



## Investigation of anatomical landmarks for paravertebral anaesthesia in West African Dwarf goats (*Capra hircus*)

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### Abstract

West African dwarf goats play important roles in providing meat, milk and generate income in farmers. Information on the techniques and morphometric dimensions on performing paravertebral regional anaesthesia in our local breeds of goats is scanty. The proximal and distal paravertebral nerve block postulated by Farquharson and Magda are used in caprine and ovine species by extrapolation. This study was carried out to quantitatively determine the anatomical site of the spinal nerves (T<sub>13</sub>, L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> and L<sub>4</sub>) for the standardized administration of paravertebral regional anaesthesia in West African dwarf goats. Ten adult WAD goats of either sex weighing 10-15kg were used for the study. The animals were euthanized then used for dissection to expose the spinal nerves and subsequently morphometry was carried out. The result of this study showed that the spinal nerve emerges from the intervertebral foramina and bifurcates into dorsal and ventral branches with the dorsal nerve branch passing cranially to the body of the succeeding lumbar transverse process in a caudolateral manner. While the ventral branches of the lumbar nerves each run obliquely, just below the intertransverse ligament, across the space between the transverse processes. The means of (T<sub>13</sub>, L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> and L<sub>4</sub>) were considered for the right and left sides of the WAD goats. The mean depth was 3.00±0.38cm while the mean length of nerve was 2.65±0.47cm. This study established reference anatomical landmarks of the spinal nerves 2-3cm away from the spine dorsolateral for proximal approach and 1-1.5cm for the distance of needle placement medially from the tip of the transverse process dorsal and ventral.

**Keywords:** Land marks, Morphometry, Paravertebral anaesthesia, Spinal nerve, WAD goat

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### Introduction

West African dwarf goats (*Capra hircus*) are homoeothermic mammals with backward-arching hollow horns, short tails and straight hairs (Mason, 1996). WAD goats are multi-functional animal and plays a vital role in the economy and nutrition of rural and urban dwellers by providing meat, milk and generates income to the small holder arable farmer in Nigeria when sold (Williamson & Payne, 1978).

Satisfactory anaesthesia is very important for both the operator and professional skills. Ethically, animals are to be handled gently with minimal restraint to minimize injury to the animal, while technical efficiency provides preservation of personnel from bite, scratch, kick, inhalation of volatile anaesthetic in the animal breath, or accidental self-injection by sedative (Maria, 2012).

Regional anaesthesia is loss of sensation in a larger, though limited body area. This is used where specific nerves to particular areas of interest are blocked; like specific nerve blocks to the limbs, paravertebral blocks (Edmondson, 2008). Regional anaesthesia is the anaesthesia of choice in ruminants, since general anaesthesia has certain limitations; due to their anatomical and physiological differences (Shokry, 1982; Hashim & Hossain, 1989). In ruminants, the flank is the commonest site for most laparotomy procedures; like caesarean section, rumenotomy, ruminal fistula, correction of intestinal obstruction, and hernia (Kumar, 2003; Lee, 2006). The nerve that supply the flank include the last thoracic (T<sub>13</sub>), first lumbar (L<sub>1</sub>), second lumbar (L<sub>2</sub>), third lumbar (L<sub>3</sub>) and the fourth (L<sub>4</sub>) spinal nerves (Getty, 1975).

