Topics in the routine assessment of newborn kitten vitality: Apgar score, reflexes and complementary assessments

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Abstract

Objectives The aim of this study was to perform neonatal clinical assessments at birth to identify newborn kittens at risk according to type of delivery, thus allowing immediate intervention and increasing their chances of survival.

Methods This study compared Apgar scores, reflexes and clinical parameters (temperature, weight, blood glucose and peripheral oxygen saturation [SpO_2]) between eutocic neonates and those delivered by emergency cesarean section. The animals were evaluated at birth and after 10 and 60 mins.

Results Thirty-two neonates were evaluated, with 19 animals in the eutocic group (EG) and 13 animals in the cesarean group (CG). When comparing groups, CG neonates had significantly lower Apgar scores ($P < 0.0001$), lower SpO_2 ($P = 0.0535$), higher blood glucose ($P = 0.0009$), reduced reflexes ($P < 0.0001$) and lower respiratory rates ($P < 0.0001$) at birth and after 10 and 60 mins than EG neonates. Apgar scores positively correlated with parameters such as heart rate, reflex score, SpO_2 and weight. The mortality rate in evaluated newborns was 15.6% (5/32). The early mortality rate (0–2 days old) was 80% (4/5) and the late mortality rate (3–30 days old) was 20% (1/5).

Conclusions and relevance This study showed lower vitality in cats delivered by emergency cesarean section than in those delivered through eutocic birth. In general, neonates delivered by cesarean section have greater depression and low vitality at birth and may require advanced resuscitation procedures. The evaluations carried out in this study identified newborns with low vitality and those requiring advanced resuscitation, thus allowing immediate intervention. Apgar and reflex scores for feline neonates were suggested. Newborn-specific clinical assessment with these feline vitality scores allows the identification of at-risk neonates. Care immediately after birth increases the chance of survival among these patients.

Keywords: Feline neonate; Apgar score; cats cesarean section; mortality

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Introduction

The neonatal mortality rate of cats is high, ranging from 9% to 16% before weaning, reaching even higher rates during delivery, immediately after delivery and in the first days of life.[1–4]

Birth is a critical period of adaptation to extrauterine life and a major challenge to neonatal survival. Feline neonates need to make an adequate fetal–neonatal transition, which includes the shift to effective lung breathing.[5,6] Owing to dystocias, prolonged deliveries and anesthetic depression induced during cesarean sections, newborns may experience exacerbated asphyxia, failure to adapt to changes in respiration, severe hypoxia, respiratory distress syndrome, bradycardia and neonatal depression (low vitality), all of which increase the chance of death in the transition period and during the first few days of life.[7–12]

Thus, birth assessment methods that identify at-risk newborns are crucial for enabling immediate intervention and monitoring of the newborn's clinical evolution after resuscitation maneuvers. However, studies on clinical evaluations and complementary examinations of cats at birth are scarce. Knowledge of the neonatal particularities of kittens and their physiological parameters at birth is essential for the proper clinical management of these patients.

The Apgar score is an assessment index routinely used in medicine to facilitate clinical assessment at the time of delivery, to immediately identify the clinical condition of the neonate at birth and to direct interventions or to monitor the effectiveness of neonatal resuscitation maneuvers.[12–14] Apgar scores should be used in conjunction with other analytical methods to assess newborn vitality and viability.[14]

This study aimed to evaluate and compare neonatal vitality in cats delivered by eutocic birth and cesarean section via Apgar scores and neonatal reflexes. Blood glucose, body temperature, peripheral oxygen saturation (SpO_2) and weight were also assessed; these measurements supported the use of an Apgar score specific to feline neonates.

Material and methods

This study was carried out by the Veterinary Neonatology Research Group of the School of Veterinary Medicine and Animal Science at Universidade Estadual Paulista (UNESP) in Botucatu, Brazil (dgp.cnpq.br/dgp/espelhogrupo/2627734671789524). The animals were included in the study only after approval by the institution's Research Ethics Committee (protocol 0024/2021) and it was carried out in accordance with the animal welfare standards and only after receiving authorization from the animals' guardians by collecting signatures indicating their informed consent.

