SPECIAL ARTICLE

Transvaginal Ultrasound in Obstetric Practice

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Ultrasound is an important diagnostic aid in modern obstetrics and has contributed greatly to the improvement in perinatal outcome over recent decades. Initially, ultrasound was looked upon in obstetrics with skepticism because the quality of the information was dubious, and there were some concerns regarding its safety for the fetus. Gradually these concerns were muted as detrimental effects were not identified, and thus ultrasound could be used whenever clinically indicated. Conventional transabdominal sonography is frequently used in pregnant patients. However, technological advances in sonographic imaging are continuing, the most recent being the application of intracavitary scanning, particularly transvaginal sonography. The use of "high frequency" transvaginal probes result in improving resolving capacities to allow earlier and more difinite diagnosis than the conventional transabdominal techniques.

Instrumentation and scanning technique

Many munufacturers now offer high resolution dedicated transvaginal transducers, with frequencies in the 5 to 7.5 MHz range, for use with their standard equipment. The preferable transducer is 6.5 MHz[1]. The depth of field used in conventional transabdominal sonography necessitated the use of low frequency transducers with their inherent less detailed resolving capacities. The proximity of the organs in the region of interest with the transvaginal technique allows the use of a higher resolution and shorter focal zone transducer. The focal properties as well as the lateral and axial resolution of the 3.5, 5.0, and 6.5 MHz sector vaginal probes are compared in Figure 1[2].

The technique of performing a transvaginal scan is relatively simple. The patient is examined in the lithotomy position using a simple gynaecological examination table with stirrups (Figure 2). The reverse Trendelenburg position may be advantageous due to the pooling of pelvic fluid in the cul-de-sac. The examination is better performed with an empty bladder, as a full bladder may a) displace most of the pelvic organs beyoud the reach of the focal zone of the transducer

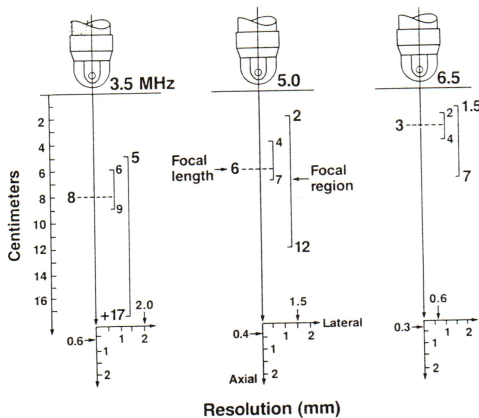


Fig. 1 Comparative figure showing the focal region, focal length as well as the lateral and the axial resolution of the 3.5, 5.0, and 6.5MHz probes.

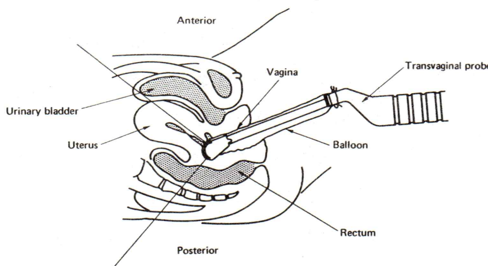


Fig. 2 The relationship between transvaginal probe and pelvic organs.

(within 7 cm), b) produce a disturbing enhancement effect and, c) distort pelvic anatomy[3]. The only exception may be the imaging of a low lying placenta because a half-full bladder will help in outlining the anterior aspect of the cervix and the internal os. The transducer/probe is covered with a condom or a rubber glove containing coupling gel. This is then lubricated with more gel on the outside of the cover and inserted into the vagina. Scans can be obtained in the sagittal and semicoronal planes.

A systematic approach with transvaginal scanning is recommended. First, on the way in, scan the cervix, then the uterus is evaluated and followed by evaluation of adnexae. After this, the cul-de-sac is scrutinized for fluid or abnormal structures. Finally, other places, structures and additional pathologies are studied.

Pelvic structures may be brought closer to the end of the transducer by placing a hand on the patient's abdomen similar to that of a bimanual examination. Similarly, the mobility of the pelvic organs can be assessed by gentle manipulation of the probe into and out of the vaginal fornices and in case of pelvic pain the probe can be used to find the exact place of the maximum tenderness, similar to that used for a pelvic examination but this time under direct vision.

At the completion of the scan, the screen should be observed during withdrawal of the transducer so as to detect cervical or vaginal pathology which may be evident.

Major limitations of the transvaginal scan are limitations in the field of view and difficulties with orientation.

The display of transvaginal image was not standardized, until Bernaschek and Deutinger[4] recently suggested a standardized image display defined according to anatomical principles. The contact surface of the transvaginal probe should be projected to the bottom of the screen. For the

sagittal section, the left side the screen should correspond with dorsal and the right side with ventral (Figure 3). For the transverse section, the bottom of the screen corresponds with dorsal and the top with ventral; the right side of the patient is imaged on the left of the screen, and the left side of patient is imaged on the right (Figure 4).

