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INTRAPARTUM TRANSPERINEAL ULTRASOUND MEASUREMENT OF HEAD– PERINEUM DISTANCE AND DELIVERY-RELATED MATERNAL OUTCOMES: A PROSPECTIVE COHORT STUDY

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RUNNING TITLE

HEAD–PERINEUM DISTANCE IN LABOR

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ABSTRACT

Background: Intrapartum head–perineum distance (HPD) measured by transperineal ultrasound may provide an objective measure of fetal head descent. This study evaluated its association with delivery-related maternal outcomes, particularly perineal trauma, in term primiparous women.

Methods: This single-center prospective cohort study included 70 term primiparous women with singleton cephalic pregnancies in active labor. At 6 cm cervical dilatation, vaginal examination and transperineal ultrasound were performed. HPD was measured three times and the mean was analyzed. Maternal outcomes were recorded through the first postpartum week. Associations were assessed using non-parametric tests, Spearman correlation, and univariable logistic regression.

Results: Mean HPD was 33.53 ± 6.29 mm. Vaginal birth occurred in 81.4% of participants and cesarean delivery in 18.6%. Episiotomy was performed in 67.1%, spontaneous perineal laceration occurred in 20.0%, and composite perineal trauma in 70.0%. HPD was lower among women with an engaged fetal head ($p = 0.031$) and among those who underwent episiotomy ($p = 0.043$). HPD was inversely correlated with cervical effacement, episiotomy, and composite perineal trauma (all $p < 0.05$). Each 1-mm increase in HPD was associated with lower odds of an engaged fetal head (OR 0.89, $p = 0.027$). HPD was not significantly associated with mode of delivery (OR 1.07, $p = 0.177$).

Conclusions: In this cohort, intrapartum HPD was associated with fetal head station and episiotomy and was inversely correlated with composite perineal trauma. No statistically significant association was found between HPD and mode of delivery. Larger prospective

studies are needed to assess these relationships and establish clinically useful threshold values.

Keywords

head–perineum distance; transperineal ultrasound; intrapartum ultrasound; perineal trauma; episiotomy; labor; vaginal examination

INTRAPARTUM TRANSPERINEAL ULTRASOUND MEASUREMENT OF HEAD–PERINEUM DISTANCE AND DELIVERY-RELATED MATERNAL OUTCOMES: A PROSPECTIVE COHORT STUDY

BACKGROUND

Accurate assessment of labor progression and maternal–fetal status is essential for optimal obstetric decision-making. Clinical judgments during labor traditionally rely on findings obtained by vaginal examination (VE); however, VE is inherently subjective and dependent on the examiner's experience. This has prompted increasing interest in more objective methods for evaluating labor progression.

Transperineal ultrasound (TPU) has emerged as a reproducible and objective tool for assessing fetal head descent and its relationship with the maternal pelvis during labor. Several studies have reported that TPU-derived parameters, particularly head–perineum distance (HPD), may be associated with labor progression and mode of delivery [1–7].

Nevertheless, the predictive value of intrapartum HPD measurement for delivery-related maternal outcomes has been directly and comprehensively evaluated in only a limited number of studies. In the present study, we investigated the association between HPD measured at the onset of the active phase of labor and delivery-related maternal outcomes. As a secondary objective, we compared HPD measurements with simultaneous vaginal examination findings.

We hypothesized that HPD measured at the beginning of the active phase is significantly associated with adverse maternal outcomes related to delivery.

METHODS

Study design and participants

This was a single-center prospective cohort study conducted at the Department of Obstetrics and Gynecology, University of Health Sciences Gaziosmanpaşa Training and Research Hospital, between June 2024 and September 2025. The study was approved by the institutional ethics committee and was reported in accordance with the STROBE guidelines for observational studies. Written informed consent was obtained from all participants.

Women aged 18–40 years with term singleton cephalic pregnancies and in active labor were eligible. All participants were primiparous. Active labor was defined as cervical dilatation of 6 cm.

Exclusion criteria were body mass index ≥30 kg/m², maternal age <18 or >40 years, malpresentation, placental implantation abnormalities, cord prolapse, multiple pregnancy, and pre-existing or pregnancy-related anorectal disease (hemorrhoids, anal fissure, abscess, fistula, rectal prolapse, or anal incontinence).

