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The application of high frequency ultrasound in the muscles, bones and the thoracodorsal artery in subscapular region and analysis of ultrasonic characteristics

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Abstract. – OBJECTIVE: To analyze the application value of high-frequency ultrasound in the muscles, bones and the thoracodorsal artery in the subscapular region and summarize the characteristics of ultrasound.

PATIENTS AND METHODS: Subscapularis muscle, bone and thoracodorsal artery of 72 healthy subjects were examined using high-frequency ultrasound, the initial segment diameter of the thoracodorsal artery and peak systolic blood flow velocity were recorded, and the ultrasonographic characteristics of subscapularis muscle, bone and thoracodorsal artery were summarized.

RESULTS: The spinous processes of 7th thoracic vertebrae, 9th thoracic vertebrae and 11th thoracic vertebrae all showed strong echoes with posterior acoustic shadow. The vertebral plates of 8th thoracic vertebrae, 10th thoracic vertebrae and 11th thoracic vertebrae showed a strong linear echo on both sides of the spinous process, and the lateral side was connected with the transverse processes of 8th thoracic vertebrae, 10th thoracic vertebrae, and 11th thoracic vertebrae. The inferior scapular artery was launched from the axillary artery, along with the deep side of the inferior scapular muscle, the *latissimus dorsi* and teres major muscle, and then it went inferior and backward which was then divided into *arteriae dorsalis scapulae* and thoracodorsal artery, showing a tubular structure with no echo. Color Doppler Flow Imaging (CDFI) showed the endovascular blood flow signal of the inferior scapular artery and its branches. The internal diameter of the initial segment of the thoracodorsal artery of the male subjects was bigger than that of the female subjects, and the difference was statistically significant ($p < 0.05$).

CONCLUSIONS: High-frequency ultrasound can provide a reliable reference for the anatomical structure and adjacent relationship of subscapular muscles, bones and thoracodorsal artery, and is worthy of being promoted as a non-invasive and reliable mean of examination.

Key Words:
High frequency ultrasound, Subscapular region, Muscle, Bone, Thoracodorsal artery.

Introduction

Subscapular region includes the region within left and right subscapular angle, 12th thoracic vertebra level and left and right inter-posterior axillary line region, the features of which include large area and complicated sub-region. Besides, it is involved in diverse forms of associated movement, thus the risk of fatigue and injury is high[1]. Therefore, the routine examination of this region is significant to the local anatomical structure and pathological change. Although magnetic resonance imaging (MRI) has high resolution, the operation is complicated and the price is too high, which cannot be applied as routine examination[2]. In the recent years, the application of high frequency ultrasound in muscle and bone is being increasingly focused in China and overseas, however most of studies focus on extremities, interarticular and peripheral nerve directions, and the focus on the subscapular muscle, bone and thoracodorsal artery is deficient[3]. We selected 72 healthy subjects and analyzed the application value of high frequency ultrasound in the muscles, bones and the thoracodorsal artery in subscapular region, and summarized the characteristics of ultrasound.

Patients and Methods

Patients

72 subjects who received routine physical examination in our hospital between September

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2015-May 2017 were selected in this study. All the subjects were confirmed healthy by comprehensive examination, laboratory examination and imaging examinations. There was no development abnormity of bilateral back and waist; the patients with trauma history, back mass or discomfort were excluded. The subjects were grouped based on the gender: there were 39 male cases, the age was 24-43 years old and the average was (27.91±3.58) years old, the body mass index was 20.1-26.2 kg/m^2 and the average was (23.69±1.88) kg/m^2; there were 33 female cases, the age was 25-41 years old and the average was (27.55±3.67) years old, the body mass index was 19.6-25.7 kg/m^2 and the average was (23.31±1.92) kg/m^2. The general data including age and body mass index between two groups were not statistically different (p>0.05), which was comparable. This study was approved by the Ethics Committee of our hospital, and all the subjects agreed to join this study and signed the informed consent.

