

## Correlations between stress hormone levels in umbilical cord blood and duration of delivery

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### Abstract

Correlations between umbilical cord blood concentration of stress response hormone cortisol and prolactin, and delivery duration were examined. Thirty-three cases were selected in which both mothers and neonates were healthy, and the neonates were delivered at full term. The umbilical cord blood was collected at the time of delivery and concentrations of cortisol and prolactin were measured. The cortisol level was significantly higher after vacuum-assisted delivery than after spontaneous delivery ( $p=0.044$ ). Significant positive correlations ( $p=0.0289$ ) were observed between cortisol level and delivery duration. In particular, the duration of the second stage of delivery showed stronger positive correlation ( $p=0.0304$ ) with the cortisol level. The prolactin level showed weak correlation with the duration of full delivery and the second stage of delivery. The findings suggest that foetuses may respond to stress by uterine contraction during delivery.

**Keywords:** Cortisol, Prolactin, Umbilical cord blood, Delivery duration.

### Introduction

In humans, delivery consists of three stages. The first stage is the period from the beginning of regular uterine contractions until full cervical dilation; the second stage is from full cervical dilation to the birth of a neonate; and the third stage is from the birth to completion of expulsion of the umbilical cord, placenta and foetal membrane. During the first and second stages, the mother undergoes labour pain stress. The foetus is also thought to be undergoing high stress by uterine contractions during the delivery period, especially during the second stage which is marked by a shorter interval between uterine contractions and a higher intensity of contractions compared to the first and the third stages.

An adrenocortical hormone, cortisol, is well known as

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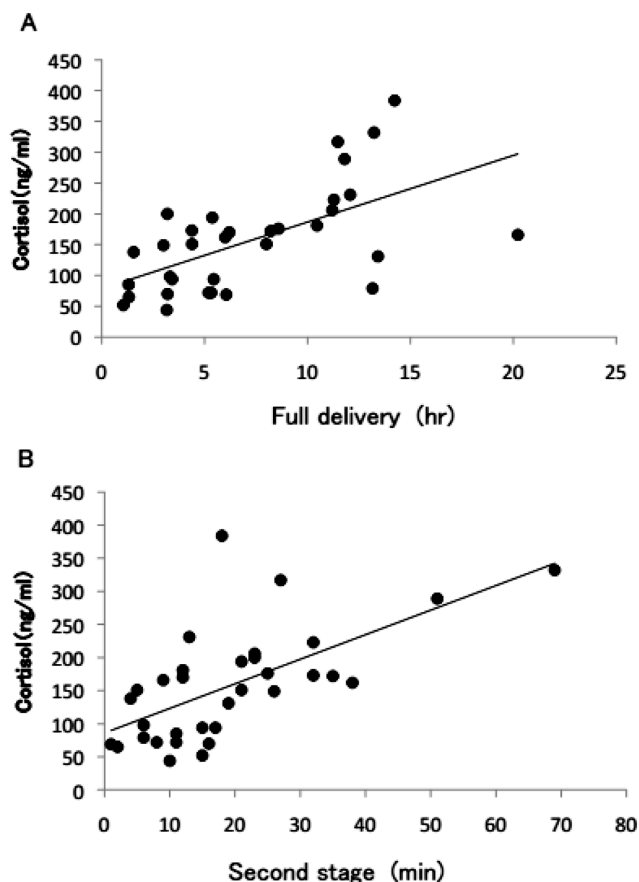
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stress-responsive hormone and its blood concentration is used as a stress marker.<sup>1</sup> Cortisol plays an important role in energy production and inflammatory response. A pituitary hormone, prolactin, is also known as a stress-responsive hormone.<sup>2</sup> The blood concentration of prolactin markedly increases during the peripartum and lactation period, reflecting its lactogenic function. In addition, the blood concentration of prolactin increases in response to stress to enhance stress tolerance.<sup>3</sup>