A total of 303 women were assessed for eligibility during the study period. Of these, 230 women were excluded because they were aged <18 years (n=14), aged >40 years (n=25), multiparous (n=150), had malpresentation (n=9), multiple pregnancy (n=5), obesity (n=13), or a history of anorectal disease (n=14). Thus, 73 women were eligible and enrolled in the study. One participant left the hospital after refusing further treatment and did not complete the

delivery process at our institution, while two participants did not attend the first-week postpartum follow-up. Therefore, 70 women were included in the final analysis (Figure 1).

Clinical and ultrasound assessment

At the onset of active labor (6 cm cervical dilatation), all participants underwent conventional VE and TPU. VE findings included cervical dilatation, effacement, fetal head station, and membrane status.

TPU measurements were performed using an Esaote MyLab Seven ultrasound system by three trained obstetrics residents. With the bladder empty and under sterile conditions, the transducer was placed transversely on the perineum. In the mid-sagittal plane where the fetal midline intracranial structures (falx cerebri, thalamus, and cavum septum pellucidum) were visualized, the shortest perpendicular distance between the outer bony contour of the fetal skull and the maternal perineal skin surface was measured as the HPD.

HPD was measured three times in each participant, and the arithmetic mean of the three measurements was used for analysis.

Data collection and outcomes

Demographic and clinical variables, including maternal age, educational/literacy status, history of chronic disease, smoking and alcohol use, indication for admission, and baseline hemoglobin/hematocrit levels, were recorded. Prophylactic antibiotic administration and labor induction were also documented.

Maternal outcomes were recorded throughout labor and until the first postpartum week. These included mode of delivery (with indication for cesarean section), duration of active labor, mediolateral episiotomy, presence of perineal laceration, anal sphincter injury, uterine atony

and its management, postpartum hemorrhage-related parameters, hemoglobin/hematocrit levels at 8 hours postpartum, need for blood transfusion, and postpartum complications (wound inflammation/infection and postpartum infection).

The primary outcome was the association between HPD measured at the onset of the active phase and composite perineal trauma, defined as episiotomy and/or spontaneous perineal laceration.

Secondary outcomes included the association between HPD and concurrent VE findings, mode of delivery, induction of labor, sociocultural indicators, and other delivery-related maternal complications.

Sample size and statistical analysis

Sample size was calculated using G*Power software based on correlation analysis between intrapartum HPD and maternal outcomes. Assuming an alpha level of 0.05 and 80% statistical power, a minimum of 67 participants was required.

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as n (%). Continuous variables were presented as mean ± standard deviation or median (minimum–maximum), according to distribution. Distribution characteristics were assessed using skewness and kurtosis. As HPD did not follow a normal distribution, non-parametric tests were applied. Comparisons between two groups were performed using the Mann–Whitney U test, and comparisons among three or more groups using the Kruskal–Wallis test. Associations between HPD and continuous or ordinal variables were evaluated using Spearman correlation analysis.

RESULTS

Seventy primiparous women were included in the study. Maternal age ranged from 18 to 34 years, with a median age of 23 years. Most participants (84.3%) had no history of chronic disease. The rate of smoking was 12.9%, and no alcohol use was reported. The literacy rate was 92.9%. On vaginal examination, the most frequent fetal head station was –2 (50%).

The mean intrapartum HPD was 33.53 ± 6.29 mm (median 33.1; range 20–60). The mean duration of active labor was 217.64 ± 130.54 minutes (median 175; range 25–537). During TPU assessment, the presence of a bulging amniotic sac was observed in 21.4% of cases, and labor induction was performed in 32.9% of participants. The most common indication for admission was term pregnancy with painful contractions (58.6%) (Table 1).