The inclusion criterion was that the neonates must have been full-term. Neonates that presented with congenital malformations were excluded.

This study included seven females of different breeds, from 6 months to 3 years of age, and their respective newborns. The cats were treated at the Small Animal Reproduction Services Center of the FMVZ UNESP Veterinary Hospital or in catteries. Thirty-two neonates were evaluated, with 19 animals in the eutocic birth group (EG) and 13 animals in the cesarean section group (CG).

All eutocic births were from catteries. Eutocic births were defined as births in which kittens were delivered spontaneously without any kind of assistance, including obstetric assistance. The mother performed the entire newborn resuscitation process (removed the newborn from the fetal envelopes and performed respiratory stimuli through vigorous licking and umbilical manipulation). The processes were observed without intervention, and, soon after, neonatal evaluations were started.

The EG and CG evaluations were carried out by the same evaluators. Emergency cesarean section deliveries were defined as births in which the mother was unresponsive to obstetric maneuvers for the correction of dystocia or in which a maternal abdominal ultrasound revealed fetal distress. Dystocias were diagnosed by the maternal clinical assessment associated with complementary examinations, such as radiography and abdominal ultrasound. The causes of dystocia varied between litters, including maternal origin (narrowing of the pelvis due to trauma, primary or secondary uterine inertia or inadvertent exposure to progestins) and fetal origin (exaggerated fetal size, inadequate fetal positioning).

Anesthetic induction was performed with propofol, followed by lumbosacral epidural anesthesia with lidocaine and anesthetic maintenance with isoflurane diluted in oxygen. The queens were placed in dorsal decubitus, performing trichotomy in the abdominal region, followed by antisepsis. After the pre-retroumbilical incision at the linea alba, the body of the uterus was exposed and incised. Immediately after removing the newborn from the uterus, the surgeon removed the fetal envelopes to keep the airway free for the beginning of breathing. Fluids from the nostrils and cavity were quickly cleaned away with the aid of a compress. Then, tactile stimulation was performed by vigorous massage with a dry and heated compress on the back and chest, in order to dry the newborn and stimulate breathing. Then, the newborn was handed over to the team to continue these procedures in a warm environment, and soon after the beginning of neonatal breathing, the assessments were carried out.

Neonatal assessments

In the first 5 mins after birth, neonates from both groups were given colored neck ribbons for the purposes of

identification and assessed for Apgar score, reflexes, blood glucose, body temperature, SpO_2 and weight. Neonatal assessments were repeated after 10 mins and 60 mins. Total mortalities were recorded and categorized as early (0–2 days old) or late (3–30 days old).

Owing to the scarcity of Apgar score studies in cats, the assessment in this study was performed based on the Apgar score index described for dogs, following adaptations of what was proposed by Lourenço[12] and Vassalo et al.[14]

Five parameters are evaluated in the Apgar score: mucosal color, heart and respiratory rates, muscle tone and reflex irritability. Heart rate auscultation was performed with a stethoscope on the left side of the chest (Figure 1a). Respiratory rate was assessed by observing the movements of the chest (Figure 1b). Mucosal coloration was assessed by observing the oral mucosa (Figure 1c). Muscle tone was determined with the newborn in the supine position, observing their active movements (Figure 1d). Reflex irritability was assessed after a painful stimulus (pressure) was applied to the interdigital space (Figure 1e). Each parameter received a score of 0, 1 or 2, according to the presentation of the neonate (Table 1); the sum of these parameters was used to identify neonatal vitality and viability. Apgar scores were interpreted as follows: scores of 0–3 indicated weak vitality, 4–6 indicated moderate vitality and 7–10 indicated normal vitality.

