Chapter 1

# Introduction to Early Pregnancy Ultrasound

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Ultrasound is the most commonly used medical imaging method in pregnancy. In the United Kingdom, all women are routinely offered ultrasound examinations at around 12 weeks and 20 weeks of gestation. However, the use of ultrasound prior to 12 weeks has become central to the management of women with suspected early pregnancy problems. In particular, earlier ultrasound examinations are indicated in women after assisted conception and those in whom an ectopic pregnancy or miscarriage is suspected.

The aims of an early pregnancy ultrasound scan (USS) are to confirm the presence of an intrauterine pregnancy, establish viability, determine number of embryos, determine gestational age and reassure a woman and her partner of the absence of complications.

## Setting

In the United Kingdom, the majority of early pregnancy ultrasound examinations are carried out in Early Pregnancy Units. These are specialist units for the provision of care for women with suspected early pregnancy complications. It is a recommendation of the Royal College of Obstetricians and Gynaecologists that all maternity units should have such a unit. Table 1.1 summarises some of the standards that should be expected in an Early Pregnancy Unit.

## Safety

In recent years, there has been much interest in the safety of early ultrasound examinations. The evidence so far suggests that ultrasound used for clinical reasons with standard presets during embryonic development (conception to ten weeks' gestation) is safe and the benefits outweigh any theoretical risks. It is, however, essential that whoever is carrying out the ultrasound examination is aware of the safety indices and scanning modes. A fundamental approach to the safe use of diagnostic ultrasound is to use the lowest output power and the shortest scan time consistent with acquiring the required diagnostic information. This is referred to as the ALARA ('as low as reasonably achievable') principle.

### Safety Indices

Ultrasound examination of the developing embryo or fetus exposes it to both mechanical and thermal stress. The potential effects of these forms of stress are represented by the mechanical index (MI) and thermal index (TI) respectively. These two indices are summarised in Table 1.2. They are displayed on the ultrasound screen during the examination, as shown in Figure 1.1.

### Scanning Modes

Evidence suggests that the most commonly used B-Mode ultrasound is safe in early pregnancy when using standard obstetric presets on modern machines. Colour Doppler and pulsed wave Doppler involve greater average intensity and power outputs as shown by higher TIS (TI soft tissue) levels compared to B-Mode imaging. There is therefore a greater risk to the developing fetus of overheating. If Doppler ultrasound is used in early pregnancy, the operator should aim to keep the TIS < 1.0 and limit the scan exposure time. Currently it is not recommended that Doppler be routinely used in early pregnancy ultrasound assessments. The M-Mode is a low-energy alternative to pulsed wave Doppler, which can be used to insonate the embryonic heart if required in early pregnancy.

There is no current evidence that three-dimensional (3D) ultrasound leads to higher ultrasound exposure than two-dimensional (2D) examinations. In fact, scanning and exposure times may actually be reduced, as the data set can be analysed offline. The routine use of 3D examinations, however, is also not routinely recommended.

**Table 1.1** Standards for provision of care in early pregnancy units

| | Essential | Desirable |
|---|---|---|
| Accessibility | • Minimum five-day opening.<br>• Access to transvaginal and transabdominal ultrasound.<br>• Acceptance of direct referrals from general practitioners (GPs), accident and emergency responders and other health care professionals seeing women in early pregnancy.<br>• Acceptance of self-referrals from women with a previous history of ectopic pregnancy or recurrent miscarriage. | • Is Open seven days a week.<br>• Accepts self-referral from all women. |
| Environment | • Units should have a designated reception and waiting area.<br>• Appropriately furnished room for breaking bad news and counseling.<br>• System for capturing all patient information and creating written reports. | • Unit separate from the main maternity unit. |
| Process | • Clear protocols for carrying out a pregnancy test and performing an ultrasound examination in any woman of reproductive age presenting with any type of abdominal pain, irregular vaginal bleeding or amenorrhoea.<br>• Direct laboratory access to same-day serum human chorionic gonadotropin (hCG) and blood group results.<br>• Clear guidelines and algorithms for the management of pregnancies of unknown location and of uncertain viability.<br>• A full range of management options (expectant, medical and surgical) for women diagnosed with miscarriage or ectopic pregnancy. | • Serum hCG results available within two hours.<br>• Access to serum progesterone levels. |
| Communication | • Clear patient information leaflets.<br>• A written report of the outcome of a woman's ultrasound examination, with a copy sent to their GP or referring health professional. | • Direct access to bereavement counselling. |

*Source*: Adapted from Moody, ed., *RCOG Standards for Gynaecology,* 2008.

