Essentials of Gynaecological Ultrasonography

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Edited by

Ahmad Sayasneh, Tom Holland and Sian Mitchell

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PREFACE

Ultrasound imaging is now a must-have tool for modern gynaecologists. It is the first-line method for diagnosing a wide range of illnesses, from early pregnancy problems to complicated cancer cases, because it is non-invasive, easy to get to, and can be used for many different types of diagnosis. But its reliance on operators makes it a constant problem that shows how important formal instruction and effective advice are.

Essentials of Gynaecological Ultrasonography is based on years of clinical work, academic research, and collaboration between people from different fields. It is meant to be both a learning tool and a useful tool for people who work in the scanning room, whether they are trainees, specialized nurses, consultants, or sonographers.

The people that wrote for us are a diverse and devoted collection of doctors and academics, each with their own field of expertise that they use to shed light on important aspects of pelvic and early pregnancy imaging. Each chapter is based on genuine clinical queries and typical diagnostic problems, from fundamental scanning techniques and probe orientation to more advanced uses like Doppler assessment and cancer staging.

There is a lot of focus on new topics in gynaecological imaging. For instance, using intraoperative ultrasonography, 3D reconstruction, and new protocols to look at endometriosis and adnexal tumours is becoming more and more important. These chapters show how ultrasound practice is changing and how it is becoming more important in planning surgeries and caring for fertility.

The book also includes safety and best practice advice, such as standards developed by the British Medical Ultrasound Society (BMUS) and the International Ovarian Tumour Analysis (IOTA) group. Every chapter has practical advice and structured scanning methods to help make exams more consistent and easier to repeat.

We hope that this book helps readers feel more confident about doing and understanding gynaecological ultrasound scans and using the technology wisely to improve patient care. It also wants to help people understand the subtle differences and interpretive abilities needed for a correct diagnosis.

Our sincere gratitude go to the contributing authors, many of whom are leaders in their disciplines, as well as to the early career clinicians and researchers whose passion and insight have helped define this project. We want to give a special thank you to Dr. Sian Mitchell for her dedication to her studies during her MD program and to Mr. Tom Holland for his leadership in both the clinical and editorial parts of this volume.

We hope that this book will be a useful tool for your work and education, and we look forward to hearing from our readers as this field changes.

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CHAPTER 1

SETTING UP THE MACHINE AND HOW TO DO A PELVIC SCAN

MS ALISON SMITH, MS SHARON DAM

Learning objectives

It is widely accepted that ultrasound is the modality of choice to examine the pelvic organs. Ultrasound is relatively cheap, accessible and does not use ionising radiation. It is, however, operator dependent, therefore is incumbent upon the operator to understand the principles and technique of ultrasound.

This chapter will focus on:

- The fundamentals of ultrasound
- How to examine the female pelvis using transvaginal and transabdominal ultrasound
- How to use the controls of the ultrasound machine to optimise your image

1.1 Definition of ultrasound

Audible sound has frequencies of less than 20kHz. Ultrasound is high frequency (high pitch) sound with frequencies more than 20kHz. Frequency refers to the number of cycles per second. Medical ultrasound uses frequencies ranging from 3 to 15MHz.

1.1.1 How ultrasound is generated

The ultrasound transducer (also known as a probe) generates sound waves and receives the returning echoes. The transducer contains piezoelectric crystals. When an electric current is applied to the crystals it causes vibrations which produce a pulse of high frequency, mechanical sound waves. The transducer is placed on the body over the anatomical area to be examined. The generated sound waves pass through body tissues at a constant speed. When the sound waves reach a reflective surface a proportion of the sound is reflected back to the transducer and emits an electrical current which is converted to a diagnostic image.

An assumption is made that the speed of sound (propagation velocity) through tissues is 1540m/s (1540m/s is the average of different velocities of tissues in the body). This means that the travel time of the transmitted and returning soundwave can be calculated so the distance from the transducer face of a reflected echo can be determined. Each returning echo is shown as a pixel, the final display being the two-dimensional grey-scale image that we are familiar with.

1.1.2 How sound interacts with tissue

When sound encounters a reflective surface, a proportion will be reflected, and a proportion will be transmitted. ***Reflection*** occurs when sound is reflected from an interface between two tissue types with a difference in acoustic impedance. Acoustic impedance refers to the stiffness of a body tissue. The stronger the reflection is, the brighter the echo is displayed on the resulting image. An example would be a septation within a simple ovarian cyst.

The strength of the ultrasound signal is greatest if the incident beam is perpendicular to the area being examined. Furthermore this will improve the image quality.