Examination Methods

E8 Color Doppler Ultrasound Diagnostic System (GE Healthcare, USA) was used for examination; linear array probe with frequency of 3-12 MHz was assorted (if necessary abdominal probe with frequency of 2-9 MHz was also used). 72 subjects received high frequency ultrasound examination. First, the subscapular muscle and bone were examined, the subjects were at prone position, both hands were placed at the side of the body parallelly with palms inwards; the probe was placed at connections between the spinous processes of 7th, 9th, 11th thoracic vertebra and subscapular angle, wide view imaging mode was selected to obtain the transection images of muscles and bones between the spinous process of thoracic vertebra and posterior axillary line[4]. After that, the thoracodorsal artery was examined, the patients were at sitting position, with his/her chest lifting and back toward the examiner, and the hands crossed on the chest; the probe was placed at posterior axillary line in the armpit, showing 60°-70° with the sagittal line and oblique position with outer part at up and inner part at low, the complex of *latissimus dorsi* and *teres major* and subscapular muscle were obtained, and then Color Doppler Flow Imaging (CDFI) mode was chosen to obtain the transection ultrasonogram of subscapular artery on the surface of subscapular muscle. The probe was moved down to obtain the image of branches of subscapular artery, and then 50°-60° clockwise rotation was completed to obtain the long axis images of subscapular artery, *arteriae dorsalis scapulae* and *arteriae thoracodorsalis*[5]; the acoustic beam was vertical to the vessel to measure the inner diameter of the initial segment of thoracodorsal artery, and then pulse doppler mode was used to adjust the angle acoustic beam and blood flow in thoracodorsal artery within 60°to measure the peak systolic velocity, the above indicators were continuously measured for 3 times and the mean value was taken. The reference range of the inner diameter of the initial segment of thoracodorsal artery is 1.12-1.81 mm, and the reference range of peak systolic velocity in thoracodorsal artery is 30.4-55.9 cm/s [6].

Analytical Method

The characteristics of spinous process ultrasound images of 7th, 9th and 11th thoracic vertebra, the distribution of subscapular artery and blood flow signal were analyzed, the inner diameter of the initial segment and peak systolic velocity of thoracodorsal artery between male subjects and

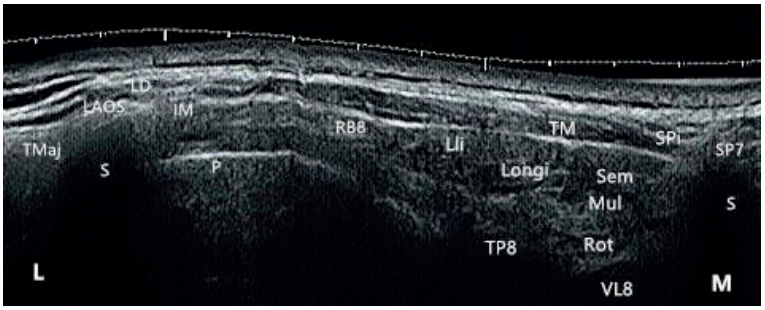

Figure 1. Transection ultrasonic images from the spinous process on the connection level between 7th spinous process of thoracic vertebra and subscapular angle to the muscles and bones on posterior axilliary line. Abbreviations - TM: *trapezius* muscle; LD: *latissimus dorsi*; Spi: spinal muscle; Longi: *longissimus* muscle; Lli: *iliocostalis* muscle; Sem: semispinalis muscle; Mul: multifidus muscle; Rot: musculi rotatores; IM: intercostal muscle; P: pleura; RTaj: teres major; SP7: spinous process of the 7th thoracic vertebra; S: acoustic shadow; VL8: vertebral plate of 8th thoracic vertebra; IAOS: inferior angle of scapula; TP8: 8th transverse process; RB8: the 8th rib; L: lateral; M: middle.

