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Can myometrial thickness measurement predict the amount of postpartum hemorrhage and delivery type?

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ABSTRACT

Aims: This study aims to determine the effect of the myometrial thickness on the amount of postpartum bleeding and to investigate its role as an auxiliary method in predicting postpartum hemorrhage.

Methods: This prospective study includes 305 pregnant women in two groups, vaginal delivery, and cesarean section patients. The fundal, mid anterior, and lower uterine segment myometrium thicknesses were measured. In the postpartum period, the amount of bleeding and the type of delivery was recorded, and the relationship between myometrial thickness measurements was determined.

Results: The amount of bleeding in the patients who had a cesarean section was higher than in those who had a vaginal delivery ($p<0.01$). The myometrium of the patients who had a cesarean section was thicker than those who had a vaginal delivery ($p<0.05$). Measurements above the cut-off value of 6.1 mm determined for the mid-anterior myometrium thickness measured in the latent phase were associated with a cesarean section with a sensitivity of 63% and a specificity of 66% ($p=0.011$).

Conclusion: Fundal myometrium thickness measured in the active phase and lower uterine segment myometrium thickness measured in the 2nd stage predict postpartum bleeding in patients with a vaginal delivery. Mid-anterior myometrium thickness measured in the latent phase can predict the probability of cesarean delivery.

Keywords: Myometrial thickness, postpartum hemorrhage, cesarean section, birth

INTRODUCTION

Almost one million mothers worldwide die yearly due to pregnancy-related complications.[1] One of the most feared situations during childbirth can be expressed as postpartum hemorrhage(PPH). Although PPH has been defined in many ways in the literature, the most popular definition is bleeding of more than 500 ml after vaginal delivery, more than 1000 ml after cesarean section, or a decrease of more than 10% in hematocrit level.[2,3] Postpartum hemorrhage occurs in 4-6% of births. Worldwide, postpartum hemorrhage accounts for 8% of maternal deaths in developed regions and 20% in developing regions.[3]

Since postpartum hemorrhage is a life-threatening condition, risk factors, prevention strategies, and what to do when faced should be known by today's obstetricians. Although many risk factors that may cause PPH have been identified, there are no clear objective indicators to help us predict the amount of bleeding that may occur during delivery.

Physiological changes in the uterine muscle layer from the implantation process of the fetus to the time of birth have been the source of many studies.[4-6] In this study, myometrial measurements were evaluated to determine the risk of PPH, one of the leading causes of maternal mortality, before birth. In this context, this study aims to investigate the relationship between uterine myometrial thickness measurements and the amount of postpartum bleeding and delivery method using ultrasonography (USG), which was introduced into obstetric practice about 50 years ago.

METHODS

This study was conducted prospectively in Bursa Yüksek İhtisas Training and Research Hospital Department of Obstetrics and Gynecology. The study was carried out with the permission of Bursa Yüksek İhtisas Training and Research Hospital Clinical Researches Ethics Committee (Date: 05.02.2020, Decision No: 2011-KAEK-25 2020/02-12). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The patient group included in the study consisted of patients at term (38-41 weeks of gestation), 18-40 years of age, single, with a head presentation, and hospitalized in the delivery room in the latent phase. Patients with multiple pregnancies, malpresentation, and comorbidity were out of the study.

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Oxytocin and amniotomy were applied to the study group according to ACOG guidelines and in the same standards. Accordingly, oxytocin was administered at 500 c.c isotonic solutions, with a dose of 5 mU per minute, with an increase of 5 mU per minute until an adequate uterine contraction activity was established, a condition of increasing to a maximum dose of 30 mU/min.[7]

While oxytocin initiated in pregnant women who were not in the active phase was considered an induction application, oxytocin initiated in pregnant women who were in the active phase but did not have sufficient uterine contraction was considered an augmentation application. The definition accepted by the world as at least three painful uterine contractions (total 200-250 Montevideo units) within 10 minutes and 6 cm cervical dilation for active labor was accepted. Myometrial thickness measurement was added to the fetal biometric measurements. While measurements were made in the latent phase, active phase, and the second stage of labor in the patient group who delivered vaginally, only the latent phase measurements were made in the patient group who delivered by cesarean section.

