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ORIGINAL ARTICLE

Role of Ultrasonography to Study Skeletal Muscles and A Review of Literature

Parthapratim Pradhan[1*], Asis Kumar Ghoshal[2], Indra Datta[2], Sankar Prasad Kabiraj[3], Sanjay Kumar Sinha[4] and Runa Das[5]

[1]Department of Anatomy & MSVP, Calcutta National Medical College & Hospital, Kolkata-14 West Bengal, India, [2]Department of Anatomy, IPGME&R, Kolkata-20 West Bengal, India, [3]Department of Radiology, North Bengal Medical College, Darjeeling, West Bengal, India, [4]Department of Anatomy, Katihar Medical College, Karim Bagh, Katihar-854105, Bihar, India and [5]Department of Radiology, IPGME&R, Kolkata-20 West Bengal, India

Abstract: *Objective:* In the present study we are trying to find out whether we can diagnose the various pathology of muscles and muscle injuries by high resolution ultrasonography. *Background:* Clinical evaluation of many pathological conditions of muscles is often very difficult. With the help of MRI, we can diagnose most of the pathologies of muscles almost accurately; but it is neither cost effective nor widely available. Similarly, CT scan is also not very helpful in this regard. *Method:* We examined forty patients with various types of unilateral pathological conditions of muscles with the help of high resolution ultrasonography and compared with the normal anatomy of the opposite side. This method is a non-invasive, rapid, less expensive and widely available. *Result:* We have shown that we can diagnose the different pathological conditions of muscles and muscle injuries with the help of high resolution USG. *Conclusion:* Therefore, ultrasonography should be the first choice of investigation, particularly in our country to diagnose pathological conditions of muscles.
Keywords: High frequency ultrasonography (US/USG), Anatomy of muscles, Pathology of muscles.

Introduction

Ultrasound has very little usefulness and limited acceptance in the imaging of subcutaneous tissue and musculoskeletal system till date. However, with the advent of high frequency transducers and production of pictures of better resolution, tissue differentiation is possible and these tissues can be visualized with the exact anatomical disposition. Real-time dynamic examination of muscles can be done in any orientation. The disadvantages of this method are very negligible and can be overcome easily. In this study, our objective was to get an initial experience in this field and help in the diagnosis of pathologies involving 'the muscles', particularly where clinical evaluation was difficult.

Material and Methods

Forty patients, from the departments of Orthopaedics and Physical Medicine of N.B. Medical College & Hospital, Darjeeling and IPGME&R, Kolkata were examined. The patients with unilateral pathology of different muscles were selected.

After taking a brief history and clinical examination, straight X-rays of the involved anatomical parts were taken. The pathological parts of the muscles were then examined by a linear 7.5 MHz transducer, compared with the normal opposite side and photographs were taken. Images were obtained in both longitudinal and transverse planes. The muscles were examined during active contraction (dynamic evaluation) and at rest. 5 MHz transducer was used to evaluate deep seated pathologies [1].

Results

Table-1: Musculo-skeletal injuries or pathologies		
Sl. No.	**Particulars**	**Cases**
1	Muscle injury at different areas	14 cases
2	Intra muscular abscess and cellulites	14 cases
3	Intra muscular haematoma	7 cases
4	Intra-muscular foreign body	1 case
5	Intramuscular haemangioma	1 case
6	Osteomyelitis	2 cases
7	SOL	1case
Total number of patients examined		40

During our study we came across forty patients with different musculo-skeletal injuries including intramuscular foreign body, haematoma, infection and inflammation, which are short listed in Table-1.

