THESIS OF DOCTORAL (PhD) DISSERTATION

SURVEY OF THE BIRTH CONDITIONS AND IMMUNE STATUS OF FOALS

WRITTEN BY:

LUCA LAURA KUMMER

MOSONMAGYARÓVÁR

2019

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SZÉCHENYI ISTVÁN UNIVERSITY
FACULTY OF AGRICULTURAL AND FOOD SCIENCES

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1. INTRODUCTION AND OBJECTIVES

The keeping of broodmares can become economical if they deliver a healthy foal every year. The length of pregnancy has great economic importance: broodmares with a longer gestation period will have a reduced chance for being rebred successfully within the given season. The objective of the foaling protocol is to prepare the broodmare for parturition, to conduct the delivery process in a professional manner, to provide care to the newborn foal, and to notice emergency situations in due time. Therefore, human presence during the foaling process is justified, as the possible complications, if any, may have fatal outcome for both the mare and the newborn foal.

By observing the physical and behavioural changes of mares the foaling time can be predicted more easily, and thus increased attention can be paid to the mare and her fetus in the terminal phase of pregnancy.

It is essential to assess the risk status of newborn foals and to determine the optimal time and degree of human intervention. Samples easily obtainable from healthy newborn foals (blood, urine) and parameters that can be measured by simple methods (heart rate, respiratory rate) provide a lot of useful information for the breeder already in the first hour of life; for this reason, reference values of these parameters are needed when assessing the health status of newborn foals.

The use of not too expensive adjunctive instruments (refractometer, on-field rapid tests for checking the immune status of foals) is also a great help for the breeders.

The possibly occurring complications of placental origin can cause substantial losses with regard to both the broodmare and the newborn foal. Therefore, the present dissertation calls attention to the importance of performing regular and thorough examinations of the equine placenta, as well.

In this study, we wished to answer the following questions:

1. How and based on the combination of which factors can the foaling time be predicted more accurately?
2. Can we obtain more accurate result in assessing the viability of foals by the modification of the so-called 'vitality test'?
3. How favourable or unfavourable is human intervention during an uncomplicated foaling? Where are the points of risk that determine the necessity of intervention?
4. What values can be expected when performing rapid tests of routine laboratory samples (blood and urine) taken from healthy newborn foals?
5. What are the values of respiratory rate and heart rate in the first moments after birth, and how do their values change in the first 8 hours?

6. How should the placenta be examined, and why would it be expedient to incorporate placental examination into the foaling protocol?

7. How reliable is colostral refractometry in determining the immunoglobulin content of the colostrum?

8. How reliable are the rapid tests done on mares with imminent foaling, mares in labour or recently foaled mares and on newborn foals) and which of them can be recommended into the foaling protocol of stud farms?

2. MATERIALS AND METHODS

We collected and compared the data of foaling seasons in a total of 7 years from 2009 to 2012 and then from 2014 to 2016, in stud farms keeping different horse breeds (Kisbéri, Gidran, Hungarian Coldblood, Arabian, Hungarian and Western Sports Horse) under different management technology systems (outdoor keeping, free-stall housing or box system), using different feeding technologies and applying different animal health protocols.

In the first four years we examined the times of foaling, the conditions of births, certain vital functions of the newborn foals and the time of placental expulsion, and compared these data in the different horse breeds included in the study.

In years 5 and 6, in addition to the data listed above, we observed and scored the physical (udders, teats, vulvar lips, flank, tailhead, oedema) and behavioural changes of the mares. To monitor these changes, each trait was scored from 0 to 3 during the evaluation of mares. From the newborn foals we took blood samples three times during the first 8 hours of life (at times T_0, T_1 and T_2, i.e. at 0, 4 and 8 hours of age). In addition, the newborn foals were subjected to the so-called 'vitality test' and their first urine was also analysed. The blood samples were tested to determine the values of different blood parameters (glucose, haemoglobin, urea, AST, creatine kinase, creatinine) and we also monitored changes in the immune status with the help of the Horse Ig One-Step rapid test. Urinalysis included the determination of different parameters (specific gravity, pH, nitrites, glucose, bilirubin,

urobilinogen, proteins, ketones, blood). In years 5 and 6, a more thorough examination of the placenta also formed part of the research.