Refraction occurs when sound encounters a reflective surface where the two tissues are at an oblique angle. If the difference in the propagation velocities and/or angle is acute between the two tissues is significant, the sound is not reflected directly back to the transducer. An assumption made about sound interacting with human tissue is that it travels in a straight line which is not necessarily the case, this may produce a confusing image.

Sound decreases in intensity as it traverses through tissue - this is known as ***attenuation.*** This is dependent upon the distance the sound travels, tissue type and the frequency of the transmitted sound. An important ultrasound machine control is gain; this can amplify returning signals to compensate for attenuation.

The ultrasound image is comprised of shades of grey. The denser the tissue the stronger the reflection which results in a brighter image which is termed hyperechoic. Less dense tissue produces a weaker reflection resulting in a darker image which is termed hypoechoic. Fluid such as blood within an artery or vein or free fluid within the recto uterine pouch (Figure 1-1) are visualised as black on ultrasound and are termed anechoic[1,2].

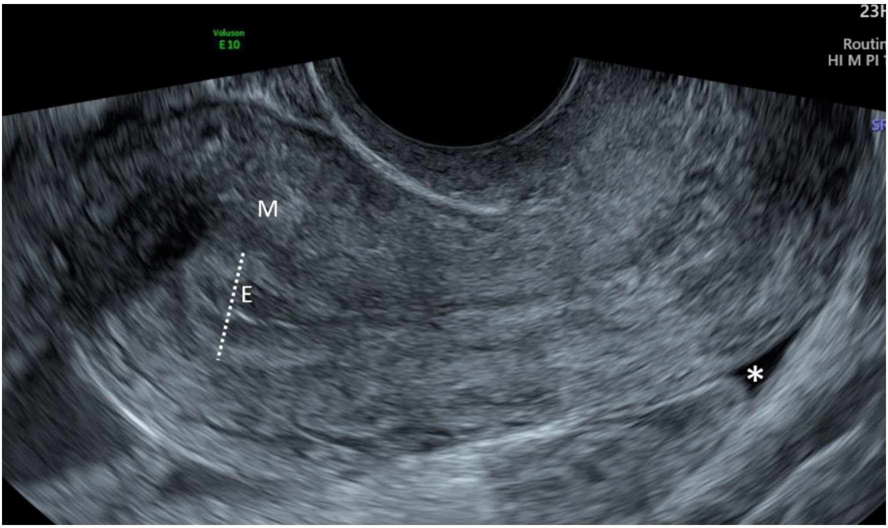

Figure 1-1: Midline sagittal uterus showing the endometrium with antero-posterior (AP) measurement. The anterior myometrium (M) is labelled. There is a small amount of anechoic physiological free fluid * seen in the recto-uterine pouch.

1.2 Ultrasound probes

The ultrasound probe design is dependent upon the examinations that are to be undertaken, in this case, the female pelvis. Ultrasound probes can be categorised as three types: linear array, convex or curvi-linear array and phased array. The differences are due to the way the crystals are arranged and produced. Probes also vary according to their frequency. A high frequency probe produces a higher resolution in effect a more detailed image. Resolution is the ability to resolve small structures that are side by side (***lateral resolution***) and/ or perpendicular to each other ***(axial resolution).*** High frequency sound has a short wavelength and is more readily attenuated, therefore does not penetrate deep structures well. Conversely, a lower frequency probe produces a lower resolution image, however it is less readily attenuated so is capable of penetration of deep structures. The choice of probe is therefore the best compromise between the need for the highest resolution against the need for adequate penetration of the tissues under examination (1, 2).

The convex transabdominal probe has a curved footprint. It operates at frequencies of 2.5 – 7.5MHz. The resulting screen image is fan-shaped. This probe is used for abdominal and gynaecological ultrasound examinations. A transvaginal or intra-cavity probe is a small curved array which has a long handle allowing it to be inserted into the vagina a few centimetres. The transvaginal probe operates at higher frequencies than a transabdominal probe in the region of 6 – 10 MHz producing a higher resolution image. Due to the proximity of the transvaginal ultrasound probe to the pelvic organs, penetration is not an issue.

The linear array probe has a large footprint and a flat ultrasound face. The resulting screen image is rectangular in shape. The probe has higher frequencies (up to 13MHz) and would be typically used for imaging superficial structures. In terms of gynaecological imaging this has limited use however it would be useful to assess wound collections and inguinal lymph nodes.

The phased array probe has a small footprint and a flat ultrasound face. It operates at frequencies of 2.5 – 7.5MHz. The resulting screen image is triangular. They are typically used in cardiac examinations where the body surface access point is limited by the ribs. This probe does not have a role in gynaecological ultrasound imaging.