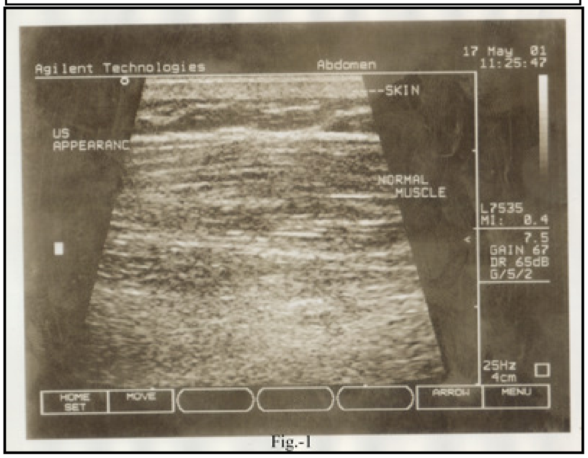
Discussion

Relevant Anatomy of Skeletal Muscles: The skeletal muscles or otherwise called voluntary muscles are made up of striped muscle fibers. These have two or more attachments, one end is origin, and others are insertions. The central contractile fleshy part of the muscle is called its belly or slips. The ends of the muscles are attached to bones, cartilage or ligaments by cords of non-contractile fibrous tissue, called tendons. Occasionally, flattened muscles are attached by a thin but strong sheet of fibrous tissue, 'the aponeuroses. Normal striped muscle is composed of multiple muscle fasciculi or bundles. Each fascicle is composed of multiple muscle fibers. A muscle fiber may range from millimeters to many centimeters in length and 10-100 um in diameter. A delicate network of connective tissue, called the endomysium, surrounds the muscle fibers. The perimysium is a substantial septa of connective tissue which ensheaths the muscle bundle or fasciculi. A thick collagenous sheath called the epimysium invests the whole muscle or muscle group.

The individual fibers of a muscle are arranged either parallel or oblique to the long axis of the muscle. The parallel fiber arrangements are seen in case of sternohyoid, sartorius. Muscles whose fibers run obliquely to the line of pull are referred to as pennate muscles (resembling a feather). A unipennate muscle is one in which the tendon lies along one side of the muscle and the muscle fibers pass obliquely to it (eg. Flexor pollicis longus). In a bipennate muscle the tendon lies in the center of the muscle and the fibers pass to it from two sides (rectus femoris).

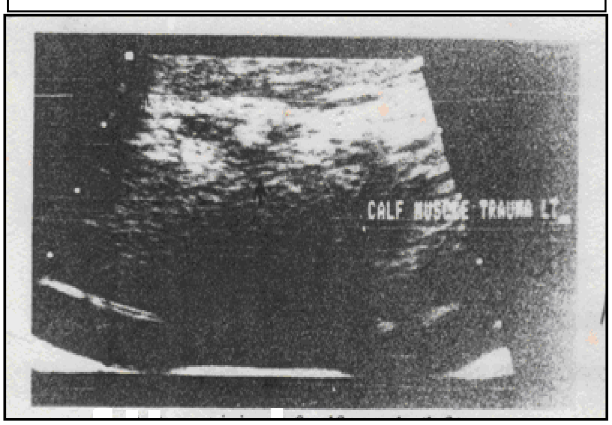
A multipennate muscle (a) may be arranged as a series of bipennate muscles lying alongside one another (acromial fibers of deltoid) or (b) the tendon lying within the centre of the muscle and the fibers converging to it from all sides (e.g. tibialis anterior) [2].

Fig-1: Longitudinal section of normal skeletal muscle showing multiple parallel echoes and pennate appearance of muscle fibres



