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Ultrasonography of shoulder [rotator cuff]

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The commonest musculoskeletal (MSK) USG examination request is for the shoulder joint. It can be very easily assessed because of anatomical reasons. Improvement in the resolution of USG machines, refined techniques, and better understanding of the pathology have contributed to high accuracy in the diagnosis of rotator cuff pathology.[1] With an experienced sonologist and good equipment, accuracy of USG equals that of MRI for full-thickness tears and is slightly better than MRI for partial-thickness tears.[2] USG's real-time capability is a big advantage; dynamic studies can be easily done. USG is preferred over MRI in several institutes.

Clinical background

Patients with rotator cuff problems present with a variety of symptoms including a painful arc, night pains, weakness, and decreased range of motion. Though there are various causes for shoulder pain, including adhesive capsulitis, cervical nerve root compresion and acute joint inflammation, 60% of shoulder abnormalities have been attributed to rotator cuff disease, which is the most common cause of shoulder pain and dysfunction in patients above 40 years of age.[3,4] A degenerated rotator cuff is seen in 60% of cadavers above 40 years and 50–70% of individuals above the age of 65 may have a rotator cuff tear.[5]

Cuff fiber failure is a degenerative process, starting as a tendinopathy and progressing through a partial-thickness tear to a full-thickness tear. This generally involves the supraspinatus tendon first and then, gradually, the other tendons.[6]

Physical findings include muscle deformity, anterolateral shoulder tenderness, muscle atrophy, weakness, and decreased range of motion.

Gross anatomy and biomechanics

The shoulder joint is a shallow ball-and-socket joint, which permits a great range of movement. Compared to other ball-and-socket joints, it is inherently unstable and depends on ligament and tendon support, as opposed to just bony support.

The power muscles around the shoulder are the deltoid, pectoralis major, and trapezius. The deltoid is the primary abductor of the arm. It is attached to the scapular spinous process, acromion, and the distal clavicle. Its main vector of action is vertical. When contracted, the deltoid tends to pull the humerus vertically rather than outwards. The ligaments and tendons of the rotator cuff provide 'antagonist' action to the deltoid, so as to hold the humeral head against the glenoid.

There are 3 levels of support:
1. The rotator cuff
2. Biceps tendon
3. Capsular ligaments

This enables the humeral head to pivot at the correct level and to abduct freely.[7]

The rotator cuff is composed of four muscles and their corresponding tendons: (1) subscapsularis, (2) supraspinatus, (3) infraspinatus, and (4) teres minor. These four muscles primarily provide dynamic stability to the intrinsically unstable genohumeral joint and also assist in internal and external rotation and in abduction of the shoulder. The subscapularis is the anterior-most component and is a large triangular, multipennate muscle arising from the subscapular fossa. Fibers of this tendon extend across the glenohumeral joint, converge into a broad, short tendon that inserts on the lesser tuberosity. The supraspinatus is the superior-most muscle. Arising from the supraspinatus fossa, it passes under the acromion, crosses over the humeral head, and inserts as a tendon into the anterior aspect of the greater tuberosity. The infraspinatus muscle originates from the infraspinatus fossa; its tendon extends laterally to insert on the greater tuberosity, posterior and inferior to the supraspinatus tendon. The teres minor is a narrow muscle that arises from a narrow strip on the lateral border of the scapula and inserts just posterior and inferior to the infraspinatus tendon. These three tendons of the rotator cuff together insert on the greater tuberosity of the humerus.[8] The tendon of the long head of the biceps brachii arises from the posterosuperior aspect of the glenoid labrum. It is covered in a synovial sheath. It crosses the shoulder joint obliquely and arches over the head of the humerus and descends into the bicipital groove. Tendinous slips from the subscapularis and supraspinatus tendons form a sheath around the biceps tendon and anchor it in the proximal end of the groove. The coracohumeral ligament originates from the lateral aspect of the base of the coracoid process and inserts into the rotator cuff at the interval between the supraspinatus and subscapularis tendons.