**Table 1.2** Ultrasound safety indices

| | | Explanation | Recommended levels * |
|---|---|---|---|
| Mechanical index | **MI** | MI is an on-screen indicator of the relative potential for ultrasound to induce an adverse bioeffect by a nonthermal or mechanical mechanism. This includes cavitation (which refers to the development of gas bubbles in an acoustic field at high negative pressures) and streaming (the expansion and contraction, or collapse, of gas bubbles during the oscillatory cycle). | An MI of < 1.0 indicates that effects arising from acoustic cavitation are very unlikely. Ideally aim for levels < 0.7 in early pregnancy scanning. |
| Thermal index | **TI** | TI provides an indication of the relative potential for a rise in tissue temperature. It is intended to give a rough guide to the likely maximum temperature rise that might be produced after long exposure. There are three types:<br>**TIS** – thermal index for soft tissue. The index used during scanning < ten weeks of gestation.<br>**TIB** – thermal index for bone.<br>**TIC** – thermal index for cranial bone. | The higher the TI, the shorter the ultrasound exposure should be. TIS < 0.7 – no restriction on scan time.<br>TIS 0.7–1.0 – restrict scan time to < 60 minutes.<br>TIS 1.0–1.5 – restrict scan time to < 30 minutes.<br>TIS > 3.0 – scanning not recommended. |

* Recommended by the British Medical Ultrasound Society.


**Figure 1.1** Image showing on-screen display of mechanical index (MI) and thermal index (TI).

## Scanning Route

There are a number of advantages of the transvaginal route over the transabdominal route in early pregnancy, as indicated in Table 1.3. There is plenty of evidence in the literature suggesting that in the early first trimester a transvaginal scan (TVS) can reliably identify normal and abnormal pregnancies and various developmental markers at an earlier stage than a transabdominal scan (TAS). A TVS has been shown to be acceptable to women attending Early Pregnancy Units and in fact some women do actually prefer it to a TAS. The reasons for this include the discomfort and time needed to fill the bladder to adequately examine the pelvis abdominally. TVS is also superior in obese patients and those with a retroverted uterus.

Occasionally it may be necessary to perform a transrectal ultrasound scan. This may be used as an alternative to a TVS if either a TVS is not possible and insufficient information is obtained by a TAS.

## Ultrasound Technique

Whether performing a TVS or TAS, it is essential that the examination is performed in a systematic fashion and the image is optimised to enable the examiner to get the most information from the procedure.

### Image Orientation

There is a general agreement that when in transverse section, the patient's right side should be seen on the left side of the ultrasound screen. With a TAS, in the longitudinal view the cranial structures should be seen on the left side of the screen and the caudal structures on the right side. Superficial structures should be seen on the top half of the screen and deeper structures on the bottom half, as indicated in Table 1.4.

With TVS, there is no agreement on image orientation. Some scan with the transducer head in the upper part of the screen and some with it at the bottom. Similarly, when examining in the longitudinal plane, some will have the bladder on the left and some will have it on the right, as indicated in Table 1.4. The most important thing is that the examiner is aware of his or her own orientation when performing the ultrasound examination.

### Image Optimisation

Whilst most modern ultrasound machines are now programmed with suggested presets for the examination type intended in order to obtain the best images, there are still some things that usually need to be changed during every examination.

#### 1. Depth

Usually the examination is started using high depth or a low magnification. Increasing the depth allows deeper structures to be viewed. Reducing the depth allows more superficial structures to be viewed.

#### 2. Magnification

For superficial structures it is usually easiest to magnify the image by reducing the depth of the image. For deeper structures or to get an even bigger image, the zoom function can be used. This zoom function just takes a portion of the screen and magnifies it. It can be used whilst scanning or whilst the image is frozen.

#### 3. Focus

The focus can be adjusted to manipulate the pulse of the ultrasound to be at its narrowest at a particular depth. This means that the image quality is maximised at this level. It allows the best lateral resolution (ability to see two things as two things) to be achieved.

#### 4. Gain

The overall brightness of the image can be adjusted by altering the gain. This is usually one of the most important changes to make to optimise the image, as if the image is too light or too dark, it is difficult to see subtle changes in texture.

The ultrasound waves change and get smaller as they pass through tissues (attenuation). In order to make structures look the same even if they are located in different depths, the time gain compensation (TGC) can be adjusted. Usually there is lower gain superficially and higher gain deeper in the image where the image quality is weaker.