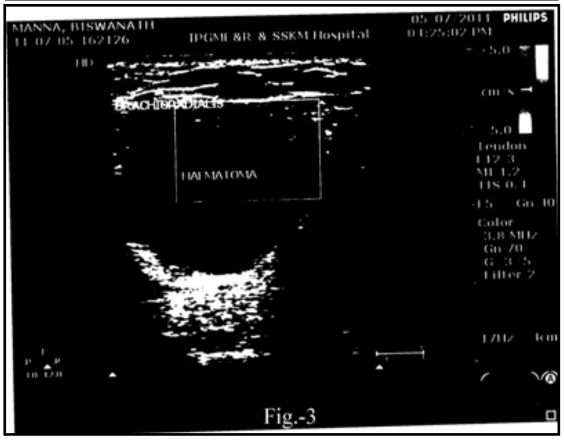
Normal US appearance of Muscles: The sonographic picture shows the muscle bundles to appear hypoechoic and the fibro-adepose septa or the sheath (endo, epi and perimysium) echogenic [3-5]. In longitudinal section the normal muscle has fine, multiple and parallel echoes, corresponding to the fibro-adepose septa (Fig.1). The pennate character of the muscle is most evident on longitudinal sections. On transverse sections, the pattern is somewhat less regular, with septa seen scattered throughout the muscle fibres. The echogenic sheaths or septa are seen surrounding the hypo-echoic muscle bundles as a "starry-sky" appearance [6]. The typical muscle also has a brightly echogenic outer margin, produced by the connective tissue fascia (epimysium). The normal relaxed muscle is generally less echogenic than the subcutaneous fat or tendons. The contracted muscle has got slightly decreased echogenicity than the relaxed muscle and shows apparent increase in diameter with foreshortening of length.

Fig-2: Injury of calf muscle (left) showing tear of muscle fibres along with oedema



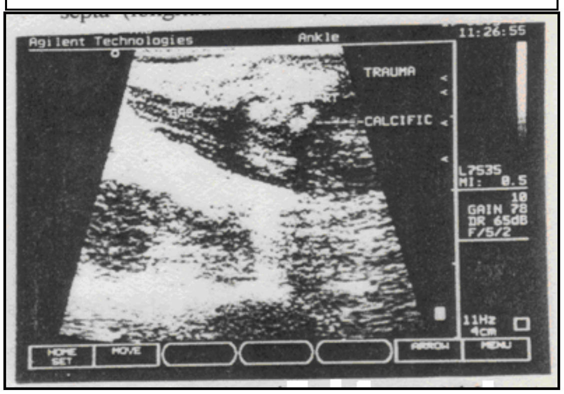
Muscle Injuries: Ultrasound is very much useful for the diagnosis, evaluation and follow-up of musculo-skeletal injuries particularly in case of sports personnel. Muscle tears, ruptures, oedema and haematomas occur frequently in active athletes [1,5]. Ultrasound can find out the presence, location and severity of damage to the anatomic parts in such cases (Fig. 2). Dynamic examination of the injured muscle can differentiate a recent trauma.

Fig-3: Haematoma of Brachioradialis muscle



Muscle haematomas: The ultrasonographic characteristics of haematoma are variable depending upon the frequency of the transducer and the age of the clot. Organized clot shows internal echoes; but clot lysis causes an anechoic appearance, regardless of the transducer frequency [1, 5]. Haematomas may have well-defined or irregular margins, with or without septations (Fig. 3). Focal collection within a muscle is typically oval or elliptical or with tapered ends when located near the muscle insertion. Scanning during contraction and relaxation of a muscle usually can differentiate the echogenic blood clot from a ruptured and retracted muscle, because with rupture, contraction of the muscle causes the lesion to appear larger. Diffuse muscle haemorrhage may appear as increased thickness and differing echogenicity of the involved muscle with an exaggerated feathery appearance.

Fig.-4: Tear along with calcification within the right gastrocnemius muscle (GAS)



Muscle rupture: It is of two types:

(a) Compression rupture is the result of blunt trauma. USG shows irregular cavities within a muscle with shaggy borders that contain haematoma.

(b) Distraction rupture is caused by functional overload during strenuous activity. Early injuries appear as sharply defined linear clefts that contain blood (Fig.2). Late features are ill-defined echogenic areas and a heterogeneous echo-texture corresponding to fibrosis and small amount of fluid. Dynamic scanning may then demonstrate lack of change in size and shape and reduced mobility, secondary to fibrosis. Ultrasound has also a great role in follow up cases of muscle injuries [1, 5], Calcification can occur occasionally in very late cases (Fig.4). It was also reported that the MRI technique failed to visualize calcification, but it can be diagnosed by ultrasonography [7].