Based on data obtained from the Hungarian Meteorological Service we studied which meteorological factors influenced the course of the foaling process.

In year 7 of the study, we collected data at the department providing foaling services at Ghent University (Department of Obstetrics, Reproduction and Herd Health, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium). At that time the analysis of the colostrum (first milk) of mares was also part of the study protocol. Colostrum samples were tested with a refractometer and the reliability of results was checked by electrophoresis. On blood samples taken from newborn foals, the performance of two rapid tests [SNAP Foal Ig (SF) and Gamma-Check E (GCh-E)] was compared, and the accuracy of the results was checked by electrophoresis.

Statistical analysis was done using the IBM SPSS 23.0 statistics program. Methods of descriptive statistics were used for characterising the data sets. Correlation analysis was performed using the Spearman's Rho calculation. The performance of two diagnostic tests (SF and GCh-E) was compared with that of electrophoresis used as reference. Sensitivity, specificity, positive and negative predictive values (PPV and NPV) as well as accuracy were calculated in two different measurement ranges, with 800 mg/dl and 400 mg/dl taken as a threshold.

3. RESULTS AND THEIR EVALUATION

3.1 Gestation length and prediction of foaling time

In the studs included in the study, the average gestation length was 339 (±10) days. In the majority of cases (63.88%) foaling took place in April and May. Regarding the entire study, 54% of the newborn foals were female and 46% were male. Premature foals were exclusively females while overmature ones were exclusively males. In average, male foals were born on day 341 (±10) while female foals on day 338 (±9) of gestation. We did not find a close correlation between gestation length and the number of lactations, the sex of the foal or the age of the mare.

Among the different properties of the teats their tightness and swelling are the most important. The appearance of the 'wax droplet' ('waxing up') on the end of the teats occurred less frequently than previously assumed; we observed it only in about 75% of the foaling mares. The tightness and swelling of the udder also provides important information; therefore, regular checking of the udders is absolutely recommended. Oedema formation occurs only in about half of the mares, so its presence cannot always be expected; however, if oedema can be observed, then foaling is expected to occur during the subsequent week. The typical changes of the vulvar lips (swelling, elongation) are remarkable, and at least one of these changes occurs in all mares. Sunken flanks are one of the most informative physical changes, as foaling can be expected to occur two or three days after

the maximum score of 3 for sunken flanks is reached. Softening (flattening out) of the tailhead can be observed for all mares, but this sign may be present already earlier and thus it is not a reliable predictor of impending foaling (see Table 1).

Table 1: Scoring of the physical changes of mares

			At foaling %	First appearance (before foaling) day
Teats	Tightness	0	0	–
		1	17	7.62 ± 5.68
		2	26	5.86 ± 4.39
		3	57	1.12 ± 1.42
	Swelling	0	0	–
		1	6	8.64 ± 6.1
		2	24	5.7 ± 4.65
		3	70	3.76 ± 4.08
	Protrusion	0	65	–
		1	15	3.06 ± 2.43
		2	13	1.49 ± 2.31
		3	7	1.75 ± 0.96
	Wax droplet	0	24	–
		1	22	4.16 ± 4.2
		2	30	1.5 ± 1.94
		3	24	0.87 ± 0.91
Udder size	Tightness	0	2	–
		1	2	7.92 ± 5.23
		2	30	5.38 ± 5.07
		3	66	2.68 ± 3.72
	Swelling	0	2	–
		1	0	–
		2	24	6.18 ± 5.13
		3	74	3.18 ± 3.82