Embryology

Early embryonic development

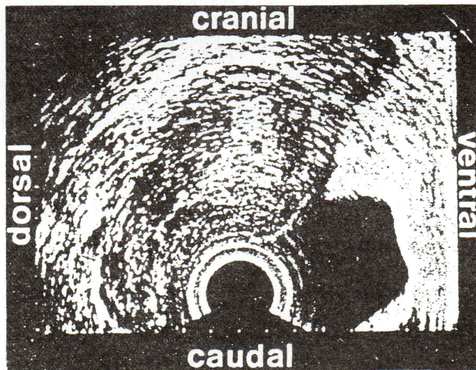


Fig. 3 Transvaginal sonography : correct image of the longitudinal section of an anteverted uterus using a frontally radiating sector scanner.

Fig. 4 Transvaginal sonography : classification of left and right in cases of cross-section of the uterus.

can be studied in detail with high frequency transvaginal probe (6.5 MHz). This facilitates insight into first trimester perinatology[5-9]. In this review, gestational age is expressed in menstrual weeks and days from a certain and reliable LMP or 14 days added to presumed day of conception.

The first sign of an intrauterine pregnancy on transvaginal scan is an intrauterine gestational sac (Figure 5) which can be detected as early as four weeks and 1 day. At this time, its diameter is about 2-3 mm. The discriminatory zone, i.e. the level of quantitative serum β–hCG at which a gestational sac should be sonographically visible, has been found to be in the range of 500-800 mIU (The First International Reference Preparation)[5] with trasvaginal sonography, in contrast to the zone reported for conventional transabdominal sonography (1800-3000 mIU/ml)[10].

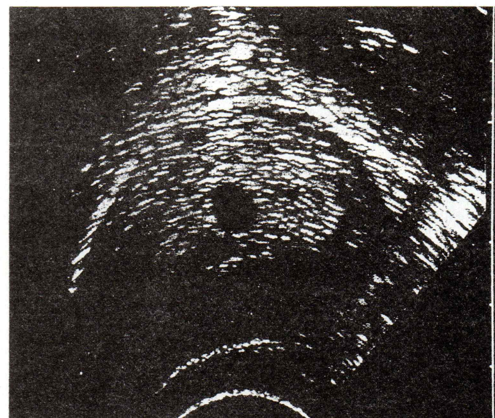


Fig. 5 Transvaginal sonography clearly demonstrates a hypoechoic gestational sac surrounded by an achogenic trophoblastic ring at five menstrual weeks.

The yolk sac (Figure 6) may be detected within the gestational sac at 5 weeks. The yolk sac at this time measures 2.5-3 mm. The structure to appear next is the embryo itself. At around six weeks, the crown-rump length (CRL) is about 3-4 mm, the heart beat is also seen within the tiny fetal embryonic pole. During week seven, when the CRL is about 12-14 mm, the small embryo assumes a curled-up position within the amnion. At this stage of gestation, it becomes apparent that the yolk sac lies within the extraembryonic coelom between the amnion and the chorion which lines the endometrial cavity.

The fetal heart beat can be first detected at five weeks and four days. By the sixth week, the majority of embryos have visible heart beats. During the ninth week, the septum within the ventricle can be recorded on the M-mode. After 14 weeks, a clear four-chamber view becomes visible.

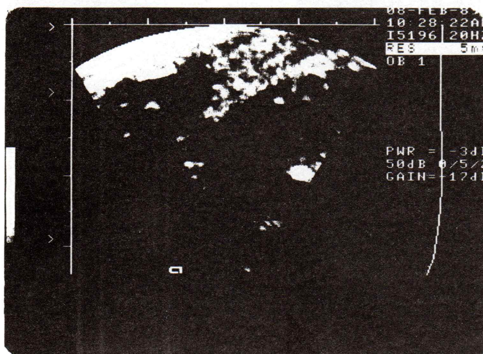


Fig. 6 The yolk sac appears as a 3-4 mm hypoechoic structure within the well-defined gestational sac.

The limbs

The arms and the forearms can be studied from week ten (Figure7). The lower limbs can be studied starting at eleven weeks. The fingers can be counted reliably after week eleven and quite easily after week twelve.

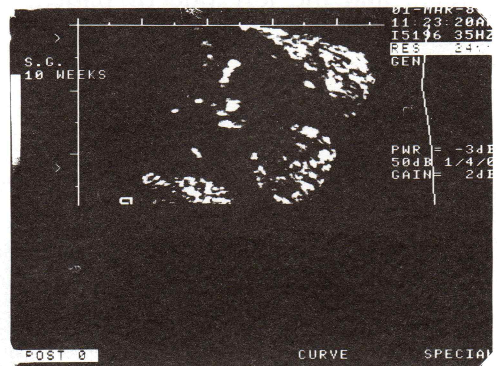


Fig. 7 Transvaginal sonography shows a clear picture of both arms at 10 weeks gestation.

