Accurate evaluation of the progress of delivery with Transperineal ultrasound may increase vaginal delivery: a single-center retrospective study

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Abstract

Although evaluation by digital examination of the cervix is the standard method used worldwide for evaluating the progress of delivery, it has a problem because it is subjective. Transperineal ultrasound (TPU) is used as an adjunct to digital evaluation for accurate assessment of the fetal descent and rotation of the advanced part of the fetus. This study aimed to clarify the impact of the introduction of TPU on perinatal outcomes at Mie university hospital. This retrospective study analyzed single pregnant women who underwent delivery management at our hospital between April 2020 and March 2021. Perinatal outcomes were compared between patients who were used TPU (TPU+ group) and those who were not used TPU (TPU- group). The angle of progression and head direction were measured. The rate of vaginal delivery was significantly increased, and the second stage of labor was significantly prolonged in the TPU+ group. There was a significant difference between termination in the latent phase occurred in 3/8 (38%) cases in the TPU+ group and 20/25 (80%) cases in the TPU- group. The rate of vaginal delivery may be increased by accurate evaluation of the progress of delivery with TPU.

Introduction

Although evaluation by digital examination of the cervix (DEC) is the standard method used worldwide, it has a problem because it is subjective. The advantage of DEC is that it can be performed at any time without needing special equipment. On the other hand, its disadvantage is that it is subjective and subject to inter-examiner error. The evaluation of delivery progression plays a major role in determining the subsequent delivery method. If DEC reveals that the degree of descent of the advanced part of the baby has not changed for a certain period, the method of delivery is changed from vaginal delivery to cesarean section. Since the degree of invasiveness of vaginal delivery and cesarean section is different for each mother, there is a concern that an inadequate assessment of the progress of delivery due to an inter-examiner error by DEC may result in an incorrect choice of delivery method and unnecessary invasiveness for the mother.

Transperineal ultrasound (TPU) is used as an adjunct to digital evaluation for accurate assessment of the fetal descent and rotation of the advanced part of the fetus. Guidelines on labor management have been published, in which TPU is not considered standard management. However, digital evaluation has been shown to have more measurement error than those evaluated by combination with TPU, and it appears to have become steadily more widespread in recent years.

Various findings have been reported for examination during delivery. We began using TPU in the management of labor and delivery in April 2020 at our hospital.

To clarify whether the introduction of TPU has any impact on perinatal outcomes, we investigated the following.

Materials And Methods
We conducted a retrospective study of single pregnant women who underwent delivery management at our hospital between April 2020 and March 2021. This study includes every primigravid woman who entered the delivery room for labor trial. Perinatal outcomes were compared between patients who were used TPU and those who were not used TPU during the abovementioned period.

The angle of progression (AoP) and head direction (HD) were measured according to the guidelines in cases where TPU was used.

All patients had TPU performed by N.E. and S.M., who are obstetricians working in this hospital and also in charge of delivery. TPU was performed at the same time as the first DEC after admission to the delivery room.

**Methods of TPU measurement**

The probe is placed between the two labia majora or more caudally, at the level of the fourchette, with the woman in a semirecumbent position with legs flexed at the hips and knees at 45° and 90° degrees, respectively. Her bladder must be empty.

The machine used included a Voluson P8 and a Convex array probe, and the frequency of the probe was phase inversion high 7.30–3.30 Hz.

The AoP and HD were measured automatically by the application of Voluson P8; however, if the automatic measurement determined a machine error, manual measurement was performed with the same image and corrected.

**Our delivery management**

**First stage of labor**

We treat more than 6 cm as an active phase, which was the standard practice during this study. An intervention is performed if there is no progress in delivery for 2 h after the 6-cm opening. In principle, an intrauterine manometer is inserted to measure intrauterine pressure. If an intrauterine manometer cannot be inserted, CTG is used to induce labor such that the number of contractions does not exceed five per 10 min. If the contractions are less than 200 Montevideo units, we use oxytocin to augment labor. If more than 200 Montevideo units are maintained but 4 h have elapsed, the patient is transferred to undergo a cesarean section.

