DOI: 10.1002/vms3.820

ORIGINAL ARTICLE

WILEY

Retrospective analysis of 302 ovine dystocia cases presented to a veterinary hospital with particular attention to uterine torsion

Viktoria Balasopoulou | Yury Zablotski | Holm Zerbe | Katja Voigt

Clinic for Ruminants with Ambulatory and Herd Health Services, Ludwig-Maximilians-Universität München, Oberschleissheim, Germany

Correspondence
Katja Voigt, Clinic for Ruminants with Ambulatory and Herd Health Services, Ludwig-Maximilians-Universität München, Sonnenstrasse 16, 85764 Oberschleissheim, Germany.
Email: katja.voigt@lmu.de

Abstract

Background: Dystocia is common in sheep, and foetal causes are predominant. Among maternal causes, insufficient cervical dilatation is the most frequent problem. Uterine torsion has been considered rare by many authors.

Objectives: This study was conducted to investigate causes of dystocia in sheep presented for veterinary attention, and particular focus was set on the description of uterine torsion and analysis of potentially predisposing factors for this condition.

Methods: Clinical records of 302 sheep treated for dystocia were evaluated retrospectively. Known and proposed risk factors for uterine torsion in cattle were analysed regarding their potential importance in sheep. These included lamb birth weights, ewe age, parity, season, nutrition, breed type, litter size and husbandry.

Results: Maternal causes of dystocia accounted for 67.2% (203/302) of the presented cases. Of these, insufficient cervical dilatation (121/203, 59.6%) was the most frequent diagnosis. Another substantial proportion of maternal causes (60/203, 29.6%) was identified as uterine torsion. Husbandry, breed type and litter size showed significance in univariate analyses, with lower odds for meat breeds (OR 0.22; $p < 0.001$), twin- (OR 0.49; $p = 0.020$) or multiple-bearing ewes (OR 0.19; $p = 0.013$) and higher odds for fully housed animals (OR 17.87; $p < 0.001$). Year-round housing was identified as the most influential factor in a subsequent multivariate analysis.

Conclusions: Uterine torsion was identified as a relevant cause of dystocia in our case load. The condition is likely to be underdiagnosed in sheep, and increased farmer and veterinary awareness is necessary to ensure adequate treatment of affected animals and to prevent unnecessary suffering.

KEYWORDS
dystocia, predisposing factors, sheep, uterine torsion

1 INTRODUCTION

Dystocia is common in sheep (Jacobson et al., 2020; Phythian et al., 2019) and can lead to increased perinatal lamb (Dwyer & Bünger 2012; Holst et al., 1997; Mahmoud et al., 2018) and dam mortality (Scott, 2005), with a negative impact on farm income (Lane et al., 2015) and animal welfare (Scott, 2005). The reported incidence of ovine dystocia is variable and largely depending on breed. Foetal causes such as foetal maldisposition or foetomaternal disproportion are the most common problems (Parkinson et al., 2019a). The relative frequency of the various foetal causes and various types of malpresentation has also been shown to vary between breeds (Dwyer & Bünger, 2012). Faulty disposition of the foetus can often be resolved by farmer intervention (Scott, 1989), thus leading to an under-representation of these causes in studies involving animals presented for veterinary attention, particularly for caesarean section. Maternal causes of dystocia are therefore often the leading causes reported in these study types (Brounts et al., 2004; Ennen et al. 2013; Sobiraj, 1994; Voigt et al., 2021). Among maternal causes of ovine dystocia, incomplete cervical dilatation is the most frequently reported problem, while other causes such as uterine torsion are considered rare in sheep (Jacobson et al., 2020; Parkinson et al., 2019a, b; Winter, 1999) in contrast to other ruminants. In bovine dystocia cases presented for veterinary attention the reported percentage of uterine torsion varied between 2.7% and 65% (Erteld et al., 2012), while the condition is the most common cause of dystocia in water buffaloes altogether, accounting for up to 75% of all dystocia cases (Purohit, 2011; Purohit & Gaur, 2014). Publications on ovine uterine torsion often refer to individual cases, thus highlighting the rare character of the condition (Ijaz & Talafha, 1999; Jones et al., 2020; Scott, 2011; Winzap et al., 2000). Among previous wider studies reporting ovine dystocia cases presented for veterinary attention, or studies exclusively describing cases of ovine caesarean sections, the observed proportion of uterine torsion was variable and ranged from none to more than a quarter of the cases. No torsion cases (0%) were reported in a cohort of 137 ovine caesarean sections examined by Scott (1989) and likewise in 130 caesarean deliveries reported by Majeed et al. (1993). Mosdøl (1986) however identified uterine torsion in 15 of 57 (26.3%) surgical deliveries. More details of a literature review regarding the occurrence of uterine torsion in sheep are provided in Table 1.

While intra- and post-cervical torsions can be diagnosed by vaginal examination, pre-cervical torsions are more difficult to diagnose (Sharun & Erdoğan, 2019). These can thus easily be mistaken for insufficient cervical dilatation (Scott, 2011; Skladany et al., 1988) and the diagnosis is often incidental at caesarean section or post-mortem examination (Ali, 2011; Jones et al., 2020; Phogat et al., 2007; Scott, 2011; Winzap et al., 2000). Transabdominal ultrasonography can be a useful aid in diagnosis by detecting increased thickness (oedema) of the uterine wall, thickened foetal membranes, altered foetal fluids and, in protracted cases, the potential presence of a dead foetus (Scott, 2011; Scott, 2012; Wehrend et al., 2002).

In cattle, the anatomy of the genital tract (Aubry et al., 2008; Erteld et al., 2012), single pregnancies (De Amicis et al., 2018; Parkinson et al., 2019b; Schönfelder & Sobiraj, 2005), age, breed, parity, housing, abdominal capacity due to high concentrate rations, behaviour and foetal weight (Aubry et al., 2008; Erteld et al., 2012; Klaus-Halla et al., 2018; Kruse, 2004; Parkinson et al., 2019b; Schönfelder & Sobiraj, 2005) are all factors identified to influence the occurrence of uterine torsion. No attempts have so far been undertaken to study potentially predisposing factors in sheep, and detailed descriptions of larger case numbers are rare in this species. This retrospective analysis thus aims to create more detailed knowledge on this condition in sheep, and to help identify potentially influential factors on its occurrence by evaluating known and proposed risk factors in cattle in a cohort of sheep with dystocia presented for veterinary attention.

2 MATERIALS AND METHODS

The clinical records of all sheep with dystocia admitted to a Southern German veterinary hospital between January 2008 and February 2021 were evaluated retrospectively. Ovine dystocia has been defined by Anderson (2014) as a failure of transition from stage I to stage II labour, or little to no progress being made for 30 min or more after the start of stage II labour. Problems may be related to a failure of either the expulsive forces or the adequacy of the birth canal, or the disposition of the foetus (Parkinson et al., 2019a). The studied cohort included all animals presented for veterinary attention which met this definition during the given time period, irrespective of diagnosis and treatment method. At the time of admission, a standardised history was taken and clinical findings and treatments were documented in detail by the veterinary surgeon on duty. The history included age, breed, parity, husbandry conditions, nutrition and owner-observed duration of labour, as well as any additionally reported clinical signs or treatments prior to admission. The clinical signs at presentation and during hospitalisation, clinical diagnoses, treatment methods, clinical outcome until hospital discharge, the duration of hospitalisation, litter size, birth weight and viability of the lambs were also recorded. Based on the clinical records, each dystocia case was assigned a single primary cause.