The face

The face can be identified from eleven weeks. Bony structures are evident earlier, sometimes at 9 or 10 weeks, and soft tissue, such as the nose and the lips, somewhat later (12-13 weeks, Figure 8).

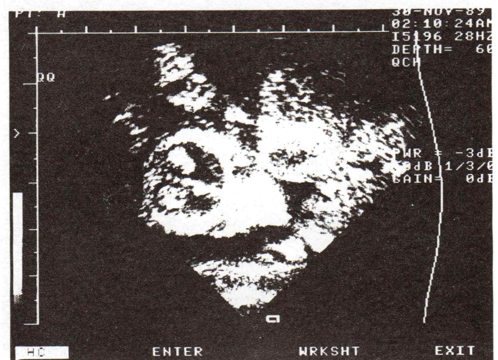


Fig. 8 Transvaginal sonography demonstrates choroid plexus and details of fetal face at 11 weeks gestation.

Physiologic herniation of the midgut

The midgut herniation can be recognised starting week 8 (Figure 9), when it becomes obvious, eventually disappearing completely during the eleventh week.

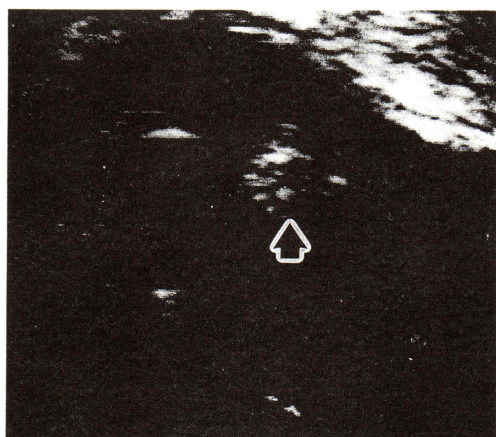


Fig. 9 Physiologic bowel herniation (arrow) within the umbilical cord may be more clearly seen transvaginally as shown in this 10 week fetus (magnified image).

The central nervous system

The central nervous system can be seen as early as the seventh week with the appearance of the unpartitioned single ventricle, while the spine can be reliably seen from week 9.

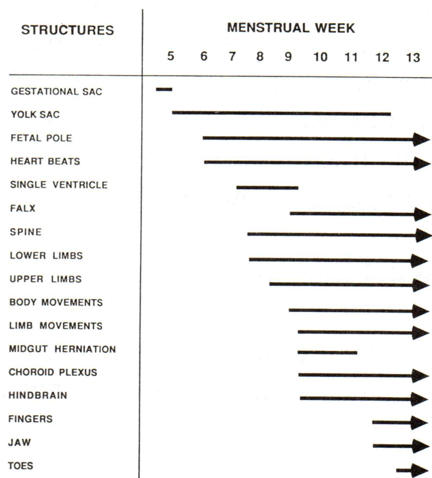


Fig. 10 Sequential appearance of embryonic structures/functions.

Table 1 Detection times for embryonic structures

Embryonic/Fetal structures	Gestational age at detection	
	TVS	**TAS**
Gestational sac	4 wk 1-3 d	5 wk
Yolk sac	5 wk	6-7 wk
Fetal heart beats	5 wk 6 d	6 wk 4-7 d
Limb buds	8 wk	9 wk
Head	8 wk	9 wk
Ventricles	8 wk 2-4 d	11 wk
Choroid plexus	9 wk	11-12 wk
Hands, Fingers	12 wk	17-20 wk

TVS = Transvaginal sonography, TAS = Transabdominal sonography

The genitalia

Since the phenotypic appearance of male and female genitalia become distinct only at around week 14, it is impractical to study the genitalia before this gestational age.

The sequential appearance of embryonic structures/functions detected by transvaginal sonograbhy is shown in Figure 10[5], and the comparison of detection times for embryological structures with transabdominal sonography is shown in Table 1[3].

Prenatal diagnosis

The clinical application of transvaginal sonography to prenatal diagnosis is outlined in Table 2.

