascularized. This rare type of tubal pregnancy occurs in 1 of 5,000 live births (2-4% of all ectopic pregnancies) and has an increased risk of traumatic rupture with hemorrhagic shock and maternal death. Its mortality rate is about 2%. This is due to the high vascularity of this area where the uterine and ovarian vessels join together. This localization is a great challenge even for experienced surgeons. The classical treatment methods are laparotomy, uterine horn resection or even hysterectomy. The intramural or interstitial pregnancy lies deep in the myometrium and therefore has to be treated conservatively or by laparoscopy with the possibility to convert quickly to laparotomy, in combination with hysteroscopy. The cornual pregnancy, by contrast, implants in the same anatomical area of the tube but opens to the uterine cavity. Therefore, the operative method of choice can be hysteroscopy. To avoid uterine perforation, larger pregnancies can be removed by curettage under laparoscopic guidance (Figs 7A to F).[2,3,7,36,48]

Cervical Pregnancy

Cervical pregnancy is a threatening localization for the patient. Due to the anatomic closeness to the uterine artery, the cervical trophoblast connects early to the corresponding large uterine vessels. The criteria for a cervical pregnancy have been described by Rubin in 1911:

1. Cervical glands must be present opposite the placental attachment.
2. The attachment of the placenta to the cervix must be intimate.
3. The placenta must be below the peritoneal reflection of the anterior and posterior surfaces of the uterus.
4. Fetal elements must not be within the uterine cavity.[37]

These criteria are easily 'ticked off' by means of transvaginal 3D-US (Fig. 8), and the extent of vascularity around the trophoblast becomes strikingly evident once color/power Doppler is activated.

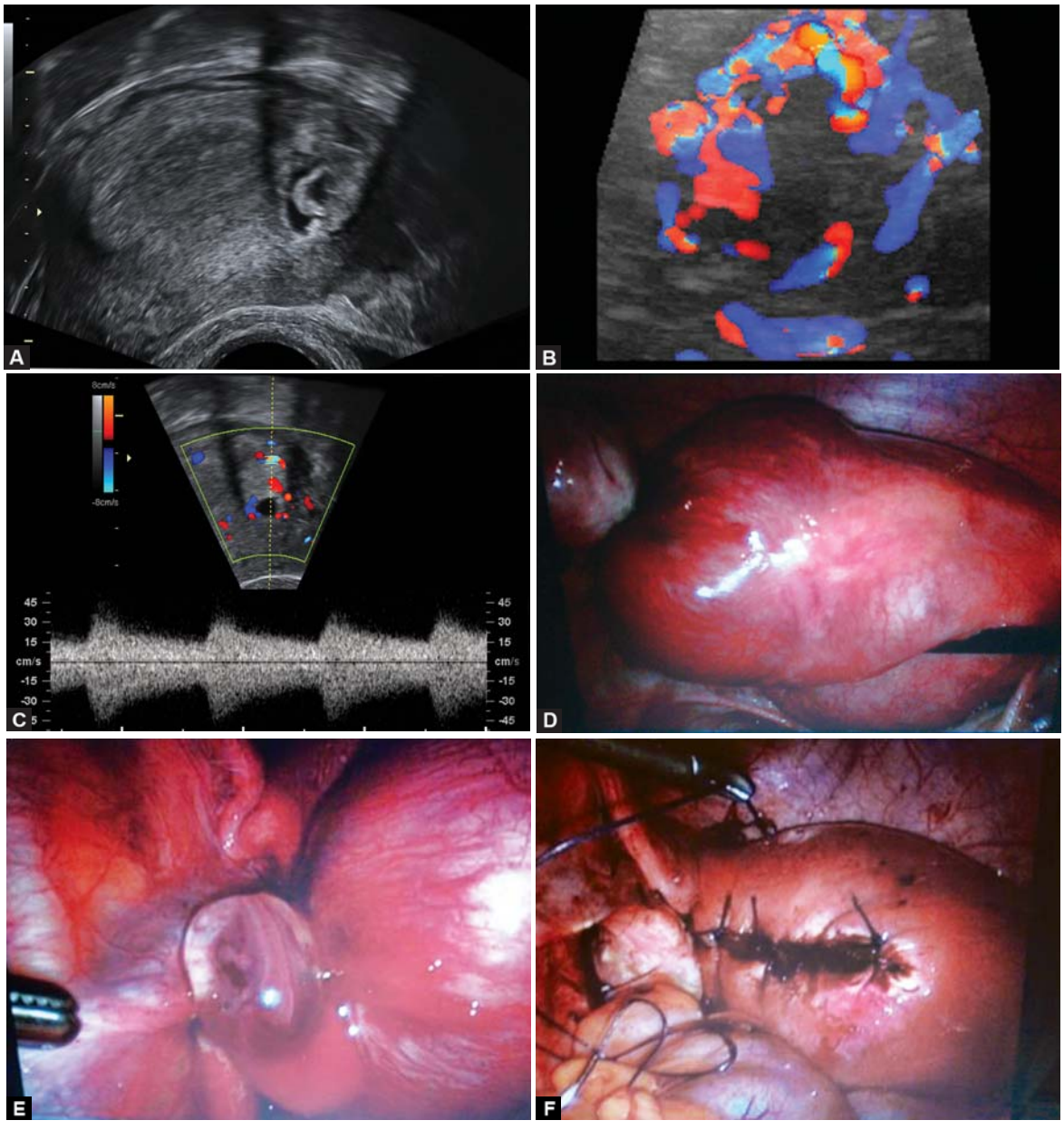
Early detection of a cervical pregnancy is a chance for conservative approach and should initiate a local or systemic medical treatment with MTX. The medical treatment can be accompanied by selective uterine artery embolization. Conservative therapy works only in those cases diagnosed before 12 weeks due to progressive trophoblast invasion of the cervical wall, accompanied by increasing MTX resistance.[38]

