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Original article

Influence of suctioning on cardiac autonomic control of neonates after delivery: impact of birth weight

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Abstract

Background: Studies have explored the airway and/or gastric suctioning impact, but its influence on cardiac autonomic control (CAC) has not yet been investigated.

Purpose: To investigate the influence of upper airway and/or gastric suctioning after delivery on CAC of neonates stratified according to weight for gestational age.

Methods: A cross-sectional study was conducted with 100 healthy full-term newborns with up to 72 hours of life. The obstetric records were accessed to obtain maternal, delivery and newborn data, and neonates were stratified as small for gestational age (SGA), appropriate for gestational age (AGA), or large for gestational age (LGA). Neonates were also grouped according to the suctioning procedure performed after delivery (i.e., suctioned and not suctioned). Time-domain parameters were obtained from successive RR intervals and compared between suctioned and not suctioned neonates of each group (SGA, AGA, and LGA).

Results: SGA neonates who were suctioned exhibited significantly higher TRI RR and TINN values in the first 72 hours after delivery.

Conclusions: The suctioning procedure seem to impact on the CAC only in SGA neonates, with better CAC in the first 72 hours of extrauterine life among suctioned SGA neonates.

Keywords

Airway management, perinatal care, infant health, autonomic nervous system, suction, gastric aspiration.

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Introduction

Birth represents the transition from intra- to extrauterine environment and requires many physiological adaptations (e.g., increased autonomic nervous system [ANS] activity and blood levels of cortisol, catecholamines, renin-angiotensin-aldosterone elements, vasopressin, and thyroid hormones) [1-3] to guarantee adjustments to internal and external demands and survival in a novel and hostile environment [4-6].

The ability of the cardiovascular system to adapt to these demands is associated with high RR interval variability (i.e., heart rate variability [HRV]), and is suggested as a predictor of individual health status [7]. The HRV analysis is a noninvasive method suitable to investigate the degree of stress of an organism and its adaptive capacity, which is useful to monitor the newborn's development and health [5, 8]. Additionally, HRV is likely to be a good indicator of the infant's overall well-being [9].

Several maternal and fetal conditions, such as hypoxemia, may impair ANS adaptation [3], and its imbalance is a possible cause of sudden infant death syndrome [10]. Airway obstruction requires greater respiratory effort and is associated with signs of biological stress, such as increased sympathetic drive (heart rate increase and/or HRV reduction) [9].

Since airway diameter influences airflow resistance [11, 12], the smaller the newborn, the greater the airflow resistance, impacting ANS modulation. In this sense, airway secretions after delivery worsen this scenario in small for gestational age (SGA) infants. Additionally, gastric dilatation caused by amniotic content may trigger the reflux of gastric contents, leading to discomfort and respiratory distress. Thus, upper airway and gastric suctioning at delivery, despite uncomfortable, may reduce gastric dilatation, airflow resistance, and respiratory effort within the first hours of extrauterine life.

Previous studies have explored airway and/or gastric suctioning [13, 14], but its influence according to the neonate dimension (i.e., length and birth weight) has not yet been investigated. Thus, this study aimed to investigate the influence of upper airway and/or gastric suctioning after delivery on cardiac autonomic control (CAC) of neonates stratified according to weight for gestational age.

Methods

A cross-sectional study was conducted with healthy full-term newborns (≥ 37 to < 42 gestational weeks) of both sexes. The study was approved by the Institutional Ethics Committee on Human Research (protocol #2.510.151) and followed the Helsinki Declaration principles.

Data collection followed a probability sampling. Between March and May 2018, all parturient women with up to 72 hours after delivery were invited to participate in the study; 102 parturient, who agreed to participate, were informed about the procedures and provided written informed consent.

Then, the obstetric records were accessed to verify the exclusion criteria. Maternal (mother's age, number of pregnancies, number of deliveries, number of medical visits during the prenatal period), delivery (type of delivery and placental weight), and newborn data (gestational age, birth weight, Apgar index at the first and fifth minutes of life, length, cephalic circumference, thoracic circumference, medications, use of phototherapy, use of ventilatory support, or morbidity diagnosed along the prenatal period or at delivery) were obtained from the obstetric records.

Neonates older than 72 hours of life, who were on medication, phototherapy, ventilatory support, or presenting any morbidity were not eligible for the study. From 102 neonates, 100 were eligible (**Fig. 1**), and successive RR intervals (i.e., the interval between two heartbeats) were acquired during 10 minutes.

