P-ISSN: 2304-3075; E-ISSN: 2305-4360

International Journal of Veterinary Science

www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2023.117

Ultrasound-Guided Brachial Plexus Block with Mepivacaine in Zaraibi Goats

Marwa H. Hassan*[1],[2], Samah H. El-Bably[3], Samar M El-Gammal[3] and Ahmed I. Abdelgalil[1]

[1]Department of Surgery, Anesthesiology and Radiology, Faculty of Veterinary Medicine, Cairo University, Egypt
[2]Department of Surgery, Faculty of Veterinary Medicine, Jordan University of Science and Technology, Irbid, Jordan
[3]Department of Anatomy & Embryology, Faculty of Veterinary Medicine, Cairo University, Egypt
***Corresponding author:** marwa.hamdi@cu.edu.eg

Article History: 23-304 Received: 21-Sep-23 Revised: 30-Oct-23` Accepted: 05-Nov-23

ABSTRACT

Ultrasound-guided block of the brachial plexus is a safe and effective anesthetic technique that has been used for forelimb surgery in dogs, cats, calves, and donkeys. The current study aimed to provide detailed description of the neuroanatomical location and branching of the brachial plexus and to evaluate the ultrasound-guided blockade of the brachial plexus in Zaraibi goats. Nine clinically normal adult male Zaraibi goats weighing 25-45kg were included in the study. Three goats were used for anatomical study and six goats were used to investigate the feasibility of ultrasound-guided brachial plexus blockade. Blockage of the brachial plexus was made using 25ml mepivacaine (3%) that was introduced through a 20 gauge, 90mm spinal needle. The needle was inserted medial and dorsal to the transducer till the needle shaft imaged at the brachial plexus and then mepivacaine was injected. Efficient brachial plexus blockade in Zaraibi goats was achieved with peak of analgesia at 40min and peak of motor depression at 30min. The peak of analgesia was maintained for 40min (duration of analgesia). Ultrasound guided brachial plexus nerve block is a safe, feasible and efficient technique for blocking the sensory and motor nerves of the forelimb in goats without noticeable complications. Clinical studies are recommended to use this technique in the forelimb operations in goats.

Key words: Goat, Ultrasound, Regional anesthesia, Nerve block, Brachial plexus.

INTRODUCTION

The goat is a multipurpose animal that has been used for meat, milk, cheese, mohair, cashmere, coarse skin and leather production. Goats are cheaper to maintain, have few housing and management demands, adapting different agro-climatic conditions and can be raised in landless agricultural laborers. Additionally, it is an excellent animal for physiological, biomedical and translational research (Martini et al. 2001; Kelly et al. 2007; Turner 2007; Raske et al. 2010; Abdelgalil et al. 2023).

Loco-regional anesthesia is a common practice in farm animals especially with the limited use of general anesthesia in these animals. It has minimal cardiopulmonary effect, requires minimum veterinary help and supervision, does not require hemodynamic monitoring, and can be performed under field practice without the need of advanced equipment (Akasaka and Shimizu 2017; Hassan and Abdelgalil 2020; Futema et al. 2022). It is simple to perform, inexpensive, safe, and effective technique that provide a reversible loss of sensation to distinct area of the body. It also provides improved postoperative pain control, decreased systemic opioid use, and improved quality of recovery (Benigni et al. 2019; Hassan and Abdelgalil 2020).

Peripheral nerve block has been used to block sciatic and femoral nerves for pelvic limb surgery in dog and sheep (Campoy et al. 2010; Adami et al. 2011; Re et al. 2014), brachial plexus for thoracic limb surgery in human, dog, cat, and cattle (Campoy et al. 2010; Iwamoto et al. 2012; Re et al. 2014, Waag et al. 2014; Ansón et al. 2017; Portela et al. 2018).

Brachial plexus blockage technique usually comprises localization of anatomic landmarks and blind nerve locators to successful perform injection. Ultrasound-guided nerve block has been used over the last three decades to facilitate effective guidance to visualize the precise placement of the anesthetic solution into the area surrounding the nerve (Enneking et al. 2005; Campoy et al. 2010; Nowakowski and Bieryło 2015). Anatomical studies are mandatory to precisely locate the proper site of injection along the course of intended nerve especially with species and breed-related anatomical variation (Iwamoto et al. 2012; Akasaka and Shimizu 2017).

