

Physiological and psychological stress responses to labor and delivery as expressed by salivary cortisol: a prospective study



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BACKGROUND: Labor is considered a stressful event, yet no study has described the course of stress measured by cortisol during labor and postpartum.

OBJECTIVE: The objective of the study was to describe the patterns of physiological and psychological stress during labor as measured by salivary cortisol concentrations and stress questionnaires and their correlation to obstetric and neonatal outcomes.

STUDY DESIGN: This prospective, observational study included 167 women with low-risk, singleton, term deliveries at a tertiary academic center. Physiological stress was evaluated by salivary cortisol measurements and emotional stress by questionnaire (stress scale ranging from 0 to 10) during the latent phase, active phase, and full dilation stages of labor as well as 2 minutes, 2 hours, and 24 hours after delivery. Cord blood cortisol and pH were also obtained. Modes of delivery, complications during labor and delivery, and early neonatal outcomes were evaluated.

RESULTS: Salivary cortisol concentrations increased gradually from latent phase to active phase. The maximum increase was observed within 2 minutes of the delivery (from an average of 1.06 $\mu\text{g}/\text{dL}$ to 1.67 $\mu\text{g}/\text{dL}$; 57% increase). Within 2 hours after delivery, cortisol decreased

and reached a nongravid concentration after 24 hours (0.16 $\mu\text{g}/\text{dL}$). Cortisol concentrations during labor and up to 2 hours postpartum were above the average concentration of nongravid women (0.5 $\mu\text{g}/\text{dL}$). Women with epidural anesthesia had lower cortisol concentrations at complete dilation ($P = .026$) and 2 hours postpartum ($P = .016$) compared with women without epidural. Psychological stress peaked during latent and full dilation phases (mean 4.56 and 4.29, respectively). Maximum decrease from 4.29 to 2.04 (52%) occurred immediately postpartum. Cord cortisol was higher among women delivered by vacuum extraction compared with spontaneous vaginal delivery (17 ± 2 vs 11 ± 3.8 , $P = .03$).

CONCLUSION: This study reveals the course of cortisol concentrations during labor for low-risk pregnancies, with maximum increase immediately postpartum. Subjective stress levels decreased over the course of labor. Salivary cortisol portrays stress during labor and may be used as a reference to evaluate complicated pregnancies and to evaluate the role of cortisol during these deliveries.

Key words: cortisol concentration, epidural analgesia, labor course, stress

Stress is defined as any uncomfortable emotional experience accompanied by biochemical, physiological, and behavioral changes.¹ Physiological stress refers to the physiological state, including sympathetic and hormonal changes that can be measured in the blood or salivary cortisol concentrations.² Psychological stress refers to the emotional and perceived feelings of distress, which can be evaluated using validated questionnaires.³

The process of labor and delivery encompasses a great amount of psy-

chological and physiological stress and is considered to be very emotionally demanding. However, reports on stress levels during labor are limited and only a few studies have addressed this subject.

Studies regarding physiological stress found that total and free plasma cortisol concentrations increase dramatically throughout term labor and delivery.^{4,5} Total and free concentrations of cortisol were reported to increase 2- to 5-fold from 10 to 17 days prepartum to the end of the first stage of labor.⁶ These physiological changes in cortisol are perceived as necessary for maintaining the maternal and fetal well-being and for helping normal labor progression, specifically by maximizing glucose availability for the fetus and myometrium during labor.⁴

Studies regarding psychological stress during labor are few. One study found women's anxiety, measured by the State Trait Anxiety Inventory (STAI),

decreased significantly after epidural anesthesia and remained low 24 hours after delivery.⁷ It was also found that postpartum stress state, as measured by the STAI, was associated with increased maternal health care utilization after discharge and shorter duration of breastfeeding.⁸

Yet studies that evaluated the stress levels during labor were small and mostly measured stress level at only 1 point during the course of labor.

The objective of the current study was to describe patterns of physiological and psychological stress during labor as measured at 6 time points (latent phase, active phase, and full dilation as well as 2 minutes, 2 hours, and 24 hours after delivery) and to evaluate their correlation with obstetric and neonatal outcomes. If this correlation was found, it could have a clinically significant relation to stress during labor. We also evaluated the effect of epidural analgesia on stress during labor.