Cervical pregnancy is associated with high morbidity and has the potential for massive hemorrhage. Mortality is fortunately now low, due to early US diagnosis with transvaginal high resolution probe.

MTX can prevent hysterectomy in 91%. The treatment of choice in the 2nd trimester remains still hysterectomy. Pitfalls in differential diagnosis include abortion, and isthmic pregnancy (which can go to term!).[39-41]

Cesarean Scar Pregnancy

Ectopic pregnancy in a previous cesarean (hysterotomy) scar is seen once in 2,000 pregnancies, and contributes 6% to



Figs 7A to F: Interstitial- or corneal pregnancy: (A) B-mode, transverse view of uterus. Note cornual GS, outside of a low echogenic thickened endometrium, (B) color Doppler image of cornual ring of fire shows trophoblast neoangiogenesis, (C) note low resistance to flow in trophoblast vessels, (D) laparoscopic demonstration of hypervascularized left horn, (E) ruptured left horn with protruding embryo, (F) situs after resection of left horn and closure with endosutures

the total number of ectopic pregnancies found in women with a prior cesarean delivery. Mean gestational age at clinical manifestation is 7.5 ± 2.5 weeks. Patients present mostly with painless vaginal bleeding. In a series of 112 cases of cesarean scar pregnancies, the following outcomes were registered: expectant management of six patients resulted in uterine rupture requiring hysterectomy in three patients. Dilation and curettage was associated with severe maternal morbidity like massive hemorrhage. Wedge resection and repair of the implantation site via laparotomy or laparoscopy was successful in 11 of 12 patients. Simultaneous administration of systemic and intragestational MTX to five women, all with β-hCG exceeding 10,000 mIU/ml, required no further treatment.[42]