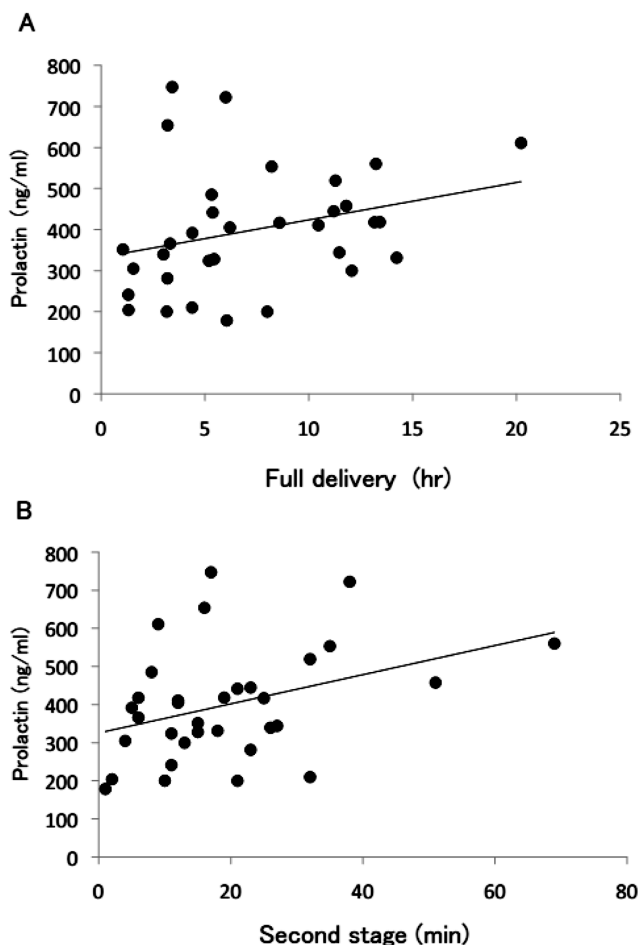
The umbilical cord blood is an important source of information on foetus's physiological condition, including stress level.<sup>4</sup> Many studies have shown correlation between cortisol levels of umbilical cord blood and mode of delivery such as spontaneous, vacuum-assisted or caesarean delivery.<sup>5-8</sup> However, few studies have assessed the effect of delivery duration on the stress response of foetuses. Therefore, in the present study, we examined the correlations of cortisol and prolactin levels in umbilical cord blood with the delivery duration of parturition.

### Methods and Results

The study was conducted at Fujinomiya City General Hospital, Shizuoka, Japan, from January 2012 to August 2013, and comprised 33 cases in which both mothers and neonates were healthy without any complications, and the neonates were delivered at full term between the 37th and 42nd gestational week. The mean age of the subjects was  $30.7 \pm 4.8$  years (range: 20-42 years). The mean duration of delivery was  $7.7 \pm 4.8$  hours (range: 2-21 hours). Of the total, 20(60.6%) women were primiparae, 9(27.3%) were para 2 and 4(12%) were para 3. Relevant data with regard to the conditions of the mothers, neonates and delivery were collected from the clinical records of their visits during their pregnancies and hospital stays, as well as the delivery at the hospital. The study was reviewed and approved by institutional ethics committee. The subjects also signed a consent form after receiving a verbal explanation and written documents regarding the study. A sample of umbilical cord blood was collected at the time of delivery. After the foetus was delivered, the umbilical cord was ligated and severed. Subsequently, the cord was deterged with gauze to prevent the mother's blood from contaminating the sample. The blood was drawn separately from the umbilical artery and vein using



**Figure-1:** Correlation between delivery duration and cortisol levels in the umbilical cord blood. A: Correlation with duration of full delivery ( $R = 0.6022$ ,  $P = 0.0289$ ). B: Correlation with duration of second stage of delivery ( $R = 0.6334$ ,  $P = 0.0304$ ).



**Figure-2:** Correlation between delivery duration and prolactin levels in the umbilical cord blood. A: Correlation with duration of full delivery ( $R = 0.2893$ ,  $P = 0.0446$ ). B: Correlation with duration of second stage of delivery ( $R = 0.3726$ ,  $P = 0.0465$ ).

**Table:** Hormone levels and length of deliver.

	SD (n=33)	VD (n=8)
Cortisol (ng/ml)	157±84.4	223.1±90.8*1
Prolactin (ng/ml)	398.8±147.9	421.1±108.3
Full Delivery (hr)	7.3±4.7	7.3±3.4
Second stage (min)	19.1±14.4	49.3±20.6*2

SD: Spontaneous delivery, VD: Vacuum-assisted delivery.

\*1: p-value=0.0440. \*2: p-value=0.0138.

a sterile disposable syringe with an 18G needle. Plasma was separated by centrifugation and stored at  $-30^{\circ}\text{C}$  until assayed. The concentration of cortisol was determined using Cortisol kit TFB (Fuji Rebio Inc. Tokyo, Japan) according to the manufacturer's instruction. The concentration of prolactin was measured by ECLusys Prolactin III kit (Roche Diagnostics Tokyo Japan) according to the manufacturer's instruction. All statistical analyses

were performed with t-test and Spearman's rank correlation coefficient test using SPSS 15.

