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Predicting the Impact of Degree and Duration of Uterine Torsion on Uterine Blood Supply in Cattle using Doppler Ultrasonography

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ABSTRACT

The aim of study was doppler ultrasonography-aided assessment of uterine blood flow in relation to duration and degree of uterine torsion in cattle. Fourteen dairy cattle with uterine torsion were detorted and fetal delivery was completed after detorsion. Six live and eight dead calves were delivered by cattle having torsion from lesser and prolonged duration, respectively. Whereas the dams of majority of live (n = 4/6) or dead (n = 5/8) fetus had uterine torsion ≤180° or >180°, respectively. Doppler ultrasonography of middle uterine artery ipsilateral (IpsiUA) and contralateral (ContUA) to the side of torsion was carried out before uterine detorsion for doppler indices viz. blood flow volume (BFV), time-average peak velocity (TAP), resistive index (RI) and pulsatility index (PI). With increase in degree and duration of torsion, BFV in both IpsiUA and ContUA reduced significantly ($p<0.05$) but TAP decreases only with increase in duration of torsion. In ipsilateral uterine artery PI (PI- IpsiUA) increased with an increase in duration of torsion ($p<0.05$). The presence of Pre-diastolic notch in IpsiUA and ContraUA validates the hindrance in blood flow through the vessel and absence of diastole in higher degree and/or duration of uterine torsion defined the severity of torsion which further relates to fetal viability. In conclusion, assessing the blood flow parameters of middle uterine artery in relation to degree and duration of uterine torsion can serve as useful prognostic indicator. The cattle having lesser degree of uterine torsion could have more chances of fetal survival due to lesser alterations in blood flow.

Keywords: Cattle, doppler ultrasonography, spectral waveform, uterine artery, uterine torsion

The duration and degree of uterine torsion in bovines affects the survivability of dam as well as fetus (Ghuman, 2010). Due to occurrence of uterine torsion, the middle uterine vein and artery is compressed, the blood supply to uterus is decreased, thus resulting in an increase in carbon dioxide and decrease in oxygen tension in the fetal blood. Consequently, due to fetal asphyxia and vigorous fetal movements, the condition is aggravated by an increase in the degree of torsion. This may further decrease uterine blood supply and the result is necrosis of uterine tissue, endotoxemia and ultimately death of fetus and/or dam (Ghuman, 2010). Transrectal colour doppler ultrasonography was applied for the investigations on uterine blood flow in cattle (Bollwein *et al*., 2002), buffalo (Varughese *et al*., 2013) and mare (Bollwein *et al.*, 2004). The studies in humans have clearly demonstrated that an abnormality in uterine blood flow was directly correlated with fetal growth retardation, fetal distress, ovarian torsion and various peri-partum diseases (Park *et al*., 1996; Shadinger *et al.*, 2008). It was hypothesized that the impact of uterine torsion on fetus as well as dam mortality and morbidity can be significantly reduced if appropriate and timely treatment is administered based on the doppler ultrasonography-aided clinical information. Thus, the present study was carried out to assess doppler indices for middle uterine artery in relation to duration and degree of uterine torsion in cattle.

MATERIALS AND METHODS

Animals and clinical examination

Fourteen multiparous dairy cattle with complete gestation period were presented at Teaching Veterinary Clinical

Complex, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana with the history of abdominal pain and restlessness for the past 24 - 72 h. Individual animal case history (age, parity, housing type, gestation period, duration of straining and previous interventions, if any) was recorded, duration of occurrence of uterine torsion was assessed from the history (≤36h, n=6; >36h, n=8) and general condition of the animal was carried out. A careful vaginal and rectal examination diagnosed degree (≤180º, n=6; >180º, n=8) and direction (clockwise or right side, n=12; counter-clockwise or left side, n=2) of uterine torsion, as well as the vaginal involvement (pre-cervical, n=0; post-cervical, n=14).

Detorsion of uterus and fetal delivery

Uterine torsion in the pregnant cattle was removed as per Sharma's modified Schaffer's method (Ghuman, 2010). During detorsion of uterus, a single roll was sufficient for five cattle and nine cattle were subjected to two rolls. Per-vaginal delivery of live (n=6) or dead (n=8) fetus was completed subsequent to complete cervical dilatation using obstetrical procedures. In all cases of the present study, fetal delivery occurred within 30 min following the successful detorsion of uterus.

