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An Apgar scoring system for routine assessment of newborn puppy viability and short-term survival prognosis

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Abstract

The Apgar scoring system is an easy and reliable method for evaluating both human and animal neonates. However, its use is not widespread in veterinary medicine. The current study assessed a modified Apgar scoring system for routine evaluation of newborn puppies. Heart rate, respiratory effort, reflex irritability, motility, and mucus color have been evaluated in the score. Specifically, we used 5 min after birth Apgar score to assess newborn viability and short-term survival prognosis, as well as related characteristics, in 193 puppies from 42 litters, 65 born by spontaneous delivery, 66 by assisted delivery, and 62 by cesarean section. The percentage of puppies that were dead 2 h after birth was higher in the 4 to 6 Apgar score group versus that in the 7 to 10 score group ($P < 0.01$) and in the 0 to 3 score group versus that in the 7 to 10 score group ($P < 0.0001$). Delivery method did not affect survival. There was a marked reduction in the number of puppies searching for the mammary gland in the 0 to 3 and 4 to 6 Apgar score groups compared with that in the 7 to 10 score group ($P < 0.0001$); there was a difference between the 0 to 3 and the 4 to 6 score groups as well ($P < 0.05$). Suckling/swallowing reflexes were present in fewer puppies in the 0 to 3 and 4 to 6 score groups compared with that in the 7 to 10 group ($P < 0.0001$), with no significant differences between the 0 to 3 and the 4 to 6 score groups.

Keywords: Apgar score; Newborn puppies; Survival; Viability

1. Introduction

Emergency care in neonatal dogs is difficult, and newborn puppies have physiologic characteristics and needs that are very different from those of adult dogs [1,2]. To provide optimal care to puppies in a pediatric intensive care situation, a veterinarian should be familiar with normal and abnormal vital signs, nursing care and monitoring considerations, and probable diseases [3]. The immaturity of newborn puppies makes them extremely vulnerable: neonatal death is very common, with an average neonatal mortality of 15% to 25% [4] and a total morbidity and mortality of 5% to 35% [5,6].

Death can occur in utero, during expulsion, after birth, in the first weeks of life, or after weaning. However, the perinatal death rate (dead puppies and neonates) is highest during parturition, immediately after birth, and in the first days of life. Predisposing factors to death include dystocia, type and timing of intervention during birth, in-breeding, malformations and genetic defects, low birth weight, diseases and the vaccination status of the mother, environmental conditions, and infectious agents [7]. The main causes of neonatal mortality are respiratory distress after dystocia, and bacterial infection [4].

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Caring for neonates is challenging in human medicine as well as in veterinary medicine, and it is helpful to use a routine evaluation method immediately after birth to identify newborns that require prompt medical intervention. In 1952, the physician and anesthesiologist Virginia Apgar developed a simple, reliable scoring system for evaluating the health of babies immediately after birth [8]. She developed this method after observing that struggling babies were frequently placed out of sight and left to die. Apgar wished to quickly identify newborns that needed additional help in the moments after delivery. Her method, termed the Apgar score, was quickly adopted in many countries, and it was noted that "...every baby born in a modern hospital anywhere in the world is looked at first through the eyes of Virginia Apgar" [9].

In humans, the Apgar score encompasses five parameters that are easy to determine without interfering with the care of the infant. This score is particularly useful in assessing the clinical status of newborns. Although the score was originally named after its creator, in 1963 the acronym APGAR was coined as a mnemonic learning aid to easily remember these signs: Appearance, Pulse, Grimace, Activity, and Respiration. Each of these is evaluated on a scale from 0 to 2, with the sum of the five values resulting in an Apgar score that ranges from 0 to 10. This test is generally performed between 1 and 5 min after birth and may be repeated later for newborns with low scores. In humans, a score less than 3 is usually considered critical, from 4 to 6 is low, and over 7 is regarded as normal [10]. A low score means that the neonate requires medical attention; if the score improves in the following few minutes, it is usually not correlated with long-term problems. In contrast, an Apgar score of 0 at 10 min represents an important risk factor for subsequent death or disability [11].

Notably, the Apgar score was not designed to make long-term predictions but rather to guide physicians in providing care to vulnerable individuals immediately after birth. Studies have demonstrated that both the 1- and 5-min Apgar scores are predictors of mortality in newborns but do not generally serve as predictive indices of long-term neurologic or mental impairments [12,13]. The Apgar score is a better predictor of survival than is umbilical artery blood gas in very low birth weight infants [14]. For early identification of acidosis and perinatal asphyxia, the relationship between Apgar score and umbilical arterial blood gas values and pH was investigated [14–16]. Results showed that the Apgar score cannot be used to measure perinatal asphyxia but should instead be considered an easy method for assessing the overall condition and, to some degree, the viability of the infant immediately after delivery and the effectiveness of resuscitation [17].

