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Retrospective analysis of factors associated with umbilical diseases in foals

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ABSTRACT

In neonatal foals, umbilical remnants can be affected by infectious and non-infectious diseases. This study aimed to retrospectively evaluate historical, management and clinical factors that may be related to the occurrence of umbilical remnant diseases. Clinical reports of foals born or hospitalized within 24 h of life during the 2017–2021 foaling seasons were reviewed. Forty/183 foals (21.9 %) developed umbilical remnant diseases (URD group), while 143/183 foals (78.1 %) had normal umbilical remnants (NUR group). In the URD group, 24/40 (60 %) had a patent urachus, 16/40 (40 %) omphalo-arteritis, 4/40 (10 %) omphalo-phlebitis, 10/40 (25 %) urachitis, 9/40 (22.5 %) abscess, 3/40 (7.5 %) periumbilical hematoma and 12/40 (30 %) more than one condition. URD frequency was higher in foals hospitalized after birth than in those born at the hospital (17/46 vs 23/137; $P = 0.0068$), lower in those that had access to the paddock before three days of life ($p = 0.0426$) and higher in recumbent foals ($P = 0.0001$). URD occurred more frequently after dystocia ($P = 0.0068$), prolonged stage II parturition (19±20.51 min vs 13±6.41 in NUR group; $P = 0.0279$), traction at parturition ($P = 0.0005$), and in foals with lower APGAR scores (8±1.72 vs 9±0.86 in NUR; $P = 0.0063$). Sepsis ($P = 0.0245$), neonatal encephalopathy ($P = 0.0014$), meconium retention ($P = 0.0241$) and congenital flexural limb deformities ($P = 0.0049$) were the most common associated diseases. Umbilical cord (UC) coiling, abnormal UC rupture, umbilical hemorrhage and increased umbilical stump volume occurred more frequently in URD than in NUR group ($P = 0.0329$, $P = 0.0191$, $P = 0.0007$ and $P < 0.00001$, respectively). Recognition of the identified predisposing historical, management and clinical factors should prompt careful umbilical remnant monitoring in neonatal foals.

1. Introduction

In the equine species, umbilical remnants (UR) include: the umbilical vein that runs cranially and regresses to become the round ligament of the liver [1], the umbilical arteries that run along both sides of the bladder and atrophy to become the two round ligaments of the bladder [1–4], the urachus that connects the bladder to the allantoic compartment during intrauterine life and regresses to form the middle ligament of the bladder [2,3,5], and the surrounding soft tissues. All these structures can be affected by infectious and non-infectious diseases [6]. These represent common findings in newborn foals [7], especially those younger than 8 weeks of age [8]. Occasionally they can also affect older foals [9]. Patent urachus, urachitis, omphalo-arteritis/phlebitis, and umbilical hernia represent the most frequent diseases [4]. Other less frequent diseases include urachal rupture, urachal diverticulum and urachal cysts, hemorrhages/periumbilical hematomas/seromas and omphalocele [4,10,11]. For management of the UR, a complete clinical examination of the foal should be performed during the first days of life, including observation and daily palpation of the umbilical stump [12]. Since UR diseases are not always evident on clinical examination, it may be necessary to proceed with diagnostic methods, such as transabdominal ultrasound [1,4,13,14]. Umbilical remnant diseases can be an important cause of morbidity in neonatal foals and, if left untreated, complications related to the dissemination of UR bacteria can develop [8,15,16]. Complications can include localized infections such as uveitis, pneumonia, meningitis, osteomyelitis or septic arthritis [4,17,18], peritonitis [19], hepatitis and abscess formation [20], uroperitoneum [4], septicaemia and bacteraemia [19,21,22], and umbilical abscesses [23]. Treatment can be medical and consists of the administration of broad-spectrum antibiotics, which must be continued for a prolonged period, or surgical with the removal of the UR, described as a successful technique [16,24,25].