The deltoid is a thick, triangular muscle. It originates from the anterosuperior aspect of the clavicle, superolateral aspect of the acromion, and inferior aspect of the scapular spine. Its tendon inserts in the lateral aspect of the proximal humeral shaft. The subacromial-subdeltoid bursa lies between the rotator cuff and the deltoid muscle. It normally does not communicate with the shoulder joint.[1]

The coracoacromial arch is the superior limit of the shoulder; it consists of the acromion process, coracoacromial ligament, coracoid process, acromioclavicular joint, and subdeltoid bursa. The rotator cuff must pass smoothly under this area, the subacromial outlet.[7]

Scanning technique

Typically, a linear high-frequency probe is used; a broadband probe like L5-12 is ideal. The best way to examine the shoulder joint is to sit on a high revolving chair, with the patient sitting opposite the examiner on a similar chair. The basic principles of MSK USG, i.e., examining each structure in 2 planes and maintaining perpendicularity to tendon fibers, should be followed. It is necessary to follow the curve of the bone, and useful landmarks include the acromion process, biceps tendon, and the labrum.[9–11]

Personally, I prefer to follow the following sequence when examining the shoulder joint: biceps tendon, subscapularis, supraspinatus (including test for impingement), infraspinatus, teres minor, posterior glenoid labrum and glenohumeral space, coraco-acromial ligament and, finally, the acromioclavicular joint.

Biceps tendon

Palpate the bicipital groove with your left thumb and place the transducer perpendicularly at the exact point. The bicipital groove is identified as a concave bright area on the bony surface of the humerus. The tendon of the long head of the biceps is visualized as a hyperechoic oval structure within the bicipital groove. The biceps tendon is traced superiorly in its intraarticular position and inferiorly up to the musculotendinous junction in both transverse and longitudinal planes. Even a small amount of fluid may indicate a rotator cuff injury [Figure 1].

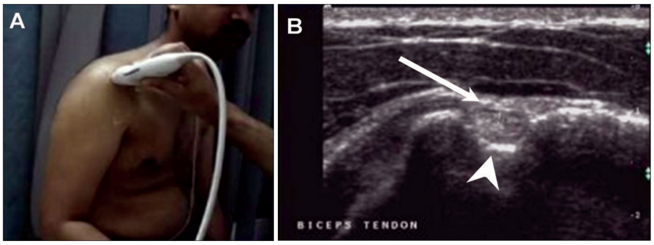

Figure 1 (A, B): Biceps tendon. The photograph (A) shows the position of the transducer for a transverse scan of the bicipital tendon. The tendon (arrow) is well visualized in the groove (arrowhead) on the transverse USG scan (B).

Subscapularis tendon

The subscapularis tendon is best examined while performing passive external rotation and internal rotation. In external rotation the tendon becomes more prominent, as it is medial to the biceps tendon [Figure 2A]. It must be examined in two planes. Injuries of the subscapularis are rare, except in the event of direct trauma [Figure 2].

Supraspinatus tendon

Scanning of the supraspinatus tendon is best done by keeping the arm in extension and internal rotation [12]. Asking the patient to hold the opposite upper arm from behind [Figure 3A] or positioning the arm on the hip [Figure 3B] is the best way to evaluate the supraspinatus tendon, which is the most important tendon. Patients with rotator cuff pathology are unable to position themselves properly. The tendon is scanned perpendicular to its axis (transverse scan) by moving the transducer laterally and posteriorly. It is visualized as a band of medium-level echoes deep to the subdeltoid bursa and superficial to the bright echoes originating from the bony surface of the greater

