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Review Article

Essential Surface and Neurovascular Anatomy of the Limbs for Clinical Nursing Practice

Yun-Yi Yang[1]

[1]*Department of Nursing, Dong-Eui University*

Abstract : This structured narrative review aimed to define clinically essential surface and neurovascular anatomy of the limbs for nursing practice. Clinically relevant anatomical studies, authoritative reviews, and practice guidance identified through targeted, non-systematic literature searches were synthesized. Structures were prioritized when nurses must directly locate them, use them for intramuscular injection, venous access, pulse palpation, or neurovascular assessment, or recognize preventable nerve, vessel, or compartment injury. The review identifies key bony landmarks, superficial veins, pulse points, peripheral nerves, muscles, and fascial compartments of the upper and lower limbs and links them to bedside assessment and procedures. It emphasizes that acute compartment syndrome should be suspected when pain is disproportionate to injury, pain increases with passive stretch, compartment tension increases, or paresthesia evolves; pulselessness and paralysis are late findings. Competency-based anatomy education should require nursing students to locate structures on the living body and apply anatomical relationships in procedure- and deterioration-based scenarios.

Keywords : Anatomy, Extremities, Nursing assessment, Injections, Intramuscular, Compartment syndromes

INTRODUCTION

Anatomy teaching for nurses should define a clinically usable core rather than reproduce the detail expected in a medical anatomy curriculum. Consensus syllabi support discipline-specific learning outcomes and prioritize surface landmarks, major vessels, peripheral nerves, and the anatomical basis of common procedures and injuries [1,2]. This review asks a practical question: which limb structures must a nurse be able to locate, palpate, protect, and reassess at the bedside?

SCOPE AND SELECTION

This article was developed as a structured narrative review rather than a systematic review. Literature was identified through targeted, non-systematic searches of academic literature sources, supplemented by relevant clinical guidance and the reference lists of selected publications. Search concepts were combined according to the clinical topic and included surface anatomy, neurovascular anatomy, limb, intramuscular injection, venipuncture, vascular access, peripheral pulse, peripheral nerve assessment, and acute compartment syndrome. Publications were considered when

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Correspondence to: Yun-Yi Yang (Department of Nursing, Dong-Eui University, 176 Eomgwang-ro, Busanjin-gu, Busan 47340, Republic of Korea)
E-mail: yangyunyi@deu.ac.kr

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they provided clinically relevant anatomical information applicable to nursing assessment, procedures, patient safety, or education. Priority was given to recent practice guidance, anatomical studies, and authoritative reviews; older sources were retained when they described established anatomical relationships or landmark evidence [3]. Structures were included when nurses must locate or palpate them, use them during injection, vascular access, or pulse assessment, assess related motor, sensory, or perfusion function, or recognize preventable nerve, vessel, or compartment injury. Detailed origins, insertions, and deep surgical anatomy were outside the scope. Because no prospectively defined systematic screening process was performed, study counts and a PRISMA flow diagram are not presented.

INJECTION AND VASCULAR ACCESS

For deltoid injection, the acromion identifies the superior boundary, but the target must remain within the central, thickest portion of the deltoid, with needle length selected according to age, body size, muscle mass, subcutaneous thickness, and injection technique [4,14]. The axillary nerve and posterior circumflex humeral vessels course deep to the deltoid around the surgical neck of the humerus, whereas the radial nerve and profunda brachii vessels lie farther distally and posteriorly along the humerus. Injection placed too proximally may enter the subacromial-subdeltoid bursa or shoulder joint; injection placed too distally or posteriorly increases neurovascular risk [4]. Clinically, a patient with limited muscle mass requires particular attention to needle length and underlying bone, whereas greater subcutaneous thickness may prevent intramuscular delivery if needle length is inadequate [14]. In the gluteal region, the anterior superior iliac spine, iliac crest, and greater trochanter define the ventrogluteal area over the gluteus medius and minimus. Compared with the dorsogluteal site, it is farther from the sciatic nerve and major vessels and has fewer local adverse effects [5].