Uterine torsion is defined as a rotation of the uterus around its long axis (Liang et al., 2020). For cases fulfilling this criterion, and a rotation of $\geq 90°$, information on direction, degree and location of the torsion was also collected from the clinical records. Cases of uterine torsion were subsequently analysed and compared to other causes of dystocia.

To allow statistical evaluation, potential predictors for the occurrence of uterine torsion available from the history were categorised as follows: Husbandry systems were assigned to three categories: pasture with seasonal housing, fully housed all year and transhumance/shepherding systems. For parity records, two categories were used: primiparous (no previous lambing experience) or multiparous ($\geq$1 previous parturition). Similarly, nutrition during late pregnancy was assigned to two categories: additional concentrates during pregnancy or roughage-only diet, while the breeds were classified as meat breeds and more extensive (leaner) breeds. To account for potential seasonal differences, the cases were assigned to the pasture season (April to October) or housing season (November to March) based on their admission date. For statistical analyses involving the various

TABLE 1 Literature review regarding the reported proportion and percentage of uterine torsion in previous studies examining ovine dystocia cases presented for veterinary attention (Dystocia) or case cohorts limited to ovine caesarean sections (C-section), plus geographical origin of the presented data

Case pre-selection	Number of uterine torsion cases within studied cohort	Percentage of uterine torsion	Reference	Country
Dystocia	2/429[1]	0.5%[1]	Hawkins et al. (2021) and Angell (2021, personal communication)[1]	United Kingdom
Dystocia	3/122	2.5%	Mahmoud et al. (2018)	Algeria
Dystocia	6/192	3.1%	Scholz (2006)	Germany
Dystocia	8/180	4.4%	Ali (2011)	Saudi Arabia
Dystocia	15/171	8.0%	Dahmani et al. (2019)	Algeria
Dystocia	28/284	9.9%	Skladany et al. (1988)	Former Czechoslovakia
C-section	0/137	0%	Scott (1989)	United Kingdom
C-section	0/130	0%	Majeed et al. (1993)	Iraq
C-section	4/168	2.4%	Sobiraj (1994)	Germany
C-section	3/110[2]	2.7%[2]	Brounts et al. (2004)[2]	United States
C-section	50/212	23.6%	Voigt et al. (2021)	Germany
C-section	15/57	26.3%	Mosdøl (1986)	Norway

Note: Individual case reports are not included
[1]The exact number of uterine torsions in the reported case load is not stated in the publication, the proportion and percentage of torsion cases presented here are therefore based on a personal communication by one of the authors.
[2]The case load included 85 sheep and 25 goats. The authors did not differentiate between the two species when reporting the less frequent causes of dystocia such as uterine torsion. The exact proportion and percentage in ovine cases may thus be higher than the values given in the table, with a maximum of 3 out of the 85 ovine cases (3.5%) if all torsion cases were diagnosed in sheep.

individual breeds, the less frequent breeds (less than 10 animals per breed) were combined as 'other'.

The data were checked for normality by Shapiro–Wilk Test. Levene's test was used to assess the homogeneity of the variances. Simple logistic regressions were initially performed for the predictors age, parity (primiparous yes/no), the most frequent individual breeds (Merino, Texel, Suffolk, Alpine Sheep, crossbred, other), breed type (meat/extensive), husbandry (pasture, transhumance, fully housed all year), nutrition (concentrates yes/no), season (pasture season/housing season) and litter size (single, twin, multiples) to check for potential differences between uterine torsion and non-torsion dystocia cases. All predictors with $p < 0.2$ were included in the subsequent multiple logistic regression model (Dohoo et al., 1997).

A potential influence of lamb birth weight(s) was analysed with Welsh's t tests. The high number of missing values for birth weights did not allow integration of this parameter into the multiple logistic regression model.

Analyses involving the direction of torsion were performed using chi-square goodness-of-fit test. A potential influence of uterine torsion on the duration of hospitalisation or ewe mortality was tested using Mann–Whitney tests as the data were not normally distributed.

Factors potentially affecting foetal viability were tested by multiple mixed-effects logistic regressions with stepwise backwards selection with the individual ewe as random effect, and included the cause of dystocia, ewe age, parity, breed type, concurrent disorders of the dam (yes/no), owner-observed duration of labour prior to presentation (<6, 7–12, >12 h) and litter size.

Analyses were performed using R (version 3.6.3; R Core Team, 2020); $p < 0.05$ was considered significant, while $p \geq 0.05$ and < 0.1 was considered a tendency. Animals with missing values on the studied parameters were excluded from the relevant analyses.

3 | RESULTS

The inclusion criteria were met by 302 sheep. These originated from 58 different flocks. Husbandry information was unavailable for three animals. The majority of the remaining 299 cases was kept on pasture with seasonal housing (225/299, 75.3%), followed by fully housed animals (42/299, 14.0%) and transhumance flocks (32/299, 10.7%). Additional concentrates were fed to 185 of the 296 ewes with available information on nutrition (62.5%), while the remainder received a roughage-only diet (111/296, 37.5%). The majority of the cases were presented during the housing season between November and March (215/302, 71.2%), while 28.8% (87/302) were treated during the pasture season (April to October). Information on litter size was available for 301 ewes. Singletons were present in 45.5% of these cases (137/301), while twin pregnancies were seen in 129 of these 301 ewes (42.9%). Triplets were delivered from 33 sheep (33/301, 11.0%), while individual ewes had quadruplets or quintuplets (1/301, 0.3% each). The animals were between 10 months and 12 years old (median age: 4 years, based on 292 ewes with available information on age). Of 295 animals with parity records, 68 (23.1%) had no previous lambing experience, while 227 were multiparous (76.9%). Meat breeds accounted for 111 of the 302

TABLE 2 Descriptive statistics for ewes presented with dystocia to a veterinary hospital between January 2008 and February 2021