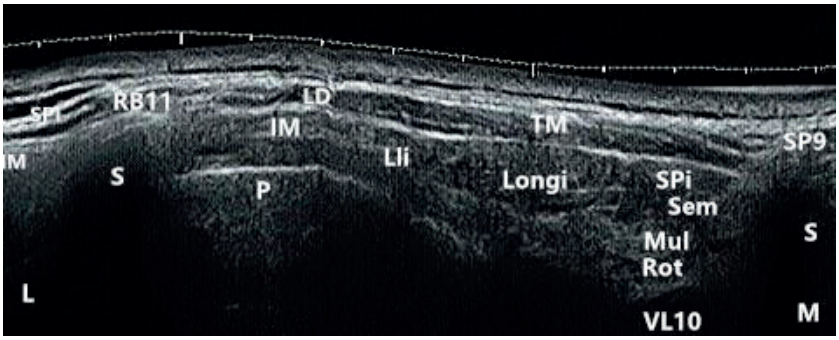

Figure 2. Transection ultrasonic images from the spinous process on the connection level between 9th spinous process of thoracic vertebra and subscapular angle to the muscles and bones on posterior axillary line. Abbreviations - SP9: spinous process of the 9th thoracic vertebra; VL10: vertebral plate of 10th thoracic vertebra; TP10: 10th transverse process; RB10: the 10th rib.

female subjects were compared, and the ultrasonic characteristics of subscapular muscle and bone were summarized.

Statistical Analysis

All the data in this study were analyzed with SPSS 21.0 (IBM Corp., IBM SPSS Statistics for Windows, Armonk, NY, USA), the inner diameter of the initial segment and peak systolic velocity of thoracodorsal artery were presented as ($\bar{x}\pm s$), and *t*-test was used for analysis. $p<0.05$ was considered as statistically significant.

Results

Characteristics of High Frequency Ultrasound

The spinous processes of 7th thoracic vertebrae, 9th thoracic vertebrae and 11th thoracic vertebrae all showed strong echoes with posterior acoustic shadow. The vertebral plates of 8th thoracic vertebrae, 10th thoracic vertebrae and 11th thoracic vertebrae showed a strong linear echo on both sides of the spinous process, and the lateral side was connected with the transverse processes of 8th thoracic vertebrae, 10th thoracic vertebrae, and 11th thoracic vertebrae (Figures 1-3). The inferior scapular artery was launched from the axillary artery, along the deep side of the inferior scapular muscle, the *latissimus dorsi* and *teres major* muscle, and then it went inferior and backward which was then divided into *arteriae dorsalis scapulae* and thoracodorsal artery, showing tubular structure with no echo. CDFI showed the endovascular blood flow signal of the inferior scapular artery and its branches (Figure 4).

The Internal Diameter of the Initial Segment and Peak Systolic Velocity of Thoracodorsal Artery

The internal diameter of the initial segment of the thoracodorsal artery of the male subjects was

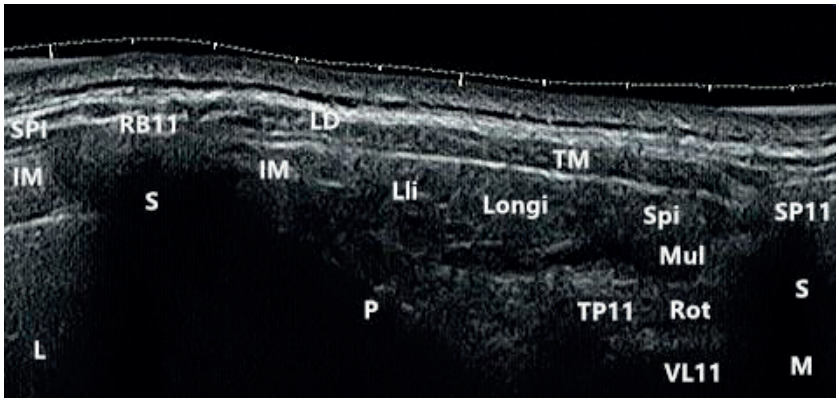

Figure 3. Spinous process of the 11th thoracic vertebra. Abbreviations - VL11: vertebral plate of 11th thoracic vertebra; TP11: 11th transverse process; RB11: the 11th rib.