1.3 Three-dimensional (3D) ultrasound

A 3D scan involves the acquisition of a volume of 2D ultrasound information. This data set can then be manipulated after the scan, once the patient has left the examination room. The information can be displayed in a multiplanar format this is particularly useful when assessing congenital uterine anomalies. Other features, such as surface rendering and multi-slice imaging, mean that there is a role for 3D scans in the diagnosis and management in the sub fertility, benign gynaecology, gynaecological oncology and urogynaecology subspecialities.

The requirements to undertake a 3D scan include a 3D ultrasound probe and software on your ultrasound machine to manipulate your image. A 3D probe used in gynaecological imaging is usually a convex or curvi-linear array either transabdominal or transvaginal. The probe requires a mechanism to acquire a volume of 2D ultrasound. Therefore, the 3D probe is usually slightly larger and heavier than a 2D probe. A 3D probe can be used as a 2D probe as a 3D scan is usually performed as an adjunct to the 2D scan[1,2].

1.4 Doppler

The Doppler effect is attributed to Christian Doppler and describes the change in frequency of a sound wave due to a reflector moving towards or away from an object. In ultrasound terms the moving reflector is blood, specifically erythrocytes, and the object is the ultrasound probe. Doppler is used to detect, measure and analyse blood flow. If the flow of blood is towards the probe the reflected wave will have a higher frequency than the incident wave – this is known as a positive Doppler shift. If the flow of blood is moving away from the probe the reflected wave will have a lower frequency than the incident wave, known as a negative Doppler shift. Doppler is used mainly in three ways:

- ***Colour Doppler*** displays a colour map over the 2D grey-scale image. Convention is that vessels flowing towards the probe will be coloured red, vessels flowing away from the probe will be coloured blue. This can be reversed by selecting an invert control if desired. The angle of the blood vessel size to the incident beam contributes to the Doppler shift and thus the intensity of the colour displayed. The maximum Doppler shift occurs if the angle is 0 degrees i.e. the blood vessel is parallel to the incident beam. There is no Doppler shift when the angle is 90 degrees i.e. the blood vessel is perpendicular to the incident beam. In the latter case there will no colour assigned to the vessel. In practice it is acceptable to employ an angle of between 0 and 60 degrees when examining a vessel.
- ***Power Doppler*** displays non directional blood flow. Therefore, it is independent of the angle. It has the ability to image much smaller vessels with lower flow rates. The magnitude of the colour output is displayed - there is no indication of different velocities.
- ***Spectral Doppler*** this demonstrates a waveform of the vessel under examination. It provides a visual assessment and measurements of the changing velocities throughout the cardiac cycle. A positive Doppler shift will be displayed above the baseline, and a negative Doppler shift will be displayed below the baseline. Each blood vessel has a waveform with features specific to it in the normal and abnormal state. In practice, spectral Doppler has a limited role in gynaecological ultrasound.

The assessment of vascularity in gynaecological ultrasound is largely done by subjective assessment using colour and/or power Doppler. A common use of colour or power Doppler in gynaecological ultrasound is to visualise circumferential flow in the corpus luteum in a pre-menopausal woman (Figure 1-2).

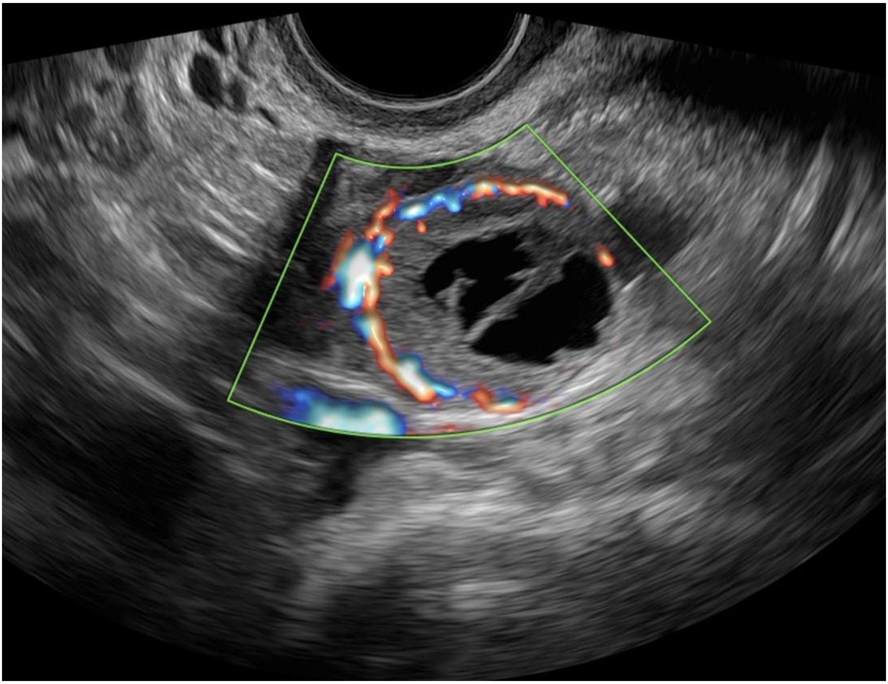

Figure 1-2: Colour Doppler showing circumferential flow of a right corpus luteum representing neo- agenesis in a pre-menopausal woman.