The myometrium was defined as the echo-homogeneous layer between the serosa and decidua of the uterus. Myometrial thickness measurements were made from the fundal, mid-anterior, and lower uterine segments of the uterus. Lower uterine segment measurement was made 2 cm above the bladder echo, mid-anterior segment measurement was made 1 cm above the umbilicus level, and fundal measurement was made from the part of the uterus that corresponds to the uterine curve area below the xiphoid.[8] The measurement methods taken are shown in **Figure 1** below.

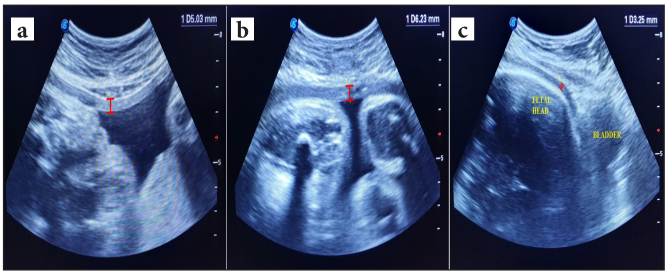

Figure 1. Myometrium thickness measurement method.

A: Fundus myometrial thickness; B: Midanterior myometrial thickness; C: Low uterine segment myometrial thickness

Each measurement was made by the same person. In patients who delivered vaginally, 9 measurements were taken from a patient in total, from 3 different regions in 3 different time periods, while measurements were taken from 3 regions only in the latent phase in patients who delivered by cesarean section. At the same time, age, gravida, parity, birth week, BMI, hospitalization time, cervical dilatation, amniotic fluid amount, delivery type, birth weight, 1st and 5th minute Apgar scores, prenatal and 6th hour postpartum hemogram, hematocrit and mean erythrocyte volume (MCV), 24-hour bleeding amounts learned with the help of pads were evaluated, recorded, and examined.

The amount of bleeding in the evaluated patient groups was estimated by the physician who gave birth during the intrapartum period, and during the service follow-up, the calculation was made based on the studies in the literature with the help of the patient diaper and sterile pad (100 cc) used in the clinic.[9] Sterile delivery bags could not be used due to technical limitations.

Statistical Analysis

Statistical analysis of the study was performed using the IBM SPSS 26.0 (Statistical Package for the Social Sciences, version 26.0) program. We analyzed the normality assumptions of the data by using descriptive methods with histogram graphics in which the normal distribution curve is drawn and the Kolmogorov-Smirnov test, which is used in cases where the sample is more than 30. The data were explained using descriptive statistics (arithmetic mean±standard deviation (SD), minimum (min.) ve maximum (max.)). The independent t-test was used to compare the two groups if the data showed normal distribution. The Mann-Whitney U test, one of the non-parametric tests, was used if the data did not show normal distribution. We preferred the Chi-square test for the comparison of categorical data.

Multiple linear regression analysis was performed to examine the independent effects of different predictors on the amount of postpartum bleeding and to develop a mathematical model. The backward LR method was used to determine the predictors.

In addition, the receiver operating characteristic curve (ROC curve) was created to evaluate the prediction of myometrial thickness measurements for cesarean section. Sensitivity and specificity were calculated with the areas under the curve (AUC). A cut-off point was determined in the cesarean section groups according to the vaginal delivery groups.

The results obtained from all analyzes were interpreted considering the 0.05 significance level.