Cite This Article as: Hassan MH, El-Bably SH, El-Gammal SM and Abdelgalil AI, 2024. Ultrasound-guided brachial plexus block with mepivacaine in Zaraibi goats. International Journal of Veterinary Science 13(4): 447-452. https://doi.org/10.47278/journal.ijvs/2023.117

To the authors' knowledge, ultrasound-guided brachial plexus block has not been previously reported in Zaraibi goats. The aim of the present study was to conduct an anatomical study describing the normal neuroanatomy of the brachial plexus and to establish the ultrasound-guided technique for blockade of the brachial plexus in Zaraibi goats.

MATERIALS AND METHODS

Ethical Statement: The experimental protocol was approved by the Cairo University Institutional Animal Care and Use Committee (CU-IACUC) (approval CU/II/F/10/23).

Animals: The present study was carried out on 9 clinically normal adult male Zaraibi goats, aging 2-5 years, weighing 25-45kg.

Anatomical Study: Three goats were sacrificed and used to study the topographic anatomy and the major anatomical landmarks of the brachial plexus in Zaraibi goats. The thoracic limb of each goat was abducted and carefully detached from its attachment with neck and the trunk. The skin was removed from the medial aspect of the shoulder and arm regions to expose the axillary vessels and the brachial plexus. The nerves were dissected, identified and photographed. The anatomical terminology for muscles and nerves was taken from Nomina Anatomica Veterinaria (Nomina Anatomica Veterinaria 2017).

Ultrasound-guided Technique for Brachial Plexus Nerve Block: Ultrasound-guided brachial plexus blockade was conducted on six goats. All goats were manually restrained in lateral recumbency, with the thoracic limb uppermost, abducted, prepared for blockade. The skin over the cranio-lateral aspect of the first rib and around the shoulder point was shaved, scrubbed and disinfected. A 7.5-9 MHz micro-convex transducer (Edan Dus 60, USA) and 8-10 MHz linear transducer (Hitachi device Aloka F37) color Doppler mode were used. The transducer was placed at the dorso-medial aspect of the shoulder point lateral to the first ribs (Fig. 1). The brachial plexus was identified as an echogenic structure located medial to the axillary blood vessel as identified by pulsed or color modes. A 20-gauge, 90mm spinal needle was inserted medial and dorsal to the transducer till the needle shaft could be visualized at the site of brachial plexus and then 25ml of mepivacaine (3%) was injected (Fig. 1).

Clinical Evaluation of Brachial Plexus Nerve Block: Subjective assessment of the motor and sensory scoring was made for all goats before brachial plexus blockage, and every 10min for 100min.

Subjective assessment of the motor incoordination, depth and duration of analgesia, and sedation were recorded by the same anesthetist. Motor scoring was recorded based on the degree of abnormal gait while standing and walking using a three-point numerical rating scale (0, 1 and 2) (Atiba et al. 2019).

Pinprick test was applied using a 21-gauge needle inserted through the skin at scapular region, forearm region, fetlock, and pastern region and inter digital space. Signs of limb withdrawal, orientation towards the pinching site or vocalization were documented to assess the onset, depth and duration of analgesia after blockade (Iwamoto et al. 2012; Singh et al. 2015; Akasaka and Shimizu 2017). The sensory inhibition was scored based on the response to a pinprick using a three-point numerical rating scale (score 0, 1 and 2) (Iwamoto et al. 2012). Duration of analgesia was recorded inmin starting from the time of loss of sensation till return of sensation at forelimb region.

Statistical Analysis: Sensory and motor inhibition scoring was tabulated and presented as median and range. Friedman test was used to detect statistically significant differences of each score over time. Kendall's Coefficient of Concordance was used for pairwise comparison of scoring overtime compared to baseline score (0 Time). Data were considered statistically significant at $P<0.05$. Data were analyzed using Statistical Package for Social Science (SPSS 28.0) (SPSS Inc, IBM, Chicago).

RESULTS

Anatomical Study: Dissection of the brachial plexus in Zaraibi goats demonstrated an elongated, thick, broad, white band located cranial to the first rib and slightly proximal to the shoulder joint. The plexus was a network of nerves formed by the ventral branches of the last three cervical and the first thoracic spinal nerves (Fig. 2A). Eleven branches were contributed for the sensory and motor innervation of the skin and muscles of the forelimb respectively as well as the lateral thoracic wall (Fig. 2B, C and D). The origin, course and nature of innervation (motor or sensory) of the brachial plexus branches are documented in Table 1.