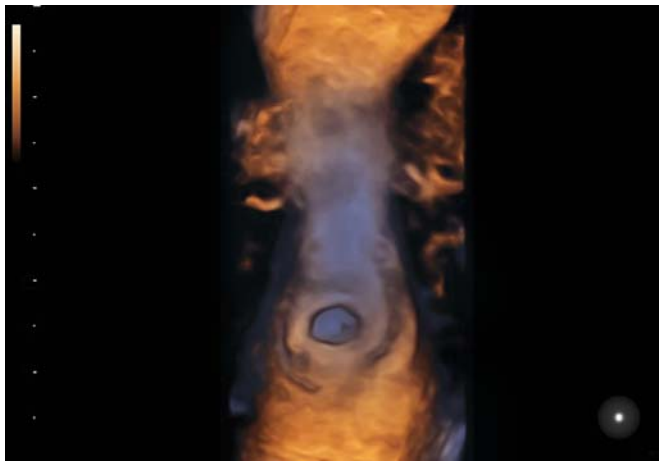
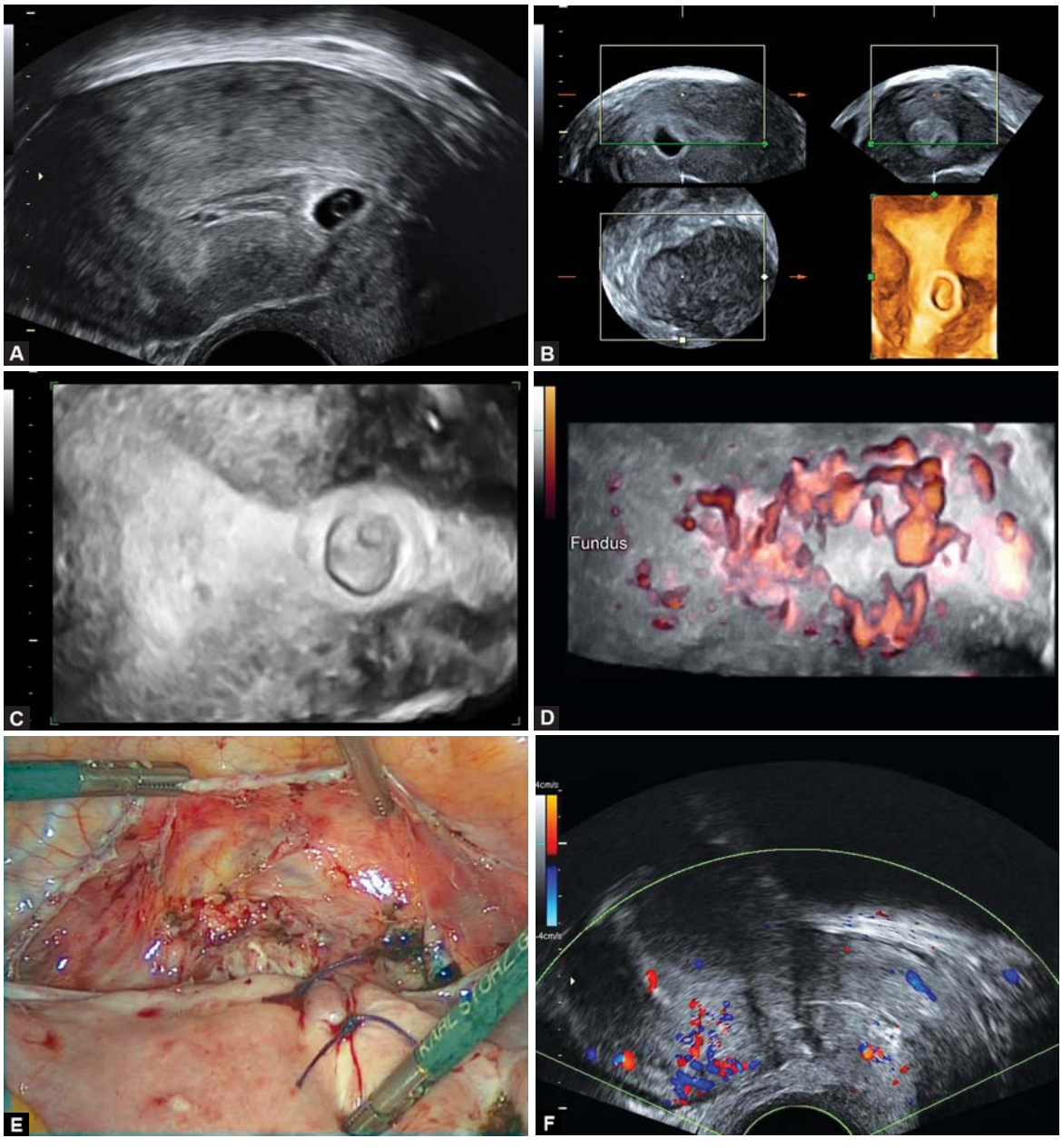


