

Anatomical and ultrasonographic landmarks of the manus nerves in camel (*Camelus dromedarius*)

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ABSTRACT

This study aims to describe the anatomical and ultrasonographic features of manus nerves to establish a guideline approach for manus nerve block in camel practice. Twelve distal parts of the forelimbs cadavers of freshly slaughtered adult dromedary camels were used in this study. Six manus cadavers were used for anatomical morphology and the other six were used for ultrasonographic examination of the manus nerves. The gross anatomical study revealed the manus of the camel including, the third and fourth metacarpus and digits receives nerve supply from the ulnar, radial, and median nerves. These nerves continued along the camel manus as lateral and medial palmar metacarpal nerves and the axial and abaxial palmar proper digital nerves of the digits III and IV. Ultrasonographic evaluation of each nerve in the manus of the dromedary camel revealed proper localization and tracking of these nerves from the surrounding structures. In conclusion, the present study provides anatomical and ultrasonographic imaging knowledge tracking of the manus nerves in camels. This is important for determining the areas of the nerve block to attain successful regional anesthesia of this region in case of manus injuries in camel.

Keywords: Diagnostic imaging, Pathology, Radiology, Ultrasonography

The global population of the dromedary camel (*Camelus dromedarius*) is nearly 14 million, mainly allocated in the Horn of Africa, the Middle East, and South Asia (Al-Sobayil *et al.* 2021). The limbs and feet are vital organs for the use of the camel in race and transportation (Dyce *et al.* 2009, Monfared 2013). The nerve supply of the distal portion of the limb in camels is very important for the motor and sensory function of the skin ligaments, and joints of the limb as well as for proper achievement of nerve block of the manus (Allouch and Alshanbari 2023). A distal limb nerve block is a very essential tool to diagnose and treat several affections of the foot in camels (Lin *et al.* 2022).

Correct and effective perception of nerves is essential in interventional procedures for pain relief (such as nerve blocks) (Helen *et al.* 2015). Conventional nerve block has been considered the standard technique of nerve block in regional anesthesia practice (Lin *et al.* 2022). For veterinary anesthesiologists, this is a challenge, often

requiring multiple and repeated attempts to achieve nerve block, resulting in long operation time, surgery-related pain, inefficiency, and complications, including bleeding, nerve damage, and injection failure (Marhofer *et al.* 2005, Rioja *et al.* 2012, Al Mohamad *et al.* 2023). Recently, ultrasound (US)-guided nerve block has been widely used in veterinary practice for facilitating the nerve blocks and overcoming the complications of the conventional technique (Campoy *et al.* 2010, Echeverry *et al.* 2012a, Echeverry *et al.* 2012b, El-Shafae *et al.* 2017).

Understanding the clinical anatomy of the manus nerves is essential for conducting proper ultrasonographic examination to facilitate non-invasive manus nerve block in camels. However, little information was found in the literature survey on the anatomy and ultrasound imaging of the manus nerves in camels. Therefore, present study was designed to describe the anatomical and US landmarks of manus nerves to establish a scientific approach for manus nerve block in camel practice. ¹

MATERIALS AND METHODS

Animals: Twelve distal forelimbs cadavers of adult healthy dromedary camel were randomly used in this study for anatomical, and ultrasonographic evaluation of the manus nerves. These cadavers were collected from the Burydah slaughterhouse of Qassim, Saudi Arabia. The slaughtered camels were of both sexes with age range from 24-36 months (mean±SD: 25±4 months), weighing

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between 350-450 kg (375 ± 50 , mean $\pm$ SD). All camels were clinically sound without a previous history of lameness or joint affection. The distal forelimb cadavers were collected, wrapped in gauze, sealed in plastic bags, and stored at -20°C , until examination. For all investigations, limbs were thawed to room temperature, clipped, and cleaned. The study protocol was approved by the Committee of Animal Welfare and Ethics, Faculty of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia.