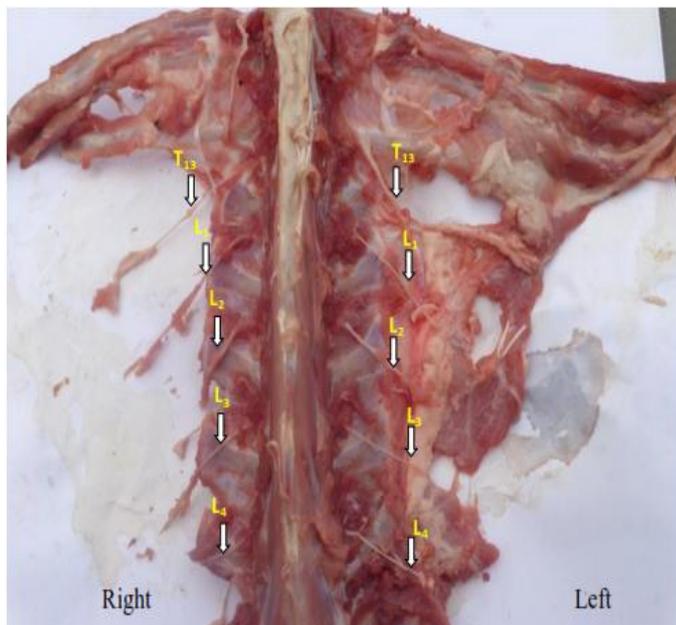
These nerves are anaesthetized during regional anaesthesia (Lee, 2006). In caprine, T<sub>13</sub>, L<sub>1</sub> and L<sub>2</sub> spinal nerves are necessary to be blocked for any operation in the flank region (Hall & Clarke, 1989). Local anaesthetic agents are injected as they emerge from the intervertebral foramina for proximal paravertebral nerve block (Lee, 2006) and at distal free ends of the lumbar transverse process for distal paravertebral nerve block (Kumar, 2003).

The paravertebral nerve block results in effective analgesia in all the muscle layers of the abdominal wall. Conversely, tissue infiltration in inverted L-block in fat animals is said not to produce analgesia of all muscle layers including peritoneum (Sloss & Dufty, 1977). The paravertebral analgesia in goat is not always successful and unreliable in conventional techniques because of variations in the course of dorsal and ventral branches of lumbar spinal nerves (Roe, 1986). However, paravertebral anaesthesia can easily be carried out with the knowledge of topographic anatomy of the courses of the T<sub>13</sub>, L<sub>1</sub>, L<sub>2</sub> and L<sub>3</sub> nerves (Shokry, 1982; Lee, 2006).

## Materials and Methods

### Study animals

A total of 10 West African Dwarf Goats aged 2-3 years with an average weight of 13.3kg were used for the study. They were obtained from local farmers in Makurdi. They were aged according to the method described by Wosu (2002) for



**Plate I:** Showing gross appearance of dorsal spinal nerve branches T<sub>13</sub> - L<sub>4</sub> on the right and left sides of WAD.

The dorsal spinal nerve emerges from the intervertebral foramina and passes cranially to the body of the transverse process of the succeeding lumbar transverse process in a caudolateral manner

ruminants. The animals were housed at the Veterinary Teaching Hospital University of Agriculture, Makurdi and fed with cassava peels and grass. Water was provided *ad libitum*.

### Dissection

The animals were weighed using weighing balance before euthanasia. The abdomen of each animal was surgically opened through the linea alba, and the viscera harvested. A caudal segment cut through transverse plane containing T<sub>13</sub> to L<sub>4</sub> was preserved in 10% formalin for 24-36 hours to allow for a good fixation, before identification of the nerves.

Both dorsal and ventral spinal nerve branches were made distinct by gentle separation of the surrounding tissue using forceps, scalpel blade and scissors. The location of (T<sub>13</sub>), (L<sub>1</sub>), (L<sub>2</sub>), (L<sub>3</sub>) and (L<sub>4</sub>) spinal nerves were identified and measured in centimeter using a measuring ruler (Plate I and II). The landmarks used for measuring the variables included;

1. Depth: Distance from the tip of the spinous process to the point of emergence of the nerve from the intervertebral foramina.
2. Length: This is the distance from the emergence of the nerve at the intervertebral foramina to a point where it bifurcates.
3. Crossing of the nerve over the dorsal aspect of the transverse process.
4. Crossing of the nerve at the ventral aspect of the transverse process.
5. Lateral Distance: Distance from crossing of the nerve over the middle of transverse process to the edge of the transverse process.

### Data analysis

Data generated on quantitative study was tabulated and presented as Mean  $\pm$  SD. Students-*t*- test was used to test the mean difference between the left and right sides of the vertebrae. Graph Pad prism software version 5.0 was used for the data analysis.  $P \leq 0.05$  was considered statistically significant.