Table 1 (continued): Scoring of the physical changes of mares

			At foaling %	First appearance (before foaling) day
Oedema	Belly / Chest	0	42	–
		1	22	5.77 ± 5.61
		2	20	4.83 ± 4.8
		3	16	4.5 ± 3.5
	Extremities	0	47	–
		1	18	5.05 ± 3.83
		2	21	3.09 ± 3.67
		3	14	1.28 ± 1.87
Vulva	Swelling	0	2	–
		1	4	8.08 ± 5.56
		2	36	4.53 ± 4.64
		3	58	3.94 ± 4.45
	Elongated	0	2	–
		1	8	6.01 ± 4.65
		2	31	5.02 ± 5.7
		3	59	3.65 ± 4.92
	Below point of the buttock (tuber ischii)	0	2	–
		1	11	6.6 ± 5.6
		2	27	4.72 ± 4.86
		3	60	4.53 ± 5.3
Flank		0	2	–
		1	24	7.2 ± 5.3
		2	31	4.69 ± 4.84
		3	43	2.31 ± 3.83
Tailhead		0	0	–
		1	8	6.98 ± 4.8
		2	26	6.51 ± 5.53
		3	66	4.1 ± 4.47

Frequent urination and defecation, looking at the belly, restlessness, pawing the ground, circling, frequent lying down and getting up are all signs indicative of imminent foaling (within 1–2 hours) or a mild colicky reaction due to the fetal movements. In the latter case, these phenomena may be observed already 7–9 days before foaling; however, if other behavioural changes (grinding of the teeth, yawning, displacement activities with the lips or tongue, swishing or rubbing of the tail, continuous movement of the head and legs) also occur, then 'water breaking' (the rupture of the chorioallantoic membrane, releasing allantoic fluid) is likely to be imminent. Sweating is rarely observed, but when it does occur, it is highly probable that foaling will start within 2 hours (Table 2).

Table 2: Summary of scores achieved on the mare sheet as a function of time

Before foaling		Total score
Hours	1	39.9 ± 9.09
	1.5–2.5	34.25 ± 4.03
	3.5–6	31.5 ± 10.82
	9–12	27.2 ± 6.39
	13–24	31.2 ± 6.86
Days	1	29.68 ± 11.16
	2	25.78 ± 9.75
	3	25.3 ± 10.49
	4	19.92 ± 8.86
	5	17.08 ± 8.44
	6	18.83 ± 4.07
	7	18.83 ± 9.96
	8–13	18.1 ± 6.92
	14–21	17.33 ± 6.98

It can be seen that the scores tend to become lower as we move away from foaling. However, no clear regularity can be established, as the reactions of mares were highly variable. In certain mares the signs were less expressed and thus the scores were lower, while other mares tended to exhibit signs, which would have been indicative of imminent foaling, already much earlier before foaling. The study of these signs was interesting rather because it made it possible to monitor the changes within individual mares. In summary, it can be concluded that mares with a total score of 30–40 will foal within one day on average.

The presence of a cold front and an occluded front greatly, while that of a warm front less markedly increases the chance of an earlier onset of foaling. A future front has a less pronounced effect on the earlier onset of foaling.

Among temperature, relative humidity and atmospheric pressure, relative humidity is probably the weather factor that has the least influence on the onset of foaling. The fall of temperature is a more important factor than its rise. As regards the changes in atmospheric pressure, a slightly higher number of mares foaled after a rise in air pressure than after its fall, although big differences could not be demonstrated between the values. Increases in relative humidity were followed by a higher number of parturitions than its decreases.

In 78.57% of the cases the Brix value measured by colostral refractometry peaked at the time of foaling. The use of a refractometer for measuring the quality of colostrum is advisable, especially because

the values determined by it may also have an important role in the prediction of foaling. Sudden changes in the Brix values (their increase to a higher percentage) of one drop of colostrum taken daily from the udder of the pre-foaling mare indicate that foaling is highly likely to occur within 24 hours. In the present work, we did not find a correlation between colostrum quality and the age, breed or lactation number of the mares, although only a limited number of samples were available and the mares were also variable in several respects.

3.2 Immunological studies

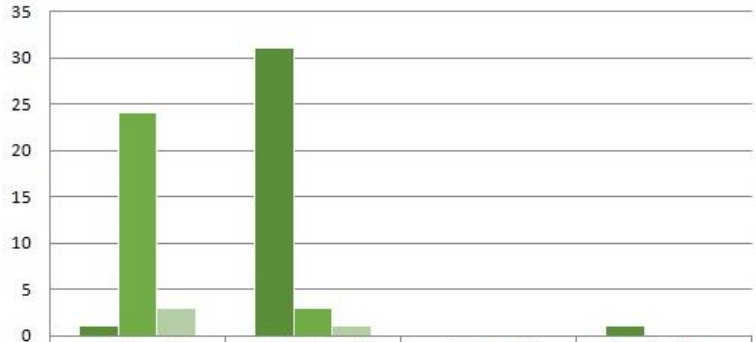
When determining the immunoglobulin (Ig) concentration of the colostrum, differences between the values measured by refractometry (REF) and those checked by electrophoresis (EPH) were found in 27.8% of the samples (Table 3).