Table 2 Transvaginal sonography in prenatal diagnosis

First trimester:
early detection of fetal anomalies
Second and third trimesters:
visualization of structures within focal zone
Diagnostic procedures:
early amniocentesis, transvaginal chorion villus biopsy, first trimester fetal blood sampling

Fetal anomalies

With the development of high-resolution transvaginal sonographic systems together with the knowledge of normal embryology as previously described, it has become possible to diagnose some major congenital abnormalities in the first trimester (Figures 11-15). The fetal abnormalities which can be definitely, probably or possibly diagnosed during the first trimester are shown in Table 3[11-16]. Two reasons for caution must be stressed. Firstly, every technical advance in ultrasound imaging has revealed structures not previously seen in the fetus and there is inevitably a lag period before their importance can be properly judged, this is especially true for first trimester diagnosis since our knowledge of the natural history of disorders at that stage is limited. Secondly, the main advantage of first trimester fetal diagnosis is that the pregnancy can be terminated (if indicated) by curettage or vacuum aspiration whereas prostaglandin-induced abortion is necessary during the second trimester. Whilst patients prefer first trimester termination, the technique of curettage or vacuum aspiration greatly limits the ability to confirm the pre-

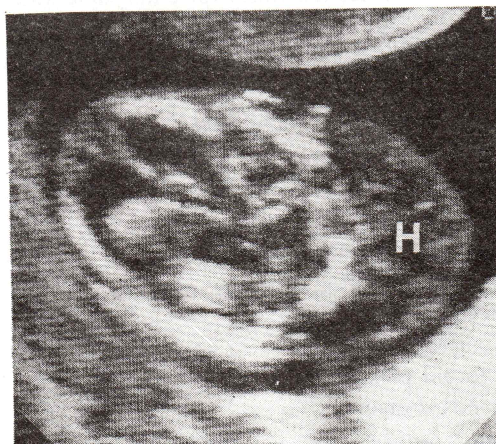


Fig. 11 Transvaginal sonography demonstrates a nuchal cystic hygroma (H) at 11.5 weeks from LMP.

operative diagnosis. It would be doubly tragic for a normal fetus to be aborted because of a mistaken diagnosis made with this new technique, and for the error to go undetected because of the nature of the abortion.

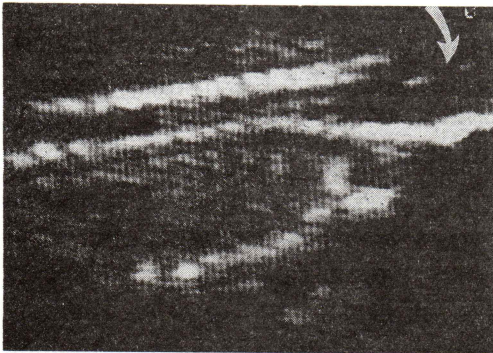


Fig. 12 Transvaginal sonography shows longitudinal scan of fetal spine at 11.5 weeks from LMP demonstrating a cervical spina bifida.

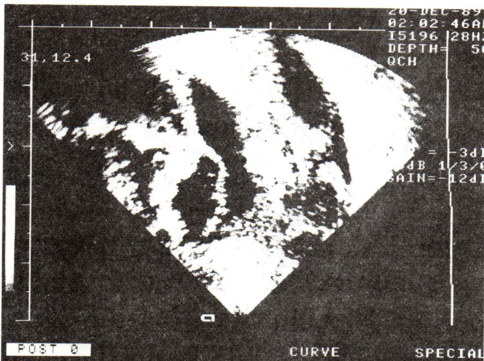


Fig. 13 Transvaginal sonography shows cross-sectional scan of a lumbar spina bifida which could not be seen by transabdominal scan at 6 weeks gestation.

Diagnostic procedures

Early amniocentesis

Transabdominal sampling of amniotic fluid has traditionally been

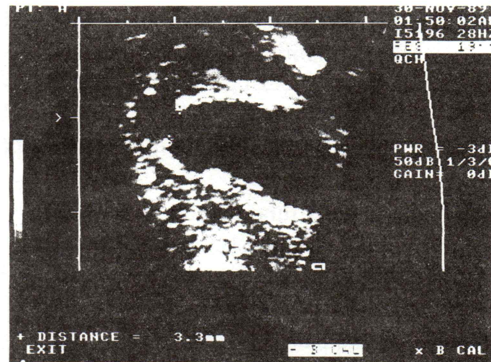
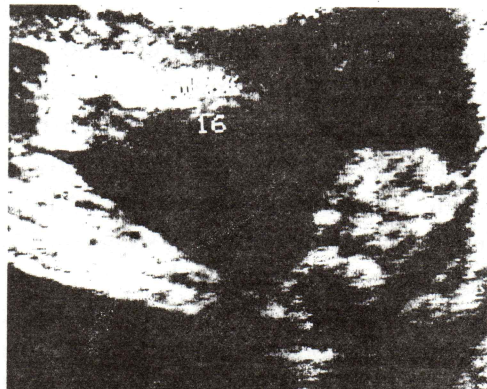


Fig.14 Transvaginal sonography demonstrates dilated posterior urethral valve and bladder due to posterior urethral valve obstruction at 11 weeks gestation.