Doppler sonography of uterine blood flow

A portable colour doppler ultrasound system (M-Turbo, SonoSite Inc., Bothell, USA) equipped with a 5.0-7.5 MHz linear transducer was used for measuring doppler indices through transrectal approach. About 30 min after the presentation of uterine torsion affected cattle at hospital and about 30 min after per-vaginal delivery of fetus subsequent to detorsion, the medial uterine artery ipsilateral (IpsiUA) and contralateral (ContUA) to uterine torsion was examined for measuring doppler indices (Bollwein *et al*., 2000; Herzog and Bollwein, 2007). In brief, the uterine artery was recognized within the mesometrium near to its origin at the rudimentary umbilical artery and close to the external iliac artery. At this location, middle uterine artery blood flow waveforms and values of various doppler indices were obtained using pulsed doppler mode by placing the doppler gate over the uterine artery adjusted to the diameter of artery (Fig. 1).

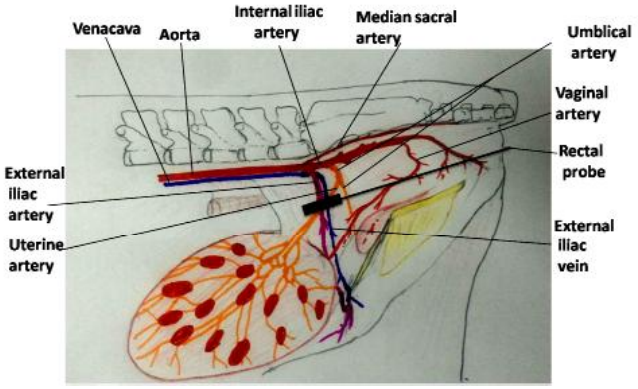


Fig. 1: Diagrammatic representation of middle uterine artery showing location for the placement of sonography probe through transrectal approach

Doppler indices

Various doppler indices over the cardiac cycle like pulsatility index (PI), resistive index (RI), time-average peak velocity (TAP) and blood flow volume (BFV) are useful for estimating the blood flow resistance in vessels distal to the point of examination (Dickey, 1997). To increase accuracy of the Doppler indices, at least 3-4 cardiac cycle wave forms were used (Fig. 2 and 3) and at least three measurements were taken for each parameter. Resistive index **(**RI = Peak systolic volume, PSV - End diastolic volume, EDV / PSV) relates to negative relation with vascular perfusion and decreasing resistance increases vascular perfusion and vice versa (Elmetwally, 2012). Pulsatility index (PI = PSV - EDV / Time-average Peak velocity, TAP) relates to negative relation with vascular perfusion and increasing PI indicates constriction of vascular bed distal to the site of measurement, decreased tissue perfusion and vice versa (Elmetwally, 2012). Time-average peak velocity (TAP, cm/s = Time average maximum frequency shift over the cardiac cycle, TAMF × ultrasound propagation speed, c / 2 × Transmitted wave frequency, F × cos-α, where α is the angle between ultrasound beam and blood flow direction) is used to evaluate the blood flow in small vessels (Bollwein *et al.*, 2002). Blood flow volume (BFV, ml/min = [TAP × π × artery diameter, *D*, cm × 0.5]^2 × 60) to the target tissue depends on the mean velocity and diameter of target blood vessel (Krueger *et al*., 2009).

Statistical analysis

Data (mean ± SE) was analyzed using IBM SPSS version 21 and the differences with $p<0.05$ were considered statistically significant. One-way analysis of variance was used to compare the values of doppler indices between groups having different duration and degree of uterine torsion. Retrospective analysis of data of doppler indices before uterine detorsion was carried out to assess the chances of fetal survivability. Doppler waveform was assessed for type of waveforms (Dickey, 1997).