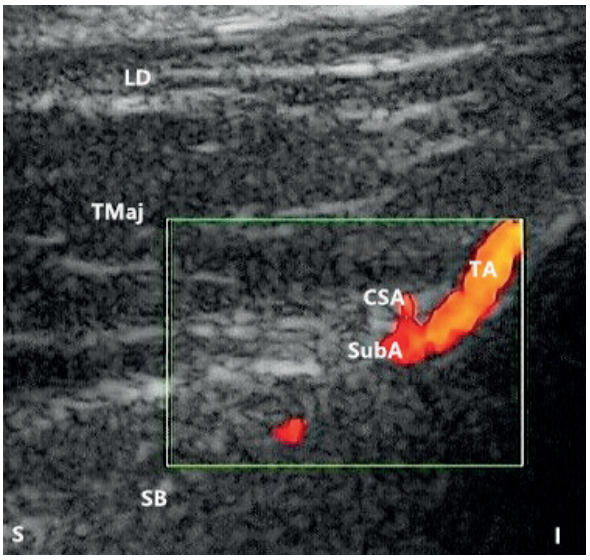

Figure 4. Long axis section ultrasonic images of subscapular artery, *arteriae dorsalis scapulae* and thoracodorsal artery. Abbreviations - TMaj: teres major; SB: subscapularis muscle; SubA: *arteriae snbscapularis*; CSA: *arteriae dorsalis scapulae*; TA: thoracodorsal artery; U: upper; I: lower.

bigger than that of the female subjects, and the difference was statistically significant ($p<0.05$). The peak systolic velocity in thoracodorsal artery was not statistically different between male subjects and female subjects ($p>0.05$) (Table I).

Discussion

The subscapular region is the region between the connection line of bilateral subscapular angles and 12th thoracic vertebra level, which is divided by posterior median line into two parts. The natural lacuna and anatomical region include armpit, *fossa suprasternalis,* supraclavicular fossa, infraclavicula, suprascapular region, *regiones scapularis and regiones interscapularis*. In the past, the criteria to diagnose subscapular region disease were mainly based on MRI, however the price is too high and the operation is complicated, thus it is difficult to be applied[7,8]. Compared with conventional ultrasound, high frequency ultrasound not only has higher resolution, but also has advantages such as cheap price, non-invasion and high accuracy, which is expected to play an important role in the imaging diagnosis, follow-up and ultrasonic intervention treatment. In this study, the examination efficacy of high frequency ultrasound on subscapular muscle, bone and thoracodorsal artery was analyzed. The results showed that high frequency ultrasound can clearly demonstrate the structure and anatomical location of subcutaneous tissue, muscle, tendon, vessel, nerve and bone surface in subscapular region. Meanwhile, the origin, diameter, distribution and abnormity of thoracodorsal artery can be dynamically observed, and the hemodynamics indexes including inner diameter, flow velocity, resistance index, pulsatility index are obtained, which has important reference value for the diagnosis and evaluation of subscapular region. As a common disease of muscles and bones in subscapular region, the chronic injury manifests as muscle, tendon tear and cumulative injury at the insertion of the tendon on the bone, high frequency ultrasound images can provide a reference basis for the diagnosis of chronic injury by clearly demonstrating the above anatomical structure and neighboring relationship [9,10]. The high frequency ultrasound images of tumor lesion in subscapular region have obvious characteristics, such as driving from dermic hair follicle or epithelium tumor under dermis, the high frequency ultrasound characteristics usually manifest as subcutaneous oval or quasi-circular lesion with clear border and bright complete envelope, the morphology is regular, the inner part contains evenly distributed weak low echo light-spots, CDFI shows there is no obvious blood flow[11]; the high frequency ultrasound characteristics of angiomatous included irregular morphology, obscure boundary and no obvious mass, CDFI showed irregular red altering

Table I. The internal diameter of initial segment and peak systolic velocity of thoracodorsal artery between male and female subjects ($\bar{x}\pm s$).