The sample was classified according to birth weight as SGA, appropriate for gestational age

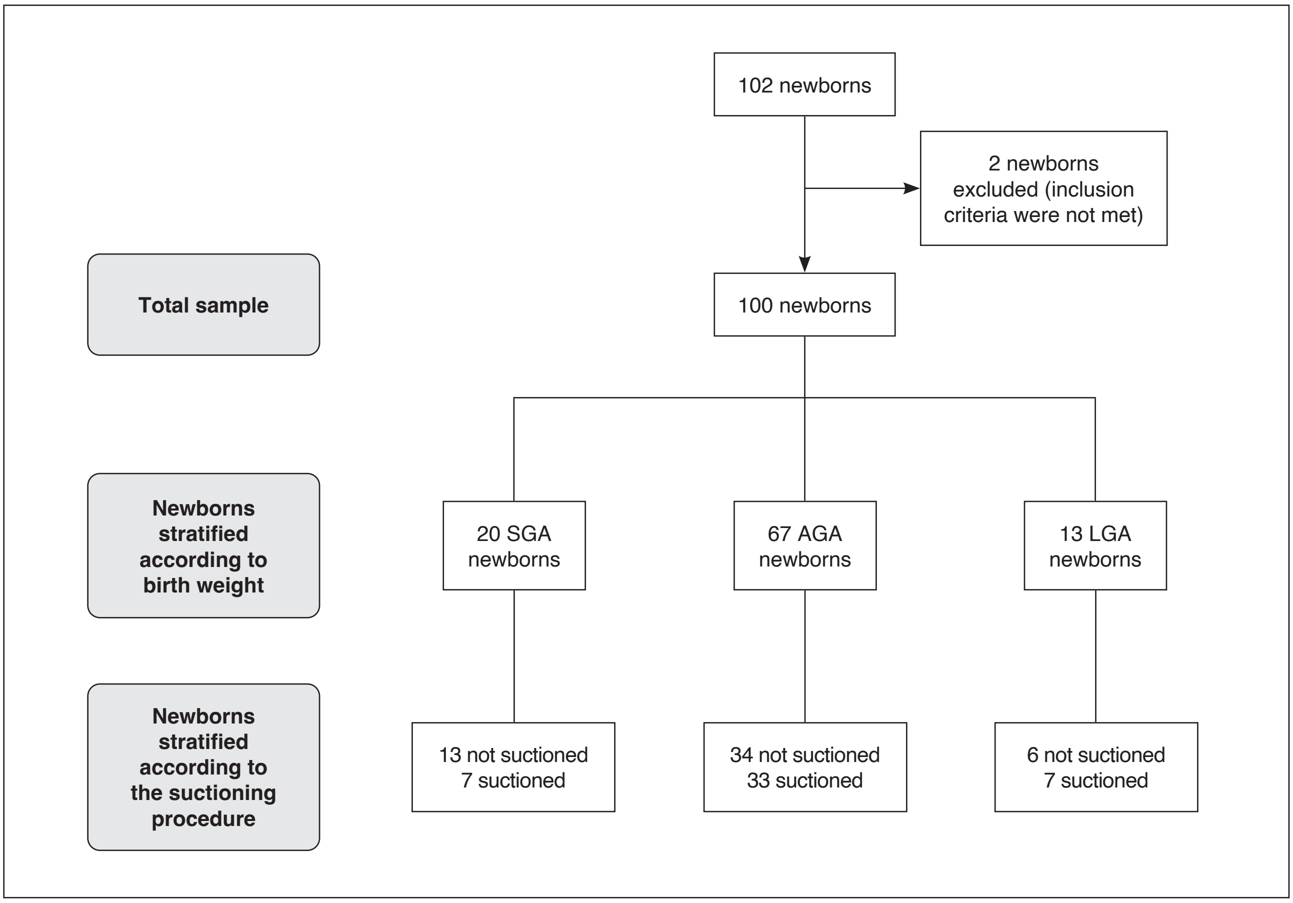

Figure 1. Flowchart of sample selection process.
SGA: small for gestational age; AGA: appropriate for gestational age; LGA: large for gestational age.

(AGA), or large for gestational age (LGA) (**Fig. 1**). The percentiles (z-score) proposed in the INTERGROWTH-21st Project [15] were used to classify the infants. The gestational age was defined according to the first day of the last normal menstrual period and confirmed by the Capurro somatic method and/or ultrasound exam performed during prenatal visits [8, 16, 17].

The neonates from each group were stratified according to suctioning history (i.e., airways, oral, and/or gastric clearance using suction) performed at delivery. Suctioning was defined as the suction of oral and nasal cavities and/or gastric content using a vacuum system. Since no established guidelines are present in the literature to guide this procedure, health care professionals (doctors and nurses) decide to perform it at the delivery room based on individualized assessment. All suctioning procedures were carried out with sterile and disposable catheters.

