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Authors

Luethy, Daniela

Cabrera, Catalina

Coll-Roman, Lisette

et al.

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Multicenter study of factors associated with nonsurvival in hospitalized periparturient goats

Daniela Luethy[1,2] | Catalina Cabrera[1,3] | Lisette M. Coll-Roman[4] | Ashley R. VanderBroek[5] | Anje G. Bauck[1] | Jenna W. Stockler[6] | Clare Scully[7] | Audrey A. Kelleman[1] | Evelyn E. Mackay[8] | Sarah M. Depenbrock[9] | Marie-Eve Fecteau[2] | Michelle Abraham[2] | Laurence Leduc[2] | Charlene V. Noll[10] | Jorge A. Hernandez[1]

[1]Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, Florida, USA

[2]Department of Clinical Studies – New Bolton Center, School of Veterinary Medicine, University of Pennsylvania, Kennett Square, Pennsylvania, USA

[3]University of Nicosia School of Veterinary Medicine, Nicosia 2414, Cyprus

[4]College of Veterinary Medicine, University of Florida, Gainesville, Florida, USA

[5]Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, Michigan, USA

[6]Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Auburn, Alabama, USA

[7]Department of Veterinary Clinical Sciences, School of Veterinary Medicine, Louisiana State University, Baton Rouge, Louisiana, USA

[8]Department of Large Animal Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University, College Station, Texas, USA

[9]Department of Veterinary Medicine and Epidemiology, School of Veterinary Medicine, UC Davis, Davis, California, USA

[10]Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Tennessee, Knoxville, Tennessee, USA

Correspondence
Daniela Luethy, Department of Clinical Studies - New Bolton Center, School of Veterinary Medicine, University of Pennsylvania, Kennett Square, Pennsylvania, USA.
Email: dluethy@upenn.edu

Present addresses
Evelyn E. Mackay, Red Heifer Veterinary Services, Bryan, Texas, USA; and
Laurence Leduc, Université de Montréal Faculté de médecine vétérinaire, Clinical Studies, Saint Hyacinthe, Quebec, Canada.

Abstract

Background: Periparturient reproductive complications appear to be common in hospitalized goats. More information is needed about periparturient reproductive complications and survival in goats with these conditions.

Objective: Identify exposure factors associated with nonsurvival in periparturient does hospitalized ≤1 day or ≥2 days.

Animals: A total of 198 periparturient does presented to 9 university veterinary hospitals from October 2021 to June 2022.

Methods: Multicenter, matched case-control study. Conditional logistic regression was used to identify exposure factors associated with nonsurvival in periparturient does hospitalized ≤1 day or ≥2 days.

Results: Overall doe survival was 79% (156/198). Survival in the 1st day of hospitalization was 71% (52/73) and survival in does hospitalized ≥2 days was 83% (104/125). Among goats hospitalized ≤1 day, labor duration before admission (odds ratio [OR] = 4.8; $P = .04$), uterine tears (OR = 48.2; $P < .001$), and vaginal/perineal trauma diagnosed during hospitalization (OR = 6.2; $P = .03$) were associated with

Abbreviations: BHB, β-hydroxybutyrate concentration; ID, identification; IQR, interquartile range; OR, odds ratio; UT, uterine tear(s); VPT, vaginal/perineal trauma.

nonsurvival. Among goats hospitalized ≥2 days, factors associated with nonsurvival included labor duration before admission (OR = 6.2; $P = .004$), pregnancy toxemia (OR = 6.07; $P = .04$), and Cesarean section (OR = 11.35; $P = .02$).

Conclusions and Clinical Importance: Longer labor duration before admission is an important predictor of nonsurvival in hospitalized does. Clients should be educated that early detection and veterinary care are critical for improving outcome in periparturient does.

