Delivery mode and the pelvic floor function of primiparous women at early postpartum: an observational retrospective cohort study

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Abstract

Objective To compare the associations between different modes of delivery and the pelvic floor function of primiparous women at early postpartum through pelvic floor muscle surface electromyography(sEMG). Design Retrospective observational study. Population A total of 3638 primiparas who experienced singleton delivery were selected as the research objects. Methods There were 1469 cases of cesarean section delivery (CD) and 2169 cases of vaginal delivery (VD). Furthermore, the vaginal delivery group were separated into four subgroups. The pelvic floor sEMG indexes of the subjects were analyzed at 6–8 weeks postpartum. Main outcome measures The pelvic floor sEMG were compared between CD and VD,and the four vaginal delivery subgroups. A modified Glazer protocol was used to analyze the pelvic floor sEMG value. Results The results showed that the average peak amplitude of phasic (flick) contractions and the average mean amplitude of tonic contractions were both significantly higher in CD than in VD ($P < 0.01$). In contrast, CD had less the mean amplitude variability of tonic contractions than VD ($P < 0.01$). The average peak amplitude of phasic (flick) contractions and the average mean amplitude of tonic contractions in forceps delivery group was statistically lower than the other vaginal delivery groups ($P<0.05$). The mean amplitude variability of tonic contractions was larger in forceps delivery group than group A, B. ($P <0.01$). Conclusion There is a clear link between mode of delivery and pelvic floor sEMG at 6-8 weeks postpartum in primiparas. Keywords pelvic floor dysfunction;pelvic floor muscle surface electromyography;postpartum;delivery mode;Glazer protocol

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Abstract

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Population A total of 3638 primiparas who experienced singleton delivery were selected as the research objects.

Methods There were 1469 cases of cesarean section delivery (CD) and 2169 cases of vaginal delivery (VD). Furthermore, the vaginal delivery group were separated into four subgroups. The pelvic floor sEMG indexes of the subjects were analyzed at 6–8 weeks postpartum.

Main outcome measures

The pelvic floor sEMG were compared between CD and VD,and the four vaginal delivery subgroups. A modified Glazer protocol was used to analyze the pelvic floor sEMG value.

Results

The results showed that the average peak amplitude of phasic (flick) contractions and the average mean amplitude of tonic contractions were both significantly higher in CD than in VD ($P < 0.01$). In contrast, CD had less the mean amplitude variability of tonic contractions than VD ($P < 0.01$). The average peak amplitude of phasic (flick) contractions and the average mean amplitude of tonic contractions in forceps delivery group was statistically lower than the other vaginal delivery groups ($P<0.05$). The mean amplitude variability of tonic contractions was larger in forceps delivery group than group A, B. ($P <0.01$).

Conclusion

There is a clear link between mode of delivery and pelvic floor sEMG at 6-8 weeks postpartum in primiparas.

Keywords

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Introduction

Female pelvic floor dysfunction (PFD) is a complex syndrome involving the impairment of the pelvic floor muscles and tissues. At present, PFD becomes one of the top five most common chronic diseases that seriously affect women's quality of life. The latest reports show that the prevalence of PFD ranged from 23.7% to 46.5%[1-3]. Pregnancy and childbirth have been recognized as the greatest risk factors of PFD. Due to the physiological changes of pregnancy and childbirth, the increased abdominal pressure and decreased collagen together can weaken pelvic floor muscle(PFM) and loosen pelvic floor tissues. Furthermore, excessive stretching during delivery causes the impairments of PFM, connective tissue and nerves. The pregnant and postpartum women more likely experience PFD, up to approximal 49% [4].