Ultrasound-guided Blockade of the Brachial Plexus: The brachial plexus was visualized as echogenic structure located medial to the pulsated or colored axillary artery. Ultrasound scanning guided a precise needle direction toward the brachial plexus and confirmed the injection of local anesthetic solution around the nerve. Both micro-convex and linear transducers were able to image and locate the brachial plexus. Color-Doppler mode allowed accurate identification of the vascular structures with decreased risk of the intravascular injection.

At 10min following injection of mepivacaine (3%) into the brachial plexus, only signs of shivering were seen without loss of either sensory or motor responses. At 20min, both sensory and motor responses were diminished with moderate weight bearing and decrease in motor response against pin prick (score 1). Sensory inhibition score was started to increase at 20 and 30min with peak of analgesia at 40min which was statistically significant compared with base line (before blockade) and ($P=0.004$). The peak of analgesia was maintained till 80min ($P<0.001$). The sensory inhibition score started to decline at 90min ($P=0.008$) and diminished at 100min ($P=0.459$). The onset of anesthesia was started at 40min and the duration lasted for 40min.

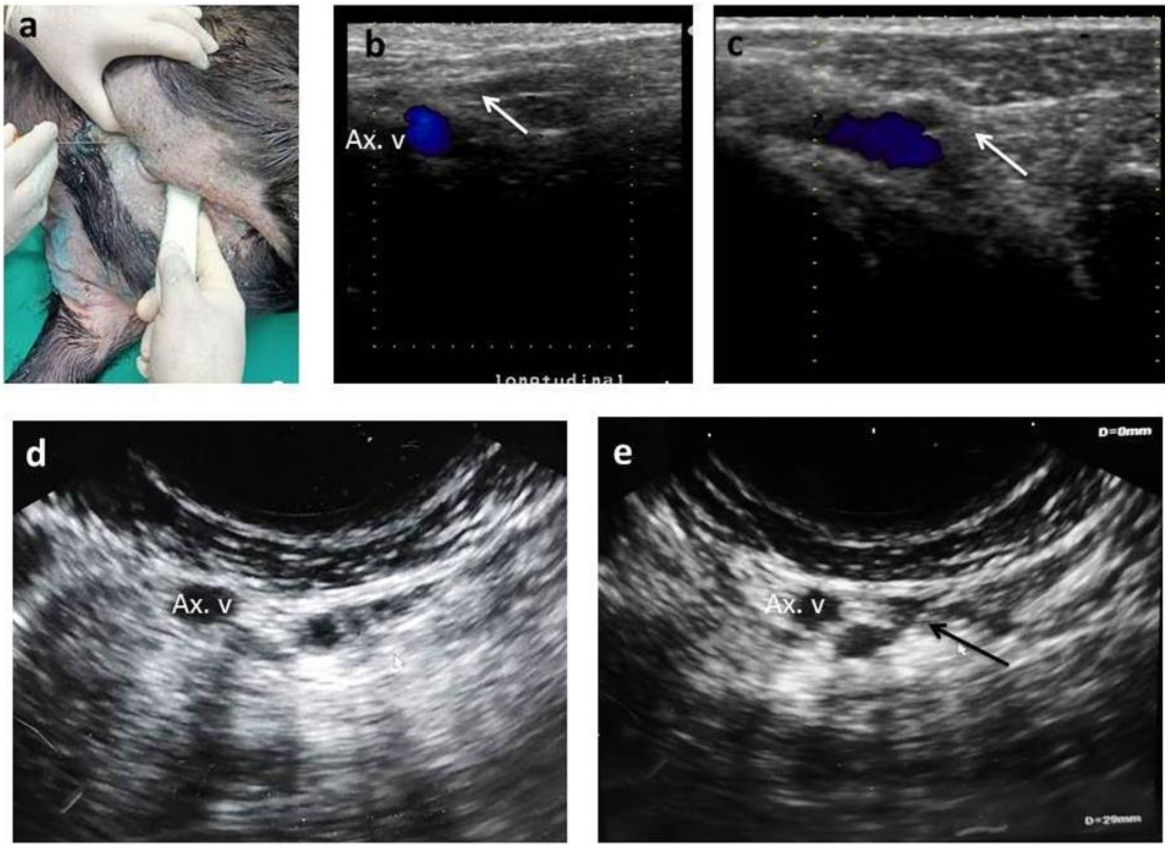

Fig. 1: Ultrasound guided brachial plexus blockade in Zaraibi goats. a- showed the position of the transducer and the needle direction. b and c- showed longitudinal and transverse scan using color Doppler technique, the brachial plexus appeared echogenic structure (white arrows) close to the axillary vessels (Ax. v). d & e showed transverse scan before and during injection of the anesthetic solution that appeared anechoic around the nerve (black arrow).