In our hospital, we proactively insert a cervical electrode and perform intrauterine manometry in cases in which CTG monitoring cannot be performed properly and, as a rule, insert the electrode around the active phase.

In the case of premature rupture of membranes (PROM) without labor onset, the cervical procedure for cervical ripening is not performed due to the risk of infection and is performed by induction with oxytocin.
administration regardless of the Bishop score.

**Second stage of labor**

Intervention is performed if there is no descent of the baby’s head for 1 h after full dilation. When possible, an intrauterine manometer is inserted to measure the intrauterine pressure. We check for abnormalities in rotation. If necessary, labor is augmented if contractions are weak, although mechanical delivery is performed when the summary for mechanical delivery is met. When weak pain has resolved, although the indications for instrumental delivery have not been met and 3 h have elapsed, the decision is made to perform a cesarean section. For the delivery effort, we select a delayed push. 25

**Epidural anesthesia**

The obstetrician in charge of delivery performs epidural anesthesia, and analgesics are administered intermittently every hour. Usually, L2/3 or L3/4 is selected as the puncture point; 6–8 ml of the drug, which includes 7 ml of 0.1% ropivacaine (7.5 mg/ml) + 2 ml of fentanyl (0.1 mg/1A) + 41 ml of saline solution, is administered as a rule. "Walking anesthesia" is the aim, in which the motor nerves are slightly preserved. Augmentation with oxytocin is always considered along with starting anesthesia.

**Vacuum delivery**

Vacuum delivery is performed with the rule of no more than five times and no more than 20 min. 23, 24, 26

**Statistical methods**

The Fisher’s exact test, the Mann–Whitney U test, and the χ-square test were used to derive p-values for the comparison of maternal characteristics. All statistical analyses were performed using JMP PRO 14 software (SAS Institute Inc, Cary, North Carolina).

**Ethics approval**

This study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Institutional Review Board of Mie University Hospital (No. H2023-012, Jan 23, 2023). All participants provided written informed consent for participating in the study.

**Results**

The backgrounds of the groups with (TPU+) and without (TPU-) TPU are shown in Table 1. No differences were found in the rates of pre-pregnancy complications, including cardiac, liver, renal/urinary tract, endocrine, psychiatric, and gynecologic issues, thrombosis/embolism, inflammatory bowel disease, severe obesity (BMI > 35 kg/m2), and orthopedic disease. Significant differences in obstetric complication rates were observed (p < 0.0001). Obstetric complications included nine cases of HDP, eight of FGR, three of oligohydramnios, one of polyhydramnios, five of PROM, seven of GDM, two of abruption of the placenta, two of chorioamnionitis, and two others in the TPU-group (duplicates included). There were 12
cases of GDM, four of HDP, two of FGR, one of abruption, and one of polyhydramnios in the TPU + group (duplicates included). There was a difference in the rates of malrotation ($p = 0.0278$) and epidural anesthesia ($p = 0.0305$).

Table 1
Backgroun ds of both groups

<table>
<thead>
<tr>
<th></th>
<th>TPU+</th>
<th>TPU-</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>88</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td>Primipara</td>
<td>88 (100%)</td>
<td>88 (100%)</td>
<td>-</td>
</tr>
<tr>
<td>Age*</td>
<td>33.8 ± 5.4</td>
<td>31.2 ± 5.9</td>
<td>NS</td>
</tr>
<tr>
<td>Pre-pregnancy BMI &gt; 25 kg/m²</td>
<td>47 (53%)</td>
<td>24 (27%)</td>
<td>0.0017</td>
</tr>
<tr>
<td>Pre-pregnancy complication</td>
<td>49 (56%)</td>
<td>40 (45%)</td>
<td>NS</td>
</tr>
<tr>
<td>Obstetric complication</td>
<td>17 (19%)</td>
<td>50 (57%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Malrotation</td>
<td>12 (14%)</td>
<td>3 (3%)</td>
<td>0.0278</td>
</tr>
<tr>
<td>Transported by ambulance</td>
<td>5 (6%)</td>
<td>4 (5%)</td>
<td>NS</td>
</tr>
<tr>
<td>Oxytocin for augmentation</td>
<td>60 (68%)</td>
<td>50 (57%)</td>
<td>NS</td>
</tr>
<tr>
<td>Metreurynter for induction of labor</td>
<td>5 (6%)</td>
<td>10 (11%)</td>
<td>NS</td>
</tr>
<tr>
<td>Controlled-release dinoprostone vaginal delivery system for induction of labor</td>
<td>25 (28%)</td>
<td>30 (34%)</td>
<td>NS</td>
</tr>
<tr>
<td>Epidural anesthesia</td>
<td>15 (17%)</td>
<td>5 (6%)</td>
<td>0.0305</td>
</tr>
</tbody>
</table>