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AJOG at a Glance

Why was this study conducted?

To describe patterns of physiological and psychological stress during labor, measured at 6 time points (latent phase, active phase, full dilation, 2 minutes, 2 hours, and 24 hours after delivery) and to evaluate their correlation with obstetric and neonatal outcomes

Key findings

Salivary cortisol concentrations increased gradually from latent to active phase. The maximum increase was observed within 2 minutes of delivery. Within 2 hours after delivery, cortisol decreased and reached a nonpregnant concentration after 24 hours. Cord cortisol was higher among women delivered by vacuum extraction, as compared with spontaneous vaginal delivery.

What does this add to what is known?

This study establishes the course of cortisol concentrations during labor for low-risk pregnancies and may be used as a reference to evaluate complicated pregnancies, such as those associated with preterm labor or preeclampsia and to evaluate the role of cortisol during these deliveries.

Material and Methods**Study design**

This prospective, observational study included a cohort of 167 women with low-risk, singleton, term deliveries at Meir Medical Center, Kfar Saba, Israel, from 2015 through 2018.

Patients

Participants were recruited during admission to the delivery room. Inclusion criteria were women above age 18 years, with a singleton, term, low-risk pregnancy. Exclusion criteria were women who were taking anxiolytics and/or antidepressants, were under psychological care during the third trimester of pregnancy, or with a high-risk pregnancy (including preeclampsia, gestational diabetes mellitus, chronic disease, intrauterine growth restriction, known fetal anomalies, or chromosomal aberrations).

A total of 230 women were approached, of which 12 were excluded because of selective serotonin reuptake inhibitor usage, 10 because of high-risk pregnancy, and 33 who declined to participate for personal reasons.

Participants who met the eligibility criteria signed an informed consent and stress was measured at 6 different times: at latent phase, active phase (from 4 cm dilation), full dilation, 2 minutes, 2 hours, and 24 hours after delivery.

Latent phase refers to contractions until 4 cm dilation and active phase from 4 cm until full dilation. Cord blood cortisol was also measured immediately after delivery.

At each assessment, physiological stress was evaluated by saliva cortisol measurements and by an emotional stress questionnaire with a 1–10 stress scale. At the first assessment, women also completed the Hospital Anxiety and Depression Scale (HADS).

Demographic and obstetric information was obtained directly from the electronic medical records. We analyzed the pattern of stress during the labor course for the entire cohort, for nulliparas compared with multiparas, and for women who received epidural analgesia compared with women who did not.

In addition, the association between stress levels (measured by salivary cortisol and the stress scale), and obstetrical outcomes were evaluated, including mode of delivery (vaginal, vaginal-assisted, or cesarean), labor complications (manual removal of retained placenta, grade III and IV perineal tears, postpartum hemorrhage above 500 mL, and intrapartum or postpartum fever above 38°C), and neonatal outcomes (cord pH below 7.1 and 1 and 5 minute Apgar scores <7).

The study was approved by the institutional ethics committee.

Procedures**Physiological assessment**

Saliva samples were measured 6 times, as described in the previous text. We used salivary cortisol because serum cortisol diffuses freely into saliva. Therefore, salivary cortisol reflects serum-free cortisol concentrations more accurately than serum total cortisol in the blood does.⁹ In addition, it is a simple, noninvasive test.

The saliva samples were collected in Salivette tubes (Sarstedt International, Nümbrecht, Germany) and then centrifuged at 1459 g for 10 minutes and stored at –20°C until further analysis. Salivary cortisol concentrations were measured in micrograms per deciliter using an electrochemiluminescence immunoassay (Elecsys cortisol kit; Roche Diagnostics, Rotkreuz, Switzerland) in a Cobas c6000 analyser (Roche Diagnostics, Rotkreuz, Switzerland). The sensitivity limit for the cortisol assays was 0.018 µg/dL and the coefficient of variation between 1% and 1.7%.

