

ULTRASONOGRAPHY OF THE EQUINE SHOULDER: TECHNIQUE AND NORMAL APPEARANCE

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This study was intended to document normal ultrasonographic appearance of the equine shoulder and anatomic landmarks useful in clinical imaging. Both forelimbs of five equine cadavers and both forelimbs of six live adult horses were used. To facilitate understanding of the images, a zoning system assigned to the biceps brachii and to the infraspinatus tendon was developed. Ultrasonography was performed with a real-time B-mode semiportable sector scanner using 7.5- and 5-MHz transducers. On one cadaver limb, magnetic resonance imaging (MRI) was performed using a system at 1.5 Tesla, T1-weighted spin-echo sequence. Ultrasonography images were compared to frozen specimens and MRI images to correlate the ultrasonographic findings to the gross anatomy of the shoulder. Ultrasonography allowed easy evaluation of the biceps brachii and the infraspinatus tendon and their bursae, the supraspinatus muscle and tendons, the superficial muscles of the shoulder, and the underlying humerus and scapula. Only the lateral and, partially, the caudal aspects of the humeral head could be visualized with ultrasound. Ultrasonographic appearance, orientation, and anatomic relationships of these structures are described. Ultrasonographic findings correlated well with MRI images and with gross anatomy in the cadavers' limbs. *Veterinary Radiology & Ultrasound, Vol. 40, No. 1, 1999, pp 44-57.*

Key words: ultrasonography, horse, shoulder, biceps brachii tendon, infraspinatus tendon, magnetic resonance imaging.

Introduction

DIAGNOSIS AND CHARACTERIZATION of equine shoulder diseases are frequently difficult.¹⁻¹⁰ Proper evaluation of shoulder lameness is based on understanding of the anatomic features of the scapulohumeral joint and the surrounding region. Although soft-tissue injuries are the single most common cause of scapulohumeral lameness in the horse,⁴ most diagnostic procedures applied to the area, such as intra-articular anesthesia, survey radiography, and arthrography, are limited to assessment of the synovial compartment and associated bones.^{3,6,7,11,12} Ultrasonography has been used to evaluate soft-tissue injuries in the equine shoulder region.^{9,12-19} The normal ultrasonographic appearance of selected anatomic structures of the equine shoulder has been described.^{12,18-20} However, the ultrasonographic morphology of soft tissues of the shoulder region has not been described thoroughly. The purpose of this study was to describe the normal ultrasonographic anatomy of the equine

shoulder and to identify the advantages and limitations of an ultrasound examination of the area.

Review of the Anatomy

The shoulder or scapulohumeral joint is formed by the junction of the distal end of the scapula with the proximal end of the humerus.²¹⁻²⁴ The scapulohumeral joint does not have well-developed ligaments. However, the heavy tendons of the infraspinatus, supraspinatus (laterally), subscapularis (medially), and the biceps brachii (cranially) cross the joint and serve as active ligaments (Fig. 1). The subscapularis muscle supports the shoulder joint medially, and its tendon inserts on the caudal eminence of the lesser tubercle (Fig. 2). Caudal support of the joint is rendered by the long head of the triceps brachii muscle (Fig. 1). Laterally, the infraspinatus muscle extends distally to insert on the caudal eminence of the greater tubercle and a triangular area on the distal part of the tubercle distal to the insertion of the supraspinatus (Fig. 3). The partly cartilaginous tendon is protected from the underlying caudal eminence by adipose tissue and a consistently found synovial bursa that may communicate with the shoulder joint cavity. The tendon of the infraspinatus muscle is the main lateral support of the shoulder joint, assisted by the teres minor, a smaller and flat muscle. Cranially, the large, partly cartilaginous tendon of the biceps brachii muscle originates on the supraglenoid tubercle of the scapula and occupies the intertubercular

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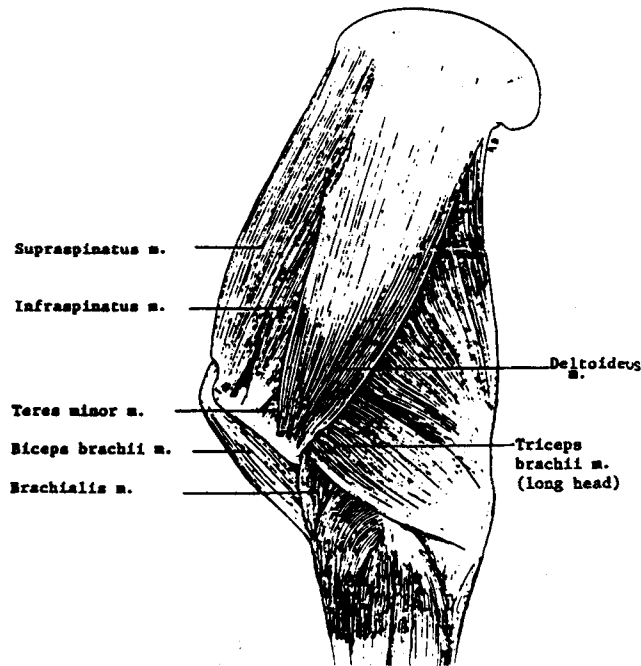


FIG. 1. Lateral view of the superficial layer of the deep muscles of the equine shoulder.²³

groove of the humerus (Figs. 2, 3). An intertubercular bursa lies under the tendon and extends around its sides. In some horses, the bicipital bursa communicates with the joint cavity.²¹⁻²⁴ Fascial sheaths of the biceps brachii muscle attach to the humeral tubercle. The supraspinatus muscle divides at the neck of the scapula into two branches, between which the tendon of origin of the biceps brachii emerges (Fig. 1). These branches, fleshy superficially, tendinous deeply, attach to the greater and lesser tubercle of the humerus (Fig. 2). A bursa is often present under the muscle at the supraglenoid tubercle.²¹ Within the shoulder joint, the articular surface of the humeral head has approximately twice the area of the glenoid cavity of the scapula (Fig. 3).

Materials and Methods

Both forelimbs of five equine cadavers and both forelimbs of six live adult horses were used to study the normal ultrasonographic anatomy of the shoulder region. The horses were of various ages and breeds (four Arabian-Barbes, three Arabians, two Anglo-Arabians, one French saddle, one Anglo-Hispano-Arabian, 3-18 years old). The shoulder regions were within normal limits. The cadavers limbs were isolated from the trunk, but were not disarticulated to maintain soft tissue tautness around the shoulder.

Ultrasonography was performed in live horses and in cadavers limbs with a real-time B-mode semiportable sector scanner using 7.5 and 5 MHz transducers with a scan angle and a curvature radius of 34°/25 mm and 47°/60 mm, re-

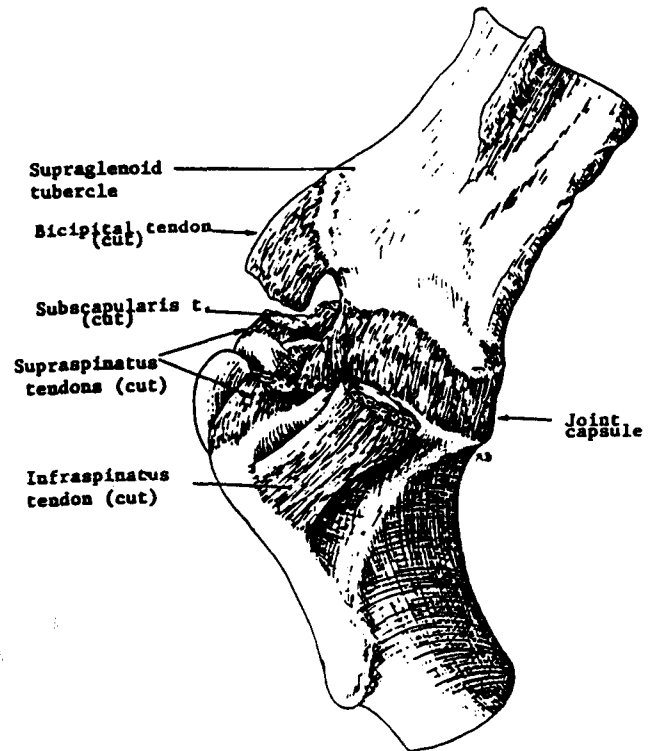


FIG. 2. Lateral view of the equine shoulder joint.²³

spectively.* In addition, one of the live horses was examined at the Veterinary Surgery Clinic of the University of Zurich with a real-time B-mode semiportable sector scanner using a 7.5-MHz transducer with a built-in stand-off pad and a scan angle of 50°.† The shoulder area was clipped and shaved prior to the examination, and an ultrasonographic coupling gel was applied.‡ Some horses were sedated to facilitate ultrasound examination. The biceps brachii, infraspinatus tendon and their bursae, and the supraspinatus tendons were studied. The articular cartilage of the humeral head and the superficial muscles of the shoulder were also examined.