Table 3: Differences in the Ig level of colostrum samples as determined by refractometer (REF) and electrophoresis (EPH)

Number of samples tested: 72							
Conformity between REF* and EPH**: 52 cases (72.2%)	Differences between REF* and EPH**: 20 cases (27.8%)						
		REF* indicates lower result: 14 cases (19.4%)			REF* indicates higher result: 6 cases (8.3%)		
		N	REF*	EPH**	N	REF*	EPH**
	1 category difference (18%)	9	good	very good	2	fair	poor
		2	fair	good			
	2 categories difference (9.7%)	2	poor	good	4	good	poor
		1	poor	very good			

*REF: refractometer
**EPH: electrophoresis

According to the results obtained by the Horse Ig One-Step (HIOS) rapid test, the immunoglobulin supply of newborn foals was satisfactory already immediately after birth, and the concentration of immunoglobulins soon reached the protective level. We did not find any group with a negative sample. One foal had the protective Ig concentration of 800 mg/dl already at the time of birth. There was only a single newborn foal that did not reach the minimal level even at time T_2, which is not surprising since this was an orphaned foal.



	> 800 mg/dl	500-800 mg/dl	<500 mg/dl	érvénytelen
T0	1	31	0	1
T1	24	3	0	0
T2	3	1	0	0

*T_0 = at the time of foaling; T_1 = at 4 hours; T_2 = at 8 hours

Figure 1: Results of the Horse Ig One-Step (HIOS) rapid test at different time points

In 75% of the foals, immunoglobulins measurable by EPH were present immediately after birth (at T_0). In most cases, the Ig level was around 100 mg/dl, but in 7.14% of the cases it reached 200–300 mg/dl at that time.

Differences were found on 22 occasions (in 47.83% of the cases) when comparing the SNAP Foal Ig (SF) test results with the EPH findings. EPH always demonstrated lower Ig concentrations that the SF rapid test. When the results of the Gamma-Check E (GCh-E) test were compared with those obtained by EPH, a difference between the two methods was found for 17 samples (36.96%). As found by comparing the SF test and EPH, the GCh-E on-field test invariably demonstrated higher Ig concentrations than laboratory determination by EPH. The detailed results are presented in Table 4.

Table 4: Differences between the results obtained by the SF and GCh-E on-field tests and those determined by electrophoresis

<table>
<tr><td colspan="5">Total number of determinations: 46 cases</td></tr>
<tr><td rowspan="6">Conformity between SF* and EPH***: 24 cases (52.17%)</td><td colspan="4">Differences between SF* and EPH***: 22 cases (47.83%)</td></tr>
<tr><td rowspan="5">SF* indicates lower result: 0 case (0%)</td><td colspan="3">SF* indicates higher result: 22 cases (47.83%)</td></tr>
<tr><td>N</td><td>SF* (mg/dl)</td><td>EPH***(mg/dl)</td></tr>
<tr><td>8 (17.39%)</td><td>400–800</td><td><400</td></tr>
<tr><td>9 (19.57%)</td><td>>800</td><td>600–800</td></tr>
<tr><td>3 (6.52%)</td><td>>800</td><td>400–600</td></tr>
<tr><td>2 (4.35%)</td><td>>800</td><td><400</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Total number of determinations: 46</td></tr>
<tr><td rowspan="5">Conformity between GCh-E** and ELF***: 29 cases (63.04%)</td><td colspan="4">Differences between GCh-E** and EPH***: 17 cases (36.96%)</td></tr>
<tr><td rowspan="4">GCh-E** indicates lower result: 0 case (0%)</td><td colspan="3">GCh-E** indicates higher result: 17 cases (36.96%)</td></tr>
<tr><td>N</td><td>GCh-E**(mg/dl)</td><td>EPH***(mg/dl)</td></tr>
<tr><td>8 (17.39%)</td><td>400–800</td><td><400</td></tr>
<tr><td>7 (15.22%)</td><td>>800</td><td>600–800</td></tr>
<tr><td>2 (4.35%)</td><td>>800</td><td>400–600</td></tr>
</table>