The aim of this study was to retrospectively evaluate historical, management and clinical factors that may influence the occurrence of

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UR diseases in neonatal foals born/hospitalized at a Veterinary Teaching Hospital.

2. Materials and methods

2.1. Ethical approval

This study was reviewed and approved by the Animal Care and Use Committee of Bologna University (Approval number, 288242; Approval date, 10 November 2022).

2.2. Clinical data

Medical reports of 183 foals and their mares born or hospitalized within 24 h of life at the Equine Perinatology Unit (EPU, Equine Clinical Service, DIMEVET, University of Bologna, Italy) during 2017–2021 foaling seasons were reviewed.

All the hospitalized foals were retrospectively divided into two groups: normal umbilical remnant (NUR) and umbilical remnant diseases (URD). The following data were recorded for each mare: breed, age (years), parity, length of pregnancy (days), eutocic or dystocic parturition. Dystocia was defined as any impediment of the normal parturition due to complications of maternal, fetal or fetal membranes origins [26]. For the foaling at EPU these data were also recorded: traction during stage II parturition, length of stage II parturition (min) and foal's APGAR score [27].

The following data were recorded for each foal: sex, age at the onset of URD (days) and weight (kg). For foals admitted after birth, the age at admission (hours) was recorded. All foals underwent a complete physical examination, which included inspection and palpation of the umbilical stump, complete blood count (ADVIA 2120 hematology analyzer, Siemens Healthcare srl, Milan, Italy), serum biochemistry (AU 400 analyzer, Olumpus/Beckman Coulter, Lismeehan, Ireland) and fibrinogen concentration (BCS XP coagulation analyzer, Siemens Healthcare srl, Milan, Italy). For all foals, IgG serum concentration at 12–24 h of life (immunoturbidimetric method; DVM Rapid Test II, MAI Animal Health, Elmwood, WI, USA) was also measured. An ultrasound evaluation of UR was performed using a 13-3 MHz linear transducer (tendon format) at six short-axis (transverse) views of the umbilical structures at predetermined points, according to a standardized protocol [28] and then repeated every 3 days until discharge.

Data on the management of the umbilical cord (UC) and umbilical stump were recorded, including the possible occurrence of umbilical bleeding, ligature/clamping, and the type of UC rupture (physiological/abnormal rupture). The UC rupture was defined as physiological when it occurred after the end of stage II parturition, following the movements of the foal and mare [6,29], and abnormal when a premature or manual rupture occurred [6,29]. Regarding the macroscopic examination of the fetal membranes, total weight (Kg), pregnant horn (right or left), total UC length (cm), number of UC coils, umbilical coiling index (UCI) defined as umbilical coils to the total length of the UC [30], site of UC insertion (base of the non-gravid horn/base of the gravid horn/in the middle of the gravid horn/between the two horns) [31] and type of vasculature pattern (I, II, III or other) [32] were recorded.

For foals hospitalized after birth, the type of protocol and product used at the breeding farm for umbilical disinfection (iodine tincture 2 %/spray products/chlorhexidine) were recorded. During the hospitalization at the EPU, all foals received a standardized protocol of umbilical stump disinfection: from 2017 to 2018, 2 % iodine tincture three times a day for the first 3 days of life (protocol 1); from 2019 to 2021 the same 2 % iodine tincture three times on day 1, twice on day 2 and once on day 3 (protocol 2). The loss (drop) of the umbilical stump (days of life) was recorded. Any abnormality of the external appearance of the umbilical stump during the entire observational period, such as an increased volume and/or a wide umbilical ring [33], was reported only if it was consistently detected by the clinicians.

In the URD group, presence of pyrexia, diagnosis and type of treatment of umbilical disease (medical or surgical) were also recorded. The factors that were considered for the diagnosis, resolution of the URD by medical treatment or those taken into account to decide for surgical removal were a complete physical evaluation, which included a thorough assessment of the stump, and ultrasonographic findings.