Psychological assessment

At the first assessment during the latent phase, patients completed the Hebrew version of the HADS, which measures anxiety and depression in a general medical population of patients.¹⁰ The questionnaire includes 7 questions for anxiety and 7 for depression. Each item is answered by the patient on a 4 point (0–3) response scale. A score above 7 of each subscale (anxiety/depression) is considered above the normal range.¹¹

In addition, patients were asked the following open-ended question: “How stressed do you feel right now?” They marked their answer on a continuous scale comprised of a 10 cm horizontal line whose extremes were labeled 0, for no stress at all and 10, for extremely stressful, based on the visual analogue scale, intended to evaluate subjective pain.¹² We termed this new measurement tool the stress scale. In a previous publication, we validated this stress scale and found that it significantly correlates with the STAI,¹³ which is an acceptable measure for evaluating the stress state.³

Statistical analysis

Statistical analysis was performed using SPSS 20.0 package for windows (SPSS, Inc, Chicago, IL). The difference in the slopes for each time assessment for cortisol and psychological stress levels were evaluated with the Student *t* test. For comparison between groups, continuous variables were analyzed with the Student *t* test, and categorical variables were analyzed with χ^2 or Fisher exact test. Pearson's coefficients were calculated between psychological and physiological stress. A value of $P < .05$ was considered significant.

Results

A total of 175 women were recruited, of whom 8 (4.6%) withdrew from the study. All 8 withdrew because of impatience with providing additional salivary cortisol samples as they entered active labor. The final sample consisted of 167 participants. [Table 1](#) shows their demographic and clinical characteristics.

The average maternal age was 31.7 ± 4.6 years and 62 women were nulliparous, accounting for 37% of the cohort, and 105 (63%) were multiparous. The average gestational age at the time of the delivery was 39.3 ± 1.3 . Epidural analgesia was requested and received by 135 women (87%). The remaining 13% did not request epidural analgesia. Eleven women (6.6%) underwent emergency cesarean delivery (CD); 8 because of nonreassuring fetal heart rate and 3 because of arrested descent. Sixteen women (9.6%) had vacuum extraction; 15 because of nonreassuring fetal heart rate and 1 because of prolonged second stage.

Nulliparas had more CD (15% vs 2%, $P = .009$) and vacuum-assisted vaginal delivery (17% vs 6%, $P = .054$) and longer second-stage duration (118 ± 77 vs 33 ± 40 minutes, $P = .0001$). No difference was found regarding the use of analgesia between groups (90% vs 85%, $P = .351$).

Stress during Labor

Physiological stress: cortisol

For the entire cohort, salivary cortisol concentrations increased gradually from

TABLE 1

Demographic and obstetrical variables for all participants (n = 167) and by parity

Basic characteristics	Entire cohort (n = 167) Mean, SD	Nulliparous (n = 62)	Multiparous (n = 105)	Pvalue
Maternal age, y	31.7 ± 4.6	29.3 ± 4.4	33 ± 4.1	.001
BMI, kg/m ²	27.6 ± 4.6	27.5 ± 4.8	27.7 ± 4.5	.773
Gravidity, median	2	1	3	.001
Parity, median	1	NA	1	.001
Gestational age at delivery, wks	39.3 ± 1.3	39.2 ± 1.5	39.3 ± 1.1	.506
Nulliparas, %	37	NA	NA	NA
Epidural anesthesia, %	87	90	85	.351
Second-stage duration, min		118 ± 77	33 ± 40	.0001
CD, n, %	11 (6.6%)	9 (15%)	2 (2%)	.009
Vacuum extraction, n, %	16 (9.6%)	10 (16%)	6 (6%)	.054

BMI, body mass index; CD, cesarean delivery; NA, not available.

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latent phase to active phase. The maximum increase of 57% was observed from full dilation ($1.06 \pm 1 \mu\text{g/dL}$) to 2 minutes after delivery ($1.67 \pm 1.3 \mu\text{g/dL}$). Then salivary cortisol concentrations decreased by 45% within 2 hours after delivery ($0.91 \pm 0.9 \mu\text{g/dL}$), continued to decrease, and reached a nongravid concentration after 24 hours ($0.16 \mu\text{g/dL}$). Cortisol concentrations during labor and up to 2 hours postpartum were above the average concentration of nongravid women ($0.5 \mu\text{g/dL}$; see [Figure 1A](#)).⁴

The changes in the cortisol concentrations between full dilation and within 2 minutes after delivery and between 2 minutes and 24 hours after delivery were significant (both $P = .001$).