An overall score of 7–10 is considered adequate and represents newborns with good vitality and in favorable clinical condition. A score of 4–6 indicates that resuscitation maneuvers may be necessary, and a score <3 is an indication for emergency care.[14,15]

Newborn cats with low Apgar scores at birth underwent advanced resuscitation procedures to increase their chances of survival.[16] This treatment consisted of clearing the neonate's airways with a nasal aspirator, drying the neonate with the aid of a heated compress, stimulating the cardiovascular system via the Jen Chung acupuncture point (at governor vessel [GV] 26), administering pulmonary ventilation (with a specific pulmonary expander for canine and feline neonates [One Puff Puppy]), providing 100% oxygen by mask and, when necessary, administering 24 mg/ml aminophylline (0.2 ml/100 g of weight, sublingually) and 0.1 mg/ml epinephrine (1 mg/ml diluted in 1:10 solution [0.01–0.03 ml/100 g of weight, IV or IO]). The neonatal environment was also warmed to 30–32°C with a space heater or an incubator to maintain the newborn's body temperature; in the CG the queens were also warmed up with the kittens.

Reflexes were evaluated for the degree of neonatal depression (vitality). The main neonatal reflexes present at birth are sucking, rooting and righting. The sucking reflex was evaluated by inserting the tip of the examiner's smallest digit into the mouth of the neonate and observing the suction force (Figure 2a). Then, the search reflex was examined by placing a hand close enough to the newborn's face to trigger the reflex and waiting for
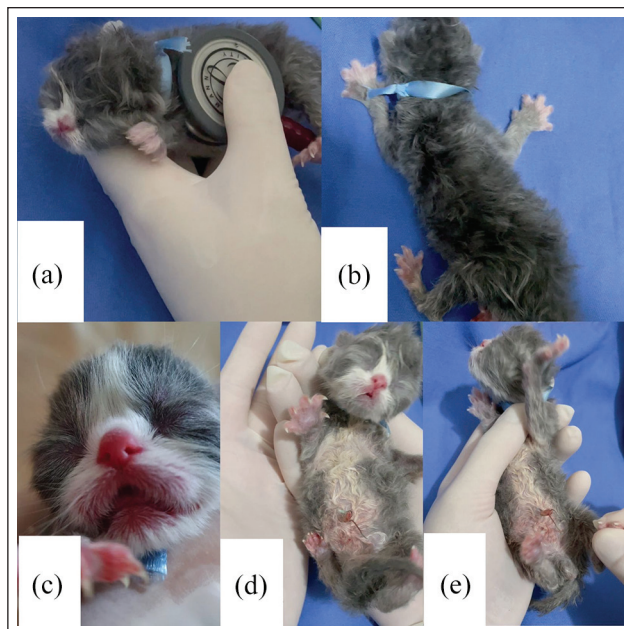

Figure 1 Apgar score assessment of (a) heart rate, (b) respiratory rate, (c) mucosal color, (d) muscle tone and (e) reflex irritability

Table 1 Apgar scores for canine neonates

Parameter/score	0	1	2
Mucosal coloration	Cyanotic	Pale	Pink
Heart rate	<100 bpm	<180 bpm	200–260 bpm
Reflex irritability	Absent	Some movement	Vigorous
Muscle tone	Flaccid	Some limb flexion	Active movement
Respiratory rate	Absent or <6 mpm	Weak and irregular, <15 mpm	Regular and rhythmic, 15–40 mpm

Adapted from Lourenço[12] and Vassalo et al[14]
bpm = beats per min; mpm = movements per min

an immediate search for the teat (Figure 2b). Finally, the vestibular righting reflex was evaluated by placing the neonate in a supine position on a soft, warm surface and waiting for it to return immediately to a prone position (Figure 2c). Each reflex received a score of 0, 1 or 2 (absent, weak or strong response, respectively) and the sum was used to categorize neonatal vitality. Scores were interpreted as demonstrating weak (0–2), moderate (3–4) or normal (5–6) vitality. This reflex evaluation followed the scheme proposed by Vassalo et al (Table 2).[14]