1.5 Undertaking a transvaginal scan

A transvaginal scan affords the best resolution; it is for this reason that it is recommended as the first approach to an ultrasound scan. A transvaginal scan is an intimate examination therefore the woman's informed consent needs to be gained (either verbal or written). Contra-indications to the scan include the woman's choice to decline, an inability to understand, e.g. due to a language barrier or mental incapacity, or that she is virgo intacta[1,2].

Consistent with all intimate examinations, a chaperone should be offered and consideration should be given to privacy, dignity, comfort and explanation throughout the examination. She should be advised that the examination may be slightly uncomfortable but should not be painful.

A prerequisite to the transvaginal scan is that the woman's bladder is emptied prior to the examination. She should be given a screened area to remove her lower outer clothes. Ideally, the woman should be in the lithotomy position with her feet supported in low stirrups at her hip level, to prevent the couch restricting movement of the probe. If this is not available, an option is to remove or fold down the edge of the couch and ask that the woman places her feet on a chair positioned at the end of the couch. Her hips need to be abducted in order that the probe handle can be moved so the pelvic organs can be examined in their entirety. A sheet should be provided for dignity; the woman can cover her lower body throughout the scan.

You, as the operator, should wash your hands prior to the scan and wear disposable gloves. The ultrasound probe should be cleaned with the appropriate antiseptic wipe or spray in accordance with your local infection control team and machine manufacturers' guidance. A small amount of sterile gel should be applied to the tip of the probe which is then covered with a probe cover. If the probe cover contains latex, you should establish whether the woman has a latex allergy at the outset of the scan. If she has a known or uncertain latex allergy a non-latex probe cover should be used. A further small amount of sterile gel is placed on the covered probe to ease insertion into the vagina. At the end of the scan when the probe is removed, the probe cover should be disposed of correctly in the appropriate bin. The woman should be given tissues to wipe herself and privacy to dress. The probe should then be cleaned using the same method as employed at the outset of the scan.

1.6 Orientation of the probe

There is no agreed convention as to how the image is displayed. One school of thought is that the apex is displayed at the top of the monitor, another is that the apex is displayed at the bottom of the monitor. If we assume that the apex is at the top of the monitor and the scan is undertaken holding the probe in the right hand the following principles apply:

- The transvaginal ultrasound probe is held in the right hand with the thumb uppermost. Most probe handles are either shaped to be comfortably held in this position. Alternatively, if the probe is symmetrical in shape there may be an identifiable groove or mark on the probe to aid orientation.

- There is a logo or symbol on the left side of the screen image. The uppermost aspect of the probe corresponds to the left side of the image.
- This can be confirmed by running a finger under the aspect of the probe nearest the thumb. The resulting shadow will be displayed on left side of the image.
- There is the ability to invert the image top to bottom and right to left with controls on the machine. However, we are assuming that for the purposes of this explanation that those controls have not been activated.

1.7 Starting the scan and the basic probe movements

Every scan should be undertaken methodically and systematically. An examination typically includes assessment of the uterus, endometrium, ovaries, adnexa and recto-uterine pouch in that order. Insert the transvaginal probe into the vagina a few centimetres whilst observing the monitor and ensuring that the woman is comfortable during the procedure. The urinary bladder may be seen to the left of the image. This forward movement of the probe is termed ***sliding.*** A fan-like shape beam of sound is emitted. It is this fan-like shape which needs to be directed across the pelvic organs in order to examine them in anatomical section. All the probe movements should be made gently and slowly. The first view to obtain is a mid- sagittal section of the uterus. The orientation of the uterus will dictate your next probe movement which is termed ***angling.*** Angling involves raising the probe handle to the ceiling or lowering it to the floor. If the probe handle is raised, the probe face is directed to the posterior fornix of the vagina. This movement is required to image a retroverted uterus. The corresponding image shows the uterine fundus to the right of the image and the cervix to the left of the image. Conversely if the probe handle is lowered, the probe face is directed to the anterior fornix of the vagina. This movement is required to image an anteverted uterus. The corresponding image shows the uterine fundus to the left of the image and the cervix to the right of the image. An axial uterus lies parallel to the ultrasound beam, with the uterine fundus seen towards the bottom of the image[1,2].