Nulliparous women had significantly higher cortisol concentrations compared with multiparas when measured 2 minutes ($P = .003$) and 2 hours postpartum ($P = .041$), with no difference during latent ($P = .237$) and active phases (0.668) or 24 hours after delivery ($P = .666$; see [Table 2](#)).

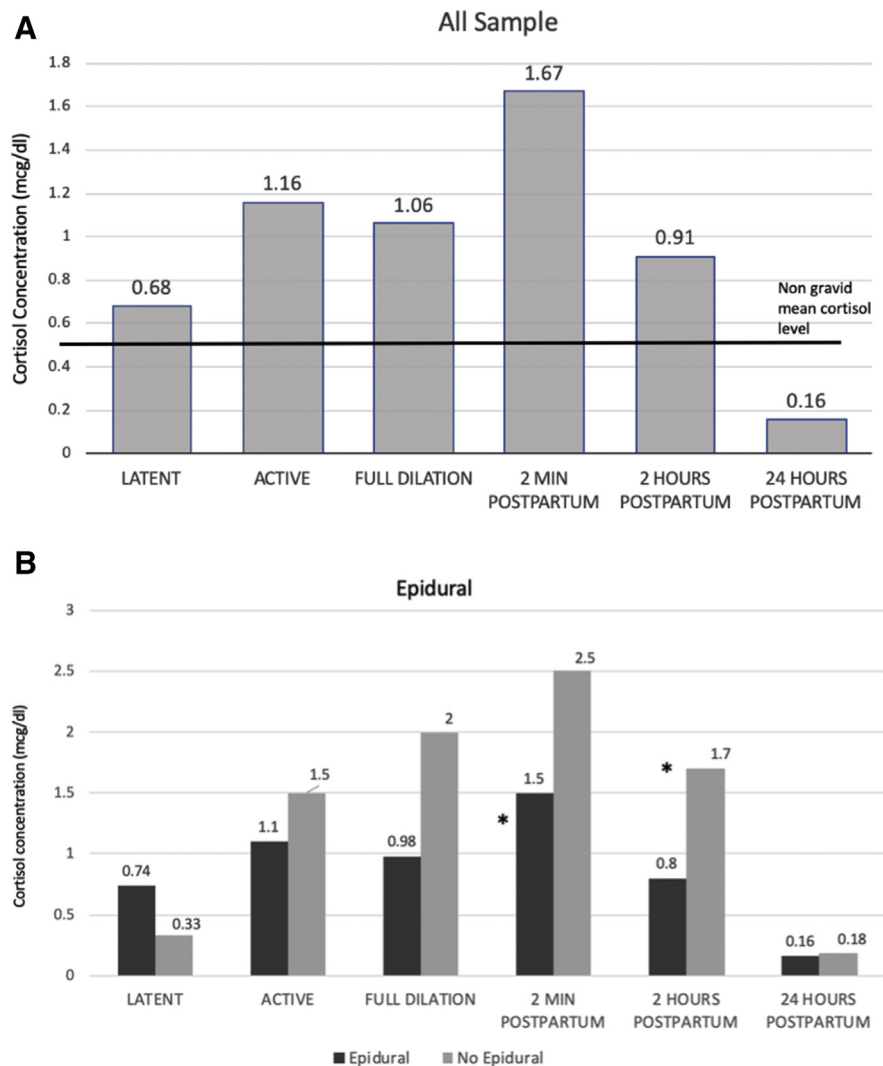
Women with epidural analgesia had lower cortisol concentrations at complete dilation ($P = .026$) as well as 2 hours postpartum ($P = .016$) compared

with women without epidural analgesia. There was also a trend toward a lower cortisol concentration 2 minutes after delivery for women with epidural ($P = .063$). The cortisol concentrations 24 hours postpartum were similar in patients delivered with or without epidural analgesia ($P = .917$; see [Table 2](#) and [Figure 1B](#)).

