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Original Research

Effect of Second-Stage Duration on Early Postpartum Pelvic Floor Function in Nulliparous Women Receiving Epidural Analgesia for Delivery

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Abstract

Background: The duration of the second stage of labor may be associated with postpartum pelvic floor function. This study aimed to explore the effect of second-stage labor duration on early postpartum pelvic floor function in nulliparous women undergoing vaginal delivery with epidural analgesia. **Methods:** This retrospective cohort study included a total of 1912 eligible participants, who were stratified into two groups according to the duration of the second stage of labor: the ≤1 hour group (n = 1301) and the >1 hour group (n = 611). Pelvic floor muscle (PFM) surface electromyography (SEMG) was performed 42 to 60 days postpartum in accordance with the Glazer protocol. The prevalence of urinary incontinence (UI), overactive bladder (OAB) and constipation was evaluated with the International Consultation on Incontinence Questionnaire – Urinary Incontinence Short Form (ICIQ-UI-SF) and the Epidemiology of Prolapse and Incontinence Questionnaire (EPIQ). **Results:** The prevalence of postpartum UI was 14.1% among participants with a second-stage of labor duration of ≤1 hour and 18.5% among those with a duration of >1 hour, with a statistically significant difference ($p < 0.05$). The total Glazer score was weakly negatively correlated with the duration of the second stage of labor ($p = 0.023$). No significant between-group differences were found in the prevalence of OAB (1.5% vs. 2.1%, $p > 0.05$) or constipation (23.1% vs. 22.9%, $p > 0.05$). **Conclusions:** A longer second stage of labor is associated with a higher incidence of postpartum UI in nulliparous women undergoing vaginal delivery with epidural analgesia. The total Glazer protocol score is weakly negatively correlated with the duration of the second stage of labor.

Keywords: second stage of labor; epidural analgesia; Glazer protocol; pelvic floor muscle surface electromyography measurements; urinary incontinence

1. Introduction

Female pelvic floor dysfunction (PFD) covers a spectrum of clinical conditions, including urinary incontinence (UI), fecal incontinence, chronic constipation, pelvic organ prolapse, and overactive bladder (OAB) [1,2]. Despite being non-life-threatening, PFD has a high prevalence in the adult female population and can exert a negative impact on patients' daily quality of life [3,4]. It is estimated that 21–26% of women are affected by PFD worldwide, with UI being the most common clinical subtype [5]. Vaginal delivery is widely recognized as one of the most critical independent risk factors for PFD [6,7], and existing data show that 20–40% of women after vaginal delivery develop different severities of urinary incontinence within 12 months postpartum [8].

The second stage of labor is defined as the period from full cervical dilatation to the successful delivery of the fetus [9]. The clinical management of the second stage of labor duration has a notable influence on maternal and neonatal outcomes, as well as the occurrence of postpartum maternal complications. In recent years, there has been increasing focus on revising the clinical guidelines for the second stage of labor management, with the core goal of avoiding unnecessary primary cesarean sections [10].

Epidural analgesia is a well-established and effective strategy for labor pain relief, and its clinical application in obstetrics is increasing annually; around 80% of parturients in developed countries choose to receive epidural analgesia during childbirth [11]. In 2014, the American College of Obstetricians and Gynecologists (ACOG) released an updated version of labor management guidelines [12] that extended the recommended maximum duration of the second stage of labor for nulliparous women undergoing vaginal delivery with epidural analgesia. This revision was intended to reduce unnecessary clinical interventions during labor and ensure that parturients have sufficient opportunities to achieve vaginal delivery. However, under the

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framework of the updated labor management guidelines, it remains necessary to further clarify the impact of the duration of the second stage of labor on pelvic floor muscle function in nulliparous women with epidural analgesia.