A flowchart of the sample selection process is presented in **Fig. 1**, and the descriptive characteristics of the studied sample are shown in **Tab. 1**.

RR interval recordings, processing, and analysis

To record the RR intervals, ECG electrodes were placed over the chest of the neonate and connected to a Polar® RS800cx device, validated for this purpose [7, 18]. This type of device has been successfully used to record the heartbeats of neonates [7, 8, 19], recording the time, in milliseconds, of the RR intervals with an accuracy of 1,000 Hz [20, 21].

To avoid the influence of crying, the chest was exposed to place the electrodes, and the recordings were initiated only when the neonates were calm (~10-20 min). If necessary, the maternal-infant contact (i.e., skin-to-skin contact) was allowed to the neonate to return to a calm state, as done by Porto et al. [8]. Thus, successive RR intervals were recorded with the neonates lying in a baby crib beside the maternal bed.

Data recorded were submitted to visual inspection to locate and select a segment of 1,000 successive RR intervals in which stationarity in the time series was acceptable [7, 8] for subsequent offline analysis. The selected segments were

Table 1. Descriptive characteristics of the studied sample.

Variable		SGA		AGA		LGA	
		Not suctioned (n = 13)	Suctioned (n = 7)	Not suctioned (n = 34)	Suctioned (n = 33)	Not suctioned (n = 6)	Suctioned (n = 7)
Maternal age (years) [a]		22 ± 7	31 ± 10	25 ± 7	28 ± 9	23.5 ± 10	30 ± 15
Number of maternal pregnancies [b]	1	8 (61.5%)	1 (14.3%)	14 (41.2%)	13 (39.4%)	2 (33.3%)	2 (28.6%)
	2	0	1 (14.3%)	13 (38.2%)	6 (18.2%)	4 (66.7%)	2 (28.6%)
	3	3 (23.1%)	4 (57.1%)	5 (14.7%)	11 (33.3%)	0	1 (14.3%)
	≥ 4	2 (15.4%)	1 (14.3%)	2 (5.8%)	3 (9.1%)	0	2 (28.6%)
Number of deliveries [b]	0	7 (58.3%)	2 (28.6%)	15 (44.1%)	13 (41.9%)	3 (50%)	2 (28.6%)
	1	1 (8.3%)	1 (14.3%)	13 (38.2%)	9 (29%)	3 (50%)	2 (28.6%)
	2	2 (16.7%)	3 (42.9%)	5 (14.7%)	7 (22.6%)	0	1 (14.3%)
	≥ 3	2 (16.7%)	1 (14.3%)	1 (2.9%)	2 (6.4%)	0	2 (28.6%)
Number of medical visits during the prenatal period [b]	≤ 5	3 (25%)	4 (66.8%)	9 (26.5%)	12 (38.7%)	1 (20%)	3 (50%)
	6	3 (25%)	0	3 (8.8%)	5 (16.1%)	2 (40%)	0
	7-10	5 (41.7%)	2 (33.3%)	18 (52.9%)	11 (35.6%)	2 (40%)	3 (50%)
	≥ 11	1 (8.3%)	0	4 (11.8%)	3 (9.7%)	0	0
Type of delivery [b]	Vaginal	11 (84.6%)	0	28 (82.4%)	2 (6.1%)	5 (83.3%)	0
	Cesarean	2 (15.4%)	7 (100%)	6 (27.6%)	31 (93.9%)	1 (16.7%)	7 (100%)
Gestational age (days) [a]		283 ± 13.5	266 ± 21	275.5 ± 10.5	273 ± 21	269.5 ± 17.25	270 ± 10
Birth weigth (g) [a]		2,590 ± 365	2,335 ± 270	3,195 ± 257.76	3,175 ± 460	3,865 ± 648.75	3,860 ± 530
Placental weight (g) [a]		535 ± 207.5	465 ± 175	627.5 ± 121.25	635 ± 177.5	705 ± 127.5	710 ± 90
Apgar 1st minute [a]		9 ± 0.5	9 ± 1	9 ± 0	9 ± 0	9 ± 0.25	9 ± 0
Apgar 5th minute [a]		10 ± 0	10 ± 1	10 ± 0	10 ± 0	10 ± 0	10 ± 0
Length (cm) [a]		48 ± 3	46 ± 2	49 ± 2	49 ± 3	51 ± 3.5	50 ± 1
Cephalic circumference (cm) [a]		33 ± 2	33 ± 2	34 ± 3.25	34 ± 1	35 ± 3.5	36 ± 0
Thoracic circumference (cm) [a]		32 ± 3	30 ± 3	34 ± 1	33 ± 2.5	34 ± 3.25	35 ± 3

[a] Data presented as median and interquartile range; [b] data presented in absolute and relative frequencies.
SGA: small for gestational age; AGA: appropriate for gestational age; LGA: large for gestational age.

preprocessed using a smoothing procedure with a cutoff frequency of 0.035 Hz to remove low-frequency noise [8]. Only the time series with less than 10% of artifacts were included to guarantee the quality of the analysis.