KEYWORDS
caprine, dystocia, pregnancy, theriogenology

1 | INTRODUCTION

Goats continue to gain popularity as production animals, pets, and show animals.[1] A concurrent increase in demand for veterinary services also has occurred with a shortage of available small ruminant veterinarians.[2,3] Therefore, tertiary referral hospitals often admit goats for treatment of periparturient conditions, such as pregnancy toxemia and dystocia. The incidence of dystocia in sheep is estimated to be approximately 3%-5%, although a recent and large-scale study in goats has not been performed.[4,5] Despite the frequency of presentation of goats with reproductive emergencies to tertiary referral hospitals, little information is available regarding survival rates and factors associated with nonsurvival in does with periparturient reproductive complications. A multicenter study recently reported the frequency of reproductive complications in periparturient does admitted to referral hospitals.[6] Reproductive complications were common in that study, with 47% of does having at least 1 periparturient reproductive complication. Retained fetal membranes, vaginal/perineal trauma (VPT), uterine tears (UT), and metritis were common complications identified in that study.

As information becomes more readily available regarding complications in periparturient does, additional studies are needed to further understand how these complications impact survival. Our main objective was to identify factors associated with nonsurvival in periparturient does hospitalized ≤1 day or ≥2 days. We hypothesized that labor duration before admission, UT, and pregnancy toxemia would be associated with a higher odds of nonsurvival. Identifying factors associated with nonsurvival is essential for implementing interventions to improve outcome as well as guide clinical decision-making according to prognosis.

2 | METHODS AND MATERIALS

The study was approved by the University of Florida Institutional Animal Care and Use Committee (IACUC 202111491).

2.1 | Study population

Data were collected as part of a multicenter cross-sectional study evaluating reproductive complications in periparturient does admitted to referral hospitals, as previously described.[6] Periparturient does that delivered kids at 1 of 9 university veterinary hospitals (Auburn University Vaughan Large Animal Teaching Hospital, UC Davis Veterinary Medical Teaching Hospital, University of Florida Large Animal Hospital, Iowa State University Lloyd Veterinary Medical Center, Louisiana State University Veterinary Teaching Hospital, Michigan State University Veterinary Medical Center, University of Pennsylvania New Bolton Center, University of Tennessee Charles and Julie Wharton Large Animal Hospital, and Texas A&M University Veterinary Medical Teaching Hospital) in the United States from October 1, 2021 to June 30, 2022 were considered for inclusion. Periparturient does treated for dystocia (assisted vaginal delivery, Cesarean section, fetotomy), or that underwent unassisted kidding during the study period were included.

2.2 | Study design

The investigation was designed as a matched case-control study with a convenience sample size of animals enrolled during the study period. All periparturient does that died or were euthanized during hospitalization (≤1 day or ≥2 days) were classified as cases (nonsurvivors). Does that survived to hospital discharge were defined as controls (survivors). Control does were matched to case does by hospital, admission date ±30 days, and duration of hospitalization (ie, ≤1 day or ≥2 days) with a case: control ratio of 1 : 1 to 1 : 6.

2.3 | Data collection

The following data were collected by the attending hospital veterinarian using a structured questionnaire for each doe: hospital identification (anonymized to hospital identification [ID] A to I for analysis), animal identification, age (years), body weight (kg), breed (Boer, Nigerian Dwarf, Pygmy, other), buck breed, parity (primiparous, multiparous, unknown), duration of labor before hospital admission (hours), admission time (daytime, after hours), clinicopathologic findings (performed based on clinicians' discretion), pregnancy toxemia diagnosis (yes, no), dystocia (yes, no), reason for dystocia, in-hospital vaginal palpation (yes, no), Cesarean section (yes, no), total number of

kids (live and dead) delivered, number of live kids delivered, development of certain complications (UT, metritis, retained fetal membranes, VPT, uterine/vaginal hemorrhage, Cesarean section complications), survival outcome, reason for nonsurvival (when applicable), total days of hospitalization, and total hospital bill ($). Data were collected until hospital discharge; no follow-up was performed beyond hospital discharge.

