Ultrasound evaluation following deep forearm laceration

Quanson Sirlyn, MMedSon, GradDip (MedUS), BAppSc (MedRad)

Capital Radiology, Vermont South, Victoria, Australia

Abstract

Deep laceration of the forearm often involves rupture to multiple tendons and nerves. Misdiagnosis of the extent of soft tissue involvement may result in subsequent functional impairment of the hand. Physical examination of suspected tendon or nerve damage, either from open or closed injuries, can be difficult. The outcome may vary depending on the clinician's experience and possibly result in missed or false-positive results. With the advances in current ultrasound (US) systems and their widespread availability, the affected tendons and nerves can be accurately depicted to provide crucial information used in formulating a treatment strategy.

Keywords: extensor tendon, forearm laceration, posterior interosseous nerve, ultrasound.

Introduction

Deep laceration of the forearm with tendon or nerve involvement requires early diagnosis and timely treatment to avoid functional impairment of the hand.[1,2] No reports have been published on US evaluation of acute rupture of tendon and nerve following forearm laceration. This article reviews the US findings 2 weeks following a deep forearm laceration that had been sutured closed at the time of the initial Emergency Department admission. This case details a clinically missed diagnosis of the extent of tendon and nerve injury at the time of initial surgical exploration and wound closure. Such cases may result in unnecessary re-exploration and subsequent repair operations. This highlights the challenges in delineating tendon or nerve disruption from open or closed injuries based on physical examination alone.[3] Indeed in open acute trauma, wound tissues are often swollen and disorganised, with blood often obscuring the deep field of view. In the setting of deep laceration, pre- or post-surgery, US can be used to demarcate the extent of tendon or nerve involvement under local anaesthetic. The efficacy of these US findings may enable the treating physician to choose between surgical exploration or conservative treatment.[4–6]

Case report

A 54-year-old right-hand dominant male sustained a 19-cm oblique laceration from a chainsaw in the mid-portion of his dorsolateral forearm. The wound extended distally to the level of Lister's tubercle (Figure 1). He was taken to the Emergency Department and had his wound stitched under sedation. The wound healed well, but the patient had persistent limited extension of his right thumb at 2 weeks following injury (Figure 2). The patient was referred by a plastic surgeon for an US of his wrist and, in particular, the state of the extensor pollicis longus (EPL) tendon. Before US examination, clinical assessment by the sonographer showed the patient was unable to extend his thumb and could not perform radial deviation of the wrist with active movement. The patient reported that there was no sensory deficit in his forearm. The ultrasound images were acquired from a Logiq E9 (GE Medical Systems, Zipf, Austria) ultrasound system, with a 6–15 MHz linear-array transducer. A pre-operation ultrasound is useful and can be achieved prior to wound stitching, whilst the local anaesthetic is still active. This can be performed by utilising sterile stand-off gel pads rather than liquid gels.

On US, the EPL tendon was absent from compartment three at the level of the Lister's tubercle, as compared to the contralateral wrist where the EPL could be seen coursing over the

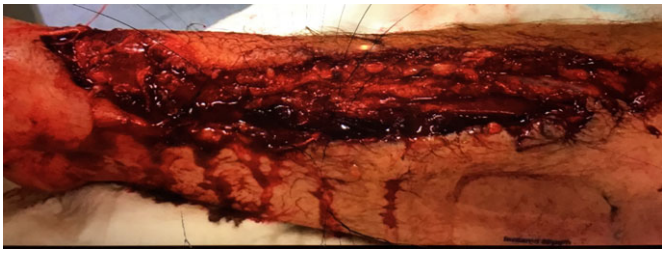

Figure 1: Right Forearm Laceration, Showed the Wound Extending to the Wrist.

Correspondence to email q.sirlyn@capitalradiology.com.au
doi: 10.1002/ajum.12079

Figure 2: Right Forearm 2 weeks Post-suture of the Wound.

extensor carpi radialis longus (ECRL) and brevis (ECRB) tendons (Figure 3a and b). The scan was then extended to interrogate the lateral wrist in search of a cause for the patient's other symptoms, revealing a complete rupture of both the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons. Transverse view at the compartment one fossa demonstrated an absence of the APL and EPB tendons when compared to the left wrist (Figure 4a). A longitudinal view showed complete discontinuity of the right EPL tendon with only the presence of a proximal stump (Figure 4b). A longitudinal panoramic image of the right lateral wrist was performed, demonstrating a 4.2-cm gap between the proximal and distal stumps of the APL and EPB tendons (Figure 4c). Finally, comparison images of the right and left mid-forearm demonstrated the disruption of the right supinator myofascial layer and the distal right posterior interosseous nerve (PIN) just before it emerged from the supinator muscle (Figure 5a, b). The US finding of complete tendon rupture of EPL, ECRL, ECRB and PIN transection was confirmed with the plastic surgeon at the subsequent exploration and repair.

