Avoiding Peripheral Nerve Injury in Arterial Interventions

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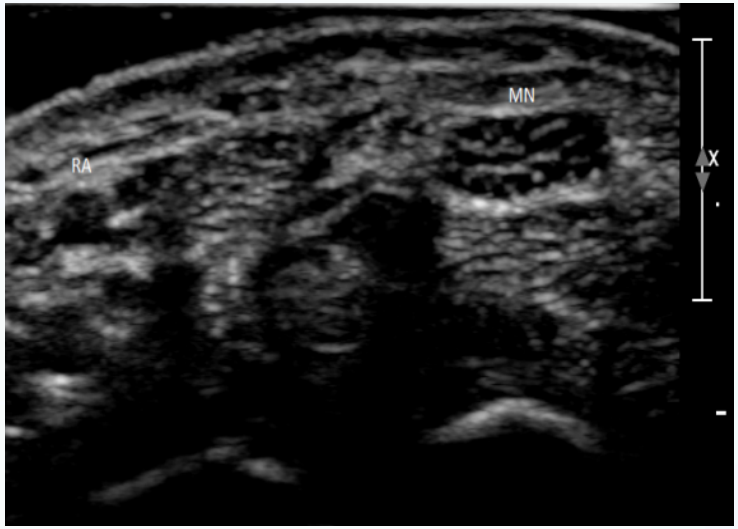
Introduction

- Peripheral nerve injuries secondary to arterial interventions are uncommon, and while usually not permanent, they can result in significant functional impairment
- Most arteries that are accessed for angiographic and endovascular interventions are in close proximity to one or more nerves
- Injury to these nerves may result directly from needle puncture, or result from compression by a hematoma, pseudoaneurysm, hemostasis device, or by manual compression
- Nerve injuries have been reported most frequently with axillary and brachial arterial access, likely due to the anatomic proximity of the vessels and nerves at this location in combination with anatomic challenges for hemostasis
- Given the increasing frequency of arterial interventions and the use of non-traditional access sites, it is important that the interventionalist have a working knowledge of peripheral nerve anatomy and function as it relates to relevant arterial access sites

Radial Artery Access

- Radial artery access is a safe and technically useful technique, particularly for coronary, upper limb, mesenteric, renal, and neurovascular interventions
- The median nerve is closest in proximity to the radial artery, but is contained in the carpal tunnel several centimeters in the ulnar direction
- Transient sensory digital impairment with radial artery access at the wrist has been reported, although it is extremely rare[1]
- The superficial branch of the radial nerve is several centimeters dorsal and radial to the radial artery and has already splayed into small cutaneous branches at the level of the wrist

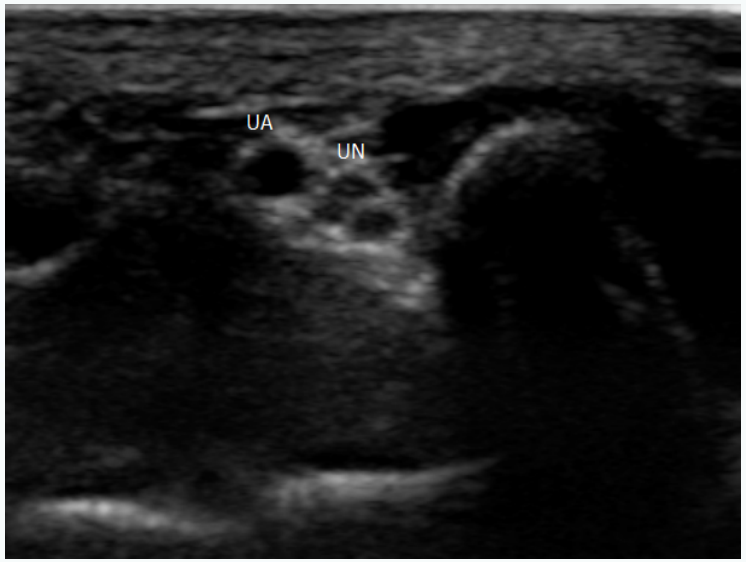


Ultrasound image of the radial artery (RA) and median nerve (MN) at the wrist

[1]Kanei Y, Kwan T, Nakra NC, Liou M, Huang Y, Vales LL et al. Transradial cardiac catheterization: a review of access site complications. Catheter Cardiovasc Interv. 2011;78:840-846.