2.4 | Definitions

Pregnancy toxemia was defined as the presence of ketonemia (blood β-hydroxybutyrate concentration [BHB] ≥1.2 mmol/L), ketonuria (presence of ketones in urine), or both in periparturient does.[7,8] Dystocia was defined as a kidding difficulty score ≥ 3, >30 minutes elapsed between kids, no progress after 2 hours in stage II of labor, or some combination of these. Kidding difficulty score was adapted from cattle and was graded on a scale of 1 to 4 (1 = unassisted, 2 = easy pull by 1 person, no mechanical assistance, 3 = difficult pull by ≥2 people consecutively [indicating a more difficult correction] or mechanical assistance [head snare, ropes], 4 = Cesarean section or fetotomy).[9] Fetal membranes were defined as retained if present >12 hours post-partum.[10] Vaginal or uterine hemorrhage, vaginal or perineal trauma, and metritis were diagnosed by the clinician upon presentation or during hospitalization. Uterine tears were diagnosed based on vaginal palpation, at surgery, or at necropsy. Survival of the doe was defined as survival to hospital discharge. Small breed was defined as Nigerian Dwarf and Pygmy breeds, or mixed breeds containing 1 of these 2 breeds and weighing <30 kg, whereas large breed was defined as Boer, Nubian, and all other breeds.

2.5 | Sample size

Sample size was limited to 17 cases and 49 controls (hospitalization ≤1 day) or 21 cases and 68 controls (hospitalization ≥2 days). In the 1st analysis (hospitalization ≤1 day), the sample size provided 95% confidence and 80% power to identify the observed exposure (%) to labor duration before admission (≥5 hours) among cases (12/15 or 80%) and controls (17/40 or 42%) as relevant and statistically significant. Similarly, in the 2nd analysis (hospitalization ≥2 days), the sample size provided 95% confidence and 80% power to identify the observed exposure (%) to labor duration before admission (≥6 hours) among cases (11/18 or 61%) and controls (12/51 or 23%) as relevant and statistically significant.

2.6 | Statistical analysis

Statistical analysis was performed using standard statistical software (Stata 17.0BE, StataCorp, State College, Texas). For categorical variables, data were reported as observed frequency and percentage. For continuous variables, data were assessed for normality using the Shapiro-Wilk test and visual inspection of histograms. Data were found to be non-normally distributed, and therefore descriptive statistics were reported as median (1st, 3rd quartiles). Characteristics of study does were compared between groups (survivors, nonsurvivors) using the Wilcoxon rank sum test (ie, age, body weight, hospitalization days, total hospital bill, clinical pathology test results) or Chi-squared test (eg, breed).

Univariate conditional logistic regression analysis was used to model the odds of nonsurvival in study does as a function of investigated exposure factors: host factors, before admission, at admission, and during hospitalization. A 1st analysis included case and control does (n = 66) that were hospitalized ≤1 day. A 2nd analysis included case and control does (n = 89) that were hospitalized ≥2 days. For continuous variables, goats were separated into 2 groups based on median distribution of selected variables.

In both analyses, variables with $P \leq .2$ were further examined. When a pair of variables was evaluated by use of a Chi-squared test (2-sided P value <.1), the exposure variable judged most biologically plausible was further examined in the analysis.[11] Because of small sample size, potential confounding and interaction effects among investigated exposure variables on nonsurvival could not be further examined. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to evaluate the magnitude of association between investigated exposure factors and nonsurvival in study does. Values of $P < .05$ were considered significant.

3 | RESULTS

3.1 | Characteristics of study does

One-hundred ninety-eight does were included in the study (Table 1). Median age was 3 years (interquartile range [IQR], 2-5 years). Median hospitalization days for all does was 1 day (range, 0-14). Number of hospitalization days was lower in nonsurvivors (median, 0; IQR, 0-2) than in survivors (median, 1; IQR, 0-3; $P = .02$).

Clinicopathologic findings of 92 does (68 survivors, 24 nonsurvivors) for which clinical pathology data were available are shown in Table 2. Plasma sodium concentration was lower in nonsurvivors than survivors (median, 143 mmol/L; IQR, 141-144 mmol/L vs median, 145 mmol/L; IQR, 143-148 mmol/L; $P = .004$). Plasma chloride concentration was lower in nonsurvivors than survivors (median, 107 mmol/L; IQR, 101-113 mmol/L vs median, 112 mmol/L; IQR, 107-115 mmol/L; $P = .01$). Plasma phosphorus concentration was higher in nonsurvivors than survivors (median, 8.2 mg/dL; IQR, 7.1-11.6 mg/dL vs median, 6.0 mg/dL; IQR, 3.3-7.4 mg/dL; $P = .03$). Although the observed differences were significant, the differences were not believed to be of clinical relevance, and these variables were not explored further.