Cause of dystocia	Relative frequency of diagnosis		Treatment method		
Maternal causes	**All dystocia cases ($n = 302$)**	**Maternal causes ($n = 203$)**	**Caesarean section**	**Manual correction**	**Partial foetotomy**
Insufficient cervical dilatation ($n = 121$)	121/302 (40.0%)	121/203 (59.6 %)	100/121 (82.6%)	21/121 (17.4%)	0/121 (0%)
Uterine torsion ($n = 60$)	60/302 (19.9%)	60/203 (29.6%)	56/60 (93.3%)	4/60 (6.7%)	0/60 (0%)
Vaginal prolapse intrapartum ($n = 12$)	12/302 (4.0%)	12/203 (5.9%)	12/12 (100%)	0/12 (0%)	0/12 (0%)
Metabolic/compromised ($n = 6$)	6/302 (2.0%)	6/203 (3.0%)	3/6 (50.0%)	3/6 (50.0%)	0/6 (0%)
Lesions due to vaginal prolapse antepartum ($n = 4$)	4/302 (1.3%)	4/203 (2.0%)	4/4 (100%)	0/4 (0%)	0/4 (0%)
Foetal causes	**All dystocia cases ($n = 302$)**	**Foetal causes ($n = 95$)**	**Caesarean section**	**Manual correction**	**Partial foetotomy**
Foetal maldisposition ($n = 44$)	44/302 (14.6%)	44/95 (46.3%)	6/44 (13.6%)	34/44 (77.3%)	4/44 (9.1%)
Foetal oversize ($n = 42$)	42/302 (13.9%)	42/95 (44.2%)	33/42 (78.6%)	7/42 (16.7%)	2/42 (4.8%)
Foetal malformation ($n = 9$)	9/302 (3.0%)	9/95 (9.5%)	9/9 (100%)	0/9 (0%)	0/9 (0%)
No definite diagnosis ($n = 4$)	4/302 (1.3%)	n/a	2/4 (50.0%)	2/4 (50.0%)	0/4 (0%)

n/a, not applicable.

dystocia cases (36.8%), while 63.2% (191/302) were of leaner, more extensive breeds. Meat breeds included Texel (61/302, 20.2%), Suffolk (34/302, 11.3%), Shropshire (9/302, 3.0%) and Blackhead Mutton (7/302, 2.3%), while the following breeds were assigned to the extensive (leaner) category: Merino (133/302, 44.0%), Alpine sheep (15/302, 5.0%), crossbred ewes (15/302, 5.0%), Coburg Fox (8/302, 2.6%), Jura (7/302, 2.3%), Jezersko–Solčava (5/302, 1.7%), East Friesian (4/302, 1.3%), Cameroon (2/302, 0.7%), Alpine stone sheep (1/302, 0.3%) and Grey heath sheep (1/302, 0.3%).

Maternal causes of dystocia accounted for 203 of the 302 cases (67.2%), while foetal causes were diagnosed in 95 ewes (95/302, 31.5%). The clinical records did not allow a definitive diagnosis in the remaining four animals (4/302, 1.3%), mostly due to protracted dystocia with emphysematous foetuses, so the initial problem was no longer obvious at the time of presentation. The most common maternal cause of dystocia was insufficient cervical dilatation (121/203, 59.6%), followed by uterine torsion (60/203, 29.6%). Other less frequently observed maternal causes included vaginal prolapse intrapartum (12/203, 5.9%), lesions due to vaginal prolapse antepartum (4/203, 2.0%) and compromised animals due to metabolic or other disease (6/203, 3.0%). Among the foetal causes, foetal maldisposition (44/95, 46.3%) and foetal oversize (42/95, 44.2%) were the most commonly observed problems. Some cases of foetal malformation were also observed (9/95, 9.5%). Dystocia was resolved by manual correction in 71 of the 302 cases (23.5%), while 225 animals (74.5%) were treated by caesarean section as previously described (Voigt et al., 2021). A partial foetotomy (Winter, 1999) was performed in six ewes (2.0%). Table 2 summarises the various diagnoses and associated treatment methods of the 302 animals submitted, while Table 3 presents the diagnoses in relation to breed.

Overall ewe survival was 88.7% (268/302). The mean hospitalisation period of the studied 302 dystocia cases was 4.3 days (range: 0–22 days) and depended on the clinical condition of ewes and/or lambs and owner preference regarding collection and care. Birth weights were recorded for 289 of the 507 lambs delivered. Lamb viability records were available for 505 of the 507 lambs. Of these, 184 (36.4%, 184/505) were stillborn, and another 59 (11.7%, 59/505) were delivered alive but died until hospital discharge. Overall lamb survival was thus 51.9% (262/505).

A diagnosis of uterine torsion was either reached by palpation of spiral folds during vaginal examination, or during caesarean section. Uterine torsion was diagnosed in 19.9% (60/302) of all 302 dystocia cases presented for treatment, and the torsion cases derived from 19 different flocks. Eighty-four lambs were delivered from the 60 ewes suffering from uterine torsion. The median age of the affected ewes was 4.1 years (range: 1–10 years) and included 14 primiparous and 45 multiparous animals plus one animal of unrecorded age and parity. Extensive breeds accounted for the majority of torsion cases (52/60, 86.7%). Caesarean section was required in 93.3% (56/60) of the cases, while four torsions (4/60, 6.7%) were resolved manually. The direction of the torsion was recorded in 49 cases. Nearly two-thirds of these (30/49, 61.2%) were counterclockwise. This was however not

TABLE 3 Descriptive statistics for ewes presented with dystocia to a veterinary hospital between January 2008 and February 2021

Total number of studied cases ($n = 302$)	Merino 133/302 (44.9%)	Alpine sheep 15/302 (5.0%)	Crossbred 15/302 (5.0%)	Texe l61/302 (20.2%)	Suffolk 34/302 (11.3%)	Other 44/302 (14.6%)
Insufficient cervical dilatation ($n = 121$)	64/121 (52.9%)	7/121 (5.8%)	6/121 (5.0%)	14/121 (11.6%)	12/121 (9.9%)	18/121 (14.9%)
Uterine torsion ($n = 60$)	39/60 (65.0%)	5/60 (8.3%)	3/60 (5.0%)	2/60 (3.3%)	3/60 (5.0%)	8/60 (13.3%)
Vaginal prolapse intrapartum ($n = 12$)	7/12 (58.3%)	0/12 (0%)	1/12 (8.3%)	2/12 (16.7%)	0/12 (0%)	2/12 (16.7%)
Metabolic/compromised ($n = 6$)	2/6 (33.3%)	0/6 (0%)	0/6 (0%)	1/6 (16.7%)	0/6 (0%)	3/6 (50.0%)
Lesions due to vaginal prolapse antepartum ($n = 4$)	3/4 (75.0%)	0/4 (0%)	0/4 (0%)	0/4 (0%)	0/4 (0%)	1/4 (25.0%)
Foetal maldisposition ($n = 44$)	6/44 (13.6%)	2/44 (4.5%)	3/44 (6.8%)	18/44 (40.9%)	9/44 (20.5%)	6/44 (13.6%)
Foetal oversize ($n = 42$)	6/42 (14.3%)	1/42 (2.4%)	1/42 (2.4%)	22/42 (52.4%)	7/42 (16.7%)	5/42 (11.9%)
Foetal malformation ($n = 9$)	5/9 (55.6%)	0/9 (0%)	1/9 (11.1%)	1/9 (11.1%)	2/9 (22.2%)	0/9 (0%)
No definite diagnosis ($n = 4$)	1/4 (25.0%)	0/4 (0%)	0/4 (0%)	1/4 (25.0%)	1/4 (25.0%)	1/4 (25.0%)

Note: Proportions and percentages of the five most frequent breeds are given in relation to the number of animals with a given diagnosis (supplied in parenthesis). The category 'other' includes nine different, less frequent breeds with one to nine animals per breed.