## Results

### Morphometric findings

The dimensions of the right and left sides of T<sub>13</sub> and L<sub>1</sub> were presented in Table 1. The mean depth in both right and left sides of T<sub>13</sub> were  $3.08 \pm 0.37$  cm

and  $3.00 \pm 0.38$ cm, respectively. However, the mean depth of both sides did not differ significantly ( $P > 0.05$ ). The mean length on the left side of the vertebra was  $2.83 \pm 0.65$  cm and  $2.83 \pm 0.57$  cm for the right side. The values obtained for the left and right was the same, ( $P > 0.05$ ). The mean dorsal crossing on the right side was  $2.61 \pm 0.35$  cm though, lower compared to that obtained on the left  $2.69 \pm 0.45$  cm did not vary significantly ( $P > 0.05$ ). The mean of the ventral crossing on the left  $2.87 \pm 0.18$  cm that was slightly higher than the value obtained from the right  $2.81 \pm 0.18$  cm but did not vary significantly. The mean lateral distance on both sides (right and left) which were  $2.08 \pm 0.39$  cm and  $2.00 \pm 0.35$  cm respectively did not also vary significantly ( $P > 0.05$ ).

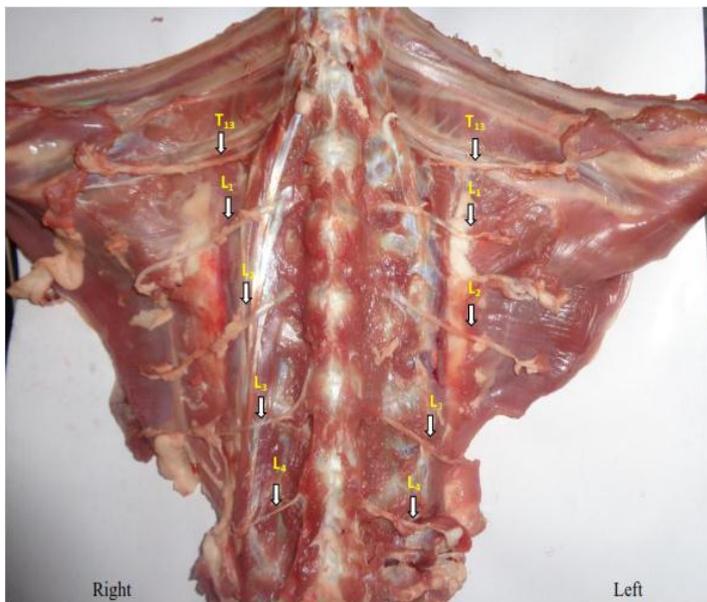
Comparison of the dimensions of the left and right sides of  $L_1$  vertebra as presented in Table 1 showed that the mean depth value on the left side of the vertebra  $3.03 \pm 0.37$ cm, was slightly lower than the right side  $3.04 \pm 0.35$ cm, but showed no significant difference ( $P > 0.05$ ). The mean lengths of the nerve were  $2.90 \pm 0.46$ cm and  $2.83 \pm 0.41$  cm respectively for the left and right sides of the vertebra. The mean length on the left side though slightly higher than the one on the right side did not vary significantly ( $P > 0.05$ ). The mean value obtained for dorsal crossing of the nerve on the right side  $2.48 \pm 0.29$  cm which was the same mean value on the left side  $2.48 \pm 0.29$  cm but was not significant ( $P > 0.05$ ). The mean value for ventral crossing of the nerve for both right and left sides were  $2.91 \pm 0.47$  cm and  $2.93 \pm 0.38$  cm respectively with the left side showing a slightly

higher value, but did not vary significantly. ( $P > 0.05$ ). The mean values for the lateral distances on sides, right  $1.68 \pm 0.26$  cm and left  $1.71 \pm 0.28$  showed no difference ( $P > 0.05$ ).

