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Review

Assessment of the vitality of the newborn: An overview

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Four million newborns die in the world every year, and reports indicate that 98% of those deaths occur in developing countries. The infant mortality rate in children under 5 years of age in Mexico has decreased progressively, in contrast to the neonatal mortality rate, where the reduction was not significant. For this reason, it is necessary and important to have resources that make it possible to assess, rapidly and efficiently, the physiological status of newborns. The objective of this review is to identify the factors involved in the vigor of the newborn. This review will thus allow us to understand the relation that exists between the vitality scores and birth weight, the repercussions of the process of prenatal asphyxia, age of gestation and mortality. Once the factors involved in decreases in the vigor of the newborn have been reviewed, additional studies will be required to use animal models to test different pharmacological therapies that newborn humans have shown their value for early diagnosis and treatment, as a means of improving their physiological and hemodynamic condition during the first hours of extra uterine life, as this is a fundamental factor in their survival.

Key words: Animal welfare, stress, vitality, neonate, asphyxia.

INTRODUCTION

Approximately 10.7 million children under 5 years of age die in the world each year, of whom 3.3 million are stillborn and another 4 million occur within the first 4 weeks of life (according to official reports). The infant mortality rate in Mexico has declined steadily from 44.2/1000 live births in 1990 to 28.5 in 2000 and 23 in 2005, in contrast to neonatal mortality, where the decline has not been as significant as reports indicate indices of 21.9/1000 live births in 1990, 17.0 in 2000 and 12.9 in 2005. Neonatal death is usually secondary to complications of prematurity, birth asphyxia, trauma, infection or congenital malformations, among other perinatal causes (Sepúlveda et al., 2006). It is reported that the highest rate (33%) in 2000 was due to neonatal disorders, which makes reducing neonatal mortality a priority worldwide (Jones et al., 2003). In 1953, the anesthesiologist Virginia Apgar devised a scoring system as a quick method to assess the clinical status of newborns in the first minute of life and thus determine the need for early intervention to establish breathing (Apgar, 1953). A second report evaluated a larger number of patients (Apgar et al., 1958). The Apgar score includes 5 components: heart rate, respiratory effort, muscle tone,

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reflex irritability and color, each of which receives a score of 0, 1 or 2. This scoring system allowed a standardized assessment of the newborn at birth. Currently, the Apgar score is determined at 1 and 5 min after birth, and has proven to be a fast and convenient method of reporting the status of the newborn and its response to resuscitation. But the Apgar scale has also been used inappropriately to predict specific neurological sequelae. This score should not be used in this age group for any purpose other than that of achieving a dynamic assessment in the delivery room. Several obstetric risk factors associated with low scores on the Apgar score at 5 min in term infants, including mortality and the risk of serious neurological morbidity, are higher in these infants (Thorngren-Jerneck and Herbst, 2001). Thus, using the Apgar score as a predictor of neonatal sequelae must first be validated if it is to be used in assessing the effectiveness of antenatal or neonatal interventions (Weinberg et al., 2000).

Given that the transition period of an animal welfare of newborn is important because it is a time when most of the problems of adaptation that might occur can be detected (Olmos-Hernández et al., 2008, 2010; González-Lozano et al., 2010; Mota-Rojas et al., 2011) (changes in thermoregulation and respiratory distress, among others), it is essential to accurately assess the condition of the newborn at birth and its progress in the first hours of life, as has been reported in studies with animal models (Trujillo-Ortega et al., 2007; Mota-Rojas et al., 2005a, b, 2006; Amer and Hashem, 2008; van DijK et al., 2006, 2008). The Apgar scoring system is an easy and reliable method for evaluating both human and animal neonates (Orozco-Gregorio et al., 2008). However, its use is not widespread in veterinary medicine (Veronesi et al., 2009). The current study assessed a modified animal welfare scoring system for the routine evaluation of newborn puppies. Heart rate, respiratory effort, reflex irritability, motility and mucus color are the factors evaluated in this scoring system (Veronesi et al., 2009).

The Apgar score so widely used in human medicine has been modified and occasionally applied in swine research. In swine, the score uses the following 5 clinical variables: respiration, heart rate, muscle tone, attempts to stand and skin color (Mota-Rojas et al., 2005c, d). Similar to its human counterpart, the porcine score is based on discreet numerical values that range from 0 to 2 (0, 1 or 2). An animal welfare score is assigned to each individual variable during the first minute of extrauterine life, and again once the umbilical cord has ruptured. Lower scores do not necessarily imply intra-partum asphyxia, because congenital infections or malformations can cause similar results (Moster et al., 2002). The Apgar score, however, may be more effective in assessing asphyxia when used in combination with other clinical and ethological indices. The most commonly used indicators of health and vigor in piglets are the time interval between birth and the first inspiratory attempts, standing, teat contact and suckling, as well as rectal temperature at 24 h after birth and survival and growth rates during the first week of life (Herpin et al., 1996, 1998; Varona et al., 2005).