Because of its usefulness for overall assessment and its unquestionable reliability in short-term survival prediction, the Apgar score was introduced into use in veterinary medicine to assess the clinical status of newborns such as foals, calves, and piglets [18–22]. Naturally, the evaluation criteria had to be changed somewhat for use in these species. A modified Apgar scoring system was found to be useful for newborn viability and perinatal asphyxia detection in foals [20]. Some parameters were modified, resulting in more effective assessment of asphyxia when used in combination with other ethological and clinical indices [18,19,21].

To date, the Apgar scoring system has not been used widely to evaluate newborn puppies, mainly due to the polytocous condition of the dog. However, the economic value of pure-breed puppies, as well as the increasing emotional involvement of owners in their pets' birthing process, has increased interest in improving puppy survival. The aim of the current study was to evaluate the reliability of a modified Apgar score system for routine evaluation of newborn puppy viability and for survival prognosis. Related characteristics were also evaluated.

2. Materials and methods

2.1. Animals

The study involved 193 puppies from 42 litters delivered by bitches 1.5 to 8 years old belonging to different breeds, 40% of the bitches belonging to small breeds ($\leq$10 kg body weight [BW]), 27% to medium breeds (11 to 20 kg BW), and 33% to large-giant breeds (>20 kg BW). Puppies included in the study were delivered by spontaneous whelping (SW), assisted whelping (AW), or by cesarean section (CS). Because dogs are polytocous, and whelping can start as spontaneous but then require further obstetric or surgical assistance, puppies were classified individually as delivered by SW, AW, or CS. The SW group included only puppies born without any kind of assistance. When any dystocia was detected, the most reliable medical, manual, or surgical resolution was applied to each single case. The medical assistance consisted of single oxytocin (0.5 to 3 IU/dog, iv) and 10% calcium gluconate (1 mL/5 kg BW, sc) administration in bitches with uterine inertia and was usually combined with gentle manual extraction of the fetus. When the medical and/or manual assistance was unsuccessful, or when other dystocias were unsolvable by medical or manual

assistance, cesarean section was performed. Anesthesia was induced by propofol administration (2 to 4 mg/kg BW) followed by isoflurane maintenance plus butorphanol line block. Cesarean section was performed by a midline incision of the abdomen from the pubis to the umbilicus and a dorsal incision on the uterine body to allow quick removal of the puppies. Immediately after removal of a fetus and its placenta, each puppy was transferred to a heat-controlled room (at 32 °C) and put under first neonatal care. This consists of: a complete and careful cleaning of the upper airway, clamping of the umbilical cord and separation from its placenta, skin drying, and gentle thorax massage before entering the incubator until re-conjunction to the bitch.

2.2. Newborn evaluation

At birth, or after first care for puppies born by cesarean section, each puppy was weighed and assessed for physical malformations. After the Apgar score was recorded, other physiologic and behavioral parameters important for newborn viability were evaluated. These parameters included body temperature, searching for the mammary gland, and suckling and swallowing reflexes. Each of the last three parameters was classified as present or absent. For all spontaneous and assisted births, the expulsion time was recorded (i.e., the time elapsed between the expulsions of two consecutive puppies or, for the first born, the time from the appearance of the fetal membranes to complete fetal expulsion). For survival data, each newborn was categorized as born dead; born alive but dead within 2 h of birth; or viable and still alive after 2 h. Viability was checked 2 h after birth, in agreement with Moon-Massat and Erb [23], and rechecked at 24 h.