PFD seriously affects women's physical and mental health. Therefore, early diagnosis and timely treatment is extremely important. The early stages of PFD are the alteration in biochemistry and electrophysiology of the pelvic floor, which may further progress to a symptomatic PFD under the further damage. The pelvic floor sEMG could be used for early diagnosis of PFD, which is an objective and non-invasive method by recording the change of voltage over the PFM fiber membrane. A number of reports confirmed sEMG is reliable in among different populations for measurement of the PFM[5,6]. sEMG assessment based on Glazer protocol are widely used for the evaluation of PFD in postpartum women[7,8]. The Glazer Protocol comprises a series of muscle relaxations and contractions, including rest pre-baseline, phasic contractions, tonic contractions, endurance contraction and rest post-baseline. Glazer Protocol can differentiate the number and type of dysfunction of PFM, and thus, it can support the selection of a proper therapeutic method.

As well known, the delivery mode was a crucial risk factor of PFD[9]. It is necessary to predict and/or diagnosis on early stage of PFD in postpartum women, hence they could be offered timely interventions to prohibit the progression. Most of previous studies applied the qualitative assessment of the different delivery modes on PFD. However, a few studies have reported with quantitative measurements. This study aimed to quantitate the impact of different delivery modes on PFM function at 6-8 weeks postpartum by sECG based on the Glacer protocol. We also tried to distinguish the detail types and grade of PFM impairment, in order to provide the individual therapeutic strategy to patients at the early stage of postpartum.

Methods

This is an observational retrospective study, consecutively screening primiparas who conducted the regular prenatal examinations and delivered between January 2019 and December 2020 at the International Peace Maternal and Child Health Hospital in Shanghai. This study was approved by the Medical Science Ethics Committee of the International Peace Maternal and Child Health Hospital.

Our study screened study subjects, who experienced singleton delivery as primipara, and whose neonates less than 4000g, who had cesarean section or vaginal delivery with / without perineum laceration limited in degree II. Meanwhile, we excluded the subjects who was younger than 18-year-old or older than 50-year-old; who had premature birth at fewer than 28 weeks gestational age; who conceive a fetus with known congenital anomalies; who had stillbirth; who had at moment vaginitis and pelvic inflammatory disease; who had chronic coughing and chronic constipation; who had other systemic comorbidities (e. g. heart, liver and kidney disease, hematological disease, respiratory disease, etc.).

In general, we set up two study groups, cesarean section delivery group (CD) and vaginal delivery group (VD), in order to analyze the impact of these two main modes of delivery on PFD. Furthermore, the vaginal delivery group were separated into four subgroups, including Group A with intact perineum or first-degree perineum laceration, Group B with second-degree perineum laceration, Group C with lateral episiotomy, as well as Group D with forceps delivery.

The clinical data of pregnancy and delivery were obtained from electronic medical records system. At 6–8 weeks postpartum, all subjects underwent the routine assessments, which included the inquiry of medical history, gynecological examination and the sEMG evaluation of the PFM function.

PFM function was evaluated with vaginal palpation and sEMG. All patients routinely were offered the instructions and information about sEMG before the examination, by a trained urogynecologist of the Pelvic Floor Diagnosis and Treatment Center. Participants were in supine position and requested to be relaxed in the whole process of the sEMG examination. During the process, the automated protocol software provided the participants real-time instruction by voice messages and figures on monitor, with which the participants could relax or contract the PFMs accordingly. The sEMG facility used in this study was a Biofeedback electrical stimulator made by Nanjing Mai Lan De Medical Technology, Ltd, Nanjing, China (mode: MLD A2). It has 2 channels, composed of Channel 1 to acquire the electromyographic signal by inserting an intravaginal sensor probe into the vaginal cavity; and Channel 2, to acquire the EMG signals from abdominal muscles by electrode patches attaching to the abdomen.

With the collected amplified the EMG signal, muscle fiber recruitment and relaxation time, muscle fiber type and fatigue, all these data were processed and presented visible interpreted curves on the computer interface by certain software. The combination of channel 1 and 2 were processed and analyzed the percentage of abdominal muscle engagement.

A modified Glazer protocol was used to analyze the pelvic floor sEMG value. The modified Glazer Protocol includes 4 activities, and the signal parameters were calculated for each activity.

1. The rest (pre-baseline) phase: the subjects were instructed to feel the pelvic floor muscle in rest remaining for 10-second. To test the PFM tension in a relaxed state.