Discussion

Extensor tendon injuries are common and if left untreated can result in substantial disability. Despite this, less attention has traditionally been given to extensor tendon in contrast to flexor tendon injuries.[5] The anatomy of the forearm and wrist extensor mechanism is complex. The close proximity of the composite system of retinacular structures and the extensor mechanism including both extrinsic and intrinsic muscles further complicates the clinical presentation and assessment of deep lacerations.[5] Among the superficial and deep muscle layers of the forearm, the radial nerve divides into the superficial sensory branch and deep motor branch. This deep branch, termed the PIN, then penetrates the supinator muscle, passing beneath the Arcade of Frohse and splitting the two heads of supinator. The nerve then continues its course through the superficial and deep muscles of the forearm extensors, providing their innervation.[1,7]

In the setting of deep forearm laceration, associated injuries including multiple tendon ruptures and nerve transection are rather common.[1] As seen in this case report, the deep laceration of the forearm resulted in complete rupture of the EPL, APL, EPB tendons and PIN. Despite overlying scarring from the laceration, an attempt to ultrasound over the scar should be made. One should adopt a systemic approach by starting from the proximal forearm's affected myotendinous origin and follow through to their osseous insertions, including their muscle bellies. Whereas with the PIN, it should be tracked as it emerges from under the Arcade of Frohse to its exit point and followed through to the level of the wrist. The disruption of the myofascial layer serves as a reminder of potential underlying tendon or nerve damage; whilst assessing the tendons and nerve, applied passive or active joint movement would improve diagnostic confidence. In a study of four patients who sustained significant laceration injuries to their forearm at zones VIII and IX, three of these patients showed associated damage to the PIN in addition to multiple extensor tendon lacerations.[1] When laceration does involve the tendons or nerve, the patients require early diagnosis and timely surgical exploration to repair the damaged structures in order to avoid functional impairment of the hand.[1]

An extensive deep forearm laceration has the potential to transect the PIN but may spare the radial nerve sensory branch, as described in this case. In this scenario, the presence of sensation may mask pathology of the underlying motor nerve. Emergency physicians and sonographers in particular when assessing deep forearm lacerations should keep in mind the possibility of collateral injury to the PIN. The cause of restricted wrist and finger extension in active movement should not be confined to an isolated tendon rupture and should act as a red flag for the treating physician and sonographer to suspect the possibility of PIN injury.[7] The detection of motor nerve involvement in dorsal forearm laceration has important implications, especially in terms of formulating an initial treatment strategy as well as for the postoperative management protocol[4,5]. Describing the classification of the

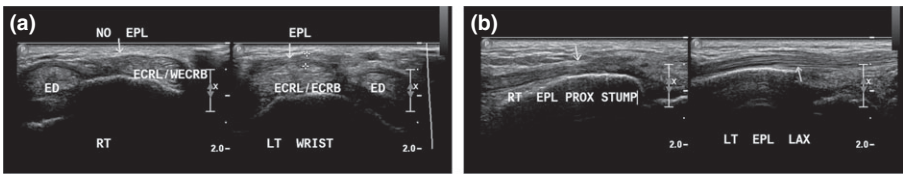

Figure 3: (a) Transverse View Comparison to the Left Wrist, there was an Absence of the EPL Over the ECRL and ECRB in the Right Wrist. (b) Longitudinal View Showed a Discontinuity of the EPL Compared to the Left Wrist.