TABLE 4 Degree of uterine torsion intrapartum in 60 ewes presented for veterinary attention at a veterinary hospital between January 2008 and February 2021

Degree of uterine torsion	Proportion of cases	Percentage
90°	1/60	1.7%
180°	18/60	30.0%
270°	4/60	6.7%
360°	18/60	30.0%
540°	6/60	10.0%
720°	4/60	6.7%
Undocumented	9/60	15.0%

significant ($p = 0.116$). Of the 28 animals with available information on the location of the torsion, a pre-cervical torsion was diagnosed in 14 (14/28, 50%), plus 4 intra- and 10 post-cervical cases. The degree of uterine torsion was measured by re-torsion efforts by counting the number of 180° rotations (or fractions thereof) necessary for the organ to resume its normal position, or by the number of rolling attempts necessary to resolve the torsion in non-surgical cases. This was documented in 51 animals and ranged from 90° to 720° (Table 4).

Animals suffering from uterine torsion carried a single foetus in 63.3% of the cases (38/60), while 20/60 ewes (33.3%) had twins and 2/60 (3.3%) carried triplets (statistical analyses see below). Lamb birth weights from ewes with uterine torsion did not differ significantly from those born to ewes with other causes of dystocia ($p = 0.267$, $n = 289$ lambs with available information on birth weights).

For cases of uterine torsion, the duration of hospitalisation ranged from 0 to 14 days (mean: 4.1 days). Three torsion cases had to be euthanised, leading to a survival rate of 95% (57/60) for this condition. Uterine torsion was thus not associated with any increased ewe mortality ($p = 0.254$) or prolonged hospitalisation ($p = 0.845$) when compared to other causes of dystocia in our study cohort.

Of the 84 lambs delivered from cases of uterine torsion, 44 (52.4%) were delivered alive, of which 7 subsequently died. Forty lambs were dead at the point of delivery (40/84, 47.6%). A diagnosis of uterine torsion was excluded as a potentially influential factor on foetal mortality (stillbirth) in the studied animals, as were age, parity and breed type of the dam ($n = 466$ lambs from 278 ewes with complete data sets). The presence of concurrent, underlying diseases in the dam showed a tendency for decreased lamb viability (OR 0.33, $p = 0.097$), while a tendency of increased survival was shown for twins (OR 3.00, $p = 0.075$). An observed duration of labour >12 h prior to seeking veterinary attention was the most important factor negatively affecting lamb viability (OR 0.01, $p = 0.021$) in the studied cases.

The number of torsion and non-torsion cases in the studied categories are summarised in Table 5. Age, parity, season and concentrate feeding were shown to be non-significant for the occurrence of uterine torsion in our case load by simple logistic regressions. The breed type was identified as significant, with lower odds of suffering from uterine torsion for meat breeds. Fully housed animals showed significantly higher odds of being diagnosed with uterine torsion. The litter size was also identified as significant, with ewes carrying more than one foetus having lower odds of suffering from torsion. Detailed results of these analyses are shown in Table 6.

TABLE 5 Descriptive statistics for ewes presented with dystocia to a veterinary hospital between January 2008 and February 2021 comparing uterine torsion to other dystocia causes

Total number of studied cases (*n* = 302)	Other causes 242/302 (80.1%)	Uterine torsion 60/302 (19.9%)
Husbandry		
Pasture (*n* = 225)	199/225 (88.4%)	26/225 (11.6%)
Transhumance (*n* = 32)	28/32 (87.5%)	4/32 (12.5%)
Fully housed (*n* = 42)	12/42 (28.6%)	30/42 (71.4%)
Information unavailable (*n* = 3)	3/3 (100%)	0/3 (0%)
Nutrition		
Additional concentrates (*n* = 185)	144/185 (77.8%)	41/185 (22.2%)
Roughage-only diet (*n* = 111)	93/111 (83.8%)	18/111 (16.2%)
Information unavailable (*n* = 6)	6/6 (100%)	0/6 (0%)
Season		
Housing season (*n* = 215)	175/215 (81.4%)	40/215 (18.6%)
Pasture season (*n* = 87)	67/87 (77.0%)	20/87 (23.0%)
Parity		
Primiparous (*n* = 68)	54/68 (79.4%)	14/68 (20.6%)
Multiparous (*n* = 227)	182/227 (80.2%)	45/227 (19.8%)
Information unavailable (*n* = 7)	6/7 (85.7)	1/7 (14.3%)
Breed type		
Meat breeds (*n* = 111)	103/111 (92.8%)	8/111 (7.2%)
Extensive breeds (*n* = 191)	139/191 (72.8%)	52/191 (27.2%)
Litter size		
Single (*n* = 137)	99/137 (72.3%)	38/137 (27.7%)
Twins (*n* = 129)	109/129 (84.5%)	20/129 (15.5%)
Multiples (*n* = 35)	33/35 (94.3%)	2/35 (5.7%)
Information unavailable (*n* = 1)	1/1 (100%)	0/1 (0%)

Note: Proportions and percentages are given in relation to the number of animals within the studied category (supplied in parenthesis)

Paired comparisons between the five most frequent breeds showed a significant difference between Merino and Texel (0 = 0.0081), and a tendency when Merinos were compared to Suffolks ($p = 0.096$), with a higher percentage of uterine torsion in Merinos in both cases. There was no significant difference between the three most frequent extensive breeds (Merino, Alpine sheep, crossbred ewes) or the two most frequent meat breeds (Texel, Suffolk).

Breed type, husbandry and litter size were used in the subsequent multiple logistic regression model, which included 298 animals with complete data sets. Year-round housing was identified as the most

TABLE 6 Results of simple logistic regressions of potentially influential factors on the occurrence of uterine torsion

Factors(observations)	Odds ratio	95% Confidence interval	*p* Value
Age (*n* = 292)	1.04	0.91–1.19	0.530
Parity (*n* = 295)			
Multiparous (*Reference*)			
Primiparous	1.05	0.52–2.01	0.892
Breed type (*n* = 302)			
Extensive (*Reference*)			
Meat	0.22	0.09–0.43	**<0.001**
Husbandry (*n* = 299)			
Pasture (*Reference*)			
Transhumance	1.03	0.29–2.95	0.957
Fully housed	17.87	8.89–43.26	**<0.001**
Concentrate feeding (*n* = 296)			
No (*Reference*)			
Yes	1.45	0.81–2.77	0.223
Season (*n* = 302)			
Housing season (*Reference*)			
Pasture season	1.44	0.79–2.62	0.226
Litter size (*n* = 301)			
Single (*Reference*)			
Twin	0.49	0.27–0.90	**0.020**
Multiple	0.19	0.05–0.71	**0.013**

Note: Animals with missing information on the studied parameter(s) were excluded from the relevant analyses. A *p* value < 0.05 was considered significant. Significant *p*-values are indicated in bold.

significant factor increasing the odds for uterine torsion in the studied animals, with decreased odds in meat breeds. The litter size was no longer significant in this mixed model. The detailed results are shown in Table 7.

