Indian J. Vet. Surg. 46(2): 119-122 December 2025

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Sonographic studies of external jugular vein and common carotid artery in Sahiwal calves

Abhishek Rathi[1], Gulshan Kumar[2†], Sanjay Purohit[2] and R.P. Pandey[2]

Pt. Deen Dayal Upadhyaya Pashu chikitsa Vigyan Vishwavidyalaya evam Go Anusandhan Sansthan, Mathura-281001 (Uttar Pradesh)

[1]MVSc Student, [2]Professor, Department of Surgery and Radiology, College of Veterinary Science and Animal Husbandry, Mathura.

DOI: 10.5958/0973-9726.2025.00031.2 *Received: December, 2023*

The objective of the study was to perform sonographic evaluation of the external jugular vein (EJV) and common carotid artery (CCA) in the neck of healthy Sahiwal calves and to study their echo-biometric parameters. Eighteen calves used in the study were divided into three groups of six animals each based on the age group: group I (0-4 months), group II (> 4 and up to 8 months) and group III (> 8 and up to 12 months). B-mode and Doppler ultrasound scanning were done in standing position in all the animals without sedation, using multi-frequency transducer.

The CCA appeared as an anechoic structure of uniform diameter in longitudinal scan, with a thicker wall in transverse scan; the three layers- intima, media, and adventitia were easily discerned. The walls of the EJV appeared as thin hyperechoic lines with a clear demarcation from the surrounding tissue. Various sonographic parameters such as diameter of vessel (D), skin to vessel distance (S), peak systolic velocity (PSV), end diastolic velocity (EDV), pulsatility index (PI) and resistivity index (RI) were recorded wherever possible. For CCA, the S was found significantly greater in group III, whereas the PSV and EDV showed a general increasing trend with age. For EJV, the D was significantly greater in group III and velocity showed a general increasing trend with age. is most suitable for scanning

In conclusion, the external jugular vein and common carotid artery in Sahiwal calves can be reliably scanned at the mid ventro-lateral aspect of the neck. Doppler evaluation can be performed in standing calves with minimal restraint, using maximum neck extension for the common carotid artery and normal neck extension for the external jugular vein.

Keywords*: Common carotid artery, External jugular vein, Sahiwal calves, Ultrasonography*

Doppler ultrasonography analyzes the flow of blood in a vessel and can be used to determine various parameters like the resistance index (RI) and pulsatility index (PI) etc., which provide useful insights about the vascular haemodynamics.

The common carotid artery (CCA) and external jugularvein (EJV), being the most superficial and direct vessels from/to the heart are likely to show alteration in Doppler blood flow parameters in certain conditions like reticulo-diaphragmatic hernia (RDH), which is common in buffaloes in India. B-mode ultrasonography of CCA and EFV has been described in cattle by many researchers (Braun *et al.*, 1994b; Pusterla and Braun, 1995; Trush and Hartshorne, 2005; Buczinski, 2009). However, the reports of pulsed wave Doppler ultrasonography of CCA and EJV in normal healthy cattle are infrequent (Braun and Fohn, 2005). Hence, the present study was undertaken to standardize a protocol for sonographic examination of the EJV and CCA in the neck of healthy Sahiwal calves and to study certain sonographic parameters.

Materials and Methods

The study was conducted on 18 Sahiwal calves, which were divided into three groups of six animals each as per their age: group I (0-4 months), group II (>4-8 months) and group III (>8-12 months).

The neck area of the animals was shaved along the jugular furrow on both sides for sonographic examination of their CCA and EJV. The animals were restrained in standing position without sedation and their neck held in normal position without over-extension or flexion. The sonographic examinations were done using multi-frequency (3.5-12 MHz) transducer of an ultrasound machine having color flow and pulsed wave Doppler functions. During scanning, care was taken to avoid pressure on the vessel by the transducer. The sonographic texture of these vessels was studied and recorded. The direction, spontaneity, smoothness (laminar or turbulence) of the blood flow was also evaluated in EJV. Various echo-biometric parameters like peak systolic velocity (PSV), end diastolic velocity (EDV), pulsatility index (PI), resistive index (RI), vessel diameter (D) and the distance of the vessel from the transducer/skin surface (S) were also recorded using the inbuilt features of the machine.

