Research Article

Selection of A New Site for Epidural Analgesia in Egyptian Goat (*Capra Hircus*) Based on Anatomy, Ultrasonography and Computed Tomography

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Abstract | This study was objected to select a new site for epidural injection in goats based on the anatomy of the lumbosacropelvic region and confirmed by computed tomography (CT) as well as successful application of the needle within the epidural space guided by ultrasonography (US). This study was conducted on seven lumbosacropelvic regions of goat cadavers and five live goats of both sexes ranged between 25-30 kg body weight. Longitudinal and cross anatomical sections were done on these samples; the sections were photographed and compared with coronal and sagittal sections of CT images. While transverse and parasagittal US were performed in goats over the selected new site (last inter-lumber space (L5-L6). The latter was compared with the L6-S space by gross anatomy, CT and image analysis. The results showed wider lumen of the vertebral canal at L5- L6 and the space between the inner part of the vertebrae and the spinal cord is wider than those at the level of L6- S. Moreover, the space between the spinous processes in this area was 1.58 ±0.089 cm and easily to be detected. The needle was inserted properly and more easily in the epidural space of the selected new site by using US. In conclusion, The L5-L6 space was considered as a new selected site for epidural analgesia in goats because it was easier and safer to perform without causing either discomfort to the animals or injury to the spinal cord.

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Introduction

Reversible motor and sensory paralysis of the spinal nerves in goat could be done by epidural analgesia, which is common in veterinary practices for diagnoses and surgical interference in the perineal region. This technique is simple, safe, economical and also do not require a sophisticated equipment (Skarda and Tranquilli, 2007; Khajuria et al., 2014). Epidural analgesia is commonly performed in ruminants more than general anesthesia due to the possibility of inhalation of ruminal contents if the airway is lifted unprotected (Hall and Clark, 1991).

Applying of epidural analgesia requires a good understanding of the anatomy of the spinal cord, its canal, and the intervertebral space. The epidural analgesia in small ruminants is applied at (L6- S1) which need the

animal to be laterally recumbent, discomfort and in stress (Lemke and Dawson, 2000; Doherty and Valverde, 2006; Plummer and Schleining, 2013). However, the epidural injection can be done sometimes in the thoracic region at T11- T12 of goat (Santos Silva et al., 2017). The most important challenges during epidural analgesia is the difficulty in detecting the injection site because it is done blindly.

The objective of this study is to select a new easy site for epidural injection (L5-L6) characterized by easily detection using anatomical landmarks and describing the US appearance of this area in goat for actual performing the needle entrance, then it confirmed by CT scanning images.

Materials and Methods

Five lumbosacropelvic specimens were collected from Beni-Suef province abattoir, then imaged freshly for describing the lumbar region. The specimens were frozen and sectioned transversely for evaluation of cross-sectional anatomy. CT scans and 3D images were applied serially on two freshly collected specimens using *(CT SCAN- W450-10A, HITACHI, Japan)*. The images were obtained rostrally from the level of 3rd lumbar vertebra passing caudally to the end of the tail. The slice thickness was 1-1.5cm CT scans interval (130 KV and 100 MA), two of these samples were embalmed with formalin 10%. Sagittal and cross sections were obtained to study the anatomy of the L5-L6 and L6 –Sac sites according to Seddek et al. (2014). By using a table of band saw, the lumbosacropelvic specimens were serially cut nearly 1-1.5 cm apart, starting from the level of 3rd lumbar vertebra till the end of the tail. The caudal surfaces of the slices were photographed directly *(*using Nikon Digital Cam, D5100, Thailand*)* after numbering and cleaning using tap water and brush. The most important anatomic structures were labeled according to (Nomina Anatomica Veterinaria, 2012).

In addition, five mature, apparently healthy goats (25-30 kg body weight) were used according to the National Institutes of Health guide for the care and use of Laboratory animals (NIH Publications No. 8023, revised 1978). Goats were calmed by using 1ml / 10 kg body weight. Valpam *(Diazepam, 10mg/2ml, Amoun Pharmaceutical Co. S.A.E),* ultrasound images were obtained when the goats were in standing position. The hair was clipped and alcohol was poured into the selected area to improve skin coupling with the ultrasonographic transducers. US machine (Mindary 5500 Prosound and Aloka Prosound SSDAlpha10, Aloka Co. Ltd., Tokyo, Japan) with multi-frequency micro-convex probe of 10 MHz was used. Both cross and parasagittal scan were done at the selected site. Image analysis was done to measure the lumen of the vertebral canal at L5-L6 and L6-S1 levels using image j software (http://rsb.info.nih.gov/ij/).