Anatomical study: In this section, six forelimb camel cadavers were used for the anatomical study of the manus nerves. Gross dissection was carried out for each nerve as part of the anatomical study. The skin and muscles related to each nerve were carefully dissected to expose the nerve. The anatomical landmarks of the manus nerves and related structures were determined and photographed by an expert anatomist with the aid of correlated anatomical references (Smuts 1987, Gahlot *et al.* 2011).

Ultrasonographic study: In the ultrasonographic study, six camel cadavers of distal forelimbs were used to evaluate the optimal site for manus nerves in camels. The sites for each nerve in the manus were shaved and thoroughly cleaned with warm water and soap. For all specimens, the nerves were examined using a real-time scanner (SSD-500, Aloka, Tokyo, Japan) equipped with a 7.5 MHz sector transducer. The ultrasound probe was directed in relation to the investigated nerve site along its longitudinal plane depending on the anatomical landmarks of superficial and deep flexor digital tendons and suspensory ligaments related to the targeted nerves as described by Lin *et al.* (2022). An ultrasound-guided injection of 3 ml methylene blue at the site of each examined nerve was used for identification and confirmation. The presence of methylene blue at the dissection of the area surrounding the target nerve confirmed positive ultrasonographic identification of the nerve.

RESULTS AND DISCUSSION

The distal limb nerves of the camel are very important because they have a motor and sensory function for the skin, tendons, ligaments, and joints of the limb (Smuts and Bezuidenhout 1987, Allouch 2018). There are no details about the anatomical landmarks of the manus region nerves in camel in the available literature. Whereas, El-Shaieb (1967) recorded the origin and distribution of the brachial plexus in the camel and did not mention terminal branches of the brachial plexus. In camel, the radial, ulnar, and median nerves contribute to the nerve supply of the forelimb (Smuts and Bezuidenhout 1987). Allouch (2018) reported the terminal branches of the nerves of the distal parts of the forelimb in camel.

Present gross anatomical study revealed that the manus of the camel consists of the third and fourth metacarpus. The manus of the camel receives their nerve supply from the ulnar, radial, and median nerves. The median nerve descends through the carpal canal with the tendons of the deep digital flexor. At the proximal third

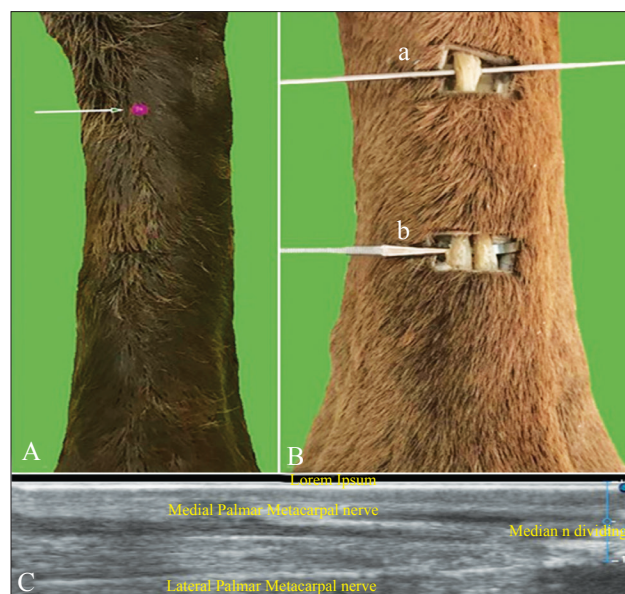


Fig. 1. A. Photograph of the median nerve site at the middle of the metacarpal region (pink pinhead) of a forelimb camel cadaver; B. Anatomical window overview of the median nerve (a) and its division lateral and medial palmar metacarpal nerves at the distal third of the metacarpal region (b); C. Linear ultrasound image showed the median nerve division into lateral and medial palmar metacarpal nerves at the distal third of the metacarpal region of a camel cadaver.