In reality, the uterus rarely lies midline within the female pelvis - it is usually deviated to one side, more commonly the woman's left. This necessitates employing the third probe movement which is termed ***panning***. Panning involves moving the probe handle laterally towards the woman's right and left thigh respectively. If the uterus is deviated to the woman's left, the probe handle needs to be moved towards the woman's right thigh. The probe face will be directed towards the left lateral fornix of the vagina. You should now be able to visualise a mid-line sagittal section of the uterus. The cervix should be seen in continuity with the endometrium. Provided the uterus is of normal size, the entire contour of the uterus should be visualised (Figure1-1). The uterus (namely the myometrium) needs to be examined para-sagitally from its right lateral border through to the left lateral border. Panning the probe handle to the woman's left thigh directs the probe face to the right lateral fornix of the vagina. If you visualise beyond the right lateral border of the uterus, this ensures that you are examining the uterus in its entirety. You may need to angle your probe in addition so that the entire uterus is visualised from fundus to cervix particularly if the uterus is enlarged. Pan your probe across the uterus back to the mid-sagittal section of the uterus, continuing the panning movement so that the probe handle is towards the woman's right thigh and the probe face directed to the left lateral fornix of the vagina. Again, visualise beyond the left lateral border of the uterus.

The uterus is next examined in the transverse plane. Strictly speaking, this is a plane mid-way between coronal and transverse as it is not possible to achieve a 90^0 angle to the sagittal plane due to the confines of the vagina. However, transverse plane is the accepted term used by ultrasound practitioners.

Manipulate the probe so that you have returned to the mid-sagittal view of the uterus. The probe handle is rotated through a quarter turn (90^0) in an anti-clockwise fashion. If you imagine a clock face your thumb will now be positioned at 9 o'clock. This probe movement is termed ***rotation.*** The probe handle is then angled/ lowered so that the probe face is directed towards the anterior fornix, and the handle is then slowly raised so that probe face is directed towards the posterior fornix. The uterus is thus examined in transverse section from the uterine fundus to the cervix for an anteverted uterus and cervix to uterine fundus for a retroverted uterus. Examination of an axial uterus in transverse section is difficult, with the view being more akin to a coronal view. Ultrasound assessment of the axial uterus is often improved by using the transabdominal approach (see later).

1.8 Measurement of the uterus

Ultrasound measurement of the uterus has limited clinical use. It may be relevant when deciding whether laparoscopy or a laparotomy is required for a hysterectomy, therefore, it is important to know how to measure the uterus. The uterus is measured in three planes orthogonal to each other. The first two diameters are taken from a mid-line sagittal section of the uterus. The longitudinal length is measured by placing one calliper on the outer border of the uterine fundus and the other calliper at the internal os. In effect this measurement does not include the cervix. The antero-posterior diameter is taken at the maximum thickness perpendicular to the longitudinal length. The callipers are placed on the outer borders of the anterior and posterior walls of the uterus respectively. The third diameter is taken from a transverse section of the uterus. The widest diameter is measured. The callipers are placed on the right and left lateral wall of the uterus respectively.

1.9 The endometrium

Once the uterus has been assessed, the endometrium should be separately examined in sagittal and transverse section. The method is the same as that used to assess the uterus namely a mid-sagittal section, with a sweep para-sagittally and then assessment in transverse. The endometrial thickness should be taken from a mid-sagittal section. The antero-posterior diameter is measured by placing the callipers at the anterior and posterior margins of the endometrium (the endometrial/ myometrial interface). The thickest diameter of the endometrium should be measured - this is usually 1-2cm from the fundal endometrial/ myometrial junction (Figure1-1). Very small probe movements are required to assess the endometrium. Assessment of the endometrium includes looking for subtle changes in the ultrasound appearances. How best to manipulate the ultrasound controls to optimise the view of the endometrium is discussed later in this chapter[1,2].

1.10 The ovaries

The ovaries are usually located medial to the iliac vessels. The right ovary is usually more easily seen so often the side that is examined first. The left ovary is often obscured by the sigmoid colon.

Rotate the probe a quarter turn (90^0) anti-clockwise in order to obtain a transverse section of the uterus, at mid uterine body level. The probe handle is moved towards the woman's left thigh using a panning movement. The image should now display the right uterine border to the right of the screen and the right iliac artery and vein (in transverse section) to the left of the screen. The right adnexa is now examined. Apply a small degree of pressure on the ultrasound probe and angle the probe up and down in order to firstly locate the right ovary and then examine it transversely from its superior to inferior border. The probe is then rotated through a quarter turn (90^0) clockwise so that the right ovary can be examined in a para-sagittal fashion. A panning movement will allow examination of the right ovary from its lateral to medial border. The probe handle is moved towards the woman's right thigh and the above technique applied to exam the left ovary.