Table 1: *Means and standard deviation of l5-l6, l6 – sac and co1 – co2.*

Item	Mean ± SD
L5-L6	1.58 ± 0.089
L6-S	1.57 ± 0.11

Results and Discussion

Correct identification of the epidural space, in goat, determined the success or failure of site selection. Moreover, multiple attempts and difficult access to the epidural space was a frequent problem in surgery and may be dangerous for the animal. Theoretically, we could inject the epidural analgesic agents through any intervertebral space. Performing epidural analgesia using the ordinary site (L6-S) could not be obviously detected in goat from the anatomical point of view, this may attributed to the long parallel ilia of the os coxae which were completely embraced the lumbosacral articulation hindering its detection.

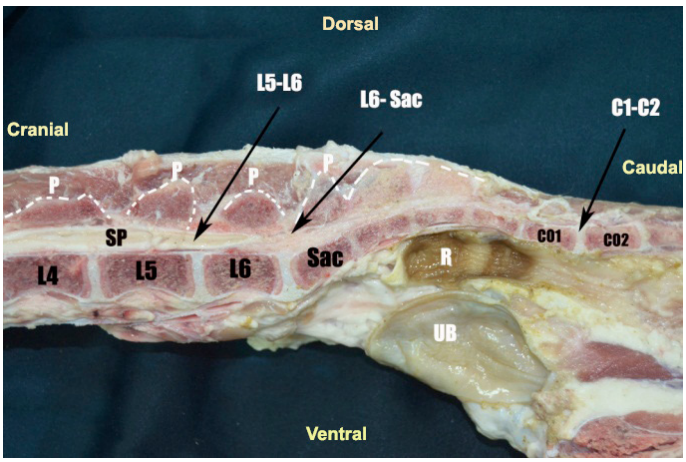

Figure 1: *Photograph of sagittal section of the lumbosacropelvic part of goat cadaver showing, L4,4th lumbar vertebra; L5, 5th lumbar vertebra; L6, 6th lumbar vertebra; L5-L6, last interlumbar space; Sac, Sacrum; L6-S, lumbosacral space P, spinous processes; Co1, 1st coccygeal vertebra; 2nd cooygeal vertebral; Co1-Co2, 1st intercoccygeal space; SP, spinal cord; R, Rectum, UB, urinary bladder.*