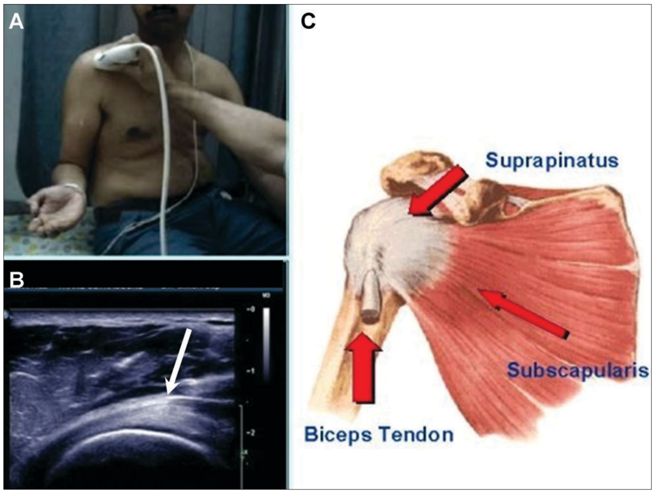

Figure 2 (A-C): Subscapularis tendon. The photograph (A) shows the position of the transducer for a longitudinal scan of the subscapularis tendon. The tendon (arrow) is well visualized on the B-mode image (B). An anatomical diagram is shown (C), the thin arrow showing the plane of orientation of the transducer for a longitudinal view of the tendon.

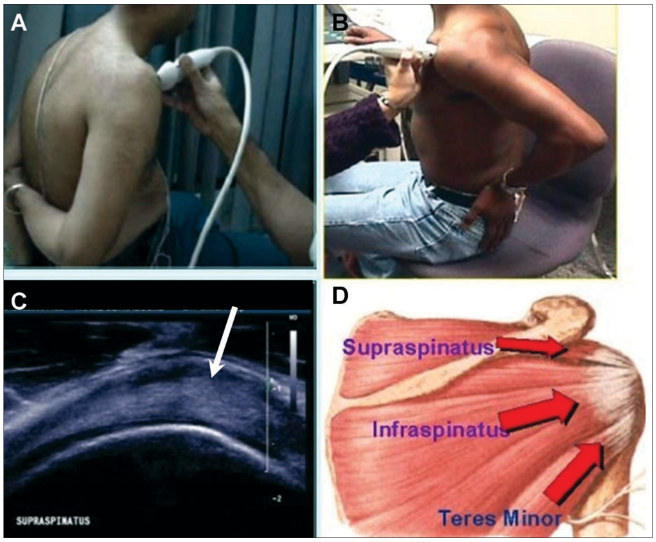

Figure 3 (A-D): Supraspinatus tendon. The photograph (A) shows the arm of the patient being held by the opposite arm behind the back, whereas (B) shows the position of the hand on the hip. The supraspinatus tendon (arrow) is well seen on the B-mode image (C), in its longitudinal plane. (D) shows the anatomy of the rotator cuff, the arrows showing the longitudinal planes of the tendons.

tuberosity [Figure 3C]. It is important to demonstrate the critical zone, the area most susceptible to injury, which is the portion of the tendon that is situated approximately 1 cm posterolateral to the biceps tendon; it is a common site for an artifact.

Infraspinatus tendon

The infraspinatus tendon is visualized by positioning the probe posteriorly. It appears as a beak-shaped, soft tissue structure that attaches to the posterior aspect of the greater tuberosity. Passive internal and external rotation may be useful in evaluating this tendon.[12] A portion of the posterior glenoid labrum is seen as a hyperechoic, triangular structure. The articular cartilage of the humeral head is seen as a thin, hypoechoic layer, superficial to the high-level echoes originating from the bony surface [Figure 4].