Occasionally the ovaries are not visualised using this technique. Either ovary may lie more centrally within the recto-uterine pouch or superior to the uterine fundus. Angling the probe to visualise the recto-uterine pouch or the uterine fundus when imaging the uterus in sagittal and para-sagittal section may aid visualisation.

If one or both ovaries are located more anterior and superior within the female pelvis then a transabdominal scan is required for visualisation. Irrespective of their location the ovaries should be examined in both sagittal and transverse plane and measured.

1.11 Measurement of ovaries

A mid transverse and mid-sagittal section image of the ovary at its widest diameter should be saved. The callipers are then placed to take three measurements which are orthogonal to each other. The three measurements are the superior- inferior (a), antero-posterior (b) and transverse (c) diameters. The ovarian volume (cc) is usually calculated on the ultrasound machine by means of the spherical volume formula:

a x b x c x 0.5233

1.12 Undertaking a transabdominal scan

If a transvaginal scan is contra-indicated or declined by the woman a transabdominal scan to exam the pelvic organs is required. A pre-requisite for a transabdominal scan is to have a full urinary bladder. This requires drinking approximately 750ml of water an hour before the scan and not voiding until completion of the scan. The full bladder acts as an acoustic window to the pelvic organs. It also alters the axis of an anteverted uterus so that it is more perpendicular to the ultrasound beam which facilitates visualisation of the endometrium.

A transabdominal scan is a useful adjunct to a transvaginal scan in several instances:

- Non-visualisation of either one or both ovaries on transvaginal scan
- The uterus is axial in orientation and not adequately visualised on transvaginal scan
- The uterus is enlarged by fibroids, and these are not adequately visualised on transvaginal scan due to poor penetration
- There are adnexal masses that are too large and/or out of the focal zone of the transvaginal probe to examine.

A transabdominal performed as an adjunct for the above reasons does not require the woman to fill her bladder.

Orientation of the probe

The transabdominal ultrasound probe is held in the right hand. There is usually an identifiable groove or mark on the probe. If the probe is placed on the woman's lower abdomen just superior the symphysis pubis, in order to obtain a longitudinal section of the uterus, with the groove or mark towards her head. The accepted convention is that the urinary bladder will be displayed to the right of the screen and the uterine fundus to the left of the screen. Similar, to the transvaginal scan this orientation can be confirmed. Run a finger under the aspect of the probe towards the woman's head (corresponding to the groove/ mark) the resulting shadow will be displayed on the left side of the image.

1.13 Starting the scan and the basic probe movements

Transabdominal ultrasound assessment of the female pelvis includes the uterus, endometrium, ovaries, adnexa and recto-uterine pouch. The initial plane to be acquired is a longitudinal section of the uterus. As previously described the probe should be placed upon the woman's lower abdomen just superior to the urinary bladder. A ***sliding*** movement refers to the movement of the probe across the abdomen. The mid-sagittal section of the uterus demonstrates the cervical canal and uterine cavity in continuity. In practice a slight clockwise ***rotation*** of the probe is required as the uterine axis is commonly deviated to the woman's left. Rotation of the probe refers to turning the probe on a fixed point. ***Dipping*** the probe involves pressing the short end of the probe into the abdomen. Dipping the distal end of the probe will ensure the ultrasound beam is perpendicular to the axis of an anteverted uterus thus improving visualisation of the endometrium.

The uterine myometrium needs to be examined para-sagittal from its right lateral border through to the left lateral border. This entails sliding the probe to the woman's right and left flank respectively whilst maintaining the degree of rotation and dipping applied for the initial mid-sagittal section.

The uterus is next examined in the transverse plane. The probe is rotated through a quarter turn (90^0) in an anti-clockwise fashion. Starting at the symphysis pubis slide the probe cranially to examine the uterus in transverse section from the cervix to the fundus. The uterine orientation i.e. anteverted, retroverted or axial will dictate the degree of ***angling*** required. Angling the probe alters the angle of the complete probe surface relative to the woman's abdomen. This probe manipulation ensures that a symmetrical antero-posterior transverse section of the uterus is achieved. Furthermore, the endometrium will be visualised in a true transverse plane rather than an oblique view. In practice the probe usually needs to be angled towards the woman's head.