Ulnar Artery Access

- The ulnar artery is less frequently accessed than the radial artery
- It is a useful access when radial or common femoral arterial access is technically difficult or inadequate
- The ulnar artery is closely related to the ulnar nerve at the wrist, with the artery slightly radial and superficial to the nerve (image)
- The ulnar artery and nerve both pass through the canal of Guyon at the wrist

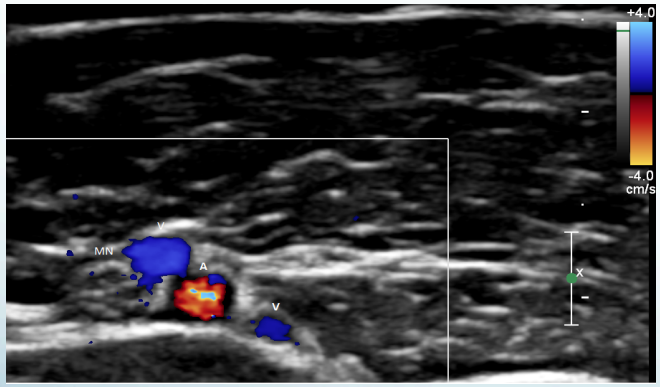


Ultrasound image of the ulnar artery (UA) and ulnar nerve (UN) at the wrist

Possible nerve injury	Muscles involved	Motor impairment	Sensory impairment
Ulnar nerve	Hypothenar muscles: abductor digiti minimi, flexor digiti minimi, opponens digiti minimi Interosseous muscles 3rd and 4th lumbricals Adductor pollicis	Small finger flexion/ abduction All MCP joint abduction/ adduction MCP joint flexion with IP joint extension (small and ring fingers) Thumb adduction	Hypothenar aspect of the palm, the small finger, and ulnar side of the ring finger

Brachial/Axillary Artery Access

- Brachial/axillary artery access has demonstrated significantly higher rates of neurologic complications than other access sites, with a reported incidence as high as 9%[2, 3]
- From the axilla to just above the elbow, the axillary and brachial vessels are contained by the medial brachial fascial compartment (MBFC), a thick brachial fascia that covers a thin, axillary sheath
- The MBFC also contains the median and ulnar nerves
- This upper arm anatomy makes hemostasis challenging and nerve injury more likely
- Median nerve injury occurs more frequently than ulnar nerve injury
- Although the radial and musculocutaneous nerves exit the compartment well proximal to the location of axillary arterial access, there have also been reports of injury involving these nerves
- Brachial artery access complications have been shown to be reduced with the employment of the Angioseal (St. Jude Medical, St. Paul, MN) device in adequately sized vessels[4, 5]
- Smaller studies support the use of multiple other closure devices, including Perclose and StarClose (Abbott Laboratories, North Chicago, IL)[5]



Ultrasound image of the brachial artery (A), paired brachial veins (V), and median nerve (MN) above the elbow

[2]Hessel SJ, Sequeira JC. Femoral artery catheterization and vessel tortuosity. Cardiovasc Intervent Radiol. 1981;4:80-82.
[3]Smith DC, Mitchell DA, Peterson GW, Will AD, Mera SS, Smith LL. Medial brachial fascial compartment syndrome: anatomic basis of neuropathy after transaxillary arteriography. Radiology. 1989;173:149-54.
[4]Lupattelli T, Clerissi J, Clerici G, Minnella DP, Casini A, Losa S et al. The efficacy and safety of closure of brachial access using the AngioSeal closure device: experience with 161 interventions in diabetic patients with critical limb ischemia. J Vasc Surg. 2008;47:782-88.
[5]Sheth RA, Ganguli S. Closure of Alternative Vascular Sites, Including Axillary, Brachial, Popliteal, and Surgical Grafts. Tech Vasc Interv Radiol. 2015;18:113-21.