No difference was found in cortisol concentrations between women who had a spontaneous vaginal delivery (SVD; or vacuum extraction) compared with CD, except for higher cortisol concentrations 2 hours after CD ($2 \pm 2 \mu\text{g/dL}$ vs $0.85 \pm 0.8 \mu\text{g/dL}$, $P = .035$; see [Table 2](#)).

Multifactorial regression analysis revealed that epidural use was negatively correlated, and duration of second stage was positively correlated with cortisol concentrations measured 2 minutes ($P = .06$ and $P = .014$, respectively) and 2 hours after delivery ($P = .001$ and $P = .05$, respectively). Nulliparity was not found to be correlated to cortisol concentration at either time point ($P = .237$ and $P = .191$). No effect was found for vacuum extraction on cortisol concentration at these times ($P = .188$ and $P = .943$, respectively).

FIGURE 1
Cortisol concentrations at each assessment



A, Entire sample. B, In relation to epidural use.

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Psychological stress

Emotional stress peaked during the latent phase (4.56 ± 2.9), then decreased during the active phase (3.41 ± 2.6), and then increased again at the full dilation phase (4.29 ± 3.3). The maximum decrease from 4.29 to 2.04 (52%) occurred immediately postpartum (see Table 3 and Figure 2).

No differences were found between nulliparas vs multiparas in stress scale scores at each assessment, between women with or without epidural, and between women who underwent SVD vs CD (see Table 3).

Correlations between physiological and psychological stress measurements

No significant correlation was found between physiological measures (cortisol) and psychological stress measures (HADS and stress score) at each assessment time (data not shown).

Cord cortisol was positively correlated with cortisol at full dilation (Pearson, 0.35, $P = .025$), 2 minutes, and 2 hours after the delivery (Pearson, 0.5, $P = .001$, Pearson = 0.53, $P = .001$, respectively).

Obstetric complications and neonatal outcomes and correlation to stress measurements

Cord cortisol was higher for women delivered by vacuum extraction compared with SVD (17 ± 2 vs 11 ± 3.8 , $P = .03$). Cord cortisol was also positively related to longer second stage of labor (Pearson, 0.455, $P = .001$).

No significant differences regarding physiological and psychological measures were found in relation to meconium, postpartum hemorrhage, manual lysis, cord pH, or 5 minute Apgar score mentioned in the previous text (data not shown).

Comment

Principal findings

The current study describes physiological and psychological stress levels during labor. We found that women exhibit gradual increases in physiological stress (cortisol) during labor, with the highest cortisol concentrations 2 minutes after delivery. Psychological stress decreased gradually during labor with the highest decrease 2 minutes after delivery. Epidural anesthesia was related to lower cortisol concentrations up to 2 hours postpartum. The novelty of our findings is in the ability to show trends and changes during and immediately after labor and to compare maternal cortisol levels with delivery outcomes.

Results

Our finding of increased salivary cortisol during labor is in agreement with previous studies that demonstrated elevated free plasma cortisol during term labor and delivery.^{4,5} Wilcox showed that total and free concentrations of cortisol increase 2- to 5-fold beginning 10–17 days prepartum to the end of first stage of labor.⁶

One explanation is that cortisol is essential to maintaining glucose levels when glycogen stores are depleted with fasting or with a long labor. High concentrations of cortisol maximize the glucose availability for the fetus and the myometrium, thus contributing to the effective progression of labor.⁴ These physiological changes in cortisol are

TABLE 2

Physiological stress at measured by cortisol concentrations (micrograms per deciliter) at each assessment time

