*General Section*

# Labor induction using modified metreurynters plus oxytocin at an institution in Japan: a retrospective study

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**Summary**

*Objective:* The authors evaluated the effectiveness and safety of "neo-metoro" or "mini-metoro" metreurynters plus oxytocin for labor induction and assessed differences in parturition outcomes, according to the metreurynter used at induction initiation. *Materials and Methods:* The authors retrospectively reviewed 146 consecutive women with live singleton pregnancies, and who underwent induction. Parturition outcomes were vaginal delivery achieved within the planned schedule (VDPS), vaginal delivery finally achieved (VDF), and induction-to-delivery interval (IDI). Women were divided into neo-metoro, mini-metoro, and without metreurynter groups based on metreurynter use at induction initiation. The authors examined the relationships of metreurynter groups with factors, parturition outcomes, and adverse events. In 113 women who underwent two-day induction, the authors calculated IDI and adjusted odds ratio (AOR) for achieving delivery per unit time. *Results*: VDPS rates were 65% in nulliparous and 81% in multiparous women. VDF rates were 78% in nulliparous and 96% in multiparous women. AORs for VDPS were 0.30 in nulliparous women and 0.18 in Bishop score (BS) 1–3 class. AORs for VDF were 0.04 in BS1–3 class and 0.14 in BS4–5 class. In 113 women undergoing two-day induction, AORs for achieving delivery per unit time were 0.45 in nulliparous women, 0.46 in obese women, and 0.48 in BS1–3 class. Neo-metoro use at induction initiation tended to reduce IDI. *Conclusions:* Labor induction using these metreurynters plus oxytocin is safe and effective. The advantages of neo-metoro over mini-metoro use at induction initiation remain unclear; neo-metoro use at induction initiation may reduce IDI.

*Key words:* Bishop score; Cervical ripening; Cesarean delivery; Foley balloon catheter; Premature rupture of membranes.

## Introduction

### *Labor induction in Japan*

Labor induction (LI) is one of the most commonly practiced obstetric intervention worldwide. LI comprises of cervical ripening and uterine augmentation. Transvaginal dinoprostone (prostaglandin E2) or misoprostol (prostaglandin E1) is often used to mature the unfavorable cervix for inducing uterine contractions [1]. Sometimes insufficient contractions necessitate uterine augmentation, which is often achieved by intravenous drip administration of oxytocin.

However, transvaginal prostaglandins are not licensed for LI in Japan where mechanical methods are mainly used to mature the unfavorable cervix. Transcervical Foley balloon catheters are used for a mechanical method worldwide. Furthermore, their use often necessitates subsequent oxytocin administration because these catheters induce active labor less effectively than prostaglandins [2]. In Japan, several types of metreurynters are commercially available and widely used for balloon catheterization on LI.

Recently, the Japanese Society of Obstetrics and Gynecology (JSOG) issued a guideline for LI [3, 4]. Nevertheless, clinical studies on LI in Japan, especially those on LI with metreurynter use, are scarce [5, 6]. Each institution has its own LI protocols based on experience and basic clinical policy. At the present institution, Fukaya Red Cross Hospital, Saitama, Japan, the authors use the discoid "neo-metoro" and spherical "mini-metoro" metreurynters. Both are transcervical balloon catheters, designed specifically for LI, made of silicon gum. Neo-metoro forms an approximately six to seven by four-cm disc when inflated with 80-100 ml sterilized water, while mini-metoro forms an approximately four-cm sphere when inflated with 40 ml of sterilized water. Both devices have a moderately hard shaft, making them easier to insert into the cervix than a Foley catheter. The shaft of mini-metoro is slightly thinner than that of neo-metoro. Both metreurynters are inserted through the cervix and placed between the internal cervical os and amniotic membrane or fetal head. Because of the dimensions of these types of metreurynters, neo-metoro is difficult to use when cervical dilatation is less than one cm or more than four cm and mini-metoro is difficult to use when cervical dilatation is less than 0.5 cm or more than three cm. The authors use osmotic dilators if insertion of any me-