Visible veins must be interpreted in relation to arteries, cutaneous nerves, joints, skin integrity, prescribed therapy, and expected dwell time, consistent with current infusion-therapy standards [13]. Superficial veins and cutaneous nerves show substantial individual variation and may cross or run closely together. In the cubital fossa, the median cubital vein is usually superficial to the bicipital aponeurosis, while the brachial artery and median nerve lie deeper; however, branches of the medial and lateral cutaneous nerves of the forearm may cross superficial veins [7,15]. The basilic-side antecubital region warrants particular caution because of its proximity to the brachial artery and medial cutaneous nerves. The dorsal venous network and cephalic forearm are common peripheral catheter sites, but site selection should not rely on visibility alone. For example, a visible vein over a flexion crease may be acceptable for a single blood draw but less suitable for an indwelling catheter because movement can impair stability. Burning, electric pain, or radiating paresthesia during puncture should prompt immediate cessation and reassessment at another site because nerve injury is possible [6,7,13].

PULSE AND PERIPHERAL NERVE ASSESSMENT

Pulse palpation should combine amplitude and symmetry with color, temperature, capillary refill, sensation, and movement, using the unaffected limb and the patient's baseline when available. The dorsalis pedis pulse may be congenitally small or absent, so comparison and Doppler confirmation are preferable to isolated interpretation [8]. Peripheral nerve testing should use a reproducible motor-sensory pair: radial nerve-wrist/finger extension and first dorsal web-space sensation; median nerve-thumb opposition and palmar index-finger sensation; ulnar nerve-finger abduction and little-finger sensation; common fibular nerve-ankle dorsiflexion/eversion and dorsal-foot sensation; and tibial nerve-plantar flexion and plantar sensation. Findings should be documented by naming the movement, sensory territory, pulse, and change over time rather than recording only "neurovascularly intact." A new asymmetry after casting, surgery, positioning, or increasing swelling—such as weaker ankle dorsiflexion with altered dorsal-foot sensation—requires prompt reassessment for compression and escalation according to local protocol [9].

ACUTE COMPARTMENT SYNDROME

Forearm and leg muscles are enclosed by relatively noncompliant fascia. Bleeding or edema raises intracompartmental pressure and progressively compromises muscle and nerve perfusion [10,11]. Patients with fractures, crush injury, reperfusion, bleeding, or constrictive casts or dressings require a documented baseline and repeated assessment at a

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frequency matched to clinical risk [9,16]. Serial comparison is more informative than a single "normal" finding. Pain disproportionate to the apparent injury, increasing analgesic requirement, pain on passive stretch of muscles within the threatened compartment, increasing firmness, and evolving paresthesia are warning findings. Pallor, paralysis, and pulselessness are late findings and should not be awaited before urgent escalation [10,11,16]. If a constrictive external device is suspected, pressure should be relieved only within the nurse's scope and local protocol while urgent medical review is obtained; persistent or equivocal findings may require intracompartmental pressure measurement by the treating team [16]. Structured education improves nurses' knowledge and agreement in neurovascular assessment [12].

UPPER- AND LOWER-LIMB HIGH-RISK ZONES

Three anatomical zones deserve repeated emphasis in skills teaching. At the medial elbow, the ulnar nerve is superficial in the groove behind the medial epicondyle and is vulnerable to sustained pressure. In the cubital fossa, superficial