of the metacarpus, it crosses to the palmar aspect of the metacarpus and bifurcates into medial and lateral palmar metacarpal nerves (medialis metacarpalis palmaris and lateralis metacarpalis palmaris; high palmar nerve) (Fig. 1). The lateral palmar metacarpal branch continued distally at the metacarpal region along the lateral aspect of the metacarpus between the deep and the superficial digital flexor tendon. It runs between the suspensory ligament and the deep digital flexor tendon and then, passes on the lateral border of the suspensory ligament. It continued on the lateral palmar aspect of the fetlock joint and was named the common palmar proper digital nerve of the IV digit (low palmar nerve). As well as it continued along the palmar-lateral aspect of the fetlock joint to be an abaxial palmar proper digital nerve of the IV digit.

The median nerve ends as common palmar digital of III and IV digits, which continue as axial palmar proper digital of III, and IV digits (Smuts and Bezuidenhout 1987). The ulnar nerve gives off the axial palmar digital of III and IV digits in bovine (Budras 2004). In the present study, the division of the common palmar digital nerve (III and IV) was at the distal third of the metacarpal bone at different levels. Present findings were in accordance with Waad (2007) Al-Sadi *et al.* (2008) and Allouch (2018) in the camel and in cows, sheep, and goats. While disagrees with Elmore (1981) who mentioned that the palmar branch of the ulnar nerve extended distally as the dorsal proper digital nerve of the 4th digit, in ox, sheep, and goats. Moreover, present findings disagree with Badawy and Eshra (2015) who mentioned that the ulnar nerve gave the axial palmar

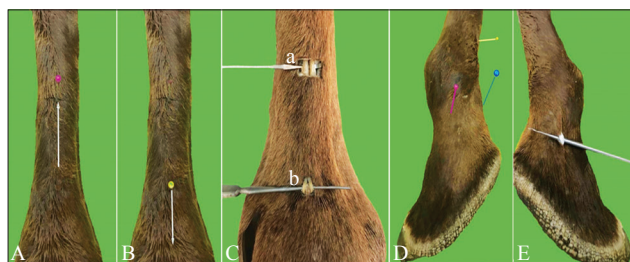


Fig. 2. A. Photograph of the lateral and medial palmar metacarpal nerve site at the middle third of the metacarpal region (pink pinhead); B. Photograph of the common palmar proper digital nerve of III and IV digits site at the distal third of the metacarpal region (yellow pinhead); C. Anatomical window overview of the lateral and medial palmar metacarpal nerve (a. High palmar nerve), and the common palmar proper digital nerve of III and IV digits (b. Low palmar nerve) of a camel cadaver; D. Photograph of the site of the common palmar proper digital nerve block of the digit's IV (yellow needle), the abaxial nerve block of the digit's IV (red needle), and the axial palmar proper digital nerve of the digit's IV (blue needle); E. Anatomical window overview of the abaxial-lateral palmar proper digital nerve of the IV digit of a camel cadaver.

digital III and IV one trunk as well as the axial palmar digital IV in camel.

The results revealed that the medial palmar metacarpal nerve runs on the medial border of the suspensory ligament. It continued in the medial palmar aspect of the fetlock joint as the common palmar proper digital nerve of digit III (low palmar nerve) then divides into two branches; abaxial palmar proper digital nerve of digit III and interdigital palmar proper digital nerve of digit III. The interdigital palmar proper digital nerve of digit III divides into two branches; the axial palmar proper digital nerve of the IV digit and the axial palmar proper digital nerve of the III digit. The radial nerve innervates the dorsal aspect of the manus region, the lateral branch of the superficial radial nerve continues as the common dorsal digital nerve, and the abaxial dorsal proper digital nerve of the digit IV. On the other hand, the medial branch of the superficial radial nerve continues as the common dorsal digital nerve of the III digit and the axial dorsal proper digital nerve of the digits III and IV. These findings were in agreement with Al-Sadi *et al.* (2008), and Allouch (2018).