4 | DISCUSSION

Similar to many previous studies on ovine dystocia (see Table 1), there was a strong and inevitable case pre-selection by only being able to include animals presented for veterinary attention. Although the study was carried out in a hospital setting, the vast majority of the animals were first opinion cases directly submitted by the farmer. Further bias by veterinary referral can therefore be ruled out. The causes of dystocia in the studied cohort are however not representative for a wider sheep population, where foetal maldisposition has been observed as the most frequent birth difficulty in whole flock studies (Dwyer & Bünger, 2012; Grommers et al., 1985). Despite these limitations, we were able to include a large dataset to study causes of moderate to severe (Dwyer & Bünger, 2012) ovine dystocia. Due to the case pre-selection, maternal causes were over-represented. The percentage of most causes of dystocia in our case load was similar to comparable previous studies (Ennen et al. 2013; Sobiraj, 1994), with the notable exception of uterine torsion. The observed frequency of this condition was

TABLE 7 Results of multiple logistic regressions to study the potential influence of breed type, husbandry and litter size on the occurrence of uterine torsion (*n* = 298 ewes with complete data sets)

Predictors	Odds ratio	95% Confidence Interval	*p* Value
(Intercept)	0.27	0.15–0.49	**<0.001**
Breed type			
Extensive	*Reference*		
Meat	0.38	0.16–0.89	**0.025**
Husbandry			
Pasture	*Reference*		
Transhumance	0.67	0.22–2.00	0.471
Fully housed	10.71	4.71–24.36	**<0.001**
Litter size			
Single	*Reference*		
Twin	0.63	0.32–1.26	0.191
Multiple	0.30	0.07–1.21	0.089
R^2 Tjur[1]	0.286		

Note: A *p* value < 0.05 was considered significant. Significant *p*-values are indicate in bold.

[1]The coefficient of determination R^2 Tjur (Tjur, 2009) indicates the explanatory power of the model. Interpretation of R^2: <0.02: very weak; 0.02 to <0.13: weak; 0.13 to <0.26: moderate; ≥0.26: substantial (Cohens, 1988).

considerably higher in our study cohort than in all previous publications comparable in case preselection (animals with dystocia presented for veterinary attention), with 9.9% being the highest reported percentage in a comparable case load (Skladany et al., 1988). It also exceeds the observed frequency in many studies on caesarean sections (Table 1). The reasons for these discrepancies are unclear and may be explained with regional differences in breed, husbandry or other factors. Potential underdiagnosis seems unlikely in these veterinary-led studies.

Uterine torsion between 180° and 360° accounted for the majority of the 51 cases with available information on the degree of torsion (40/51; 78.4%). This observation is in accordance with previous publications in cattle, with the majority of observed bovine torsions ranging from 180° to 360° (Frazer et al., 1996; Tamm, 1997). Individual case descriptions in sheep also reported a severity of up to 360° (Chauhan et al., 2018; Mahal et al., 2020; Naidu, 2012). However, 19.6% (10/51) of our torsion patients with available information on the degree of torsion suffered from a more severe rotation of up to 720°. Such severe torsions have also previously been reported by Mosdøl (1986), who diagnosed a 720° torsion in 4 out of 15 ovine torsion cases (26.7%), and in a case described by Scott (2011).

Sheep with uterine torsion showed an above average survival rate of 95%, and the diagnosis was not associated with prolonged hospitalisation. The condition thus seems to be better tolerated by sheep than by cattle, where 24.1% dam mortality was reported by Zerbe et al. (1998), who studied 518 bovine torsion cases. Compared to cattle and buffaloes (Erteld et al., 2012; Purohit, 2011), uterine torsion still seems to be less frequent in sheep. Some authors suggest that difficulties in diagnosis may lead to under-reporting of the condition (Skladany et al., 1988), particularly given extensive management conditions (Jones et al., 2020) or a lack of veterinary involvement (Scott, 2011). It is also possible that less severe cases of uterine torsion (in the absence of severe uterine damage or oedema) may be underdiagnosed even at caesarean section, if the attending veterinary surgeon does not actively check for the presence of rotation during surgery. Pre-cervical torsions in particular are not commonly associated with palpable vaginal spiral folds and are likely to be mistaken for insufficient cervical dilatation on vaginal examination (Scott, 2011; Skladany et al., 1988) as rectal palpation, which is used to aid diagnosis in cattle, cannot be performed in sheep due to the small size of the species (Sharun & Erdoğan, 2019). The location of uterine torsion was only documented in 28 of the 60 studied torsion cases, so conclusions on the frequency of a diagnostically challenging pre-cervical location can only be based on this relatively small dataset. The high percentage of pre-cervical torsions in these animals (14/28, 50%) however highlights the considerable risk of underdiagnosis in sheep. In ewes showing signs of obvious dystocia, this does not hinder the adequate treatment of the animal as timely caesarean section would be performed if the animal is presented for veterinary attention, even if the attending veterinarian misdiagnoses the condition for suspected cervical non-dilation. However, Scott (2003) raised concerns about a very low percentage of ovine dystocia cases receiving veterinary treatment. In cases solely attended by farmers, the risk of misdiagnosis is high if farmers are not aware of the condition, leading to delayed or inadequate treatments and subsequent foetal and/or maternal death. Even more severe diagnostic problems arise in antepartal cases or animals not exhibiting clear signs of dystocia, leading to a high risk of under- or misdiagnosis. Cases may present as recumbency in a late pregnant ewe and thus be mistaken for metabolic disease (Winzap et al., 2000) or may entirely be missed and go untreated for prolonged periods. Foetal death and mummification, uterine tissue necrosis, peritonitis and additional organ damage with prolonged suffering of the ewe have been reported (Jones et al., 2020; Scott, 2011). Other potential consequences of untreated uterine torsion include vaginal rupture and subsequent intestinal prolapse (Mosdøl, 1999), or severe haemorrhage due to rupture of large blood vessels (Blanchard, 1981), a condition that has also been seen by the authors in an antepartal case presented with recumbency (not included in this study). Accurate diagnosis and timely intervention are therefore paramount in terms of animal welfare and will also aid to raise lamb survival rates.

Predisposing factors for the occurrence of uterine torsion in cattle have been reviewed by Erteld et al. (2012). The anatomical properties of the bovine genital tract and uterine instability caused by the monocornual nature of mostly single bovine pregnancies are being discussed as causes for a relatively high incidence in cattle (De Amicis et al., 2018; Erteld et al., 2012; Schönfelder & Sobiraj, 2005). It is likely that the condition is truly less frequent in sheep despite the discussed potential of underdiagnosis. Slight differences in small ruminant anatomy with a sublumbar rather than subileal attachment of the broad ligaments may lead to improved uterine stability in sheep (Blanchard, 1981; Chahar et al., 2018; Parkinson et al., 2019b). The higher twinning rate in small ruminants, bicornual pregnancies and thus higher uterine stability may additionally contribute to a lower incidence of uterine torsion in sheep. The generally higher weight of bovine foetuses as opposed to relatively light-weight ovine foetuses may also play a role. Bicornual twin pregnancies have a stabilising effect. In addition, twins would have to synchronise their movements in order to cause the pregnant uterus to rotate. However, uterine torsion has also been observed in cattle carrying twins (Aubry et al., 2008; Erteld et al., 2012), and Tamm (1997) observed twin pregnancies in bovine torsion cases at a comparable rate to all studied parturitions (1.1% as opposed to 1.3%). Reports on the number of foetuses in ovine torsion cases are variable. Gupta et al. (2021) observed mostly single pregnancies in small ruminant cases (24/27, 88.9%), an observation supported by Dahmani et al. (2019), while Mosdøl (1986) reported that 7/15 cases (46.7%) carried more than one lamb. Based on our study cohort, simple logistic regressions suggested that ewes carrying singletons had higher odds of suffering from uterine torsion, a factor that was however outweighed by breed type and particularly husbandry in the multiple logistic regression model.

