ANATOMICAL AND ULTRASOUND CORRELATION OF THE SUPERFICIAL BRANCH OF THE RADIAL NERVE

STEFAN MENG, MD,1,2 INES TINHOFER, MD,2 WOLFGANG J. WENINGER, MD,2 and WOLFGANG GRISOLD, MD3

1Department of Radiology, KFJ Hospital, Vienna, Austria
2Center for Anatomy and Cell Biology, Medical University Vienna, Vienna, Austria
3Department of Neurology, KFJ Hospital, Vienna, Austria

ABSTRACT: Introduction: This anatomical study evaluates the role and correlation of ultrasound (US) with anatomy in depicting the superficial branch of the radial nerve (SBRN) and to evaluate the feasibility of US guided perineural infiltration as a potential therapeutic option in Wartenberg syndrome. Methods: Twenty-one arms from 11 non-embalmed cadavers were examined with US. Under US guidance perineural injection with ink was performed proximal to the site where the SBRN perforates the forearm fascia. The distribution of ink around the nerve was evaluated with dissection. Results: US allowed the distinction of the SBRN segments and their relation to the fascia. In all cases, the subfascial segment was stained. In only 57% the subcutaneously applied ink also reached the subcutaneous compartment. Conclusions: With US it is possible to examine and differentiate all segments of the SBRN. US guidance can be used for perineural injection of all relevant segments.


Ultrasound (US) examinations are used increasingly to determine entrapment syndromes of peripheral nerves. Concomitantly with electrophysiology, these studies provide a morphological equivalent to the site of the lesion and can add valuable information for further surgery or other types of interventions. This study aims to compare anatomical landmarks and their potential impact on therapy in Wartenberg syndrome obtained by US and anatomical dissection. For this study a sample of cadaver arms received the same type of US examination and intervention as is performed in patients.

The Wartenberg syndrome is a compression syndrome of the superficial branch of the radial nerve (SBRN) which causes abnormal sensation and pain in the distribution of the SBRN. Usually trauma of the SBRN distal to its perforation through the superficial fascia of the forearm is the cause of the nerve lesion. Pathogenic causes can include watchband or handcuff compression, braces, fractures, lacerations, casts, vein cannulation, dialysis-shunt operation, tendon sheath injection procedures, and others1–3. Additional entrapment sites for the SBRN have been identified proximally. First, where the SBRN emerges from under the brachioradialis muscle (BR) into the space between the tendons of the extensor carpi radialis longus muscle (ECRL) and the BR. Here, the nerve can be irritated mechanically by scissoring movements of the tendons. Second, a potential entrapment site is where the SBRN perforates the forearm fascia. Here, the nerve can be fixed and strained during movements of the forearm and wrist. This pathological mechanism can be aggravated if posttraumatic scar tissue fixes the SBRN distally, for example at the wrist joint, or if the SBRN is swollen secondary to trauma or an underlying neuropathy.2,4 The primary therapy of the Wartenberg syndrome involves removal of a possible cause and conservative treatment of local inflammation and edema as well as splinting.2,4 Perineural injection of a corticosteroid with an anti-inflammatory effect is well established in the therapy of the carpal tunnel syndrome but not for Wartenberg syndrome.5. In our opinion this has 2 reasons. First, evidence for the role of US in diagnosis or treatment of SBRN lesions is scant. Second, there are no cadaver studies of the feasibility of perineural injection of the SBRN to verify the procedure outcome.

The aim of this study is to demonstrate that US can correctly identify and distinguish all segments of the SBRN and their relation to the tendons and the superficial fascia of the forearm. The study also aims at evaluating the effect of performing a perineural injection with US guidance around the SBRN at potential entrapment sites.

MATERIALS AND METHODS

Twenty-one upper limbs (11 women and 10 men) were examined. They were obtained from the cadavers of 6 women and 5 men (mean age, 75.6 years), who donated their bodies to the Center for Anatomy and Cell Biology of the Medical University of Vienna. According to their records, the body donors had no neuromusculoskeletal diseases. The study was conducted with approval of the local ethics committee.