**Table 1.3** Advantages and Disadvantages of Transvaginal Sonography and Transabdominal Sonography

| | Advantages | Disadvantages |
|---|---|---|
| Transvaginal (TVS) | • Higher frequencies<br>• Superior resolution of images<br>*Less ultrasound penetration is needed as probe is closer to pelvic structures, therefore higher frequencies can be used to obtain higher resolution of images.*<br>• Requires an empty bladder, so often more comfortable.<br>• The probe can be used to exert localised pressure on the pelvic organs to test for pain.<br>• The pelvic organs can be moved with the probe to see if they slide easily.<br>*If the organs do not slide easily, this suggests that adhesions may be present. The TVS can actually be combined with a bimanual examination. The examiner can place his or her hand on the patients abdomen while operating the vaginal probe with the other.*<br>• The probe can be moved in and out of the vagina to adjust the depth of the organs on the screen.<br>• Allows better imaging in obese patients. | • Depth of penetration is limited due to high-frequency of the ultrasound<br>• Lack of probe mobility.<br>*Due to the confines of the introitus and vagina, the probe cannot be moved in all dimensions* |
| Transabdominal (TAS) | • May allow better visualisation of a pregnancy in a large fibroid uterus. | • Decreased resolution.<br>This is due to:<br>1. The lower frequency of abdominal probes compared to vaginal probes<br>2. The scan being performed through the abdominal wall which contains fat, muscle and tendons which distorts the ultrasound image<br>3. The relative greater distance bowel which may contain air and block visualisation of deeper structures.<br>• Often requires a full bladder.<br>• Poor views in obese patients. |

### 5. Frequency

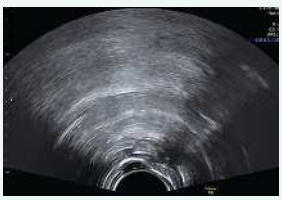
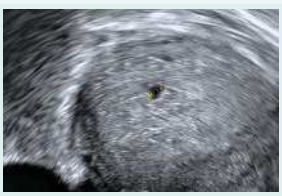
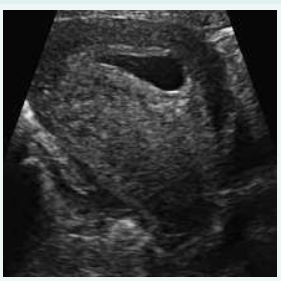
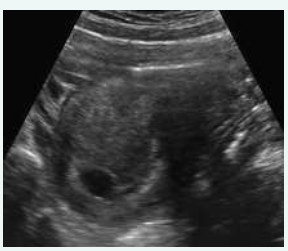
The highest ultrasound frequency possible should be chosen. However, the higher the frequency, the lower the depth of penetration. Therefore, if the object of interest is situated far away from the transducer, the frequency may need to be reduced to get the best image. A disadvantage of the lower frequency, however, is a reduction in the image resolution.

## Transvaginal Scan (TVS)

A TVS should be performed when the patient has an empty bladder. The procedure should be explained to the woman and consent taken. The probe should be thoroughly cleaned by a gloved operator, ideally in front of the patient, before the procedure. The probe should be covered with a protective sheath. There should be a layer of ultrasound gel between the transducer head and the probe cover, with all air expelled. Extra lubricating gel should then be put on the covered probe. The operator should introduce the probe slowly into the vagina whilst watching the screen. It is sometimes helpful to ask the woman to take a deep breath at this point. The scan should then be performed in a systematic manner. A suggested method of doing this is shown in Table 1.5. After the examination is completed, the probe should be removed from the vagina, the probe cover removed and the probe cleaned.

If a transrectal scan is performed, the same examination technique should be used as for a TVS.

**Table 1.4** Image orientation

| | Transabdominal Scan | Transvaginal Scan | Transvaginal Scan |
|---|---|---|---|
| | | *Transducer head at top of image* | *Transducer head at bottom of image* |
| |  |  |  |
| **Transverse view** |  |  *The right ovary will be on the left of the screen.* |  |
| **Longitudinal view** | | | |
| Anteverted uterus |  |  *The fundus of the uterus appears on the left side of the screen and the external os of the cervix points to the right side of the screen.* |  *The fundus of the uterus will be on the right side of the screen and the cervix points down to the left side of the screen, as in the anatomical position.* |
| Retroverted uterus |  |  *The fundus of the uterus appears on the right side of the screen and the cervix points towards the left side of the screen.* |  *The fundus of the uterus will be on the left side of the screen and the cervix points down to the right.* |

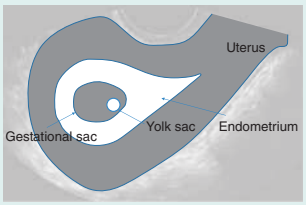
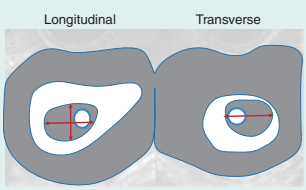
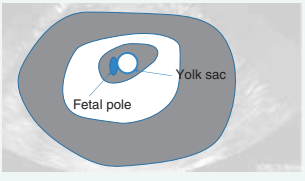
## Transabdominal Scan (TAS)

A TAS should be performed when the patient has a full bladder. A full bladder displaces the bowel and allows the ultrasound beam to travel through the urine until it reaches the uterus and ovaries. Again, it should be performed in the same systematic way suggested for TVS (see Table 1.5).