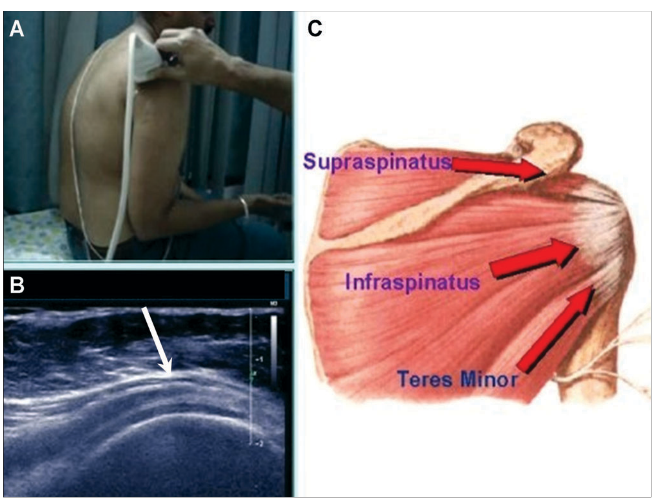

Figure 4 (A-C): Infraspinatus tendon. The photograph (A) shows the plane of examination of the infraspinatus and the corresponding image (B) along the longitudinal axis of the tendon. An anatomical diagram is shown (C), the thin arrow showing the plane of orientation of the transducer for a longitudinal view of the tendon.

Teres minor tendon

The teres minor tendon is seen as a trapezoid structure. It can be seen by moving the transducer distally on the humerus. It can be differentiated from the infraspinatus by its oblique internal echoes. A tear of this tendon is very rare, but mild intraarticular fluid may be best visualized at this level.[13] Visualization of the teres minor ensures that the entire infraspinatus has been scanned.

Acromioclavicular joint

The acromioclavicular joint is best evaluated by keeping the probe perpendicularly on the joint.

Test for Impingement

The test for impingement is done by asking the patient to elevate his hand (as in the combing action). A smooth gliding of the supraspinatus tendon below the subacromial outlet rules out impingement [Figure 5].

Critera for diagnosis of rotator cuff tear

Over the years, major and minor criteria for rotator cuff tear have been desribed.

While evaluating the rotator cuff, one must always examine the integrity, thickness, and echogenicity of the cuff and look out for calcification. The criteria suggested by Middleton[14–16] are easy to follow and report. The size of the tear, its orientation, and its location relative to the biceps tendon have to be reported.

Major criteria

1. Nonvisualization of the cuff [Figure 6]: A total nonvisualization of the rotator cuff occurs often, suggesting a complete tear. This can be easily missed by

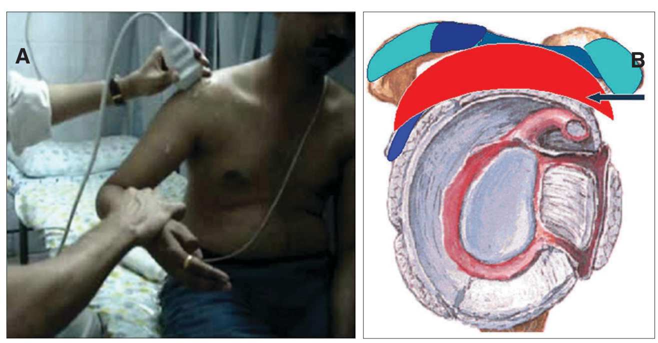

Figure 5 (A, B): Test for impingement. The photograph (A) shows the method of performing the impingment test, which assesses the ability of the supraspinatus tendon (B) to pass smoothly under the subacromial outlet (red), coracoid and acromion processes (light blue) coracoacromial ligament (dark blue).

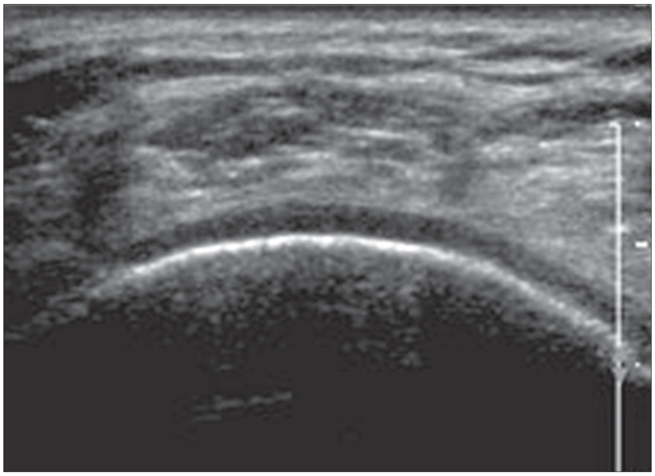

Figure 6: Full-thickness supraspinatus tear. Longitudinal scan of the supraspinatus shows complete absence of the tendon, the space filled by the deltoid muscle.