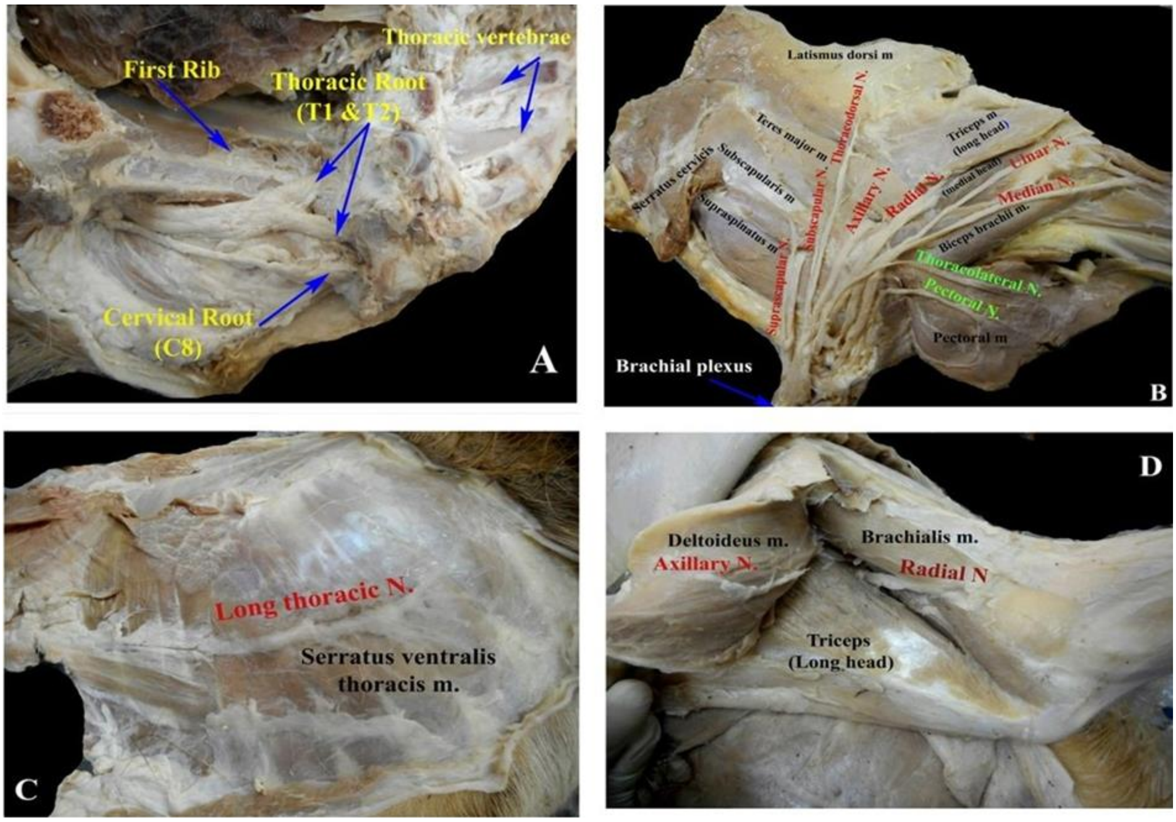

Fig. 2: A Photograph showing the origin and innervation of the brachial plexus of the goat. A- Origin of the brachial plexus, B- Branches of the brachial plexus (Medial view), C- Long thoracic N distribution (Lateral thoracic wall), and D- Axillary N and Radial N distribution (Shoulder and arm region, lateral view, reflected deltoideus m.).