## Documentation and Storage of Images

It is important to carefully document all findings in a systematic fashion when providing a report of the ultrasound examination. Suggested information to include in a report is given in Table 1.6. It is also important to store copies of the USS images taken. When writing the report and storing images, it is

**Table 1.5** Systematic approach to the TVS

| | | Ultrasound image | Schematic drawing | Details |
|---|---|---|---|---|
| 1. | Longitudinal View of the Uterus |  |  | • It is important to obtain a lo visualising the whole of the cervix.<br>• The uterus should be scanne longitudinal plane.<br>• An image should be saved, s gestational sac within the en seen continuous with the ce intrauterine pregnancy).<br>• If no intrauterine pregnancy should be measured where i<br>• The endometrium should be myometrial border on one s |
| 2. | Transverse View of the Uterus |  |  | • After examination in the lon be rotated 90° so that the ut transverse plane.<br>• The uterus should then be s cervix.<br>• Even if a gestational sac is im pan through the uterus in th to check for the presence of uterine anomalies. |
| 3. | Visualisation of the Gestational Sac |  |  | • The gestational sac should b longitudinal and transverse<br>• The height and length of the longitudinal plane and the w plane.<br>• It should be stated if the sac |
| 4. | Assessment of Embryonic Structures |  |  | • The sac should be examined absence of a yolk sac, embry<br>• Measurements should be ta |

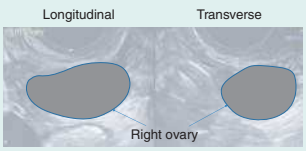
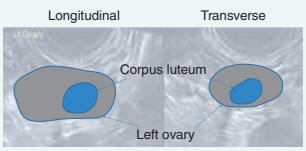
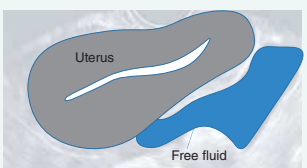
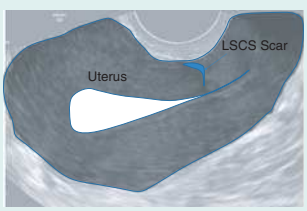
| | | | | |
|---|---|---|---|---|
| 5. | Visualisation of the right ovary |  |  | • The ovaries should be visual<br>• The value of measuring ovar is documented that both ov measured, it implies that the examination. |
| 6. | Visualisation of the Left Ovary |  |  | • The presence of any ovarian size in 3 planes documented<br>• The side of the corpus luteu haemorrhagic, solid) should |
| 7. | Assessment of the Adnexa |  |  | • Both adnexa should be fully<br>• If present the size of the mas documented.<br>• It should be documented w the ovary or not. |
| 8. | Inspection of the Pouch of Douglas |  |  | • The Pouch of Douglas shoul presence of any free fluid. It the fluid is anechoic or echo<br>• The deepest pool should be |
| 9. | Other sites |  |  | • In a woman with a previous important to visualise and e<br>• If a pregnancy is not obviou important to visualise the in tubes. |