Therefore, in this study, we adopted pelvic floor surface electromyography parameters based on the Glazer protocol and the Epidemiology of Prolapse and Incontinence Questionnaire (EPIQ) to conduct a comprehensive evaluation of postpartum pelvic floor muscle function. We further analyzed the association between the duration of the second stage of labor and early postpartum pelvic floor function in nulliparous women receiving epidural analgesia during vaginal delivery. The findings of this research are expected to deepen our understanding of the relationship between the duration of the second stage of labor and PFD incidence, and provide a theoretical foundation for the early postpartum screening and clinical intervention of PFD.

2. Materials and Methods

2.1 Study Participants

This retrospective cohort study was conducted at the International Peace Maternity and Child Health Hospital affiliated to Shanghai Jiao Tong University, and a total of 1912 nulliparous women with singleton pregnancies were enrolled between September 2020 and January 2023. All enrolled participants underwent spontaneous vaginal delivery with epidural analgesia, and none of them received instrumental delivery assistance including forceps or vacuum extraction. Patients (n = 1912) were divided based on the length of the second stage of labor (≤1 hour group, n = 1301; >1 hour group n = 611), with the 1-hour threshold selected as it has been widely used as a key risk stratification point for adverse maternal pelvic floor outcomes in previous studies investigating the association between the duration of the second stage of labor and postpartum pelvic floor dysfunction [13,14,15].

2.2 Inclusion and Exclusion Criteria

Primipara patients who received epidural analgesia during delivery were included in this study. The inclusion criteria of the study were as follows: all patients were 18–40 years of age, had a normal mental status, and cooperated during the examination. The infants were singletons who had a cephalic presentation at delivery, with a birth weight ranging from 2500 to 4500 g. Patients with a history of long-term constipation, UI, other pelvic floor disorders, or pelvic surgery; severe hearing impairment; or intellectual disabilities were excluded from the study.

2.3 Study and Evaluation Methods

Relevant obstetric clinical data of the participants were collected from the hospital's electronic medical record system, and these included maternal age, duration of the first and second stages of labor, educational background, pre-pregnancy weight body mass index (BMI), gestational age at delivery, gestational weight gain, pregnancy-related complications, and neonatal birth weight. All participants received surface electromyography (SEMG) examination in strict accordance with the Glazer protocol at the hospital's pelvic floor screening and rehabilitation center. In addition, the International Consultation on Incontinence Questionnaire – Urinary Incontinence Short Form (ICIQ-UI-SF) and EPIQ were used to evaluate the occurrence of UI, OAB, and constipation in all enrolled individuals.

The primary outcome indicator of this study was the pelvic floor muscle SEMG values detected by the modified Glazer protocol [16,17]. All examination operations were performed by professional medical staff who had received standardized training at the hospital's pelvic floor screening and rehabilitation center. The device used for pelvic floor muscle electrical signal collection was a customized metal vaginal probe (model CACB04, MLD V1, manufactured by Nanjing Medlander Medical Instruments Co., Ltd., Nanjing, China), and the supporting signal processing device used was a neuromuscular stimulator (model SA9800, MLD B4, Nanjing Medlander Medical Instruments Co., Ltd., Nanjing, China).

The Glazer protocol was performed in four stages [18,19]:

Stage 1: Pre-baseline resting phase, with a duration of 60 s. The electromyography values of pelvic floor muscles in the vaginal resting state were measured, and the average value was calculated (the normal reference value is less than 4 μV; a value higher than 4 μV indicates potential pelvic floor muscle overactivity).

Stage 2: Phasic contraction phase. The individuals were guided to perform rapid voluntary contraction of the pelvic floor muscles, and the maximum electromyography value during contraction was recorded. This phase is used to evaluate the contractile strength of fast-twitch muscle fibers (type II fibers) of the pelvic floor muscles (the normal reference maximum value is higher than 40 μV; a value less than 40 μV indicates reduced fast-twitch muscle fiber strength).