To facilitate interpretation of the images of the biceps brachii and infraspinatus tendon, which have different axial orientations, a zoning system was developed (Fig. 3). For the biceps brachii tendon, four zones were established: zone A—origin of the tendon on the supraglenoid tubercle of the scapula; zone B—its course over the scapulohumeral joint; zone C—its passage over the intertubercular groove; and zone D—its fusion with the biceps brachii muscle. For the infraspinatus tendon, three zones were established: zone A—the tendon within the infraspinatus muscle; zone B—its passage over the caudal part of the greater tubercle; zone

*Aloka SSD 500 V, Corometrics Medical, Wallingford, Connecticut, USA.

†Ausonics Opus 1, Ausonics AG, 1700, Ch-Freiburg, Germany.

‡Aquasonic 100, Socofren Maroc SA, Casablanca, Morocco.

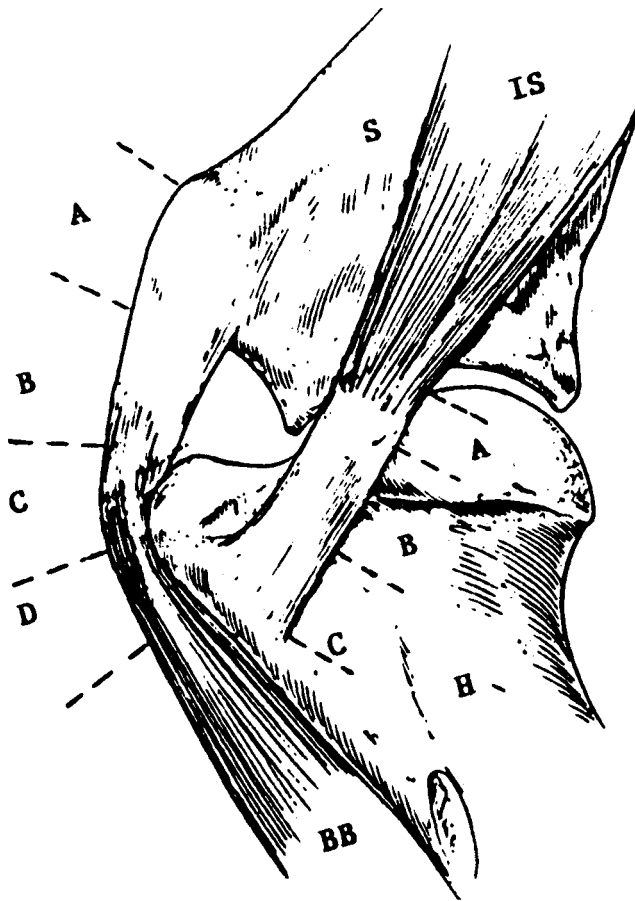


FIG. 3. Lateral view of the equine shoulder, the zones used in the sonographic examination of the biceps brachii (BB) (A, B, C, D) and the infraspinatus (IS) tendon (A, B, C) are illustrated; H, humerus; S, scapula.

C—its course toward its insertion. The diameters of the various structures were measured at one centimeter intervals, and the shape and appearance of these structures were described. Sagittal and transverse plane images of all the examined structures were recorded on a video tape,[§] and printed on thermal paper.^{||}

After the ultrasonographic examination, the limbs examined were dissected to provide gross anatomic comparison with the ultrasound images. Two cadaver limbs were frozen and sliced in the shoulder area, one perpendicularly to the long axis of the limb, the other longitudinally. Two-centimeter thick slices were obtained and photographed on both sides.

To confirm the histological composition, one biceps brachii tendon was collected and fixed in neutral 10% formalin, and processed for histologic examination in zone B. Paraffin tissue sections were cut at 5- μ m thickness and stained with hematoxylin and eosin.

In addition, on one cadaver limb, magnetic resonance imaging (MRI) of the shoulder was performed using a 1.5 Tesla magnet.[#] Transverse, sagittal, and dorsal plane images, 5-mm thick, were made with 0.5 mm interslice spacing. Images obtained with a T1-weighted spin-echo sequence (TR of 475 ms and TE of 15 ms) provided the best anatomic detail. The ultrasonographic images were compared with gross anatomic sections and with MRI images to assist in the verification of the ultrasonographic anatomy and to evaluate advantages and limitations of ultrasonography.

On two additional cadaver limbs, the bursae associated with the biceps brachii and the infraspinatus tendon, as well as the scapulohumeral joint were injected, respectively, with 10 to 15 ml, 5 to 8 ml, and 15 to 20 ml of water to determine further the boundaries of these synovial spaces during subsequent ultrasound examination.

Results

The anatomic structures that were sonographically examined around the shoulder joint included: cranially, the tendon of the biceps brachii muscle with its bicipital bursa and the supraspinatus muscle with its two tendons of insertion; and laterally, the infraspinatus muscle, its tendon with its tendon sheath. In addition, the lateral and, partially, the caudal aspects of the articular cartilage of the humeral head could be assessed ultrasonographically.

Biceps Brachii Proximal Tendon

After having recognized by palpation the cranial part of the greater humeral tubercle, and its adjacent intertubercular groove, the transducer was positioned perpendicularly to this groove to obtain a transverse image of the tendon. With the transducer moved slightly laterally and medially, the cranial part of the greater and the lesser tubercles can be visualized, respectively. To image the origin of the tendon on the supraglenoid scapular tubercle, the transducer should be moved proximally. The 7.5-MHz transducer provided the best quality images of the biceps brachii tendon, but in horses with thick, overlying musculature, the 5-MHz transducer was needed, especially when the medial lobe of the biceps brachii tendon was evaluated.

Transverse Images

In zone A, the biceps brachii tendon originates from the supraglenoid tubercle of the scapula, which appears as a hyperechoic convex structure. The tendon has crescent shape with a homogeneous echogenic appearance and has a lateromedial width of 25 to 30 mm and a craniocaudal thickness of 7 to 9 mm (Fig. 4). The supraspinatus muscle, which has a moderate echogenicity, wraps around the biceps

[§]Sharp, VC-579 E, Sharp Co. Osaka, Japan.

^{||}Sony UP-870 MD, Corometrics Medical, Wallingford, CT, USA.

[#]Gyrosan ASC-II, Philips Co. The Netherlands.

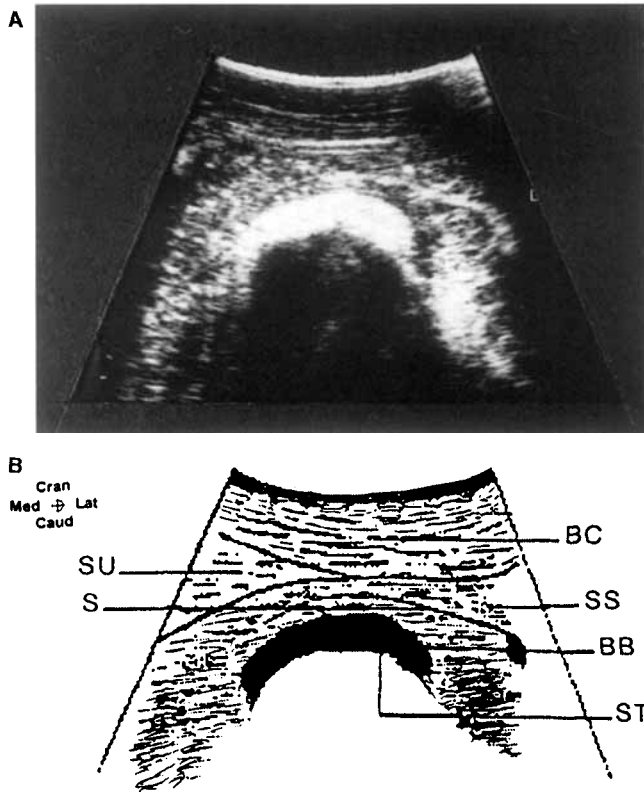


FIG. 4. Transverse image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in zone A: BC, brachiocephalicus muscle; SS, supraspinatus muscle; S, SS septum; ST, supraglenoid tubercle of the scapula; SU, subclavius muscle.

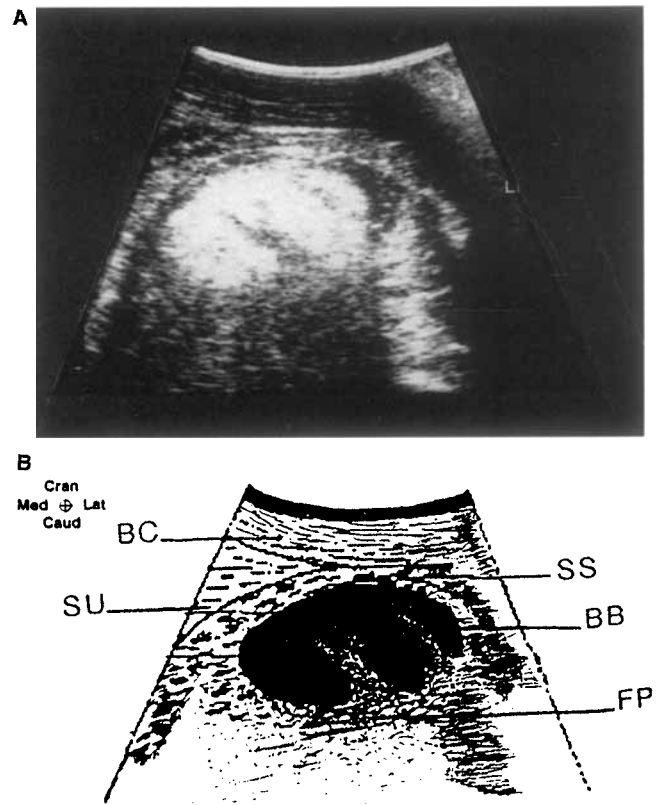


FIG. 5. Transverse image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in the proximal level of zone B; BC, brachiocephalicus muscle; SS, supraspinatus muscle; SU, subclavius muscle; FP, fat pad; H, humerus.

brachii tendon and has an echogenic septum within its fleshy body. Medial to the supraspinatus muscle, the subclavius muscle has a hypoechoic texture. The brachiocephalicus muscle lies superficially to these structures and has a hypoechoic texture with parallel echogenic lines.