Helen and O'Donnell (2015) stated that the knowledge of the position and distribution of nerves of distal parts of limbs is of great importance for nerve block practice. Nerve block anesthesia is very important for the diagnosis and treatment of distal limb affections, especially in the angioneurotomy, tendonitis osteoarthritis, and sesamoiditis (Lin *et al.* 2022). There is a current interest in the practice of veterinary anesthesia in finding suitability in exchange for nerve block procedures that provide the potential for greater success based on precision needle positioning in relation to the target nerve (Bagshaw *et al.* 2009, Echeverry *et al.* 2012a, Kramer *et al.* 2014, El-Shafaey *et al.* 2017). The needle insertion in the blind technique is based on observation and palpation of the surface according to

anatomical landmarks. This also results in an inability to locate the anatomical site properly for needle insertion and can result in incorrect positioning of the needle and insufficient nerve block (Rioja *et al.* 2012, Badawy and Eshra 2015). Thus, in current study, the conjunction of the anatomical and ultrasonographic landmarks of the manus nerves provided an accurate approach for the manus nerve block and guard against the complication of blind techniques.

US guidance could be easily integrated into a diagnostic or therapeutic procedure, especially in manus injuries. Most nerve block techniques in human medicine have moved to imaging-guided interventional procedure techniques (Sites and Brull 2006, Badawy and Eshra 2015). However, in camel practice, ultrasonography is not being routinely used despite improvements in ultrasound (US) imaging equipment (Martinoli *et al.* 2002). Modern US imaging supports and enhances refinements in scanning techniques by illuminating the morphology of an increasing number of distal nerves. The US-guided technique is a noninvasive safe radiation-free imaging method that is simple to perform with little risk and is cost-effective under field conditions (Bartels *et al.* 2012, Hamed *et al.* 2020, El-Shafaey *et al.* 2023).

In the current study, the point of probe deposition for each target nerve was based on the anatomical landmarks of the camel's manus (Fig. 1-3). Ultrasonographically, the anatomical features of each nerve were readily distinguished. The nerves appeared as hypoechoic structures surrounded by parallel, straight, sharply hyperechoic borders without any difference in nerve echogenicity related to each specimen. There were no apparent differences in nerve echogenicity relative to each cadaveric specimen as well. In addition, the ultrasonographic appearance of camel manus nerves was similar to that of horses (Alexander and Dobson 2003) and dogs (Guilherme and Benigni 2008). Moreover,

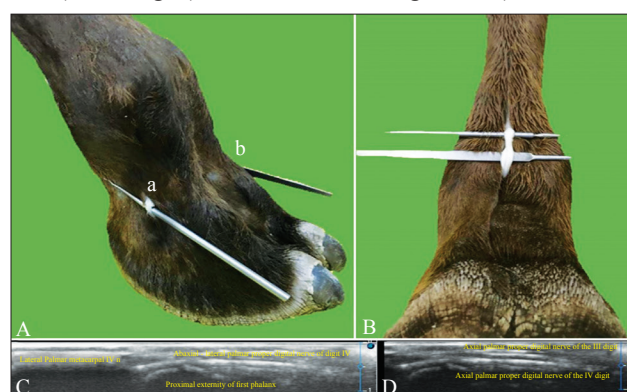


Fig. 3. A. Anatomical window overview of the abaxial-lateral palmar proper digital nerve of the digit IV (a), and the abaxial-lateral palmar proper digital nerve of the digit III (b); B. Anatomical window overview of the axial (interdigital) palmar proper digital nerve of the digit III of a camel cadaver; C. Linear ultrasound image of the abaxial-lateral palmar proper digital nerve of the digit IV; D. Linear ultrasound image of the axial (interdigital) palmar proper digital nerve of III and IV digits of a camel cadaver.

the linear transducer was found adequate for easy follow-up of the manus nerves. This could be attributed to the higher resolution of the linear transducer in relation to the linear nature of nerves.