*SF: SNAP Foal Ig test
**GCh-E: Gamma-Check E test
***EPH: electrophoresis

Sensitivity, specificity, positive and negative predictive value and accuracy were calculated at two different measurement thresholds: 800 mg/dl and 400 mg/dl Ig concentration, respectively (Table 5).

Table 5: Comparison of the characteristics of SF and GCh-E Ig tests at different measurement thresholds

	SF	**SF**	**GCh-E**	**GCh-E**
	400 mg/dl	800 mg/dl	400 mg/dl	800 mg/dl
Sensitivity	0.38	0.53	0.5	0.8
Specificity	1	1	1	1
Positive predictive value	1	1	1	1
Negative predictive value	0.75	0.53	0.79	0.73
Accuracy	78%	70%	83%	87%

The correlations between the Ig content of the mare's colostrum and the foal's blood serum are presented in Table 6. Close correlations were not found at any of the time points; however, the highest positive correlation coefficient occurred between mare T_1 and foal T_2 samples (0.326). This means that the closest correlation can be observed between the immunoglobulin content of the colostrum sample taken 4 hours after foaling and the Ig concentration of the foal blood sample taken at 8 hours after birth.

Table 6: Correlations between the immunoglobulin concentrations of the mares' colostrum and the foals' blood serum at the different time points

Time points	**Correlation coefficient**
Mare T_0 – Foal T_0	–0.357
Mare T_0 – Foal T_1	–0.213
Mare T_0 – Foal T_2	0.281
Mare T_1 – Foal T_1	–0.281
Mare T_1 – Foal T_2	0.326
Mare T_2 – Foal T_2	–0.068

3.3 Vitality of newborn foals and assessment of their risk status

Of the newborn foals examined by us, 74% stood up within one hour, 86% within two hours, and 77% passed meconium within three hours.

The foals had vitality scores between 5 and 8, the majority (62%) of them had a score of 7. Performing the 'vitality test' is a useful and absolutely recommended method for assessing the viability of newborn foals. It is fast and easy to use and requires no instrument. However, in our opinion the test requires a slight modification regarding the heart rate and the respiratory rate. Namely, not only the absolute values of these parameters but also their quality (regularity or irregularity) provide decisively important information. Therefore, in the modification of the test recommended by us, these two factors are given a score of only 1 even if they are above the expected ≥ 60/min value but are irregular.

The table and flow chart complementing the 'vitality test' (see New scientific results) help us identify the points where human intervention is very important for the proper development of the newborn foal and also enable us to avoid unnecessary interactions which might interfere with the formation of bonding between the mare and the newborn foal or even hinder the natural processes (e.g. forced nursing from a feeding bottle).

3.4 Blood, urine and clinical parameters

The values of haemoglobin (Hb) measured in the **blood** samples showed high variability, which is at variance with previous reports in the literature. For urea we obtained lower values or those close to the lower limit of the reference range. The change in glucose (GLU) level clearly reflects the pre-suckling and after-suckling status of foals. At the beginning of their extrauterine life, the foals had glucose levels below the physiological range but some hours later, after a few episodes of suckling, their glucose values easily exceeded the upper limit of the reference range. The activities of the aspartate aminotransferase (AST) enzyme varied within an extremely wide range and clearly tended to increase with time. The creatine kinase (CK) activity of newborn foals was multiple times (even ten times) higher that the value typical of adult horses. For creatinine (CREA) we found a novelty. According to earlier reports in the literature, the creatinine values of adult horses greatly differ from those of newborn foals, with the physiological range of adult animals being much higher. The creatinine values of the newborn foals examined by us, however, came close to, fell within or even exceeded the adult reference range.