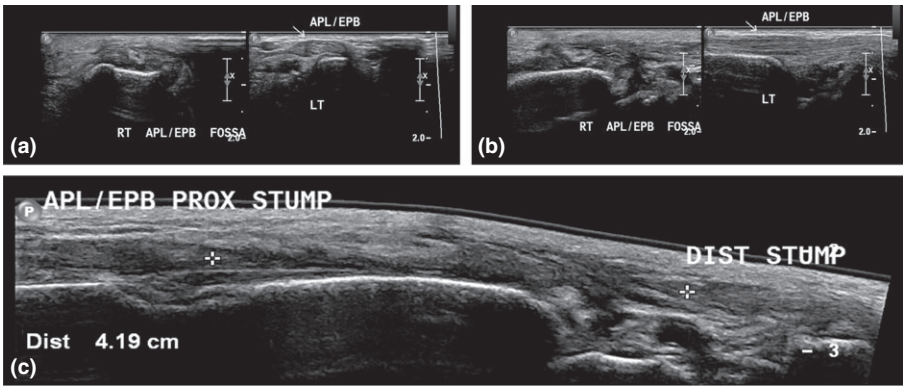

Figure 4: (a) Transverse View Compared to Left Wrist. There was an Absence of APL/EPB at the Compartment One Fossa of the Right Wrist. (b) Longitudinal View Showed a Discontinuity and Absence of APL/EPB at the Lateral Wrist Compared to the Left Side. (c) Panoramic View of the Right Lateral Wrist, Showed a Gap of 4.2 cm Between the Proximal and Distal Stump of APL/EPB.

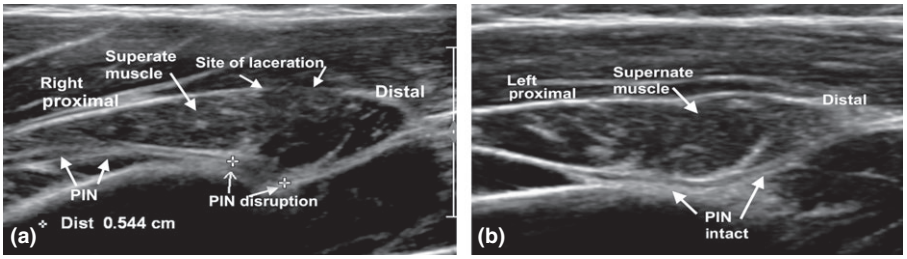

Figure 5: (a) Longitudinal View of the Mid-right Forearm. Showed the Disruption of Supinator Myofascial Layer and the Distal PIN Before it Emerged from the Supinator Muscle. (b) Longitudinal View of the Mid-left Forearm. Showed an Intact Supinator Myofascial Layer and the Mid-distal Portion of the PIN.

forearm laceration pattern with or without nerve innervation is complex and beyond the framework of this study, though has been summarised in the work by Fischer and Tang.[1]

Physical examination with suspected tendon rupture or nerve damage, either from open or closed injuries, can be difficult; the outcome varies depending on the clinician's experience and may result in either false-positive or false-negative assessments.[3] A prospective study by McNicholl *et al.*[8] of 100 consecutive deep hand and forearm lacerations assessed the involvement and incidence of underlying structure damage as related to the clinical severity of injuries. A total of 49 deep injuries were discovered at exploration, none of which had been detected on clinical examination, of these 33 cases showed tendon laceration. In another study of 147 deep lacerations of the hand, surgically confirmed complete tendon tears were preoperatively diagnosed clinically in only 64% of cases by emergency physicians, and 84% of cases by hand surgeons.[9] The limited reliability of physical examination even by specialist surgeons has therefore led to a widespread embrace of surgical exploration whenever a deep lesion is suspected.[3]

As demonstrated by this case report, US is able to depict partial or complete tendon tears along their length from the myotendinous origin to their osseous insertion. US can measure retraction distance and precisely which tendon is involved. When integrated with the dynamic examination, the diagnostic ability is enhanced further by passive or active joint movement.[3,6] Tendon or nerve adhesion can be diagnosed when the intact tendon or nerve shows tethering or immobilisation.[10] US can also delineate and track the entire length of the PIN as it emerges from under the Arcade of Frohse. An accurate ultrasound will therefore enable the treating physician to adequately diagnose the injury extent and therefore customise a surgical treatment to optimise patient outcomes[5] and may even limit the need for extensive surgical exploration at the time of tendon and wound repair.[4]

Conclusion

Forearm laceration with tendon or nerve involvement can result in functional impairment of the hand if left untreated.[2] Physical examination of suspected tendon rupture or nerve disruption, either from open or closed injuries, can be a challenge.[3] Tendon rupture from extensive laceration, with or without the sensory deficit, may mask underlying motor nerve damage. In the setting of deep forearm laceration, pre- or post-surgery, ultrasound may be utilised for the evaluation of the extent of possible tendon

and nerve injury. Detailed ultrasound findings can provide the treating physician with crucial information to be used in formulating the treatment strategy.

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