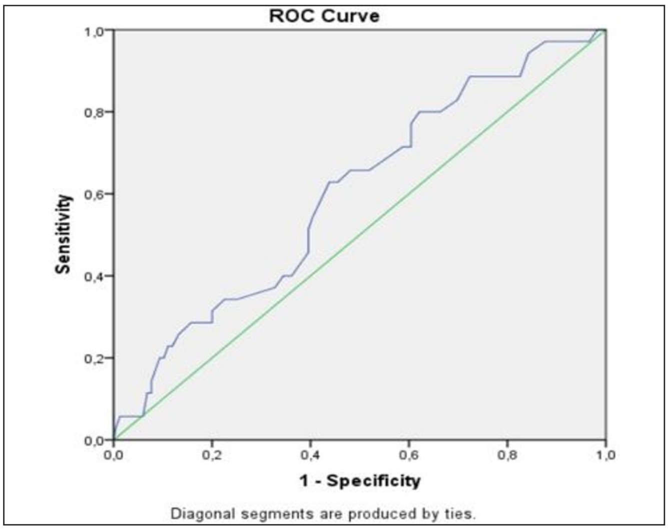

Figure 2. ROC analysis curve of latent phase mid anterior myometrial thickness according to delivery groups

RESULTS

This study includes 305-term pregnant women admitted to the delivery room in the latent phase planned for vaginal delivery. The patients were divided into two groups: the patient group with a vaginal delivery and the cesarean delivery group. There were 235 (77%) patients who had a vaginal delivery and 70 (23%) patients who delivered by cesarean section. Cesarean section indications were of three types. Of these, 32 (45.7%) were due to acute fetal distress, 30 (42.8%) were due to non-progressed labor, and 8 (11.5%) were due to cephalopelvic disproportion. The characteristic features of the patients are available in **Table 1**.

In the study, nine measurements were taken from 235 patients who had spontaneous vaginal delivery in 3 different periods (latent phase, active phase, 2nd stage) and from 3 different regions (fundus, mid anterior, lower uterine segment). Measurements were taken from 3 different regions only in the latent phase of the patients who gave birth by cesarean section. The comparison of the measurements made in the latent phase of the patients in the vaginal delivery and cesarean section group is shown in **Table 1**. The myometrium thickness of the patients in the cesarean section group was statistically significantly thicker than the myometrium of the patients who had a vaginal delivery ($p<0.05$).

Myometrial thicknesses of the patients who had spontaneous vaginal delivery were evaluated separately for nulliparous and multiparous patient groups. The measurement values related to this are shown in **Table 2**. Accordingly, myometrial thicknesses of nulliparous patients were thinner than those of multiparous patients. While no difference was there between the measurements taken from the lower segment in the active phase between these two groups ($p>0.05$), a statistically significant difference was found between the other eight measurements ($p<0.05$).

Table 1. The sociodemographic characteristics and findings of the study population

	Vaginal delivery (n=235)				Cesarean delivery (n=70)				p
	$\bar{x}$	SD	Min.	Max.	$\bar{x}$	SD	Min.	Max.	
Age (y)	24.35	5.34	18	37	24.06	5.05	18	39	0.81
Gestational age (wk)	39.	0.94	38	41	39.34	1.10	38	41	0.33
Gravidity	2.2018	1.33	1	8	1.91	1.16	1	5	0.086
Parity	0.99	1.08	0	4	0.71	1.01	0	3	0.038*
Nulliparous (n,%)	103 (43.8%)				42 (60%)				0.017*
Multiparous (n,%)	132 (56.2%)				28 (40%)				
Vaginal examination (cm)	3.20	2.20	1	5	3.32	2.09	1	5	0.52
BMI (kg/m²)	27.73	3.93	20.4	41.4	28.70	3.70	23	39.4	0.028*
AFI (SDP) cm	3.37	1.16	2	7.9	3.27	1.00	2.1	6.2	0.52
Hospitalization (d)	1.10	0.37	1	4	2.13	0.38	2	4	<0.01*
Birth weight (g)	3277	408	2470	4490	3246	387	2460	4260	0.55
APGAR-1.minute	8.87	0.71	3	9	8.59	1.20	3	9	<0.01*
APGAR-5.minute	9.90	0.55	5	10	9.71	0.71	7	10	<0.01*
Amount of bleeding (cc)	394.13	67.3	150	700	542.71	125	250	1000	<0.01*
Fundus Latent (mm)	5.42	1.06	3.1	8.2	5.79	1.30	3.1	8.7	0.03*
Midanterior Latent (mm)	6.12	1.63	3.2	11.0	6.71	1.70	3.4	11.0	0.01*
Low Segment Latent (mm)	3.15	0.55	2.1	4.8	3.34	0.60	2.4	4.9	0.02*