The presence or development of diseases, other than URD, were recorded: prematurity [34]; sepsis [35,36]; neonatal encephalopathy (NE) [37]; meconium retention [38]; congenital flexural limb deformities [39,40]. For all foals recumbency (days), failure of passive transfer of immunity (FPT), defined as serum IgG concentration <800 mg/dL [41] and access to the paddock (days after birth) were also recorded.

2.3. Statistical analysis

The data distribution was analyzed using the Kolmogorov-Smirnov test. Most of the data were not normally distributed and for this reason, non-parametric tests were used. The data are presented as median, interquartile range (IQR). Group comparisons (NUR group and URD group) for quantitative variables were performed using a Mann-Whitney test. Categorical variables association were tested using the chi-square test ($\chi 2$). The results were considered significant at $P < 0.05$. Analysis-it software for Microsoft Excel 5.68 was used for data analysis (www.analyse-it.com).

3. Results

In total 183 foals were included: one hundred forty-three/183 (78.1 %) in the NUR group and 40/183 (21.9 %) in the URD group. Breeds recorded included: Standardbred ($n = 123$, 67.2 %), Italian Saddlebred ($n = 21$, 11.5 %), Quarter Horse ($n = 11$, 6 %), Arabian ($n = 8$, 4.4 %), Koenigin Warmblood Paard Netherland ($n = 7$, 3.8 %), Holstein ($n = 3$, 1.6 %), Hannover ($n = 2$, 1.1 %), Paint Horse ($n = 2$, 1.1 %), Italian Draft Horse ($n = 2$, 1.1 %), and one of each for Appaloosa, Belgian Saddlebred, Wurttenberger and Mixed breed.

One hundred and thirty-seven/183 foals (74.9 %) were born at the EPU from mares hospitalized for attended parturition, while 46/183 foals (25.1 %) were admitted to the hospital within 24 h of life with an average age of 13±5 h. One hundred and eighteen/137 mares (86 %) had normal pregnancies, while 19/137 (14 %) had high risk pregnancies; forty/46 (87 %) had normal pregnancies while 6/46 (13 %) had high risk pregnancies.

Forty/183 foals (21.9 %) developed URD ($n = 66$), while 143/183 (78.1 %) had NUR. The frequency of URD was higher in foals hospitalized after birth than in those born at the EPU (17/46 vs 23/137; $P = 0.0068$). The average age of the onset of URD was 6 ±5 days (0–18 days) for foals born at EPU and 6±4 days (1–17) for foals admitted after birth. Twelve/40 foals (30 %) had more than one disease concurrently; making a total of 66 umbilical diseases that were considered singularly. Twenty-four/66 diseases (36.3 %) were patent urachus, 16/66 (24.2 %) omphalo-arteritis, 4/66 (6.06 %) omphalo-phlebitis, 10/66 (15.1 %) urachitis, 9/66 (13.6 %) abscess and 3/66 (4.5 %) periumbilical hematoma. Thirteen/40 foals (32.5 %) showed pyrexia during hospitalization. The most common concomitant diseases, conditions and foal management factors associated with URD are presented in Table 1.

Regarding the mares, no influence/effect of the age, parity or length of pregnancy (Table 2) on the development of URD was found. The type of parturition was available for 157/183 foals (85.8 %) and 54/157 (34.4 %) were born from an abnormal parturition. URD was more frequent after dystocia ($p = 0.0068$). Data regarding the types of dystocia are reported in Table 3.

Data regarding parturition of mares hospitalized for attended delivery and foal Apgar score are shown in Table 4.

Among all the foals, 83/183 (45 %) had access to the paddock during hospitalization. Forty-seven/83 foals (56.6 %) had access to the paddock

Table 1
Concomitant diseases, conditions and foal management in the two groups (NUR, normal umbilical remnants; URD, umbilical remnant disease). For qualitative variables (concomitant diseases, failure of passive transfer diagnosis and recumbency), data are expressed as number (%). For quantitative variables (days in recumbency, first access to the paddock), data are expressed as median (IQR).