Therefore, this review is crucial because once the factors involved in decreasing the score of vigor of the newborn have been reviewed; future studies will need to test different drug therapies from animal models that allow newborns to increase their strength during the first hours after birth, as a key survival factor.

OVERVIEW OF THE USE OF THE APGAR SCORE

The transition from fetal to extrauterine life is characterized by a unique series of physiological events: the change from amniotic fluid-filled lungs to progressive air-filling, a dramatic increase in pulmonary blood flow , the intra and extracardiac shunts (foramen ovale and ductus arteriosus), and the initial parallel circulation followed by the physiological and anatomical closure of these flow holes in series. Such physiological considerations affect resuscitative interventions in the newborn (Kattwinkel et al., 1999).

The Apgar test is widely used to identify infants who require resuscitation and to assess their condition during the first minutes of life (Patel and Piotrowski, 2002). However, Kattwinkel et al. (1999) indicated that the vitality score should not be taken into account when determining the resuscitation technique to be utilized. Program guidelines for neonatal resuscitation state that the Apgar score should not be used to determine actions for resuscitation, or be delayed until the assessment at 1 min after birth to decide on interventions for the depressed newborn. If the Apgar score is less than 7 at 5 min, neonatal resuscitation guidelines state that the assessment should be repeated every 5 min until reaching 20 min (AAP, 2005). There is no accepted standard for reporting Apgar scores in newborn infants undergoing resuscitation after birth, precisely because several of the elements that make up the score are altered by resuscitation. One suggestion is to use an assisted score that takes resuscitation into account, but the predictive reliability of this model has not yet been studied. In order to correctly describe the status of newborns and assure secure documentation and data collection, we propose an extended form of Apgar (AAP, 2006).

The score on the Apgar scale was used as a tool for predicting the neurological development of newborns, the exact use for which it was originally designed (Committee on Fetus and Newborn, 1986; Casey et al., 2001; Whelan, 2006). Whelan (2006) mentioned that low scores on the Apgar scale are risk factors for developing cerebral palsy, while Flidel and Shinwell (2007) reported that a correlation exists between the vitality score and an increase in the severity of neurological damage when the score attained is between 0 and 3 at 10, 15 and 20 min.

The Apgar score at 1 min of life generally correlates with the pH of the umbilical cord blood as an index of intra-partum depression. It has been observed that infants with scores between 0 and 4 have a significantly lower pH, higher blood pressure carbon dioxide (PaO_2) and lower numbers of buffers in the blood, compared to those whose scores are above 7 (Ringer, 2002).

Kattwinkel et al. (1999) defined that the Apgar scale quantifies and summarizes the response of the newborn to the extrauterine environment, and mentioned that analyses of vitality using the Apgar test should be conducted every 5 min after birth until all vital signs –heart rate, respiratory rate, reflexes, muscle tone and color have stabilized. The 5 min interval assessment of the vitality of the newborn by the Apgar scale is regarded as the best predictor of survival in the neonatal period (Casey et al., 2001). Whelan (2006) referred to previous studies showing that low scores on the vitality by Apgar scale at 5 min were associated with death or cerebral palsy, and that this tendency increases if the two assessments made in 1 min and at 5 min are both low.

Karin et al. (1981) undertook an assessment of Apgar at 1 and 5 min in approximately 49,000 newborns, and at 10, 15 and 20 min in infants who did not reach an Apgar score >8 at 5 min, with monitoring of those infants up to 8 years of age. They found that low Apgar scores are a risk factor for infant palsy. Of all the children who developed cerebral palsy, 55% had Apgar scores of 7-10 per min, and 73% scored from 7 to 10 at 5 min. Of 99 children who had Apgar scores of 0 to 3 at 10, 15 or 20 min and survived, 12 (12%) had cerebral palsy, 11 of those 12 also had mental retardation (the IQ of 10 of them was <50), and fully half of those children presented convulsive disorders. While 8 children who survived after obtaining low Apgar score had no cerebral palsy, they did suffer from less severe disabilities. On the other hand, Thorngren-Jerneck and Herbst (2001) reported that a low Apgar score in the first minute of life is usually caused by temporary depression, while a low score at 5 and 10 min usually involves clinically significant complications, indicating that the newborn has not responded optimally to resuscitation. Those authors mentioned that regardless of the cause of low scores on the Apgar scale. They indicated the involvement of the newborn and, therefore, are not desirable.