Comparison of the dimensions of right and left sides of  $L_2$  and  $L_3$  vertebra of West African dwarf goats were presented in Table 2. The mean values for the depth on both right and left sides of  $L_2$  vertebra were  $3.10 \pm 0.40$  cm and  $3.10 \pm 0.36$ cm respectively. However, no significance difference ( $P > 0.05$ ) was observed in their comparison. The mean length for the right side of the vertebra was  $2.71 \pm 0.44$  cm while the left side was lower  $2.65 \pm 0.47$  cm. However, there was no significant difference ( $P > 0.05$ ). The mean values obtained from dorsal crossing of the nerve on the left side was  $2.51 \pm 0.42$  cm did not vary significantly ( $P > 0.05$ ) from that of the right side  $2.57 \pm 0.41$ cm. The ventral crossing had a mean value of  $2.99 \pm 0.34$  cm for the left side and  $3.01 \pm 0.36$  cm for the right. The value obtained on the right side was higher than that obtained for the left side though it was not significant ( $P > 0.05$ ). The right and left lateral distances had values  $1.71 \pm 0.23$  cm and  $1.70 \pm 0.24$  cm that were almost equal but did not differ significantly ( $P > 0.05$ ).

Comparison of the dimensions of the left and right sides of  $L_3$  in WAD goats is also presented in Table 2. The mean values for depths of both right and left sides of the vertebra were  $3.12 \pm 0.37$ cm and  $3.11 \pm 0.37$ cm respectively the difference between them was not significant ( $P > 0.05$ ). The mean value for length of  $L_3$  nerve on the left side was  $2.78 \pm 0.54$ cm but slightly lower than that on the right  $2.81 \pm 0.49$  cm though the difference was not significant ( $P > 0.05$ ). The dorsal crossing on the right side had a mean value  $2.69 \pm 0.27$  cm while for the left side it was  $2.67 \pm 0.34$  cm. On the contrary, the mean value for the ventral crossing on the left side  $3.08 \pm 0.22$ cm was higher than the value obtained on the right side  $3.02 \pm 0.28$ cm. The lateral distances for the right  $1.66 \pm 0.22$  cm and left side  $1.63 \pm 0.22$  cm did not differ significantly ( $P > 0.05$ ).

Comparison of the dimensions of the left and right sides of  $L_4$  vertebra in WAD was presented in Table 3. The mean values for depths of both right and left sides of the vertebra were  $3.00 \pm 0.39$  cm and  $3.0 \pm 0.42$  cm, respectively ( $P > 0.05$ ). The mean value for length of  $L_4$  nerve were  $2.75 \pm 0.53$  cm for the left side and  $2.78 \pm 0.51$  cm for the right sides of the vertebra. The dorsal crossing of the nerve in the right side of the vertebra had a mean value of 2.70



**Plate II:** Showing gross appearance of ventral spinal nerve branches T13 - L4 on the right and left side of the animal. The ventral branches of the lumbar nerves each run obliquely, just below the intertransverse ligament, across the space between the transverse processes

**Table 1:** Comparison of the dimensions of the left and right sides of T<sub>13</sub> and L<sub>1</sub> in West African dwarf goat. (cm)

Nerve	Parameter	Right (n=10)	Left (n=10)	P-value
		Mean ± SD	Mean ± SD	
T <sub>13</sub>	Depth	3.08 ± 0.37	3.00±0.38	0.6445
	Length	2.83±0.57	2.83±0.65	1.0000
	Dorsal Crossing	2.61±0.35	2.69±0.45	0.6653
	Ventral Crossing	2.81±0.18	2.87±0.18	0.4825
	Lateral Distance	2.08±0.39	2.00±0.35	0.6407
L <sub>1</sub>	Depth	3.04±0.35	3.03±0.37	0.9519
	Length	2.83±0.41	2.90±0.46	0.7260
	Dorsal Crossing	2.48±0.29	2.48±0.29	1.0000
	Ventral Crossing	2.91±0.47	2.93±0.38	0.9186
	Lateral Distance	1.68±0.26	1.71±0.28	0.8103

(P &gt; 0.05)

**Table 2:** Comparison of the dimensions of the left and right sides of L<sub>2</sub> and L<sub>3</sub> in West African dwarf goats (cm)