The analysis of **urine** samples for nitrite, glucose and bilirubin consistently and invariably yielded negative results (values of 0). Although in 22 cases we obtained a negative result for protein in the urine, in 29% of the cases we detected protein in the urine, in an average concentration of 34 mg/dl. As regards the presence of ketone bodies, the samples invariably belonged to the '<16 mg/dl' category.

In 90% of the urine samples, urobilinogen was in the normal range, while the remaining three samples fell into the '<17 mg/dl' category in terms of urobilinogen concentration.

The urine samples collected from foals older than 8 hours were much more concentrated than those of foals that voided their first urine sooner. However, even the former foals did not come close to the urine specific gravity reference range typical of adult horses; thus, on the basis of our results it can be stated that the urine specific gravity values of newborn foals are markedly lower than those of adult horses.

In our study, the pH of the urine was found to be highly variable: we obtained values ranging between 5.5 and 9. Newborn foals are characterised by a slightly acidic urine pH, which is attributable to the substantial physical exertion associated with the birth process.

Thirty-eight per cent of the urine samples contained blood, which might even indicate some severe problem. However, this high ratio may partially be attributable to the blood contamination of urine samples from the umbilical stump in male foals.

The **heart rate** showed a marked decrease between time points T_0 and T_1, but later the difference was no longer significant. The **respiratory rate** per minute also decreased with time, but this decrease was not so pronounced as that found for the **heart rate** per minute. After the 4th hour of life already a stagnation was observed (Table 7). These factors are influenced not only by the birth process as a physical exertion, but also by the foal's 'struggle' in the first few hours of life: standing up,

finding food, getting acquainted with the new environment, the mare's behaviour and the human interventions, if any, have an effect on them.

Table 7: Heart rate and respiratory rate (mean ± standard deviation, SD) as a function of time

	Heart rate			Respiratory rate		
	T_0	T_1	T_2	T_0	T_1	T_2
Mean	112	103	102	66	59	60
SD	± 26.02	± 21	± 15.75	± 14.12	± 22.11	± 20.74

3.5 Placenta

Based on our summarised data, expulsion of the placenta took place in the 164th (±184) minute after birth on the average. This value was elevated by the higher values of Hungarian Coldblood horses within the breeds studied, and the high standard deviation is also attributable to mares of that breed. The comparison of warmblood and coldblood horses clearly shows that expulsion of the placenta occurs sooner in warmblood mares (83.09±40.55 minutes postpartum) than in coldblood mares (486.76±744.04 minutes after birth).

4 NEW SCIENTIFIC RESULTS

1. According to our observations, 75% of the healthy foals have immunoglobulins detected by on-field tests in their blood already at the moment of birth.

2. Healthy newborn foals that receive about 250 ml colostrum immediately after birth will acquire the minimal immunoglobulin level necessary for protection much sooner. Among these newborn foals, 42.82% had 800 mg/dl serum Ig concentration already in the 8th hour after birth.

3. The use of the modified 'vitality test' recommended by us provides more accurate results in the assessment of viability, as the hitherto disregarded irregularity is also an important factor that should be taken into consideration when measuring heart rate and respiratory rate. The complemented test (Table 8) and the flow chart (Figure 2) are useful in determining the risk status of the newborn foal and the intervention points, which are important complementary elements of foaling assistance.

Table 8: Complementary table to the vitality test

Score	**0**	**1**	**2**
Presence of suckle reflex	*Absent*	*The foal is seeking the teats after standing up*	*Present already before standing up*
Standing up	*After 60 minutes*	*Between 30 and 60 minutes*	*Within 30 minutes*
Suckling	*After 120 minutes*	*Between 60 and 120 minutes*	*Within 60 minutes*
Passing of meconium	*After 180 minutes*	*Between 90 and 180 minutes*	*Within 90 minutes*

Table 8 (continued): Complementary table to the vitality test

Score 7–8:	*A problem-free 24-hour newborn foal can be expected – there is no need for human intervention*
Score 4–6:	*Slightly debilitated foal – human intervention is recommended*
Score 2–3:	*Foal at risk – human intervention is expressly recommended*
Score 0–1:	*Severely debilitated foal – human intervention is indispensable*