	NUR (n = 143)	URD (n = 40)	P value
Prematurity (n = 6)	4 (2.2 %)	2 (1.1 %)	–
Sepsis (n = 9)	4 (2.2 %)	5 (2.7 %)	P=0.0245
NE (n = 31)	17 (9.3 %)	14 (16.9 %)	P=0.0014
Meconium retention (n = 15)	8 (4.4 %)	7 (3.8 %)	P=0.0241
Flexural limb deformities (n = 12)	5 (2.7 %)	7 (3.8 %)	P=0.0049
FPT (n = 52)	38 (20.8 %)	14 (7.7 %)	–
Recumbency (n =43)	23 (12.6 %)	20 (10.9 %)	P=0.0001
Days in recumbency	4 (4) n = 23	3 (6.46) n = 20	–
First access to the paddock (days of life) (n = 83)	3 (2) n = 60	5 (4.8) n = 23	P=0.0426
Foal weight at birth/hospitalization (Kg)	46 (12) n = 142	46 (12) n = 40	–

NE, neonatal encephalopathy; FPT, failure of passive transfer of immunity.

Table 2
Age, parity and length of gestation of mares in the two groups (NUR, normal umbilical remnants; URD, umbilical remnant disease). Data are expressed as median (IQR).

	NUR	URD
Age (year)	10 (7.6) n = 140	10.5 (7) n = 38
Parity	2 (4) n = 127	2 (3) n = 35
Lenght of gestation (days)	338 (14) n = 131	335 (15) n = 37

Table 3
Types of dystocia in foals born at EPU in the two groups (NUR, normal umbilical remnants; URD, umbilical remnant disease). For qualitative variables (causes of dystocia), data are described as number (%).

Dystocia causes (n =54)	NUR (n =35)	URD (n = 19)
Maternal (n = 18)	14 (25.9 %)	4 (7.4 %)
Fetal (n = 15)	9 (16.7 %)	6 (11.1 %)
Fetal membranes (n = 6)	2 (3.7 %)	4 (7.4 %)
Mixed (n = 15)	10 (18.5 %)	5 (9.3 %)

Table 4
Data regarding parturition of mares hospitalized for attended delivery and foal Apgar score in the two groups (NUR, normal umbilical remnants; URD, umbilical remnant disease). For quantitative variables at birth of foals born at EPU (duration of stage II parturition, APGAR score), data are expressed as median (IQR). For qualitative variables (manual traction), data are expressed as number (%).

	NUR	URD	P value
Duration of stage II parturition (min)	12 (7.8) n = 111	16.5(13.3) n = 22	P=0.0279
Manual traction (n = 49)	33/49 (67.3 %)	16/49 (32.7 %)	P=0.0005
APGAR score at birth	9 (1) n = 112	9 (2) n = 22	P=0.0063

before the third day of life and 54/83 foals (65 %) had access to the paddock within 3–5 days of life. There was a lower frequency of umbilical diseases in foals that had access to the paddock before the third day of life (8/47 URD, 39/47 NUR group; P = 0.0134).

Macroscopic examination of the fetal membranes of 141/183 foals (77 %) was performed: 4/141 were from foals admitted after birth while 137/141 were from foals born at EPU. Data regarding fetal membranes were reported in Table 5, and data regarding umbilical management after birth in Table 6.

For 175/183 foals (95.6 %) it was possible to obtain information on the disinfection of the umbilical stump at birth. Among them, 152/175 (86.9 %) received disinfection with iodine tincture, 14/175 (8 %) with spray products and 9/175 (5.1 %) did not receive any disinfection. After birth/hospitalization, 174/183 foals (95.1 %) received one of the two standardized disinfection protocols: protocol 1 used in 70/174 foals (40.2 %) and protocol 2 in 104/174 (59.8 %). The chi-square test did not detect an increased incidence of URD in relation to different disinfection protocols.