Hübner and Juarez (2002) reported that a low score on the vitality scale certainly indicates an abnormal condition, but does not necessarily imply a specific cause. A low score may be due to suffocation, drug use, birth trauma, dehydration, infection or other abnormalities. Hegyi et al. (1998) indicated that preterm infants with birth weights <2.500 g, evaluated with Apgar at 1 and 5 min, correlated with pH and other variables, such as gender, race, gestational age and birth weight, while variables included in Apgar –respiratory effort, muscle tone and reflex activity– correlated well with one another; heart rate correlated less and color was the least correlated of all the factors, the reason for which they consider that it is of only limited utility in the premature infant. Weinberger et al. (2000) indicated that the use of Apgar score in preterm infants is widespread, despite controversy about its reliability in terms of measuring morbidity and mortality in the neonatal period. Obviously, the result of the Apgar scale is a reflection of the complex interaction between complications of pregnancy and therapeutic interventions. Nonetheless, Apgar is currently used worldwide to clinically evaluate newborns, and is ever present in medical records that report the status of infants.

THE RELATIONSHIP BETWEEN LOW BIRTH WEIGHT AND THE VITALITY OF THE NEONATE

About 60% of newborns in the developing world are not weighed, there is no data that would allow comparisons and, therefore, assess progress. However, it seems that the incidence of low birth weight (LBW) has remained more or less constant since 2000. In developing countries, about 16% of infants (over 19 million) are born weighing less than 2,500 g. These babies are 20 times more likely than normal birth weight babies to die in their first years of life, while those who survive are often more susceptible to infectious diseases and impediments to cognitive development and, likewise, are more likely to develop chronic diseases later in life (WHO, 1995). LBW is the main factor known to be involved in infant mortality, and is also closely associated with impaired child development (Trujillo-Ortega et al., 2011). Indeed, some reports suggest that over 50% of all chronic neurological morbidity is attributable to this disorder. Recently, LBW was associated with fetal growth irregularities and some adult disorders such as coronary heart disease. Moreover, LBW is a result of inadequate intrauterine growth, a shortened gestation period or a combination of these two phenomena (Bortman, 1998). Infants who have extremely LBW account for less than 1% of live births and half of all perinatal deaths. Locatelli et al. (2005) have shown that predictions of survival are significantly related to birth weight and Apgar scores at 5 min after birth. Recently, Apgar has incorporated into scoring systems that are highly predictive of neonatal mortality in infants with very LBW (Weinberger et al., 2000). LBW is associated with a number of indicators of abnormal conditions in the perinatal period and results in, among many other conditions, abnormal psycho-neurological development in human infants and animal neonates (Vázquez et al., 1990; Orozco-Gregorio et al., 2011).

Weinberger et al. (2000) reported that the result obtained from Apgar assessments at 5 min are correlated with the survival of infants with birth weights below 1,000 g.

In an assessment of the vitality of 62 infants who weighed between 501 and 750 g, Davis (1993) found that newborns with a score between 0 and 3 did not survive, but that those who achieved a score of 6 had a 75% chance of survival.

In his retrospective analysis of 87 newborns with low vitality at birth, Laffita (2005) found that 18.4% had a weight <2,500 g, while 10.3% were macrosomic newborns and affirmed that products with LBW support adaptation to extrauterine life less well, whereas in products with high birth weights in relation to their gestational age, the incidence of low Apgar scores is lower. Finer et al. (1999) noted that of 45 infants weighing between 401 and 500 g who received cardiopulmonary resuscitation (CPR), 44% achieved failing scores on the vitality scale.

Recently, Locatelli et al. (2005) performed a study aimed at evaluating the factors that affect the independent survival of toddlers weighing 750 g or less, through a logistic regression analysis which showed that a higher score on the Apgar score at 5 min after birth is an indicator of survival. Therefore, birth weight and Apgar scores at 5 min will remain the best predictors of neonatal mortality (Ambalavanan et al., 2001).

Thorngren-Jerneck and Herbst (2001) indicated a strong influence of birth weight and gestational age on low Apgar scores. LBW is known to be a risk factor for fetal compromise, as in cases of chronic placental insufficiency. It is frequently found that either an increase or decrease in birth weight deviations is accompanied by a similar increase in the risk of achieving low Apgar scores at 5 min.