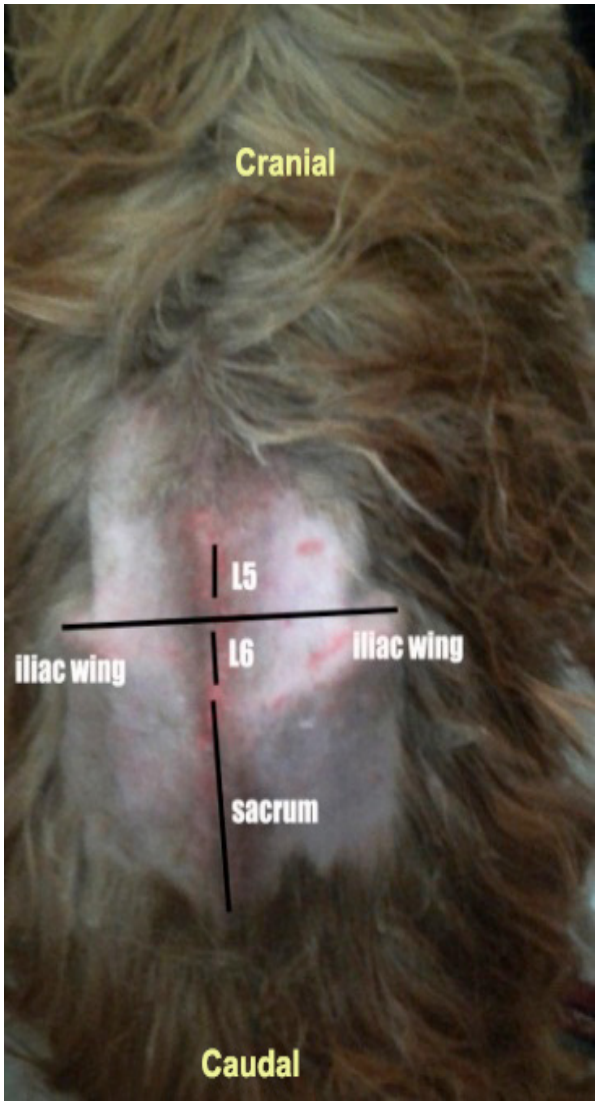

Figure 2: *Photograph of the lumbosacropelvic part of goat showing the last inter lumbar space; L5, 5th lumbar vertebra; L6, 6th lumbar vertebra; L5-L6, last interlumbar space; Sac, Sacrum.*

For proper understanding the anatomy of this area of the native Egyptian goat, the lumbosacropelvic region was dissected using growth anatomy. The 3D Ct scan visualized boney structure of this area. Six lumbar, fused four sacral and eleven caudal vertebrae constituted the dorsal boundaries of this region. The lumen of the vertebral canal was reduced at the level of the 5th lumbar vertebra, then gradually decreased at the level of lumbosacral articulation to be much narrower at the level of the inter-coccygeal space. The spinal cord usually became tapered into conus medullaris which ended as terminal filaments at the level of the 1st sacral segment (Figure 1). The epidural space was located between the periosteum of the vertebral canal and tough spinal dura matter, this space contained fat, veins and lymphatics. In CT scan, the low-density, spinal cord was surrounded by high-density boney boundaries of the vertebral canal (Figure 2). This gradual decrease could be asserted by using image analysis of the obtained CT scan images in both perimeter and area to be recorded as follows; 104.07μm and 769 μm in L5-L6 and 102.029 μm and 622 μm in L6-S1 respectively (Figure 3). Good and clear resolution using bone window images could be performed by CT scans for the fine bone and soft tissue architecture. The vertebral bodies and its processes considered as landmarks due to their constant position and cleared detection, the most similar cross section anatomical images were selected to be compared with their corresponding CT scans. (Figure 4).

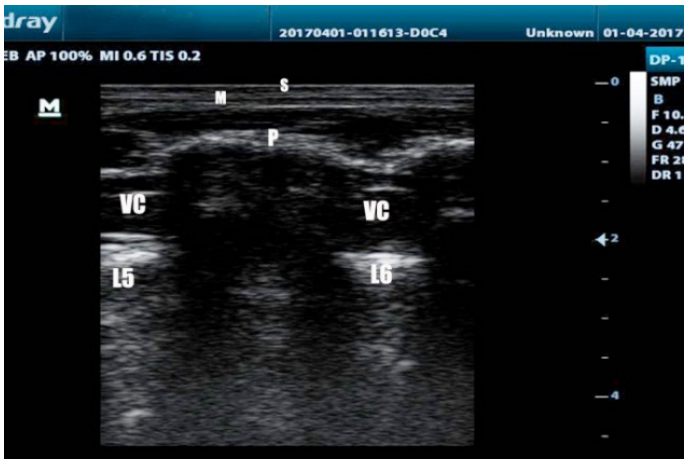

Figure 3: *Parasagittal ultrasonogram of epidural space of goat at L5- L6 showing hypoechoic muscles and the echoic lumbar fascia (M), vertebral canal as a hypoechoic round area (VC) and hyper-echoic vertebral body of L5 and L6. Hyper-echoic line of ligamentum flavum. (P). Nervous structures appeared as multiple, small hyperechoic rods. Skin (S).*