Cesarean section was performed in 115 does, including terminal Cesarean sections in 4 does. Antimicrobials were administered to 153 goats (77%). Flunixin meglumine was administered to 147 goats (74%). Oxytocin was administered to 72 goats (36%). Antimicrobials and flunixin meglumine were associated with Cesarean section (Chi-squared = 18.85 and 21.31, respectively; $P < .001$) and therefore were not explored further.

TABLE 1 Characteristics of 198 does admitted to referral hospitals for peri-parturient conditions.

Variable	All (n = 198)	Survivors (n = 156)	Nonsurvivors (n = 42)	*P* value
Age (years)[a]	3 (2, 5)	3 (2, 5)	3.5 (2, 5)	.57
Body weight (kg)[a]	37 (25, 61)	36 (25, 60)	44 (25, 72)	.39
Hospitalization days[a]	1 (0, 3)	1 (0, 3)	0 (0, 2)	.02
Total hospital bill ($)[a]	$612 (335, 1015)	$626 (317, 1020)	$606 (397, 862)	.89
Breed[b]				.43
Boer	31 (16)	21 (14)	10 (24)	
Nigerian Dwarf	75 (38)	60 (38)	15 (36)	
Pygmy	32 (16)	26 (17)	6 (14)	
Other	60 (30)	49 (31)	11 (26)	

[a]Data are reported as median (1st, 3rd quartiles).
[b]Data are reported as observed frequencies N (%).
P < .05 indicates statistical significance.

TABLE 2 Clinicopathologic findings of 92 does admitted to referral hospitals for peri-parturient conditions, with hematologic analysis performed based on clinician discretion.

	All (n = 92)	Survivors (n = 68)	Nonsurvivors (n = 24)	*P* value
BHB (mmol/L)	1.6 (0.4-4.6)	1.25 (0.4, 4.4)	4 (0.7, 4.6)	.19
PCV (%)	30 (24-35)	30 (24, 35)	30 (25, 33)	.73
Total Solids (g/dL)	6.6 (5.8-7)	6.5 (5.8, 7)	6.8 (5.9, 7)	.58
Lactate (mmol/L)	4.4 (2.3-7.3)	4.5 (2.3, 6.8)	4.2 (3.2, 8.5)	.62
Sodium (mmol/L)	144 (142-147)	145 (143, 148)	143 (141, 144)	**.004**
Potassium (mmol/L)	3.9 (3.6-4.3)	3.9 (3.6, 4.3)	4 (3.6, 4.3)	.94
Chloride (mmol/L)	110 (106-115)	112 (107, 115)	107 (101, 113)	**.01**
Bicarbonate (mmol/L)	20 (15-23)	20 (17, 23)	16 (15, 25)	.14
Ionized Calcium (mmol/L)	1.12 (1.03-1.21)	1.1 (1.03, 1.2)	1.17 (1.09, 1.28)	.21
Ionized Magnesium (mmol/L)	0.51 (0.47-0.7)	0.51 (0.48, 0.71)	0.46 (0.44, 0.62)	.29
Phosphorus (mg/dL)	7.4 (5.4-9.1)	6 (3.3, 7.4)	8.2 (7.1, 11.6)	**.03**

Note: Data are reported as median (1st, 3rd quartiles). Comparisons between groups made using Wilcoxon rank sum test. *P* < .05 indicates statistical significance (bolded).
Abbreviations: BHB, beta-hydroxy butyrate concentration; PCV, packed cell volume.

Of the 198 goats, 156 (79%) survived to hospital discharge. Of the 42 nonsurvivors, 32 were euthanized and 10 died. When noted, the most common reasons for euthanasia were poor prognosis associated with severe disease (sepsis, UT, neurologic disease) or insufficient client financial resources to treat disease. Of the 10 does that died, 3 died in the preoperative period before Cesarean section, 3 died during hospitalization for unspecified reasons, 2 were noted to be clinically declining cases of pregnancy toxemia, 1 was reported to be in septic shock, and 1 died during Cesarean section (with death attributed to severe sepsis and cardiovascular compromise while under anesthesia).