Medical treatment was successful for complete resolution in 28/40 foals (70 %), while surgical remnant removal was required in 12/40 (30 %): in particular, 5/11 had an umbilical abscess, 3/11 omphalitis, 1/11 patent urachus, 2/11 omphalo-arteritis and 1/11 periumbilical hematoma.

4. Discussion

This is the first study that analysed in detail the clinical significance of several factors in a large population and several historical, managemental and clinical factors that could influence the occurrence of umbilical remnant diseases in neonatal foals were identified. Umbilical remnant diseases were more frequent in foals hospitalized after birth than in those born from mares admitted for attended parturition. However, is should be noted that foals born at EPU were mostly healthy foals born from normal pregnancies, while foals admitted after birth were all sick. This study found that the presence of systemic disease influenced the occurrence of URD, in fact, the incidence of URD was 37 % considering all sick foals. Other studies revealed an incidence of 0.71

Table 5
Data on umbilical cord and placenta in both foals born at EPU and hospitalized after birth in the two groups (NUR, normal umbilical remnants; URD, umbilical remnant disease). BGH, base of the gravid horn; BNGH, base of the non-gravid horn; MGH, midway of the gravid horn; BH, between horns. For quantitative variables (total weight, total length of the UC, coils numbers, UCI), data are expressed as median (IQR). For qualitative variables (gravid horn, type of vascularization, site of UC insertion), data are expressed as number (%).

		NUR	URD	P value
Total weight (Kg)		5 (1.64) n = 141	5.75 (2.24) n = 38	–
Total length of UC (cm)		55 (13.3) n = 135	60 (21) n = 20	–
Coils of UC (n)		5 (1) n = 124	6 (3) n = 20	P=0.0329
UCI		0.09 (0.024) n = 123	0.094 (0.042) n = 20	–
Gravid horn (n=56)	Right	26 (46.4 %)	6 (10.7 %)	–
	Left	20 (35.7 %)	4 (7.1 %)	–
Vascularization of the placenta (n = 57)	Type I	33 (57.9 %)	8 (14.3 %)	–
	Type II	7 (12.3 %)	0	–
	Type III	2 (3.5 %)	0	–
	Other	6 (10.5 %)	1 (1.8 %)	–
Site of UC insertion (n = 114)	BGH	17 (14.9 %)	2 (1.8 %)	–
	BNGH	13 (11.4 %)	1 (0.9 %)	–
	MGH	0	0	–
	BH	66 (57.9 %)	15 (13.2 %)	–

Table 6
Management of umbilical cord and umbilical stump in the two groups (NUR, normal umbilical remnants; URD, umbilical remnant disease). For quantitative variables (days with umbilical clip, loss of the umbilical stump in days), data are expressed as median (IQR). For qualitative variables (abnormal rupture, umbilical haemorrhage, umbilical clip, ligature with inadequate materials, disinfection at birth, wide umbilical ring, increased umbilical volume), data are expressed as number (%).

	Population (*n*)	NUR	URD	*P* value
Abnormal rupture ($n = 18$)	148	11 (7.4 %)	7 (4.7 %)	P=0.0191
Umbilical hemorrhage ($n = 34$)	183	19 (10.4 %)	15 (8.2 %)	P=0.0007
Umbilical clip ($n = 20$)	183	13 (7.1 %)	7 (3.8 %)	–
Days with umbilical clip	16	2 (1.5) $n = 11$	2 (1.33) $n = 5$	–
Ligature with inadequate material ($n = 5$)	183	2 (1.1 %)	3 (1.6 %)	–
Disinfection at birth ($n = 166$)	175	132 (75.4 %)	34 (19.4 %)	–
Wide umbilical ring ($n = 39$)	179	29 (16.2 %)	10 (5.6 %)	–
Increased umbilical stump volume ($n = 56$)	183	31 (16.9 %)	25 (13.7 %)	P<0.00001
Loss of umbilical stump (days)	57	7 (5.1) $n = 30$	8 (4.8) $n = 27$	–

% in foals aged 0–30 days [42] and 16.6 % in foals from birth up to 12 months of age [43].