Body temperature was measured rectally using a digital thermometer (Figure 3), and weight was assessed in grams using a digital scale (Figure 4). Blood glucose was measured with a portable glucometer (On Call Plus) by using 21 G needles to collect a drop of blood from the neonate's pad after site antisepsis with 70% alcohol
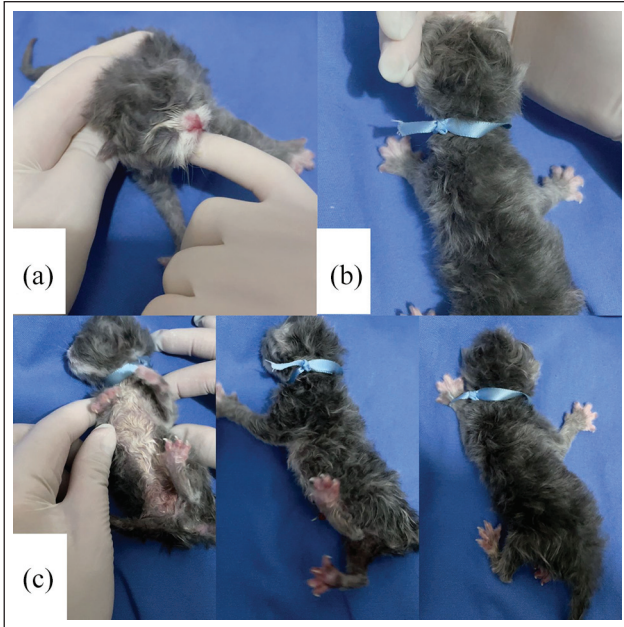
Figure 2 Assessment of neonatal reflexes: (a) sucking reflex, (b) rooting reflex and (c) righting reflex

Table 2 System used to evaluate neonatal reflexes

Reflex/score	0	1	2
Sucking	Absent	Weak	Strong
Rooting	Absent	Slow muzzle fitting inside the evaluator's hand	Immediate fitting muzzle within the evaluator's hand
Righting	Absent (continues in initial position)	Slow body repositioning	Immediate body repositioning

Vassalo et al[14]

Figure 3 Body temperature measurement in a newborn cat

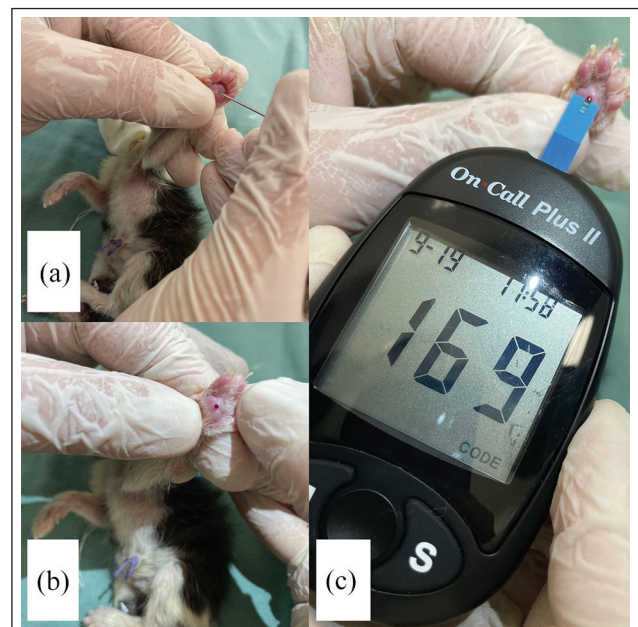**Figure 4** Weight assessment in a newborn cat

Figure 5 Blood glucose measurement in a newborn cat: (a) pad pricked with needle, (b) formation of blood droplet for measurement by the (c) portable glucometer

Statistical analysis

The data were not normally distributed and therefore were log transformed and analyzed using parametric tests.

The statistical analysis of the parameters was performed using SAS software version 9.3 and conducting generalized linear models using the least squares method of the generalized linear model procedure. This model included the fixed effects of group (CG or EG), time (at birth and after 10 and 60 mins) and a group × time

(Figure 5). Peripheral oxygen saturation was assessed using the R40VET Rzvet oximetry monitor in the femoral artery region of newborn cats (Figure 6).

Figure 6 Peripheral oxygen saturation assessment in a newborn cat

interaction. The model was followed up with Tukey's mean comparison test. Pearson correlation coefficients of the variables were also calculated (using the Corr procedure).

All differences were considered significant at the 5% level ($P < 0.05$).

Results

Eutocic group

The EG consisted of 19 newborn cats, with the following breed distribution: Maine Coon (n = 7), Persian (n = 8) and mixed breed (n = 4). All queens were monitored during delivery. The shortest duration of eutocia was 1h and the longest was 5h, with the interval between kittens ranging from 10 mins to 5h.