a novice since the entire supraspinatus tendon is missing and the deltoid with the subdeltoid bursa then rests on the head of the humerus. The best way to confirm this is by comparing with the other side. An important indirect clue in this situation is the loss of the normal convexity of the deltoid and bursa, with dipping of the same (with concavity) in the empty space. This is the most important indirect sign. Bursal thickness, and fluid in the subdeltoid bursa and along the biceps, are very commonly associated. The hyaline cartilage on the humeral head stands out. This is often referred to as the 'naked tuberosity' or 'double arc' sign.

2. Focal nonvisualization: Focal nonvisualization of the tendon is relatively easy to diagnose, as the remaining tendon is seen adjacent to it. Within this gap, the subdeltoid bursa can also dip. Confirmation in two planes is important. Most rotator cuff pathologies occur in the terminal 1 cm of the tendon, which is the critical zone.
3. Discontinuity [Figure 7]: Discontinuity of fibers may be seen, the gap filled with fluid or reactive tissue. A stress test, by positioning the elbow with the arm internally rotated, is the best way to check for discontinuity of the fibers. It is also apparent by the 'compressibility' of the tendon compared to a normal tendon, which is noncompressible.
4. Focal abnormal echogenicity: It has been associated with small full and partial-thickness tears. The area of increased echogenicity is thought to result from granulation tissue, hypertrophied synovium, and hemorrhage. The examiner must confirm that this is real and not an artifact or rotator cuff calcification.

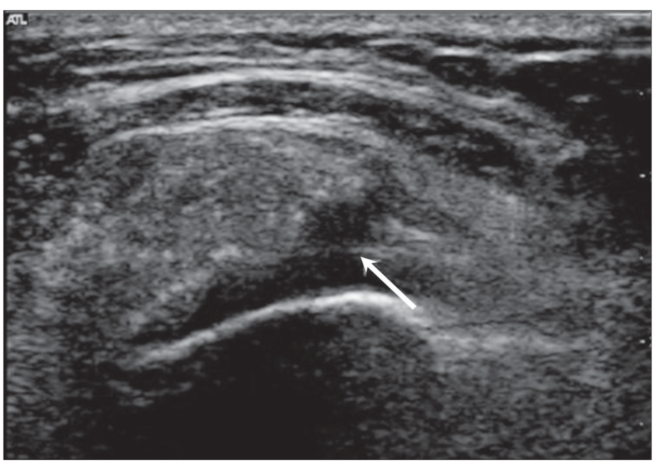

Figure 7: Full-thickness supraspinatus tear. Longitudinal scan of the supraspinatus tendon shows an obvious focal area of discontinuity (arrow), suggesting a tear.

Partial-thickness tear

Middleton's group uses either a distinct hypoechoic or mixed hyper- and hypoechoic defect visualized in two planes at the deep articular side of the cuff, or minimal flattening of the bursal side of the cuff, as evidence of a partial-thickness tear. Partial tears can be classified as bursal surface, intrasubstance, or articular surface tears [Figure 8]. Accuracies of 80–92% have been described[17] in the diagnosis of partial-thickness tears. A recent report suggests that USG is a signifiantly better modality for the evaluation of partial-thickness tears than MRI.

Minor criteria for rotator cuff tear:

1. Fluid along the biceps tendon sheath and in the subdeltoid bursa and the joint is a very reliable sign of rotator cuff injury. Presence of fluid along the biceps tendon and in the joint suggests a 95% probability of a cuff tear.[16,17]
2. Concave subdeltoid bursal contour.
3. Irregularity of the greater tuberosity.[8]
4. Compressibility.