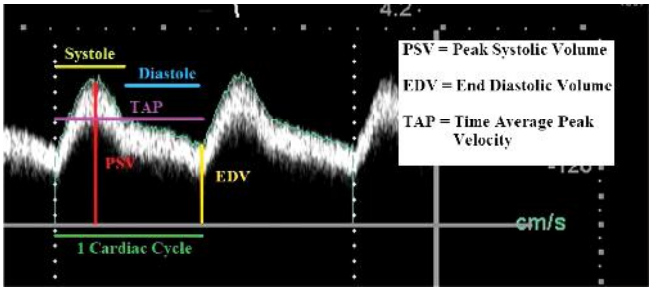


Fig. 2: Sonograph image showing spectral waveform (a cardiac cycle) of middle uterine artery

RESULTS AND DISCUSSION

Fetal survivability

Following uterine detorsion, six cattle delivered live fetus and all of these cattle had history of uterine torsion of about ≤36h, whereas all the eight fetus which were delivered dead had the history of uterine torsion of their dams of >36h (Table 1). The analysis based upon degree of uterine torsion indicated that the dams of majority of live (n=4/6) or dead (n=5/8) fetus had uterine torsion ≤180° or >180°, respectively (Table 1). These findings suggested that higher duration or degree of uterine torsion has negative impact on the chances of fetal survival. The previous observations have also suggested that the delivery of a live calf is possible only if the duration as well as the degree of uterine torsion is less (Ghuman, 2010). This suggested a possible relation between the degree of uterine torsion and the constriction of uterine blood vessels. The pathological changes of uterus are severe with an increase in degree of uterine torsion persist for a prolonged duration (Ghuman, 2010; Jeenger *et al.*, 2015).

Table 1: Fetal survivability (Live, L or Dead, D fetus) in relation to degree and duration of uterine torsion in cattle

	≤36h(n=6)	>36h (n=8)	≤180° (n=6)	>180° (n=8)
LIVE	6	0	4	3
DEAD	0	8	2	5

Doppler indices

The present study clearly indicated higher disturbance in blood flow parameters in the middle uterine artery following an increase in duration and degree of uterine torsion in cattle. The blood flow volume in the middle uterine artery, both ipsilateral (BFV-IpsiUA) and contralateral (BFV-ContUA) to the side of uterine torsion, decreased both with an increase in duration (>36 h) and degree (>180°) of uterine torsion in cattle (Table 2). Also, in a previous study, the higher compression of middle uterine artery for longer time led to the decrease in blood volume flow (Hussein, 2013). In addition, the decrease in time average peak velocity in TAP-IpsiUA and TAP-ContUA was observed with an increase in duration (>36 h, $p<0.05$) and degree (>180°, $p>0.05$) of uterine torsion (Table 2). In the present study, the resistive index of middle uterine artery in uterine torsion affected cattle was similar over the observed duration and degree of uterine torsion (RI-IpsiUA; RI-ContUA, Table 2).

The failure to observe significant difference ($p>0.05$) in resistive index despite the observed decrease in blood flow volume over the increasing degree and duration of torsion needs further investigations. Nevertheless, the pulsatility index is more suitable than the resistive index when the flow is absent during all or part of diastole (Dickey, 1997). The pulsatility index in ipsilateral uterine artery (PI-IpsiUA) increased with an increase in duration of torsion (Table 2), which indicated that vascular perfusion due to constriction of vascular bed in the uterus decreases following the persistence of uterine torsion for longer periods.

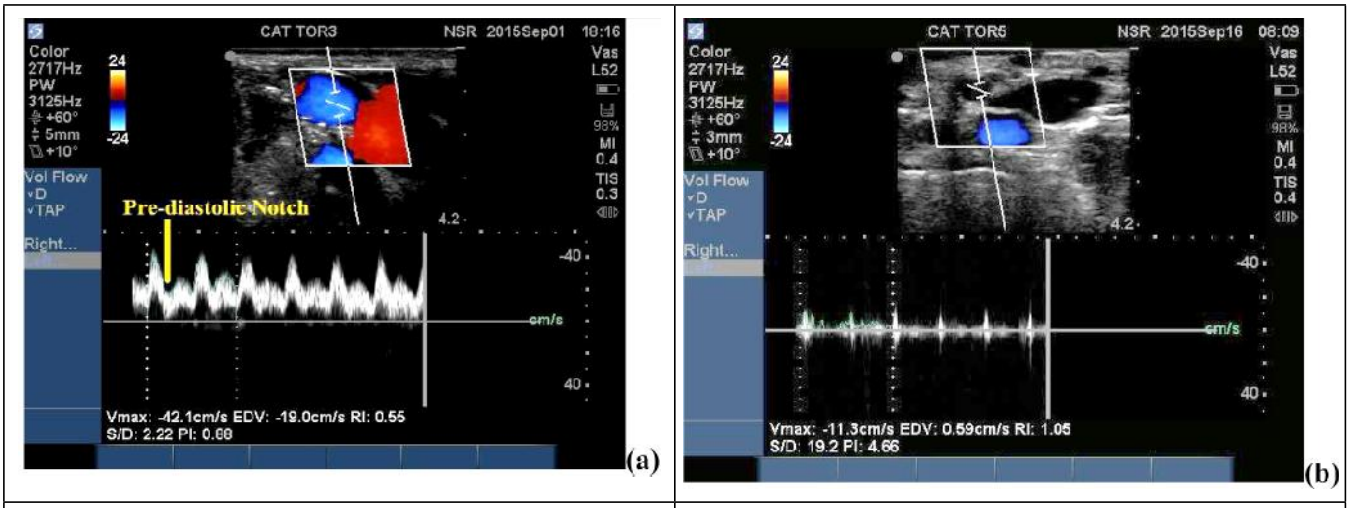
Nevertheless, this study clearly indicated longer the duration and degree of torsion, lesser is the blood flow through that vessel, hence lesser the chances of the survival of calf, because source of nutrition to the fetus passes through middle uterine artery.