Table 1: The origin, course and innervation supply of the brachial plexus

Nerves	Origin	Course	Motor Innervation	Sensory Innervation
Suprascapularis N	(C6, C7) from the cranial part of the plexus	Passed between the subscapularis & supraspinatus mm.	Supra spinatus and Infra spinatus mm.	
Subscapulares Nn (2 or 3 Nn)	(C6, C7)	Distributed on the subscapularis m.	Subscapularis m.	
Pectorals Nn (4 or 5 Nn)	(C6, C7, T1)	Distributed on the surface of the superficial and deep pectoral muscles	Superficial pectoral, subclavian and deep pectoral mm.	
Thoracicus longus N	(C7, T1)	coursed lateral between parts of the scalenus medius m.	Serratus ventralis cervicis and .thoracis m.	
Thoracodorsalis N	from (C7, T1) the caudal part of the plexus	The nerve divided into dorsal and ventral branches.	Latssimus dorsi and pectoral mm.	
Thoracicus lateralis N	(T1, T2)	Ran caudally to the lateral thoracic wall	Cutaneous trunci and latssimus dorsi m.	Skin of the lateral thoracic wall
Axillaris N	(C7, C8)	At its origin, it entered between the m. subscapularis and m. teres Major, and then appears laterally on the deep face of the m. deltoideus	Teres minor, teres major and deltoideus Muscles, subscabularis and brachiocephalicus mm.	Skin of the anteriolateral aspect of the Brachium and the anterior aspect of the antebrachium
Musculocutaneus N	(C7, C8)	It passed ventrocaudally, traversing the lateral surface of the axillary artery to join the median nerve	Coracobrachilais, biceps brachii and brachialis mm.	Skin of the dorsomedial aspect of the forearm and manus regions down to the fetlock
Radialis N	(C7, C8, T1)	Passed caudoventrally, parallel to the brachial artery on the medial aspect of the arm between teres major and triceps m, then coursed reaching the musclospiral groove of the humerus	Triceps brachii, tensor fasciae antebrachii, anconeus, extensors of carpal and digit.	Skin of the craniolateral aspect of the antebrachium and manus
Ulnaris N	(T1, T2)	Passed caudal to the brachial artery, accompanied the median nerve	Flexors of carpus and digit	Skin of the caudolateral aspect of the forearm and skin of the dorsolateral .metacarpus and digits
Medianus N	(C8, T1, T2)	The median and ulnar nerves were in a common sheath. Then the median nerve ran distally	Flexor carpi radialis and radial head of deep digital flexor mm.	Skin of the palmar aspect of .metacarpus and digit

Table 2: The score of sensitive and motor response every 10min from zero time before injection to the end of the study at 100min.

Time/sensory & Motor response	0 Time	10 min	20 min	30 min	40 min	50 min	60 min	70 min	80 min	90 min	100 min
Sensory score	0	0	1	1	2	2	2	2	2	1.5	0.5
Median (range)	(0-0)	(0-0)	(1-1)	(1-2)	(1-2)	(2-2)	(2-2)	(2-2)	(2-2)	(1-2)	(0-1)
P value		1.000	0.139	0.068	0.004*	<0.001*	<0.001*	<0.001*	<0.001*	0.008*	0.459
Motor score	0	0	1	2	2	2	2	2	2	1	0
Median (range)	(0-0)	(0-1)	(1-2)	(2-2)	(2-2)	(2-2)	(2-2)	(2-2)	(1-2)	(1-1)	(0-0)
P value		0.828	0.090	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.002*	0.195	1.000

Motor inhibition score started earlier compared to the sensory inhibition. The peak of motor blockade was achieved at 30min (P<0.001) and continued till 80min. Motor blockade score started to decline at 90min (P=0.195) and returned to base line at 100min (P=1.000). All goats showed complete smooth recovery without any neurological complications. Subjective sensory and motor inhibition scoring is demonstrated in Table 2.

DISCUSSION

The current study investigated the feasibility of ultrasound guided brachial plexus blocking in Zaraibi goats. The formation of the brachial plexus was derived from the anastomoses of the ventral branches of last three cervical and, first and second thoracic spinal nerves. Similar results have been previously reported in Bengal goats (Sultana et al. 2011), dog (Sisson et al. 1975), donkeys (Atiba et al. 2019), horses (Sisson et al. 1975; Levine et al. 2007), ox (Levine et al. 2007). On the other hand, the plexus was originated from the ventral rami of the last three cervical and the first thoracic spinal nerves (C6, C7, C8 and T1) in black Bengal goat (Karim et al. 2008), wild goat "Japanese Serow" (Magilton 1966), sheep and goat (Magilton 1966).

The suprascapular and the subscapular nerves in Zaraibi goat emerge from the ventral branches of C6 and C7 spinal nerves, similar to previous reports in dog and ox (Levine et al. 2007) and wild goat (Atoji et al. 1987). These nerves were derived from the ventral branches of the C8 and T1 in the Bengal goat (Sultana et al. 2011).

