BIOT221
Western Diagnostic Techniques

Session 10

Imaging
Ultrasound Sonography

Bioscience Department
SESSION OBJECTIVES

• Understand why imaging techniques are a valuable tool in clinical practice

• Understand the application and clinical relevance of the following imaging techniques
WHAT SHALL WE LEARN TODAY..

• What is Ultrasound Sonography
• When is it used?
• What are the different types?
• What are the advantages and disadvantages of a USG?
• Few clinical applications
ULTRASOUND

• Ultrasonography uses high-frequency (ultrasonic) sound waves directed at the internal body structures. The density of the underlying structures determines the degree to which the sound is reflected back. This echo is then detected by the ultrasound machine and converted into a real-time moving image, from which still images can be captured.

• The image produced on the screen is similar to the image of an x-ray where dense matter (more echo) appears lighter, and less dense matter (less echo) appears darker.

• Doppler ultrasound is generally used to image blood flow through blood vessels or the heart. It is similar to the standard ultrasound, except that the image is formed by analysing the change in the sound wave frequency, which is caused by the moving red blood cells.

• The faster the blood is moving, the more distortion there is to the frequency wave, the slower the blood flow, the less distortion. The difference in frequency is displayed in the image as different colours, or can be converted into sound (e.g. fetal heart rate, echocardiography)
Ultrasound - Uses

- To evaluate the size, structure and position of body organs
- To evaluate the blood flow in arteries and veins
- To detect cysts, tumours and calculi
- To assess functional movements in real time
- Foetal visualisation to check for gestation, abnormalities, heart contraction, digestive movement, bone growth, size and growth, and placental status
- To detect ectopic pregnancy
- To monitor therapy (e.g. to determine whether thyroid-suppression therapy of a thyroid nodule is successful)
- Used to guide needle or catheter insertion during certain procedures
Ultrasound - Types

- **Pregnancy** – relatively safe technique
- **Pelvic** – bladder function, endometriosis
- **Renal** – kidney distension, torsion, reflux
- **Chest** – heart size, lung pleurisy
- **Abdominal** – pain, distension, size of organs, fluid collection, faecal compaction, obstructions
- **Limbs** – detection of DVT
ULTRASOUND – ADVANTAGES

• Non invasive (except trans-vaginal, per rectal, trans-oesophageal and per rectal) and painless

• Requires no Ionizing radiation or use of contrast

• Repeated studies may be performed and multiple images obtained with no risk

• Less expensive that CT or MRI

• Can be performed at an office/lab/at the bedside
ULTRASOUND – LIMITATIONS

• Resolution is difficult to maintain

• Requires specialist interpretation

• Can miss entire structures as they can be masked by another structure

• Some recent research has suggested there may be side effects in using ultrasound, however there is insufficient evidence to support this
Ultrasound

- Ultrasound waves do not pass through air therefore an evaluation of the stomach, small intestine and large intestine may be limited.

- Intestinal gas may also prevent visualisation of deeper structures, such as the pancreas and aorta.

- Patients suffering from obesity are more difficult to image—this is because it weakens the sound waves as they pass deeper into the body.

- Ultrasound has difficulty penetrating bone and therefore can only see the outer surface of bony structures and not what lies within and beyond.
ULTRASOUND

Ultrasonography room

Source: Mosby’s Manual of Diagnostic and Laboratory tests
## Clinical Problems - Ultrasound

<table>
<thead>
<tr>
<th>Organ</th>
<th>Abnormal findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal aorta</td>
<td>Aortic aneurysms, aortic stenosis</td>
</tr>
<tr>
<td>Arteries and veins (Doppler)</td>
<td>Arterial occlusion (partial or complete), deep-vein thrombosis, chronic venous insufficiency, arterial trauma</td>
</tr>
<tr>
<td>Brain</td>
<td>Intracranial haemorrhage, lesions (tumours, abscess), hydrocephalus</td>
</tr>
<tr>
<td>Breast</td>
<td>Cysts, tumours, metastasis to the lymph nodes and muscle tissue</td>
</tr>
<tr>
<td>Carotid artery</td>
<td>Carotid plaque, thrombus, degree of stenosis</td>
</tr>
<tr>
<td>Eye and eye orbit</td>
<td>Vitreous opacities, detached retina, foreign bodies, orbital lesion, orbital inflammation, meningioma, glioma, neurofibroma, cyst, keratoprosthesis</td>
</tr>
<tr>
<td>Gallbladder</td>
<td>Acute cholecystitis, cholelithiasis, biliary obstruction</td>
</tr>
</tbody>
</table>
Clinical Problems - Ultrasound

