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Research Article

The Human Newborns' Behavioral Defense Responses to the Stress of Birth

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Abstract

Background: The first behaviors of the human newborns' at birth have not yet been completely described. In-depth knowledge of newborns' normal behavior could help identify newborns at risk of developmental disorders.

Methods: This is a retrospective video study of 30 normal births from Time 0 of birth (T0), which we defined as the moment between the exit of the thorax and pelvis of the newborn from the maternal birth canal. The videos were analyzed by independent observers using the inductive method and concepts of ethology.

Results: The very first human behaviors at birth were a cascade of flight and fight active or flaccid immobility and freezing passive responses to the stress of birth. Passive behavior responses may be followed by trauma-related symptoms. They were significantly associated with psycho-social events reported by mothers during pregnancy, which we considered as maternal prenatal stress (p=0.017). Newborns' passive behavior at birth might compound the risks of developmental disorders associated with maternal prenatal stress.

Conclusion: Maternal stress should be detected during pregnancy and passive defense behavior of the newborn should be detected during the first seconds after time 0 of birth to be able to organize the follow-up of infants who have shown such behavior.

Keywords: Human birth; Newborns' passive defense behavior; Maternal prenatal stress; Neonatology

Abbreviations

HR: Heart Rate; MPS: Maternal Prenatal Stress; s: Second; T0: Time 0 of Birth; UCP: Umbilical Cord Palpation

Introduction

The endocrine and physiological changes during the transition from intrauterine to extra uterine life have been well-documented. During the last trimester of pregnancy, multiple physiological and anatomical changes occur in the fetus as a result of increasing amounts of maternal and fetal cortisol, such as the maturation of the lungs to allow breathing [1]. After uneventful deliveries, normal full-term newborns had arterial and venous umbilical blood with extremely high catecholamine levels, which help the newborn cope with the stress of entering the extra uterine environment [2]. To date, there is no comprehensive description of the early human newborns' behavior at birth. They were described after routine neonatal care [3], after the newborns had been placed in an incubator [4], they have been observed [5] or videotaped [6] after the newborns had been dried and laid on the mother's chest. In a video study, we described a newborns' immobility behavior during the first minute after normal vaginal births that we interpreted as a response to severe stress [7]. After that publication, a review of the literature [8] helped us to understand that our description of the newborns' immobility behavior at birth did not consider recent knowledge regarding the defense responses to danger. To test the hypothesis that human newborns' behavior at vaginal birth is defense responses to the stress of birth, we undertook a re-analysis of the videos of our study by a new team of independent observers. The purpose of this article is to present the results of the re-analysis of our data.

Methods

Participants

The research project has been approved of the hospital's ethics committee (Notice no 659). Informed consent was presented to pregnant women from December 1999 to May 2003 and accepted by both parents, who agreed to the filming of their child's birth. A total of 75 births were filmed from December 1999 to June 2003 using a Panasonic digital camera in European PAL format at a rate of 25 frames per second. No professional cameraman was allowed to enter the delivery room to avoid disturbing the privacy of the parents and their newborn. Of the 75 videos, the inclusion criteria for this study were good visibility of the newborns' face, gestational age 37-41 weeks, minimum birth weight of 2500 g, spontaneous or induced labor with or without epidural analgesia, cephalic presentation, intrapartum fetal heart rate Category I or Category II with terminal deceleration less than 10 minutes before birth [9], spontaneous vaginal delivery, clear amniotic fluid, a 5-min Apgar score of seven or above. Exclusion criteria were maternal hypertension, smoking, diabetes or abnormal glucose tolerance test, general anesthesia, breech presentation, instrumental delivery, cesarean section, resuscitation or malformation of the newborn. Data on mothers, newborns, and deliveries were

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extracted from obstetric records. After exclusion of one observation from our previous publication [7] because the newborns' face was not sufficiently visible, the sample for this study was 30 newborns, 20 boys and 10 girls aged 37 to 41 gestational weeks (mean 39.63).

Procedure

Mothers were delivered vaginally in supine position on a birthing table. Newborns were placed in a ventro-lateral or supine position in skin-to-skin contact on the mother's chest and dried by a nurse, without gastric aspiration nor resuscitation. The births were videotaped with the camera focused on the newborn's face. Neonatal Heart Rate (HR) was assessed by Umbilical Cord Palpation (UCP) as close as possible to T0. After being soothed, the newborns remained for two hours in skin-to-skin contact with their mother under the supervision of a midwife.