Age and parity have also been discussed as potentially predisposing factors in cattle. Aubry et al. (2008) found cows to have 5.2 times greater odds of suffering from torsion than heifers. According to Ghosh et al. (2013), this may be attributed to weaker abdominal muscles and a lack of tonicity of the broad ligament in multiparous animals. Higher susceptibility to subclinical hypocalcaemia in older cattle with subsequently reduced muscle tone has also been discussed as a potential explanation for this observation, but Aubry et al. (2008) did not find a conclusive association between hypocalcaemia and the occurrence of uterine torsion. Kruse (2004) could not show a correlation between uterine torsion and age in dairy cattle. Similarly, an age-related predisposition could not be shown for sheep in our study population.

Cattle fed high concentrate rations seem to be predisposed to uterine torsion, possibly due to a reduced rumen size in relation to abdominal capacity (Drost, 2007; Parkinson et al., 2019b). A nutritional effect could not be proven for the sheep in our study. However, nutrition was predominantly roughage-based in both nutritional categories, so the relatively small amounts of concentrates fed to the supplemented animals are unlikely to have significantly affected rumen capacity.

A breed predisposition has been reported for Brown Swiss cattle (Erteld et al., 2012; Frazer et al., 1996; Schönfelder & Sobiraj, 2005), and Frazer et al. (1996) showed lower odds for beef cattle. Similar results were obtained here, with ovine meat breeds showing lower odds of suffering from torsion, while extensive breeds were significantly more prone to the condition. Among the most frequent extensive breeds, a direct breed predisposition could however not be proven. Ovine meat breeds are more prone to dystocia associated with foetal oversize and foetal malpresentation than leaner breeds (Dwyer & Bünger, 2012). We also made a similar observation in our study cohort (Table 3). The relative over-representation of meat breeds within the group of foetal causes is a factor that will have led to a lower percentage of uterine torsion cases in the animals belonging to these breeds. The true incidence of uterine torsion in the various breeds remains unknown. Whether meat breeds are truly less likely to suffer from uterine torsion than more extensive breeds remains to be determined.

Cows confined to stables or kept in tie-stalls had a higher incidence of uterine torsion (Aubry et al., 2008), possibly due to a lack of exercise leading to weakening of the abdominal muscles (Erteld et al., 2012). Low exercise levels were also considered a predisposing factor for uterine torsion in goats (Jayaganthan et al., 2020). We made a similar observation in sheep, as year-round housing was identified as the most influential factor increasing the odds of suffering from uterine torsion in our study population. Stabling also increases the chances of animals being pushed, causing sudden movements that may accidentally lead to uterine torsion (Aubry et al., 2008; Ghosh et al., 2013; Parkinson et al., 2019b). It is interesting to note that short-term, seasonal housing did not seem to affect the odds of suffering from torsion. However, the classification of pasture and housing season by admission date may not reflect the true husbandry conditions at a given time, with shorter or longer housing periods applied in the various flocks. These categories may therefore be unreliable. The proportion of fully housed animals was relatively high in our study cohort, which may serve as an explanation for the higher number of torsion cases in comparison to the majority of previous studies. While the cases reported by Voigt et al. (2021) are also part of this analysis and thus do not form an independent population, the only other previous study reporting a very high proportion of uterine torsion cases originated from Norway (Mosdøl, 1986). Norwegian climatic conditions warrant an extended winter housing period, which supports the assumption that prolonged housing and possibly an associated lack of exercise may indeed be an important factor in the pathogenesis of ovine uterine torsion. It however remains to be determined whether additional factors such as stocking density or other elements of husbandry may also be important.

5 | CONCLUSION

Uterine torsion was a relevant maternal cause of ovine dystocia in our study cohort. Fully housed ewes and extensive breeds were particularly prone to the condition in our case load. Single pregnancies may also have some predisposing effect. There is a risk of underdiagnosis of uterine torsion in sheep, and it is important that veterinarians and farmers consider this condition in their treatment decisions as an important differential diagnosis to insufficient cervical dilatation, as well as in compromised, late pregnant ewes to ensure timely and adequate treatment, and to prevent unnecessary suffering of these animals.

AUTHOR CONTRIBUTIONS

Conceptualisation: KV. Data curation: VB. Formal analysis: VB and YZ. Investigation: VB and KV. Methodology: YZ and KV. Project administration: KV and HZ. Resources: HZ. Supervision: KV and HZ. Validation: KV. Visualisation: VB. Writing – original draft: VB and KV. Writing – review & editing: KV, VB, YZ and HZ. Final approval VB, YZ, HZ and KV.

ACKNOWLEDGEMENTS

We thank Nour-Addeen Najm and Panajota Vassiliadis for assistance in data curation. We thank the three anonymous reviewers for their valuable comments.

CONFLICT OF INTEREST

The authors confirm that there is no conflict of interest.

FUNDING INFORMATION

No external funding was received for this study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL STATEMENT

All animals were treated to best practice standards and according to German and EU animal welfare legislation and received appropriate veterinary treatment based on the nature of their clinical condition(s). All veterinarians were proficient in performing ovine obstetrical procedures. This clinical retrospective study did thus not involve any procedures requiring formal ethical approval. Informed client consent was obtained in writing upon submission of the animals for treatment.

ORCID

Viktoria Balasopoulou https://orcid.org/0000-0002-9267-2204

REFERENCES

Ali, A. M. H. (2011). Causes and management of dystocia in small ruminants in Saudi Arabia. *Journal of Agricultural and Veterinary Sciences*, *4*, 95–108.

Anderson, D. E. (2014). *C-section in small ruminants*. University of Tennessee, Knoxville. https://www.semanticscholar.org/paper/1-C-Section-in-Small-Ruminants-Anderson/bdb2ac89e36ad8e3e240c81b8368b1485a8c2cc0 (accessed 23.2.2022)

Aubry, P., Warnick, L. D., DesCôteaux, L., & Bouchard, E. (2008). A study of 55 field cases of uterine torsion in dairy cattle. *Canadian Veterinary Journal*, *49*, 366–372.

Blanchard, T. L. (1981). Uterine torsion with ovarian vein rupture in a ewe. *Journal of the American Veterinary Medical Association*, *179*, 1402–1403.

Brounts, S. H., Hawkins, J. F., Baird, A., & Glickman, L. T. (2004). Outcome and subsequent fertility of sheep and goats undergoing cesarean section because of dystocia: 110 cases (1981–2001). *Journal of the American Veterinary Medical Association*, *224*, 275–281. https://doi.org/10.2460/javma.2004.224.275

Chahar, S. K., Dholpuria, S., & Choudhary, A. K. (2018). Management of uterine torsion in goat: A case report. *International Journal of Applied Engineering Research*, *13*, 11034.