3.2 | Analysis 1: Exposure factors associated with nonsurvival in does hospitalized for ≤1 day

Seventy-three goats were hospitalized for ≤1 day. Of these 73, 52 survived to hospital discharge (71%) and 21 died or were euthanized (29%). No goats hospitalized for ≤1 day at hospital A, C, or D died, and therefore control goats from these hospitals were excluded from further analysis, resulting in a total of 66 goats (17 cases, 49 controls) for further case-control analysis.

In the univariate analysis, labor duration before hospital admission, admission time, Cesarean section, number of live kids, UT, and VPT during the 1st day of hospitalization had *P* values <.2 and were further examined (Table 3).

Using Chi-squared analysis for correlation between selected exposure variables, admission time was not associated with labor duration before admission ($P = .54$), but was associated with UT during hospitalization, where the frequency of goats with UT was lower in those admitted after hours compared with those admitted during regular hours (10% vs 31%; $P = .06$). Cesarean section during hospitalization was associated with longer labor duration before admission ($P = .06$) and lower number of live kids during hospitalization ($P = .02$). The diagnosis of UT was

TABLE 3 Results of univariate conditional logistic regression analysis of exposure factors associated with nonsurvival in 66 does hospitalized ≤1 day.

Variable	Category	Survival (N = 49)	Nonsurvival (N = 17)	OR	95% CI	*P*
Host factors						
Doe breed	Large	20	6	1.00	Referent	NA
	Small	28	10	1.75	0.43, 7.19	.43
Age (years)	<3	15	8	1.00	Referent	NA
	≥3	34	9	0.53	0.14, 2.06	.36
Weight (kg)	<37	25	9	1.00	Referent	NA
	≥37	24	8	0.95	0.26, 3.45	.94
Buck breed	Large	9	5	1.00	Referent	NA
	Small	23	2	ND	ND	ND
Parity	Primiparous	17	7	1.00	Referent	NA
	Multiparous	24	7	1.14	0.19, 6.88	.89
Factors before admission						
Labor duration before admission (hours)	<5	23	3	1.00	Referent	NA
	≥5	17	12	4.87	1.04, 22.81	**.04**
Manipulation on farm by layperson	No	20	7	1.00	Referent	NA
	Yes	25	8	1.01	0.27, 3.74	.99
Factors at admission						
Admission time	Day time	21	13	1.00	Referent	NA
	After hours	27	4	0.20	0.04, 0.94	**.04**
Pregnancy Toxemia	No	7	3	1.00	Referent	NA
	Yes	1	0	ND	ND	ND
Dystocia	No	3	0	1.00	Referent	NA
	Yes	46	17	ND	ND	ND
Factors during hospitalization						
Total hospital bill ($)	<600	42	14	1.00	Referent	NA
	≥600	7	3	1.19	0.26, 5.32	.82
Cesarean section	No	34	7	1.00	Referent	NA
	Yes	15	10	3.35	0.94, 11.99	.06
No. of total kids	0 to 1	19	9	1.00	Referent	NA
	2 to 6	30	7	0.69	0.19, 2.57	.59
No. of live kids	0 to 1	30	15	1.00	Referent	NA
	2 to 5	19	1	0.17	0.02, 1.39	.10
Uterine Tear	No	44	5	1.00	Referent	NA
	Yes	1	12	48.20	7.45, +INF	**<.001**
Metritis	No	38	6	1.00	Referent	NA
	Yes	6	2	0.54	0.05, 5.65	.61
Retained fetal membranes	No	29	5	1.00	Referent	NA
	Yes	7	1	0.91	0.00, 13.27	.95
Vaginal/perineal trauma	No	36	5	1.00	Referent	NA
	Yes	11	8	6.22	1.21, 31.86	**.03**
Uterine/vaginal hemorrhage	No	46	7	1.00	Referent	NA
	Yes	0	1	ND	ND	ND

Note: $P < .05$ indicates statistical significance (bolded).
Abbreviations: NA, not applicable; ND, not determined.

associated with longer labor duration before admission ($P = .06$) and a diagnosis of VPT during hospitalization ($P < .01$). The diagnosis of VPT was not associated with labor duration ($P = .14$), but was associated with lower number of live kids ($P = .02$) and a diagnosis of UT ($P = .01$). Thus, the exposure factors of labor duration before admission, UT, and VPT were selected for further examination using logistic regression.