The following parameters were extracted from the successive RR intervals: mean RR interval, the square root of the mean squared difference of successive RR intervals (RMSSD), the percentage of successive RR intervals differing more than 50 ms (PNN50), the triangular index (TRI RR) – calculated as the quotient of the area of the triangle (corresponding to the total number of RR intervals used to construct the histogram) and its height (corresponding to the number of RR intervals with modal frequency) – , and the triangular interpolation of the RR interval histogram (TINN) – represented as the baseline width of the RR histogram assessed through triangular interpolation. A bin width of 1/128 s was used for the TRI RR and TINN to obtain comparable results [4].

All analyses were performed using the Kubios HRV analysis software 2.2 (Department of Applied Physics, University of Eastern Finland) [22], and the procedures followed the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology recommendations [4].

Statistical analysis

Data normality was verified using the Shapiro-Wilk test. Considering that most variables did not exhibit a normal distribution, the results were presented as median and Q1 and Q3 (i.e., the cutoff for the first [25%] and third [75%] quartiles). Descriptive data of both groups related to categorical characteristics (number of pregnancies, number of deliveries, and number of medical visits during the prenatal period) were presented as absolute and relative frequencies.

The Mann-Whitney test was used to compare CAC parameters between suctioned and not suctioned groups. Each group (SGA, AGA, and LGA) was compared separately since gestational age influences ANS maturity [3, 8, 23]. All statistical procedures were performed using the GraphPad Prism 8 (GraphPad Software, La Jolla, CA, USA), with a significance level of $p < 0.05$.

Results

Tab. 2 shows the results according to weight for gestational age. Only the TRI RR and TINN parameters of the SGA neonates were significantly different between suctioned and not suctioned groups ($p < 0.05$). SGA neonates who were suctioned exhibited higher TRI RR and TINN values in the first 72 hours after delivery.

Discussion

This study aimed to investigate the influence of upper airway and/or gastric suctioning on CAC of neonates stratified according to weight for gestational age. The main finding was that HRV parameters (TRI RR and TINN) were higher in SGA neonates who were suctioned compared with those SGA neonates who were not.

Birth is a transition period marked by abrupt adaptations to the new environment, especially owing to respiratory onset and circulatory changes [2], leading to increased respiratory demand and ANS modulation. Inadequate adaptation could culminate in perinatal asphyxia, one of the leading causes of infant mortality [24]. Asphyxia is even more harmful to low birth weight newborns, being responsible for 10-12% of early neonatal deaths in developing countries, including Brazil [25].

Secretion in airways and gastrointestinal tract at delivery is common due to the liquid present in

Table 2. Median [Q1-Q3] of the cardiac autonomic control (CAC) parameters obtained from neonates and stratified according to weight for gestational age.

Variable	Not suctioned	Suctioned	Median difference [95% CI] [a]	p-value
SGA				
Mean RR interval	485.8 [442.0-524.3]	497.5 [456.1-560.3]	11.7 [-39.6 to 82.5]	0.437
RMSSD	6.9 [6.2-9.7]	10.1 [8.5-18.1]	3.19 [-1.5 to 11.06]	0.134
PNN50	0.0 [0.0-0.1]	0.1 [0.1-2.8]	0.1 [0.0 to 2.7]	0.126
TRI RR	3.2 [2.6-3.6]	5.3 [3.6-6.2]	2.1 [0.1 to 3.5]	**0.036** [b]
TINN	60.0 [45.0-70.0]	105.0 [82.5-135.0]	45.0 [5.0 to 85.0]	**0.019** [b]
AGA				
Mean RR interval	484.8 [451.6-536.2]	467.9 [434.1-513.7]	16.9 [-5.5 to 37.3]	0.133
RMSSD	9.3 [6.6-11.9]	8.9 [6.5-18.2]	-0.32 [-1.2 to 4.2]	0.349
PNN50	0.1 [0.0-0.4]	0.2 [0.0-1.5]	0.1 [0.0 to 0.3]	0.201
TRI RR	4.1 [2.3-5.5]	3.9 [3.1-5.0]	-0.2 [-0.8 to 1.1]	0.603
TINN	85.0 [55.0-110.0]	80.0 [55.0-130.0]	-5.0 [-15.0 to 30.0]	0.476
LGA				
Mean RR interval	502.8 [471.5-541.3]	458.1 [419.9-523.8]	-44.7 [-98.6 to 36.4]	0.181
RMSSD	8.5 [5.5-15.1]	7.1 [6.1-8.5]	-1.3 [-16.5 to 3.4]	0.601
PNN50	0.1 [0.0-0.4]	0.0 [0.0-0.0]	-0.1 [-6.0 to 0.0]	0.119
TRI RR	3.8 [2.8-6.0]	2.8 [2.6-2.9]	-0.9 [-4.7 to 0.1]	0.137
TINN	77.5 [50.0-105.0]	50.0 [50.0-57.5]	-27.5 [-120.0 to 10.0]	0.262