<table>
<thead>
<tr>
<th>Organ</th>
<th>Abnormal findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>Cardiomegaly, mitral stenosis, aortic stenosis and insufficiency, pericardial effusion, congenital heart disease, left ventricular hypertrophy, ischaemic heart disease, septal effects</td>
</tr>
<tr>
<td>Kidney</td>
<td>Renal cysts and tumours, hydronephrosis, perirenal abscess, acute polynephritis, acute glomerulonephritis</td>
</tr>
<tr>
<td>Liver</td>
<td>Hepatic cysts, abscess, tumours, hepatic metastasis, hepatocellular disease, congenital abnormalities</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Pancreatic tumours, pseudocysts, acute pancreatitis</td>
</tr>
</tbody>
</table>
Clinical Problems - Ultrasound

<table>
<thead>
<tr>
<th>Organ</th>
<th>Abnormal findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis</td>
<td>Uterine tumour, fibroids, hydatiform mole, endometrial changes</td>
</tr>
<tr>
<td>Uterus</td>
<td>Uterine tumour, fibroids, hydatiform mole, endometrial changes</td>
</tr>
<tr>
<td>Ovaries</td>
<td>Ovarian cysts or tumour</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>Foetal age, foetal death, placenta previa, abrupto placenta, hydrocephalus, breech foetal presentation</td>
</tr>
<tr>
<td>Prostate</td>
<td>Cancer, benign prostatic hypertrophy, prostatitis</td>
</tr>
</tbody>
</table>
# Clinical Problems - Ultrasound

<table>
<thead>
<tr>
<th>Organ</th>
<th>Abnormal findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrotum</td>
<td>Hydrocele, spermatocele, varicocele, testicular tumours, torsion, epididymitis</td>
</tr>
<tr>
<td>Spleen</td>
<td>Splenomegaly, splenic cysts, abscess, tumour, congenital anomalies</td>
</tr>
<tr>
<td>Thoracic</td>
<td>Pleural fluid, abscess formation, malposition of the diaphragm</td>
</tr>
<tr>
<td>Thyroid</td>
<td>Thyroid tumours, goiters or cysts</td>
</tr>
</tbody>
</table>
Obstetric/Pelvic Ultrasound

Used to:

- Determine gestational age
- Confirm fetal viability
- Determine location of fetus (ie intrauterine vs ectopic)
- Check the location of the placenta in relation to the cervix
- Determine multiple pregnancies
- Check for major physical abnormalities
- Assess fetal growth
- Check for fetal movement and heartbeat
- Determine the sex of the baby
- To assess the pelvic organs and detect pathology in non-pregnant patients

- **Note:** The patient is required to have a full bladder during the initial part of the ultrasound examination which may be uncomfortable
Obstetric Ultrasound

Pelvic ultrasonography. Ultrasonography is often used for obtaining diagnostic information on pregnant women.

Source: Mosby’s Manual of Diagnostic and Laboratory tests
Obstetric Ultrasound

Sonogram of 14 week old foetus

Ectopic implantation (pregnancy) in the left uterine tube (UT). Also visible is the left ovary (L OV) and the uterus (UT)

Gynaecological Ultrasound

Depending on the organs that needs to be imaged a gynaecological ultrasound may be performed as a trans-abdominal or trans-vaginal approach

Used to:

- to assess pelvic organs
- to diagnose and manage gynaecologic problems including endometriosis, leiomyoma, adenomyosis, ovarian cysts and lesions
- to identify adnexal masses, including ectopic pregnancy,
- to diagnose gynaecologic cancer
- in infertility treatments to track the response of ovarian follicles to fertility medication
Gynaecological Ultrasound