In the proximal part of zone B, the tendon is irregularly elliptical in shape, has a heterogeneous echo pattern, and a trilobulated appearance (Fig. 5). The tendon is 30- to 37-mm wide and 13- to 19-mm thick. There is a fat pad between the tendon and the shoulder joint. This fat pad is hypoechoic to the tendon and dissects between the tendon lobes.

In histological sections of the tendon at the level of zone B, areas of fat connective tissue composed mainly of adipocytes, and also of collagen fibers, blood vessels, and nerves, were visible (Fig. 6). In MRI images, it was apparent that the tendon was lobulated and infiltrated at this level by a structure of high-intensity signal representative of fat (Fig. 7).

In the distal zone B, the tendon becomes bipartitioned, almost homogeneously echogenic and widens to 40 to 50 mm (Fig. 8). The thickest portion is located laterally. A hypoechoic fat pad infiltrates between the two portions and

is interposed between the tendon and the hyperechoic humeral head. Moreover, in zone B, the tendon margins were not clearly identifiable caudally. The MRI examination of the tendon at this level revealed a structure of heterogeneous low- and high-intensity signal. From distal zone B to distal zone C, a hypoechoic thin layer was displayed extending

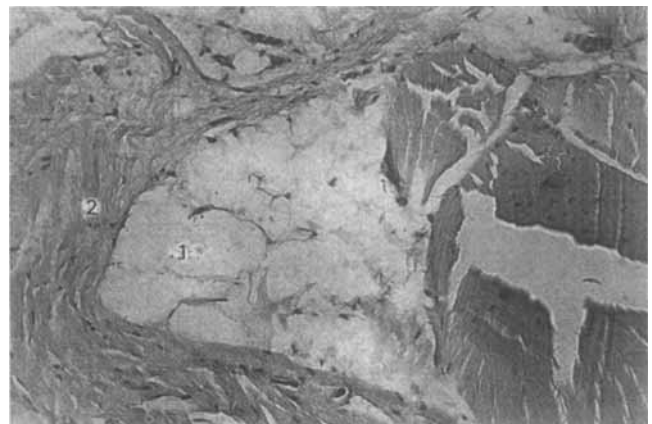


FIG. 6. Histological cross section of the biceps brachii tendon at the level of zone B; 1, fat connective tissue; 2, tendinous tissue (H & E $\times 200$).

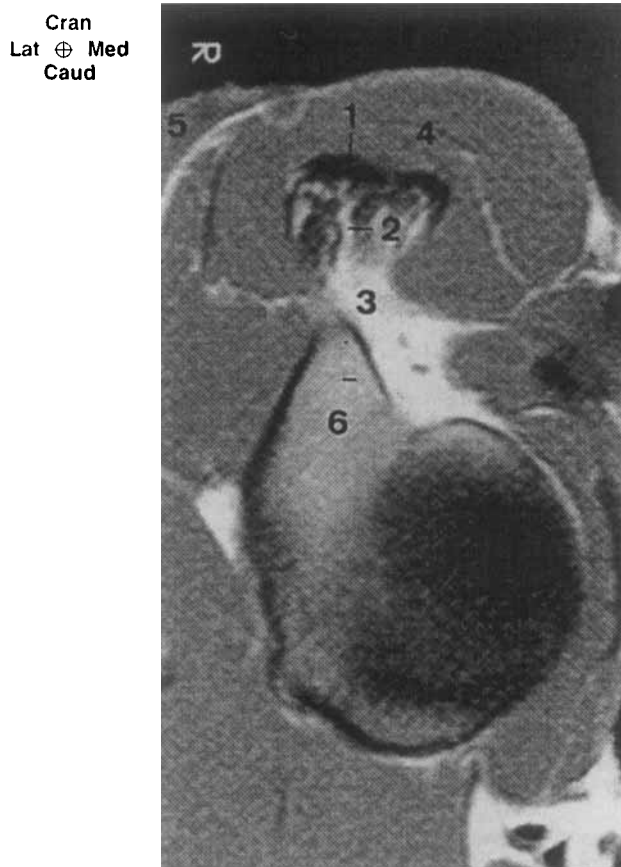


FIG. 7. Transverse MR image of the equine shoulder, just distal to the supraglenoid tubercle; 1. biceps brachii tendon; 2. fat within the biceps brachii tendon; 3. fat pad; 4. supraspinatus muscle; 5. brachiocephalic muscle; 6. scapula. (the brachiocephalic muscle is partially retracted and should cover the supraspinatus muscle).

over the cranial aspect of the tendon on all the examined horses. This represents fibers of the biceps brachii muscle (Fig. 8). In zone B, the supraspinatus, subclavius, and brachiocephalicus muscle are visible cranial to the tendon.

As it proceeds through the proximal zone C, the tendon fills the deeply convoluted intertubercular groove that is characterized by a well-defined and smooth hyperechoic contour. The tendon has, at this level, a uniform echogenic appearance, especially when each lobe was examined individually. The tendon adopts a narrower size in the center of zone C to conform to the intermediate tubercle, with the lateral lobe remaining bigger than the medial one (Fig. 9). Further distally, the tendon widens to 50 to 60 mm and craniocaudally the lateral and medial lobes measure 15 to 20 mm and 14 to 18 mm, respectively. The anechoic thin interface interposed between the intertubercle groove and the tendon represents the synovial space of the bicipital bursa and the hyaline cartilage layer.

In the distal zone C, the tendon lobes become progressively more even in size (Fig. 10), the tendon is 55 to 60 mm

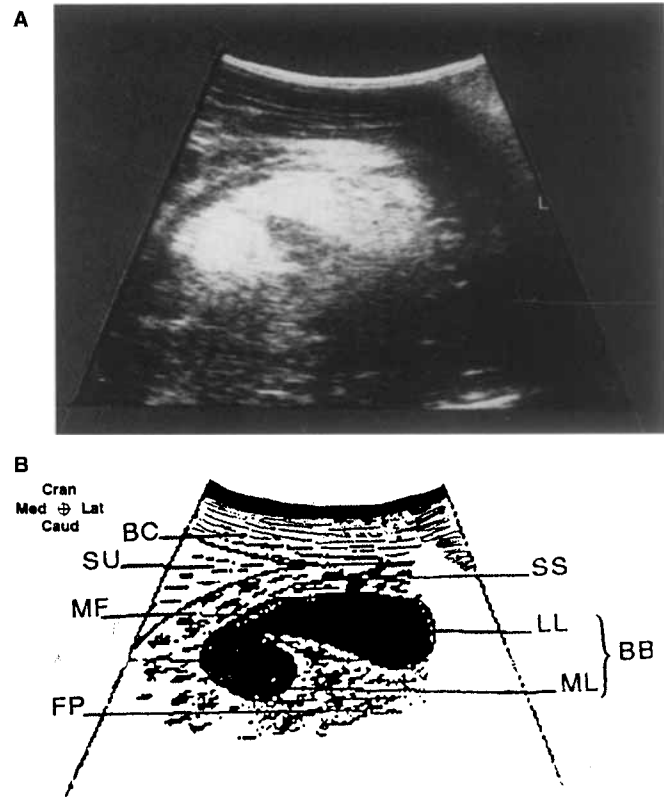


FIG. 8. Transverse image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in the distal level of zone B; BC, brachiocephalic muscle; SS, supraspinatus muscle; LL, lateral lobe; ML, medial lobe; MF, muscle fibers of the biceps brachii muscle; FP, fat pad; SU, subclavius muscle.

wide, and both lobes are approximately 19- to 22-mm thick. The bicipital bursa is well visualized, the hypoechoic brachiocephalicus muscle covers the tendon medially, and the subclavius is still imaged.

In zone D, the tendon begins to merge with the hypoechoic biceps brachii muscle, acquires an irregular shape, and therefore is more difficult to identify. Centrocadally to the tendon, the anechoic-to-hypoechoic space represents the distal expansion of the bicipital bursa. In this zone, a hypoechoic fat pad is present between the tendon and the hyper-echoic humerus.