Accuracy

Accuracy of USG is operator and equipment dependent. USG has a sensitivity and specificity of 94% or greater for the detection of full-thickness tears,[18] and 93% or greater for partial-thickness tears [Weiner]. In comparison with

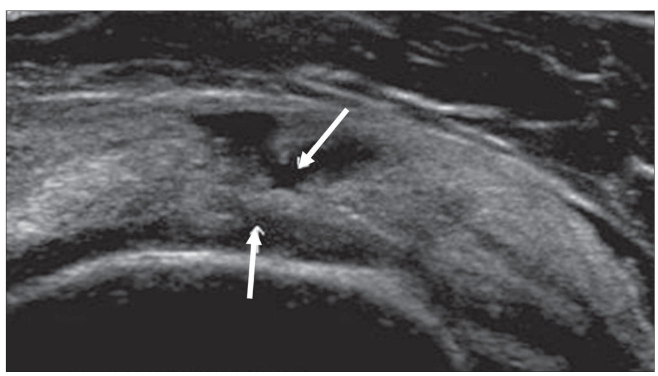

Figure 8: Partial-thickness tear of the supraspinatus. Longitudinal scan of the supraspinatus tendon shows a partial-thickness tear of the articular surface with intrasubstance involvement (arrows).

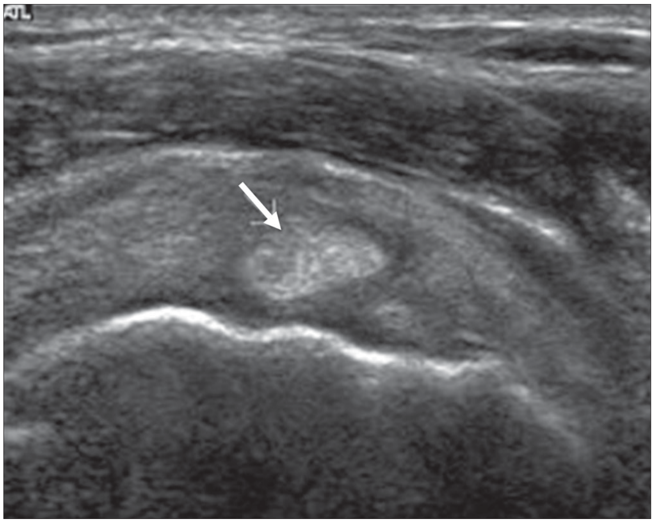

Figure 9: Calcific tendonitis. Longitudinal scan of the supraspinatus tendon shows focal calcification (arrow).

arthroscopy, USG has a 100% sensitivity and 85% specificity, with 95% overall accuracy.[19]

Pitfalls

One of the major pitfalls in MSK USG is 'anisotropy.' An anisotropic artifact in the critical zone can result in an erroneous report. Other problems include poor understanding of the anatomy and wrong positoning of the patient and transducer. Normally, a hypoechoic region is present on either side of the biceps tendon. This is the biceps tendon–rotator cuff interval and should not be confused with tendon disruption. The posterior cuff is thinner as compared with the anterior portion. This should not be mistaken for a tear. Age-related changes in the appearance of the tendon due to fibrofatty infiltration, are symmetrical.[6] As described earlier, a massive tear with an absent tendon may not be easily recognized by a novice.

Other pathologies

Calcific tendinitis [Figure 9]

The critical zone in the supraspinatus is the most common site for calcification, probably due to its hypovascularity. It is asymmetric in one-third of patients. USG is more reliable than x-rays for identifying calcification and judging its consistency and degree. Slurry calcifications found on USG have been proven to be nearly liquid in 93% of cases and can be successfully aspirated.[6] Dilution of calcific foci and their aspiration has also been shown to reduce symptoms.