Table 1. Participant Characteristics and Intrapartum Findings

Variable Category	**n (%)**
Age (years)	
18–22	34 (48.6)
23–34	36 (51.4)
Chronic disease	
No	59 (84.3)
Yes	11 (15.7)
Smoking status	
No	61 (87.1)
Yes	9 (12.9)
Alcohol consumption	
No	70 (100)
Yes	0 (0)
Literacy status	
No	5 (7.1)
Yes	65 (92.9)
Fetal head station (vaginal examination)	
-3	11 (15.7)
-2	35 (50)
-1	19 (27.1)
0	4 (5.7)
+1	1 (1.4)
Membrane status during TPU*	
Intact	15 (21.4)
Ruptured	55 (78.6)
Induction of labor	
No	47 (67.1)
Yes	23 (32.9)

Variable Category	n (%)
Prophylactic antibiotic use	
No	49 (70)
Yes	21 (30)
Epidural analgesia	
No	66 (94.3)
Yes	4 (5.7)
Indication for admission	
Painful term pregnancy	41 (58.6)
Rupture of membranes	23 (32.9)
Term pregnancy + oligohydramnios	5 (7.1)
Term pregnancy + uncontrolled gestational diabetes	1 (1.4)
	Mean ± SD / Median (min–max***)**
Age (years)	23.19 ± 3.79 / 23 (18–34)
Effacement (%)	68.79 ± 10.27 / 70 (40–80)
HPD (mm)****	33.53 ± 6.29 / 33.1 (20–60)
Duration of active labor (min)	217.64 ± 130.54 / 175 (25–537)

Abbreviations: TPU, transperineal ultrasound; SD, standard deviation; HPD, head–perineum distance; min, minimum; max, maximum.

Of the participants, 81.4% delivered vaginally and 18.6% underwent cesarean section. The most common indication for cesarean delivery was labor arrest, followed by fetal distress and face presentation. Episiotomy was performed in 67.1% of cases, and spontaneous perineal laceration occurred in 20.0%. Composite perineal trauma, defined as episiotomy and/or spontaneous perineal laceration, occurred in 70.0% of participants. No cases of anal sphincter injury were observed (Table 2).

Table 2. Maternal and Delivery Outcomes

Variables	Group	n(%)
Mode of delivery	Normal spontaneous delivery (NSD)	57(81.4)
	Cesarean section (C/S)	13(18.6)
Indication for cesarean section	Fetal distress	3(23.1)
	Labor arrest	6(46.2)
	Face presentation	2(15.4)
	Occiput posterior	1(7.7)
	Cephalopelvic disproportion (CPD)	1(7.7)
Episiotomy	No	23(32.9)
	Yes	47(67.1)
Spontaneous perineal laceration	No	56(80)
	Yes	14(20)
Composite perineal trauma	No	21(30)
	Yes	49(70)
Anal sphincter injury	No	70(100)
	Yes	0(0)
Uterine atony	No	65(92.9)

Variables	Group	n(%)
	Yes	5(7.1)
Management of atony	No atony	65(92.9)
	Medical management	4(5.7)
	Medical and surgical management	1(1.4)
Incision line infection	No	66(94.3)
	Yes	4(5.7)
Hemorrhoids	No	69(98.6)
	Yes	1(1.4)
Vulvar edema	No	69(98.6)
	Yes	1(1.4)
Postpartum infection	No	65(92.9)
	Yes	5(7.1)
Postpartum psychosis/depression	No	69(98.6)
	Yes	1(1.4)
Postpartum blood transfusion	No	67(95.7)
	Yes	3(4.3)
Mean blood loss (mL)	Mean±SD* / Median (Min–Max**)	648.44 ± 304.82/656.55 (89.2–1300.8)

Abbreviations: SD, standard deviation; min, minimum; max, maximum.

HPD was significantly shorter in cases with lower fetal head station on vaginal examination ($p = 0.031$). Additionally, HPD was significantly higher in women who underwent labor induction compared to those who did not ($p = 0.032$). A significant difference was also observed between cases with and without episiotomy, with higher HPD values in women who did not undergo episiotomy ($p = 0.043$) (Table 3).

Table 3. HPD by Participant and Clinical Characteristics

Variable	Group	n	HPD (mm) Mean±SD / Median (Min–Max)	p
Age (years)	18–22	34	33.57 ± 7.38 / 33 (20–60)	0.906
	23–34	36	33.49 ± 5.16 / 33.6 (25–48)	
Chronic disease	No	59	33.72 ± 6.56 / 33.2 (20–60)	0.722
	Yes	11	32.51 ± 4.68 / 33 (25–38.2)	
Smoking status	No	61	33.76 ± 6.41 / 33.3 (20–60)	0.395
	Yes	9	31.73 ± 5.29 / 29.5 (26.3–40.7)	
Literacy status	No	5	38.88 ± 13.15 / 38 (25.4–60)	0.321
	Yes	65	33.12 ± 5.42 / 33 (20–48)	
Fetal head station (vaginal examination)	Not engaged (–3, –2)	46	34.75 ± 6.54 / 34.05 (25–60)	0.031*
	Engaged (–1, 0, +1)	24	31.18 ± 5.12 / 31.1 (20–40.7)	
Membrane status during TPU	Ruptured	55	32.9 ± 5.42 / 33 (20–48)	0.302
	Intact	15	35.84 ± 8.62 / 33.4 (26.3–60)	
Induction of labor	No	47	32.81 ± 6.92 / 32 (20–60)	0.032*