Concerning the pectoral nerve, its origin was formed by the roots of C7, C8 and T1 spinal nerves in Zaraibi goat. Whereas in Japanese Serow found that it arose from C8-T1 and received a thin fiber from the cranial division of C6-C7 (Atoji et al. 1987). Sultana et al. (2011), in black Bengal goat, clarified that the pectoral nerve emanated from the ventral branches of T1 and T2 and sometimes fibers from C8 spinal nerves and added that the nerve formed a loop by first thoracic root with the axillary artery, that loop was not reported in the present study.

The radial nerve in the current study provided motor innervation to the extensors of the elbow, carpus and digit and cutaneous branch to the skin of the craniolateral aspect of the antebrachium and manus. These findings were in accordance with that given by Sultana et al. (2011) in black Bengal goat and by Magilton (1966) in domestic animals. Atiba et al. (2019) in donkeys and Levine et al. (2007) in horses noticed that the sensory innervation of the radial nerve does not continue distal to the carpus. The course and distribution of the median nerve in Zaraibi goats were similar to findings in donkeys (Atiba et al. 2019), in horse and ox (Levine et al. 2007).

Detailed anatomical study facilitated ultrasound-guided injection through probe orientation (El-Bably and Abdelgalil 2018; Benigni et al. 2019; Hassan and Abdelgalil 2020) and the echolocation of the brachial plexus. The brachial plexus is considered the major forelimb nerve as it provides the sensory and motor supply of the whole limb. Therefore, the successful block of the brachial plexus leads to complete desensitization of the forelimb without the risk of either epidural or general anesthesia (Ansón et al. 2017; Atiba et al. 2019). General anesthesia is commonly associated with long recovery and respiratory distress. Epidural anesthesia may lead to recumbency of the animal and increased the anesthetic dose that may increase the risk of cranial migration of the anesthetic (Edmondson 2016).

In the present study, ultrasonography enabled perfect direction of the spinal needle and successful peri-neural distribution of the local anesthetic solution in all goats without any complications of intravascular or intra neural injections. Nielsen (2008) and Castillo-Zamora and Castillo-Peralta (2022) reported that ultrasound-guided injection allows optimum visualization of the nerve and the spread of local anesthetic around it which minimize the dose and drug volume, provide faster onset and longer duration of action.

Brachial plexus appeared as echogenic structure with multiple discontinuous lines adjacent to the anechoic vessels. Similar findings were reported during ultrasound blockade of the brachial plexus in donkeys (Atiba et al. 2019), calves (Iwamoto et al. 2012), dogs (Campoy et al. 2010) and cats (Ansón et al. 2017). Doppler ultrasound minimizes the risk of intravascular injection and confirms the spreading of anesthetic drug around the nerve and these results were in the same direction with the previous studies (Iwamoto et al. 2012; Atiba et al. 2019; Chiba et al. 2022).

The type, amount and concentration of the anesthetic drug for brachial plexus blockade remain questionable (Campoy et al. 2010; Ricco et al. 2013). The diffusion of the local anesthetic drugs from perineural to neural tissue depends mainly on the amount and concentration of the injected drug (Akasaka and Shimizu 2017). An optimum distribution of contrast medium around brachial plexus after blockade in sheep was obtained with 30ml volume. Incomplete spreading was obtained at 20ml volume (Estebe et al. 2000). So, the current investigation used 25ml of Mepivacain (3%).

Motor inhibition score was achieved rapidly and increased significantly compared to the sensory inhibition scoring. Meanwhile, the sensory inhibition score extended more than the motor one. These results were in the same line with Iwamoto et al. (2012) in calves. Atiba et al. (2019) reported the motor inhibition score was rapidly increased and has longer duration than the sensory one.

Our study revealed rapid and significant motor and sensory blockade that were achieved at 40min (onset) and extended for 40min (duration). Atiba et al. (2019) reported that the significant motor scores were faster than the significant sensory scores for brachial branches. Estebe et al. (2000) reported that 75mg of bupivacaine induced motor blockade of brachial plexus in sheep at onset 35±9min and duration was 169±60min. The variation between studies may be due to the fact that increased the dosage and amount of the anesthetic drug may result in rapid onset and prolonged the duration (Estebe et al. 2000; Atiba et al. 2019). The current study showed also rapid recovery period about 40min which is almost important to the anesthetist in the small ruminant.

Conclusion

The present study investigated ultrasound guided blockade of the brachial plexus in Zaraibi goats. The anatomical study facilitated probe orientation and the echolocation of the brachial plexus in goats. Ultrasound guided brachial plexus blockade in goats was feasible technique without sedation or complications. Further clinical studies are required to judge the applicability and efficacy of this technique in forelimb surgery in goats.