[a] Median difference (“suctioned” minus “not suctioned”) and its 95% confidence interval; [b] significant difference between newborns who received and those who did not receive suctioning at birth ($p < 0.05$).
SGA: small for gestational age; AGA: appropriate for gestational age; LGA: large for gestational age; RR interval: the interval between two heartbeats; RMSSD: the square root of the mean squared difference of successive RR intervals; PNN50: the percentage of successive RR intervals differing more than 50 ms; TRI RR: the triangular index – calculated as the quotient of the area of the triangle (corresponding to the total number of RR intervals used to construct the histogram) and its height (corresponding to the number of RR intervals with modal frequency); TINN: the triangular interpolation of the RR interval histogram – represented as the baseline width of the RR histogram assessed through triangular interpolation.

the intrauterine environment. Although respiratory onset in neonates occurs spontaneously, 1 out of 10 newborns requires assistance to start breathing at birth [26].

When spontaneous breathing is established, partial airway obstruction may remain, increasing airflow resistance and causing difficulty breathing. Also, the presence of gastric content increases the risk of engorgement and bronchial aspiration, hindering the adaptation to spontaneous breathing and increasing biological stress.

In this sense, our results suggest that airway size and the gastrointestinal tract of neonates may be crucial to determine the impact of suctioning at delivery. It is plausible to hypothesize that the minimum amount of secretion can generate respiratory distress with a consequent sympathovagal imbalance in SGA neonates since airway diameter is proportional to the neonate dimensions. Indeed, the HRV parameters were not significantly different between suctioned and not suctioned neonates classified as AGA and LGA. Dezateux et al. [27] stated that low birth weight for gestational age was associated with reduced airway function in early childhood, corroborating our hypothesis.

The cardiovascular adaptation in the first hours of extrauterine life is associated with ANS modulation [3], which justifies its wide use in researches investigating the influence of ANS on heart rate control of neonates [23]. In fact, the analysis of successive RR intervals provides relevant information regarding homeostasis, and a high HRV indicates good cardiovascular adaptation to the internal and external environmental demands. On the other hand, a low HRV is suggested as poor cardiovascular adaptation and/or abnormal autonomic control, which may indicate increased cardiovascular stress or impairments in the protective mechanisms of the ANS [21, 28].

Neonates present immature cardiovascular system and ANS [3, 29-31], which justify the HRV analysis, a noninvasive and useful tool to evaluate CAC [5, 8]. This issue is even relevant when environmental stress is involved, such as inadequate oxygen supply.

Airway secretion increases airflow resistance and consequently the breathing effort to achieve adequate oxygen supply. Although breathing pattern was not evaluated in our study, the reduced geometric HRV parameters (i.e., TRI RR and TINN) suggest sympathovagal imbalance, sympathetic predominance, and vagal tone withdrawal [4, 21].

It is worth stating that previous studies raised concerns regarding suctioning after delivery [13, 14, 32]. O'Neal et al. [32] examined 50 blue bulb syringes used in the intrapartum and postpartum periods and observed that bacterial growth was present in 42% of the bulbs (identification of 57 microbial isolates). The use of sterile and disposable catheters during suctioning should be used to avoid this concern.

Further studies should investigate the impacts of suctioning on other clinical outcomes (e.g., immune resistance and weight gain after delivery, and others) in SGA neonates.

Conclusion

Upper airway and/or gastric suctioning are uncomfortable procedures, and their need has been questionable. However, our results highlight that the neonate dimensions should be considered when performing the suctioning procedure since airway secretion and/or the stomach content of SGA neonates may induce sympathovagal imbalance during the first 72 hours of extrauterine life.

Declaration of interest

The Authors declare that there is no conflict of interest.

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