Stage 3: Tonic contraction phase. The participants were instructed to perform slow and gentle contraction of the pelvic floor muscles and maintain the maximum contraction state for 10 s. The average value of five repeated measurements was used for statistical analysis. This phase is used to assess the contractile strength of slow-twitch muscle fibers (type I fibers) of the pelvic floor muscles (the normal reference maximum value is higher than 35 μV; a value less than 35 μV indicates decreased slow-twitch muscle fiber strength).

Stage 4: Post-baseline resting phase, with a duration of 60 s. The electromyography values of pelvic floor muscles in the vaginal resting state were re-measured and the average value was calculated, to assess whether the pelvic floor muscles could return to the baseline state after contraction (the normal reference value is less than 4 μV; a value higher than 4 μV suggests potential muscle overactivity).

The secondary outcome indicator was the prevalence of pelvic floor dysfunction (PFD) in the participants, which was assessed using the ICIQ-UI-SF and EPIQ scales. Both of these scales have been verified by a large number of clinical studies and are confirmed to be applicable for large-scale population screening of pelvic floor function [20,21]. To ensure the accuracy and scientificity of the questionnaire results, all questionnaires were completed on site under the guidance of a professional pelvic floor urologist.

2.4 Statistics

For the statistical description of this study, categorical variables are presented as case number and constituent ratio (percentage). For continuous variables, data conforming to normal distribution are described as mean ± standard deviation, while non-normally distributed data are presented as the median and interquartile range. For intergroup comparisons, the chi-square test or Fisher's exact probability test was used for categorical variables, and the independent samples *t*-test (for normal distribution) or Mann–Whitney U test (for non-normal distribution) was adopted for continuous variables.

Glazer pelvic floor function scores and the incidence of UI OAB, and constipation at 42–60 days postpartum were compared between the two groups using regression analyses adjusted for confounding factors. Linear regression was applied for the assessment of continuous outcomes, and logistic regression for binary outcomes. Covariates were selected based on two principles: first, clinically relevant confounders frequently reported in obstetric and pelvic floor dysfunction research and validated by high-quality peer-reviewed journals; second, commonly recorded clinical baseline characteristics. Prior to model fitting, the variance inflation factor (VIF) was used to assess multicollinearity among all included covariates. All covariates met the statistical criteria for the absence of multicollinearity and were thus eligible for inclusion in the final multivariable regression models. Spearman correlation analysis was used to correlate the duration of the second stage of labor with the total Glazer score. Statistical significance was set at $p < 0.05$. All analyses were conducted using R software (version 3.6.0; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

A total of 25,527 women received postpartum pelvic floor function screening at the hospital's pelvic floor screening and rehabilitation center from September 2020 to January 2023. After strict screening in accordance with the inclusion and exclusion criteria, 1912 participants were finally included in the statistical analysis (see Fig. 1 for the screening flow). There were no statistically significant differences in pre-pregnancy weight BMI, gestational weight gain, educational background, pregnancy-induced hypertensive disorders, gestational anemia, gestational age at delivery, and placental expulsion mode between the two groups (all $p > 0.05$). However, there were significant differences in maternal age, duration of the first stage of labor, neonatal birth weight, and the incidence of perineal laceration during delivery between the two groups ($p < 0.05$) (see Table 1 for details).

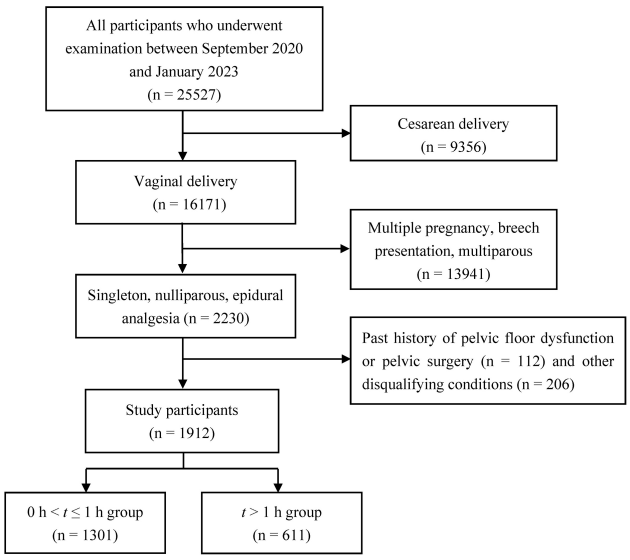


Fig. 1. Flowchart of the participant screening process.