Author's Contribution: All authors contributed to this work. All authors wrote the manuscript, and all authors approved the final version and are accountable for this work.

Conflict of Interest: The authors declare that there is no conflict of interest.

Funding: The authors received no financial support for this study.

REFERENCES

Abdelgalil A, Hassan E and Torad F, 2023. Objective radiographic evaluation of cardiac size in clinically normal Zaraibi goats. Indian Journal of Animal Research 57(9): 1232-1235.

Adami C, Bergadano A, Bruckmaier RM, Stoffel MH, Doherr MG and Spadavecchia C, 2011. Sciatic-femoral nerve block with bupivacaine in goats undergoing elective stifle arthrotomy. The Veterinary Journal 188(1): 53-57. https://doi.org/10.1016/j.tvjl.2010.02.008

Akasaka M and Shimizu M, 2017. Comparison of ultrasound-and electro stimulation-guided nerve blocks of brachial plexus in dogs. Veterinary Anaesthesia and Analgesia 44(3): 625–635. https://doi.org/10.1016/j.vaa.2016.08.001

Ansón A, Laredo FG, Gil F, Soler M, Belda E and Agut A, 2017. Evaluation of an ultrasound-guided technique for axillary brachial plexus blockade in cats. Journal of Feline Medicine and Surgery 19(2):146–152. https://doi.org/10.1177/1098612X15618703

Atiba AS, Ghazy A, Farrag FA, El-Magd MA and Almadaly EA, 2019. Ultrasound-Guided Brachial Plexus Nerve Block in Donkeys. Slovenian Veterinary Research 56(22): 7-14. https://doi.org/10.26873/SVR-739-2019

Atoji Y, Suzuki Y and Sugimura M, 1987. The brachial plexus of the Japanese serow (Capricornis crispus). Anatomischer Anzeiger 163(1): 25-32.

Benigni L, Lafuente P and Viscasillas J, 2019.Clinical comparison of two techniques of brachial plexus block for forelimb surgery in dogs. The Veterinary Journal 244: 23-27.

Campoy L, Bezuidenhout AJ, Gleed RD, Martin-Flores M, Raw RM and Santare CL, 2010. Ultrasound-guided approach for axillary brachial plexus, femoral nerve, and sciatic nerve blocks in dogs. Veterinary Anaesthesia and Analgesia 37(2): 144–153. https://doi.org/10.1111/j.1467-2995.2009.00518.x

Castillo-Zamora C and Castillo-Peralta LA, 2022. Brachial plexus block with ultrasound: a descriptive study of routine clinical practice in 283 children. Revista Mexicana de Anestesiología 46(1): 21-25.

Chiba E, Hamamoto K, Kanai E, Oyama-Manabe N and Omoto K, 2022. A preliminary animal study on the prediction of nerve block success using ultrasonographic parameters. Scientific Reports 12(1): 3119.

Edmondson MA, 2016. Local, regional, and spinal anesthesia in ruminants. Veterinary Clinics: Food Animal Practice 32(3): 535-552. https://doi.org/10.1016/j.cvfa.2016.05.015

Enneking KF, Chan V, Greger J, Hadžić A, Lang SA and Horlocker TT, 2005. Lower-extremity peripheral nerve blockade: essentials of our current understanding. Regional Anesthesia & Pain Medicine 30(1): 4-35. http://dx.doi.org/10.1016/j.rapm.2004.10.002

El-Bably SH and Abdelgalil AI, 2018. Ultrasonographic anatomy of the equine carpal region (Equus caballus). International Journal of Veterinary Science 7(1): 44-49.

Estebe JP, Le Corre P, Chevanne F, Cathelineau G, Le Verge R and Ecoffey C, 2000. Motor blockade by brachial plexus block in the sheep. Anesthesiology 93(1): 291-293. https://doi.org/10.1097/00000542-200007000-00048

Futema F, Fantoni DT, Auler J, Cortopassi SR, Acaui A and Stopiglia AJ, 2022. A new brachial plexus block technique in dogs. Veterinary Anesthesia and Analgesia 29(3): 133-139.

Iwamoto J, Yamagishi N, Sasaki K, Kim D, Devkota B and Furuhama K, 2012. A novel technique of ultrasound-guided brachial plexus block in calves. Research in Veterinary Science 93(3): 1467–1471. https://doi.org/10.1016/j.rvsc.2012.05.010

Karim MR, Haque Z, Khan M, Akther SH and Gofur R, 2008. The brachial plexus of the black bengal goat (Capra hircus). Journal of Bangladesh Society of Agricultural Science and Technology 6: 113-116.