REPERCUSSIONS OF THE PROCESS OF NEONATAL ASPHYXIA ON VITALITY

It has been reported that birth asphyxia is responsible for about 19% of the 5 million neonatal deaths (WHO, 1995) that occur around the world each year (Kattwinkel, 2006). Approximately 1 million of those infants die from asphyxia, and an approximately equal number develop sequelae such as cerebral palsy, mental retardation and epilepsy. The clinical diagnosis of asphyxia at birth, together with related conditions, such as hypoxia-ischemia and neonatal encephalopathy, are recognized as an important cause of morbidity and mortality in neonates (Vineta and Kari, 1988; Wu et al., 2004). But a low Apgar score is not, in and of itself, a specific indicator of birth asphyxia, as there may be other causes of this depression at the time of birth (Thorngren-Jerneck and Herbst, 2001). In order to speak of intrapartum asphyxia, the following conditions must be met: a) a low Apgar score of 0 to 3 after more than 5 min; b) a mixed acidemia or metabolic acidosis (umbilical artery pH of less than 7.0); c) events indicating neurological disorders including: hypotonia, seizures or coma; d) evidence of organ dysfunction (Hübner and Juarez, 2002). Casey et al. (2001) mentioned that the combination at 5 min of a score of 0 to 3 on the Apgar scale with values of 7.0 or less in pH increase the risk of neonatal death in both preterm and term infants. A newborn with a low score on the Apgar scale and an acidotic umbilical cord is likely to also be affected by a process of asphyxiation (Committee on Fetus and Newborn, 1986). Over the last two decades, there have been numerous studies of the relationship between blood gases and umbilical cord pH values at birth as an objective measure for diagnosing asphyxia and subsequent neonatal development (Victory et al., 2004).

Vineta and Kari (1988) determined the values of 964 newborns; of 111 (12%) infants with a low umbilical pH, only 12 scored ≤7 on the Apgar scale, and those same newborns presented acidosis at birth. In contrast, of 853 infants with normal umbilical pH, 836 had a score ≥7 on the Apgar scale. Furthermore, Casey et al. (2001) demonstrated that Apgar scores at 5 min after birth were a better indicator than the result of measuring the pH of umbilical arterial blood, even in neonates with acidemia. However, the combination of 0 to 3 Apgar scores at 5 min and values of 7.0 or less in the pH of the umbilical artery increased the relative risk of death of premature and term infants.

Hogan et al. (2007) proposed studying the frequency of failing grades in the assessment of Apgar in terms newborns and their association with signs of intrapartum hypoxia, and the frequency with which other diagnoses could explain the depression of the newborn at birth. Results obtained in the absence of major malformations showed that Apgar scores below 4 at 5 min of life are more likely to reflect intrauterine asphyxia in severely depressed infants, as 70% of the 183 infants studied had signs of hypoxic-ischemic neonatal death by asphyxiation, while the rest presented aspiration of meconium-stained amniotic fluid (most of them had acidemia, indicating intrauterine hypoxia). Their conclusion was that the result of the assessment of Apgar scores below 4 at 5 min is a good indicator of asphyxia, while a score of 4 to 6 can indicate suffocation in half of the cases. On the other hand, Thorngren-Jerneck and Herbst (2001) reported that Apgar scores ≤7 at 5 min in terms of infants are associated with an increased risk of neonatal morbidity, mortality and neurological disorders (Sánchez-Aparicio et al., 2008, 2009).

REPERCUSSIONS OF THE GESTATION AGE ON THE VITALITY OF THE NEONATE

In their analysis, Locatelli et al. (2005) indicated that the prediction of survival was strongly correlated with gestational age; likewise, Catlin et al. (1986) noted that Apgar scores at 1 and 5 min of life are positively correlated with gestational age and that only children born under 30 weeks required intubation. Mcintire et al. (1999) stated that at any gestational age, children with LBW have relatively high morbidity and mortality. It is not known, however, if there is a threshold below which birth weight, morbidity and mortality are significantly higher, or whether that threshold varies with gestational age.

Weinberger et al. (2000) studied 261 newborns at 23 and 28 weeks of gestation. One group of 54 infants weighing 796 ± 207 g at birth and with a gestational age of 25.7 ± 1.6 weeks showed a low score on the Apgar scale. These values were significantly different from the group that received normal Apgar scores (n = 207) (1.007 ± 289 g, 26.5 ± 1.4 weeks). When the low grades and normal Apgar assessments of the two groups were compared with respect to sex and race, there were a significantly higher proportion of deaths in the group that had low scores on the Apgar scale. Another study found that at 26 and 27 weeks of gestation, the neonatal mortality rate is 385 per 1,000 live births, among infants with Apgar scores of 0 to 3 at 5 min, compared to 147 of 1,000 for those with scores of 4 to 6 (P = 0.002) (Casey et al., 2001).