Sagittal Images

In zone A, the tendon originates from the convex supraglenoid tubercle and has a parallel linear echoic appearance of 7- to 9-mm thickness (Fig. 11). In zone B, the tendon is imaged as an echoic but heterogeneous band. The hypoechoic zones within the tendon represent fat between the tendon lobes (Fig. 11). A hypoechoic fat pad lies deep to the tendon. In these zones, the moderately echoic supraspinatus muscle covers the tendon. The brachiocephali-

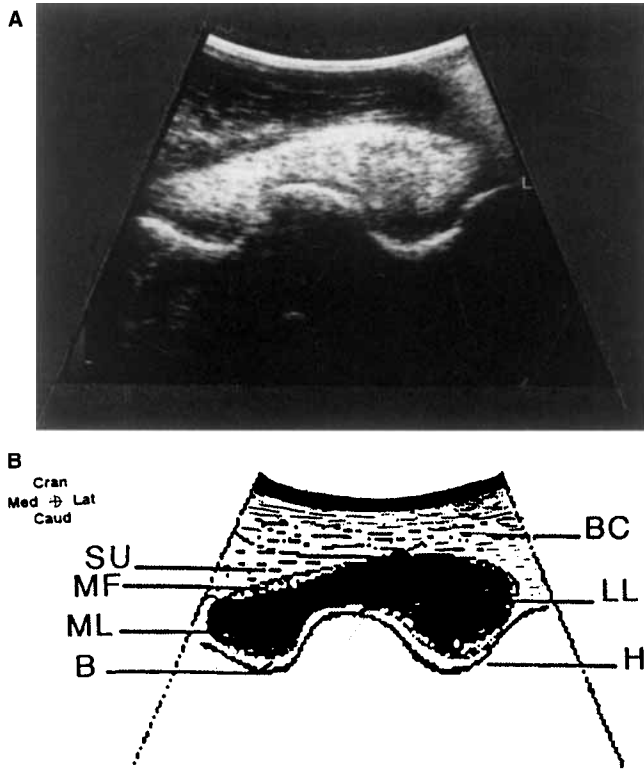


FIG. 9. Transverse image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in the proximal level of zone C; BC, brachiocephalicus muscle; LL, lateral lobe; ML, medial lobe; MF, muscle fibers of the biceps brachii muscle; SU, subclavius muscle; B, bicipital bursa; H, humerus.

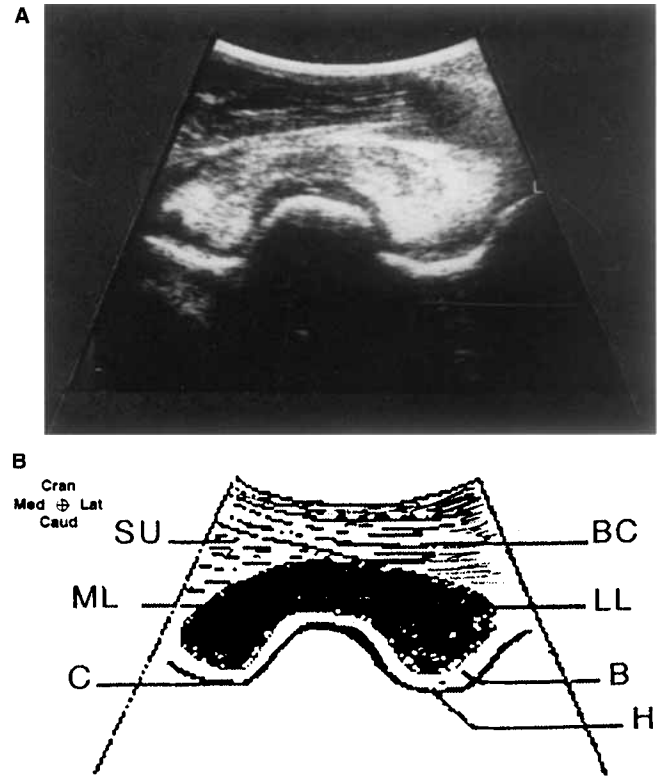


FIG. 10. Transverse image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in the distal level of zone C; BC, brachiocephalicus muscle; LL, lateral lobe; ML, medial lobe; MF, muscle fibers of the biceps brachii muscle; B, bicipital bursa; SU, subclavius muscle; C, hyaline cartilage; H, humerus.

cus muscle has a linear hypoechoic appearance and represents the most superficial structure.

Distal in zone C, the tendon has a uniform echoic texture and curves sagittally over the hyperechoic line that represents the bony interface of the convex humeral intermediate ridge (Fig. 12). To visualize the tendon in the intertubercular grooves, one should position the transducer medially and/or laterally. At this level, the bicipital bursa can be seen caudal to the tendon.

Over the distal zone B and zone C, the hypoechoic muscle layer overlying the tendon could also be assessed. In zone D, the tendon has an echogenic pattern and enters distally the hypoechoic muscular portion of the biceps brachii muscle. The tendon lies against a fat pad that appears somewhat echoic and separates it from the humerus (Fig. 13). In all the examined horses, the bicipital bursa had an anechoic appearance and expanded distally to an echoic pouch (Fig. 13).

When water was injected into the bicipital bursa, it could be seen extending around its sides and expanding distally to a bladder-shaped recessus. The ultrasonographic description of the biceps brachii tendon is summarized in Table 1. With MRI images, the tendon was visualized over its entire course. High-intensity signals corresponding to fat could be

depicted within the tendon as it crossed the scapulohumeral joint (Fig. 14).

Supraspinatus Tendons

Because of the small size of the supraspinatus tendons, their boundaries, especially those of the medial one, were somewhat difficult to distinguish. Nevertheless, these tendons were visualized with the 7.5-MHz transducer in all horses. Between these tendons, emerges the proximal tendon of the biceps brachii tendon.

Lateral Supraspinatus Tendon

To help visualize this tendon, one should first localize sagittally the biceps brachii tendon, at the level of the intertubercular groove. Then the transducer should be moved slightly to the cranial part of the greater tubercle. The lateral supraspinatous tendon appears triangular in shape and homogeneously echoic (Fig. 15). The tendon inserts on the cranial part of the greater tubercle, which is noted as an echogenic interface generating acoustic shadowing. The tendon measures 10 to 12 mm in medial-to-lateral and 6 to 8 mm in cranial-to-caudal direction and is covered by the hypoechoic brachiocephalicus muscle. The tendon is medially in close proximity to the lateral bicipital tendon lobe,

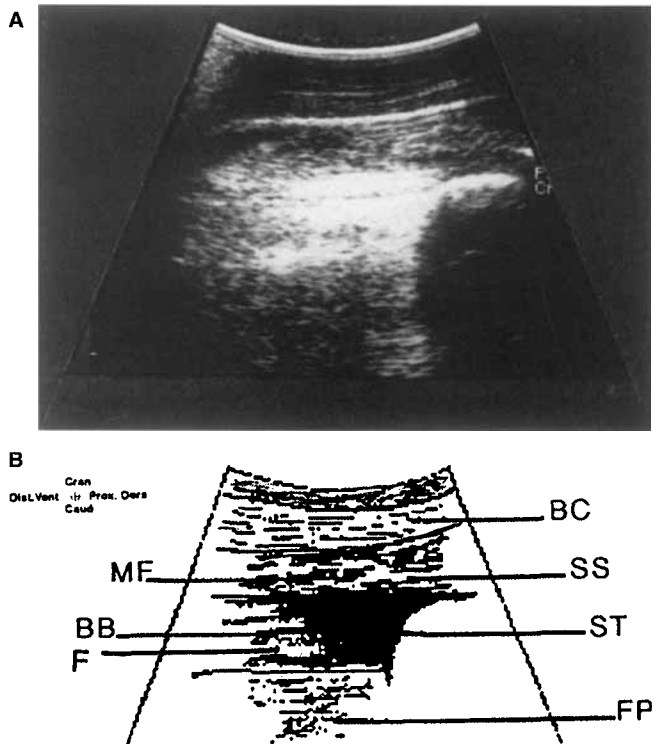


FIG. 11. Sagittal image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in zones A and B; BC, brachiocephalicus muscle; SS, supraspinatus muscle; ST, supraglenoid tubercle of the scapula; MF, muscle fibers of the biceps brachii muscle; F, fat within BB; FP, fat pad.

and the anechoic bicipital bursa is interposed between these structures. Sagittally, the tendon appears short, echoic, triangular in shape and inserts on the convex cranial part of the greater tubercle.

Medial Supraspinatus Tendon

To visualize this tendon, the transducer is positioned in the same manner as for the lateral tendon, but on the cranial part of the lesser tubercle. On transverse images, the tendon is more or less round in shape, echoic, small in size, and measures 3 to 5 mm in cranial-to-caudal and 5 to 7 mm in lateral-to-medial direction (Fig. 16). The tendon inserts on the cranial part of the lesser tubercle and is in close proximity to the medial biceps brachii tendon lobe. Cranial to the tendon, the remaining part of the supraspinatus, the subclavius, and the brachiocephalicus muscle are imaged. On sagittal images, the tendon is a small structure of approximately 10-mm in length.

Infraspinatus Tendon

Palpation of the caudal part of the greater tubercle with the infraspinatus tendon running over it in a caudodistal direction facilitates the scanning of this tendon. A 7.5- or 5-MHz transducer can be used to examine this tendon and its bursa.