Fig. 15 A) Transvaginal sonography shows fetal clubfoot at 13 weeks. Note foot and toes are visible in the same plane as lower leg.



B) The same clubfoot at 16 weeks.

Table 3 First trimester diagnosis of fetal abnormalities

Definite:	anencephaly
	cystic hygroma with or without hydrops
Probable:	neural tube defects
	renal agenesis
	infantile polycystic kidneys
	obstructive uropathy
	skeletal dysplasia
	congenital clubfoot
Possible:	cardiac malformations
	abdominal wall defects
	diaphragmatic hernias
	sacrococcygeal teratomas

performed at around 16 weeks, when the uterus is easily palpable, making it technically easy, however, such timing predates the now routine use of ultrasound-guided amniocentesis. Several studies in Europe and in the USA have reported the use of "early" amniocentesis in prenatal diagnosis[17,18], mainly in the 12-15 weeks range. Recently it has been reported that amniocentesis could be performed during 8-11 weeks with the culture success rate of 68.7%, whereas after 12 weeks there were no culture failures using standard cytogenetic tech niques[19]. The preliminary experience at Queen Charlotte's and Chelsea Hospital with transvaginal ultrasound to guide transabdominal amniocentesis during the first trimester suggests that this may have some advantages. Before early amniocentesis becomes accepted into routine practice, it requires critical appraisal by controlled, preferably randomized, clinical trials.

Transvaginal chorionic villus sampling (CVS)

Transvaginal CVS was first reported by the groups in Italy and Germany using the technique shown in Figure16[20]. They suggested that transvaginal CVS can be performed in conditions where other sampling methods are contraindicated, the ideal gestation being from 8 to 11 weeks. However, due to limited data and experience, transvaginal CVS should not be employed in clinical practice at this moment. In addition, most contraindications of transcervical CVS can now be got around by transabdominal CVS.

First trimester fetal blood sampling

Due to advances in fetal me-

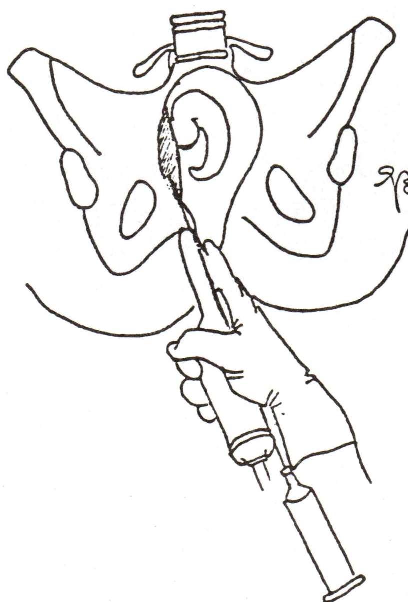


Fig. 16 Transvaginal chorionic villi sampling.

dicine, cordocentesis can now be performed as early as 13 weeks pregnancy under transabdominal ultrasound guidance[21]. However, the lower limit of gestation for this procedure is imposed by the operator's experience and the transabdominal ultrasound view. With high resolution transvaginal sonography, cordocentesis may, at least theoretically, be performed during the first trimester (especially between 12 and 14 weeks) under-transvaginal ultrasound-guided needling. This technique may offer new possibilities in the field of intrauterine transplantations, preventing, problably, the fetal immunocompetency.

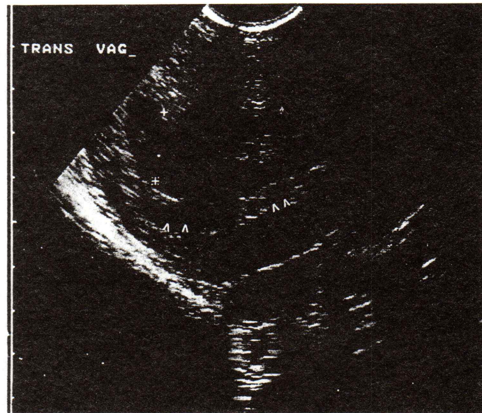


Fig. 17 Hypoechoic area (arrowheads) seen beneath the echogenic choriodecidua represent areas of subchorionic blood pooling which were not as readily visualized on transabdominal scan.

Complicated early intrauterine pregnancy

Threatened abortion

Spotting and/or pain are common in the first few weeks of pregnancy. In many instances, this is related to trophoblastic implantation within the decidualized endometrium. With development of the gestational sac, the small hypoechoic areas seen immediately beneath the echogenic choriodecidua are thought to be representative of areas of blood pooling (Figure 17). These are much better delineated on transvaginal than transabdominal scan.