Intramuscular foreign bodies: Ultrasound is an excellent adjunct to plain X rays for detecting foreign bodies in muscles showing the exact location. It detects non-radio-opaque foreign bodies like wood, which is not visible by conventional X-rays [5, 8].

Fig.-5: Abscess in quadriceps femoris muscle showing heterogeneous hypoechoic area and a rounded solid mass.

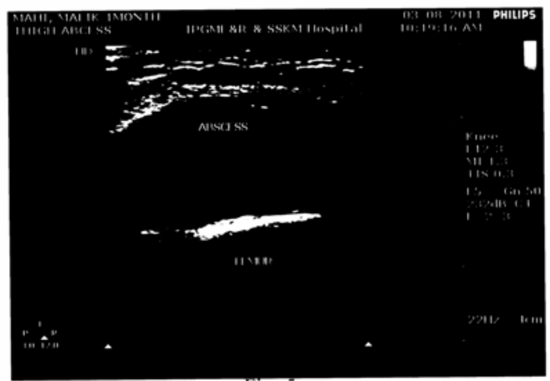
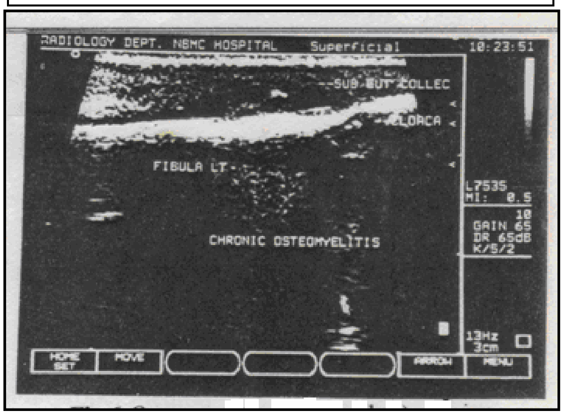


Fig.-5

Fig-6: Osteomyelitis of fibula (left) showing hypoechoic area adjacent to bone and presence of cloaca.



Intramuscular abscess and cellulitis: USG can differentiate cellulitis and abscess from osteomyelitis, by showing location of fluid adjacent to bone [5]. USG of normal soft tissue shows he muscle layer as a hypo-echoic area with linear echogenic striations. Subcutaneous tissue may appear as either echogenic or hypoechoic. The cortex of the bone is seen as a dense echogenic line with a smooth surface and acoustic shadowing. In intramuscular abscess, there is loss of muscular architecture and a heterogeneous hypoechoic area (Fig. 5).

Vascular structures are recognized by their characteristic pulsations. Normally there is no fluid collection adjacent to bone. Any hypo-echoic area within the muscles and usually away from the bone is suggestive of an abscess. In osteomyelitis, an anechoic or hypo-echoic area adjacent to bone, swelling and hypoechogenicity of the overlying muscles and subcutaneous tissue and cloaca are found (Fig. 6). Sometimes elevation of periosteum is also seen [9]. Some of these changes are usually present long before plain X-ray changes. In cellulitis, the subcutaneous tissue is thickened and hypoechoic, with no evidence of a localized abscess.

Haemangioma: In ultrasound haemangioma of muscle is seen as multiple serpegenous conglomerated lesion which in Color Flow Imaging (CFI) and spectral study reveals venous type of spectral pattern (Fig. 7).