TPU; transperineal ultrasound, BMI; body mass index

*; mean ± standard deviation

Table 2 shows the outcomes in both groups. The rate of vaginal delivery was significantly increased, and the second stage of labor was significantly prolonged in the TPU + group.
Table 2
Outcomes in both groups

<table>
<thead>
<tr>
<th></th>
<th>TPU+</th>
<th>TPU-</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 88</td>
<td>n = 88</td>
<td></td>
</tr>
<tr>
<td>Delivery days (days)*</td>
<td>278.2±7.9</td>
<td>276.8±8.6</td>
<td>NS</td>
</tr>
<tr>
<td>Birth weight (g)*</td>
<td>3090±438</td>
<td>2959±444</td>
<td>NS</td>
</tr>
<tr>
<td>Blood loss &gt; 1000 g</td>
<td>28 (32%)</td>
<td>20 (23%)</td>
<td>NS</td>
</tr>
<tr>
<td>Apgar score 1 min*</td>
<td>7.9±0.9</td>
<td>7.9±1.0</td>
<td>NS</td>
</tr>
<tr>
<td>Apgar score 5 min*</td>
<td>8.9±0.6</td>
<td>8.8±0.7</td>
<td>NS</td>
</tr>
<tr>
<td>Umbilical artery pH*</td>
<td>7.27±0.07</td>
<td>7.27±0.08</td>
<td>NS</td>
</tr>
<tr>
<td>Vaginal delivery rate</td>
<td>80 (91%)</td>
<td>63 (72%)</td>
<td>0.0017</td>
</tr>
<tr>
<td>The second stage of delivery (min)*</td>
<td>148±108</td>
<td>76±89</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

*; mean ± standard deviation
min; minutes

[insert Table 2]

The reasons for emergent cesarean section in both groups are shown in Table 3. There are no significant differences in each category of indication. The indications included one case for HDP in the TPU+ group and one for HDP, one for positional abnormalities during ongoing labor, one for advanced umbilical cord, one for intrauterine infection, and one for abruption in the TPU- group. Termination in the latent phase occurred in 3/8 (38%) cases in the TPU+ group and 20/25 (80%) cases in the TPU- group, with a significant difference (p = 0.04).

Table 3
Reasons for emergency cesarean section in both groups

<table>
<thead>
<tr>
<th></th>
<th>TPU+</th>
<th>TPU-</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 8/88</td>
<td>n = 25/88</td>
<td></td>
</tr>
<tr>
<td>Failure to vacuum delivery</td>
<td>1</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Arrest of labor</td>
<td>5</td>
<td>10</td>
<td>NS</td>
</tr>
<tr>
<td>NRFS</td>
<td>1</td>
<td>10</td>
<td>NS</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>5</td>
<td>NS</td>
</tr>
</tbody>
</table>
| NRFS; non-reassuring fetal status

[insert Table 3]
As shown in Fig. 1, vacuum deliveries accounted for 16% and 40%, vaginal deliveries for 58% and 51%, and emergent cesarean sections for 26% and 9% of TPU- and TPU+ deliveries, respectively. The increase in the number of vacuum deliveries and decrease in the number of emergent cesarean sections increased the rate of vaginal deliveries.