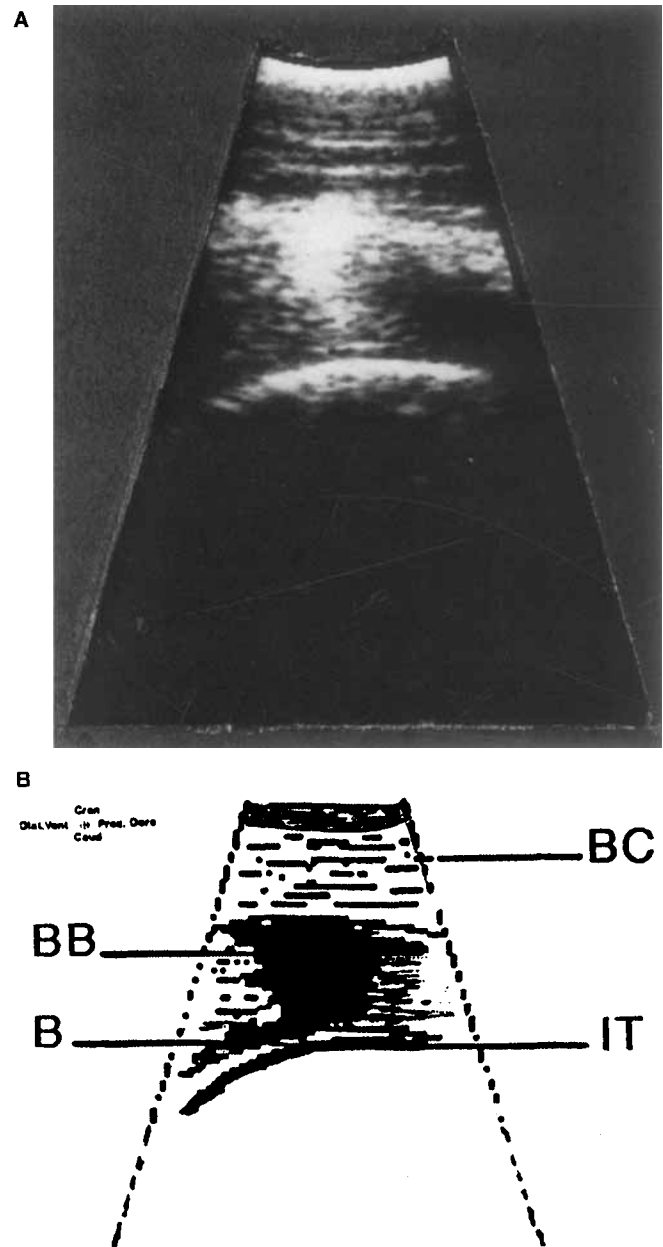


FIG. 12. Sagittal image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in zone C; BC, brachiocephalicus muscle; B, bicipital bursa; IT, intermediate humeral tubercle.

Transverse Images

In zone A, the tendon is visualized as an echogenic, rectangle-like-shaped structure within the infraspinatus muscle (Fig. 17). Distocranially, the tendon is superficially located. The hypoechoic omotransversarius muscle lies laterally to the infraspinatus muscle.

In zone B, the tendon runs over the hyperechoic and regularly convex caudal part of the greater tubercle, is almond-like in shape, has three superimposed portions, and is, in fact, not homogeneously echoic (Fig. 18). The deep por-

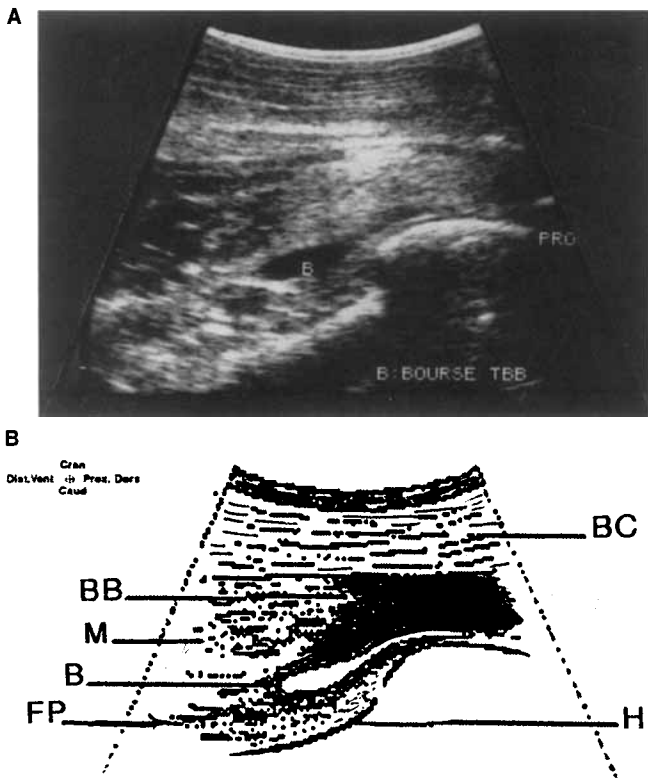


FIG. 13. Sagittal image (A) with corresponding diagram (B) of the biceps brachii tendon (BB) in zone D; BC, brachiocephalicus muscle; B, bicipital bursa; M, muscular portion of BB; FP, fat pad; H, humerus.

TABLE 1. Ultrasonographic Description of the Equine Biceps Brachii Tendon

Zone	Measurements (mm)	Comment
A	cc*: 7-9 lm†: 25-30	Crescent shaped, echoic, linear structure
B proximal	cc: 13-19 lm: 30-37	Irregularly elliptic, heterogeneously echoic seems triportioned, lies over fat pad
B distal	lm: 40-50	Biportioned, lateral portion bigger, homogeneously echoic, hypoechoic muscle fibers over the tendon, poorly defined, lies over a fat pad
C proximal	cc: 14-18 (medial lobe) 15-20 (lateral lobe) lm: 50-60	Echoic, lateral lobe bigger, fills the intertubercular groove, bicipital bursa visible
C distal	cc: 19-22 lm: 55-60	Lobes almost symmetric, echoic, bicipital bursa visible
D		Merges with bicipital muscle, irregular in shape, heterogeneously echoic, lies over a fat pad, distal recessus of bicipital bursa

*Cranio-caudal.
†Lateromedial.

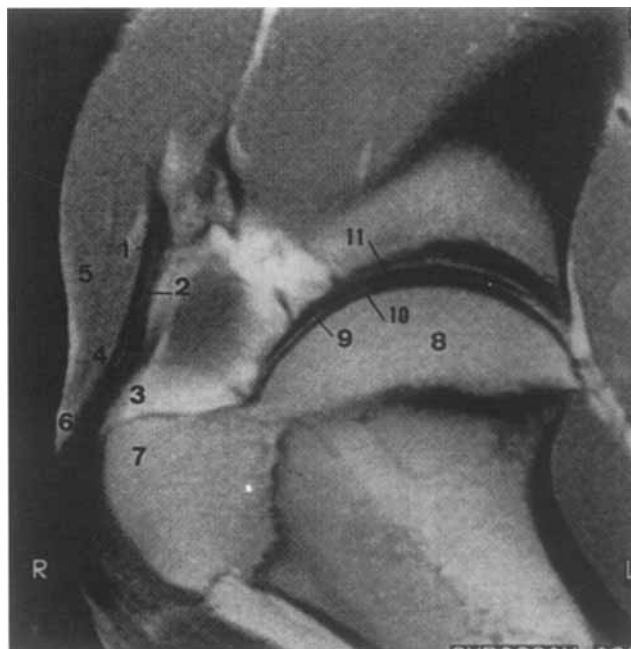


FIG. 14. Sagittal MR image of the equine shoulder at the level of the intermediate tubercle; 1. biceps brachii tendon; 2. fat within the biceps brachii tendon; 3. fat pad; 4. supraspinatus muscle; 5. brachiocephalicus muscle; 6. muscle fibers of the biceps brachii muscle; 7. intermediate tubercle; 8. humeral head; 9. articular cartilage of the humeral head; 10. subchondral bone of the humeral head; 11. synovial fluid. (T1 image; TR: 475 ms; TE: 15 ms).

tion is small, crescent shaped, and covers the caudal part of the greater tubercle in a craniodistal orientation. The middle portion is the biggest and is covered by the superficial portion, which extends more caudally. In zone B, the infraspinatus tendon measures 22 to 28 mm in proximo-cranial-to-distocaudal and 9 to 15 mm in medial-to-lateral direction. The infraspinatus bursa can be visualized as an anechoic space interposed between the tendon and the caudal part of the greater tubercle. Lateral to the tendon, the omotransversarius muscle is imaged. The boundaries of the bursa could be examined when it was injected with water.

At the beginning of zone C, the tendon has only two portions (middle and superficial), distocranially, it becomes triangular in shape and distocaudally, it is located in close proximity to a hypoechoic structure, representing a fat pad (Fig. 19). The tendon is echoic and lies against the greater tubercle. At this level, the tendon widens slightly to a thickness of 25 to 31 mm in proximocranial-to-distocaudal and a width of 10 to 15 mm in medial-to-lateral direction. Toward its insertion, the tendon flattens progressively, becomes fusiform in shape, and uniformly echoic. The tendon lies proximocranially against the greater tubercle and distocaudally against the hypoechoic teres minor muscle.