Average Mean Amplitude (μV)

2. The phasic (flick) contraction phase: the subjects were instructed to quickly contract the PFM, and then fully relax the PFM immediately after contraction (five 2-second contraction with a 2-second rest in-between). To test muscle strength and reaction velocity of the fast muscle fibers (Class II fibers).

Average Peak Amplitude (μV): the mean value of 5 contractions

Time Before Peak (s): the mean value of 5 contractions

Time After Peak (s) - the mean value of 5 contractions

3. The tonic contraction phase:the subjects were instructed to contract the PFM as strongly as possible and hold the contraction for 10 seconds,then fully relax the PFM after contraction for 10 seconds. To test muscle strength and contractile stability of the slow muscle fibers (Class I fibers).

Average Mean Amplitude(μV) - the mean value of 5 contractions

Mean Amplitude Variability (%)

4. The rest (post-baseline) phase: the subjects were instructed to feel the PFM in rest for 10-second. To test the PFM tension in a relaxed state.

Average Mean Amplitude (μV)

All the relevant data were filled in Excel to establish a database. Statistical analysis was performed using SPSS 26.0. If the date showed normal distribution and the equal variance, the measurements presented as x±s and were analyzed by t-test for comparisons between two groups and one-way ANOVA for comparisons among multiple groups. Those data that did not meet a normal distribution or a equal variance, presented as the median [M (P25, P75)], the Mann-Whitney U-test was used for comparisons between two groups, while the Kruskal-Wallis rank sum test was used for comparisons among multiple independent samples. $P<0.05$ was considered statistically significant.

Results

Our study screened successfully in total 3385 subjects, including 1286 cases in CD group and 2099 cases in VD group. No significant differences were detected in age, BMI, gestational age at delivery, and neonatal weight between CD and VD ($P > 0.05$, table 1). Our analysis showed that the average peak amplitude of phasic (flick) contractions and the average mean amplitude of tonic contractions were both significantly higher in CD than in VD ($P < 0.01$, table 2). In contrast, CD had less the mean amplitude variability of tonic contractions than VD ($P < 0.01$, table 2). The results revealed that the muscle strength of fast muscle (class II fibers) and slow muscle (class I fibers) were higher in CD than in VD, and the variation of slow muscle (class I fibers) was significantly higher in the VD. For the comparison of the value at rest pre-baseline and post-baseline, CD had higher average mean amplitude compared to VD(P¡0.01, table 2). It suggested that the PFM tension in a relaxed state were higher in CD than in VD. Our results showed that the engagement of the abdominal muscles in VD was significantly higher than that in CD(P¡0.01, table 2).

We further differentiated as 4 subgroups of vaginal delivery. There was no statistically difference in maternal age, BMI, gestational age at delivery, and neonatal weight among the four subgroups of vaginal delivery ($P > 0.05$, Table 3). We identified the significant difference among the four subgroups of vaginal delivery group(Table 4). The average mean amplitude of rest pre-baseline was significantly higher in group B compared to group D ($P=0.041$, Fig.1). The average peak amplitude of phasic (flick) contractions (Fig.2) and the average mean amplitude of tonic contractions (Fig.3) in group D was statistically lower than the other vaginal delivery groups ($P<0.05$). The mean amplitude variability of tonic contractions was larger in group D than group A, B. (P was 0.002,0.003, respectively, Fig.4). The average mean amplitude of rest post-baseline was shorter in group D than groups A, B, and C (P was 0.000,0.000,0.003, respectively, Fig.5). There was no significantly difference in the engagement of the abdominal muscles among 4 subgroups of vaginal delivery($P > 0.05$, Table 4).