1.14 The ovaries

To image the right ovary, rotate the probe to obtain a transverse section of the uterus, at mid uterine body level. Dip the right aspect of the probe into the woman's abdomen to direct the beam towards her right iliac fossa. The image should now display the right uterine border to the right of the screen and the right iliac artery and vein (in transverse section) to the left of the screen. Slide the probe up and down to locate the right ovary and examine it from its superior to inferior border. The probe is then rotated through a quarter turn (90^0) so that the right ovary can be examined in a para-sagittal fashion. A sliding movement will allow examination of the right ovary from its lateral to medial border. The above technique is repeated on the left adnexa to image the left ovary.

If one or either of the ovaries are not located in the adnexa examine the pouch of Douglas and/ or superior to the uterine fundus. Occasionally the ovaries lie more anteriorly and superiorly within the pelvis. Place the probe in a sagittal plane position and slide laterally to image the iliac artery and vein. Rotate the probe slightly usually anti-clockwise to view the iliac vessels in their full length. Slide the probe cranially along the course of the vessels assessing medial to them. The ovaries can be located as high as level with the iliac crest (1, 2).

1.15 Basic controls

Irrespective of the design and specification of your ultrasound machine the basic controls are common to all systems the most fundamental being the on/ off switch and should be readily located. As the operator you need to understand the ultrasound controls and the effect that they have on the image. This will allow you to optimise your image and improve your diagnostic capability.

All gynaecological ultrasound scans should be undertaken so that the images and reports are stored electronically i.e. connected to PACS (Picture Archiving Communications Systems).

At the outset of the scan the patient to be scanned is selected from a worklist. The demographic details are displayed on the ultrasound monitor; an identification check should be undertaken to confirm the correct patient is being scanned and that the details are correct. The probe is chosen from the machine's control panel. The operator is prompted to select one of the manufacturer's pre-sets. These are pre-saved settings selected to best optimise the image according to the examination type for example a pelvic scan. There may be an option of a pelvic penetration pre-set an option when scanning an obese woman.

The freeze button when selected will freeze the image. Most machines have the option to scroll back through a cine loop of several frames to select the preferred image. On screen callipers can be selected a tracker ball or touch screen is used to perform measurements e.g. endometrial thickness, ovarian cyst size. Representative images of normal anatomy and any pathology can be saved and thus digitally archived.

1.16 Frequency

Your selected probe will operate at a range of frequencies for example between 6 to 10MHz on a transvaginal probe. The probe operates at a default central frequency. There is a control to increase or decrease frequency. Increasing the frequency to 10MHz will improve the image where greater resolution would be helpful for example an antral follicle count of the ovary in a slim woman. Decreasing the frequency to 6MHz will improve the image where more penetration is required for example imaging a fibroid throughout its depth.

1.16.1 Depth

Depth control alters the distance from the probe face into the abdomen that can be examined. Ideally the region of interest should be made as large as possible. Measurements are more accurate if the area under interrogation is made larger. If the region of interest is located at depth. The zoom control needs to be employed.

1.16.2 Zoom

There are two types of zoom: read and write zoom. Read zoom is performed on a frozen image in one of two ways. Either the whole image can be magnified by manipulating the zoom control, or a region of interest (ROI) box is placed over the smaller area of the image. The ROI box can be moved to be positioned over the desired anatomical area once the zoom control is activated the ROI box is expanded. The number of pixels is not increased but each pixel is magnified therefore the resultant image can appear pixelated. Write zoom is performed on a real time image. The ROI box is placed over the area of interest. The ROI box can be moved, and its size expanded upon activation of the zoom control. More pixels are added to the resultant image thus having greater resolution than an image magnified using read zoom.

1.16.3 Focus

The focus should be set at the level of interest. This corresponds to the point at which the lateral resolution is at its optimum thus improving the image quality. The focus control alters the depth at which the focus is set and is indicated on the image[1,2].

1.16.4 Gain

The overall gain controls the brightness of the image it can compensate for attenuation of the ultrasound beam. Typically, the gain needs to be altered at varying depths throughout the image this is referred to time gain compensation (TGC) to compensate for different tissue types. For example, a full urinary bladder will attenuate the beam less than a fibroid. Therefore, the gain may need to be lowered posterior to the bladder so that the uterus can be optimally visualised[1,2].

1.16.5 Sector angle

Narrowing the sector angle increases the line density which improves the lateral resolution and ultimately the image quality.