2.3. Apgar score evaluation

A modified Apgar test for puppies was formulated in accordance with the basic rules proposed by Virginia Apgar for babies. Specifically, we chose to score a few parameters that were easily detectable without the use of sophisticated tools: heart rate, respiration, irritability reflex, motility, and membrane mucus color. The reference range for each parameter was adapted for use in dogs according to the physiology of the canine neonate. The heart rate references applied in this score are in agreement with data reported in Ref. [24]. Heart rate >220 beats per minute (bpm) was rated as 2, between 180 and 220 bpm was rated as 1, and <180 bpm was rated as 0. In the evaluation of the respiratory effort, the most important factor considered was the presence and clearness of puppy vocalization at birth, a neat index of vitality not only in newborn babies but also in dogs [23]. However, for a better evaluation of respiration, the respiratory frequency was calculated also in association with vocalization. Clear crying associated with >15 respiratory rate was rated as 2, mild crying and 6 to 15 respiratory rate was rated as 1, and no crying with <6 respiratory rate was rated as 0. On the basis of the authors' experience, the reflex irritability, not easily inducible and detectable in the newborn dog, was evaluated by the gentle compression of the tip of a paw, evaluating the degree of newborn reaction: crying and quick leg retraction was rated as 2, weak leg retraction and no or just weak vocalization was rated as 1, and no leg retraction and no vocalization was rated as 0. Motility was evaluated observing the strength of spontaneous movement of the newborn, rating as 2 strong movement, as 1 mild movement, and as 0 weak or absent attempt of newborn movement. The mucus color was evaluated considering that pink mucus membranes are considered as normal in newborn dogs [25] and therefore rated as 2, pale membranes could have been related to several cardiovascular troubles and thus rated as 1, whereas cyanosis should be considered as the severest expression of respiration failure and therefore rated as 0 (Table 1). Assigning a rate from 0 to 2 to each parameter, the total sum provided a final Apgar score. The scores were used to identify three levels of newborn distress: 7 to 10, no distress; 4 to 6, moderate distress; and 0 to 3, severe distress. The Apgar

Table 1
The modified Apgar scoring system used in this study (rr = respiratory rate).

Parameter	Score		
	0	1	2
Heart rate	<180 bpm	180 to 220 bpm	>220 bpm
Respiratory effort	No crying/ < 6 rr	Mild crying/6 to 15 rr	Crying/ > 15 rr
Reflex irritability	Absent	Grimace	Vigorous
Motility	Flaccid	Some flexions	Active motion
Mucus color	Cyanotic	Pale	Pink

score was calculated within 5 min of birth to avoid interference with maternal grooming in spontaneous whelping. The relationship of the Apgar score with newborn survival was evaluated, as well as its relationship to the type of whelping, the puppy's search for mammary glands, and suckling and swallowing reflexes.

2.4. Statistical analysis

Fisher's exact test was used to detect the significance of the association between (1) dead and live birth puppies according to the type of delivery; (2) differences in viability and mortality 2 to 24 h after birth among the Apgar score groups; (3) differences in searching for mammary gland behavior and suckling and swallowing reflexes among the Apgar score groups.

3. Results

All 42 litters were normal-sized according to the breed. Of a total of 193 puppies, 65 were born spontaneously (SW), 66 after assisted parturition (AW), and 62 after cesarean section (CS); thus, 66.3% of the puppies were born by AW or CS. The male-to-female ratio was 98:95. In the SW group, the time elapsing between two consecutive fetal expulsions ranged from 10 min to 3 h. In the AW group, obstetric assistance was provided in all cases of dystocia, when the expulsion of the first pup took more than 1 h, and when the expulsion between two consecutive pups took more than 3 h. Three puppies born by cesarean section were euthanized immediately after birth because they had severe cleft palates. The other 190 puppies appeared normal. The birth weights (range, 100 to 640 g BW) were all within the normal range for each breed, and body temperature measurements were between 35.5 °C and 36.5 °C. Of a total of 193 newborns, 27 (14%) were born dead, whereas 166 (86%) were live births. Table 2 shows the number of dead puppies and live puppies according to the type of delivery. No significant differences were detected in puppies that were dead versus live in terms of the type of delivery.

Table 2
Dead and live puppies born according to the type of delivery.

Type of whelping	Puppies, n (%)	Dead, n (%)	Live birth, n (%)
SW	65 (33.7)	9 (33.3)	56 (33.7)
AW	66 (34.2)	13 (48.2)	53 (32)
CS	62 (32.1)	5 (18.5)	57 (34.3)
Total	193 (100)	27 (100)	166 (100)

SW, spontaneous whelping; AW, assisted whelping; CS, cesarean section.

Table 3
Puppy death and survival 2 to 24 h after birth according to the type of delivery.

Type of whelping	Puppies, n	Dead at 2 h, n (%)	Alive 2 to 24 h after birth, n (%)
SW	56	2 (22.2)	54 (34.4)
AW	53	4 (44.5)	49 (31.2)
CS	57	3 (33.3)[a]	54 (34.4)
total	166	9 (100)	157 (100)

SW, spontaneous whelping; AW, assisted whelping; CS, cesarean section.
[a] Three puppies born by cesarean section were euthanized due to severe cleft palates.