There was no significant difference ($P > 0.05$) between time points in terms of the Apgar score, reflex score, blood glucose, body temperature, SpO_2 or weight for EG neonates. However, the neonatal parameters of heart rate (HR) and respiratory rate (RR) differed significantly ($P < 0.0001$) between the time points: lower HR and RR were found at birth than at 60 mins after birth. On average, newborns in the EG had good vitality (normal vitality >7) and favorable clinical parameters.

Apgar scores positively correlated with HR ($P < 0.0001$), reflex score ($P < 0.0001$), SpO_2 ($P < 0.0001$) and weight ($P = 0.0104$) in EG neonates, with correlation coefficients of 0.70, 0.58, 0.67 and 0.33, respectively. HR also positively correlated with reflex score ($P = 0.0240$) and SpO_2 ($P = 0.0007$), with correlation coefficients of 0.30 and 0.43, respectively.

Cesarean group

The CG consisted of 13 mixed-breed neonate cats. In CG neonates, Apgar scores, HR, RR, SpO_2 and body temperature differed significantly between birth and 60 mins after birth ($P < 0.0001$). Specifically, the vitality parameters were lower at birth than after 60 mins. There were no significant differences between times for reflex score, blood glucose or weight. Most CG neonates had moderate vitality at birth and evolved to normal vitality after 60 mins. Neonates that required advanced resuscitation procedures also demonstrated an improvement in clinical parameters after 60 mins.

Apgar scores positively correlated with HR ($P = 0.0012$), RR ($P < 0.0001$), reflex score ($P < 0.0001$) and weight ($P = 0.0094$) in CG neonates, with correlation coefficients of 0.50, 0.85, 0.65 and 0.41, respectively. RR also positively correlated with the HR ($P = 0.0034$) and reflex ($P = 0.0002$) parameters, with correlation coefficients of 0.46 and 0.56, respectively. Thus, in the CG it was observed that the lower the HR, reflex score, SpO_2 and weight, the lower the Apgar score. Also, the lower the HR, the lower the reflex score and SpO_2.

Comparison between groups

Significant differences ($P < 0.05$) were found between the EG and CG, at the different time points.

Specifically, CG neonates had lower Apgar scores ($P < 0.0001$) and SpO_2 ($P = 0.0535$) and higher blood glucose ($P = 0.0009$) at birth than EG neonates. CG neonates had lower reflex scores ($P < 0.0001$) and RR ($P < 0.0001$) at birth, as well as after 10 and 60 mins than EG neonates. There were no significant differences between the groups in terms of HR, body temperature or weight. The means, SDs, statistical significance between timed assessments and groups, and minimum and maximum of the evaluated parameters are provided in Table 3.

A specific Apgar score for neonatal cats was proposed after observing the averages and range of parameters presented by newborn cats, as shown in Table 4. An evaluation of the neonatal reflex scores is available in Table 5.

The total mortality rate in the evaluated neonates was 15.6% (5/32). The early (0–2 days old) mortality rate was 80% (4/5) and the late (3–30 days old) mortality rate was 20% (1/5). All the early kitten mortalities occurred in the CG due to hypoxia during dystocia and emergency

Table 3 Apgar score, reflex score, heart rate (HR), respiratory rate (RR), peripheral oxygen saturation (SpO$_2$), blood glucose, body temperature and weight of the two groups of kittens at birth and after 10 and 60 mins