*$p < 0.05$, $\bar{x}$: Mean, SD: Standard Deviation, Min: Minimum, Max: Maximum, y: year, wk: week, kg: kilogram, m²: meter square, cm: centimeter, d: day, g: gram, Student-t test was performed

Table 2. Comparison of myometrium thicknesses of vaginal delivery patients by parity

	Spontaneous Vaginal Delivery (n=235)								p
	Nullipara (n=103)				Multipara (n=132)				
	$\bar{x}$	SD	Min.	Max.	$\bar{x}$	SD	Min.	Max.	
Fundus Latent (mm)	5.13	0.96	3.7	8.2	5.65	1.09	3.1	8.1	<0.01*
Midanterior Latent (mm)	5.71	1.59	3.2	9.8	6.43	1.60	3.4	11.0	<0.01*
Low Segment Latent (mm)	3.06	0.47	2.3	4.4	3.23	0.59	2.1	4.8	0.02*
Fundus Active (mm)	4.94	1.17	3.3	8.2	5.36	1.24	3.2	10.0	<0.01*
Midanterior Active (mm)	5.35	1.49	3.0	10.0	5.97	1.50	2.8	9.8	<0.01*
Low Segment Active (mm)	2.82	0.39	2.2	3.9	2.93	0.52	2.1	4.7	0.12
Fundus Stage 2 (mm)	6.88	1.37	4.9	11.4	7.40	1.24	5.4	10.8	<0.01*
Mid anterior Stage 2 (mm)	6.97	1.28	5.0	10.1	7.75	1.51	5.2	11.7	<0.01*
Low Segment Stage 2 (mm)	2.56	0.28	2.1	3.5	2.66	0.38	2.0	3.8	0.02*

*$p < 0.05$, $\bar{x}$: Mean, SD: Standard Deviation, Min: Minimum, Max: Maximum, mm:millimeter, Student-t test was performed

It was observed that the myometrium thicknesses of all three regions were thinned when the patients transitioned from the latent phase to the active phase during labor follow-up. When transitioning from the active phase to the 2nd phase, it was observed that the thickness of the lower segment continued to thin. In contrast, the thickness of the fundus and mid-anterior myometrium increased significantly and even exceeded the values measured in the latent phase.

Fundus, mid anterior, and lower segment myometrium thickness parameters in the patient group's first and second stages of labor followed by vaginal delivery were analyzed by multiple linear regression analysis. After the backward method, fundus thickness in the active phase and lower segment thickness in the 2nd stage was determined as the predictors that most affected the amount of postpartum hemorrhage. The findings are presented in Table 3. In this context, it can be stated that the fundal measurement taken in the active phase and the lower segment measurement taken in the 2nd phase significantly predict the amount of postpartum bleeding and explain 9% of it ($R=.30$, $R2=.09$, $p<0.01$). In addition, when the t-test results regarding the significance of the regression coefficients are examined, fundus measurement in the active phase ($\beta=-0.20$, $p=0.02$) and lower segment measurement taken in the 2nd stage ($\beta=-0.20$, $p=0.02$) significantly predict the amount of postpartum hemorrhage.