Some patients with significant vaginal bleeding may have subchorionic hemorrhage. Subchorionic hemorrhage manifests as a crescentic, hypoechoic area between the chorion and myometrium. The subchorionic bleeding reflects some degree of chorio-myometrial separation, and with time the fluid collection may contain echogenic material representing clotted blood. The presence of subchorionic hemorrhage is an important prognostic indicator in a patient with vaginal bleeding. The relative size of the subchorionic hemorrhage can be quantitated and related to the size of the gestational sac itself. It has been shown that the relative size of the subchorionic hemorrhage has predictive value as to the outcome of the pregnancy. When the relative area of the subchorionic hemorrhage is less than 0.4 of the gestational sac or less than 60 ml, it is likely that the pregnancy will progress normally[22]. The sonographic detection of subchorionic hemorrhage usually necessitates a fol-

low-up sonographic examination to confirm fetal viability even if signs of fetal life are present on the initial examination.

Abnormal yolk sac

The yolk sac performs important functions for embryonic development during organogenesis and the remnant of the yolk sac (secondary yolk sac) seen on ultrasonography is often considered to be potential predictor of fetal outcome[23]. Growth of the yolk sac diameter has been found to have a curvilinear relationship with gestational age[24]. Although in general the size of the yolk sac does not appear to be a sensitive predictor of embryonic integrity and pregnancy outcome[24], total collapse of the yolk sac may be associated with chromosomal abnormalities. At present more information about this extremely rare condition is needed.

Non-viable early intrauterine pregnancies

Anembryonic pregnancy

A blighted ovum or anembryonic pregnancy implies cessation of embryonic development at a very early stage with continued development of the choriodecidua and membranes into gestational sac. The underlying abnormality is usually genetic (trisomy, triploidy, or monosomy).

Sonographically, an anembryonic pregnancy appears as a gestational sac which may be irregular in shape and surrounded by an irregular and thin decidua or interruped trophoblastic ring. No embryonic fetal pole or yolk sac are definable (Figure 18). When a gestational sac lacks an embryo, one must distinguish between a normal early intrauterine pregnancy and blighted ovum. The criteria established for transabdominal sonography include a distorted gestational sac with a mean linear dimension of greater

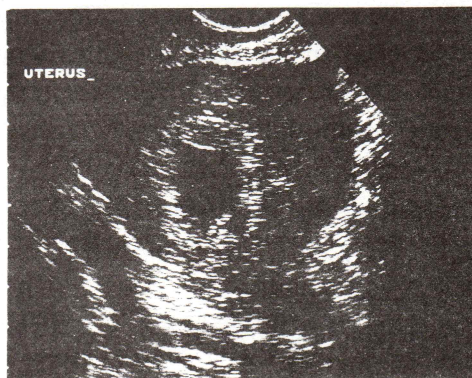


Fig. 18 Excellent delineation of an irregular empty sac with an interrupted choriodecidua consistent with an anembryonic pregnancy.

than 25 mm without sonographic delineation of an embryo or a mean linear sac dimension of greater than 20 mm without sonographic delineation of a yolk sac[25]. The definite criteria will be forthcoming with transvaginal sonography.

One should always emphasize that an abnormal-appearing gestation may develop normally. This seems to be the generally accepted clinical opinion. Therefore, caution must be

stressed, and it is advisable to give the suspected threatened abortion the benefit of the doubt when there is a normal-appearing or mildly atypical gestational sac without fetal pole or yolk sac. The patient should be re-examined in 1 or 2 weeks.

Incomplete abortion

An incomplete abortion implies vaginal bleeding associated with the passage of the fetus and/or products of conception with portions of the choriodecidua and membranes remaining within the uterine lumen. Sonographically, the gestational sac appears irregular, partially collaped filled with inhomogeneous echogenic material. Subchorionic hemorrhage may be present. The sac may have an abnormally low position and the choriodecidua is significantly disrupted. These features can be easily appreciated on the transvaginal sonogram.

Complete abortion

Complete abortion implies spontaneous passage of the fetus and all choriodecidua and membranes. Sonographically, a thin (<4mm) central uterine interface arising from the coapted endometrial surfaces is apparent. No distention of the uterine lumen is present. While these findings could be delineated on the conventional transabdominal sonogram. They can be made with greater confidence with the transvaginal technique.

Fetal death

The sonographic features of fetal death vary with the period of time elapsed between fetal demise and sonographic examination. If the fetal death is recent, a fetus is identified without evidence of fetal cardiac activity. If the fetal death is remote from the examination, maceration of the placenta and fetus may limit their sonographic delineation. The transvaginal sonography improves delineation of fetal cardiac motion, therefore, absence of detectable fetal heart motion with this techinque confirms fetal demise. In obese patient or patient with a retroflexed uterus, the use of transvaginal probe with doppler ultrasound or M-mode tracings may be helpful in detection of fetal heart activity.