Brachial/Axillary Artery Access

Median nerve injury

Muscles involved	Motor impairment	Sensory impairment
Forearm: Pronator teres, pronator quadratus* Flexor carpi radialis, palmaris longus Flexor digitorum superficialis Flexor digitorum profundus (index and middle fingers)* Flexor pollicis longus* *Branches of the anterior interosseous nerve	Forearm pronation Wrist flexion/radial deviation MCP and PIP joint flexion DIP joint flexion (index and middle fingers) Thumb IP joint flexion	Palmar surface of the hand (with sparing over hypothenar region) Palmar surface of thumb, index finger, middle finger, radial half of ring finger
Hand: Opponens pollicis, abductor pollicis brevis, flexor pollicis brevis Lumbricales 1 and 2, palmaris brevis	Thumb abduction/ flexion/ opposition MCP joint flexion with IP joint extension (index and middle fingers)	

Ulnar nerve injury

Muscles involved	Motor impairment	Sensory impairment
Forearm: Flexor carpi ulnaris Flexor digitorum profundus (small and ring fingers	Wrist flexion/ ulnar deviation DIP joint flexion (ring and small fingers)	Sensory impairment involving the posterior aspect of the ulnar side of the hand owing to involvement of sensory fibers supplying the dorsal ulnar cutaneous nerve
Hand: See ulnar nerve involvement from injury at the wrist	Hand: See ulnar nerve involvement from injury at the wrist	Hand: See ulnar nerve involvement from injury at the wrist

Brachial/Axillary Artery Access

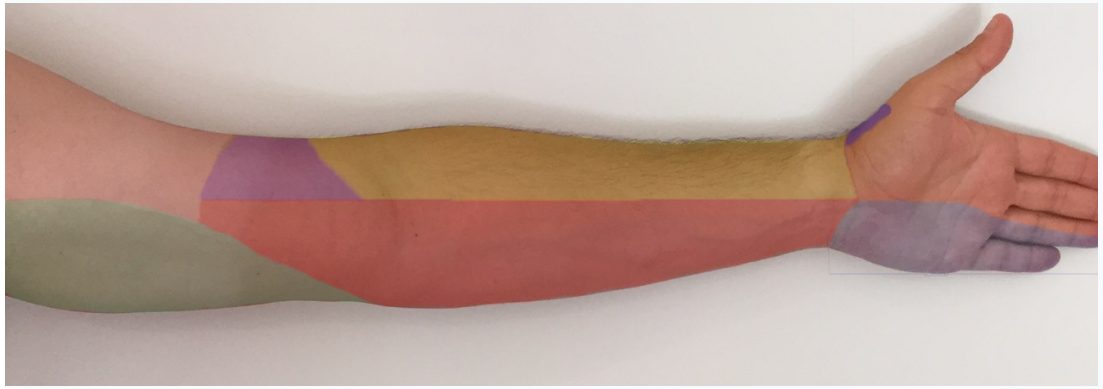
Radial nerve injury (variable impairment depending on relationship of injury to site motor branches)

Muscles involved	Motor impairment	Sensory impairment
Upper arm: Triceps, anconeus Brachioradialis, brachialis** Extensor carpi radialis longus, extensor carpi radialis brevis, extensor carpi ulnaris Supinator **Brachialis shares innervation from the radial and musculocutaneous nerves	 Elbow extension Elbow flexion Wrist extension Forearm supination	 Posterior, radial aspect of the hand, posterior forearm, and posterior arm
Hand: Abductor pollicis longus, extensor pollicis longus, extensor pollicis brevis Extensor indicis, extensor digitorum communis, extensor digiti minimi	 Thumb abduction/ extension MCP joint extension of all digits	

Musculocutaneous nerve injury (variable impairment depending on relationship of injury to site motor branches)

Muscles involved	Motor impairment	Sensory impairment
Upper arm: Coracobrachialis Biceps brachii Brachialis** **Brachialis shares innervation from the radial and musculocutaneous nerves	 Shoulder flexion Shoulder flexion, elbow flexion, supination Elbow flexion	Injury to the lateral antebrachial cutaneous nerve (the terminal sensory branch of the musculocutaneous nerve) may yield sensory impairment in the anterior-radial aspect of the forearm

Upper Limb



Depiction of the sensory nerve territories of the upper limb (anterior view)