Data analysis

The videos of the 30 newborns in this study were analyzed during the first minute from Time 0 of birth (T0), which we defined as the moment between the exit of the thorax and pelvis of the newborn from the maternal birth canal (Figure 2A), using Edius Neo 3.5 editing software (Grass Valley, USA) for frame-by-frame video analysis, event recording and visualization of sound intensity on the timeline. We used the inductive method and concepts of ethology, which include the description of observed behaviors, their interpretation and their inclusion in existing theories or new hypotheses [10]. Two independent observers (FM) and (RL) noted the delays between Time 0 and newborns' body and arm movements, first breath, first cry, first eye movements, and the beginning of rubbing by a nurse to dry the infant. The first breath was detected by a sound like that of inhaling water with a peak on the video software timeline.

Statistics

Statistical analysis was conducted using IBM SPSS (V 27). P values were considered statistically significant when < 0.05. The reliability of the data between the observers was checked using the Pearson's r bilateral test. Inter-observer correlations were good, except for the delay between T0 and the first breath ($r = 0.186$, $p = 0.352$) due to environmental noise. Numerical data were compared using the independent samples t test. Associations between categorical data were searched for using Mantel-Haenszel Odds-ratio, X2 test, and two-sided Fisher's exact test.

Results

Amongst the 30 videos in the study, 21 newborns had active behaviors from T0 (Group 1. Active newborns) and 9 newborns had immobility behaviors (Group 2. Passive newborns), at T0 in Subgroup 2A newborns (n=6) or after T0 in Subgroup 2B newborns (n=3).

Group 1 active behaviors N=21

The 21 Group 1 newborns had rapid umbilical cord pulsations at T0, a sudden extension-adduction with internal rotation, elbow flexion, and forearm pronation of both arms on average 2.2 s after T0, which is characteristic of the Startle reflex (Figure 1B) [11], a first breath on average 4.9 s after T0, and a first cry on average 7.6 s after T0. Among these 21 newborns, nineteen had a brief opening and closing the eyes on average 8.2 s after T0, fourteen had an extension-abduction of both arms with open hands and spread fingers on average 7.7 s after T0, which is characteristic of the Moro reflex [12] (Figure 1B), teen of them hit their mother with a fist and let out a loud cry an average of 16.1 s after T0 (Figure 1D), and nine of them tried to grasp the mother's breast, finger, or clothes on average 55.2 s after T0 (Figure 1) (Table 1) (Video 1) Newborns' active behaviors at birth) https://youtu.be/WCt2TIWCuD8).

Group 2 passive newborns N=9

The nine newborns in Group 2 showed a slow, irregular umbilical cord pulse at T0, followed by a progressive acceleration and the appearance of a pinkish skin color. The six newborns in Subgroup 2 A were in flaccid immobility at T0 for a mean duration of 8.9 s (Figure 2A), they froze with wide open eyes on average 19.2 s for a mean duration of 10.7 s (Figure 2B), and they cried on average 28.2 s after T0 (Video 2) (Group 2. Newborns' passive behaviors at birth: https://youtu.be/P4GRJsBDK-0). The three newborns in Subgroup 2 B had a Startle reflex on average 1.3 s after T0, they were then moving for a mean duration of 14.3 s before freezing with wide open eyes for a mean duration of 28.3 s (Figure 2 B). There was no significant difference between the delay after T0 between Group 2 and Group 1 newborns' behaviors, except for the first cry, whose time after T0 was significantly longer (Mean 33.6 *vs.* 7.6 s, p=0.015) (Table 1). The delay between T0 and the other behaviors was not significantly different between Group 2 and Group 1 newborns (Table 2).

Associated variables with newborns' passive behaviors at birth

Among numerical variables, we found no significant difference between Group 2 Active newborns for Group 1 Passive newborns for maternal age and parity, duration of the first and second stages of labor, amniotomy duration, gestational age, and birth weight of the child (Table 3A. Numerical Variables).

Among categorical variables, we found a significant association between Group 2 newborns' and the distressing life events reported by the mothers during pregnancy (88.9% *vs.* 38.1%, p=0.017): long-term infertility, unwanted pregnancy, bleeding during pregnancy, excessive fear of abnormality of the child, pregnancy following miscarriage or termination of pregnancy, family violence, abandoned by the father of the child, and death or serious illness of a loved one. We considered these life events as Maternal Prenatal Stress (MPS), since they can cause prenatal stress, as can cause psychological distress and natural disasters [13,14]. We found no significant difference for mothers' testing positive Group B streptococcus, labor induction, epidural anesthesia, amniotomy, male *vs.* a female child's sex, placing the newborn in a supine position on the mother's chest, or rubbing by the nurse to dry the newborn (Table 3B. Categorical variables).