Nine of the 166 puppies that were born alive (5.4%) died within 2 h of birth; however, it should be stressed that 3 of the 9 puppies were euthanized, and there were only 6 spontaneous deaths. The other 157 (94.6%) puppies were alive 2 h after birth, and all were still alive 24 h after birth, so that the 2-h survival rate was the same as the 24-h survival rate. Table 3 shows death and survival 2 to 24 h after birth according to the type of delivery. No significant differences were detected in puppies that died versus those that survived in terms of the type of delivery. Table 4 shows the Apgar scores and 2- to 24-h survival after birth according to the type of delivery.

All puppies with Apgar scores of 0 to 6 at birth were given medical treatment aimed at improving their chances of surviving. The treatment consisted mainly of breathing stimulation by rubbing the thorax, ventilation and/or oxygen mask administration, and, in puppies with severe distress, also the administration of epinephrine (0.2 mg/kg, intraosseous) [25]. In the group with severe distress (Apgar score 0 to 3), four puppies died after 20 min of unsuccessful resuscitation, whereas three others improved quickly and achieved Apgar scores of 6 to 7 within 20 min. These three puppies survived and were alive and viable at 24 h. In the group of puppies with Apgar scores of 4 to 6, neonatal assistance was successful in 15 of 17 puppies. Thus, 88.2% of moderately distressed puppies survived with the help of medical treatment.

Statistical analysis showed that the percentage of puppies that were dead at 2 h was higher in the 4 to 6 Apgar score group compared with that in the 7 to 10 score group ($P < 0.01$). This difference was even greater when the 0 to 3 Apgar score group was compared with the 7 to 10 score group ($P < 0.0001$). The type of delivery did not affect the death rate.

Table 4
Survival of puppies (n = 163) 2 to 24 h after birth in relation to the type of delivery and Apgar score.

Apgar score	Puppies, n (%)	Dead within 2 to 24 h, n (%)			Viable and alive after 2 to 24 h, n (%)		
		SW	AW	CS	SW	AW	CS
7 to 10	139 (85.3)	0 (0)	0 (0)	0 (0)	50 (92.6)	38 (77.6)	51 (94.4)
4 to 6	17 (10.4)	0 (0)	2 (50)	0 (0)	3 (5.5)	9 (18.4)	3 (5.6)
0 to 3	7 (4.3)	2 (100)	2 (50)	0 (0)	1 (1.9)	2 (4)	0 (0)
Total	163 (100)	2 (100)	4 (100)	0 (0)	54 (100)	49 (100)	54 (100)

SW, spontaneous whelping; AW, assisted whelping; CS, cesarean section.
Note: Apgar score was not evaluated in the three euthanized puppies.

Table 5
Presence or absence of mammary gland searching and suckling and swallowing reflexes in relation to the Apgar score group in puppies (n = 163).

Apgar score	Mammary gland searching		Suckling reflex		Swallowing reflex	
	Present, n (%)	Absent, n (%)	Present, n (%)	Absent, n (%)	Present, n (%)	Absent, n (%)
7 to 10	139 (100)	0	135 (97.1)	4 (2.9)	135 (97.1)	4 (2.9)
4 to 6	13 (76.5)	4 (23.5)	7 (41.2)	10 (58.8)	7 (41.2)	10 (58.8)
0 to 3	1 (14.3)	6 (85.7)	0	7 (100)	0	7 (100)
Total	153	10	142	21	142	21

The presence or absence of suckling and swallowing reflexes, as well as whether the puppies searched for mammary glands, is reported in Table 5 according to the Apgar score group. We observed that some newborns with high Apgar scores searched for mammary glands but did not show suckling and swallowing reflexes. Interestingly, all puppies exhibiting the suckling reflex also showed the swallowing reflex. Not surprisingly, 6 of 10 puppies that did not search for mammary glands were in the group of puppies with Apgar scores of 0 to 3; of 21 puppies that lacked suckling and swallowing reflexes, 7 were in the 0 to 3 Apgar score group. Statistical analysis showed a marked reduction in the number of puppies searching for mammary glands in the 0 to 3 and 4 to 6 Apgar score groups compared with that of the 7 to 10 score group ($P < 0.0001$), as well as a difference between the 4 to 6 score group and the 0 to 3 score group ($P < 0.05$). In terms of the suckling/swallowing reflexes, the same differences were observed between the 0 to 3 and the 4 to 6 score groups compared with the 7 to 10 score group ($P < 0.0001$); there was no significant difference between the 0 to 3 and the 4 to 6 score groups.

4. Discussion

Parturition and the start of respiration are undeniably the most critical moments for the newborn puppy. Prompt identification of even weak signs of distress can be extremely important for providing rapid treatment to less viable newborns. The current study showed the reliability of a modified Apgar scoring system for routine assessment of newborn viability in dogs. The Apgar evaluation required just a few minutes and did not interfere with maternal grooming in puppies born by spontaneous whelping; in addition, it did not affect postnatal care after AW or CS.