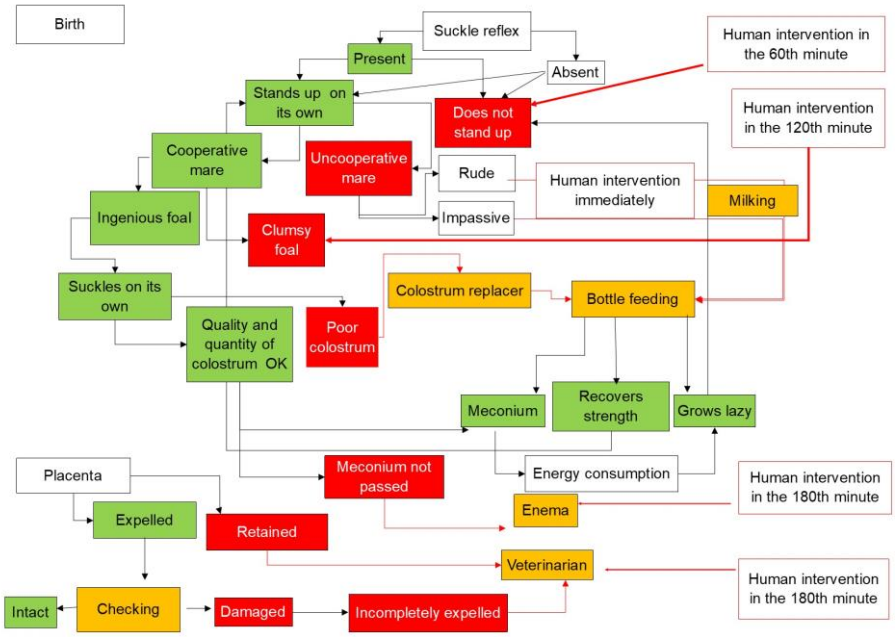


Figure 2: Flow chart for the determination of critical points

4. The reference ranges proposed by us for certain blood parameters of healthy newborn foals are presented in Table 9. This represents a new results especially for creatinine (CREA).

Table 9: Proposed reference ranges of certain blood parameters of newborn foals

Hb g/dl	UREA mmol/l	GLU mmol/l	AST U/l	CK U/l	CREA µmol/l
8.77–21.46	2.27–8.4	2.1–7.9	20–293	35–533	38–290

5. The reference values of certain urine constituents of newborn foals, as proposed by us, are presented in Table 10.

Table 10: Proposed reference ranges of certain urine constituents of newborn foals

Nitrite mg/dl	Glucose mg/dl	Bilirubin mg/dl	Protein mg/dl	Ketones mg/dl	Urobilinogen mg/dl	Specific gravity g/ml	pH
neg.	neg.	neg.	0–68	<16	0–17	1.003–1.013 0.998–1.023	6.25–6.9 (5.5–9)

6. The refractometer is an important instrument in determining the quality of colostrum. The correlation coefficient between refractometry (REF) and electrophoresis (EPH) is 0.7. The refractometer has a decisively important role also in the prediction of foaling time: in 92.86% of the cases the Brix value measured by colostral refractometry peaked at the time of foaling or in the last few (<12) hours preceding it, which is regarded as an important change.

7. In foals that are certainly healthy, the use of the less expensive GCh-E test is recommended; however, in foals where a possible inflammation is suspected, the SF test is the method of choice.

5 LIST OF PUBLICATIONS

Papers published in a Hungarian-language peer-reviewed journal:

1. Kummer L., Bába A., Egri B.: Csikók születési körülményeinek jellegzetességeiről, eltérő tartástechnológiájú ménesekben [Characteristics of the birth conditions of foals kept in studs of different management technology]. Magyar Állatorvosok Lapja (December 2013): Volume 135, pp. 717–727. **Impact factor: 0.185.**

2. Kummer L., Szarvady O., Egri B., Bába A.: Összehasonlító vizsgálatok egyes lófajták magzatburok eltávozási idejének sajátosságairól [Comparative examinations of the expulsion time of fetal membranes in various horse breeds]. Magyar Állatorvosok Lapja (May 2015): Volume 37, pp. 259–269. **Impact factor: 0.212.**

Paper published in a foreign-language peer-reviewed journal:

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