Discussion

Group 1: active newborns

The 21 newborns in active group 1 had a first breath, a first cry, a startle reflex, a Moro reflex, and a brief opening and closing of the eyes during the first minute after T0 (Table 1). The rapid onset of these behaviors is made possible by their development during fetal life [13].

Newborns' cries are graduated signals that indicate its degree of distress and alert caregivers for care, support, and protection [14]. The Startle reflex is a defense response to sudden or threatening stimuli that is triggered by the amygdala [15]. It may be caused by the sudden perception of the noise of the birth room and/or by the fear of heights when the mother is delivered in supine position on a delivery table (Figure 1 A). The Moro reflex was considered by Moro himself to be a fear response [12]. It was recently interpreted as a ritualized communication behavior by which the human newborn

Figure 1: Group 1. Newborns' cascade of active defense behaviors at vaginal birth. A. Startle reflex at T0+3 seconds. B. Crying and Moro reflex at T0+8 seconds. C. Hitting the fist at T0+27 seconds.

Table 1: Group 1 and Group 2 newborns' behaviors at vaginal birth.

Variables	Group 1. Active newborns N=21				Group 2. Passive newborns N=9 T-test[b]				
	Valid	Min	Max	Mean (SD)	Valid	Min	Max	Mean (SD)	p value
Newborns' behaviors[a]									
Flaccid immobility duration from T0	0	-	-	-	6	2	17	8.9 (5.20)	-
Freezing start	0	-	-	-	9	12	39	17.6 (8.23)	-
Freezing duration	0	-	-	-	9	2	57	16.6 (17.07)	-
Startle reflex	21	0	5	2.2 (1.34)	6	1	66	13.8 (25.76)	0.319
First breath	21	0	24.8	4.9 (5.46)	9	2	18	8.7 (7.94)	0.097
Eye brief opening and closing	19	0	31.5	8.2 (7.70)	8	1	17	7.4 (4.73)	0.81
First cry	21	1	25	7.6 (6.32)	9	2	67	33.6 (25.43)	0.015
Moro reflex	14	2	14	7.7 (3.97)	2	6	8.5	6.8 (2.12)	0.893
Hit the mother with the fist	10	5	35	16.1 (8.61)	2	42	75	58.5 (23.33)	0.231
Grasp the mother's clothes	9	7	241	55.2 (74.1)	1	-	-	-	-
Nurses' behavior									
Rubbing start[a]	19	5	34	12.3 (6.9)	9	4	18	10.2 (4.49)	0.419

[a]Seconds from Time 0 of birth; [b]Independent samples t-test

Figure 2: Group 2. Newborns' cascade of passive and active defense behaviors at birth. A: Flaccid immobility at Time 0 of birth; B: Freezing at T0+18 seconds; C: Crying face at T0+28 seconds.

asks to be taken in the arms because he cannot move or speak in the face of the danger of extrauterine life [16]. Hitting the mother with the fist may be interpreted as a fight response of the cascade of behaviors in the face of danger [8]. Grasping the mother's clothes is an attachment behavior as it was proposed by John Bowlby [17], which can be interpreted as a flight behavior. We propose to interpret these five behaviors as active "flight or fight" responses of the fear system to the stress of birth [8]. This interpretation is consistent with the large release of catecholamines that occurs at birth [2].

Group 2: passive newborns

Among the 9 Group 2 Passive newborns, six of them (Subgroup 2A) were in flaccid immobility with irregular bradycardia at T0. Such behavior could be the diving reflex if these newborns were asphyxiated in the amniotic fluid [18]. However, the gradual acceleration of the umbilical cord pulsation after irregular bradycardia at T0, the appearance of a pinkish color on their skin, the sudden cries during the first minute after T0, and the 5 minute Apgar scores >7 without any resuscitation may have an alternative interpretation, which is suggested by the association we found between passive newborns and MPS (p=0.017). The newborns' flaccid immobility with irregular bradycardia at T0 may instead be the collapse associated with the hypometabolic defense response controlled by the parasympathetic system when the danger is severe [8] or when the Hypothalamic-Pituitary-Adrenal (HPA) axis of the fetus has been dysregulated by epigenetic alterations, mainly DNA-methylation associated with MPS [19].