Using univariate logistic regression analysis, the odds of nonsurvival were 4.87 times higher in goats with labor duration ≥5 hours before admission than in goats with labor duration <5 hours (95% CI, 1.04-22.81; $P = .04$; Table 3). The odds of nonsurvival were 48.2 times higher in goats with UT (95% CI, 7.45-infinity; $P < .001$) and 6.22 times higher in goats with VPT (95% CI, 1.21-31.86; $P = .03$) than in goats without these conditions.

3.3 | Analysis 2: Exposure factors associated with nonsurvival in does hospitalized for ≥2 days

One-hundred and twenty-five goats were hospitalized for ≥2 days. Of these, 104 (83%) survived to hospital discharge and 21 (17%) died or were euthanized during hospitalization. No goats hospitalized for ≥2 days at hospital D, F, or G died, and therefore goats from these hospitals were excluded from further analysis, resulting in a total of 89 goats (21 cases, 68 controls) for further case-control analysis.

In the univariate analysis, doe breed size, body weight, labor duration before admission, admission time, pregnancy toxemia, total hospital bill, Cesarean section, number of live kids, and metritis during hospitalization had P values <.2 and were further examined (Table 4).

Large doe breed was associated with higher body weight ($P < .01$). Labor duration was not associated with doe breed size ($P = .76$). Admission time and pregnancy toxemia were not associated with labor duration before admission ($P = .5$; $P = .31$). Among investigated exposure factors during hospitalization, hospital bill was associated with Cesarean section ($P = .02$). Cesarean section was associated with small goat breed size ($P = .04$) and pregnancy toxemia ($P = .07$). Higher number of live kids was associated with large goat breed size ($P < .01$), pregnancy toxemia ($P = .09$), and Cesarean section ($P < .01$). Finally, metritis was associated with longer labor duration before admission ($P = .03$) and admission time ($P = .01$). Thus, the exposure factors of labor duration before admission, pregnancy toxemia, and Cesarean section were selected for further examination.

In the univariate analysis, the odds of nonsurvival were 6.21 times higher in goats with longer labor duration (≥6 hours) before admission, compared with those with a shorter labor duration (<6 hours; 95% CI, 1.59-24.14; $P = .004$; Table 4). The odds of nonsurvival were 6.07 times higher in goats diagnosed with pregnancy toxemia, compared with those without pregnancy toxemia (95% CI, 1.14-32.41; $P = .04$). The odds of nonsurvival were 11.35 times higher in goats that underwent a Cesarean section, compared with those that did not (95% CI, 1.47-87.84; $P = .02$).

4 | DISCUSSION

Our multicenter case-control study provides useful clinical information regarding factors associated with nonsurvival of periparturient does during hospitalization. Among study does hospitalized ≤1 day, the odds of nonsurvival were higher in does with longer labor duration (≥5 hours) before admission or with a diagnosis of UT or VPT during hospitalization. In contrast, among study does hospitalized ≥2 days, the odds of nonsurvival were higher in does with a longer labor duration (≥6 hours) before admission, those diagnosed with pregnancy toxemia, and those that underwent Cesarean section during hospitalization. In our study, case and control does were matched by hospital to mitigate potential selection bias.

Regardless of short-term or long-term hospitalization, goats with longer labor duration before admission were at higher risk of nonsurvival. This finding supports the need for early veterinary intervention in does with prolonged labor. Client education regarding the need for early veterinary intervention is crucial for improving outcome in some periparturient goats. Unfortunately, additional information regarding the degree of on-farm veterinary intervention before referral was not obtained in our study.