The US scans were conducted with an US system (S2000, Siemens, Mountain View, California) with a high frequency linear US transducer (18L6
They were performed by a radiologist who has 7 years of clinical experience with US (S.M.). The SBRN was located in the cubital space between the muscle bellies of the BR and ECRL. From there, the nerve was tracked distally to the wrist joint. We captured US still images in an axial body plane with SBRN cross section for documentation. Using the software package ImageJ (National Institute of Mental Health, Bethesda, Maryland) we measured the cross-sectional area (CSA) of the nerve segment that perforated the superficial fascia and of the segments immediately proximal and distal to this site.

US guided perineural infiltration with India ink was performed. The arm was in full supination and in a neutral position in relation to the wrist joint. With the same US transducer position as mentioned above and under real-time US monitoring, a needle (22 gauge) aligned with the identical axial body plane was inserted from the palmar side of the forearm. We advanced the needle tip into the subfascial compartment proximal to the site where the SBRN perforated the fascia (Fig. 1). The tip of the needle was placed directly beneath the SBRN. One ml of India ink (Pelikan, Hannover, Germany), diluted 1:10 with physiologic saline solution, was injected with a 2-ml syringe. In all cases successful injection was documented with an US still image which showed ink completely surrounding the SBRN (Fig. 2).

After infiltration, the distance between a virtual line connecting the epicondyles of the humerus and the radial styloid process was measured. The limb was then dissected with scalpels and tissue forceps. The radial nerve was exposed in the cubital space and followed distally to the wrist region. During the dissection, the distance between the site where the SBRN entered the space between the BR and ECRL tendons and the site where the SBRN perforated the fascia were measured. Finally, the length of the SBRN that was stained with ink proximal and distal of the site of its fascial perforation was measured. All measurements were performed with a vernier caliper or a ruler. We documented the dissection with photos including a reference scale.

RESULTS

The mean length of the forearms was 26.8 cm (median 27; SD 2.11). The mean distance from the fascial perforation to the radial styloid process was approximately 8 cm (median 7.5; SD 1.65), respectively, 29.8% (median 29.6; SD 0.05) of the length of the forearm. The site where the SBRN entered the space between the BR and ECRL tendons is located on average 9.78 cm (median 9.5; SD 2) proximal to the radial styloid tendon and 1.73 cm (median 1.5; SD 0.89) proximal to the fascial perforation of the SBRN.

In all specimens, US permitted tracking the SBRN from its origin from the radial nerve to its branching into the small branches of the back of the hand. It was also possible to demonstrate the SBRN topology to identify its segments and its perforation of the fascia (Fig. 1). During the US examination, the location of the SBRN perforation...
of the fascia presented itself as a short deviation of the nerve conduit. Proximal to the perforation site the nerve ascended gradually toward the fascia at a flat angle. At the perforation site for a distance of a few millimeters, the nerve crosses the fascia at a steep angle and enters the subcutaneous tissue. Distal to the perforation site the SBRN continues in a flat course.

We measured a mean CSA of 2.75 mm² (median 2.68; SD 0.98) for the SBRN segment immediately proximal to the fascial perforation. At the site of perforation, we measured a mean CSA of 2.64 mm² (median 2.32; SD 1.22), and for the SBRN segment immediately distal to the perforation site we measured 2.49 mm² (median 2.22; SD 1.03).

The dissection following the injection of India ink revealed that in all specimens the ink stained the subfascial part of the SBRN (Fig. 3). In 20 of 21 arms, the entire length of the segment of the SBRN between the BR and ECRL tendons was stained. In 1 arm, only the distal 75% of this segment was stained. In all specimens, the staining was confined to the nerve sheath and its immediate surroundings. No other nerve, vessel, or tendon sheath was stained.

In 12 of 21 cases (57%) the injected ink penetrated the fascia along the SBRN at its perforation and, in addition to the subfascial segment, stained the subcutaneous part of the SBRN for an average length of 1 cm (Fig. 3c). Again, the ink dyed only the nerve sheath and the immediately surrounding tissue.

**DISCUSSION**

This study shows that US can depict the SBRN segment between the BR and ECRL tendons, the SBRN passage through the forearm fascia, the SBRN subcutaneous segment, and the relation of those segments to such surrounding structures as the BR and ERCL tendons and the forearm fascia. We also demonstrated that US guided perineural infiltration of ink at the subfascial segment of the SBRN is feasible. Furthermore, the distribution of ink revealed that the forearm fascia could form a barrier for subfascially applied ink; the subcutaneous segment of the SBRN was not reached in 43%.