The high percentage (66%) of puppies born by AW or CS confirmed that dystocia could interfere with SW in dogs [7]. Overall, the rate of puppies born dead was 14% and was independent of the type of delivery. This finding is in general agreement with the reported rate of 19% dead puppies in a study of CS delivery by Moon-Massat and Erb [23]. Although no significant differences in mortality were detected among different types of delivery in this study, it seems likely that there is a higher risk of death in AW compared with that of SW or CS. Of 193 puppies in the current study, 3 (1.6%) were malformed. This percentage is very low compared with the 14% reported by Moon-Massat and Erb [23], but that study involved more puppies. The overall percentage of live births (86%) in our study was very similar to the live-birth percentage (92%) reported by Moon-Massat and Erb [23] for CS. It should be noted that in the current study, the percentage of live births by CS (92%) was identical to the percentage (92%) reported by Moon-Massat and Erb [23]. The overall survival rates at 2 h after birth (94.6% overall; 87% in the CS group) were in agreement with the survival rate (87%) reported by Moon-Massat and Erb [23] in CS-

delivered puppies. No puppies died between 2 and 24 h, so the 2-h survival rate and the 24-h survival rate were the same. This highlights the importance of identifying and treating vulnerable puppies immediately after delivery.

We are aware that there is a risk of death for puppies in their first 2 wk of life. In dogs, death in the days after parturition can be due to causes that are unrelated to factors associated with newborn viability (i.e., crushing by large-breed mothers, poor maternal skills, environmental conditions, infections, etc.). The absence of significant differences in the distribution of puppies surviving at 2 to 24 h after birth in relation to the type of delivery supports the hypothesis that the type of delivery does not influence newborn survival in dogs. However, the aim of the current study was to evaluate puppy survival/viability at birth in relation to Apgar scores. Interestingly, most of the newborn deaths were puppies with Apgar scores of 0 to 3; no puppies with Apgar scores of 7 to 10 died within 24 h of birth. There were significant differences among Apgar score groups in terms of survival; although a good Apgar score did not guarantee newborn survival per se, puppies with high scores had a survival advantage over those with lower scores. Despite the relatively small number of puppies evaluated in the current study, our data concerning the high probability of death of puppies with low Apgar scores are in agreement with results obtained by Casey et al. in a larger study of human babies [26]. In that study, the mortality rate of babies with Apgar scores of 0 to 3 was 24% compared with the 0.02% of babies with Apgar scores of 7 to 10.

The hypothesis that a poor Apgar score is an important tool for detecting less viable newborn dogs is supported by the significant relationship between Apgar score and some physiologic and behavioral characteristics of newborn viability, such as mammary gland searching behavior and suckling and swallowing reflexes. In fact, in the current study, puppies that did not search for mammary glands and that did not have suckling and swallowing reflexes also had poor Apgar scores. However, this had no relation to the puppies' body temperatures, which were always in the normal range for newborn puppies [1]. Statistical analysis showed a stronger relationship between searching for mammary glands and suckling/swallowing reflexes in newborns with Apgar scores of 7 to 10 ($P < 0.0001$) compared with Apgar scores of 0 to 3. Less significant was the relationship between searching for mammary glands and Apgar scores of 4 to 6 versus scores of 0 to 3 ($P < 0.05$).

True to the principles of Virginia Apgar, systematic evaluation of puppies in this study allowed the timely detection of puppies with poor Apgar scores that might otherwise have been overlooked after birth. Three of seven puppies with Apgar scores of 0 to 3 recovered completely, as did 15 of 17 puppies with scores of 4 to 6. This is evidence that the prompt detection of less viable newborns, followed by attempts to resuscitate, could improve neonatal survival. From an economic standpoint, there is no cost associated with Apgar scoring, but the survival of even a single puppy that would otherwise have died increases the profit for the breeder.

Taken together, the results of the current study show the reliability of routine Apgar evaluation of newborn dogs for assessing viability and determining survival prognosis. In addition, systematic use of the Apgar evaluation allowed the prompt identification of puppies requiring neonatal care. Even though a control group for the actual evaluation of resuscitation effectiveness was lacking in the current study, we suggested that repeated Apgar measurement after assistance of depressed newborns could in some way allow the clinician to evaluate the puppy response to resuscitation. Use of this simple method of neonatal evaluation of puppies should be encouraged whenever veterinary assistance is available at whelping. In conclusion, we believe that in puppies as in humans, every puppy born in every part of the world should be seen at birth first through the eyes of Virginia Apgar.

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