In our initial survey of vaginal delivery cases, there were no differences in the length of full delivery time between the spontaneous delivery group and vacuum-assisted delivery group; but the length of the second delivery stage of the vacuum-assisted delivery group was 3-fold longer than that of spontaneous delivery group (Table). Therefore, we examined the cortisol and prolactin levels in the umbilical cord blood of both groups. The cortisol level of the vacuum-assisted delivery group was significantly higher than that of the spontaneous delivery group ( $p=0.044$ ).

The correlation between cortisol levels and delivery duration among the spontaneous delivery group was significantly positive ( $R=0.6022$ ;  $p=0.0289$ ) (Figure-1A). In particular, there was a stronger positive correlation

( $R=0.6334$ ;  $p=0.0304$ ) between the duration of the second stage of delivery and the cortisol level (Figure-1B). The prolactin level showed weak correlation with the duration of full delivery ( $R=0.2893$ ;  $p=0.0446$ ) and the second stage of delivery ( $R=0.3726$ ;  $p=0.0465$ ) (Figure-2A and B).

## Discussion

It is well known that deliveries are associated with high levels of cortisol in the umbilical cord blood of newborns.<sup>4-8</sup> The cortisol level differed between groups according to the different modes of delivery. The lowest level of cortisol was observed in elective caesarean section group without labour.<sup>4,7</sup> In the present study, the cortisol level of the vacuum-assisted delivery group was significantly higher than that of spontaneous delivery group. Because the vacuum-assisted delivery is applied to cases of prolonged second stage of delivery, the length of the second stage of the vacuum-assisted delivery group was 3-fold longer than that of the spontaneous delivery group. Therefore, the higher cortisol levels may reflect the longer exposure to stress from uterine contractions during the second stage of the vacuum-assisted delivery group. To clarify the effect of the length of delivery on the cortisol level in the umbilical cord blood, we examined correlations between delivery duration and the levels of cortisol in the spontaneous delivery group. Our study revealed positive correlations between delivery duration and cortisol levels. In particular, a stronger correlation was observed with the duration of the second stage of delivery.

Cord blood prolactin levels are reportedly not significantly different between elective caesarean section groups and spontaneous delivery groups.<sup>9,10</sup> In the present study, cord blood prolactin levels were weakly correlated with delivery duration. Although prolactin is known as a stress-responsive hormone, but its serum level got temporarily elevated in response to stress and

decreased during stress loading.<sup>4</sup> Therefore, cord blood prolactin level is less useful as a stress marker.

## Conclusion

Cortisol levels and prolactin levels in the cord blood correlated positively with the delivery duration, particularly with the duration of the second stage of delivery. Findings are suggestive of the presence of a foetal response to the stress caused by uterine contraction during delivery.

## References

1. Benfield RD1, Newton ER, Tanner CJ, Heitkemper MM. Cortisol as a biomarker of stress in term human labor: physiological and methodological issues. *Biol Res Nurs* 2014; 16: 64-71.
2. Gala RR. The physiology and mechanisms of the stress-induced changes in prolactin secretion in the rat. *Life Sci* 1990; 46: 1407-20
3. Fujikawa T, Soya H, Yoshizato H, Sakaguchi K, Doh-Ura K, Tanaka M, et al. Restraint stress enhances the gene expression of prolactin receptor long form at the choroid plexus. *Endocrinology* 1995; 136: 5608-13.
4. Gitau R, Menson E, Pickles V, Fisk NM, Glover V, Mac Lachlan N. Umbilical cortisol levels as an indicator of the fetal stress response to assisted vaginal delivery. *Eur J Obstet Gynecol Reprod Biol* 2001; 98: 14-7.
5. Weekes AR, Wade AP, West CR. Umbilical vein cortisol after spontaneous and induced labour and at elective Caesarean section. *Br J Obstet Gynaecol* 1976; 83: 870-2
6. Kauppila A, Koivisto M, Pukka M, Tuimala R. Umbilical cord and neonatal cortisol levels. Effect of gestational and neonatal factors. *Obstet Gynecol* 1978; 52: 666-72
7. Mears K, McAuliffe F, Grimes H, Morrison JJ. Fetal cortisol in relation to labour, intrapartum events and mode of delivery. *J Obstet Gynaecol* 2004; 24: 129-32
8. Vogl SE, Worda C, Egarter C, Bieglmayer C, Szekeres T, Huber J, et al. Mode of delivery is associated with maternal and fetal endocrine stress response. *BJOG* 2006; 113: 441-5
9. Procianny RS, Cecin SK, Pinheiro CE. Umbilical cord cortisol and prolactin levels in preterm infants. Relation to labor and delivery. *Acta Paediatr Scand* 1983; 72: 713-6.
10. Lao TT, Panesar NS. The effect of labour on prolactin and cortisol concentrations in the mother and the fetus. *Eur J Obstet Gynecol Reprod Biol* 1989; 30: 233-8.