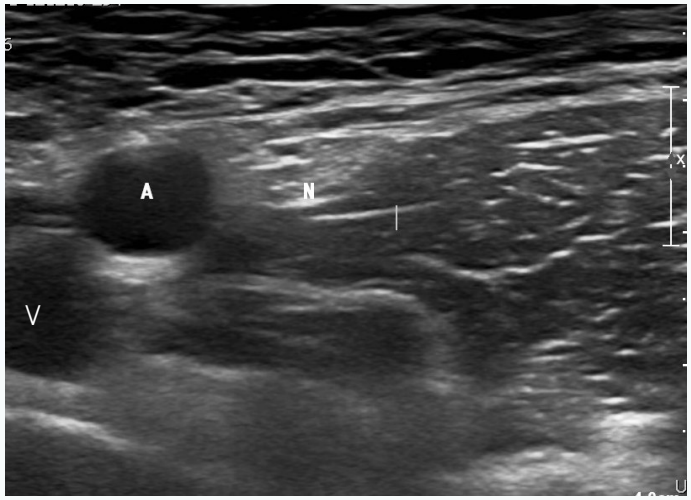
Depiction of the sensory nerve territories of the upper limb (posterior view)

Figure Legend

Orange: Median nerve
Purple: Superficial radial nerve
Cornflower: Ulnar nerve
Yellow: Lateral antebrachial cutaneous nerve (branch of the musculocutaneous nerve)
Red: Medial antebrachial cutaneous nerve
Magenta: Posterior antebrachial cutaneous nerve (branch of the radial nerve)
Pink: Axillary nerve
Green: Medial brachial cutaneous nerve

Common Femoral Artery Access

- Most frequently performed access for arterial interventions
- The femoral nerve is located just lateral to the common femoral artery in the femoral triangle
- Complications are reduced when ultrasound guided access is performed[6]



Ultrasound image of the femoral triangle structures from lateral to medial (N), Common femoral artery (A), and Common femoral vein (v)

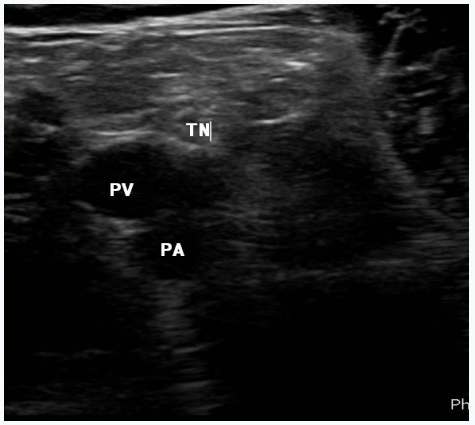
Possible Nerve Injury	Muscles involved	Motor impairment	Sensory impairment
Femoral nerve (variable impairment depending on relationship of injury to site motor branches)	Quadriceps Pectineus, sartorius	Knee extension Hip flexion	Anterior-medial thigh and medial calf, from involvement of the anterior femoral cutaneous and saphenous nerves[7, 8]

[6]Seto AH, bu-Fadel MS, Sparling JM, Zacharias SJ, Daly TS, Harrison AT et al. Real-time ultrasound guidance facilitates femoral arterial access and reduces vascular complications: FAUST (Femoral Arterial Access With Ultrasound Trial). JACC Cardiovasc Interv. 2010;3:751-58.
[7]Jabara B, Punch G, Ching B. Neurologic complication after use of a percutaneous vascular closure device. J Vasc Interv Radiol. 2012;23:1099-101.
[8]Barcin C, Kursaklioglu H, Kose S, Isik E. Transient femoral nerve palsy after diagnostic coronary angiography. Anadolu Kardiyol Derg. 2009;9:248-49.