Table 3. Multiple linear regression analysis of vaginal postpartum bleeding amount and myometrial thickness parameters and Cesarean section midanterior myometrial thickness ROC analysis chart

Variables	B	Std. error	β	t	p	
Fundus active	-10.85	3.48	-.20	-3.12	.002*	
Low segment stage 2	-38.62	12.51	-.20	-3.09	.002*	
AUC (%95)	**Cut off (mm)**	**p**	**Sens. (%)**	**Spes. (%)**	**PPV (%)**	**NNPV (%)**
0,600 (0.526-0,673)	6,1 mm	0.011*	63	66	56.2	62.9

RF: Risk factor, AUC: Area under the curve, mm: milimeter, Sens.: sensitivity, Spes.: Specificity, PPV: Positive Predictive Value, NPV: Negative Predictive Value ve *p < .05 significiant value

As a result of the multiple linear regression analysis, the model that can predict the amount of bleeding after vaginal delivery was created as follows. Amount of bleeding= 551+(-11 × Active Fundus Measurement) + (-39 × 2nd Stage Low Segment Measurement)

Accordingly, it is thought that a decrease of 1 mm in these two measurements in patients who delivered vaginally will increase the amount of bleeding by 50 c.c..

ROC analysis was also performed regarding myometrial thickness parameters to predict cesarean delivery. A cut-off point was determined in the cesarean section groups according to the vaginal delivery groups. Accordingly, the area under the curve was most determined in mid anterior myometrial thickness (AUC=0.600). When Table 3 is examined, when the mid anterior myometrium thickness is measured as 6.1 mm and above in the latent phase, the probability of cesarean delivery with 63% sensitivity and 66% specificity was determined ($p=0.011$).

DISCUSSION

The patient group of the study consists of patients who were admitted to the delivery room in the latent phase and followed up for vaginal delivery. The evaluation was made by dividing them into two groups according to the type of birth. When the characteristics of the patients were examined, a significant difference was found between parity, length of hospital stay, body mass index, and Apgar scores of newborns at 1 and 5 minutes ($p<0.05$). The reason for the significant difference between newborn Apgar scores was thought to be that 46% of the indications of the patient group who had cesarean section were fetal distress. In the study by Eyowas et al.[10] in 2016 examining the neonatal effects of delivery type, 1st minute Apgar scores were found to be significantly higher in the vaginal delivery group than in the cesarean section group ($p=0.001$). However, no significant correlation was found between the 5th minute Apgar scores ($p=0.055$).

In the study of Buhimschi et al.[8] the myometrial thicknesses of patients in active and non-active labor were compared and recorded during labor. Accordingly, the myometrium thickness of the active labor group was calculated to be statistically significantly thin on the fundal and mid anterior lines ($p<0.01$), but no statistically significant difference was found between the lower uterine segment thicknesses ($p>0.05$). At the same time, while the myometrium thickens significantly in the fundus and mid-anterior line in the second stage of labor ($p<0.05$), the postpartum effect is reversed (fundal dominance). In the study of Durnwald et al.[11] in 2008, the myometrial thickness was evaluated according to the week of gestation, uterine region, and patients with a previous cesarean section, and the myometrial thickness of the nulliparous patient group was calculated to be statistically significantly thinner than the multiparous patient group ($p<0.05$). In this study, results have been obtained that support these two studies. The myometrial thickness of the nulliparous patient group was significantly thinner than the multiparous patient group ($p<0.05$). At the same time, it was observed that the thickness of the myometrium was thinned in the active phase. In the second stage, while the lower segment continued to thin, it was observed that the fundus and the mid-anterior line significantly thickened.

The generally accepted definition for postpartum hemorrhage is 500 cc of bleeding in vaginal delivery, 1000 cc in cesarean section, or more than 10% decrease in hematocrit value.[12] In the bulletin published by ACOG in 2017, PPH was defined as bleeding more than 1000 cc at birth or developing hypovolemia symptoms.[6] Some studies have emphasized that the patient's vital signs and the development of hypovolemia symptoms are more important than laboratory values for PPH.[13]

In a Cochrane analysis prepared by Diaz et al.[14] different techniques were presented to help predict PPH. One is sterile delivery bags; the other is hemoglobin concentration in spectrophotometry and venous blood. However, although these techniques are thought to provide more precise results in measuring blood loss, their accessibility is difficult. One of the study's limitations is measuring the amount of bleeding with visual estimation during the intrapartum period and using sterile pads in the postpartum period.