Kelly BT, Robertson W, Potter HG, Deng XH, Turner AS, Lyman S, Warren RF and Rodeo SA, 2007. Hydrogel meniscal replacement in the sheep knee: preliminary evaluation of chondroprotective effects. American Journal of Sports and Medicine 35(1):43-52. https://doi.org/10.1177/0363546506292848

Levine JM, Levine GJ, Hoffman AG, Mez J and Bratton GR, 2007. Comparative anatomy of the horse, ox, and dog: the vertebral column and peripheral nerves. Equine veterinary Education 2: 279-292.

Magilton JH, 1966. A comparative morphological study of the brachial plexus of domestic animals (Bovidae, Ovidae, Capridae, Suidae, Equidae). 1st edition. Iowa State University.

Martini L, Fini M, Giavaresi G and Giardino R, 2001. Sheep model in orthopedic research: a literature review. Companion Medicine 51: 292–299.

Hassan MH and Abdelgalil AI, 2020. Ultrasonographic Characteristics of the Stifle Joint in Clinically Normal Donkeys (Equus asinus). International Journal of Veterinary Science 9(2): 254-258. http://doi.org/10.37422/IJVS/20.016

Nielsen KZ, 2008. Ultrasound guided peripheral nerve blocks: what are the benefits? Acta Anaesthesiolology Scandinavica 52(6): 727–737. https://doi.org/10.1111/j.1399-6576.2008.01666.x

Nowakowski P and Bieryło A, 2015. Ultrasound guided axillary brachial plexus block. Part 1 Basic sonoanatomy. Anaesthesiology Intensive Therapy 47(4): 409–416. http://doi.org/10.5603/AIT.2015.0052

Portela DA, Verdier N and Otero PE, 2018. Regional anesthetic techniques for the thoracic limb and thorax in small animals. A review of the literature and technique description. Veterinary Journal 241: 8–19. https://doi.org/10.1016/j.tvjl.2018.09.006

Raske T, Pelkey S, Wagner A and Turner A, 2010. Effect of intravenous ketamine and lidocaine on isoflurane requirement in sheep undergoing orthopedic surgery. Laboratory Animals 39: 76–79. http://doi.org/10.1038/laban0310-76

Re M, Blanco-Murcia J, Fernandez AV, Simon I and Gomez de Segura IA, 2014. Ultrasound-guided anaesthetic blockade of the pelvic limb in calves. Veterinary Journal 200 (3): 434–439. https://doi.org/10.1016/j.tvjl.2014.04.010

Ricco C, Shih A, Killos M, Henao-Guerrero N and Graham L, 2013. Use of different volumes of injectate and electrostimulator-guided blind techniques for brachial plexus block in dogs. Veterinary Records 173: 608. https://doi.org/10.1136/vr.101876

Sisson S, Grossman JD and Getty R, 1975. The Anatomy of the Domestic Animals. 5th Edn. W. B. Saunders Co. Phildelphia. London. Toronto.

Sultana N, Islam MR and Masum MA, 2011. Study on the Innervations of Brachial Plexus in Black Bengal Goat of Bangladesh. International Journal of Bio –Research 1(1): 1–3.

Singh S, Goyal R, Upadhyay KK, Sethi N, Sharma RM and Sharma A, 2015. An evaluation of brachial plexus blocks using a nerve stimulator versus ultrasound guidance: A randomized controlled trial. Journal of Anaesthesiology, Clinical Pharmacology 31(3): 370. http://doi.org/10.4103/0970-9185.161675

Turner A, 2007. Experiences with sheep as an animal model for shoulder surgery: strengths and shortcomings. J Shoulder Elbow Surgery 16: 158–163. https://doi.org/10.1016/j.jse.2007.03.002

Nomina Anatomica Veterinaria, 2017. Prepared by the international committees on veterinary gross anatomical nomenclature and authorized by the general assambly of the world association of veterinary anatomists (6th Ed). Hanover, Germany, Ghent, Belgium, Columbia, MO, Rio de Janeiro, Brazil: The Editorial Committee.

Waag S, Stoffel MH, Spadavecchia C, Eichenberger U and Rohrbach H, 2014. Ultrasound-guided block of sciatic and femoral nerves: an anatomical study. Laboratory animals 48(2): 97–104. https://doi.org/10.1177/0023677213516314