Discussion

Main findings

In this study, the analysis of pelvic floor sEMG data at 6-8 weeks postpartum in primiparous women represented that the fast muscle strength was significantly weaker in VD compared with CD, as well as for the slow muscle, muscle strength and stability of contractile control were both significantly weaker in VD compared with CD. The vitality of the pelvic floor muscles decreases significantly after pregnancy, and the supporting force becomes weaker. The high pressure generated by pregnancy and delivery to the pelvic floor results in the impairment of PFM, connective tissue and nerves, eventually leading to PFD. Numerous previous studies have shown that compared with cesarean section, the incidence of PFD, like pelvic organ prolapse (POP), stress urinary incontinence (SUI) and so on in women with vaginal delivery is significantly higher [10-12]. Blomquist[13] found that the cumulative incidence of POP, SUI and overactive bladder (OB) after vaginal delivery was associated with decreased PFM strength. A meta-analysis [14], reviewed in total nine studies, also demonstrated the PFM strength in the VD group was significantly lower than that in the CD group. Our study aligned with other reports, suggested that vaginal delivery, as the main risk factors for impairment of postpartum PFM strength, can affect postpartum PFM function via decreasing the muscle strength of the fast and slow muscles and the stability of the slow muscles.

Several studies[14,15] suggest that elective cesarean delivery may protect the pelvic floor muscles. But other reports[16] showed that this protection from cesarean delivery could be ignored with the long-term postpartum follow-up and its effects in this regard remain controversial. Our study found that the mean values of the pre-baseline and post-baseline rest in sEMG were higher at early postpartum of the CD group than those in the VD group. Guo et al [17] found the higher pressure at pre-baseline rest in CD in the early postpartum compared with VD group, which is consistent with our findings. The pre-baseline and post-baseline resting phases is correlated to the magnitude of muscle tension in a relaxed state. Increased resting tension of pelvic floor muscles can easily lead to pelvic floor muscle ischemia, present as clinical symptoms such as dyspareunia, urinary retention, and constipation. A study on quality of life with 6 years follow up postpartum[18], revealed that the incidence of lower abdominal, genital pain, and pain related to sexual life were significantly more frequent after cesarean delivery than that with vaginal deliveries. The causes of increased muscle tone could be neurogenic and non-neurogenic hypertonicity, which are both associated with muscle contraction and/or passive stiffness[19]. Our findings suggest that cesarean section may increase pelvic floor muscle tension and impact the PFM function in the early postpartum period. The relevant mechanism needs further investigation.

Numerous studies have shown that assisted vaginal delivery, especially forceps delivery, significantly increases the risk of PFD. The study reported that the risk of fecal incontinence and POP was significantly higher in those had assisted vaginal delivery compared with natural vaginal delivery [20]. Meyer et al[21] reported a higher incidence of PFM weakness (20% vs 6%) in women with forceps delivery than spontaneous delivery at 10 months postpartum. Among all kinds of vaginal deliveries, forceps delivery brings the highest risk of impairment of pelvic floor structure, mainly due to its potential destruction on the pelvic floor muscles, nerves, and connective tissue. Weakened PFM strength may be caused by levator avulsion injuries and extensive levator hiatus[22]. Our results suggest that the forceps delivery has the worst impact on the PFM function among all vaginal delivery in the early postpartum period, mainly by reducing the muscle strength of fast and slow muscles as well as the stability of slow muscles. And for those with necessary forceps delivery as high-risk PFD population, pelvic floor function assessment should be performed at the early postpartum stage, and a precise and effective strategy for postpartum PFM recovery should be initiated as early as possible.

So far there are no reports on comparison of abdominal muscle engagement among the different modes of delivery. In our clinical routine, EMG signal representing the abdominal muscle engagement, was captured by an additional channel via the patch attaching the abdomen. Our results showed that the engagement of the abdominal muscles was significantly higher in VD compared with CD. The potential reason behind could be the compensative utilization of abdominal muscle in vaginal delivery group as they had weakened pelvic floor muscle. The discordance of pelvic-abdominal muscle was more pronounced in women who delivered vaginally, thus their pelvic floor muscle requires the professional rehabilitation therapy.