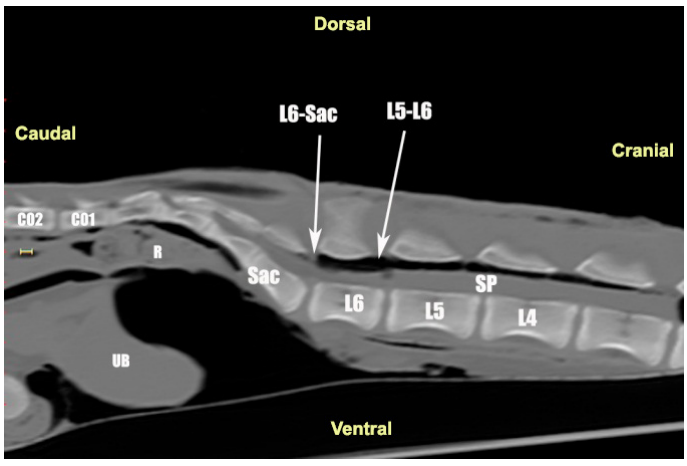

Figure 4: *Sagittal CT scan section of the lumbosacropelvic part of goat cadaver showing; L4, 4th lumbar vertebra, L5, 5th lumbar vertebra, L6, 6th lumbar vertebra, L5-L6, last interlumbar space; Sac, Sacrum; L6-S, lumbosacral space P, spinous processes; Co1, 1st coccygeal vertebra; SP, spinal cord; R, Rectum, UB, urinary bladder.*

The current investigation showed that, the L5-L6 space is the easiest site for epidural injection where, the intervertebral space was measured about 1.58

± 0.089 cm between the 5th and 6th spinous processes (Table 1). Basing on the anatomical landmarks, this site could be identified easily by palpation, using both your thumb and middle fingers on both cranial part of the iliac crest while the index finger was used to palpate the space between the 5th and 6th lumbar vertebrae in the midway between the two preceding fingers (Figure 5 and Figure 6). Performing the epidural injection in this area could be accomplished in a standing position without the occurrence of any restriction or discomfort to the animal. The needle passed through; skin, facia, supraspinous ligament, interspinous ligament, epiaxial muscles, ligamentum flavum, then epidural space easily guided by ultrasound (Figure 7 and Figure 8).

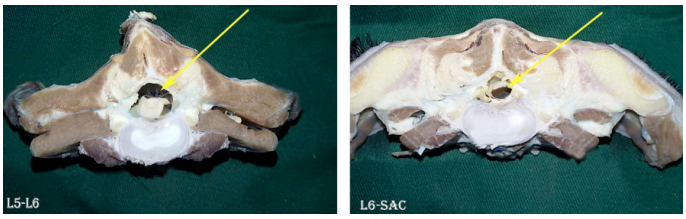

Figure 5: *Photograph of cross sectional anatomy at the levels of; A) last inter lumbar space; B) lumbo-sacral space of goat cadavers showing, (arrow) the lumen of the spinal canal.*

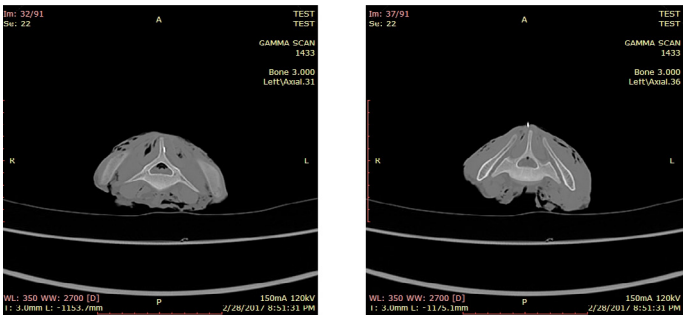

Figure 6: *Coronal CT scan sections at the levels of; A) last inter lumbar space; B) lumbosacral of goat cadaver showing, the lumen of the spinal canal.*

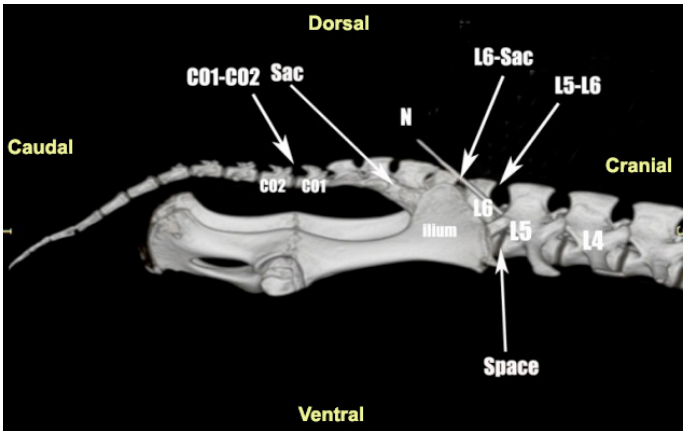

Figure 7: *Volume 3D dimension CT scan of a lateral view of the lumbosacropelvic part of goat cadaver showing; L4,4th lumbar vertebra; L5, 5th lumbar vertebra; L6, 6th lumbar vertebra; L5-L6, last interlumbar space; Sac, Sacrum; L6-S, lumbosacral space P, spinous processes; N, needle; Co1, 1st coccygeal vertebra; 2nd cocygeal vertebral; Co1-Co2, 1st intercoccygeal space.*