Gender	Case number	Internal diameter of the initial segment of thoracodorsal artery (mm)	Peak systolic velocity of thoracodorsal artery (cm/s)
Male	39	1.52±0.13	43.60±7.29
Female	33	1.40±0.08*	43.41±7.71
Mean	72	1.47±0.10	43.58±7.62

Note: *$p<0.05$ compared with male subjects.

with blue blood flow signal in the lesion[12]. In the observation of anatomical characteristics of subscapular region bones, we found that the direction of spinous process of thoracic vertebrae direction was different, the spinous processes of 7-10th thoracic vertebrae showed imbricate toward backside and down, and was at the same level with the next vertebral plate and transverse process; spinous processes of 11th and 12th thoracic vertebrae inclined toward backside and down, the inclination angle was not as big as 7-10th spinous process of thoracic vertebrae, which is at the same level as the vertebral plate and transverse process of the same thoracic vertebrae. Meanwhile the 7-12th inter-spinous process space with was narrow, thus most of studies consider that 7-12th thoracic vertebrae is not the ideal sites for thoracic spinal puncture [13-15]. Furthermore, knowing the characteristics of muscles in subscapular region is significant in diagnosing the disease in subscapular region. In this study, we found that subscapular regions muscles can be divided into three layers from shallow to deep, the first layer is *trapezius* muscle and *latissimus dorsi*, *trapezius* muscle is subscapular region is mainly bundle muscle, which incline from outer up to inter down, and attach on 7-12th spinous process of thoracic vertebra with short and thin tendon fiber[16]; the deep later of *trapezius* muscle is *pinniform latissimus dorsi*, which is derived from lower part of 7-12th spinous process of thoracic vertebrae, the cover area is big, it inclines from inner down to out up. The second layer muscle is *serratus posterior inferior*, which locates at the deep part of *latissimus dorsi*, the muscle belly is small, the inner part attaches on the transverse process of 11-12th thoracic vertebrae, the outer border attaches on the surface of 9-12th ribs with a small amount of fibers[17]. The third layers is *erector spinae* and *musculi intertransversarii,* from inner to outer the *erector spinae* is constituted of spinal muscle, *longissimus* muscle, *iliocostalis* muscle, and *iliocostalis* muscle is constituted of *iliocostalis* muscle and lumbar *iliocostalis* muscle, *longissimus* muscle is constituted of cervical *longissimus* muscle, thoracic *longissimus* muscle and spinal muscle spinal[18-20]; the septum between different muscles shows thin and slightly strong echo light band.

Conclusions

We analyzed the ultrasound characteristics of muscles, bones and thoracodorsal artery in subscapular region and verified that high frequency ultrasound can provide reliable reference for the anatomical structure and adjacent relationship of above structure. In the future practice, we will further focus on the application of high frequency ultrasound and summarize the diagnosis and treatment experience, which is expected to provide a non-invasive, convenient and highly repetitively reference for the diagnosis, treatment and follow-up of subscapular region disease. It is worthy of more attention.

Conflict of Interest

The Authors declare that they have no conflict of interest.