1.16.6 Colour Doppler

The colour Doppler control activates a ROI box which is placed over the area to be examined for example an ovarian tumour. As a rule, a smaller ROI box improves the image quality. The PRF (pulse repetition frequency) needs to be set so that the maximum and minimum blood flow velocities under interrogation can be analysed. Put simply if it is set too high low velocity flow will not be detected, if set too low it will cause aliasing in vessels with high velocity. Aliasing is a phenomenon whereby the high velocity flow is misrepresented by the colour pixels creating a confusing image. In gynaecological ultrasound it is typically low velocity flow that is being investigated. For this reason, the PRF should be lowered, the recommended PRF to assess vascularity within adnexal masses is 0.3 kHz (IOTA). The final adjustment to the Colour Doppler assessment is colour gain. If the colour gain setting is too high the image is saturated with extraneous colour signal. Conversely if the colour gain setting is too low colour signal may be missing[1.2].

1.16.7 Power Doppler

Power Doppler is a useful tool to assess low flow velocities for example a vascular stalk in an endometrial polyp. As power Doppler is not demonstrating directional flow aliasing is not an issue. Similar to colour Doppler, on activation of power Doppler a ROI box is placed over the area to be examined.

1.17 Artefacts

1.17.1 Definition of artefacts

Ultrasound artefacts occur because the interaction of ultrasound with tissues is not consistent. The image is formed based on several assumptions. These include:

- ultrasound travels at a constant speed of sound 1540m/s
- ultrasound travels in a straight line
- attenuation of ultrasound is uniform
- reflection of the ultrasound beam is perpendicular to the incident beam when it encounters an interface

In reality, this is not always the case. Ultrasound artefacts can cause an image to give a false representation of anatomy.

It is important that as the operator you are aware of when artefacts are being produced and the effect that they are having on your image. Indeed, some artefacts can aid you in the interpretation of your image. The most common artefacts encountered in gynaecological ultrasound are described below.

1.17.2 Acoustic shadowing

This occurs when the beam encounters tissue or material of high attenuation for instance a Mirena coil within the uterine cavity (Figure 1-3) or calcified tissue such as teeth and bone present within a dermoid cyst. The shadowing is depicted as a solid anechoic stripe distal to the high attenuation tissue or material. The width of the shadowing is relative to the calcified tissue's presenting surface area to the incident beam.

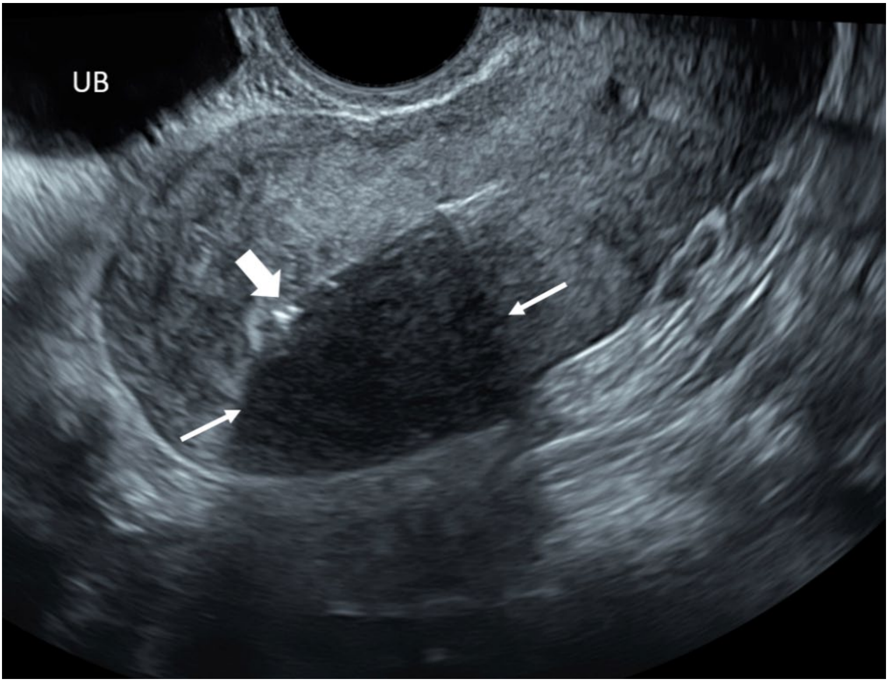

Figure 1-3: Sagittal mid-line section of the uterus. The large arrow shows the proximal end of a Mirena coil. Acoustic shadowing posterior the coil is seen between the smaller arrows.

1.17.3 Posterior enhancement

Structures distal to fluid filled structures such as a serous cystadenoma or a full urinary bladder will appear hyperechoic compared to surrounding tissues at a similar depth. The sound has been subjected to less attenuation as it traverses fluid therefore the returning echoes are relatively stronger.

1.17.4 Reverberation

This occurs when the sound encounters two highly reflective surfaces. Some of the incident sound is reflected and forth between the two layers rather than traversing through tissue unimpeded. The received echoes are assumed to have originated from a greater depth. The resulting image typically