Fig-7: Venous haemangioma in medial head of gastrocnemius

Fig.-7

Fig-8: SOL in calf muscle (gastrocnemius)

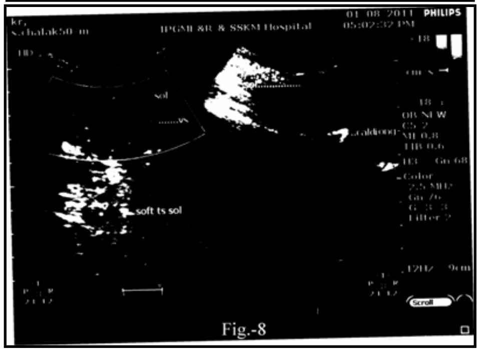
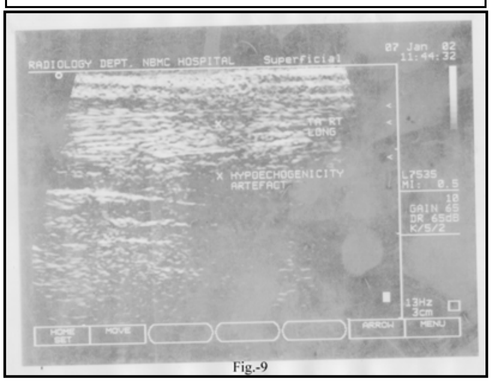


Fig-9: Artefacts (hypoechogenicity), due to improper method.



SOL: Us appearance of SOL in muscle is seen as ill defined hypoechoic area with evidence of calcification Color Flow Imaging (CFI) reveals increased vascularity with low resistance type of spectral pattern (Fig.8).

Artefact: The echogenecity of the tendon and muscle depends on angle of the transducer relative to the tendon and muscle during interrogation.The curved footprint of mechanical transducer will result in heterogenous appearance of the tendon and muscle.Even with optimal perpendicular technique center of image will appear hyperechoic and sides hypoechoic which can be mistaken as pathology (Fig.9).

Like the tendons, MRI is the most accurate modality for imaging the muscles. But its high cost and less or non-availability becomes a great disadvantage. CT has a very limited use in evaluation of most of the pathophysiology of muscles.We have already studied the normal anatomy and some pathological condition of 'the tendons' with the help of high resolution ultrasonography and concluded that this method should be the first choice of investigation in case of suspected 'tendon pathologies', specially in our country [10]. Here we have studied the different pathological conditions of 'the muscles' with the help of high resolution ultrasonography. But, according to our and some other studies [7, 11-13] the following advantages of high frequency ultrasonography can be stated.

- It is the only real-time (dynamic) cross-sectional imaging technique.
- Quick scanning can be done in virtually any orientation with the patient in any position.
- It has got an excellent spatial resolution.
- It is very useful for follow-up.
- Us has high specificity and sensitivity rates.
- It is an widely available technique.
- It can be done at a very low cost.
- It is a non-invasive investigation technique, and
- It does not have the hazards of radiation.

However, our study and some other studies [7, 11, 13-14] also revealed some disadvantages of this method viz:

- It is operator dependant
- It has a long learning curve
- Accurate results can only be obtained by a person with considerable experience
- There are some technique related artefacts e.g. hypo-echogenicity in case of obliquity of the transducer beam etc. (Fig.6)
- If the size of intra-muscular haematoma or any other lesion is relatively large, it becomes difficult to detect the exact anatomical extension by ultrasonography.

Therefore, we think that the ultrasonography should be the first choice of investigation in detecting the pathologies of the muscles, and related tissues, and thus helping in their clinical management. Only when the US findings are negative or questionable, but clinics are positive, further investigation, like MRI, CT, arthroscopy etc is necessary [7, 13, 15]. One case of haemangioma was found in the medial head of gastrocnemius (left), which was confirmed by colour Doppler study (Fig.7). Thus it can be concluded that ultrasonography is an under utilized tool for the diagnosis of the musculo-skeletal pathologies, especially in our country.

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*All correspondences to: Dr. Partha Pratim Pradhan, 78B, Harish Chatterjee Street, Bhowanipur, Kolkata, West Bengal, India. Email: parthapratimpradhan@gmail.com