Time of cortisol measurement	Entire cohort	Nulliparas (n = 62)	Multiparas (n = 105)	Pvalue	Epidural (n = 134)	No epidural (n = 33)	Pvalue	SVD (n = 156)	CD (n = 11)	Pvalue
Latent phase	0.68 (0.6)	0.88 (0.3)	0.57 (0.6)	.170	0.74 (0.6)	0.33 (0.6)	.263	0.65 (0.5)	1 (1.4)	.786
Active phase	1.16 (0.9)	1.22 (0.9)	1.1 (1)	.668	1.1 (1)	1.5 (1)	.244	1.1 (0.9)	1.7 (1.2)	.186
Full dilation	1.06 (1)	1.2 (0.8)	1 (1)	.486	0.98 (0.8)	2 (2.3)	.026	1 (1)	1.5 (0.7)	.538
2 min after delivery	1.67 (1.3)	2.4 (1.4)	1.3 (1.2)	.003	1.5 (1.3)	2.5 (1.6)	.063	1.6 (1.3)	2.3 (2)	.389
2 h after delivery	0.91 (0.9)	1.3 (1.1)	0.75 (0.7)	.041	0.8 (0.8)	1.7 (1.1)	.016	0.85 (0.8)	2 (2)	.035
24 h after delivery	0.16 (0.4)	0.2 (0.4)	0.15 (0.3)	.666	0.16 (0.3)	0.18 (0.4)	.917	0.15 (0.3)	0.33 (0.6)	.425
Cord cortisol	12 (4)	13.9 (3.8)	11.5 (3.9)	.053	12.2 (3.8)	12 (5.4)	.915	12 (4)	17 (0.1)	.231

All values are mean (SD).

CD, cesarean delivery; SVD, spontaneous vaginal delivery.

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perceived as necessary for maintaining the maternal and fetal well-being and helping the normal progression of labor.

Cortisol returns to nonpregnant concentrations within 24 hours after delivery. It is interesting and reassuring to find that cortisol concentrations return to those of the nonpregnant state within a relatively short time.

Data regarding parity and cortisol during labor are controversial. Kono et al¹⁴ showed that maternal cortisol concentrations during SVD were higher in primiparous compared with parous women from 3 and up to 9 hours after the onset of labor, with no differences

between primiparous and nulliparous before or after this period. Yet Stjernholm et al¹⁵ found no difference in cortisol concentrations between nulliparous and multiparous during labor. These studies measured cortisol during labor and not during delivery.

Our study also found no difference in cortisol concentrations during labor between these groups. Yet we found that nulliparous had significantly higher cortisol concentrations compared with multiparas when measured 2 minutes ($P = .003$) and 2 hours postpartum ($P = .041$). Based on a multifactorial analysis, we assume that these higher

concentrations were due to a longer second-stage duration among nulliparas in our study.

The current study showed that epidural anesthesia was related to lower cortisol concentrations at complete dilation, 2 minutes after delivery, and 2 hours postpartum, with no differences between women who did or did not receive epidural anesthesia 24 hours after delivery. Alehagen et al¹⁶ also found that cortisol increased throughout labor in women without epidural anesthesia compared with women with epidural.

It is already known that epidural anesthesia suppresses unstimulated and

TABLE 3

Psychological stress at each assessment

Stress scale ^a	Entire cohort	Nulliparas (n = 62)	Multiparas (n = 105)	Pvalue	Epidural		Pvalue	SVD (n = 156)	CD (n = 11)	Pvalue
					Yes (n = 134)	No (n = 33)				
Latent phase	4.56 (2.9)	5.4 (2.8)	3.8 (2.9)	.139	4.7 (2.7)	3.5 (4.3)	.448	4.8 (2.8)	1 (0)	.075
Active phase	3.41 (2.6)	3.58 (2.3)	3.3 (2.7)	.538	3.5 (2.6)	2.9 (2.3)	.377	3.4 (2.6)	3.6 (3)	.818
Full dilation	4.29 (3.3)	4.4 (3)	4.2 (3.5)	.785	4.2 (3.3)	5 (3.2)	.381	4.3 (3.3)	4.8 (3.8)	.646
2 min after delivery	2 (2.6)	2.3 (3.1)	1.8 (2.2)	.320	2 (2.7)	1.6 (1.7)	.488	1.9 (2.4)	4.7 (4.5)	.307
2 h after delivery	1.1 (1.7)	1.2 (2)	1 (1.6)	.699	1.2 (1.8)	0.46 (0.5)	.155	1.1 (1.7)	1.3 (1.5)	.825
24 h after delivery	0.7 (1)	0.5 (0.8)	0.8 (1)	.188	0.75 (1)	0.25 (0.5)	.180	0.67 (0.9)	1.1 (2)	.241
HADS score (anxiety)	3.96 (2.9)	3.8 (2.8)	4 (3)	.569	4.2 (2.9)	3.9 (2.7)	.687	4.1 (2.8)	3.6 (3)	.569