Present results revealed that, the lateral and medial palmar metacarpal nerve could be approached with the transducer held in a longitudinal plane, at the distal third of metacarpal region in a groove formed between the suspensory ligament and the deep digital flexor tendon on both sides respectively (Fig. 3). The abaxial palmar proper digital nerve of the digit IV (palmar branch of the ulnar nerve) was examined at the palmar aspect with the beam directed lateromedially, at the level of fetlock joint on the lateral edge of the proximal sesamoid bone (Fig. 2 D-E, Fig. 3A and Fig. 3D). The abaxial branch (lateral common palmar proper digital nerve of the digit III) was examined ultrasonographically at the level of fetlock joint on the lateral edge of the proximal sesamoid bone (Fig. 3A). While the axial palmar proper digital nerves of digit III and IV were located by direction of the probe on the palmar aspect, above the fetlock joint between the two digits palmary III and IV (Fig. 3B and Fig. 3E).

In conclusion, the present study provides anatomical and ultrasonographic imaging knowledge tracking of the manus nerves in camels. This is important for determining the areas of the nerve block to attain successful regional anesthesia of this region in case of manus injuries in camel. However, further clinical studies are required to apply the proposed approach in the clinical practice of camel limbs regional anesthesia.

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REFERENCES

- Al Mohamad Z, Hamed M, Abdellatif A, Eldoumani H, El-Shafaey E and Abouelnasr K. 2023. Topographical anatomy of the mandibular foramen in the dromedary camels (*Camelus dromedarius*): an extraoral approach for the inferior alveolar nerve blocks. *Frontier in Veterinary Science* **10**: 1–6.
- Alexander K and Dobson H. 2003. Ultrasonography of peripheral nerves in the normal adult horse. *Veterinary Radiology and Ultrasound* **44**: 456–64.
- Allouch G M and Alshanbari F A. 2023. Anatomical study of the nerve supply of the dromedary camel (*Camelus dromedarius*) in the distal hindlimb with a special reference to the cutaneous innervation. *Veterinary Sciences* **10**: 305.
- Allouch G. 2018. Anatomical study of the nerve supply of camels (*Camelus dromedarius*) in distal forelimb with a special reference to the cutaneous innervation. *NJMBS* **7**.
- Al-Sadi S and Al-Omari A. 2008. Arterial, nerve supply, and venous drainage of tendons with sheath and suspensory ligament to the distal part of limbs in camels. *Al Baath University Journal* **30**: 53–76.
- Al-Sobayil F, Sadan M A, El-Shafaey E A and Allouch G. 2021. Intra-articular injection in the hind limb joints of dromedary camels (*Camelus dromedarius*) using anatomical and arthrographic-guided landmarks. *Veterinary World* **14**: 2055.
- Badawy A M and Eshra E A. 2015. Supra-orbital nerve block in dromedary camel (*Camelus dromedarius*). *Journal of Camel Practice and Research* **22**: 285–88.
- Bagshaw H S, Larenza M P and Seiler G S. 2009. A technique for ultrasound-guided paravertebral brachial plexus injections in dogs. *Veterinary Radiology and Ultrasound* **50**: 649–54.
- Bartels E, Bartels S and Poppert H. 2012. Ultrasonography of the peripheral nervous system. *Perspective in Medicine* **1**: 417–21.
- Budras K D. 2004. Bovine Anatomy, An Illustrated Text, First Edition. Schlütersche, Verlagsgesellschaft, Hannover, Germany. P 138.
- Campoy L, Bezuidenhout A J, Gleed R D, Martin-Flores M, Raw R M, Santare C L, Jay A R and Wang A L. 2010. Ultrasound-guided approach for axillary brachial plexus, femoral nerve, and sciatic nerve blocks in dogs. *Veterinary Anaesthesia and Analgesia* **37**: 144–53.