References

1) Smereczyński A, Kołaczyk K, Bernatowicz E. Chest wall–underappreciated structure in sonography. Part I: examination methodology and ultrasound anatomy. J Ultrason 2017; 17: 197-205.
2) van de Pol D, Maas M, Terpstra A, Pannekoek-Hekman M, Kuijer PP, Planken RN. B-mode sonographic assessment of the posterior circumflex humeral artery. J Ultrasound Med 2016; 35: 1015-1020.
3) Jankovic D, Kessler J, Gray AT. Lumbar plexus and femoral nerve block. Traditional and ultrasound guided techniques. Regional nerve blocks in anesthesia and pain therapy. Springer International Publishing 2015; pp. 775-800.
4) Bignotti B, Tagliafico A, Martinoli C. Ultrasonography of peripheral nerves: anatomy and pathology. Ultrasound Clin 2014; 9: 525-536.
5) Vlad VM. Pitfalls in musculoskeletal ultrasound. musculoskeletal ultrasonography in rheumatic diseases. Springer International Publishing 2015; pp. 21-55.
6) Korbe S, Udoji EN, Ness TJ, Udoji MA. Ultrasound-guided interventional procedures for chronic pain management. Pain Manag 2015; 5: 465-482.
7) Blum A, Raymond A, Louis M, Aptel S, Lecocq-Teixeira S, Gondim Teixeira PA. General considerations on muscle denervation in sports activities: shoulder entrapment syndromes and compressive neuropathies. Muscle injuries in sport athletes. Springer International Publishing; 2017: pp. 145-184.
8) Natsis K, Piagkou M, Panagiotopoulos NA, Apostolidis S. An unusual high bifurcation and variable branching of the axillary artery in a Greek male cadaver. SpringerPlus 2014; 3: 640.
9) El-Boghdadly K, Chin KJ, Chan VWS. Phrenic nerve palsy and regional anesthesia for shoulder surgery: anatomical, physiologic, and clinical considerations. Anesthesiology 2017; 127: 173-191.
10) Walter U, Dressler D. Ultrasound-guided botulinum toxin injections in neurology: technique, indica-

tions and future perspectives. Expert Rev Neurother 2014; 14: 923-936.

11) Barry KE. Investigating neck muscle size and strength with concussion risk in soccer players. Ohio University 2014.

12) Dik KJ, Weller R, Saunders JH, Van den Belt AJM, Bergman HJ, De Sadeleer C, Peremans K. Diagnostic imaging of equine sport injuries. nuclear medicine and radiologic imaging in sports injuries. Springer Berlin Heidelberg 2015; pp. 1007-1034.

13) Addar AM, Al-Sayed AA. Update and review on the basics of brachial plexus imaging. Med Imag Radiol 2014; 2: 1.

14) Madhuripan N, Mehta P, Smolinski SE, Njuguna N. Computed tomography angiography of the extremities in emergencies. Semin Ultrasound CT MR 2017; 38: 357-369.

15) Yu J, Li J, Zhou X. Repair and reconstruct of mandibular defects. Oncoplastic surgery. Springer, Singapore 2018; pp. 227-245.

16) Harrison NJ, Daste LS, McDaniel GS, Patterson ME, Guirguis M. Central neuraxial anatomy and anesthetic application (central neuraxial blockade). Basic sciences in anesthesia. Springer International Publishing AG 2018; pp. 17-39.

17) Schomberg DT, Miranpuri G S, Chopra A, Patel K, Meudt JJ, Tellez A, Resnick DK, Shanmuganayagam D. Translational relevance of swine models of spinal cord injury. J Neurotrauma 2017; 34: 541-551.

18) Murlimanju BV. Reply to: "medical record review for faculty promotion: a cohort analysis". Biomed J 2016; 39: 87.

19) Tian Q, Zhu HH, Li H. Interstitial brachytherapy of oral squamous cell carcinoma with ultrasound-guided iodine-125 radioactive seed implantation. Eur Rev Med Pharmacol Sci 2018; 22: 1680-1685.

20) Afaq AA, Stokes S, Fareed H, Zadeh HG, Watson M. Ultrasound in the selective screening of developmental dysplasia of the hip. Eur Rev Med Pharmacol Sci 2011; 15: 394-398.