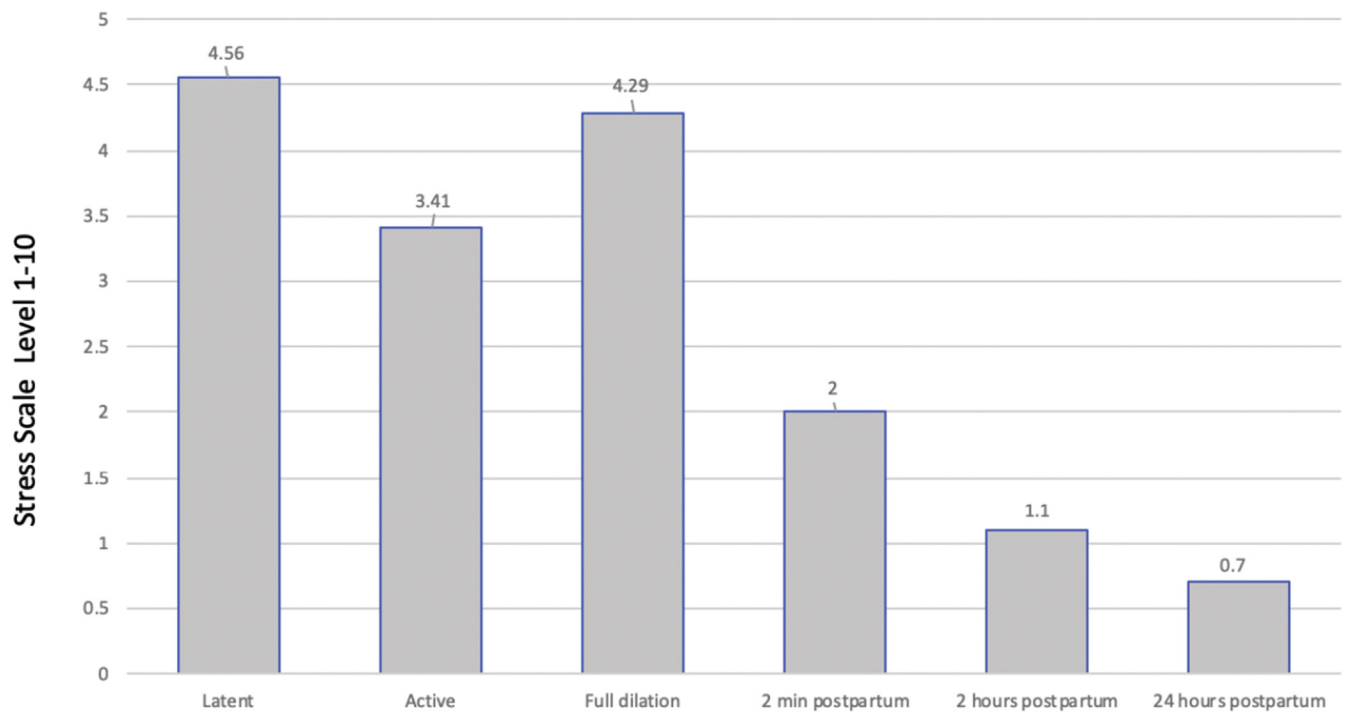
All values are mean (SD).

CD, cesarean delivery; HADS, Hospital Anxiety and Depression Scale; SVD, spontaneous vaginal delivery.

^a A continuous scale comprised of a 10 cm horizontal line whose extremes were labeled 0 for no stress at all and 10 for extremely stressful.