After adjusting for confounding factors, including maternal age, duration of the first stage of labor, neonatal birth weight, and the occurrence of perineal laceration during delivery, there were no statistically significant differences in the SEMG indicators of the pre-baseline resting phase ($p = 0.141$), phasic contraction phase ($p = 0.618$), tonic contraction phase ($p = 0.245$), and post-baseline resting phase ($p = 0.541$) of pelvic floor muscles between the two groups (Table 2).

The total Glazer score of the group in which the second stage of labor was ≤1 hour was significantly higher than that of the group in which the second stage of labor was >1 hour. Spearman correlation analysis showed that there was a weak negative correlation between the total Glazer score and the duration of the second stage of labor ($r_s = -0.08$, $p = 0.023$) (see Fig. 2).

The incidence of postpartum urinary incontinence in the group in which the second stage of labor was >1 hour (18.5%) was significantly higher than that in the group in which the second stage of labor was ≤1 hour (14.1%). After adjusting for relevant confounding factors, the difference in the incidence of postpartum urinary incontinence between the two groups remained statistically significant ($p < 0.05$). Multivariate logistic regression analysis showed that the risk of postpartum urinary incontinence in women for which the second stage of labor was >1 hour was 1.339 times that of women for which the second stage of labor was ≤1 hour. However, there were no statistically signifi-

Table 1. Baseline characteristics.

Variable	Total	Second stage of labor ≤1 hour (n = 1301)	Second stage of labor > 1 hour (n = 611)	*p*
pre-pregnancy weight BMI (kg/m^2)				0.264
<18.5	327	210 (16.1)	117 (19.1)	
18.5–24	1404	967 (74.3)	437 (71.5)	
>24	181	124 (9.5)	57 (9.3)	
Gestational weight gain (kg)				0.173
<20	1730	1169 (89.9)	561 (91.8)	
≥20	182	132 (10.1)	50 (8.2)	
Educational level				0.367
Less than junior college	53	37 (2.8)	16 (2.6)	
Junior college	280	195 (15.0)	85 (13.9)	
Undergraduate	1011	699 (53.7)	312 (51.1)	
Graduate and above	568	370 (28.4)	198 (32.4)	
Hypertensive disorders of pregnancy	72	51 (3.9)	21 (3.4)	0.605
Gestational anemia	386	253 (19.4)	133 (21.8)	0.238
Gestational age (weeks)				0.393
34–36 + 6	39	29 (2.2)	10 (1.6)	
≥37	1873	1272 (97.8)	601 (98.4)	
Placental expulsion				0.056
Active management	90	53 (4.1)	37 (6.1)	
Passive management	1822	1248 (95.9)	574 (93.9)	
Age (years)				0.005*
<35	1819	1250 (96.1)	569 (93.1)	
≥35	93	51 (3.9)	42 (6.9)	
Duration of first stage of labor (hour)	7.649 ± 3.336	7.381 ± 3.252	8.218 ± 3.444	<0.001*
Birth weight (g)				0.016*
≥2500, <4000	1864	1276 (98.1)	588 (96.2)	
≥4000	48	25 (1.9)	23 (3.8)	
Perineal laceration/episiotomy				<0.001*
No perineal laceration	30	22 (1.7)	8 (1.3)	
First-degree perineal laceration	729	538 (41.4)	191 (31.3)	
Second-degree perineal laceration	852	564 (43.4)	288 (47.1)	
Episiotomy	301	177 (13.6)	124 (20.3)	

*$p < 0.05$.