In the present study, foals with URD were all in the same group and were not divided on the basis of different URD because of the low representativeness of some of them. Moreover, it is not always possible to understand which disease is the main/primary, as they frequently occur concurrently. In the population examined, the most common umbilical diseases were patent urachus, followed by omphalo-arteritis, urachitis, umbilical abscess, omphalo-phlebitis, and periumbilical hematoma, in contrast to the literature in which urachitis was the most frequently reported condition [8,22,44]. In addition, 30 % of foals had more than one disease at the same time, reflecting the fact that the contiguity between the umbilical structures could predispose to an easy spread of the infection [6,18].

Data regarding pyrexia were consistent with the literature: in fact, it was not a constant clinical sign in foals with URD [1,45,46]. It is noteworthy that for 70 % of the URD foals, the conservative treatment which mainly includes exercise and the use of antibiotics in case of infection, was sufficient for URD resolution according to clinical, hematobiochemical and ultrasonographic parameters. Reimer [47] successfully described the medical treatment, which only in rare cases was replaced by surgical removal of residues. The reluctance to adopt surgery derives from the risks it entails, including general anaesthesia in foals suffering from local or systemic diseases, the possible development of secondary adhesions due to laparotomy [46], incisional edema/infection, dehiscence of the surgical suture and peritonitis [6,48]; the presence of septic arthritis, in foals after surgical removal of pathological umbilical remnants, appears to be a factor predisposing to high mortality [16,24]. In addition, there are situations where the extension of the infection, especially if the umbilical vein is involved, can prevent a complete excision of pathological tissues, unless an invasive surgical procedure is used, leading to a worsening of the prognosis [4,8]. Despite this, the surgical approach is sometimes described as the preferred strategy for treating UR infections [6].

Neonatal diseases that showed an association with the onset of URD were sepsis, neonatal encephalopathy, meconium retention and congenital flexural limb deformities. Sepsis has been reported as a cause or consequence of UR diseases, as the umbilical stump can act as a gateway for pathogens or represent a secondary site of pathogen spread from blood to body tissues [21]. Meconium retention could predispose to patent urachus or acquired reopening of urachus, as it causes tenesmus and increase abdomen pressure and volume [45,49].

In this study, the frequency of occurrence of URD was higher in foals in recumbency, as this situation exposes the umbilical stump to contamination, in addition to the fact that the foal cannot urinate physiologically, and this increases the risk of reopening the urachus [45]. Neonatal encephalopathy and congenital flexural limb deformities are often associated with the inability to stand [37,39], so they are forced to recumbency for a variable period of time.

URD occurred more frequently in foals with lower Apgar score. The APGAR score is used to evaluate foals' vital functions at birth and identify conditions of asphyxia and stress [50], therefore, the significance of this parameter may be an indirect consequence of other parameters, such as dystocia or the presence of a concomitant disease that will subsequently predispose the foal to recumbency.

Of all the data collected during parturition, URD occurred more frequently after a longer stage II parturition, which may require manual traction, or after dystocia. Manual traction during parturition is used in the equine species and should not be associated with consequences for the foal if it is performed correctly (in synergy with mare's contractions by pulling the foal's limbs towards mare's hocks) [51]. In the population examined, foals were more susceptible to URD even if the procedure was performed correctly; therefore, obstetric interventions should only be performed if strictly necessary [26,29]. Dystocia could result from maternal, fetal or fetal membrane causes [26]; individually, none of these had a significant influence on the occurrence of URD. Perhaps the influence of dystocia is attributable to obstetric interventions which can lead to traction and trauma on the UC. However, due to low representativeness of some types of dystocia (especially related to fetal membranes), it would be interesting to evaluate them in a larger population.