Table 2: Subgroup 2A and Subgroup 2B newborns' behaviors.

Variables	Subgroup 2A. Immobility at T0 N=6				Subgroup 2B. Immobility post T0 N=3				T-test[b]
	Valid	Min	Max	Mean (SD)	Valid	Min	Max	Mean (SD)	p value
Newborns' behaviors[a]									
Flaccid immobility duration from T0	6	2	17	8.9 (5.2)	0	-	-	-	-
Freezing start	6	12	39	19.2 (9.91)	3	13	18	14.3 (1.53)	0.57
Freezing duration	6	1.5	24	10.7 (7.48)	3	4	57	28.3 (26.8)	0.212
Startle reflex	3	4	66	26.4 (34.37)	3	1	3	1.3 (1.50)	0.332
First breath	6	2	18	7.9 (2.94)	3	6	14	9.6 (4.23)	0.658
Eyes brief opening and closing	6	1	17	7.7 (5.52)	2	6	7	6.3(1.13)	0.735
First cry	6	8	65	28.2 (19.64)	3	2	67	44.5 (36.81)	0.399
Moro reflex	1	-	-	8	1	5	5	5	-
Hit the fist	1	-	-	75	1	42	42	42	-
Grasping the mother's clothes	0	-	-	-	-	-	-	-	-
Nurses' behavior									
Drying start[a]	6	8	18	11.5 (3.78))	3	4	14	7.7 (5.51)	0.252

[a]Seconds from Time 0 of birth; [b]Independent samples t-test

The immobility with irregular bradycardia, wide-open and fixed eyes (Figure 2B) followed by a gradual acceleration of umbilical cord beating can be interpreted as freezing or tonic immobility. Freezing is understood as a "flight-or-fight response put on hold" with irregular bradycardia controlled by the parasympathetic system [20]. The rapid transition from active to passive responses and vice versa we observed in Group 2 newborns was made possible by the simultaneous activation of the sympathetic and parasympathetic systems during freezing [21] and the presence of neural fibers in both systems of the vagal nerve [22]. During freezing, wide open and fixed eyes predict the speed of active responses to a threat [23,24], which may explain the sudden burst of crying and movement that followed the newborns' state of immobility. The above arguments lead us to call this immobility freezing rather than tonic immobility. Importantly, newborns' flaccid immobility and freezing are passive defense behaviors that may be followed by trauma-related symptoms [8].

Strengths and weaknesses of the study

This observational study has two main strengths. First, using video allowed us to provide the first description of the human newborns' early behavior at birth. This description leads us to interpret these behaviors as a cascade of active and passive responses to the stress of birth, which are common to all mammals, but adapted by evolution to insure the human infant's survival at birth. Second, the significant association we found between Group 2 Passive newborns and MPS (p=0.017) (Table 3) may be an important finding as the newborns' passive defense responses at birth could be an early sign of MPS and an indicator of the risk of developmental disorders associated with MPS [25,26].

The weaknesses in this observational study could pave the way for future research. The small sample size of the study should be complemented by video studies on larger samples to confirm the significance of the association we found between Group 2 Passive newborns and MPS. The newborns' motionlessness in contact with the mother during the first hours after birth is usually interpreted as sleeping. It could instead be the "quiescent immobility" that is needed to recover from the stress of birth (20), but this interpretation has not been investigated in this study. The limitation of MPS to distressing life events reported by mothers during their pregnancy should be complemented by antenatal distress level measurements in mothers, stress hormone assays in newborns and mothers, epigenetic analysis of the umbilical cord or the placenta. These studies should include cesarean deliveries for understanding the mechanisms of developmental disorders in cesarean children [27]. The follow-up of Group 2 Passive newborns should be designed to determine whether the risks of developmental disorders associated with MPS [25,26] might be compounded by the risks of post-traumatic stress disorders [8,21].

Implications for clinical practice

The newborns' passive defense responses at birth should be detected as soon as possible after T0. UCP we used in this study to detect irregular bradycardia soon after T0 is not as accurate as Electrocardiography (ECG) or pulse oximetry, but the delay in obtaining reliable ECG signal often exceeds 1 to 2 minutes [28]. Since a pediatrician is not always available in the delivery room to check the newborns' heart, UCP seems to be one of the quickest methods to assess a newborns' HR immediately after birth [29], even in underdeveloped countries. Not only can UCP provide early detection of early neonatal irregular bradycardia, which is pathognomonic of passive defense responses to danger [8], it can also detect progressive HR acceleration, which is the most important indicator of effective ventilation [30], and thus avoiding unnecessary resuscitation. What's more, video has become easier with the smartphone since its widespread use. Its systematic use in birth rooms could enable the detection of flaccid immobility that last only a few seconds, and thus identify infants at risk of developmental disorders.