Parameter	Group	At birth	10 mins after birth	60 mins after birth
Apgar (0–10)	CG	7.0 ± 2.0^c (4–10)	8.38 ± 1.6^{bc} (5–10)	9.0 ± 1.5^{ab} (5–10)
	EG	8.84 ± 1.3^{ab} (6–10)	9.89 ± 0.3^a (9–10)	9.94 ± 0.2^a (9–10)
Reflex (0–6)	CG	1.3 ± 1.5^b (0–4)	1.84 ± 2.2^b (0–6)	2.69 ± 2.3^b (0–6)
	EG	4.68 ± 1.7^a (0–6)	5.26 ± 0.9^a (4–6)	5.47 ± 0.9^a (4–6)
HR (bpm)	CG	200.92 ± 42.4^b (120–268)	231.07 ± 30.9^{ab} (164–272)	250.31 ± 31.2^a (180–280)
	EG	208.42 ± 35.5^b (152–264)	229.05 ± 21.3^{ab} (188–268)	248.84 ± 18.8^a (224–288)
RR (mpm)	CG	48.76 ± 27.5^d (12–96)	74.38 ± 30.7^{cd} (35–128)	90.46 ± 25.4^{bc} (48–128)
	EG	94.52 ± 28.0^{bc} (40–148)	110.26 ± 19.2^{ab} (75–156)	117.47 ± 24.6^a (68–160)
SpO$_2$ (%)	CG	84.46 ± 18.1^b (53–99)	99.0 ± 0.0^a	99.0 ± 0.0^a
	EG	93.73 ± 13.4^a (49–99)	98.79 ± 0.9^a (95–99)	97.89 ± 4.8^a (78–99)
Glycemia (mg/dl)	CG	129.0 ± 59.6^a (52–246)	–	150.23 ± 63.8^a (70–300)
	EG	68.52 ± 36.9^b (26–151)	–	101.79 ± 78.2^{ab} (30–296)
Temperature (°C)	CG	31.6 ± 2.3^b (28.2–35.4)	33.8 ± 2.1^{ab} (28.2–35.7)	35.1 ± 1.6^a (32.5–37.9)
	EG	31.9 ± 2.6^b (29–35.9)	32.2 ± 2.1^b (29–35.4)	33.6 ± 2.3^{ab} (29–35.9)
Weight (g)	CG	84.7 ± 11.9^b (74–110)	84.7 ± 11.9^b (74–110)	85.8 ± 12.3^{ab} (74–110)
	EG	102.1 ± 19.9^{ab} (59–132)	101.9 ± 19.6^{ab} (59–132)	103.1 ± 18.6^a (62–132)

Data are mean ± SD (range). Different superscript letters indicate significant differences (P <0.05) between groups or time points
EG = eutocic group; CG = cesarean section group

Table 4 Proposed modified Apgar scores for feline neonates

Parameter/score	0	1	2
Mucosal coloration	Cyanotic	Pale	Pink
Heart rate	<100 bpm	<180 bpm	200–280 bpm
Reflex irritability	Absent	Some movement	Vigorous
Muscle tone	Flabby	Some limb flexion	Active movement
Respiratory rate	Absent or <10 mpm	Weak and irregular, <40 mpm	Regular and rhythmic, 40–160 mpm

Vitality score interpretations: weak (0–3), moderate (4–6) and normal (7–10)
bpm = beats per min; mpm = movements per min

Table 5 Proposed modified neonatal reflex scores for feline neonates

Reflex/score	0 (absent)	1 (weak)	2 (strong)
Sucking	Absent	Weak intensity	Strong intensity or vacuum with tongue
Rooting	Absent	Slow search with muzzle and limbs inside evaluator's hand	Immediate search with muzzle and limbs inside of evaluator's hand
Righting	Absent (remained supine)	Slow body repositioning	Immediate body repositioning

Vitality score interpretations: weak (0–2), moderate (3–4) and normal (5–6)

cesarean section. The late kitten mortality occurred in the EG, with the cause of death being unknown.

Discussion

Previous studies have assessed Apgar scores in newborn dogs delivered by eutocic births or cesarean sections.[14,17–20] However, studies in cats are scarce, and we found just one study on the evaluation of Apgar scores in kittens that were delivered only by eutocic births.[21]

The pattern of lower Apgar scores at birth than after 60 mins align with existing findings. Newborns experience transient physiological hypoxemia resulting from reduced blood flow from the mother to the fetus, induced by uterine contractions during labor. Consequently, a decrease in the partial pressure of oxygen (pO$_2$) and tissue hypoxia are observed, which can culminate in neonatal depression or transient neonatal low vitality. An evolution of these parameters can be observed within

60 mins after birth, as the newborn adapts to extrauterine life.[12,14,20,22]