- Dyce K M, Sack W O and Wensing C G. 2009. Textbook of Veterinary Anatomy-E-Book. Elsevier Health Sciences, P 834.
- Echeverry D F, Laredo F G, Gil F, Belda E, Soler M and Agut A. 2012. Ultrasound-guided ‘two-in-one’ femoral and obturator nerve block in the dog: An anatomical study. *Veterinary Anaesthesia and Analgesia* **39**: 611–17.
- Echeverry D F, Laredo F G, Gil F, Belda E, Soler M and Agut A. 2012. Ventral ultrasound-guided suprainguinal approach to block the femoral nerve in the dog. *Veterinary Journal* **192**: 333–37.
- Elmore R. 1981. Food animals region anesthesia. Bovine blocks: Interdigital nerve block. *Veterinary Medicine Small Animal Clinic* **76**: 82–83.
- El-Shafaey E, Abdellatif A, Elfadl E, Al Mohamad Z and Hamed M. 2023. Ultrasound-guided versus blind intraarticular injection of the foot of Egyptian buffaloes (*Bubalus bubalis*): A pilot study. *Indian Journal of Animal Sciences* **93**: 686–90.
- El-Shafaey E, Hamed M, Abdellatif A and Elfadl E A. 2017. Comparison of blind, ultrasound and computed tomographic-guided injection techniques for nerve block of the head in one-humped camel (*Camelus dromedaries*) cadavers. *Pakistan Veterinary Journal* **37**: 180–84.
- El-Shaieb M. 1976. The Brachial Plexus of the Camel (*Camelus dromedarius*). *Assiut Veterinary Medical Journal* **3**: 11–20.
- Gahlot T K, Saber A S, Nagpal S K and Wang J. 2011. Selected research on gross anatomy and histology of camels. Camel Publishing House, Rajasthan, India, P 439.
- Guilherme S and Benigni L. 2008. Ultrasonographic anatomy of the brachial plexus and major nerves of the canine thoracic limb. *Veterinary Radiology and Ultrasound* **49**: 577–83.
- Hamed M, El-Shafaey E, Elfadl E and Abdellatif A. 2020. Intra-articular injection techniques of the buffalo (*Bubalus bubalis*) hindlimb digit using anatomical and contrast arthrography-guided landmarks. *Acta Veterinaria Hungarica* **68**: 310–17.
- Helen L, O'Donnell B D and Moore E. 2015. Nerve localization techniques for peripheral nerve block and possible future directions. *Acta Anaesthesiologica Scandinavica* **59**: 962–74.
- Kramer A H, Doherr M G, Stoffel M H, Steiner A and Spadavecchia C. 2014. Ultrasound-guided proximal paravertebral anaesthesia in cattle. *Veterinary Anaesthesia and Analgesia* **41**: 534–42.
- Lin H, Passler T and Clark-Price S. 2022. Farm animal anesthesia: Cattle, small ruminants, camelids, and pigs, John Wiley and Sons, P 136–54.
- Marhofer P, Greher M and Kapral S. 2005. Ultrasound guidance in regional anaesthesia. *British Journal of Anaesthesia* **94**: 7–17.

- Martinoli C, Schenone A, Bianchi S, Mandich P, Caponetto C, Abbruzzese M and Derchi L E. 2002. Sonography of the median nerve in Charcot-Marie-Tooth disease. *American Journal of Roentgenology* **178**: 1553–556.
- Monfared A L. 2013. Applied anatomy of the head regions of the onehumped camel and its clinical implications during regional anesthesia. *Global Veterinaria* **10**: 322–26.
- Rioja E, Sinclair M, Chalmers H, Foster R A and Monteith G. 2012. Comparison of three techniques for paravertebral brachial plexus blockade in dogs. *Veterinary Anaesthesia and Analgesia* **39**: 190–200.
- Sawad A A and Waad S K. 2012. Anatomical and histological study of the foot of Iraqi endogenous buffaloes (*Bubalus bubalis*). *Journal of Agricultural Science and Technology* **2**: 1011.
- Sites B D and Brull R. 2006. Ultrasound guidance in peripheral regional anesthesia: Philosophy, evidence-based medicine, and techniques. *Current Opinion in Anaesthesiology* **19**: 630–39.
- Smuts M S and Bezuidenhout A J. 1987. Anatomy of the dromedary. Oxford University Press, P 230.