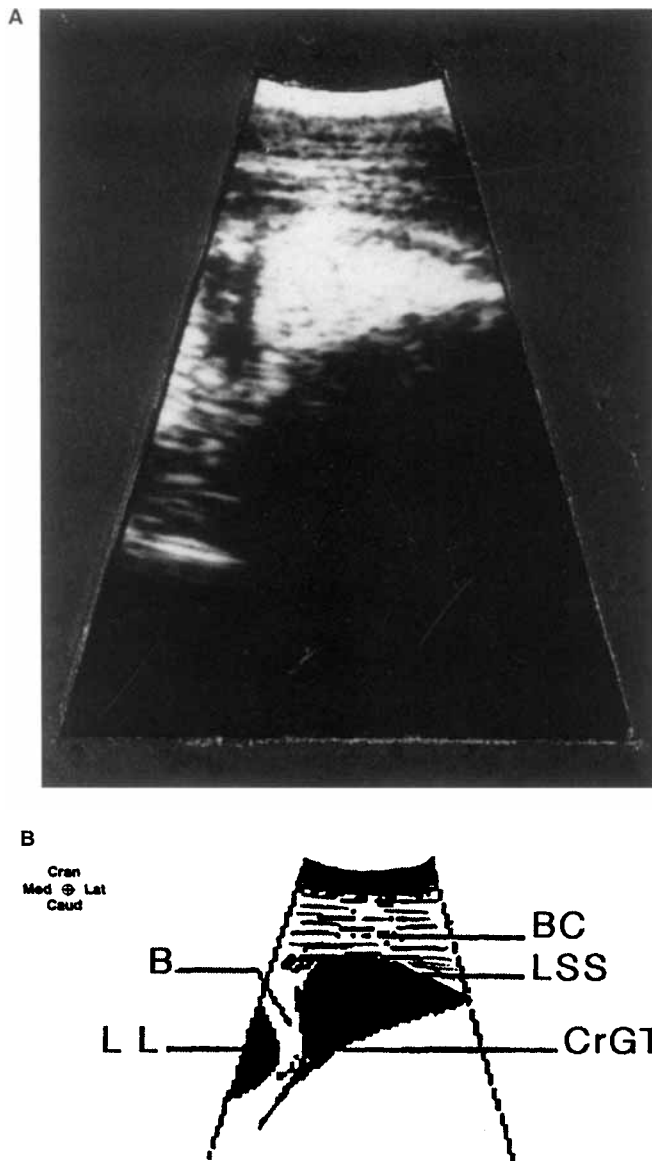


FIG. 15. Transverse image (A) with corresponding diagram (B) of the lateral supraspinatus tendon (LSS); BC, brachiocephalicus muscle; B, bicipital bursa; LL, lateral lobe of the biceps brachii tendon; CrGT, cranial part of the greater humeral tubercle.

Sagittal Images

In zone A, the tendon is visible within the infraspinatus muscle as an echoic structure with a linear parallel texture (Fig. 20). In zone B, the tendon curves over the caudal part of the greater tubercle, with the infraspinatus bursa being interposed between these two structures. The tendon appears echoic, and its three portions can be also identified. The transducer should be moved from side to side to visualize the entire tendon. The hypoechoic structure between the tendon and the skin represents the omotransversarius muscle.

In zone C, the tendon initially has two portions, then becomes homogeneously echoic. At this level, the tendon

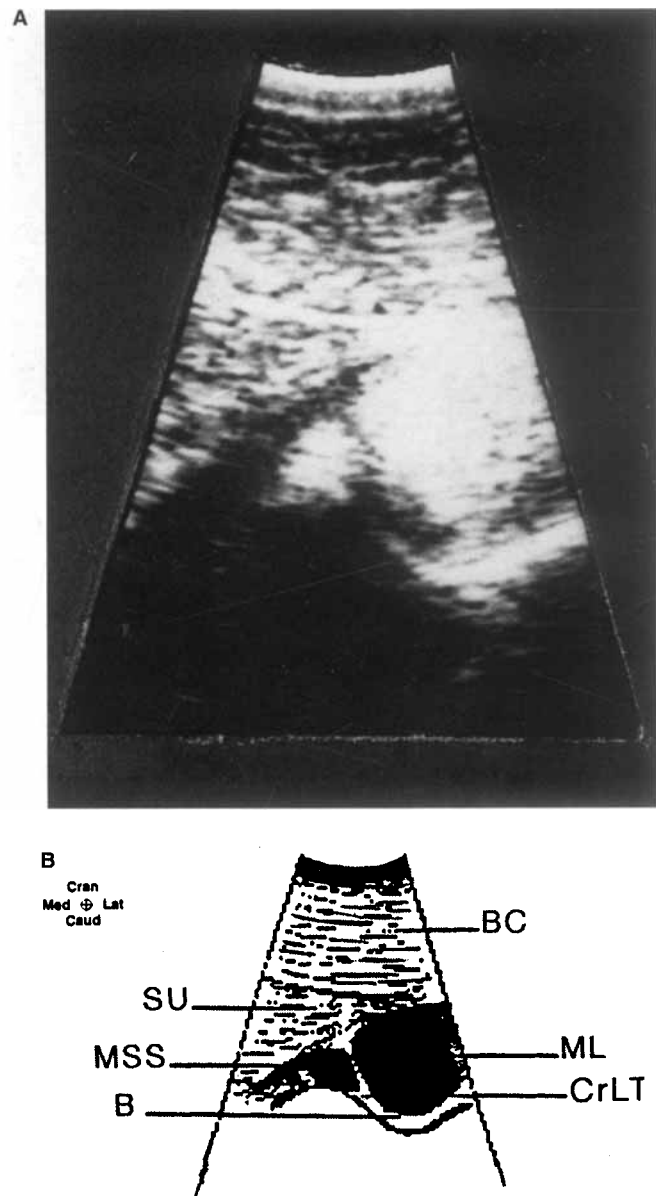


FIG. 16. Transverse image (A) with corresponding diagram (B) of the medial supraspinatus tendon (MSS); BC, brachiocephalicus muscle; B, bicipital bursa; ML, medial lobe of the biceps brachii tendon; CrLT, cranial part of the lesser humeral tubercle; SU, subclavius muscle.

seems to fill a depression over the greater tubercle, passes distocaudally over the teres minor muscle, and inserts distal to the lateral insertion of the supraspinatus muscle (Fig. 21). The ultrasonographic description of the infraspinatus tendon is summarized in Table 2.

Articular Cartilage of the Humeral Head

Only the lateral and, partially, the caudal aspects of the articular cartilage of the humeral head could be evaluated ultrasonographically. To achieve this, the operator should first palpate the cranial and caudal parts of the greater humeral tubercle. Both 5- and 7.5-MHz transducers can be

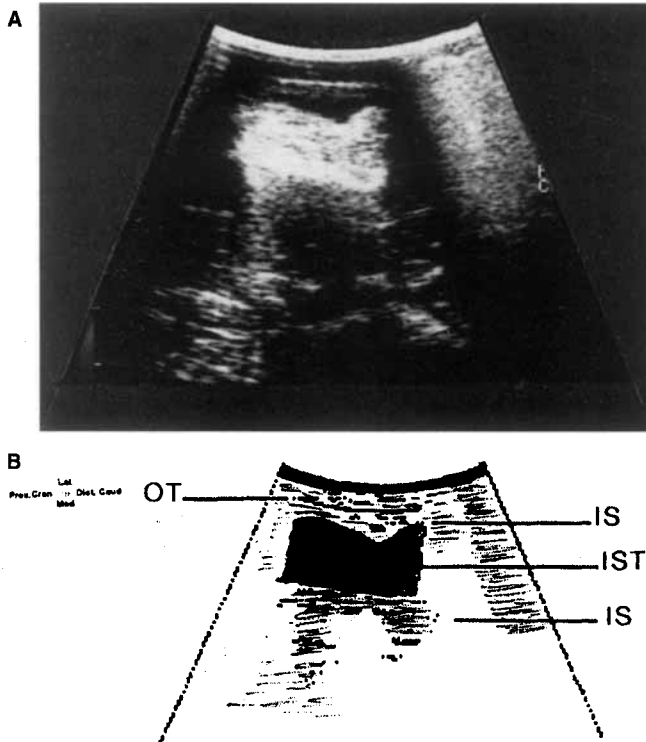


FIG. 17. Transverse image (A) with corresponding diagram (B) of the infraspinatus tendon (IST) in zone A; IS, infraspinatus muscle; OT, omotransversarius muscle.