Significantly lower HRs and RRs were also observed at birth than at 60 mins later, in both groups. Neonatal bradycardia can occur owing to myocardial hypoxia and is not mediated by the vagus nerve due to the immaturity of the autonomic nervous system. Therefore, these patients are predisposed to lower HRs during the physiological hypoxemia associated with birth. In addition, the compensatory response to hypoxia is reduced in neonates due to the immaturity of carotid chemoreceptors, structural immaturity of the lungs and reduced capacity for chest wall expansion.[23] The gradual evolution of the RRs and HRs is expected 10 and 60 mins after birth, with the onset of adequate lung breathing and increased myocardial oxygenation.[12,14] However, neonates born with respiratory distress and intense bradycardia due to exacerbated perinatal asphyxia and consequent severe hypoxia require advanced resuscitation procedures to normalize their cardiorespiratory parameters and increase their chances of survival.

This study demonstrated significantly lower Apgar scores and reflex scores (ie, low vitality) in newborn cats delivered by emergency cesarean section than in those delivered by eutocic birth. In addition, CG neonates also had lower SpO_2 and RRs. Similar results have been found in several previous studies on neonatal dogs.[14,17–19] This difference between groups may occur owing to the contact of CG neonates with anesthetics during a cesarean section, as inhaled agents cross the placenta and the fetal blood–brain barrier.[11] Prolonged delivery or dystocia that culminate in cesarean sections may also lead to exacerbated asphyxia, prominent hypoxemia and further cardiorespiratory depression.[10,11,20,24] However, despite lower Apgar scores and reflex scores upon delivery, after resuscitation procedures CG neonates displayed clinical evolutions of the measured parameters and vitality after 60 mins.

When comparing our results with those in dogs born by emergency cesarean section under the same anesthetic protocol,[14,20] we observed that cats born by emergency cesarean section have a slower clinical evolution. For example, suction remained weak in most CG neonates at 60 mins after birth. The sucking reflex is an essential assessment in neonates as kittens with weak or absent suction force due to dystocia or cesarean depression require veterinary or breeder assistance, such as orogastric tube feeding, in order to nurse in the first hour of life. Failure to provide adequate nursing assistance can lead to the neonatal triad (hypoglycemia, hypothermia and dehydration) and an increased risk of death.[12,23] In general, in both the CG and EG groups, reflex scores were strongly correlated with Apgar scores, and kittens that had Apgar scores <6 displayed decreased rooting and sucking reflexes than kittens that received Apgar scores of 7–10.

The anesthetic protocol used in this study (anesthetic induction with propofol, followed by lumbosacral epidural anesthesia with lidocaine to reduce percentage inhalation anesthesia and by anesthetic maintenance with isoflurane) is described for cesarean anesthesia in female dogs and cats.[23,25,26] This protocol has a positive impact on queens, who wake up faster and can care for their kittens. However, studies that compare anesthetic protocols and evaluate the anesthetic depression effects of these drugs in newborns (by assessing Apgar scores) are mainly described in dogs[27,28] and are scarce in cats.

In this study, several cats delivered by emergency cesarean section, owing to previous dystocia, were apneic at birth due to anesthetic depression and required advanced resuscitation procedures, such as stimulating the cardiovascular system via the Jen Chung GV-26 acupuncture point and administering positive pressure pulmonary ventilation with the neonatal-specific canine/feline expander (One Puff Puppy) to start breathing. Thus, our findings highlight the importance of studies on anesthetic protocols in pregnant cats to reduce fetal–neonatal depression.

Despite the significant difference in Apgar scores between the groups, there was no significant difference in HRs. This lack of difference in HR contrasts with previous studies of dogs, which demonstrated reduced HR in pups delivered by cesarean section vs pups delivered via eutocic birth.[12,16,29] The normal neonatal HR in kittens can be >200 beats per min (bpm).[6] Owing to neonatal immaturity and prominent hypoxemia in dystocia and cesarean sections, it was assumed that CG cats would also have lower HRs. Furthermore, unlike what has been observed in dogs, the mean HR of cats at birth was >200 bpm. Thus, we hypothesize that the feline species possibly present greater maturity of cardiac autonomus development, as well as of carotid chemoreceptors, and thus myocardial hypoxia can be more effectively compensated for.