Variable	Group	n	HPD (mm) Mean±SD / Median (Min–Max)	p
	Yes	23	34.99 ± 4.53 / 35 (23–44)	
Prophylactic antibiotic use	No	49	33.1 ± 7.05 / 33 (20–60)	0.124
	Yes	21	34.52 ± 3.98 / 35 (26–42)	
Indication for admission	Painful term pregnancy	41	33.28 ± 7.01 / 33 (20–60)	0.843
	Rupture of membranes	23	33.67 ± 4.19 / 34 (26–42)	
	Other	6	34.67 ± 8.57 / 33.95 (25.4–48)	
Epidural analgesia	No	66	33.37 ± 6.37 / 33 (20–60)	0.293
	Yes	4	36.08 ± 4.67 / 35.35 (31.6–42)	
Mode of delivery	NSD	57	33.03 ± 6.42 / 33 (20–60)	0.057
	Cesarean section	13	35.72 ± 5.36 / 36 (25–43)	
Episiotomy	No	23	35.72 ± 7.21 / 35.8 (25–60)	0.043*
	Yes	47	32.46 ± 5.56 / 33 (20–48)	
Spontaneous perineal laceration	No	56	33.83 ± 6.34 / 33 (23-60)	0.623
	Yes	14	32.31 ± 6.15 / 33.75 (20-44)	
Composite perineal trauma	No	21	35.79 ± 7.55 / 36 (25–60)	0.063
	Yes	49	32.56 ± 5.47 / 33 (20–48)	

Abbreviations: HPD, head–perineum distance; SD, standard deviation; min, minimum; max, maximum.

*p < 0.05; **p < 0.01. Mann–Whitney U test was used for two-group comparisons and Kruskal–Wallis test for three or more groups.

The results of the correlation analysis between intrapartum HPD and the participants' demographic, obstetric, and clinical characteristics are presented in Table 4 and Figure 2.

Table 4. Correlations Between HPD and Clinical Characteristics

Variable	HPD		Variable	HPD	
	r	p		r	p
Age	0.044	0.72	Episiotomy	-0.243*	0.042
Chronic disease	-0.043	0.725	Spontaneous perineal laceration	-0.059	0.626
Smoking	-0.102	0.399	Composite perineal trauma	-0.237*	0.048
Literacy status	-0.238*	0.047	Uterine atony	-0.071	0.557
Effacement (%)	-0.285*	0.017	Incision line infection	-0.119	0.327
Membrane status during TPU	0.124	0.306	Hemorrhoids	-0.152	0.209

Variable	HPD		Variable	HPD	
	r	p		r	p
Duration of active labor (min)	0.181	0.134	Vulvar edema	0.110	0.363
Induction of labor	0.258*	0.031	Postpartum blood transfusion	-0.095	0.435
Prophylactic antibiotic use	0.185	0.125	Mean blood loss (mL)	0.221	0.066
Epidural analgesia	0.127	0.297	Postpartum blood transfusion	-0.134	0.267
Mode of delivery	0.229	0.056			

*p < 0.05; **p < 0.01. r, correlation coefficient.

HPD measured by TPU at the onset of active labor was significantly lower in literate women. A significant negative correlation was also observed between cervical effacement on vaginal examination and HPD.

For delivery-related maternal outcomes, HPD was inversely correlated with episiotomy and composite perineal trauma.

Variables that were statistically significant or approached the significance threshold in previous analyses—including fetal head station assessed by vaginal examination, induction of labor, mode of delivery, episiotomy, and composite perineal trauma—were included in the model. Associations between HPD and these outcomes were evaluated using univariable logistic regression (Table 5).