Conclusion

The first behaviors of Group 1 newborns-crying, startle and Moro reflexes, punching and grasping-were interpreted as active "fight or flight" responses to danger. This interpretation is consistent with the very large release of catecholamines that occurs during birth [2]. Group 2 Passive newborns showed two types of immobility behavior-flaccid immobility and freezing-which were interpreted as passive responses to danger. These passive defense responses were significantly associated with MPS (p=0.017). This association with MPS, the risks of adverse effects on a child's development, and the risks of postnatal maternal mental health disorders after perinatal stress need detection of emotionally distressed pregnant women (31). During pregnancy, psychologically distressed women should be supported to seek social support to mitigate the adverse effects of their distress on fetal development [32]. Antenatal education should inform parents that babies' first behaviors are fear to the stress of birth, and that they need to be soothed. At birth, parents should be informed of why children who had passive defense behaviors at birth need long-term follow-up. After birth, breastfeeding should be encouraged to enhance the child's development [33], as well as maternal stroking during the first weeks of life, which can reduce the infant's HPA axis reactivity [34].

Table 3A and B: Maternal and obstetric variables associations with newborns' immobility behaviors at birth.

	Total N=30		Group 1. Active newborns N=21				Group 2 Passive newborns N=9				T-test[b]
	Valid	Mean[a] (SD)	Valid	Min	Max	Mean[a] (SD)	Valid	Min	Max	Mean[a] (SD)	p value
Mothers											
Age (years)	30	29.87 (5.44)	21	21	42	29.7 (6.09)	9	24	37	30.3 (3.78)	0.764
Parity	30	2.17 (0.95)		1	4	2.29 (1.06)	9	1	3	1.9 (0.60)	0.205
Labor											
First stage duration (min)	30	239.2 (129.42)	21	8	590	259.3 (143.68)	9	60	300	192.2 (74.59)	0.198
Second stage duration (min)	30	23.9 (14.43)	21	2	47	22.5 (12.95)	9	10	64	27.3 (17.83)	0.408
Amniotomy duration	23	243.68 (198.77)	17	2	762	260 (221.10	6	50	348	196.67 (117.67)	0.515
Newborn's condition at birth											
Gestational Age (weeks)	30	39.6 (0.81)	21	37	41	39. 5 (0.87)	9	39	41	39.9 (.60)	0.264
Birth weight (grams)	30	3309 (476.31)	21	2510	4050	3251.7 (467.52)	9	2800	4010	3443.9 (496.88)	0.32
Rubbing delay	28	11.6 (6.27)	19	5	34	12.3 (6.96)	9	4	18	10.2 (4.49)	0.252

Categorical variables	Total N = 30	Group 1. Active newborns N = 21	Group 2. Passive newborns N = 9	Chi-square	Mantel- Haenszel Odds Ratio	Fisher's exact test
Mothers	N (%)	N (%)	N (%)			
Primiparity	7 (23.3)	5 (23.8)	2 (2.2)	0.925	0.91 (0.14-5.90)	1
Maternal prenatal stress	16 (53.3)	8 (38.1)	8 (88.9)	0.011	13.00 (1.36-124.30)	0.017
GBS[c]	5 (16.7)	4 (19.0)	1 (11.1)	0.593	0.53 (0.05-5.55)	1
Labor						
Induction	16 (53.3)	9 (42.9)	7 (77.8)	0.079	4.67 (0.78-28.05)	0.118
Epidural anesthesia	20 (66.7)	13 (66.7)	7 (77.8)	0.398	2.1 (0.36-13.05	0.675
Amniotomy	23 (76.7)	14 (66.7)	9 (100)	0.048	[d]	0.071
Newborn						
Male versus Female	20 (66.7)	14 (66.7)	6 (66.7)	1	1 (0.19-5.24)	1
Placement in supine position	12 (40.0)	10 (47.6)	2 (2.22)	0.193	0.31 (0.05-1.88)	0.249
Rubbing dry by a nurse	28 (93.3)	19 (90.5)	9 (100)	0.338	[d]	1

[a]Seconds from Time 0 of birth; [b]Independent samples t-test; [c]Mother positive for Group B streptococcus; [d]Not calculated because some cells were empty

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