Ultrasonography In Orthopaedic Practice - A Review

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Introduction

Ultrasonography is an invaluable non-invasive imaging technique that uses non-ionizing high frequency sound energy of 1 - 10 mHz in the diagnosis and management of a variety of disorders. There is increasing awareness of the role of this diagnostic modality in combination with other imaging modalities in clinical Orthopaedic practice and management of a variety of musculoskeletal disorders. It is often used as an adjunct to such other modalities of imaging as MRI in the assessment of soft tissue disorders.

The technique is based on the variable acoustic impedance produced at tissue interphases as sound waves are reflected at various organ surfaces to produce an image. The reflected sound beam (echoes) produce diagnostic anatomic information about the size, shape and internal structure of normal tissues and also pathologic processes. The interpretation of the images formed calls for sound knowledge of cross-sectional anatomy and dynamic imaging for proper and accurate diagnosis. The time interval between the emitted ultrasound wave from the transducer and the arrival of the reflected wave gives a measure of the skin to organ distance hence localization of pathology is made possible. This information from the reflected waves are digitalized and thousands of such measurements generate an ultrasound cross-sectional image which is then recorded on the monitor and can be interpreted.

Several types of transducers are available for clinical imaging based on their frequencies. The higher frequency probes (5 - 7.5 mHz) are less penetrating but they provide better resolutions. These are mainly used in paediatric scans and scans of small parts or superficial structures. For adult scans and for deeper structures the lower frequency probes are preferable (3-5 mHz).

Diagnostic ultrasound requires skill and operators need long time for training and acquisition of the relevant skills. These are some of the limitations militating against the wide spread use of this imaging modality in Orthopaedic practice in our setting. Sound knowledge of anatomy and careful dynamic imaging are needed for proper and accurate diagnosis of these musculoskeletal disorders. It is very easy for the inexperienced operator to produce dangerously inaccurate scan results. The outcome could be misleading to the clinician and disastrous for the patient.

The advantages of ultrasound over the other imaging modalities is that it is cheap and readily affordable, relatively available, safe i.e. no known deleterious somatic or genetic effects have been detected and so can be repeated often. It is a painless examination, it does not require sedation and above all it does not involve the use of ionizing radiation.

The outcome of diagnostic ultrasound must however be monitored by comparison with the results of other imaging modalities and correlate this with findings at surgery to make the best of it.

Indications For Ultrasound In Orthopaedic Practice

Antenatal

Fetal musculoskeletal abnormalities are neither rare nor esoteric. Ultrasound can thus be used in the antenatal period to detect these abnormalities involving the musculoskeletal system. Such abnormalities include osteochondrodysplasia, club foot, arthrogryposis and other limb anomalies associated with congenital or chromosomal abnormalities (fig 1a & b).

Fig 1.Osteochondrodysplasia. (a) Longitudinal scan showing shortened ulnar (u) and radial bones with contractures.
Spinal Lesions
Spinal sonography is helpful in evaluating the spine and its contents especially in the new born and young children. This is usually done with high frequency probes (5 - 7mHz) in either a sagittal or axial plane. Normal scans will demonstrate the alternating echogenic dorsal vertebral bodies, the ventral epidural fat, the ventral dura, the spinal cord with a central echo complex, then the dorsal dura and the posterior spinous processes. Such pathological conditions as tethered cord syndrome with low lying conus medullaris below the L2/L3 level, subcutaneous and epidural masses of the spine and spinal neoplasms, all can be detected by ultrasound. Prominent among the spinal neoplasms which can be picked on ultrasound is the sacrococcygeal teratoma. This is a congenital tumour derived from the three germinal layers. The commonest site is the sacrococcygeus. It presents as a huge soft tissue mass in the sacrococcygeal region; more frequently in females (m:f: l:4) and can be detected easily by ultrasound in-utero or at birth. By ultrasound it is easy to confirm the tumour and even characterize it into cystic, solid or mixed types. This determines the outcome as those lesions which are either completely cystic or partly cystic are usually benign whereas those which are completely solid are frequently malignant.

Ultrasound is also valuable in determining the extent of the mass and the presence of secondary obstructive lesions like hydronephrosis of the kidneys.