Strengths and limitations

In our study we recruited a large sample size in the final analysis, which can reduce the bias and provide the decent comparisons in different study groups. And we applied the modified Glazer protocol to evaluate the signal data of pelvic floor sEMG, which demonstrated the precise scale and detailed type of PFM in dysfunction based on a quantitative approach. It is powerful to support the comprehensive and accurate analysis on the impact on PFM function by different deliveries at the early postpartum stage.

Our study also has several limitations. Firstly, our study is hospital-based, it contains selective bias. Secondly, due to the small sample size of third-degree perineal lacerations, we did not have enough power to analyze the third-degree perineal lacerations in vaginal delivery. Finally, since this study only evaluated pelvic floor sEMG at 6-8 weeks postpartum, it may not be sufficient for accessing final pelvic muscle function. Therefore, a long-term follow-up epidemic study is further suggested.

Interpretation

It is a controversial debate to perform the routine lateral episiotomy on low-risk pregnant women. Some believe that routine lateral episiotomy not only prevents the anal sphincter [23] but also defend against the defects of central support from the anterior vaginal wall[24]. In contrast, others believe that routine lateral episiotomy increases the incidence of infection and pain at perineal incision, postpartum hemorrhage, and urinary tract disorders[25]. A systematic review[26] showed that lateral episiotomy is not beneficial for the prevention of urinary and fecal incontinence and pelvic floor tissue relaxation, and ironically it increases the incidence of dyspareunia. Our study, there was no statistical difference in sEMG examination among the episiotomy group, the vaginal delivery with hard-protected perineal integrity group, and the 1^{st}- and 2^{nd}-degree perineal laceration groups. Our study revealed episiotomy had no protection on the function of the pelvic floor muscles, compared with the perineal integrity group and 1^{st}- and 2^{nd}-degree perineal laceration group. Hence episiotomy should be performed under carefully evaluation and the restriction of episiotomy is suggested.

Conclusions

In this study, the analysis found that muscle strength of fast and slow muscles and the stability of slow muscles in vaginal delivery group, especially in forceps delivery subgroup, were weaker than those in cesarean delivery group at 6-8 weeks postpartum. And cesarean section may also impact PFM function through increased muscle tension. Pelvic floor function examination, performed at the early postpartum stage, could timely identify the scale and type of postpartum pelvic floor muscle impairment. It is very useful to instruct the particular recovery training to improve women's quality of life.

Disclosure of interests

Full disclosure of interests available to view online as supporting information. **Contribution to authorship**

HXZ was responsible for the initial concept, data acquisition, wrote the manuscript and final review of the manuscript; LW performed the statistical analysis and wrote the manuscript; LC assisted in the acquisition and analysis of clinical data.

Details of ethics approval

This study was approved by the Medical Science Ethics Committee of the International Peace Maternal and Child Health Hospital. (GKLW 2016-55, 8 June 2017)

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Table 1 Comparison of basic characteristics between the cesarean section delivery group and the vaginal delivery group

Groups	**Sample size**	**Age (year old)**	**Gestational age at delivery(week)**	**BMI(kg/m^2)**	**Neonatal weight**
VD	2099(62.01)	29.93±3.03	38.957±1.16	20.79±2.56	3272.26±337.49
CD	1286(37.99)	29.99±3.53	38.838±1.36	20.92±2.11	3279.62±422.97
t/Z		-0.466	-0.832	-1.649	-0.530
P		0.641	0.405	0.099	0.596

The values are given in the form of a number (percentage) or mean ± SD.

The independent sample t-tests or Mann-Whitney U-tests were used for continuous variables.