Figure 2 shows the trends of change in AoP of TPU + group. The average AoP among the vacuum cases was 151°. A patient underwent an emergent cesarean section after a failed vacuum delivery had no abnormalities of rotation, and the HD was upward. The remaining seven patients in whom cesarean sections were performed underwent the procedure before full dilatation and are not plotted in this graph.

As shown in the Fig. 3, the AoP trend was slower in patients who underwent vacuum delivery than in those who underwent vaginal delivery. Delayed push was selected at our institution.

Discussion

When practicing TPU, have you ever had the impression that the head station was high on digital evaluation due to vaginal shape changing or deformation of the head, although you were able to vacuum with confidence by checking the AoP? If so, you might agree that digital evaluation alone may underestimate the descent of the head station.

This study's results suggest that TPU, an accurate and objective method of evaluating the course of delivery, may have improved DEC techniques and increased the rate of vaginal delivery. We believe this is a result of decreased underestimation of the delivery process.

Although not significantly different, emergent cesarean sections after full dilation decreased from 9/189 in 2019 to 2/192 in 2020. Avoiding emergent cesarean section after full dilation may also lead to better perinatal outcomes in the future, especially given the negative impact on the next pregnancy.27–30

Our hospital has a high preconception complication rate and is a high-risk center with 93 (48%) preconception complications and 81 (42%) obstetric complications (including overlap) of 192 participants in this study. The impact of the current study results, which is the increased rate of vaginal delivery in high-risk centers, is considered substantial.

In Japan, mechanical stimulation had been employed for cervical ripening, although in 2020, a controlled-release dinoprostone vaginal delivery system was introduced. Although this was a major change, we found no difference in its use in this study. Further studies are needed to determine whether there were differences in background factors, such as preconception and obstetric complications.
The prolongation of the second stage of labor shown in Table 2 suggests that the cases in which a cesarean section would have been required before the introduction of TPU progressed and resulted in vaginal delivery after the addition of ultrasound evaluation. However, in Table 3, there was no significant decrease in the arrest of labor.

Before TPU was introduced, the delivery progress was judged only by digital evaluation. Diagnosis of the head station was more difficult due to the appearance of a caput succedaneum than cervical dilation. Therefore, some cases might have been diagnosed as the arrest of labor when there was no change in cervical dilation, especially after full dilation, and judged only by its descent.

As for the head station of the vacuum group in Fig. 3, the average AoP at the time of full dilation was 135°, and the average AoP at 1, 2, 3, 4, 5, and 6 hours after full dilation was 143, 143, 149, 151, 151, and 141°, respectively. Some patients delivered before 2 hours after full dilation, because of which we could not compare them. The mean change of AoP was several degrees/hours, which is difficult to diagnose by digital evaluation alone. Small changes in AoP measurement could be considered within the error range, although the ability to measure ΔAoP at a push and to combine multiple ultrasound findings, such as head direction and Midline angle, provides more information than digital evaluation alone. In such cases, a cesarean section could be performed if it is impossible to determine the descent. On the other hand, in the spontaneous delivery group, the average AoP at full dilation was 145°, and the AoP at 1, 2, and 3 hours after full dilation was 160, 159, and 150°, respectively. The declining angles are likely due to the large number of cases being delivered. One of the 36 successful cases of vacuum delivery in this study was vacuumed at 140°. However, the failed case was vacuumed at 156°.

The time of the second stage of labor may also be affected by the increasing rate of epidural anesthesia. It has been shown that the duration of the second stage of labor increases, the rate of instrumental delivery increases, and the rate of weak contractions increases. Some reports indicate that cesarean section rates remain the same, while other studies suggest that they increase. Increased malrotation may be due to anesthesia.

In our hospital, augmentation with oxytocin is always considered along with starting anesthesia. Most cases used oxytocin with the initiation of epidural anesthesia. To examine the effect of anesthesia on the second stage of labor in this study, Fig. 3 was created. The χ-square test was performed on the slope of the AoP from initiation of full dilation to 2 hours afterward, and no clear difference was found between with and without anesthesia.