Congenital Hip Dysplasia
Ultrasoundography can demonstrate the relationship of the unossified femoral head and the acetabulum and assessment of the cartilage is better than with plain radiographs. For this reason ultrasonography has become very essential in the management of developmental or congenital hip displasias and this has actually in recent times increased the rate of detection of these abnormalities and other hip instabilities which are common findings in Orthopaedic practice. Early detection of these instabilities and diagnosis of true hip dislocations are very important clinically for it affects the management and prognosis.

Static or dynamic scanning in coronal plane affords the opportunity of measuring and assessing the relationship between the bony roof line of the acetabulum, the cartilaginous part of the acetabulum covering the head of femur and a base line along the Iliac wing. By use of angular measurements the hip can be classified into various sonographic Hip types.

Sonographic Hip Types

<table>
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<tr>
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<th>Alpha Angles (x)</th>
<th>Beta Angles(B)</th>
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<tr>
<td>1. Mature Hip (Normal)</td>
<td>&gt;60</td>
<td>&lt;77°</td>
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<tr>
<td>2. Unstable Hip</td>
<td>43 - 49° (critical angle)</td>
<td>70 - 77°</td>
</tr>
<tr>
<td>3. Subluxed Hip</td>
<td>43</td>
<td>&gt;77°</td>
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<tr>
<td>4. Dislocated Hip</td>
<td>&lt;43</td>
<td>&gt;77°</td>
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( fig 2). Diagram of Sonographic Hip types (Courtesy Wolfgang D. Radiology Review Manual 2nd Edition 1993) (see text)

Coronal view of L-Hip

X-angle = angle between the straight lateral edge of iliac bone and the bony acetabular margin on coronal view.

B-angle = angle between the straight lateral edge of the iliac bone and the fibrocatilaginous acetabulum.

Ultrasoundography has become the initial modality of choice for the assessment of the neonatal hip for confirmation of the irritable hip syndrome, for exclusion of effusions and septic arthritis. It is becoming increasingly relevant in the detection of slipped upper femoral epiphysis and the visualization of fragmentation of the femoral head as may be seen in Perthes disease.

Joint Abnormalities
In the diagnosis and management of joint abnormalities diagnostic ultrasound has become a very essential practice in the detection of joint effusion and it allows a guided aspiration for symptomatic relief. Ultrasonography helps in the accurate deposition of intra-articular injections and can also be used to guide the therapeutic extraction of deposits e.g. calcium salts at the joints as is commonly seen in the shoulder joint in rotator cuff syndrome.

Tendon And Ligament Pathologies
Ultrasoundography can be used in the assessment and
evaluation of tendon and ligament pathologies. It can detect small tears and the presence of fluid around them in cases of inflammation or trauma. The supraspinatus tendon for instance in cases of rotator cuff syndrome can be easily assessed with the arm in adduction and internally rotated and calcifications within can be easily identified and demonstrated even better than by MRI.

Other conditions such as Achilles tendon rupture, patellar tendinitis, edema of the tendon sheath as may occur in tennis or golf players elbow and thickening as may be seen in carpal tunnel syndrome can all be assessed by ultrasound. Occult ganglia and neoplasia involving the tendons and ligaments can easily be excluded in mass lesions.

In terms of management, steroid injections into the tendon sheaths can be guided by Ultrasonography.

**Soft Tissue Abnormalities And Muscle Injuries**

Soft tissue masses/swellings are readily recognizable on ultrasound. They can be differentiated in terms of being either cystic, solid or complex i.e mixed, based on their sonographic appearances. For instance, cystic swellings like popliteal cysts which arise from the medial head of the gastrocnemius muscle will show a classical soap bubble appearance while solid masses like neuromas will present as hypoechoic masses with dorsal acoustic enhancement.

Partial or complete muscle tear arising from trauma can easily be diagnosed ultrasonographically. Such features as local haemorrhage/haematoma, muscle herniations which may present as a lump, abnormal striation or muscle fibre separations can be easily demonstrated.