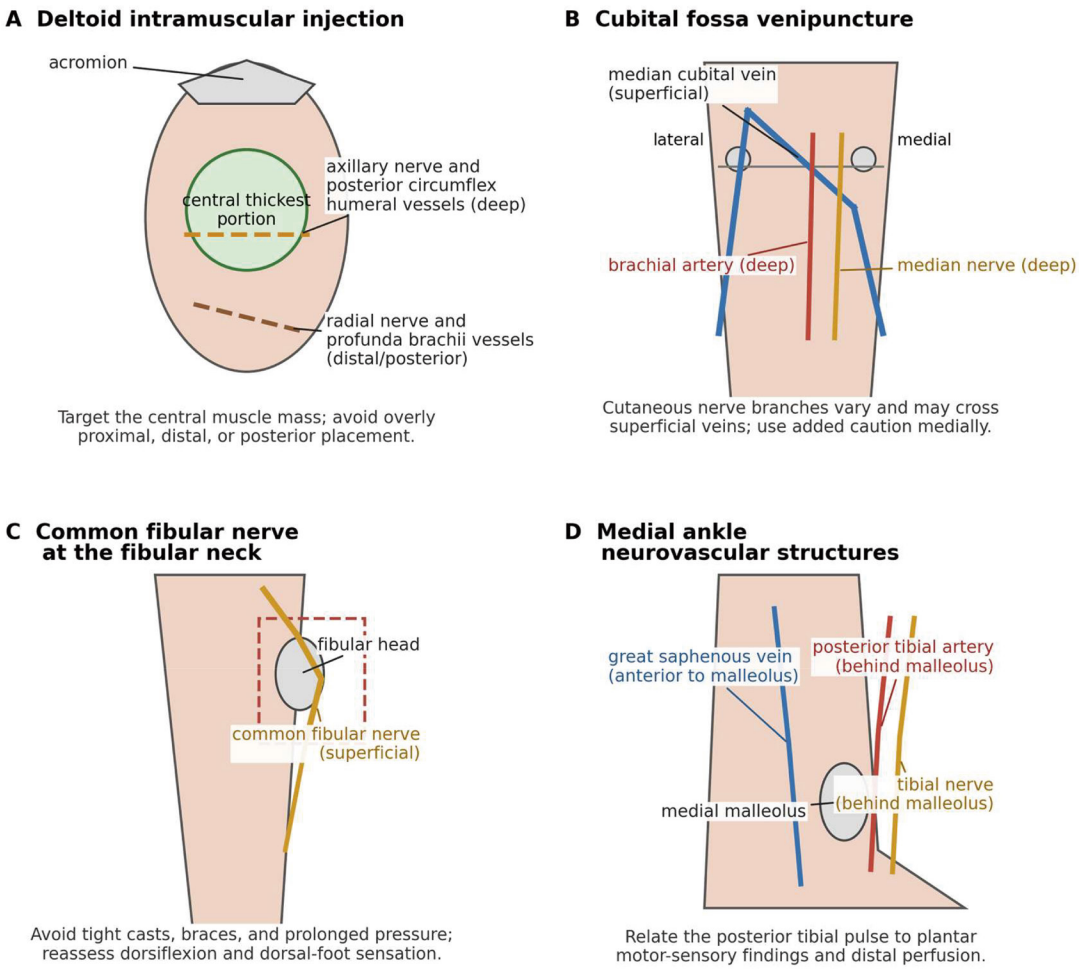


Fig. 1. Clinically important surface landmarks and adjacent neurovascular structures. (A) The acromion defines the superior landmark for deltoid injection; the central, thickest muscle mass is selected while avoiding overly proximal, distal, or posterior placement. The axillary nerve and posterior circumflex humeral vessels pass deep to the deltoid near the surgical neck, whereas the radial nerve and profunda brachii vessels lie farther distally and posteriorly. (B) In the cubital fossa, the median cubital vein is usually superficial to the bicipital aponeurosis, with the brachial artery and median nerve deeper; variable cutaneous nerve branches may cross superficial veins. (C) The common fibular nerve winds superficially around the fibular neck and is vulnerable to external compression. (D) The posterior tibial artery and tibial nerve pass behind the medial malleolus, while the great saphenous vein passes anterior to it. The diagrams are schematic and not to scale; neurovascular courses vary among individuals. The diagrams were prepared by the author with AI-assisted support. The author reviewed and verified all anatomical content and assumes full responsibility for the accuracy of the figure.

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veins lie above the deep fascia and bicipital aponeurosis; the brachial artery lies medial to the biceps tendon, and the median nerve is usually medial to the artery. Variable cutaneous nerve branches may cross the superficial veins and remain vulnerable during venipuncture [3,7,15]. At the fibular neck, the common fibular nerve winds superficially around the lateral proximal fibula before dividing, explaining vulnerability to tight casts, braces, leg crossing, and prolonged pressure. Behind the medial malleolus, the posterior tibial artery and tibial nerve pass through the tarsal tunnel with the flexor tendons; the artery provides a palpable perfusion point, whereas tibial nerve compromise