Table 5. Univariable Logistic Regression of HPD and Obstetric Outcomes

Dependent variable	Independent variable	B	S.E.	p	Odds ratio (Exp[B])	95% CI Lower	95% CI Upper	R^2
Fetal head station (engaged)	HPD (mm)	-0.11	0.05	0.027*	0.89	0.81	0.99	0.112
Induction of labor	HPD (mm)	0.06	0.04	0.183	1.06	0.97	1.15	0.036
Mode of delivery (cesarean)	HPD (mm)	0.06	0.05	0.177	1.07	0.97	1.17	0.042
Episiotomy	HPD (mm)	-0.09	0.05	0.054	0.92	0.84	1.00	0.082
Composite perineal trauma	HPD (mm)	-0.08	0.05	0.062	0.92	0.84	1.00	0.077

*p < 0.05; **p < 0.01. OR, odds ratio; B, beta coefficient; SE, standard error; CI, confidence interval.

According to the results of the univariable logistic regression analysis, HPD was found to have a significant effect on the likelihood of an engaged fetal head on vaginal examination (B = −0.11, p < 0.05). Each 1 mm increase in HPD was associated with an 11% decrease in the odds of the fetal head being in an advanced (engaged) position (OR 0.89, p < 0.05). No significant association was observed between HPD and induction of labor or mode of delivery (cesarean section) (p > 0.05).

DISCUSSION

In this prospective cohort study, shorter HPD values were associated with episiotomy and composite perineal trauma. In contrast, no statistically significant association was found between HPD and mode of delivery.

Although previous studies have demonstrated an association between intrapartum TPU measurements and labor progression, data directly evaluating the relationship between HPD and perineal trauma are limited. In the study by Xodo et al., this association was not demonstrated [8]; however, differences in patient population and methodology may account for the discrepancy. The relatively homogeneous primiparous population in our study may have contributed to the observed association.

The observed correlation between HPD and findings from vaginal examination is consistent with the existing literature [1, 2, 9]. The decrease in HPD with increasing fetal head descent and cervical effacement suggests that TPU may provide an objective assessment of labor progression.

In addition, HPD was not significantly associated with maternal age, chronic disease, or smoking status. However, lower HPD values were observed in literate women, which may reflect underlying sociocultural differences and better adherence to intrapartum guidance rather than a direct causal effect, consistent with previous reports showing improved labor outcomes in educated and physically active women [10]. No significant difference in HPD was found according to membrane status at the time of TPU, suggesting that early amniotomy may have limited impact on fetal head descent, in line with studies indicating that amniotomy before the onset of active labor may not facilitate labor progression [11]. Furthermore, higher HPD values were observed in women undergoing labor induction; however, this finding should be interpreted cautiously, as it may be related to delayed fetal descent in women without adequate spontaneous contractions.

Although the relationship between HPD and mode of delivery did not reach statistical significance, a trend consistent with previous reports was observed [2, 6]. Larger studies are

needed to establish clinically relevant threshold values that could be incorporated into decision-making processes during labor management.

The strengths of this study include its prospective design, the standardized definition of the active phase of labor, and the performance of measurements at a consistent cervical dilation. However, several limitations should be acknowledged, including the single-center design, the relatively small sample size, the absence of operative deliveries and anal sphincter injuries in the cohort, and potential interobserver variability in the ultrasound measurements.

In conclusion, HPD measured at the onset of active labor was associated with episiotomy and composite perineal trauma, but not significantly with mode of delivery. The combined use of TPU and vaginal examination may contribute to assessment of labor progress; further studies are needed to establish its clinical role.

DECLARATIONS

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Gaziosmanpaşa Training and Research Hospital (approval no. 27; 3 July 2024). Written informed consent was obtained from all participants.

Consent for publication

Not applicable. No individual person’s data are presented in this manuscript.

Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request. [Please confirm that this statement accurately reflects your data-sharing arrangements.]

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conceptualization: S.R.B. Data collection: S.R.B., İ.T.Ö., and İ.D.C. Analysis: S.R.B., H.B.B., G.Y.T., and E.S.C. Writing—original draft: S.R.B., F.K.G., and S.S. Critical review: all authors. [Please confirm the initials, role descriptions, and that all authors approved the submitted version.]

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ABBREVIATIONS

BMI, body mass index; CI, confidence interval; HPD, head–perineum distance; NSD, normal spontaneous delivery; OR, odds ratio; SD, standard deviation; TPU, transperineal ultrasound; VE, vaginal examination.