On the other hand, for those who had a spontaneous vaginal delivery, the χ-square test showed a difference in the slope of the AoP in the second stage of delivery (p = 0.0004) compared with the vacuum group. This suggested that the cases requiring vacuum delivery had slower delivery progress, regardless of the use of anesthesia.
In Supplementary Fig. 1, in the cases it was measured, intrauterine pressure remained higher in the group with anesthesia, leading to spontaneous labor. Although a decrease in uterine contractility was shown, this study shows that using appropriate uterine contractions might prevent weak contractions.

This study did not find prevention of delivery overestimation, that is, increased cesarean section due to failed instrumental delivery. As shown in Table 3, there was only one TPU + case of failed vacuum delivery. There are several reports on mechanical deliveries, and continued case accumulation should be conducted to determine whether the overestimation of deliveries can be reduced.

We have a conference every morning to review CTGs of deliveries as part of the education of the residents, although until now, we have not had an intervention on DEC. The residents had been trained to evaluate the degree of head station through digital evaluation with senior doctors. Now, with ultrasounds, they have improved more quickly than in previous years, perhaps because they can look at objective numerical values. The AoP values allow us to examine the degree of head station retrospectively and to provide more practical feedback. An ultrasound image is also useful as a communication tool for decision-making in the delivery room for midwives, nurses, and patients.

This study has some limitations. First, this is a retrospective study, and there was no difference in the percentage of the arrest of labor, which was most expected but may be due to the sample size. Second, a significant difference in the rate of the use of anesthesia was observed. The impact of this difference cannot be ignored. Third, as shown in Supplementary Figs. 2A and B, the rate of vaginal deliveries increased significantly from 2019, when no TPU was performed, to 2020, when partial TPU was performed. This suggests that the introduction of TPU may have improved the facility's overall digital evaluation techniques. If so, the effect of the improvement of DEC techniques throughout the facility on the TPU- group cannot be ruled out. The inconsistency in the measurement interval is another limitation. In this study, we started AoP measurement when the patient entered the delivery room and measured it at each DEC. In our hospital, the midwife decides to enter the delivery room. However, there is a difference in the rate of terminations during the latent phase. It is necessary to standardize the time of diagnosis of the active phase as the starting point of AoP measurement in the future. Finally, the results may be influenced by the fact that many patients entering the delivery room during the night shift due to obstetric complications, such as PROM, are in the TPU- group. This is because emergency-induced deliveries are frequently performed. Based on these considerations, a prospective study is a next step.

Conclusion

In this study, the rate of vaginal delivery may be increased by TPU. Accurate evaluation of the descent of the head station may prevent underestimation of delivery and decrease emergency cesarean section. It can also be used as a basis for retrospective reviews, such as CTGs, and as feedback for teaching.

Declarations
Authors’ contributions

Drs Enomoto, Maki, Takakura, Nii and Katsuragi conceptualized and designed the study and developed search strategies. Drs Enomoto, Yamaguchi, and Tamaishi designed the data extraction sheet. Drs Enomoto, Magawa and Nii analysed and interpreted data. Drs Enomoto, Maki, Nii and Kayo Tanaka drafted the manuscript. Drs Hiroaki Tanaka, Kondo, and Ikeda reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Disclosure statement

The authors report there are no competing interests to declare.

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No Fundings

Data availability statement

The data that support the findings of this study are available on request because the data contain potentially identifying or sensitive patient information. This restriction is imposed by the Institutional Review Board. (Contact; Data Manager: imaiya@med.mie-u.ac.jp)

References


Figures
Figure 1

The percentage of the mode of delivery
Figure 2

The trend of change in AoP of TPU+ group

This graph depicts the plots of the measurement of the TPU+ group. Black dots represent vaginal delivery cases, and white dots represent vacuum cases. One patient, illustrated by the thick solid line, underwent an emergent cesarean section after a failed vacuum delivery at the arrowed point.
Figure 3

The trends of change in AoP of spontaneous or vacuum delivery with/without anesthesia

This is a graph of hourly changes measured with the center of the horizontal axis at the point of full dilation. The vertical axis is the angle of AoP.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarymaterial.docx