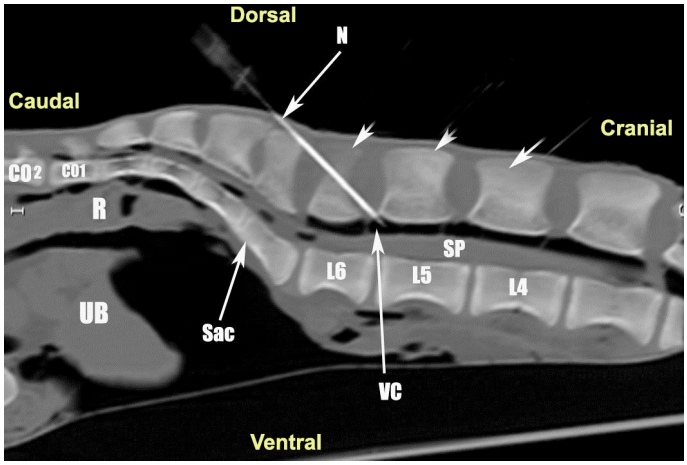

Figure 8: *Sagittal CT scan section of the lumbosacropelvic part of goat cadaver with the needle inserted in the L5-L6 showing; L4,4th lumbar vertebra; L5, 5th lumbar vertebra; L6, 6th lumbar vertebra; L5-L6, last interlumbar space; Sac, Sacrum; L6-S, lumbosacral space P, spinous processes; Co1, 1st coccygeal vertebra; N, needle; VC, vertebral canal; SP, spinal cord; R, Rectum, UB, urinary bladder.*

On parasagittal US images, all bony structures appeared hyper-echoic associated with distal acoustic shadowing. While in cross US images, the spinous processes appeared as a hyper-echoic spot. The external soft tissues surrounding the L5-L6 vertebral canal were hypo-echoic muscles and echoic lumbar fascia**.** The vertebral canal was seen either round or trapezoid an-echoic space in cross and parasagittal sections respectively, showing echoic inter-arcuate ligament dorsally and hyper-echoic vertebral body ventrally (Figure 9).

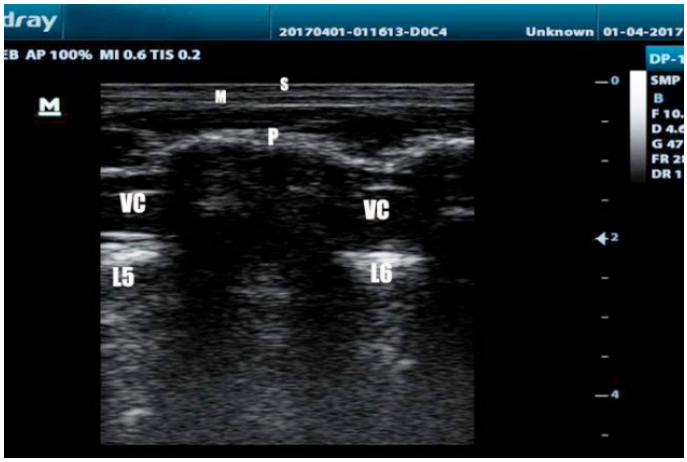

Figure 9: *Parasagittal ultrasonogram of the epidural space in the goat at L5- L6 showing hypoechoic muscles and the echoic lumbar fascia (M), vertebral canal as a hypoechoic round area (VC) and hyper-echoic vertebral body of L5 and L6. Hyper-echoic line of ligamentum flavum. (P). nervous structures appeared as multiple, small hyperechoic rods. Skin (S).*

In the cross section, the epidural space was occupied by the hypo-echoic epidural fat. The US appearance of

the nervous structures was different according to the section, in cross images, nervous structures appeared as multiple, small and rounded-shaped echoic spots, sometimes containing a hypo-echoic center, while in parasagittal section appeared as thin tapering echoic rods (Figure 10 and Figure 11).