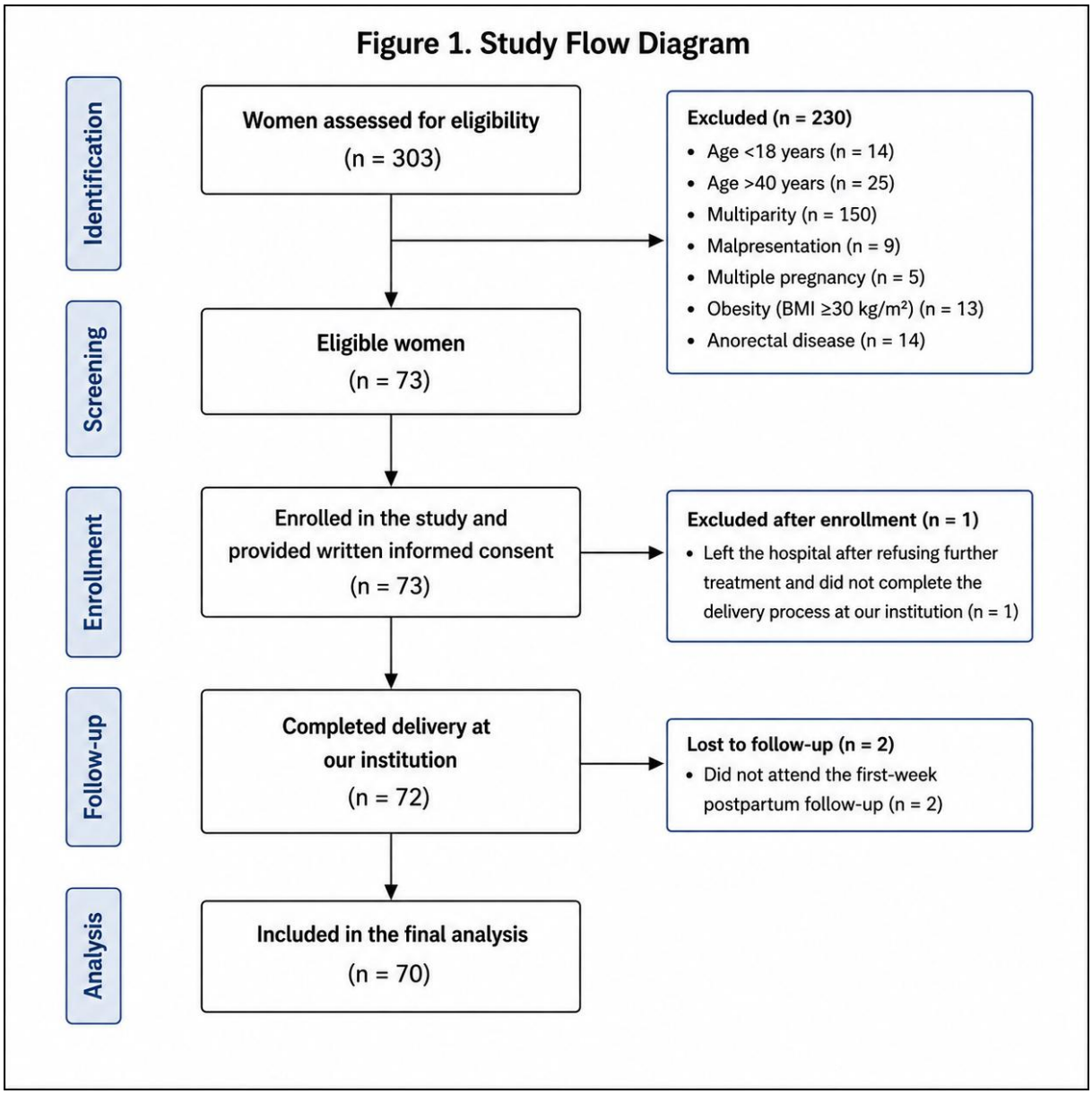
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FIGURES

Figure 1. Flow of participants through eligibility assessment, enrollment, and follow-up.



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298 Figure 2. Correlation matrix between HPD and participant, obstetric, and clinical

299 characteristics. Correlation coefficients (r) are shown; asterisks indicate $p < 0.05$.