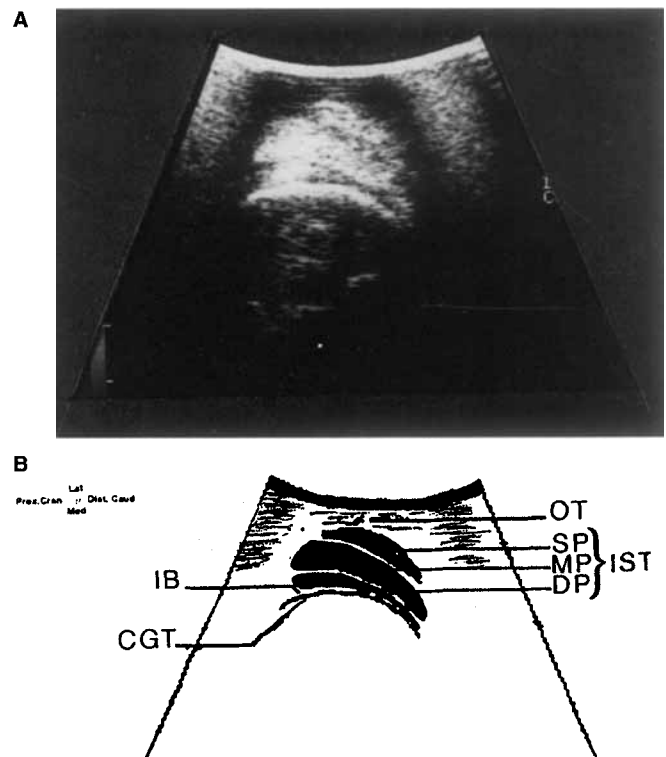


FIG. 18. Transverse image (A) with corresponding diagram (B) of the infraspinatus tendon (IST) in zone B; OT, omotransversarius muscle; SP, superficial portion; MP, middle portion; DP, deep portion; IB, infraspinatus bursa; CGT, caudal part of the greater humeral tubercle.

used. A round or small transducer head is advisable. The sagittal images were considered better than the transverse images. The transducer should be positioned obliquely between the two parts of the greater tubercle and angled in a caudodistal direction. A correct transducer position is needed to obtain satisfactory images of this cartilage. The cartilage appeared as a smooth anechoic layer of 2- to 3-mm thickness, and is delineated by two echogenic interfaces representing the joint capsule in the near field and the well-defined, smooth and convex cartilage-bone interface in the far field (Fig. 22). Slight medial, lateral, and caudodistal movements of the transducer allow the examination of the lateral and, partially, the caudal aspects of this cartilage. On MRI images, the articular cartilage of the humeral head had a hyposignal and appeared as a gray layer interposed between opposite subchondral bones of the scapula and humeral head (Fig. 14).

Superficial Muscles of the Shoulder

Superficial muscles of the shoulder were easy to assess with ultrasound (Figs. 4, 11, 17). The brachiocephalicus muscle covers the craniolateral aspect of the shoulder joint and had an hypoechoic appearance with parallel echogenic lines. At the level of the shoulder joint, the infraspinatus, subclavius, and omotransversarius muscle were also assessed as hypoechoic structures; however, the supraspinatus

muscle appeared more echogenic than the other described muscles and wrapped around the biceps brachii tendon (Fig. 4).

Discussion

In the present study, although a 7.5-MHz transducer allowed better resolution for all the examined anatomic structures, a 5-MHz transducer provided adequate images. Ultrasonographic imaging was easily performed and allowed evaluation of the biceps brachii and the infraspinatus tendon and their bursae, supraspinatus muscle and tendons, surface of the underlying humerus and scapula, brachiocephalicus, omotransversarius, subclavius and teres minor muscle, cranial aspects of the lesser and greater tubercles, supraglenoid tubercle of the scapula, caudal aspect of the greater tubercle, and the articular cartilage of the humeral head.

The biceps brachii tendon with its bursa is clinically the most relevant structure of the shoulder region. The localization by palpation of the greater humeral tubercle, and immediately medial to it, the intertubercular groove, facilitates sonographic assessment of the tendon. Just distal to its proximal insertion, the biceps brachii tendon does not appear uniformly echoic, because it is infiltrated by hypoechoic areas representing fat. This was confirmed in histological sections of the tendon at this level. In this zone, the

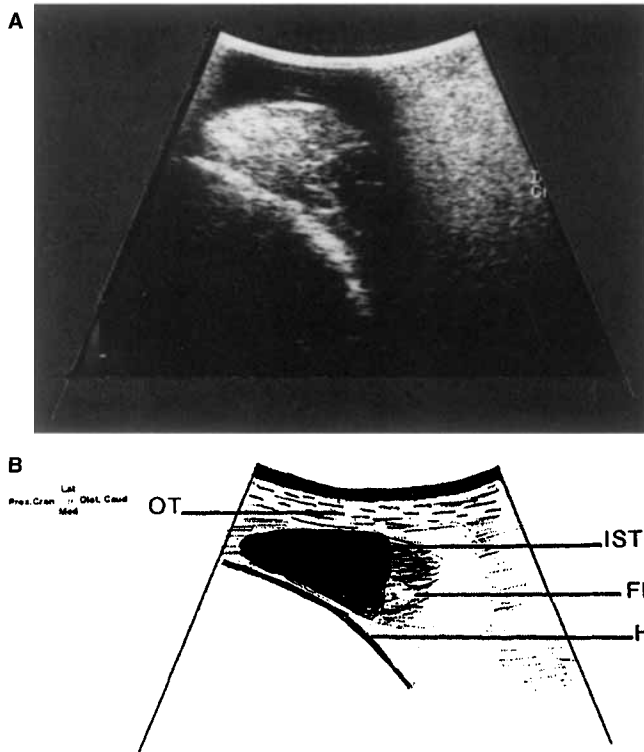


FIG. 19. Transverse image (A) with corresponding diagram (B) of the infraspinatus tendon (IST) in zone C; OT, omotransversarius muscle; FF, fat pad; H, humerus.

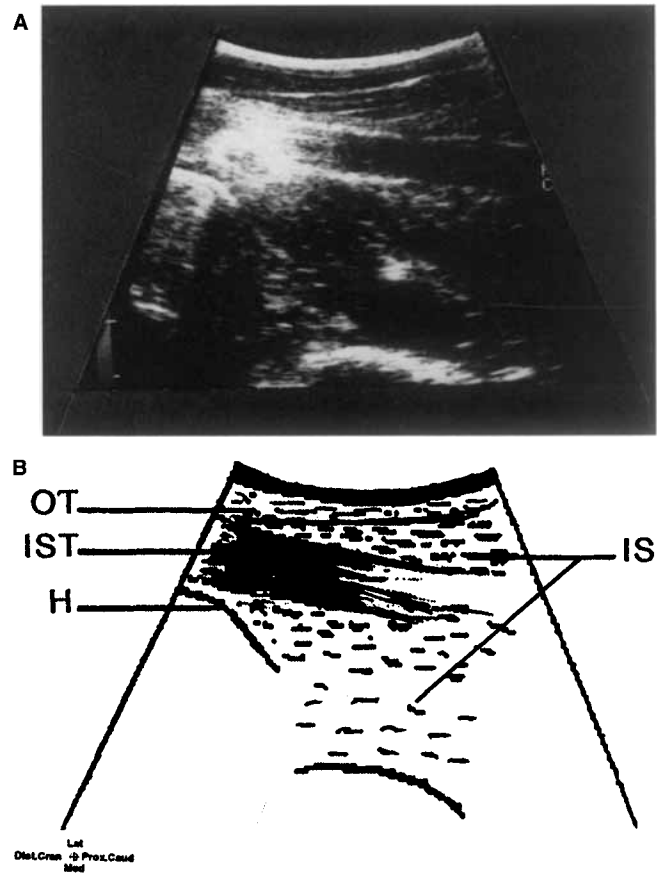


FIG. 20. Sagittal image (A) with corresponding diagram (B) of the infraspinatus tendon (IST) in zone A; IS, infraspinatus muscle; OT, omotransversarius muscle; H, humerus.

tendon initially appears trilobulated, then distally bilobulated. Previous reports documenting ultrasonography of the biceps brachii tendon did not describe this heterogeneous echoic aspect of this tendon while it crosses the scapulo-humeral joint (zone B).^{12,18-20} Therefore, it is of paramount importance that the examiner should be aware of this normal texture of the biceps brachii tendon to avoid confusion with hypoechoic lesions within the tendon. In zone C, over the intertubercular groove, the tendon becomes easy to visualize and appears uniformly echoic. However, the biceps brachii tendon is a curved tendon, and this may cause hypoechoic artifacts during examination. To avoid this, each lobe of the tendon should be examined individually. From the distal zone B to the distal zone C, a thin hypoechoic layer was seen in all the examined horses, extending over the cranial aspect of the tendon representing fibers of the biceps brachii muscle. This should not be misinterpreted as hypoechoic lesions within the tendon. To assess sagittally the entire biceps brachii tendon, one should position the transducer laterally and medially. Over zone B, the tendon is heterogeneous in appearance because of the fat within, which is hypoechoic to the tendinous fibers. Over zone C, the tendon has a linear, fibrillar echoic pattern.

The bicipital bursa was visualized in all examined horses, and appears as an anechoic space underlying the biceps brachii tendon. Longitudinal images allowed better assess-

ment of this bursa. Ultrasonography has been already advocated for evaluating the equine bicipital bursitis.^{12,14-17} Water injection into the bicipital bursa delineated the boundaries of this structure well. The bicipital bursa was visualized extending around the sides of the biceps brachii tendon, and distally to a bladder-shaped recessus.