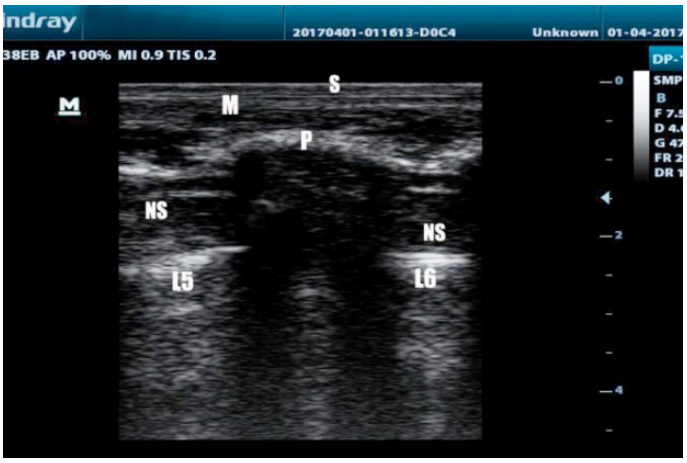

Figure 10: *Parasagittal ultrasonogram in epidural space in goat at L5- L6 showing hypoechoic muscles and the echoic lumbar fascia (M), hyper-echoic vertebral body of L5 and L6 posteriorly by an-echoic body of sacrum (Sac). Hyper-echoic line ligamentum flavum. (P). nervous structures appeared as multiple, small hyperechoic rods (NS). Skin (S)*

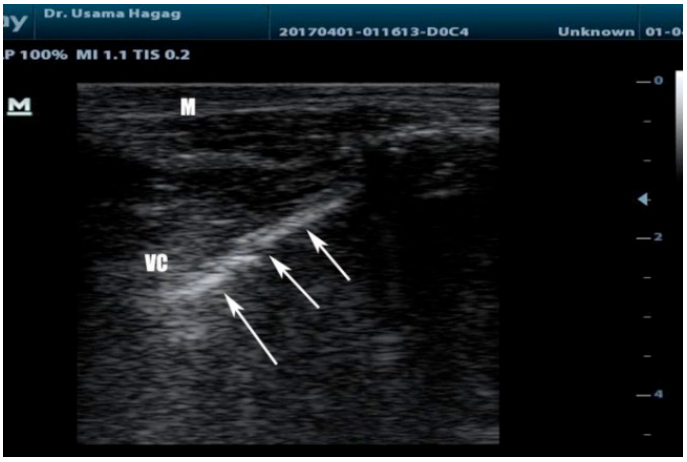

Figure 11: *Parasagittal ultrasonogram of the epidural space in the goat at L5- L6 showing hypoechoic muscles and the echoic lumbar fascia (M), vertebral canal as a hypoechoic area (VC) and hyper-echoic needle (white arrow).*

In US images, the needle appeared hyper-echoic during its entrance into L5-L6 space. By parasagittal scan, the needle appeared as hyper-echoic oblique cranio-ventrally line, while it appeared as hyper-echoic spot in an-echoic subarachnoid space by cross section scan (Figure 12 and Figure 13).

The present investigation revealed that, the lumbar vertebrae are six in number this come in accordance with (Dyce et al., 2010) in small ruminants; Abdel-Maksoud 2007, in goat. However, their number is recorded to be five or six (Hussain, 2010, in goat), seven vertebrae in goat (Frandson, 2010) or six to seven in sheep (Pasquini et al., 2003; Frandson, 2010). While, the number of sacral and caudal vertebrae in our investigation simulate the findings of Abdel-Maksoud (2007).