Table 1. Essential upper-limb structures for clinical nursing practice

Key anatomical structure	Surface location/relation	Clinical nursing use	Safety focus
Acromion; deltoid; axillary nerve	The acromion is the superior bony landmark. The axillary nerve and posterior circumflex humeral vessels pass deep to the deltoid around the surgical neck; the radial nerve and profunda brachii vessels lie more distally and posteriorly along the humerus.	Deltoid injection; shoulder motor-sensory check.	Use the central, thickest muscle mass and individualize needle length; avoid proximal, distal, or posterior misplacement. Assess abduction and lateral shoulder sensation if injury is suspected.
Medial and lateral epicondyles; olecranon	Epicondyles are palpable on each side of the distal humerus; the olecranon projects posteriorly; the ulnar nerve lies in the groove posterior to the medial epicondyle.	Elbow alignment; splint or cast and positioning checks.	Avoid sustained medial-elbow pressure; test finger abduction and little-finger sensation.
Radial head; anatomical snuffbox	Radial head is palpated distal to the lateral epicondyle during pronation-supination; anatomical snuffbox lies between the extensor pollicis longus and brevis tendons over the scaphoid region.	Elbow rotation and suspected scaphoid-region injury assessment.	Pain or restricted rotation requires comparison; snuffbox tenderness warrants escalation.
Radial and ulnar styloid processes; pisiform	Radial styloid is palpable on the thumb side of the wrist; ulnar styloid is on the little-finger side; pisiform is a palmar ulnar carpal landmark adjacent to the ulnar neurovascular region.	Wrist alignment; distal circulation and swelling assessment.	Interpret with finger color, capillary refill, movement, and sensation.
Dorsal venous network; cephalic, basilic, and median cubital veins	Dorsal hand veins continue into the lateral cephalic and medial basilic systems. In the cubital fossa, the median cubital vein is usually superficial to the bicipital aponeurosis; the brachial artery and median nerve are deeper, but cutaneous nerve branches may cross superficial veins.	Peripheral IV insertion and venipuncture.	Select by therapy, vessel, site, and dwell needs-not visibility alone. Use caution at flexion creases and medially; stop for electric or radiating pain.
Brachial, radial, and ulnar arteries	Brachial artery lies medial to the biceps tendon in the cubital fossa; radial artery is on the thumb side of the anterior wrist; ulnar artery is radial to the pisiform and deeper.	Blood pressure and peripheral pulse assessment.	Use gentle pressure and bilateral comparison; combine with skin and capillary findings.
Radial, median, and ulnar nerves	Radial nerve supplies wrist and finger extension with first dorsal web-space sensation; median nerve supports thumb opposition and palmar index sensation; ulnar nerve supports finger abduction and little-finger sensation.	Focused examination after trauma, surgery, cast, or swelling.	Document the exact movement and sensory area rather than only “intact.”
Forearm flexor and extensor compartments	Flexor-pronator and extensor-supinator muscle groups are enclosed by antebrachial fascia and may become tense after fracture, bleeding, edema, or constrictive dressings.	Serial swelling, pain, sensory, and motor assessment.	Passive-stretch pain and increasing tension require urgent escalation.

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affects plantar sensation and intrinsic-foot or plantar-flexion function. These relationships explain why surface localization and a named motor-sensory-perfusion baseline must precede puncture, immobilization, and interpretation of a changing examination [3,9]. These high-consequence surface relationships are summarized schematically in Fig. 1.

HOW TO USE THE TABLES

The tables serve as a rapid bedside and teaching reference: Tables 1 and 2 map each structure to its surface relation, nursing use, and principal hazard, whereas Table 3 provides a serial assessment framework. The body text therefore focuses on anatomical reasoning, clinical examples, and escalation rather than repeating every landmark listed in the tables.

PRACTICE AND EDUCATION IMPLICATIONS

Competency requires four linked actions: identify the structure on an image or model; locate and palpate it on a