Data are provided as number (percentage).

Abbreviations: BMI, body mass index.

cant differences in the incidences of OAB and constipation between the two groups ($p > 0.05$) (see Table 3 for details).

4. Discussion

In this study, no significant differences in the Glazer protocol characteristics for the early postpartum pelvic floor assessment were identified between patients for which the second stage of labor was ≤1 hour and those for which the second stage of labor was >1 hour. However, the maximal value of the phasic contraction stage was <40 μV, and the mean value of the tonic contraction stage was <35 μV in both groups. The abnormal SEMG values of the pelvic floor muscles in both groups may be due to the effect of the vaginal delivery, during which the neonatal head directly compresses and pulls the pelvic floor muscles and neuromuscular junctions. While the pelvic floor muscles and nerves are stretched, the muscle extension rate (length of tissue after stretching/initial length of tissue) is up to 3.26 [22], which is 217% of the maximum extension rate of skeletal muscles in non-pregnant women. In addition, pudendal nerve tension increases to up to 33% [23], resulting in damage to the pelvic floor muscles. A weak correlation between the total Glazer score and the duration of the second stage of labor was identified in this study. Due to the relatively closed structure of the pelvic floor and minimal mobility of the pelvis, the abdominal pressure on the fetus acts mainly on the soft tissues of the pelvic floor when the fetus passes through the birth canal during the second stage of labor [9], during which the pelvic floor muscle groups are the principal force-bearing part [24]. The prolonged pressure of the

Table 2. Glazer protocol evaluation of the two groups.

Stage/parameters	Second stage of labor $t \leq 1$ hour (n = 1301)	Second stage of labor >1 h (n = 611)	Univariate analysis	Multivariate analysis
			p	*p*
Pre-testing rest				
Average (μV)	3.73 (2.04, 5.96)	3.28 (1.78, 5.45)	0.003*	0.141
Variability	0.15 (0.13, 0.20)	0.15 (0.13, 0.20)	0.910	/
Phasic contraction				
Maximum (μV)	35.68 (25.46, 46.44)	33.39 (22.99, 43.45)	0.001*	0.618
Rise time (s)	0.34 (0.26, 0.44)	0.34 (0.27, 0.44)	0.440	/
Recovery time (s)	0.42 (0.33, 0.55)	0.43 (0.33, 0.57)	0.580	/
Tonic contraction				
Average (μV)	24.77 (16.11, 33.56)	21.72 (14.50, 30.99)	<0.001*	0.245
Variability	0.21 (0.18, 0.27)	0.22 (0.18, 0.27)	0.110	/
Rise time (s)	0.39 (0.26, 0.58)	0.39 (0.26, 0.60)	0.820	/
Recovery time (s)	0.82 (0.63, 1.10)	0.82 (0.64, 1.14)	0.360	/
Post-testing rest				
Average (μV)	4.13 (2.45, 6.24)	3.63 (2.19, 5.64)	0.001*	0.541
Variability	0.15 (0.13, 0.20)	0.15 (0.13, 0.20)	0.650	/
Overall score	69.06 (56.08, 77.99)	65.65 (52.38, 75.56)	0.001*	0.606

*$p < 0.05$.

Data are presented as median with 25th–75th percentiles.

Table 3. Incidence of postpartum PFD.

PFD	Second stage of labor $t \leq 1$ hour (n = 1301)	Second stage of labor >1 hour (n = 611)	Univariate analysis			Multivariate analysis		
			OR	*p*	χ^2	*p*	OR	95% CI
UI	183 (14.1)	113 (18.5)	1.386	0.0151*	5.897	0.030*	1.339	1.028–1.744
Constipation	301 (23.1)	140 (22.9)	0.990	0.914	0.012	/	/	/
OAB	19 (1.5)	13 (2.1)	1.457	0.289	1.125	/	/	/

*$p < 0.05$.