- Ultrasound picture of a polycystic ovary from a woman with PCOS
- A number of immature follicles (black circles) are seen here

Abdominal Ultrasound

- This technique is used to visualize the abdomen and the organs within it.
- Its uses are as shown below:

### Table 10-1: Overview of Abdominal Ultrasonography

<table>
<thead>
<tr>
<th>Area Visualized</th>
<th>Possible Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney</td>
<td>Cysts, tumors, calculi, hydronephrosis, malformations, abscess, transplant rejection</td>
</tr>
<tr>
<td>Aorta</td>
<td>Aneurysm</td>
</tr>
<tr>
<td>Liver</td>
<td>Cysts, abscess, dilated hepatic ducts, tumors</td>
</tr>
<tr>
<td>Gallbladder, extrahepatic ducts</td>
<td>Gallstones, polyps, dilation secondary to strictures or tumors</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Tumors, pseudocysts, inflammation, abscess</td>
</tr>
</tbody>
</table>

Source: Mosby’s Manual of Diagnostic and Laboratory tests
ABDOMINAL ULTRASOUND

Source: Mosby’s Manual of Diagnostic and Laboratory tests

Figure 10-4  Ultrasonogram of the kidney.

Figure 10-6  Abdominal ultrasonography.
Abdominal Ultrasound

Ultrasonogram of the gallbladder. Long-axis view of the gallbladder containing a gallstone. Note the posterior acoustic shadowing, typical for gallstones.

Gallstones in a normal gallbladder

BREAST ULTRASOUND

• Ultrasound examination of the breast is most commonly performed to determine if a mammographic abnormality of a palpable lump is a cyst (fluid-filled) or solid tumour (benign or malignant)

• Diagnostic accuracy is improved when breast ultrasonography is combined with mammography.

• It can be used to locate a non-palpable breast abnormality for biopsy or aspiration

Source: Mosby’s Manual of Diagnostic and Laboratory tests
• Ultrasound is especially useful in patients with an abnormal mass identified on a mammogram, because the nature (cystic or solid) of the mass can be determined

• Most cysts are benign

Prostate and Rectal Sonography

- A per rectal approach is used
- Helpful in detection of prostate cancer in patients with an elevated prostate-specific antigen (PSA) titer, and to guide needle insertion for prostate biopsy
- Study can be used to stage and monitor rectal cancer and to detect other perirectal diseases
- Can be performed in the office of most urologists
Scrotal Ultrasonography (Ultrasound of Testes)

- Allows thorough evaluation of the testes and other scrotal structures for evidence of suspected disease

- Evaluation of scrotal masses, measurement of testicular size, scrotal trauma/pain and identification of benign and malignant tumours

- Extratesticular lesions such as hydrocele (fluid in the scrotum), hematocele (blood in the scrotum), and pyocele (pus in the scrotum) can be identified

- Test is 90-95% accurate

- Very little discomfort is associated with this test
Thyroid Ultrasonography

- Indicate whether a thyroid nodule is a fluid-filled cyst (likely benign) or a solid tumour (possibly malignant)

- Also used to monitor the medical treatment or observation of a thyroid nodule, and to monitor the contralateral thyroid lobe when one side was surgically removed because of cancer

- Procedure of choice for studying the thyroid gland in pregnant women, because no radioactive material is used

- Study may be repeated at intervals to determine the response of a thyroid mass to medical therapy

- No discomfort is associated with this study
CLASS ROOM ENHANCED ACTIVITY

In order to complete this activity please refer to the following:

• Tutorial activity Instructions (Week Eleven)
• Readings (Week Eleven)
• SSG (Week Eleven)
References

• Mosby’s Manual of Diagnostic and Laboratory tests, Pagana, Pagana.; 5th Edition – Elsevier
• Pagana & Pagana, Mosby’s Diagnostic and Laboratory Test Reference. 11th edn, Mosby
• Your Medical Tests. What do they really mean? Dr Jonathan Upfal and Jill O’ Callaghan, Black Inc; 2001.