**Table 1.6** Suggested information to be included in the structured ultrasound report

| | | |
|---|---|---|
| **General information** | | |
| | Maternal age | |
| | Previous obstetric history | • Parity – include live births and stillbirths<br>• Number of miscarriages<br>• Number of terminations of pregnancy<br>• Number of ectopic pregnancies – include mode of management |
| | Conception | • Spontaneous<br>• Assisted |
| **Pregnancy** | | |
| | Gestational age | • According to last menstrual period (LMP) or USS measurements as appropriate |
| | Gestational sac | • Present or absent<br>• Number of gestational sacs<br>• Intrauterine or extrauterine (and site – tubal, interstitial, Caesarean section scar, cervical etc.)<br>• Size in three orthogonal dimensions |
| | Yolk sac | • Present or absent<br>• Size |
| | Amniotic sac | • Present or absent<br>• Size<br>• number |
| | Embryo/fetus | • Measurement of crown rump length (CRL) |
| | Fetal cardiac pulsations | • Present or absent (may include heart rate) |
| | Other | • Presence of retained products of conception in the uterine cavity<br>• Documentation if any tissue appears cystic and suggestive of a possible molar pregnancy<br>• Presence or absence of a:<br>  ○ Subchorionic haematoma<br>  ○ Chorionic bump<br>  ○ Caesarean section scar niche<br>• Presence of fluid in the Pouch of Douglas, measurement of the deepest pool, and a description of whether it appears anechoic or echogenic |
| **Maternal structures** | | |
| | Uterus | • Anteverted<br>• Retroverted<br>• Axial<br>• Presence of a uterine anomaly<br>• Fibroids – including location and size<br>• Intrauterine contraceptive device (IUCD) if present with exact location and relationship to pregnancy<br>• Cervical length if clinically indicated |
| | Ovaries | • Size in three dimensions<br>• Side of corpus luteum<br>• Morphology of corpus luteum<br>• Size and morphology of any ovarian cysts if present |
| | Other | • Presence of a paraovarian/fimbrial cyst<br>• Presence of a hydrosalpinx or other tubal pathology |
| **Serum biochemistry** | | • Serum hCG and progesterone levels if clinically indicated and known |

**Table 1.6** (continued)

| | |
|---|---|
| **Diagnosis** | |
| | • Single/multiple viable intrauterine pregnancy<br>• Intrauterine pregnancy of uncertain viability<br>• Missed miscarriage<br>• Incomplete miscarriage<br>• Complete miscarriage (only if the patient had a previously visualised pregnancy on USS)<br>• Pregnancy of unknown location<br>• Ectopic pregnancy<br>• Suspected molar pregnancy |
| **Follow-up/recommendation** | |
| | • Further follow-up scan if indicated and suggested time interval<br>• Recommendations for serial hCG or progesterone estimations if indicated<br>• Advice to book for antenatal care if indicated<br>• Referral to discuss management of ectopic pregnancy or miscarriage |

important to document all findings and to label all images taken and stored.

Specialist computer programs are available that allow the storage of USS images and offer the ability to generate a structured report as soon as the examination is complete. As all reports and images are saved under a patient's particular identification number, all previous scan images and reports can be reviewed easily. This is extremely useful when a patient is returning for a follow-up scan after a previous inconclusive scan. Normal values for USS measurements such as gestational sac size and crown rump length (CRL) are contained within the programs, allowing them to assist with pregnancy dating. Another advantage of such a program is that they can enable a clinic to run efficiently by becoming paperless. However, the most important thing is that they allow a patient to leave the clinic with a written report in her hand.

## Auditable Standards

It is good practice for all those performing ultrasound examinations in early pregnancy to attend regular departmental meetings to review guidelines and protocols and discuss difficult cases. Regular audits should also be performed on the rates of pregnancy of unknown locations and number of ectopic pregnancies diagnosed on ultrasound prior to treatment.

## Learning Points

- The aims of an early pregnancy ultrasound scan are to confirm pregnancy location, establish viability, determine number of embryos, and determine gestational age.
- Ideally all women with suspected complications should be seen in a dedicated Early Pregnancy Assessment Unit.
- Ultrasound used with standard presets for clinical reasons during embryonic development (conception to ten weeks' gestation) is safe and the benefits outweigh any theoretical risks.
- A transvaginal scan has a number of advantages over a transabdominal scan in early pregnancy.
- It is essential to provide a structured written report of the ultrasound scan examination findings.

## Further Reading

1. Moody J, ed. (2008). *RCOG Standards for Gynaecology.* RCOG Press.
2. Joy J, Cooke I, Love M (2006). Is ultrasound safe? *The Obstetrician & Gynaecologist* 8: 222–227.
3. RCOG ultrasound from conception to 10+0 weeks of gestation. Scientific Impact Paper No. 49. March 2015.
4. World Federation for Ultrasound in Medicine and Biology. Safety statements. www.wfumb.org/about/statements.aspx. Accessed 20 October 2014.

5. British Medical Ultrasound Society. Statement on the safe use, and potential hazards of diagnostic ultrasound. https://www.bmus.org/static/uploads/resources/STATEMENT_ON_THE_SAFE_USE_AND_POTENTIAL_HAZARDS_OF_DIAGNOSTIC_ULTRASOUND.pdf
6. Kaur A. (2011). Transvaginal ultrasonography in first trimester of pregnancy and its comparision with transbdominal ultrasonography. *J Pharm Bioallied Sci* 3: 329–338.
7. Dutta R L, Economides D L. (2003). Patient acceptance of transvaginal sonography in the early pregnancy unit setting. *Ultrasound Obstet Gynecol* 22: 503–507.