Data are shown as number (percentage).

Abbreviations: OR, odds ratio; CI, confidence interval; PFD, pelvic floor dysfunction; UI, urinary incontinence; OAB, overactive bladder.

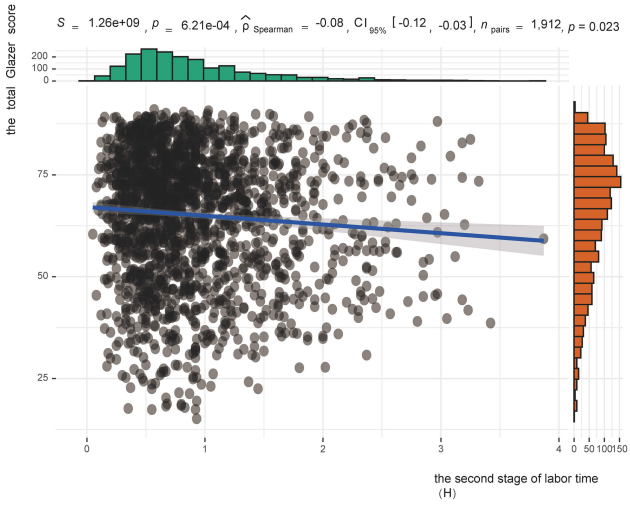


Fig. 2. Spearman correlation analysis between the duration of the second stage of labor with the total Glazer score.

fetal head on the nerve tissue and pelvic floor muscles during the second stage of labor leads to extreme stretching of the muscle tissue, resulting in edema, congestion, and relaxation of the muscle tissue, and even rupture, resulting in injuries [25].

In this study, the incidence of postpartum incontinence was found to be significantly higher among patients with a longer second stage of labor. A prospective study by Serati et al. [13] reported that a second stage of labor >1 hour was associated with the development of postpartum UI and that epidural analgesia indirectly affects pelvic floor muscle function by prolonging the second stage of labor. Similarly, Diez-Itza et al. [14] found that a second stage of labor >1 hour was associated with an increased incidence of postpartum UI, similar to the results of the present study. Caudwell-Hall et al. [15] proposed in their study that prolonged second stage of labor causes continuous and strong mechanical stimulation to the pelvic floor muscle fibers, which increases the risk of laceration and rupture of the pelvic floor muscles, thus leading to the elevated incidence of urinary incontinence.

Limitations

The study has several limitations. First, we focused on the SEMG values of the postpartum vaginal muscles, and the corresponding values before and during pregnancy were not evaluated. Therefore, SEMG assessments at 6–8 weeks postpartum may be inadequate. In addition, the long-term outcomes of maternal pelvic floor function require further clinical follow-up studies.

5. Conclusions

A prolonged second stage of labor was found to be associated with a lower total Glazer score and a higher incidence of postpartum UI in nulliparous women who received epidural analgesia during a vaginal delivery. According to the most recent labor management guidelines, maternal and fetal conditions (such as pre-pregnancy overweight or obesity, high fetal weight, and cephalopelvic compatibility) should be assessed carefully to minimize the duration of the second stage of labor and reduce the risk of PFD.

Availability of Data and Materials

The primary data for this study are available from the authors on direct request.

Author Contributions

XChi, SY contributed equally to this article. Conceptualization, XChi, SY, XW and Xchen and WL; data curation, XChi, SY and WL; formal analysis, YX; funding acquisition, XChen; investigation, XG; writing - original draft, XChi, SY WL, YX and XG; writing - review & editing, XW and XChen. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

All subjects signed the written informed consent form before enrollment in this study. All research procedures were carried out in strict accordance with the ethical principles of the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of the International Peace Maternity and Child Health Hospital, School of Medicine, Shanghai Jiao Tong University (Approval No.: GKLW 2023-024-01).

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Conflicts of Interest

The authors declare no conflicts of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/CEOG48297.

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