**Vascular Anomalies**

In Orthopaedic practice the commonest vascular problem that follows most hip and knee replacement procedures is deep vein thrombosis (DVT). Ultrasonography is one quick and non invasive modality of detecting this condition. In DVT, there is the presence of a hypoechoic intravascular mass or there is turbulence in the intravascular flow on real-time ultrasound scan. However, compressibility of the veins of the lower limb is a good confirmation of the absence of a thrombus.

**Interventional Procedures**

The diagnosis and management of certain conditions in orthopaedic practice has been revolutionized by use of ultrasound guidance in these interventional procedures. For instance the detection and localization of foreign bodies prior to extraction has now been made easy and possible. The size, site, nature of foreign body or the extent of incision needed by the surgeon for the extraction can be determined by ultrasound. Detection and drainage of abscesses and cysts can be easily and accurately done via ultrasound guidance. This can now save the patient open surgical procedures.

**Fracture Management**

The effect of application of low intensity pulsed ultrasound on patients with bone related disorders including normally healing fractures, stress fractures, delayed or nonunion or as post surgical intervention are considered positive. Among the beneficial effects of using therapeutic ultrasound (low intensity ultrasound of 0.03 W cm$^{-2}$ at 1.5 mHz) for normally healing fresh fractures as well as those that demonstrated either delayed or non-union include significant reduction in the healing time, and an over all success rate of 96% in the diagnosis and treatment of stress fractures.

Low dose ultrasound (0.1 W cm$^{-2}$) results in non-significant increase in tissue temperature. It has however been shown to have a stimulative effect on bone tissues thus encouraging healing while at high doses (1 2 W cm$^{-2}$), inhibitory effects occur. The mechanism by which low dose therapeutic ultrasound can be effective for fracture healing includes the nitric oxide pathways and the prostaglandin pathways (PGE$_2$). This observation has been demonstrated in the less favourable outcome of the use of low dose ultrasound in patients who are on non-steroidal anti-inflammatory drugs (NSAID), calcium channel blockers or steroids.

Low intensity ultrasound are also beneficial during distraction osteogenesis, in post spinal fusion surgery and in combination with porous intramedullary implants.
Post Operative Monitoring Limb Lengthening

Following limb lengthening procedures, the rate of formation of callus and detection of the same at the osteotomy site can be visualized and assessed by ultrasound earlier than by plain radiographs. If the distraction at the site of osteotomy is too rapid, a cyst may form. This can be slowed and aspiration of the cyst can be guided by ultrasound.

Bone Lesions

It must be mentioned that ultrasonography cannot be used to reliably detect pathology within the bone but in:

a). Trauma; ultrasound can detect subtle fractures and subperiosteal fluid collection adjacent to these fractures.

b). Inflammation. In such conditions as osteomyelitis, subperiosteal inflammatory exudates/collections can be easily detected on ultrasound even before such changes can be appreciated on plain radiographs.

c). Degenerative changes: Osteophytes may be detected by ultrasound but not as precisely as by plain radiographs.

d). Neoplasm: Ultrasound may be useful in the diagnosis of some bone tumours especially where there is a large soft tissue component e.g. Ewing’s tumour and osteosarcoma. Ultrasound guided biopsy may aid confirmation of diagnosis in these cases.

Biopsy

Ultrasound guided biopsies of masses and lymph nodes for histology are gaining ground in clinical orthopaedic practice, fig. 4.

Aspirates are easily obtained from joints and abscess cavities for culture and sensitivity studies. This practice has shortened the duration of or in some cases completely avoided in-patient care. This ultrasound guided biopsy has great advantage of being done under local anaesthesia thus saving the patient the risk of general anaesthesia.

Conclusion

Ultrasonography in Orthopaedic practice is helpful. The areas of application are gradually widening in scope and are already gaining a position of prominence in the management of sports injuries, rheumatic disorders and traumatology.

For now in our setting, the practice is hampered by lack of experienced sonologists or sonographers. It is hoped that this will improve as the demand for these skilled staff increases. However for the acquisition of experience and for accurate diagnosis of orthopaedic conditions, the need for regular comparison of sonographic findings with surgical results cannot be over emphasized and this imperatively calls for constant cooperation and team work, with regular clinical meetings amongst the various clinical departments.

References