Fig. 8: Cervical pregnancy, surface rendered 3D image

TVU is highly accurate in detecting cesarean hysterotomy scars. The cesarean scar defect, defined by the presence of fluid within the incision site, was more common when labor had preceded cesarean delivery, and after multiple cesarean deliveries.[43]

Early diagnosis can offer treatment options of avoiding uterine rupture and hemorrhage, thus preserving the uterus and future fertility. Available data suggest that termination of pregnancy is the treatment of choice in the first trimester soon after the diagnosis. Expectant treatment has a poor prognosis because of risk of rupture. There are no reliable scientific data on the risk of recurrence of the condition in future pregnancy, role of the interval between the previous cesarean delivery and occurrence of cesarean scar pregnancy, and effect of cesarean wound closure technique on cesarean scar pregnancy.[44]

3D color/power Doppler is useful to quantify neovascularization around the ectopic trophoblast. Visualization of vascularity will improve accuracy of decisions in the individual management of each case, when pondering the options of conservative versus laparoscopic approach, uterine artery ligation or -embolization. Postoperative follow-up Doppler allows sufficient judgment of operative results and eventual trophoblast remnants (Figs 9A to F).[45]



Figs 9A to F: Cesarean scar pregnancy: (A) B-mode, sagittal plane of uterus. Note GS in level of cesarean scar, (B) 3D surface rendered image demonstrates GS distending isthmic uterine segment, (C) glass body mode, GS, just above the inner cervical os, (D) power Doppler glass body mode. Note the intense trophoblast neovascularization, (E) laparoscopic situs after clipping of uterine arteries and removal of trophoblast from cesarean scar niche, (F) color Doppler, sagittal plane of uterus, 4th postoperative day. Note absence of vascularity around cesarean scar

CONCLUSION

The combination of β-hCG testing and high resolution transvaginal ultrasound (TVS) has changed our approach to patients with suspected ectopic pregnancy. An important advantage of currently used transvaginal transducers is their ability to allow simultaneous 3D, color and spectral Doppler studies, enabling the operator to identify the ectopic peritrophoblastic flow. Therefore, color/power Doppler should be applied whenever, a finding is suggestive of ectopic pregnancy. Transvaginal 3D-US enables the clinician to perceive the true spatial relations and thus easily distinguish the origin of an adnexal mass, while 3D power Doppler permits detailed analysis of the vascularization. Transvaginal color and pulsed Doppler imaging may be potentially used for detection of patients with less prominent tubal perfusion, suitable for expectant management of ectopic pregnancy. It is likely that increased sensitivity of serum β-hCG immunoassay and of quality of transvaginal B-mode, color Doppler, and more recently 3D-US combined with color and power Doppler facilities, will allow even earlier detection with more conservative management of ectopic pregnancies. Furthermore, it seems that fertility outcomes and number of women attempting to conceive after ectopic pregnancy will also increase.

Core Statements

- Ectopic pregnancy remains a serious and life-threatening condition.
- With TVU alone, correct diagnosis could be missed.
- Serum β-hCG is essential in unclear adnexal masses.
- If in doubt, serial serum β-hCG and TVS follow-up, or even diagnostic laparoscopy, will clarify diagnosis.
- Careful diagnostic evaluation of ectopic pregnancies with high resolution TVS is required to recognize their exact localization.
- 3D color and power Doppler help to determine anatomy and intensity of neovascularization and may direct interventional choices.
- *In vitro* fertilization and increased cesarean section rates contribute to more frequent occurrence of uterine ectopic pregnancies.[46,47]
- Treatment options of uterine ectopic pregnancies include MTX, uterine artery embolization/ligation and minimal invasive laparoscopic surgery.
- Misjudgment of uterine ectopic pregnancies can lead to catastrophic developments and hysterectomy.

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