This hypothesis is supported by the comparison of RRs between feline and canine neonates. Regardless of delivery method, the RR of cats was higher than that of dogs.[12,16,20,29] While an average RR of up to 40 movements per min (mpm) is expected in newborn dogs,[12,30] in newborn cats in this study, averages above 100 mpm were observed. It is possible that cats demonstrate greater maturity of the adaptive breathing reflex, carotid chemoreceptors or lung structures than dogs, or a greater expansion of the chest wall, to compensate for hypoxemia during parturition. However, further studies are needed to examine cardiorespiratory maturity in newborn cats compared with dogs. In cats, a higher SpO_2 than that in dogs[29,31] was observed in both groups, possibly due to their higher RR and HR.

Owing to the differences in vitality parameters between newborn cats and dogs, we suggest a novel, modified feline Apgar score. As few studies exist on the

clinical evaluation of newborn cats, the routine use of canine Apgar scores in cats is common; however, there are various physiological and hemodynamic differences between these two species. Therefore, studies on specific clinical evaluations in cats facilitate the appropriate clinical management of these patients.

Similar to existing findings on blood glucose levels in neonatal puppies, we found elevated glucose concentrations in neonates delivered by cesarean section than in those delivered through eutocia.[32] This difference is likely due to the mobilization of hepatic glycogen stores in CG neonates due to the stress of asphyxia and/or hypoxemia that often accompanies dystocia and cesarean sections,[23] as well as the stress resulting from the advanced resuscitation procedures at birth or from the administration of epinephrine.[32] However, in neonates that did not experience excessive fetal stress, glucose levels have been directly linked to maternal glycemia.[33,34]

We also found a positive correlation between Apgar scores and neonatal weight. This aligns with previous studies on feline[21,35] and canine[14] neonates. In other words, puppies with low birth weights may be more immature and debilitated than puppies with medium birth weights, presenting with lower Apgar scores, lower vitality and, consequently, a higher risk of death.[35] Neonatal weight assessment is essential, as newborns with low birth weight require greater attention from veterinarians and breeders to ensure adequate development and improved survival rates.[6,14,35]

Feline neonates in both groups were hypothermic at birth, probably due to their immature thermoregulatory systems and their contact with amniotic fluid, as damp kittens quickly lose heat to the environment.[23,36] The CG neonates showed significantly higher body temperatures after 60 mins compared with those at birth. Possibly, this was due to CG neonates' time in the incubator, which was maintained at 30–32°C. It is crucial to manage neonatal body temperatures, as hypothermia can cause bradycardia, hypoxia and low vitality, as well as reduce the effectiveness of resuscitation maneuvers.[6,12,23]

The total mortality rate was 15.6% in the evaluated newborns, which is similar to the values observed by Cave et al[1] and Fournier et al,[2] who had losses of 14% and 16%, respectively. Mortality in feline and canine neonates is relatively higher in the first days of life.[3,4,37] In dogs, hypoxia during parturition is the leading cause of neonatal mortality, according for over 60% of deaths; approximately 90% of all deaths in hypoxemic puppies occur during the first 2 days.[37] In this study, the feline mortality rate was also highest over the first 2 days, corresponding to 80% of the losses. These deaths occurred due to hypoxia during dystocia and emergency cesarean section in neonates with low Apgar scores at birth.

It is important to be aware of the particularities of cats vs dogs so that we can distinguish key differences in their neonatal and adult parameters.

Conclusions

Cats delivered by emergency cesarean section experience neonatal depression and may require advanced resuscitation procedures. The clinical evaluations carried out in this study allowed us to identify newborns with low vitality, as well as those requiring advanced resuscitation procedures due to prominent hypoxemia; thus, we could immediately intervene. In addition, these evaluations allowed us to monitor the clinical evolution of the newborn after these procedures. It is essential that cat labor is overseen by a veterinarian and that clinical evaluation of the newborns is carried out using cat-specific vitality scores. The use of the modified feline Apgar score proposed in this study allows the provision of immediate assistance at birth and increases the chance of survival for these patients.

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