US can visualize the topology of the SBRN along its course through the forearm and has an excellent correlation with the landmarks verified by anatomical dissection. With US, it was possible to measure the CSA of all potentially pathologically relevant segments of the SBRN. The values obtained are consistent with previously published data.6 Such syndromes as lesions of the lateral antebrachial cutaneous nerve, De Quervain tenosynovitis, and Wartenberg syndrome may have similar clinical symptoms. US measurement of the CSA of the SBRN could be used to differentiate between Wartenberg syndrome and diseases that mimic it. Based on these findings, it is possible to design studies aiming at evaluating the significance of US for diagnosing Wartenberg syndrome in a clinical setting.7

US guided perineural infiltration of corticosteroids is increasingly and successfully applied to treat nerve entrapment syndromes, especially in carpal tunnel syndrome.5 We intended to determine which segments of the SBRN might benefit from subfascial infiltration near the site of the perforation of the nerve through the forearm fascia. We injected India ink into the subfascial compartment near the perforation site and analyzed which segments of the nerve were stained.
segments of the SBRN were dyed. In all but 1 specimen, the ink stained the entire SBRN segment between the BR and ECRL tendons. In all specimens, the ink only colored the neural sheath and the closely surrounding connective tissue. No other structure was stained. From this finding, we infer that US guided perineural infiltration would be a safe procedure.

In slightly more than a half of the specimens (57%), the injected ink travelled through the nerve’s fascial perforation and stained the tissue surrounding the subcutaneous part of the nerve. However, the length of the stained segment was approximately 1 cm. This shows that the forearm fascia forms an effective barrier for fluids. Thus, subfascial injections of corticosteroids can be only recommended for treating lesions of the subfascial segment of the SBRN or entrapment of the nerve at the site of its perforation through the fascia. For treating lesions of the subcutaneous nerve segment, subcutaneous or combined subfascial / subcutaneous infiltrations are required.

In our material, the site where the SBRN pierces the forearm fascia was approximately 8 cm proximal to the radial styloid process or 29.8% of the forearm length proximal to the radial styloid process. Other authors published comparable values for the site of fascial perforation by the SBRN. However, the position of the perforation site varied broadly. In our material, it was found between 5 and 12.5 cm proximal to the radial styloid process. According to our infiltration experiment, an injected liquid travels only for a distance of approximately 4.95 cm along the subfascial segment of the SBRN. Thus a “blind” infiltration without US in the lateral forearm at a position 8 cm proximal to the styloid process would prove to be insufficient. In our material, only 15 of 21 specimens (71.4%) would have had the entire intertendinous segment of the SBRN surrounded by the infiltrated fluid with a blind infiltration. Our data therefore suggest that US guided infiltration is the only option for achieving an almost 100% success rate in placing an injection at the intertendinous segment of the SBRN.

We showed that US allows analysis of the different segments of the SBRN in the forearm, which can be potentially affected in Wartenberg syndrome, especially with respect to their relation to the forearm fascia and the BR and ECRL tendons. Based on these findings, we demonstrated that perineural infiltration of the SBRN with US guidance could reach all potentially relevant segments of the SBRN. Real time US injection monitoring is of exceptional importance, as this cadaver study shows that the forearm fascia forms an effective barrier to injected ink, and thus the needle must be placed according to the local anatomical topology.

This study demonstrates, by a correlation of nerve US and anatomy, the precise anatomical correlations and landmarks of the SBRN. One particular aspect is the relation of the fascia to the nerve which might restrict the diffusion of local therapies and will need to be considered in an US approach to treatment of Wartenberg syndrome.

REFERENCES
学霸图书馆
www.xuebalib.com

本文献由“学霸图书馆-文献云下载”收集自网络，仅供学习交流使用。

学霸图书馆（www.xuebalib.com）是一个“整合众多图书馆数据库资源，
提供一站式文献检索和下载服务”的24小时在线不限IP图书馆。

图书馆致力于便利、促进学习与科研，提供最强文献下载服务。

图书馆导航：
图书馆首页 文献云下载 图书馆入口 外文数据库大全 疑难文献辅助工具