Acromioclavicular joint

Acromioclavicular joint inflammation often presents clinically in a similar fashion to rotator cuff disorders. The small amount of fluid that is usually present can be detected easily on USG.

Impingement syndrome

Repetitive friction results in bursal thickening and is often accompanied by minimal fluid accumulation. The focal bursal thicknening may be tender on USG palpation. During dynamic testing, the thickened bursal tissue may be seen to bunch up against the outer edge of the acromion, failing to pass beneath it. This can be easily demonstrated on USG during the impingement test.

Neer described impingement lesions in the following 3 progresive stages:

1. Edema and hemorrhage result from excessive overhead use and are observed in patients less than 25 years of age.
2. Fibrosis and tendinitis affect the bursa and the cuff, following repeated episodes of inflammation, in patients aged 25–40 years of age.
3. Bone spurs and incomplete and complete tears of the rotator cuff and the long head of the biceps tendon are found almost exclusively in patients who are more than 40 years old.

Acknowledgement

Anatomical illustrations are from the Atlas of Human Anatomy 2nd Ed. 1997.By Frank H. Netter.

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FORTHCOMING EVENTS

5th National Convention
Date: 2007-09-22
From: 2007-09-22 To: 2007-09-23
Venue: Krest Auditorium, Hyderabad
Organized by: Indian Society of Pediatric Radiology
Information: Pediatric Imaging. Tel: 040-23560005/65888459.
E-mail: vijayabhaskarnori@gmail.com

Mumbai Ultrasound Course
From: 2007-09-27 To: 2007-09-30
Venue: Mumbai
Organized by: Dr. Mukund Joshi
Information: 37/900, Adarsh Nagar, Near Century Bazar, Worli P. O., Mumbai - 400 030. E-mail: muc2007@varriance.com

PET CT Conference
From: 2007-09-29 To: 2007-09-29
Venue: Place: - City Palace Udiapur. Durbar Hall
Organized by: Dr. Manas Mayank
Information: Ph - 09825780094.
Topics included: -Basics of FDG production (cyclotron), Basics of PET-CT technology. Normal variants. Disease specific topics by experts. Open discussion with oncologists using PET in their day-to-day clinical practice.

FETAL ULTRASOUND UPDATE
Date: 2007-10-28
From: 2007-10-28 To: 2007-10-28
Venue: Hotel Fortune Landmark, Indore
Organized by: Ultrasound Study Foundation: Dr Sudheer Gokhale, Hon Secretary
Information: Focus on Fetal Anomalies & sick fetus, Live demo.
E-mail: ultrasoundadvice@hotmail.com

10th Annaul Conference of ISVIR
From: 2007-11-01 To: 2007-11-04
Venue: Hotel Taj Deccan, Hyderabad
Organized by: ISVIR – Dr. S Rammurti
Information: Prof & Head, Dept. of Radiology & Imaging, Nizam's Insitute of Medical Sciences, Panjagutta, Hyderabad – 500 082, A.P. T: 040-23320332 Ext – 431, M-9848019234. Website: www.isvir2007.org

The 61st Annual Conference of IRIA
From: 2008-01-17 To: 2008-01-20
Venue: Bangalore International Exhibition Center, Bangalore, Karnataka.
Organized by: IRIA Karnataka State Branch
Information: E-mail: iriablr08@gmail.com

USCON XVIII : Annual Conference of IFUMB
From: 2008-02-15 To: 2008-02-17
Venue: Hotel J. P. Palace, Agra
Organized by: Dr. Bhupender Ahuja
Information: Tel: 0562-3292959, 2852605.
E-mail: drahujab@sancharnet.in

Dr. Harnam Singh mid Term CME
From: 2008-08-04 To: 2008-08-05
Venue: Hotel Clark's Shiraj, Agra
Organized by: drahujab@sancharnet.in
Information: Organized by UP & Uttarkhand State Chapter of IRIA.
E-mail: drahujab@sancharnet.in