Figure 12: *Cross ultrasonogram of the epidural space in the goat at L5- L6 showing hyper-echoic vertebral body and vertebral canal appear as a hypoechoic round area (VC).*

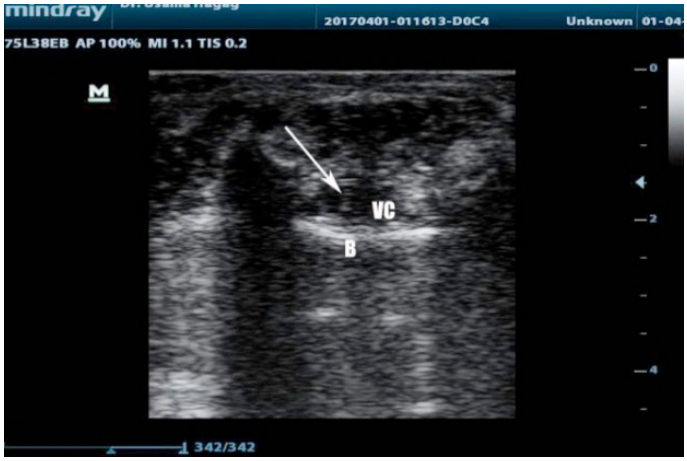

Figure 13. *Cross ultrasonogram of epidural space in goat at L5- L6 showing vertebral canal as round a hypoechoic area (VC) and hyper-echoic needle (white arrow) and hyper-echoic vertebral body (B).*

In accordance with (Dyce et al., 2010) the ilia of the os coxae of goat were long, our data added that, the ilia embraced the lumbosacral articulation hindering its detection.

Concerning to the spinal cord, it reduced in size at the 5th lumbar vertebra, at the level of the last lumbar vertebra it became tapered and formed the terminal filament to be terminated at the level of the 1st sacral segment. Similar termination was observed by (Bas-

set et al., 2014, in goat; Pasquini et al., 2003, in sheep; Dyce et al., 2010, in cattle). However, another termination was observed at the caudal end of 5th sacral vertebrae (Ramkrishna et al., 1991, in goat; Dyce et al., 2010, in small ruminants).

In the present study, L5-L6 is preferred for applying epidural injection than the other common sites due to not only this area provides the widest lumen of the spinal canal giving enough space above the spinal cord for riskless injection but also the interspinous space is large, accessible and easily detectable for external anatomical landmark. However, (Mpanduji et al., 2000; Bani ismail, 2016) reported that, the L6-S is the most common site for epidural injection in small ruminants with taking precautions to avoid traumatizing the conus medullaris and/or cauda equina in goats. In addition, CO1- CO2 is commonly used for epidural technique but it calcified in older ages cattle, moreover it was hard to be detected in small ruminants (Beltman et al., 2010).

The present investigation showed some unexpected and interesting results about the verification of L5-L6 that also assessed by US-guided epidural analgesia which becomes progressively popular, not only in human but also in veterinary practice. Needle orientation is no longer based on surface landmarks that may differ between animals, but can be based on US visualization of the internal anatomical structures. However, Needles can be guided, accurately placed and moved into an optimal position even during injection, making it easier to reach the target area (Greher et al., 2004).

Regarding the use of US-guided technique described the space of epidural injection, which is the common site used in small ruminant, our data come in line with the findings of Valverde (2008).

The present study was conducted with the aim of saving the animal from any injury or discomfort when using L5-L6. in contrast, the animal must be recumbent laterally with arched back while hind limbs are pulled cranially to increase the distance between vertebrae at the L6- S (Hall and Clarke, 1991).

Not only parasagittal direction was a good approach as it allowed the best visibility of the L6- S as described by Di Concetto et al. (2012) but also our results revealed that the cross and parasagittal directions were a good approach in L5- L6 space. US of the nervous structures appeared hyper-echoic sometimes containing a hypo-echoic center, round or elongated and tapering, depending on section plan, similar findings could be detected by (Annalisa et al., 2015) in dog. However, Etienne et al. (2010) observed that, clear visualization of nervous structures within the vertebral canal was variable and depended on animal's size, fat or skin quality.

Conclusion

The L5-L6 is considered a good site for epidural analgesia in goat due to easier and safer for application without risk to the spinal cord and causing discomfort to the animals.

Conflicts of Interest

The authors report no conflicts of interest to disclose.

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Author's Contribution

AS Awaad: Anatomical, CT and 3D image acquisition and interpretation of images, drafted article, revision of article for intellectual content.
MZ Fathy: CT and US image acquisition and interpretation of images, data collection, tabulation of data, animal handling, manuscript preparation.

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