Nerve	Parameter	Right(n=10)	Left (n=10)	P-value
		Mean ± SD	Mean ± SD	
L <sub>2</sub>	Depth	3.10±0.40	3.10±0.36	1.0000
	Length	2.71±0.44	2.65±0.47	0.7746
	Dorsal Crossing	2.57±0.41	2.51±0.42	0.7514
	Ventral Crossing	3.01±0.36	2.99±0.34	0.9005
	Lateral Distance	1.71±0.23	1.70±0.24	0.9265
L <sub>3</sub>	Depth	3.12±0.37	3.11±0.37	0.9529
	Length	2.81±0.49	2.78±0.54	0.8983
	Dorsal Crossing	2.67±0.34	2.69±0.27	0.8869
	Ventral Crossing	3.02±0.28	3.08±0.22	0.6024
	Lateral Distance	1.66±0.22	1.63±0.22	0.7682

(P &gt; 0.05)

**Table 3:** Comparison of the dimensions of the left and right sides of L<sub>4</sub> vertebra in West African Dwarf goat (cm)

Parameter	Right(n=10)	Left (n=10)	P-value
	Mean ± SD	Mean ± SD	
Depth	3.01±0.39	3.00±0.42	0.9570
Length	2.78±0.51	2.75±0.53	0.8999
Dorsal Crossing	2.70±0.33	2.67±0.33	0.8420
Ventral Crossing	3.19±0.44	3.13±0.45	0.7685
Lateral Distance	1.70±0.06	1.72±0.08	0.8528

(P &gt; 0.05)

± 0.33 cm while the left side was 2.67 ± 0.33 cm. The ventral crossing of the L<sub>4</sub> nerve had a mean of 3.19 ± 0.44 cm and 3.13 ± 0.45 cm for the right and left sides respectively. The lateral distance had a mean value of 1.70 ± 0.06 cm for the right side of the vertebra and 1.72 ± 0.08 cm for the left side. In all these parameters examined, there were not statistically significant differences. (P > 0.05).

### Discussion

Satisfactory anaesthesia is said to be important for the operator and the animal; structurally, it has been reported that the paired spinal nerves are attached to the spinal cord at their respective segments by dorsal and ventral roots. Furthermore, each spinal nerve is formed by the union of these roots at the level of the intervertebral foramina through which they leave

the vertebral canal in the dog (Everett, 1972). In this study, the spinal nerves (T<sub>13</sub> – L<sub>4</sub>) were numbered according to the corresponding vertebral segment with which each is associated. These spinal nerves emerged through the intervertebral foramen immediately caudal to the vertebra of the same number (For example, T<sub>13</sub> emerged caudal to the 13<sup>th</sup> thoracic vertebra. This pattern was observed throughout the lumbar (L<sub>1</sub> - L<sub>4</sub>) region. The reason for these spinal nerves (T<sub>13</sub> - L<sub>4</sub>) emerging caudal to their corresponding vertebra was presented by Everett (1972).

The overall mean depth value obtained for both the right and left sides of spinal nerves (T<sub>13</sub>) was 3cm. This depth was observed as a distance from the tip of the spinal process of thoracic T<sub>13</sub> down to the point of emergence of the dorsal nerve at the intervertebral foramen. This may suggest that the

skin, muscles thickness, and connective tissues within these areas (from T<sub>13</sub> – L<sub>4</sub>) have no appreciable difference, both on the left and right sides of the vertebrae. Similar study was conducted by Hindson & Winter (2002) in goat, where they documented a 4 - 5 cm range as the depth for needle insertion for infiltration of anaesthesia on the spinal nerves. The dimensional differences observed in this work compared with Hindson & Winter (2002), may be due to breed and age differences.