In a study by Stafford et al.[15] estimated and measured blood loss in vaginal delivery and cesarean section were compared. A significant difference was found between the delivery groups regarding blood loss. In this study, the amount of bleeding in the patient group who had a cesarean section was higher than in the group who had a vaginal delivery ($p<0.01$).

In the study of Biguzzi et al.[16] with 6011 women, there are data showing that nulliparity is a risk factor for PPH. Our article showed that myometrial thickness was thinner in nulliparous patients than in multiparous patients, which was thought to be the inverse correlation. The significant parameters in the correlation table were examined with the multiple linear regression model. It was determined that the fundal measurement in the active phase and the lower segment measurement in the 2nd phase were the predictors that most affected the bleeding in the patients who had vaginal deliveries, regardless of parity ($p=0.02$). In this study, fundal measurements in the nulliparous patient group with vaginal delivery and lower segment measurements in the multipara patient group with vaginal delivery were found to have a moderate negative correlation with the amount of bleeding.

Regular uterine contractions that increase with the active phase in vaginal delivery may be more associated with the fundus. The descent of the fetus, which starts after the active phase, from the fundus to the lower segment also supports this situation. At the same time, lower segment myometrium thickness measured after a fully dilated cervix was determined as one of the parameters affecting the amount of postpartum hemorrhage. This makes it essential to evaluate the lower uterine segment, the thinnest and shortest uterine segment in the 2nd stage, in predicting postpartum hemorrhage. Invasive procedures are mainly applied to the lower segment, and adjacent structures in postpartum hemorrhage also support this situation.

Myometrium thicknesses in the latent phase of the patient groups who had cesarean section and vaginal delivery were also compared. It was found that the myometrium thicknesses measured from 3 regions were statistically different ($p<0.05$). ROC analysis of myometrial thicknesses was performed to evaluate the prediction of cesarean delivery. The area under the curve was the highest in the measurements made from the mid-anterior line (AUC=600). The cut-off value for the mid-anterior line was 6.1 mm. For the values measured above, the probability of cesarean delivery was predicted with a sensitivity of 63% and a specificity of 66% ($p=0.011$).

In the thick myometrium tissue, vascularization may occur more, and uterine contractions may be more frequent and stronger. Considering that the more hypoxic environment, which occurs due to more frequent and strong uterine contractions in pregnant women receiving oxytocin induction, increases the possibility of cesarean section, it can be thought that the increase in myometrium thickness may also be a marker for cesarean section prediction. The fact that fetal distress constituted the majority of cesarean section indications in the study supports this situation. Although myometrial thickness parameters are statistically significant in predicting cesarean section, more long-term prospective studies are needed to strengthen its diagnostic feature due to its low specificity.

The limitations of the study were that the study was conducted in a single center, the amount of bleeding could not be measured with more objective criteria, and the interobserver variability in estimating the amount of intrapartum bleeding.

CONCLUSION

As a result of the data obtained, fundal myometrium thickness measured in the active phase and myometrial thickness measured from the lower uterine segment in the 2nd stage were found to be associated with the amount of bleeding in patients who had a vaginal delivery. When the myometrium thickness measured from these two regions became thinner, an increase in the amount of bleeding was observed.

At the same time, myometrial thickness measured from the mid anterior line in the latent phase may also indicate a relationship with cesarean section. It has been observed that the increase in myometrium thickness measured from the mid anterior line also increases the cesarean section rates.

These findings and relationships revealed in the study suggest that examining myometrial changes that show physiological changes in labor with different studies may contribute more to the practice of obstetrics.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Bursa Yüksek İhtisas Training and Research Hospital Clinical Researches Ethics Committee (Date: 05.02.2020, Decision No: 2011-KAEK-25 2020/02-12).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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