During preliminary data analysis, differences were observed in the factors associated with survival in goats that died or were euthanized early vs later in hospitalization. Therefore, the data were divided into 2 groups, 1 of which included goats hospitalized ≤1 day, and the other which included goats hospitalized ≥2 days. In doing so, our goal was to provide useful clinical information for clinicians to utilize when assessing prognosis, recognizing that patient factors can change throughout hospitalization. Most goats hospitalized for ≥2 days had a Cesarean section performed (69%) and all but 1 goat with pregnancy toxemia was hospitalized for ≥2 days. Therefore, these 2 variables could have impacted our results and should be further explored in future studies. However, approximately 40% of does hospitalized for ≤1 day also underwent Cesarean sections. Although UT and VPT were associated with nonsurvival to hospital discharge in goats hospitalized ≤1 day, such was not the case for goats hospitalized for >1 day. This finding suggests that, when these complications occur, they often lead to death or euthanasia in the acute period and those that survive surgical repair or clinical management in the acute period could survive long-term, although long-term survival was not assessed in our study. This finding appears to be biased by the fact that clinicians might recommend euthanasia immediately if such complications are detected because of the perceived poor prognosis or substantial client financial investment associated with such conditions. Of the 32 goats with UT, 16 were euthanized upon detection of UT, either intraoperatively or after vaginal examination at admission. Of the 11 goats with UT that had attempts at surgical correction, 10 survived to hospital discharge. Numerous factors likely are associated with survival of goats with UT, such as the severity, chronicity, degree of abdominal contamination, and client financial limitations that could not be fully evaluated in our study. Additionally, because of the design of our study, animals that were discharged but subsequently developed complications could not necessarily be accounted for. We did not collect data beyond hospital

TABLE 4 Results of univariate conditional logistic regression analysis of exposure factors associated with nonsurvival in 89 does hospitalized ≥2 days.

Variable	Category	Survival (N = 68)	Nonsurvival (N = 21)	OR	95% CI	*P*
Host factors						
Doe breed	Large	28	10	1.00	Referent	NA
	Small	36	8	0.41	0.11, 1.46	.16
Age (years)	<3	33	10	1.00	Referent	NA
	≥3	35	11	1.18	0.42, 3.39	.76
Weight (kg)	<37	31	7	1.00	Referent	NA
	≥37	37	14	3.05	0.81, 11.46	.09
Buck breed	Large	9	6	1.00	Referent	NA
	Small	26	6	0.45	0.08, 2.6	.37
Parity	Primiparous	36	7	1.00	Referent	NA
	Multiparous	23	9	1.53	0.39, 5.84	.54
Factors before admission						
Labor duration before admission (hours)	<6	39	7	1.00	Referent	NA
	≥6	12	11	6.21	1.59, 24.14	**.004**
Manipulation on farm by layperson	No	46	16	1.00	Referent	NA
	Yes	19	5	0.74	0.22, 2.49	.63
Factors at admission						
Admission time	Day time	35	17	1.00	Referent	NA
	After hours	28	3	0.25	0.07, 0.96	**.03**
Pregnancy Toxemia	No	17	2	1.00	Referent	NA
	Yes	14	10	6.07	1.14, 32.41	**.04**
Dystocia	No	18	9	1.00	Referent	NA
	Yes	50	12	0.49	0.15, 1.49	.21
Factors during hospitalization						
Hospitalization days	1-2	32	8	1.00	Referent	NA
	>2	32	11	1.45	0.48, 4.36	.51
Total hospital bill ($)	<600	20	4	1.00	Referent	NA
	≥600	48	17	4.37	0.89, 21.35	.07
Cesarean section	No	28	2	1.00	Referent	NA
	Yes	40	19	11.35	1.47, 87.84	**.02**
No. of total kids	0 to 1	29	10	1.00	Referent	NA
	2 to 6	39	11	0.89	0.30, 2.68	.84
No. of live kids	0 to 1	43	18	1.00	Referent	NA
	2 to 5	25	3	0.33	0.09, 1.24	.10
Uterine Tear	No	52	14	1.00	Referent	NA
	Yes	9	3	0.95	0.20, 4.43	.95
Metritis	No	60	11	1.00	Referent	NA
	Yes	7	4	3.04	0.72, 12.91	.13
Retained fetal membranes	No	42	10	1.00	Referent	NA
	Yes	17	6	2.01	0.51, 7.91	.32
Vaginal/perineal trauma	No	57	15	1.00	Referent	NA
	Yes	8	0	ND	ND	ND
Uterine/vaginal hemorrhage	No	64	13	1.00	Referent	NA
	Yes	2	2	2.81	0.35, 22.58	.33