The numerical data obtained were expressed as Mean±SE and analyzed by One Way ANOVA for means by IBM SPSS 20 and MS Excel (Microsoft Professional Plus 2013). A significance level of $P < 0.05$ was set for all comparisons.

Results and Discussion

The EJV and CCA were scanned by placing the curvilinear transducer in the jugular furrow. The scanning was done both in transverse and longitudinal

†Correspondence; E-mail: ishitagulshan@rediffmail.com

planes. Though EJV is located immediately beneath the skin in the proximal one-third of the neck region, its localization was not as easy as the CCA as EJV is a collapsible blood vessel. The CCA was easily located in the jugular furrow on both sides while moving the transducer from the tracheal plane towards the EJV upon application of mild pressure on the skin. Both the vessels were visible in a single frame in both transverse and longitudinal scans. These appeared as band-shaped structures in longitudinal scanning plane and as oval to circular structure in transverse plane.

Both the vessels appeared as anechoic tubular structures with hyperechoic walls that were clearly demarcated from the surrounding tissue. The CCA showed a uniform diameter in longitudinal scan unlike EJV, which was collapsible. The echogenicity of the walls of CCA were more intense as compared to that of EJV. All the three layers of the CCA were easily discernible on B-mode scan. The EJV appeared relatively oval and thin-walled as compared to CCA in transverse scan.

Scanning of the blood vessels in the neck region in calves did not require use of sedation or anaesthesia. In several earlier studies also scanning of the vessels in dogs, cattle, buffaloes and horses was done without using any anaesthetic agent (Braun *et al.*, 1994b; Cipone *et al.*, 1997; Lee *et al.*, 2004; Duque *et al.*, 2010; Jung *et al.*, 2010; Svicero *et al.*, 2013; Sangwan *et al.*, 2015; Nogueira *et al.*, 2016; Saini *et al.*, 2018; Fogaca *et al.*, 2020).

The CCA appeared as an anechoic structure with a uniform diameter in longitudinal scan. The wall of the CCA appeared as an intensely echogenic line as compared to the wall of the jugular vein. In the transverse approach the vein appeared relatively more oval, thin-walled, and more compressible compared to the artery, which was medial, more round with a thicker wall. In longitudinal or sagittal approach, the EJV appeared as a band shaped structure with anechoic lumen. Both the vessels were visible in a single frame in both transverse and longitudinal scans. Several earlier studies have also reported that the CCA and EJV appear as anechoic structures with thin, hyperechoic walls; and they can be differentiated by the presence of pulsations and by the artery's circular, less collapsible appearance compared to the vein (Braun *et al.*, 1994b; Cipone *et al.*, 1997; Schmucker *et al.*, 2000; Svicero *et al.*, 2013; Sangwan *et al.*, 2015; Chapel and Scansen, 2017; Saini *et al.*, 2018; Pasolini *et al.*, 2019).

The sonographic measurements of the CCA and the EJV are summarized in table 1. There was no significant difference in the mean±SE values of left and right CCA diameters (D) among groups I, II and III (Table 1). However, the skin to vessel distance (S) of the CCA were significantly higher in the animals of group III as compared to other groups. The diameters of EJV appeared to be significantly higher in animals of group III. The Doppler haemodynamic parameters namely, the peak systolic velocity, end diastolic velocity, pulsatility index, and resistivity index of the CCA are presented in table 2.