BMI: body mass index; VD: Vaginal delivery group; CD: Cesarean section delivery group

Table 2 Comparison analysis of pelvic floor muscle in sEMG data between cesarean section delivery group and vaginal delivery group

Parameter	Groups	Groups	Z/t	P
	VD(n=2099)	CD(n=1286)		
Rest pre-baseline				
Average Mean Amplitude (μV)	4.77±3.98	7.64±5.57	-16.129	0.000
Phasic (flick) contractions				
Average Peak Amplitude (μV)	33.4(22.37,44.67)	42.85(31.34,54.70)	-14.883	0.000
Time Before Peak (s)	0.34(0.27,0.44)	0.35(0.27,0.45)	-0.646	0.519
Time After Peak (s)	0.41(0.32,0.55)	0.42(0.32,0.56)	-0.101	0.919
Tonic contractions				

Parameter	Groups	Groups	Z/t	P
Average Mean Amplitude(μV)	21.90(14.14,30.79)	29.64(20.75,37.53)	-15.230	0.000
Mean Amplitude Variability (%)	0.22(0.18,0.28)	0.20(0.16,0.26)	-8.790	0.000
Rest post-baseline				
Average Mean Amplitude (μV)	4.83±3.25	7.33±4.72	-16.752	0.000
abdominal muscle engagement	16.24 (7.18,32.24)	10.18 (4.41,21.35)	-10.840	0.000

The values are given in the form of mean ± SD or median and interquartile range.

The independent sample t-tests or Mann-Whitney U-tests were used for continuous variables.

Table 3 **Comparison of characteristics of vaginal delivery subgroups**

Subgroup	Sample size	Age (years old)	BMI(kg/m^2)	Gestational age(w)	Neonatal Weight(kg)
A	674	29.75±3.08	20.65±2.49	38.94±1.04	3251.59±318.23
B	806	29.92±2.90	20.91±2.58	39.06±1.06	3291.07±320.92
C	341	29.99±3.10	20.74±2.78	38.87±1.61	3256.23±398.10
D	278	30.35±3.13	20.81±2.36	38.83±1.01	3287.45±346.70
H		6.380	6.066	5.065	7.727
P		0.095	0.108	0.167	0.052

A:With perineum laceration and/or first-degree perineum laceration; B:second-degree perineum laceration; C: Lateral episiotomy; D:Forceps Delivery

Table 4 Analysis of pelvic floor EMG data in 4 groups of vaginal delivery

Parameter	Groups of vaginal delivery	Groups of vaginal delivery	Groups of vaginal delivery	Groups of vaginal delivery	P
	A (n=674)	B (n=806)	C (n=341)	D (n=278)	
Rest pre-baseline					
Average Mean Amplitude (μV)	3.87(2.07,5.99)	4.01(2.22,6.36)	3.86(2.35,6.64)	3.49(1.84,5.73)	0.037
Phasic (flick) contractions					
Average Peak Amplitude (μV)	34.18(24.46,45.42)	33.39 (22.46,44.66)	33.95(23.36,44.59)	29.19(18.38,40.08)	0.000
Time Before Peak (s)	0.33(0.26,0.43)	0.34(0.26,0.44)	0.35(0.27,0.46)	0.35(0.28,0.46)	0.184
Time After Peak (s)	0.41(0.32,0.54)	0.42(0.32,0.55)	0.41(0.32,0.55)	0.43(0.33,0.60)	0.325

Parameter	Groups of vaginal delivery	Groups of vaginal delivery	Groups of vaginal delivery	Groups of vaginal delivery	P
Tonic contractions					
Average Mean Amplitude(μV)	22.85(15.10,31.89)	22.39(14.19,31.04)	22.32(14.31,30.82)	17.51(12.18,27.02)	0.000
Mean Amplitude Variability	0.22(0.18,0.28)	0.22(0.18,0.28)	0.23(0.19,0.28)	0.24(0.19,0.32)	0.002
Rest post-baseline					
Average Mean Amplitude (μV)	4.23(2.62,6.46)	4.48(2.60,6.67)	4.35(2.33,6.55)	3.31(1.91,5.72)	0.000
abdominal muscle engagement	15.71 (7.17,31.76)	16.45 (7.48,32.09)	15.07 (6.86,31.81)	19.72 (7.54,36.61)	0.30

The values are given in the form of a number (percentage) or median and interquartile range.

Nonparametric test(Kruskal-Wallis H test) were used for multiple independent samples of continuous variables.

A:No laceration of perineum+ laceration I B:laceration II C: Lateral episiotomy D:Forceps Delivery

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