The length of the nerve determines how far a needle can be walked off the midline to dorsolateral in order to infiltrate anaesthetic agent in proximal approach. This study showed that the length of the right and left sides of the vertebrae were similar to the length of T<sub>13</sub>-L<sub>4</sub> nerves, but shorter than the report of Sikder *et al.* (2010), in black Bengal does, documented the length of T<sub>13</sub> spinal nerve to be 3.4 ± 0.20cm. The authors also showed the length of L<sub>1</sub> spinal nerve located at the cranio-lateral angle of L<sub>2</sub> transverse process to be 3.5 ± 0.17 cm, while lateral to the dorsal mid line L<sub>2</sub> spinal nerve was 3.7 ± 0.14 cm. A higher value of 5 to 6 cm for the length of spinal nerve lateral to the midline in cattle has been reported (Venugopalan, 2000; Hall & Clark 1989). These dimensions determine the depth of infiltration of local anaesthetic at the perineural area during proximal paravertebral anaesthesia. The difference in the dimensions observed in the black Bengal does and cattle by (Venugopalan, 2000; Hall & Clark 1989) may be due to species variation and age of the animals.

The dorsal crossing of the nerve as described by Edwards (2001), is the distance after its bifurcation to the point of crossing over the transverse process of the vertebral bone. The dorsal crossings of the L<sub>1</sub> and L<sub>2</sub> spinal nerves for WAD goats were higher than the report in black Bengal doe for the same parameters (Sikder *et al.*, 2010). Similarly, the distance observed in ventral crossing of these spinal nerves, (T<sub>13</sub>, L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> and L<sub>4</sub>) was lower than those of the dorsal crossing. Everett (1972) had earlier documented that the ventral length is longer than the dorsal, and serve as the intercostal nerves in addition to formation of the lumbosacral plexus. The short division (dorsal branch) innervates the expaxial region.

Spinal nerves run obliquely, deviating in an increasing caudal direction (Dyce *et al.*, 1987). The

T<sub>13</sub> ventral branch of the nerve passed below the tip of the first lumbar transverse process, while L<sub>1</sub> ventral branch run below the tip of the second lumbar transverse process of L<sub>2</sub>. L<sub>3</sub> run below the tip of the transverse process of L<sub>4</sub> and L<sub>4</sub> below the tip of the transverse process of L<sub>5</sub> (Dyce *et al.*, 1987). These findings agrees with that of Narong *et al.* (2003) in water Buffalo which reported that the ventral branches of T<sub>13</sub>, L<sub>1</sub>, L<sub>2</sub> and L<sub>3</sub> spinal nerves crossed obliquely on the ventral surface of the succeeding lumbar transverse processes, respectively. Also, Edwards (2001) reported that the ventral branches of the lumbar nerves run obliquely, just below the intertransverse ligament across the space between the transverse process. In a similar view, Cakala (1961) showed that the ventral branches of the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> lumbar spinal nerves all lie caudal along the body of the vertebrae to the dorsolateral wall of the pelvic cavity. In addition the author stated that these nerves lie about 3.5 - 4.5cm from the dorsal midline. The mean of 3.5 - 4.5 cm reported by Cakala (1961), was higher than the 2cm in WAD goats obtained in this study. The difference in dimension was not surprising considering the large size of Buffalo to the small size of WAD goats.

The distance between the end of the transverse process of the lumbar bones and where the spinal nerve crosses on the same transverse process is useful for distal paravertebral nerve block on both the dorsal and ventral aspect of the transverse process. In this study, the mean length of this parameter ranged between 1.66cm to 2.08 cm for the right and 1.63cm to 2.00 cm for the left, though not significant (P < 0.05). In cattle Weaver *et al.* (2005) showed that 3cm depth of infiltration can achieve anaesthesia for T<sub>13</sub> L<sub>1</sub> L<sub>2</sub> and L<sub>4</sub>. Khursheed (2013) documented the depth on the lateral aspect of the transverse process in cattle to be 3cm dorsal to the tip of the transverse process. These values were higher than those we obtained in this study possibly because of the difference in the size of animal and tropical weather condition in Nigeria.

In conclusion, this study was able to establish reference anatomical landmarks of the spinal nerves 2-3 cm dorsolateral for proximal nerve block and 1-1.5cm from the tip of the transverse process, needle should be directed medially for distal paravertebral nerve block.

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