THE VITALITY SCALE AND ITS VALIDATION IN AN ANIMAL MODEL

Tuchscherer et al. (2000) analyzed the relationships between farrowing traits, early postnatal vitality and blood chemistry, including the immunity of piglets at birth. Compared to dead piglets, surviving neonates significantly heavier at birth, were born earlier in the birth order, reached the udder and took in the first colostrum faster, and had a smaller decline in rectal temperature at 1 h after birth (Mota-Rojas et al., 2002; Alonso-Spilsbury et al., 2007; González-Lozano et al., 2009a, b). This information also showed higher concentrations of inorganic phosphorus, calcium and urea, but a lesser concentration of alpha 2-macroglobulin in the blood collected from dead piglets. Alterations in the acid-base balance and in the saturation of gases in the blood are some of the most reliable indicators of asphyxia in the neonate. Herpin et al. (1996) reported that blood obtained from the umbilical cord during delivery of asphyxiated piglets had elevated pCO_2 levels, a lower pH and elevated lactate concentrations. Cerebral hemodynamics and oxygenation have also been used to assess neonatal asphyxia. Cerebral oxyhemoglobin (HbO), deoxyhemoglobin (Hb) and total hemoglobin (HbT) are monitored at birth by optical spectroscopy to measure neonatal asphyxia in piglets. However, Stankovic et al. (1998) reported that none of the optical variables (Hb, HbO and HbT) alone can be used as reliable correlates of cerebral hemodynamics and oxygenation, though all three variables combined do reflect changes in cerebral hemodynamics and oxygenation. Recent work (Castro-Najera et al., 2006; Mota-Rojas et al., 2006) has shown that the degree of meconium staining of the skin is a reliable indicator of fetal hypoxia and acidosis in piglets. Meconium staining and the pH of the umbilical cord were associated, indicating that, as other studies have reported, hypoxia leads to neonatal acidosis in piglets. However, meconium staining appears to be a poor predictor of meconium aspiration or Meconium aspiration syndrome (MAS) in piglets. Ongoing research will help determine if Apgar scoring used with ethophysiological and biochemical variables form reliable indicators of perinatal asphyxia (Castro-Najera et al., 2006; Mota-Rojas et al., 2006). Studies by Orozco-Gregorio et al. (2008, 2010) showed the application of 20 and 35 mg of caffeine to newborn piglets improved weight gain by approximately 20 and 26%, respectively, thus demonstrating that in the first hours of life of piglets that suffer oxygen restriction in utero, it is possible to reverse the resulting metabolic alterations by administering caffeine, and thus increase the probability of survival and improve prognoses for life. Studies by Trujillo-Ortega et al. (2006) indicated that 6 mg recombinant porcine somatotropin (rpST)/day administered to pregnant sows from days 80 to 114 of gestation resulted in higher blood glucose levels in the sows and their offspring and in an increased rate of intrapartum deaths. Considering the lack of transplacental rpST passage, whether the higher mortality rate observed in the offspring of rpST-treated sows was secondary to difficulties during parturition due to the increased piglets' size or to alterations in the metabolism of piglets secondary to maternal exposure to rpST, remains to be elucidated in future studies.

CONCLUSIONS

The neonatal period entails the adaptation demanded by the transition from intrauterine to extrauterine life. During this time, the newborn is affected by multiple changes. In general, neonatal pathology is a problem of adaptation or immaturity in one or more of the newborn's systems. The care of the normal newborn consists in monitoring the process of adaptation so as to assure that no factors occur that might alter it and, if necessary, take preventive measures or anticipate possible problems.

Vitality assessments and immediate attention at birth are fundamental elements that can affect the survival of newborns. The most important objective is to opportunely detect and evaluate any emergency situation that might affect the newborn's vitality, the most frequent of which is cardio-respiratory depression because it requires that appropriate equipment and trained personnel be on hand to perform an effective and timely neonatal resuscitation.

Finally, because the causes of neonatal mortality are prematurity and sepsis, especially when secondary to neonatal asphyxia and the rates of these conditions are still high around the world, particularly in developing countries like Mexico, the priority must be to attempt to lower levels through prevention, timely diagnoses and early treatment when assessments of altered vitality occur. This initiative forms part of the effort to reach the fourth millennium goal for 2015; namely, attain a 2/3 reduction in the mortality of children under 5 years of age.

Therefore, this review is crucial because once you review the factors involved in decreasing the score of vigor of the newborn, future studies will need to know and test the different animal model drug therapies that allow the newly born and increase their strength during the first hours after birth, as a key survival factor.

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