Molar pregnancy

A molar pregnancy should be considered in the patient presenting with exaggerated symptoms of pregnancy, for example hyperemesis or a uterus that is large for dates. This entity can usually be diagnosed by transabdominal ultrasound. The transvaginal approach should be used in obese patients or those with an inconclusive image on transabdominal sonography. The sonographic picture obtained by transvaginal sonography shows a multitude of different sized sonolucent structures with great clarity, thus, a reliable diagnosis of hydatidiform mole or molar degeneration can be

made.

Ectopic pregnancy

The diagnosis of extrauterine or ectopic pregnancy has been largely based on history, clinical examination and biochemical tests before the advent of ultrasound techniques. The combined use of transabdominal sonography and serum hCG determinations has resulted in a relatively high accurate in predicting ectopic pregnancy. Suspicion for the diagnosis of ectopic pregnancy is raised in the presence of a positive pregnancy test and clinical signs or symptoms, an abnormally rising titer of hCG, or the absence of an identifiable intrauterine gestational sac on abdominal ultrasound examination when the hCG titer has reached 6500 mIU/ml utilizing The First International Reference Preparation(26,27). However, with multiple follicular development and embryo replacement the incidence of heterotopic pregnancy (intrauterine and extrauterine pregnancy) has risen sharply. Thus, a presumptive diagnosis that ectopic pregnancy can be excluded when an intrauterine gestation sac seen is not always applicable. Even though low hCG levels have been shown to be associated with ectopic pregnancy, these can also occur with intrauterine pregnancies that are nonviable or in those with retroimplantation bleeds. The ability to detect an ectopic pregnancy would, therefore, be enhanced if the adnexal mass itself could be identified. In most reports the specificity and the sensitivity for making the correct diagnosis of ectopic pregnancy by transabdominal sonography were 97% and 77 to 88% respectively(28-30). As previously described, transvaginal sonography can be used to detect early gestation and focus on the fallopian tube. Attention has been directed to the early and reliable imaging of tubal gestations (Figure 19). In a recent report of 145 patients who were referred for ultrasonographic work-up because of a suspected ectopic gestation, the sensitivity of diagnosing ectopic pregnancy by high-frequency transvaginal sonography was 100%, the specificity was 98.2%(31). The positive predictive value of this method was 98%, and the negative predictive value was 100%. The rate of the beating fetal heart seen and unruptured

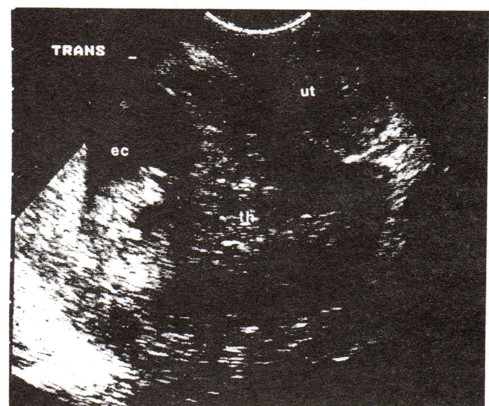


Fig.19 Transverse transvaginal sonography confirms an empty uterus (ut), right extrauterine gestational sac with viable fetus (ec) and thrombus in the region of the cul-de-sac (th) in a ruptured right tubal pregnancy.

tubal pregnancies were 23% and 66% respectively. A prospective study has been conducted to compare the accuracy of transvaginal sonography in 100 women suspected of having an ectopic pregnancy with transabdominal sonograbhy[32]. It was found that the vaginal scanning was more accurate than the abdominal scanning in detecting the ectopic pregnancy (90 versus 80%) and cul-de-sac fluid (77 versus 46%), in identifying an ectopic gestational sac (69 versus 44%), and in diagnosing a tubal pregnancy as unruptured (76 versus 50%).

In addition to the usefulness of transvaginal sonography in diagnosing early ectopic pregnancies, conservative treatment of ectopic pregnancies by transvaginal aspiration and methotrexate injection has been reported[33]. Thus, transvaginal sonography affords investigation of new types of treatment for ectopic pregnancies in selected patients in the future.