The infraspinatus tendon was the second easier-soft tissue structure in the shoulder region to visualize ultrasonographically. Palpation of the caudal part of the greater tubercle helps visualize this tendon. The infraspinatus tendon was proximally visualized within the infraspinatus muscle, then over the caudal aspect of the greater tubercle, where the tendon has three superimposed echoic portions. Other anatomy books have described a superficial and a deep portion of the infraspinatus tendon at the same level, a short, deep portion, which attaches to the edge of the caudal part of the greater tubercle, and a broad, superficial portion, which attaches more craniodistally.^{25,26} The third additional portion of the infraspinatus tendon was not previously described. Hence, the finding is the bipartitioned appearance of the previously described superficial portion of the infraspinatus tendon in zone B. The examiner should know this normal tendon appearance to avoid confusing this with

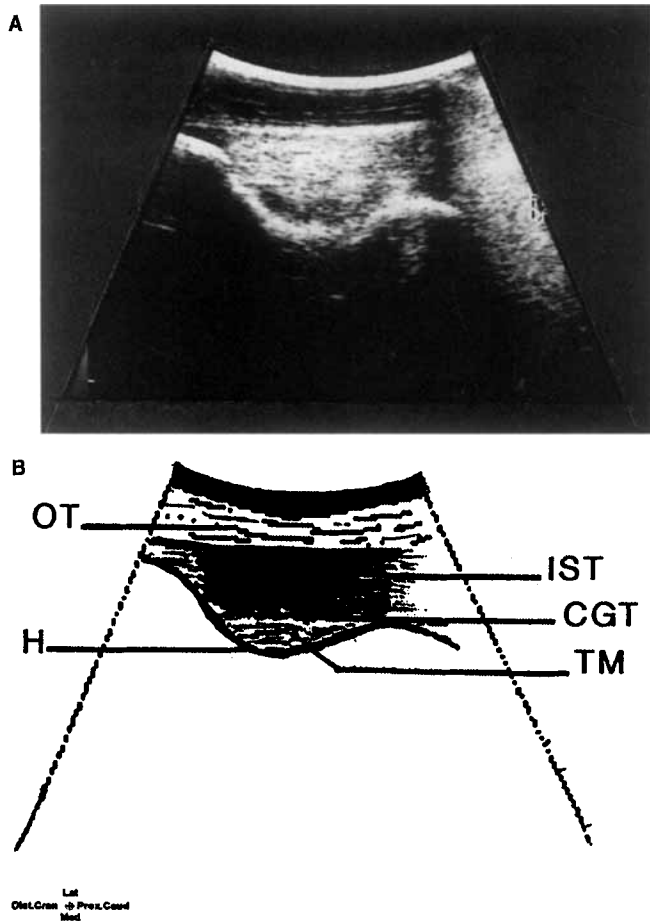


FIG. 21. Sagittal image (A) with corresponding diagram (B) of the infraspinatus tendon (IST) in zone C; OT, omotransversarius muscle; TM, teres minor muscle; CGT, caudal part of the greater tubercle; H, humerus. With the transducer oriented toward zone C, the infraspinatus bursa was not visible.

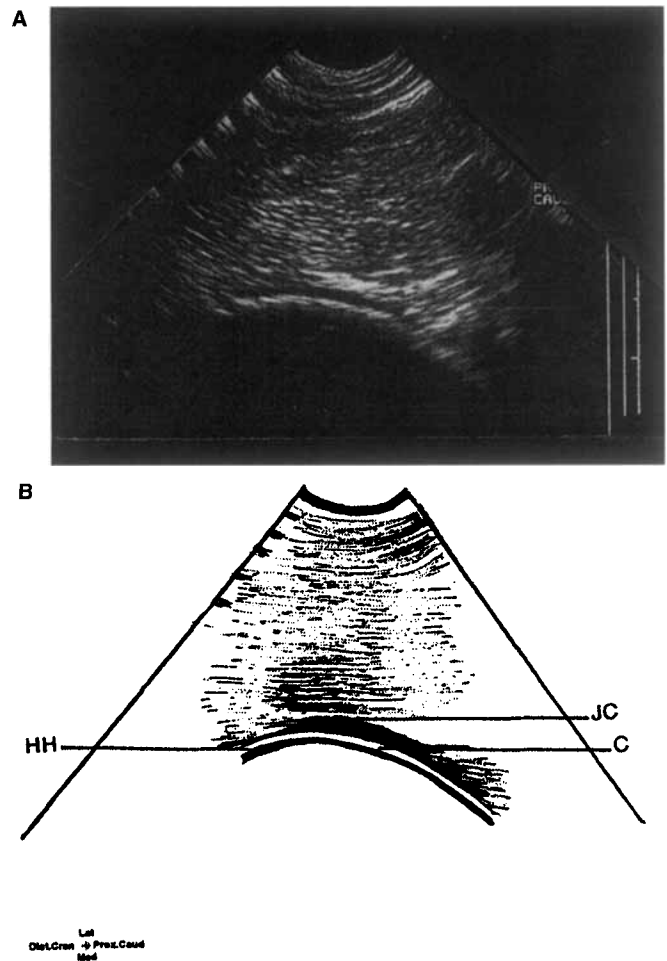


FIG. 22. Sagittal image (A) with corresponding diagram (B) of the articular cartilage of the lateral aspect of the humeral head (C); JC, joint capsule; HH, humeral head. A 7.5 MHz round transducer head was used (Ausonics Opus 1).

TABLE 2. Ultrasonographic Description of the Equine Infraspinatus Tendon

Zone	Measurements (mm)	Comment
A		Echoic, linear structure, localized within the muscle
B	pc-dc*: 22-28 lm†: 9-15	Over caudal part of greater tubercle, three superimposed portions, echoic, almond-like shape, infraspinatus bursa visible
C	pc-dc: 25-31 lm: 10-15	Initially bipartitioned, then uniform, echoic, fat pad distocaudally, toward insertion fills depression, fusiform, flattens, lies over teres minor muscle

*Proximocranial-distocaudal.
†Lateromedial.

a lesion. At this level, the infraspinatus bursa was visible in both transverse and sagittal images in all horses. However, other anatomy books described the infraspinatus bursa more distally in association with the superficial portion of the tendon.^{25,26} After having crossed the caudal part of the greater tubercle, the infraspinatus tendon has only two portions, then toward its insertion, it is uniformly echoic and lies in part over the hypoechoic teres minor muscle. On sagittal images, care must be taken not to confuse the teres minor muscle with a hypoechoic lesion within the infraspinatus tendon. Because of its small size, the medial tendon of the supraspinatus muscle was difficult to visualize, however the lateral tendon was easier to assess.

In the present study, the articular cartilage of the humeral head was evaluated ultrasonographically as a smooth anechoic layer of 2- to 3-mm thickness. However, this examination requires correct positioning of the transducer and was limited to the lateral and, partially, to the caudal aspects of this cartilage. A round or small transducer head is preferred

for such an examination. On MRI images, this cartilage was better seen; it had an intermediate intensity signal and appeared gray.

Osteochondrosis and degenerative joint disease are the most frequent intraarticular lesions of the scapulohumeral joint associated with lameness in young horses.²⁷⁻³¹ In addition, osteochondrosis was diagnosed with ultrasonography at the laterocaudal aspect of the humeral head in two horses with shoulder lameness.³² The caudal aspect of the humeral head is one of the most commonly affected articular surfaces with osteochondrosis in the horse.^{7,28,31} Ultrasonography has proved to be helpful in diagnosing cartilage defects in the humeral head. This technique merits further investigation in the horse.

In this study, two different ultrasound scanners were used to compare the obtained images. No difference in the ultrasonographic findings were noted between the two devices. With the current MRI units, examination of the equine shoulder cannot be performed in live animals. In this study, MRI was used with the intention to correlate with ultrasonography and gross anatomy. At the parameters used, MRI accurately depicted gross anatomy structures of the shoulder, and the signal intensity differences correlated with ultrasonographic findings.

Because of the small sample size and the different breeds used, measurements of the various structures were presented to help the clinician imaging these structures. In one study, measurements of the biceps brachii tendon and its bursa in Quarter Horses was reported.²⁰

Diagnostic ultrasonographic imaging of the soft tissue in the shoulder region, allowing dimensional and qualitative assessments, can easily be performed. Ultrasonography of the shoulder region can be useful in the following conditions: biceps brachii tendinitis and ossification, bicipital bursitis, enthesiophytosis of the supraglenoid tubercle, injuries of the brachiocephalicus, infraspinatus, and supraspinatus muscles, infraspinatus tendinitis, infraspinatus bursitis, osteochondrosis of the humeral head, degenerative joint disease and arthritis of the shoulder joint.

In addition, ultrasonography permits surface assessment of the supraglenoid, greater, and lesser tubercles, the intertubercular groove with its convoluted ridges, and the body of the scapula, thus, allowing fracture diagnosis of these structures,³² which can be difficult to diagnose with radiography. Therefore, ultrasonography seems to be a valuable addition to radiography in diagnosing fractures in the shoulder region. The absence of radiographic abnormalities should not deter a clinician from using ultrasound as alternate method of imaging to confirm or rule out pathology of the humerus, scapula, and soft tissues when clinical signs indicate that this area is the source of lameness.

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