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FIGURE 2
Stress scale score at each assessment



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corticotropin-releasing hormone-stimulated adrenocorticotropin and cortisol secretion,¹⁷ which explains the decrease in cortisol for women receiving epidural analgesia. Because the effects of an epidural last an average of about 114 minutes after delivery,¹⁸ it was also reasonable to expect that cortisol concentrations, which are affected by the epidural, would be similar for women who received or did not receive epidural analgesia after 24 hours.

A comparison between women who delivered vaginally (spontaneous or vacuum assisted) with women who delivered by a cesarean revealed higher cortisol concentrations 2 hours after an emergent CD. In contrast to our findings, Stjernholm et al¹⁵ found significantly higher concentrations of cortisol during the third stage of labor among women vaginally compared with cortisol concentrations 2 hours after elective CD. Yet they did not measure cortisol concentrations 2 hours after a vaginal delivery. These methodological differences might explain the variances between the results.

We evaluated psychological stress using a new stress scale, which was found to be correlated with the STAI.¹³ It should be noted that the stress scale provides a subjective, relative stress score. The change in stress scores provides more information than does the absolute number. In the current study, we found a gradual decrease in stress scores during labor, with the biggest decrease occurring 2 minutes after delivery. Because labor is known to be a stressful event encompassing a large amount of uncertainty, it is reasonable that the perceived psychological stress will decrease dramatically immediately after birth. Although we hypothesized nulliparas would be more stressed as compared with multiparas, our data showed that for both populations, the labor process is perceived as a stressful event, with no difference between groups based on the HADS questionnaire or the stress scale.

In our study, no correlation was found between physiological stress (measured by cortisol) and psychological stress (measured by HADS and the stress

scale). This suggests that there are different aspects to a patient's response to the labor process, as measured by cortisol and stress questionnaires.

The current study showed that cord cortisol levels were higher among women going through vacuum extraction compared with SVD. Higher cortisol concentrations are also related to a longer second stage of labor. Previous data showed that deliveries are associated with high cortisol concentration in the umbilical cord.^{19,20} Mears et al²¹ also found that infants delivered by elective cesarean had the lowest cortisol concentrations, while the highest were recorded in infants following instrumental delivery. Sano found that umbilical cortisol concentration was significantly higher after vacuum-assisted delivery as compared with SVD and that the duration of the second stage was a predictor of higher cortisol concentrations.²²

These data suggest that vacuum extraction may be a stressful event for the infant. Yet it is important to mention that no correlation was found between cord

cortisol and cord pH, a measurement that is known to reflect the metabolic state of the newborn. This may suggest that vacuum extraction increases stress for the infant but may not directly attribute to the metabolic state; possibly because vacuum extraction is usually of short duration.

Clinical implications

This study is the first to evaluate the course of cortisol concentrations during labor and up to 24 hours postpartum. It describes the association between epidural anesthesia and cortisol concentrations and between mode of delivery and salivary cortisol concentrations. Because these data reflect low-risk, singleton pregnancies, they may be considered as a reference to evaluate complicated pregnancies such as those associated with preterm labor or preeclampsia and to evaluate the expression of cortisol during these deliveries.

Strengths and limitations

The major strengths of this study are its prospective design as well as the relatively large sample size. In addition, both physiological and psychological stress levels were assessed at 6 points during labor and postpartum, thus providing a broader and more informative picture of stress during labor.

However, we did not take continuous measurements, which might have provided more detailed results, although, practically, difficult to achieve. Although the sample size was relatively small, we believe it was large enough to ascertain a pattern of cortisol during labor. We encourage other researchers to replicate these findings in future studies. Another limitation of the study was that we measured physiological stress with salivary cortisol only and no other stress measurements such as catecholamines, which might have provided additional insights to our results.

Research implications

Future studies should try to include additional measures to evaluate stress and its effect on obstetrical and neonatal outcomes. Further research needs to

be conducted to evaluate the clinical utility of measuring salivary cortisol concentrations.

Conclusions

This study shows the course of cortisol during labor for low-risk pregnancies, with maximum increase immediately postpartum. Subjective stress levels decreased over the course of labor. Salivary cortisol portrays stress during labor and may be used as a reference to evaluate complicated pregnancies such as those associated with preterm labor or preeclampsia and to evaluate the role of cortisol during these deliveries. ■

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