In case of external jugular veins, the mean values of velocity (V) increased significantly with increase in age of calves but no significant differences were found in the PI values (Table 3). Braun *et al.* (1994b) have reported no significant difference in the mean diameter of the CCA on the right and the left side in cattle. Sangwan *et al.* (2015) also observed a significant positive correlation with the age, vessel diameter and venous velocity of EJV in cattle and buffalo. All the carotid arteries scanned in this study had an antegrade flow direction, having a pulsatile blood flow and multiphasic waveform. Similar flow characteristics have also been reported by several others in different species of animals such as in cattle (Braun *et al.*, 1994b), horses (Cipone *et al.*, 1997; Schmucker *et al.*, 2000), canines (Svicero *et al.*, 2013), and ruminants (Sangwan *et al.*, 2015). All the external jugular veins scanned in this study had an antegrade/central/forward flow direction. Scanned veins had a phasic (respirophasic) to non-phasic (continuous) blood flow. Similar waveform has been observed by Sangwan *et al.* (2015) in cattle and buffalos, and Braun *et al.* (1994b) in cattle.

From the present study, it can be concluded that the mid ventro-lateral region of the neck is the most suitable site for scanning the external jugular vein and common carotid artery in Sahiwal calves. Doppler

Table 1: Mean±SE values of diameter (D) and skin to vessel distance (S) of the left and right common carotid arteries (CCA) and external jugular veins (EJV) in calves of different age groups.

Vessels	Parameter	Group I	Group II	Group III
Left CCA	Diameter (cm)	0.44±0.02	0.44±0.05	0.46±0.07
	Skin to vessel distance (cm)	1.07^{a}±0.01	1.17^{a}±0.04	1.71^{b}±0.08
Right CCA	Diameter (cm)	0.43±0.03	0.45±0.04	0.49±0.04
	Skin to vessel distance (cm)	1.11^{a}±0.04	1.22^{a}±0.10	1.71^{b}±0.25
Left EJV	Diameter (cm)	0.47^{a}±0.03	0.51^{a}±0.03	0.83^{b}±0.14
	Skin to vessel distance (cm)	0.37±0.04	0.38±0.04	0.42±0.05
Right EJV	Diameter (cm)	0.49^{a}±0.02	0.58^{a}±0.05	0.81^{b}±0.07
	Skin to vessel distance (cm)	0.36±0.03	0.38±0.02	0.39±0.03

The values with different superscripts differ significantly among groups (P<0.05)

Table 2: Mean±SE values of Doppler haemodynamic parameters of the left and right common carotid artery of calves in different age groups.

CCA	Parameter	Group I	Group II	Group III
Left	Peak Systolic Velocity (cm/s)	63.18^{a}±4.08	72.41^{b}±2.08	89.79^{c}±1.75
	End Diastolic Velocity (cm/s)	15.88^{a}±0.84	21.93^{b}±0.34	31.30^{c}±1.83
	Pulsatility Index	1.25±0.17	1.49±0.15	1.64±0.22
	Resistivity Index	0.63±0.03	0.72±0.04	0.73±0.05
Right	Peak Systolic Velocity (cm/s)	63.14^{a}±2.72	73.18^{b}±2.33	90.21^{c}±0.90
	End Diastolic Velocity (cm/s)	16.30^{a}±0.77	23.22^{b}±1.61	30.11^{c}±1.23
	Pulsatility Index	1.33±0.15	1.42±0.17	1.48±0.12
	Resistivity Index	0.69±0.03	0.71±0.05	0.74±0.03

The values with different superscripts differ significantly among groups (P<0.05)

The mean values of PSV and EDV increased significantly with age, while there were no significant changes in the values of PI and RI of the CCA (Table 2).

Table 3: Mean±SE values of Doppler haemodynamic parameters of the left and right external jugular vein of calves in different age groups.

EJV	Parameters	Group I	Group II	Group III
Left	Velocity (cm/s)	12.17^{a}±0.68	16.94^{b}±0.38	19.81^{c}±0.63
	Pulsatility Index	0.17±0.04	0.26±0.04	0.32±0.05
Right	Velocity (cm/s)	12.97^{a}±0.88	16.62^{b}±0.28	19.69^{c}±0.7
	Pulsatility Index	0.28±0.05	0.31±0.04	0.57±0.26

The values with different superscripts differ significantly among groups (P<0.05)

evaluation can be effectively performed in standing calves with minimal restraint, requiring maximum neck extension for the common carotid artery and normal neck extension for the external jugular vein.

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