In the present study, pre-diastolic notch was present in spectral waves of uterine artery ipsilateral and contralateral to uterine torsion (Fig. 3a) which was due to narrowing

Table 2: Doppler indices (mean±se) of middle uterine artery in uterine torsion affected cattle (n = 14) in relation to degree and duration of torsion

Parameters	≤36h (n=6)	>36h (n=8)	≤180° (n=6)	>180° (n=8)
BFV-IpsiUA*(ml/min)*	2544±307[a]	697±232[b,c]	2223±408[e]	1015±210[f]
BFV-ContUA*(ml/min)*	2516±235[a]	1280±149[b,d]	2361±233[e]	1361±137[f]
TAP-IpsiUA*(cm/s)*	81.64±12.36[a]	21.89±9.21[b]	66.17±13.24	35.93±9.99
TAP-ContUA *(cm/s)*	86.27± 10.29[a]	36.43±2.65[b]	67.34±10.9	56.57±7.56
RI-IpsiUA*(Index)*	0.67±0.03	0.80±0.07[c]	0.77±0.08	0.67±0.04
RI-ContUA*(Index)*	0.57±0.05	0.60±0.03[d]	0.56±0.04	0.63±0.03
PI-IpsiUA*(Index)*	1.16±0.11[a]	2.87±0.62[b,c]	1.48±0.26	2.16±0.51
PI-ContUA*(Index)*	0.99±0.14	0.99±0.07[d]	0.98±0.12	1.07±0.08

a *vs* b, c *vs* d, e *vs* f $p<0.05$



(a) Spectral waveform of middle uterine artery (MUA) of cattle having less degree of uterine torsion persisting from shorter duration. Presence of pre-diastolic notch confirms the hindrance of blood flow through the vessel. Blue colour filled in cross-section of MUA is indicative of blood flow.

(b) Spectral waveform of middle uterine artery (MUA) of cattle with higher degree of uterine torsion persisting from long time. Amplitude of wave is shorter and absence of diastole with higher pulsatility index (PI) due to greater impedance in vessel confirms the severity of condition. Decrease in blue colour in cross-section of MUA is indicative of poor blood flow.

Fig. 3: Sonograph image showing waveform of middle uterine artery in cattle with uterine torsion

of arterial lumen that further led to rise in downstream impedance and poor blood perfusion (Abuhamad *et al.*, 1995; Harrington *et al.*, 1996; Hussein, 2013). Diastole was absent in most of the waves of ipsilateral arteries of cattle having higher degree of uterine torsion persisting from prolonged duration (Fig. 3b). The absence of diastole is indicative of the rise of impedance (Dickey, 1997), hence severity of uterine torsion. Also, in humans, presence of decreased, absent, or reversed diastolic flow in the uterine artery has been correlated with fetal growth restriction, increased maternal morbidity and even fetal or maternal death (Pattison *et al.*, 1993; Zarko and Neilson, 1995).

CONCLUSION

In conclusion, assessing the blood flow parameters in middle uterine artery in relation to degree and duration of uterine torsion can serve as useful prognostic indicator. The cattle having lesser degree of uterine torsion could have more chances of fetal survival due to lesser alterations in blood flow.

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