Note: $P < .05$ indicates statistical significance (bolded).
Abbreviations: NA, not applicable; ND, not determined.

discharge, and this factor might have impacted the frequency of certain complications seen in our study, such as retained fetal membranes and metritis.

In goats hospitalized ≥2 days, labor duration before admission, pregnancy toxemia, and Cesarean section were associated with a higher risk of nonsurvival to hospital discharge. Although an association was found between Cesarean section and nonsurvival in goats hospitalized for ≥2 days, the overall survival rate of goats that underwent Cesarean section was 72% (83 of 115 goats that underwent Cesarean section survived to hospital discharge), but this association might have been negatively affected by the frequent complications of goats in our study. Overall survival to hospital discharge was 79%, which varied slightly from 71% in goats hospitalized for ≤1 day to 83% in goats hospitalized ≥2 days. This survival frequency is similar to what has been reported previously in other ruminants. A previous study of goats and sheep undergoing Cesarean sections reported a similar survival rate of 81%.[12] Beef cattle undergoing Cesarean section had a survival rate of 93% in 1 study.[13] Goats with pregnancy toxemia in another study were reported to have a 70% survival rate.[7]

Our study had several limitations. First, although the study population included periparturient does from 9 hospitals, the sample size was small, which prevented a more robust epidemiologic analysis that could adequately measure potential confounding or interaction effects of explanatory variables on the outcome of interest (nonsurvival). Second, because our study only involved university veterinary hospitals, the data are likely biased toward more severely affected animals and might have failed to include goats with normal parturition or dystocia managed by the owner or local veterinarian. Therefore, our data does not represent the survival of periparturient goats in the general caprine population, and the general population should be evaluated in the future. Additionally, goats that developed complications after hospital discharge might not have been captured by our study because animals were not followed beyond hospital discharge. Finally, a major limitation of veterinary survival studies is the impact of client finances on decision-making and outcomes. Furthermore, in a multicenter study, regional impacts of finances on outcomes could have been present. Therefore, we collected information on total hospital bill for transparency and to evaluate for association with outcome when interpreting results.

Our study supports the need for early veterinary intervention in does with prolonged labor duration before admission. Additionally, does diagnosed with UT or those that undergo Cesarean section during hospitalization are less likely to survive, but can still survive with attempted treatment. In cases in which animals are financially or emotionally valuable and clients are committed to treatment, complications such as UT might not always result in poor outcome. Clients should be educated that early veterinary intervention is critical for improving outcome in periparturient does. Clients also should be advised that a recent history of labor duration of ≥5 hours might result in worse outcome for that particular patient, although further investigation of additional confounding factors is needed. Future studies should aim to enroll a larger number of animals to adequately assess potential confounding and interaction effects of selected exposure factors on non-survival in periparturient does during hospitalization.

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CONFLICT OF INTEREST DECLARATION

Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION

Anti-microbials were administered to goats included in this study, but descriptions of which antimicrobials and how used are not included in this manuscript.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Approved by the University of Florida IACUC (IACUC 202111491).

HUMAN ETHICS APPROVAL DECLARATION

Authors declare human ethics approval was not needed for this study.

ORCID

Daniela Luethy https://orcid.org/0000-0003-1693-2147
Catalina Cabrera https://orcid.org/0000-0003-3802-406X
Jenna W. Stockler https://orcid.org/0000-0002-6502-7445
Sarah M. Depenbrock https://orcid.org/0000-0002-3481-776X
Laurence Leduc https://orcid.org/0009-0005-6676-7137
Jorge A. Hernandez https://orcid.org/0000-0002-3096-4762

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