Chauhan, P., Patelia, H., Patel, D., Suthar, B., & Sharma, V. (2018). Clinico-obstetrical management of clockwise 180° post cervical uterine torsion in a ewe. *Journal of Pharmacognosy and Phytochemistry*, *SP1*, 3162–3164. https://www.phytojournal.com/archives/2018/vol7issue1S/PartAX/SP-7-1-880-270.pdf

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd Ed.). New York: Routledge.

Dahmani, A., Dahmani, H., Rahal, K., & Kaidi, R. (2019). Description of dystocia in ewes of the Ksar el Boukhari region (Algeria). *Agriculture*, *3–4*, 111–112.

De Amicis, I., Veronesi, M. C., Robbe, D., Gloria, A., & Carluccio, A. (2018). Prevalence, causes, resolution and consequences of bovine dystocia in Italy. *Theriogenology*, *107*, 104–108. https://doi.org/10.1016/j.theriogenology.2017.11.001

Dohoo, I. R., Ducrot, C., Fourichon, C., Donald, A., & Hurnik, D. (1997). An overview of techniques for dealing with large numbers of independent variables in epidemiologic studies. *Preventive Veterinary Medicine*, *29*, 221–239. https://doi.org/10.1016/s0167-5877(96)01074-4

Drost, M. (2007). Complications during gestation in the cow. *Theriogenology*, *68*, 487–491. https://doi.org/10.1016/j.theriogenology.2007.04.023

Dwyer, C. M., & Bünger, L. (2012). Factors affecting dystocia and offspring vigour in different sheep genotypes. *Preventive Veterinary Medicine*, *103*, 257–264. https://doi.org/10.1016/j.prevetmed.2011.09.002

Ennen, S., Scholz, M., Voigt, K., Failing, K., & Wehrend, A. (2013). Puerperal complications in ewes following dystocia: A retrospective analysis of two approaches to caesarean surgery. *Veterinary Record*, *172*, 554. https://doi.org/10.1136/vr.101370

Erteld, E., Wehrend, A., & Goericke-Pesch, S. (2012). Torsio uteri beim Rind – Häufigkeit, klinische Symptomatik und Theorien zur Pathogenese (Uterine torsion in cattle – Frequency, clinical symptoms and theories about the pathogenesis, in German). *Tierärztliche Praxis. Ausgabe G, Grosstiere/Nutztiere*, *40*, 167–175.

Frazer, G. S., Perkins, N. R., & Constable, P. D. (1996). Bovine uterine torsion: 164 hospital referral cases. *Theriogenology*, *46*, 739–758. https://doi.org/10.1016/s0093-691x(96)00233-6

Ghosh, S., Singh, M., Prasad, J., Kumar, A., & Rajoriya, J. (2013). Uterine torsion in bovines – A review. *Intas Polivet*, *14*, 16–20.

Grommers, F. J., Elving, L., & Van Eldik, P. (1985). Parturition difficulties in sheep. *Animal Reproduction Science*, *9*, 365–374.

Gupta, C., Murugan, M., Ramprabhu, R., & Kumar, S. S. (2021). Uterine torsion in small ruminants – Outcome and fertility following different management approaches. *Indian Journal of Small Ruminants*, *27*, 139–141. https://doi.org/10.5958/0973-9718.2021.00020.9

Hawkins, E. L., McDonnell, S., & Angell, J. W. (2021). Estimation of immediate and 7-day clinical prognostic indicators for ewe and lamb survival in the UK following vaginal delivery and caesarean section at a single veterinary practice. *Small Ruminant Research*, *204*, 106511. https://doi.org/10.1016/j.smallrumres.2021.106511

Holst, P., Fogarty, N., Hopkins, D., & Stanley, D. (1997). Lamb survival of Texel and Poll Dorset crossbred lambs. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics*, *12*, 313–316.

Ijaz, A., & Talafha, A. Q. (1999). Torsion of the uterus in an Awassi ewe. *Australian Veterinary Journal*, *77*, 652–653. https://doi.org/10.1111/j.1751-0813.1999.tb13154.x

Jacobson, C., Bruce, M., Kenyon, P. R., Lockwood, A., Miller, D., Refshauge, G., & Masters, D. G. (2020). A review of dystocia in sheep. *Small Ruminant Research*, *192*, 106209. https://doi.org/10.1016/j.smallrumres.2020.106209

Jayaganthan, P., Palanisamy, M., Prabaharan, V., Rajkumar, R., & Raja, S. (2020). Successful management of uterine torsion in a Kodi Aadu goat by modified Schaffer's method. *International Journal of Science, Environment and Technology*, *9*, 486–488.

Jones, E. M., Neef, A., Shearer, P. L., & Gunn, A. J. (2020). Hydroureteronephrosis and fetal mummification secondary to uterine torsion in a Merino ewe. *Australian Veterinary Journal*, *98*, 529–532. https://doi.org/10.1111/avj.12999

Klaus-Halla, D., Mair, B., Sauter-Louis, C., & Zerbe, H. (2018). Torsio uteri beim Rind: Therapie sowie Verletzungsrisiko für die Kuh und Prognosestellung für das Kalb (Uterine torsion in cattle: Treatment, risk of injury for the cow and prognosis for the calf, in German). *Tierärztliche Praxis Ausgabe G Grosstiere Nutztiere*, *46*, 143–149.

Kruse, M. (2004). Genetische und umweltbedingte Einflüsse auf das Auftreten von Torsio uteri bei Milchkühen (Genetic parameters and environmental influences on the incidence of uterine torsion in dairy cattle, in German). *Dissertation, Tierärztliche Hochschule Hannover*, https://elib.tiho-hannover.de/receive/etd_mods_00002472

Lane, J., Jubb, T., Shephard, R., Webb-Ware, J., & Fordyce, G. (2015). Priority list of endemic diseases for the red meat industries. Final Report, Meat & Livestock Australia Limited. http://era.daf.qld.gov.au/id/eprint/5030/1/B.AHE.0010_Final_Report_Priority%20list%20of%20endemic%20diseases%20for%20the%20red%20meat%20industries.pdf

Liang, R., Gandhi, J., Rahmani, B., & Khan, S. A. (2020). Uterine torsion: A review with critical considerations for the obstetrician and gynecologist. *Translational Research in Anatomy*, *21*, 100084. https://doi.org/10.1016/j.tria.2020.100084

Mahal, J., Honparkhe, M., Ahuja, A., & Anand, I. (2020). Successful uterine detorsion with plank method and fetal delivery in a ewe. *Journal of Entomology and Zoology Studies*, *8*(2), 864–865. https://www.entomoljournal.com/archives/2020/vol8issue2/PartO/8-2-110-110.pdf

Mahmoud, D., Abdelhadi, F., Khiati, B., Smail, N., & Abdelhadi, S. (2018). Etude des dystocies ovines et de la pertinence de la césarienne dans des élevages de la wilaya de Tiaret (Algérie) (Study on sheep dystocia and caesarean section in farms of Tiaret wilaya (Algeria), in French). *Livestock Research for Rural Development*, *30*, Article #189. http://www.lrrd.org/lrrd30/11/si_am30189.html

Majeed, A. F., Taha, M. B., & Azawi, O. I. (1993). Cesarean section in Iraqi Awassi ewes: A case study. *Theriogenology*, *40*, 435–439. https://doi.org/10.1016/0093-691x(93)90280-i

Mosdøl, G. (1986). Keisersnitt på søye I alminnelig praksis. Indikasjoner og betydning for fertilitet (Indications for and fertility after cesarean section in the ewe in common practice, In Norwegian). *Norsk Veterinaertidsskrift*, *98*, 441–444.