Lower Limb

Popliteal Artery Access

- Operators should be aware of the important anatomy in this region
- Usually the sciatic nerve divides into the tibial nerve and common peroneal nerve in the popliteal fossa (the sciatic nerve may divide further proximally in some cases)
- The popliteal artery is generally positioned anterior to the popliteal vein and anteromedial to the tibial nerve (image)
- The tibial nerve courses through the mid portion of the popliteal fossa into the deep posterior compartment of the leg
- The common peroneal nerve courses more laterally in the popliteal fossa to wrap laterally around the fibular neck where it divides into the deep and superficial peroneal nerve branches

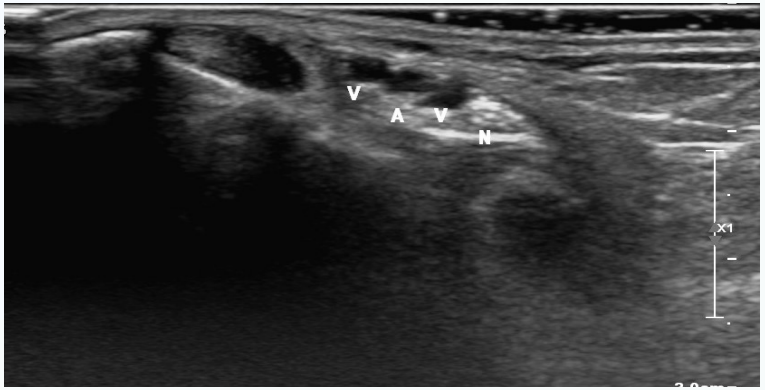


Ultrasound image demonstrating the tibial nerve (TN) posterior laterally, popliteal vein (PV), and popliteal artery (PA). The common peroneal nerve is further lateral and not included on this image.

Nerve injured	Muscles involved	Motor impairment	Sensory impairment
Tibial nerve (variable impairment depending on relationship of injury to site motor branches)	Foot: Flexor hallucis brevis, flexor digitorum brevis, quadratus plantae Abductor hallucis, adductor hallucis, abductor digiti minimi, interossei Lumbricals Leg: Gastrocnemius, soleus, tibialis posterior Flexor hallucis longus, flexor digitorum longus	Flexion of all digits Abduction/adduction of all digits IP joint extension with MCP joint flexion Plantar flexion Flexion of all digits	Involves the plantar aspect of the foot
Common peroneal nerve	Foot: Extensor digitorum brevis, extensor hallucis brevis Leg: Tibialis anterior Extensor digitorum longus, extensor digitorum brevis Peroneus longus, peroneus brevis	Extension of all digits Ankle dorsiflexion Extension of all digits Ankle eversion	Involves the dorsal foot and ankle and first webspace

Posterior Tibial Artery Access

- When performing posterior tibial artery access at the ankle, operators should be aware that the posterior tibial artery lies just medial to the tibial nerve in the region of the tarsal tunnel
- As the tibial nerve courses distally into the foot, it divides into the medial and lateral plantar nerves and supplies the muscles and skin of the plantar foot



Ultrasound of the tarsal tunnel region demonstrating the posterior tibial artery (A) with paired veins (V) and the tibial nerve (N) medially.

Possible nerve injury	Muscles involved	Motor impairment	Sensory impairment
Tibial nerve	Flexor hallucis brevis, flexor digitorum brevis, quadratus plantae Abductor hallucis, adductor hallucis, abductor digiti minimi, interossei Lumbricals	Flexion of all digits Abduction/adduction of all digits IP joint extension with MCP joint flexion	Impaired sensation of the plantar foot

Dorsalis Pedis/Anterior Tibial Artery Access

- Nerve injury from access at this location is exceedingly unlikely as at the ankle the deep peroneal nerve has already given off all except the most distal of its motor branches in the anterior compartment
- A tiny caliber deep peroneal nerve at this location contains motor fibers to the extensor digitorum brevis and extensor hallucis brevis on the dorsal foot, and has a sensory branch that innervates the first webspace
- Should access at this location cause nerve injury, the functional impairment would be miniscule owing to the redundant function of the extensor digitorum longus and extensor hallucis longus, which would remain intact

Possible nerve injury	Muscles involved	Motor impairment	Sensory impairment
Deep peroneal nerve	Extensor digitorum brevis Extensor hallucis brevis	Extension of all digits* *minimal functional impairment due to redundant function of the extensor digitorum longus and extensor hallucis longus	First webspace

References

1. Kanei Y, Kwan T, Nakra NC, Liou M, Huang Y, Vales LL et al. Transradial cardiac catheterization: a review of access site complications. Catheter Cardiovasc Interv. 2011;78:840-846.
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