Doppler ultrasound

Doppler ultrasound has been widely used in the second and third trimesters to study flow velocity waveforms from the arcuate artery, uterine artery, fetal umbilical artery, descending aorta and cerebral artery. Many statistical correlations have been reported between perinatal complications and quantitative alterations, often minor, in indices of flow resistance. Doppler ultrasound can now be performed in the first trimester with the use of pulsed wave doppler instrument with transvaginal sector probe. However, the interpretation of the Doppler waveforms in the first trimester may be entirely different from the second or third trimesters. Absence of end-

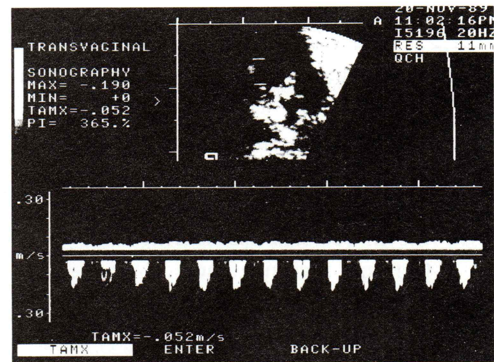


Fig. 20 Doppler umbilical artery velocity waveforms at 9 weeks gestation demonstrate physiologic absent end-diastolic frequencies (lower channel).

diastolic frequencies in the umbilical arteries, which is strongly associated with adverse perinatal outcome[34-36], appears to be physiological in the first trimester (Figure 20)[37]. Recently, in a series of 8 patients, it has been found that pulsed Doppler ultrasound does not offer the clinician additional information in the diagnosis of early pregnancy failure[38]. The applications of transvaginal Doppler ultrasound in the prediction of pregnancy outcomes requires further evaluation in the large longitudinal studies.

Transvaginal sonography in later pregnancy

The potential clinical applications of transvaginal sonography in later pregnancy are shown in Table 4.

Table 4 Transvaginal sonography in later pregnancy

Complimentary role to abdominal ultrasound
- Visualisation of fetal anatomy in the presenting part
- Localisation of placenta previa

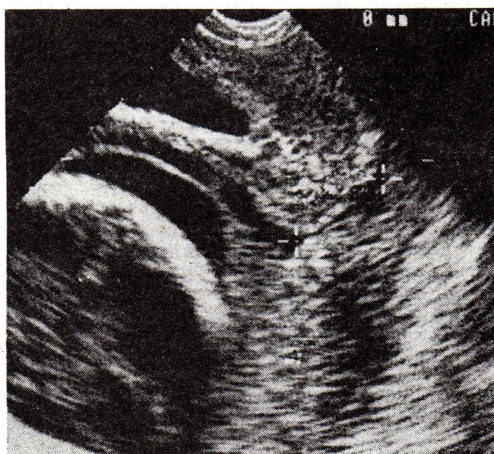
A role in cervical assessment
- Cervical incompetence
- Preterm labour
- Pre-induction of labour

Later gestational development

In spite of the fact that the use of transvaginal sonography in fetal scanning is probably limited by gestational age, fetal size and presentation, one should remember that any fetal organs in close proximity to the cervix may be examined at any given time throughout the pregnancy. Therefore, transvaginal ultrasound should be considered when fetal anomalies are suspected in the presenting part or detailed views of the presenting part are required.

Placenta previa

Transabdominal sonography remains the first step in the work-up of antepartum hemorrhage. However, if that scan is unsatisfactory or equivocal, as in obesity, a low-lying posterior placenta or an acoustic shadow being cast by the fetal head, then transvaginal sonography should be considered (Figure 21). There is some controversy in this recommendation since vaginal manipulation is



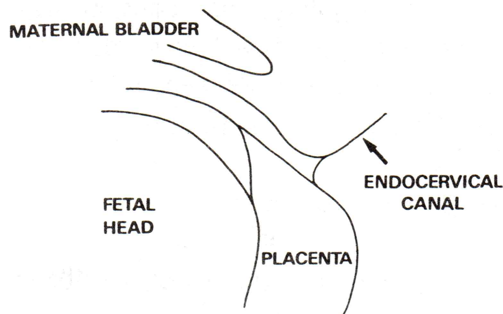


Fig. 21 Transvaginal sonography demonstrating posterior placenta previa.

usually contraindicated in patients with suspected placenta previa. However, the probe need not be inserted more than 3 cm, if this is done properly by careful insertion of the probe and constant monitoring of the image as the probe is advanced there should be no

contact with the cervix or lower uterine segment, so further bleeding should not be provoked if placenta previa is present. Preliminary studies suggest that not only is the procedure safe but also that it is better at diagnosing and excluding placenta pre via[39,40]. In a recent series of 63 patients suspected of placenta previa, transvaginal sonographic localization of the placenta was performed. A predictive value of a positive test was 100% and a negative test 98%. Sensitivity and specificity of the technique were 92% and 100%, respectively[41].

Cervical assessment

Transvaginal sonography may have a role in cervical evaluation. The closed, uneffaced cervix with a clear internal and external os can be seen early, in the first and early second trimesters of pregnancy. Therfore, transvaginal sonography may have the potential in identifying patients at risk for an incompetent cervix or preterm labour. In addition, it may be used to evaluate the favourability of cervix (i.e. cervical length, width, dilatation, application and position, and lower uterine segment thickness), as Bishop scores, before induction of labour. However, these cervical assessment by transvaginal sonography need randomized clinical trial before it is used in routine practice.

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