Mosdøl, G. (1999). Spontaneous vaginal rupture in pregnant ewes. *Veterinary Record*, *144*, 38–41.

Naidu, G. V. (2012). A case of uterine torsion in sheep. *Indian Journal of Animal Reproduction*, *33*(2), 102–103.

Parkinson, T. J., Vermunt, J. J., & Noakes, D. E. (2019a). 12 – Prevalence, causes and consequences of dystocia. In: D. E. Noakes, T. J. Parkinson, & G. C. W. England (Eds.) *Veterinary reproduction and obstetrics* (10th edn., pp. 214–235). St. Louis: W.B. Saunders.

Parkinson, T. J., Vermunt, J. J., & Noakes, D. E. (2019b). 13 – Maternal dystocia: Causes and treatment. In: D. E. Noakes, T. J. Parkinson, & G. C. W. England (Eds.), *Veterinary reproduction and obstetrics* (10th edn., pp. 236–249). St. Louis: W.B. Saunders.

Phogat, J., Behl, S., Singh, U., & Singh, P. (2007). Uterine torsion in sheep: A case report. *The Haryana Veterinarian Journal*, *46*, 110–111.

Phythian, C. J., Angell, J. W., Crilly, J. P., & Martin, A. D. (2019). Ewe Caesarean section: reviewing the evidence base and sharing cross-country experiences part one. *Livestock*, *24*, 90–101. DOI: 10.12968/live.2019.24.2.90

Purohit, G. N. (2011). Maternal dystocia in cows and buffaloes: A review. *Open Journal of Animal Sciences*, *1*(2), 41–53. https://doi.org/10.4236/ojas.2011.12006

Purohit, G. N., & Gaur, M. (2014). Uterine torsion in buffaloes: A critical analysis. *Buffalo Bulletin*, *33*, 363–378.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Scholz, M. (2006). Untersuchungen zur puerperalen Entwicklung von Schafen nach Schwergeburt unter besonderer Berücksichtigung zweier unterschiedlicher Operationsverfahren der Sectio caesarea (Studies on the puerperal development of sheep following dstocia with particular focus on two different approaches to caesarean section, in German). Dissertation, Justus-Liebig-Universität Gießen, VVB Laufersweiler, Gießen.

Schönfelder, A., & Sobiraj, A. (2005). Ätiologische Aspekte der Torsio uteri beim Rind: Eine Übersicht (Etiology of torsio uteri in cattle: A review; in German). *Schweizer Archiv für Tierheilkunde*, *147*, 397–402.

Scott, P. R. (1989). Ovine caesarean operations: A study of 137 field cases. *British Veterinary Journal*, *145*, 558–564. https://doi.org/10.1016/0007-1935(89)90118-8

Scott, P. R. (2003). A questionnaire survey of ovine dystocia management in the United Kingdom. *Animal Welfare*, *12*, 119–122.

Scott, P. R. (2005). The management and welfare of some common ovine obstetrical problems in the United Kingdom. *The Veterinary Journal*, *170*, 33–40. https://doi.org/10.1016/j.tvjl.2004.03.010

Scott, P. (2011). Uterine torsion in the ewe. *UK Vet Livestock*, *16*, 37–39.

Scott, P. (2012). Applications of diagnostic ultrasonography in small ruminant reproductive management. *Animal Reproduction Science*, *130*, 184–186. https://doi.org/10.1016/j.anireprosci.2012.01.013

Sharun, K., & Erdoğan, G. (2019). A review: Obstetrical emergencies in small ruminants. *Alexandria Journal of Veterinary Sciences*, *62*, 1–16. https://doi.org/10.5455/ajvs.40558

Skladany, J., Balascak, J., & Kiss, M. (1988). Die Torsio uteri als Ursache für Geburtsstockungen beim Schaf (Kurzmitteilung) (Uterus torsion – Cause of obstruction of labour in sheep (brief communication), in German). *Monatshefte für Veterinärmedizin*, *43*, 212–213.

Sobiraj, A. (1994). Geburtsschwierigkeiten bei Schaf und Ziege – Auswertung des Patientenaufkommens aus sieben Ablammperioden an einer geburtshilflichen Klinik (Dystocia in sheep and goats – A survey of seven lambing periods at a clinic for obstetrics, in German). *Deutsche Tieärztliche Wochenschrift*, *101*, 471–476.

Tamm, T. (1997). Untersuchungen zur Gebärmutterverdrehung des Rindes (Studies on uterine torsion in cattle, in German). Dissertation, Tierärztliche Hochschule Hannover.

Tjur, T. (2009). Coefficients of determination in logistic regression models – A new proposal: The coefficient of discrimination. *The American Statistician*, *63*(4), 366–372. https://doi.org/10.1198/tast.2009.08210

Voigt, K., Najm, N. - A., Zablotski, Y., Rieger, A., Vassiliadis, P., Steckeler, P., Schabmeyer, S., Balasopoulou, V., & Zerbe, H. (2021). Factors associated with ewe and lamb survival, and subsequent reproductive performance of sheep undergoing emergency caesarean section. *Reproduction in Domestic Animals*, *56*, 120–129. https://doi.org/10.1111/rda.13855

Wehrend, A., Bostedt, H., & Burkhardt, E. (2002). The use of transabdominal B mode ultrasonography to diagnose intra-partum uterine torsion in the ewe. *The Veterinary Journal*, *164*, 69–70. https://doi.org/10.1053/tvjl.2002.0736

Winter, A. (1999). Dealing with dystocia in the ewe. *In Practice*, *21*, 2–9. https://doi.org/10.1136/inpract.21.1.2

Winzap, B., Bächler, C., & Hässig, M. (2000). Torsio uteri als Differentialdiagnose der Trächtigkeitstoxikose beim Schaf (Torsio uteri as the differential diagnosis for gestational ketosis in sheep, in German). *Schweizer Archiv für Tierheilkunde*, *142*, 391–392.

Zerbe, H., Tamm, T., & Grunert, E. (1998). Zur Problematik der Behandlung der Torsio uteri sub partu beim Rind (Treatment of uterine torsion sub partu in the cow, in German). *Der Praktische Tierarzt, collegium veterinarium*, *28*, 50–53.

How to cite this article: Balasopoulou, V., Zablotski, Y., Zerbe, H., & Voigt, K. (2022). Retrospective analysis of 302 ovine dystocia cases presented to a veterinary hospital with particular attention to uterine torsion. *Veterinary Medicine and Science*, *8*, 1683–1693. https://doi.org/10.1002/vms3.820