Table 2. Essential lower-limb structures for clinical nursing practice

Key anatomical structure	Surface location/relation	Clinical nursing use	Safety focus
Iliac crest; anterior superior iliac spine; greater trochanter	Iliac crest and anterior superior iliac spine are palpable pelvic landmarks; greater trochanter is the lateral proximal femoral landmark; together they define the ventrogluteal region over gluteus medius and minimus.	Ventrogluteal intramuscular injection.	Confirm all landmarks and tissue depth; dorsogluteal region is closer to the sciatic nerve.
Patella; tibial tuberosity	Patella lies within the quadriceps tendon anterior to the knee; tibial tuberosity is a palpable anterior tibial landmark distal to the patella.	Alignment, swelling, and active knee-extension assessment.	Compare patellar position and ability to extend the knee.
Fibular head and neck; common fibular nerve	Fibular head is palpable laterally below the knee; the common fibular nerve winds superficially around the fibular neck.	Cast, brace, and positioning checks; motor-sensory testing.	Compression may cause foot drop and dorsal-foot sensory loss.
Medial and lateral malleoli; calcaneus	The posterior tibial artery and tibial nerve pass behind the medial malleolus within the tarsal tunnel; the great saphenous vein passes anterior to the medial malleolus.	Ankle alignment, edema, pressure injury, and distal perfusion assessment.	Relate the posterior tibial pulse to plantar sensation and motor findings; off-load sustained heel and malleolar pressure.
Femoral and popliteal arteries	Femoral artery is palpated below the inguinal ligament near the midinguinal point within the femoral triangle; popliteal artery lies deep in the popliteal fossa with the knee flexed.	Proximal lower-limb perfusion assessment.	Popliteal pulse is difficult to palpate; avoid excessive compression.
Posterior tibial and dorsalis pedis arteries	Posterior tibial artery lies posterior to the medial malleolus; dorsalis pedis artery runs on the dorsum of the foot, usually lateral to the extensor hallucis longus tendon.	Foot perfusion after trauma, surgery, or vascular disease.	Normal variation occurs; confirm uncertainty with comparison or Doppler.
Great and small saphenous veins	Great saphenous vein passes anterior to the medial malleolus and ascends medially; small saphenous vein passes posterior to the lateral malleolus and ascends posteriorly.	Inspection of superficial veins and distal access planning.	Consider edema, varicosities, skin integrity, and therapy characteristics.
Tibial nerve; four leg compartments	Tibial nerve travels in the posterior leg and tarsal tunnel; the leg contains anterior, lateral, superficial posterior, and deep posterior fascial compartments.	Plantar motor-sensory testing and compartment surveillance.	Escalate disproportionate pain, passive-stretch pain, tension, or evolving sensory change.

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Table 3. Structure-based serial neurovascular assessment

Domain	What to assess	Interpretation and action
Pain	Disproportionate or increasing pain; escalating analgesic requirement; pain with passive stretch.	Early warning pattern; compare with baseline and escalate urgently rather than waiting for all signs.
Perfusion	Color, temperature, capillary refill, distal pulse amplitude and symmetry.	A pulse may persist in compartment syndrome; interpret with the complete serial examination and use Doppler if uncertain.
Sensation	New numbness, tingling, burning, or reduced discrimination in named nerve territories.	Map the exact area and trend rather than record only "intact."
Motor function	Active movement linked to radial, median, ulnar, common fibular, tibial, and femoral nerves.	Weakness may reflect compression or ischemia; paralysis is late.
Compartment tension	Increasing firmness or tense swelling of the forearm or leg.	Do not await pulselessness; remove constrictive causes per protocol and notify urgently.

living person; explain its relation to adjacent nerves and vessels; and apply it to a procedure or deterioration scenario. Suitable stations include injection landmarking with selection of needle length, superficial-vein mapping with exclusion of a pulsatile structure, bilateral pulse comparison, named-nerve motor-sensory testing, and serial neurovascular charting. Assessment should require students to state when a finding is a normal anatomical variant, when comparison or Doppler confirmation is needed, and when a change requires immediate escalation. A short scenario can integrate these actions—for example, reassessing pain, passive-stretch response, sensation, movement, temperature, capillary refill, and pulses after cast application—and can be scored with an observable checklist. This approach reduces duplication between anatomy lectures and skills laboratories while preserving relationships required for patient safety [1,9,12].

KEY PRACTICE MESSAGES

- Landmarking and tissue-depth assessment must be combined; a memorized distance alone is insufficient for intramuscular injection.
- A visible vein is not automatically an appropriate access site; adjacent artery, nerve, joint, skin, therapy, and dwell time matter.
- Distal pulse presence does not exclude evolving compartment syndrome; pain pattern, passive-stretch pain, tension, sensation, and motor change require serial assessment.
- Neurovascular documentation should name the movement, sensory area, pulse, and trend rather than record only "intact" or "normal."

CONCLUSION

The limb anatomy most essential to nursing practice is a limited, high-consequence set of surface landmarks, superficial veins, pulse points, peripheral nerves, and fascial compartments. Safe practice depends on integrating location with surrounding relationships and serial motor, sensory, and perfusion findings. Teaching these structures through palpation, procedures, and clinical deterioration cases can convert anatomical terminology into observable nursing competence.

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