In this study, excessive coiling but not, the UC length were associated with the development of URD. The excessive coiling of the UC has already been studied in the literature as a predisposing factor for URD [52], while the influence of the coils has not been evaluated. A high number of coils could potentially affect the urachus, which has a thin wall, and can be partially obstructed; the points of sub-occlusion could result in dilation of the urachus lumen, which will require more time to regress, thus representing a potential entry point for bacteria and predisposing to persistent urachus [53].

In this study, URD were more frequent in foals suffering from umbilical bleeding after UC rupture. The presence of blood inside the vessels could prevent proper involution of the structures, also representing an excellent substrate for bacterial growth [45]. Surprisingly, neither the placement of an umbilical clip, nor the ligature with inadequate material were associated with URD, but only five foals received an inappropriate ligature, so this parameter should be investigated in a larger population. Abnormal umbilical cord rupture has frequently been associated with the onset of URD [3,18,52]. In the present study, the manual rupture of the UC was considered abnormal, as well as its premature rupture during stage II parturition. Physiologically, after stage II parturition, UC remains intact for a variable period and its vessels continue to pulse for several minutes [54]. UC rupture occurs as a result of the tension caused by foal' movements or when the mare stands after birth [6,29,55]. In this species, the UC is provided with a sphincter extending from the abdomen to its junction with the amnion, composed of a smooth circular musculature that is able to narrow the lumen of the vessels and a longitudinal musculature that occludes them; however, the latter is stimulated to contraction only by the stretching that comes from the foal and the mare [56]. Perhaps the abnormal rupture could interfere with the proper retraction of tissues, delaying the regression of umbilical structures.

Umbilical disinfection at birth and the use of different protocols for disinfection in the following days did not influence the onset of umbilical diseases. However, in this study even foals that have not received a stump disinfection at birth underwent a disinfection protocol once

hospitalized; therefore, this data should not be considered sufficient to underestimate the importance of disinfection. URD frequency was higher in foals showing an increase of volume of the umbilical stump, consistently with the literature [1,6,18,44,46], but not in those with wide umbilical ring, confirming that the abdominal wall defect is a fairly frequent finding in the newborn foal, often resolving within the first days of life [57].

Regarding access to the paddock, some authors had already mentioned that the restriction of movement is a possible predisposing factor for URD [58]; physical activity is excellent for the activation and strengthening of the abdominal musculature, as demonstrated in the adult horse [59], which suggests that it also has a beneficial effect on the neonatal foal for the involution of umbilical remnants. The present study supported the potential benefit of early access to the paddock, especially before the third day of life.

5. Conclusion

Several historical management and clinical factors were associated with a URD. Umbilical characteristics, such as UC coiling, cord haemorrhage, dystocia and related diseases, which often force the foal to recumbency, may be considered predisposing factors, although they cannot be predicted. However, factors such as manual traction during parturition, duration of stage II parturition, access to the paddock and abnormal UC rupture, which have not been evaluated before, should be taken into consideration for proper foal management during parturition and in the first days of life, in order to reduce the risk of umbilical disease.

Ethical statement

The study “Retrospective analysis of factors associated with umbilical diseases in foals” was reviewed and approved by the Animal Care and Use Committee of Bologna University (Approval number, 288242; Approval date, 10 November 2022).

Preliminary results were presented as a Poster at the 1st European Symposium on Animal Reproduction, Nantes, 21–23 September 2023.

CRediT authorship contribution statement

F. Perina: Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision. **J. Mariella:** Conceptualization, Methodology, Software, Validation, Formal analysis, Resources, Data curation, Writing – review & editing. **N. Ellero:** Investigation, Writing – review & editing. **F. Freccero:** Writing – review & editing. **C. Castagnetti:** Investigation, Resources, Writing – review & editing. **A. Lanci:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – review & editing, Visualization, Project administration.

Declaration of competing interest

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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