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Table 1. — *Relationship of the metreurynter groups with characteristic factors, parturition outcomes, and adverse events in the 146 women.*

| Factors, parturition outcomes, adverse events | | Total n = 146 | *Metreurynter groups* | | | *p* |
|---|---|---|---|---|---|---|
| | | | Without metreurynters n = 12 (8%) | Neo-metoro n = 99 (68%) | Mini-metoro n = 35 (24%) | |
| Age (years) | | 31.4 ± 4.7 | 33.2 ± 4.9 | 31.4 ± 4.6 | 30.7 ± 4.7 | 0.29 |
| Parity | Nulliparous | 93 64% | 33% | 61% | 83% | 0.005* |
| | Multiparous | 53 36% | 67% | 39% | 17% | |
| Maternal height (cm) | | 159.0 ± 5.3 | 156.8 ± 5.6 | 159 ± 5.3 | 159.6 ± 5.0 | 0.30 |
| Maternal weight (kg) | | 65.7 ± 10.1 | 65.2 ± 10.7 | 66.2 ± 10.3 | 64.3 ± 9.7 | 0.65 |
| Maternal BMI (kg/m$^2$) | | 25.9 ± 3.8 | 26.3 ± 3.6 | 26.1 ± 3.9 | 25.3 ± 3.7 | 0.50 |
| Gestational age (weeks) at induction † | | 40.1 (35.0-41.4) | 39.2 (35.0-41.0) | 40.1 (36.0-42.4 ) | 40.9 (36.1-42.1) | 0.016* |
| Indication for labor induction | Post-term | 58 40% | 0% | 39% | 54% | < 0.001* |
| | PROM | 45 31% | 42% | 31% | 26% | |
| | PRH | 17 12% | 8% | 14% | 6% | |
| | Complications | 10 7% | 17% | 7% | 3% | |
| | Prevention of a precipitate labor | 4 3% | 25% | 1% | 0% | |
| | Others | 12 8% | 8% | 7% | 11% | |
| Maternal complications (including PRH or GDM) | No | 80 55% | 42% | 51% | 71% | 0.065 |
| | Yes | 66 45% | 58% | 49% | 29% | 0.065 |
| Bishop score at induction initiation | | 5.3 ± 1.7 | 7.8 ± 1.6 | 5.3 ± 1.5 | 4.4 ± 1.6 | <0.001* |
| Achieving vaginal delivery without oxytocin | | 28 19% | – | 21% | 20% | 0.88 |
| Oxytocin administration | Yes | 111 76% | 100% | 73% | 77% | 0.61‡ |
| | Maximum dose (mu/min) | 6.9 ± 3.0 | 6.7 ± 3.6 | 6.7 ± 3.0 | 7.5 ± 2.4 | 0.44 |
| Planned schedule | Two-day induction | 125 86% | 0% | 91% | 100% | 0.50 |
| | One-day induction | 21 14% | 100% | 9% | 0% | |
| Induction-to-delivery interval (h) | | 21.7 ± 13.6 | 8.7 ± 11.4 | 21.3 ± 12.7 | 27.5 ± 13.8 | 0.016*‡ |
| Mode of delivery | Normal | 106 73% | 67% | 77% | 63% | 0.53 |
| | Vacuum or forceps | 18 12% | 17% | 11% | 14% | |
| | Cesarean | 22 15% | 17% | 12% | 23% | |
| Indication for cesarean delivery | Arrest of labor | 13 9% | 100% | 42% | 75% | 0.32 |
| | NRFS | 6 4% | 0% | 33% | 25% | |
| | Others | 3 2% | 0% | 25% | 0% | |
| Vaginal delivery achieved during the planned schedule | | 103 71% | 67% | 77% | 54% | 0.041* |
| Vaginal delivery finally achieved | | 124 85% | 83% | 88% | 77% | 0.31 |
| Neonatal birth weight (g) | | 3,090 ± 434 | 3,294 ± 603 | 3,091 ± 428 | 3,017 ± 376 | 0.17 |
| Low Apgar score (≤ 7 at 1 or 5 min) | | 11 8% | 8% | 8% | 6% | 0.90 |
| NICU admission | | 2 1% | 8% | 1% | 0% | 0.089 |
| Fever during induction of labor (≥ 38.0°C) | | 6 4% | 8% | 3% | 6% | 0.59 |

Data are presented as number, mean ± standard deviation, or percentage (in each metreurynter grouping) unless otherwise indicated.
BMI: body mass index; GDM: gestational diabetes mellitus; NICU: neonatal intensive care unit; NRFS: non-reassuring fetal status; PRH: pregnancy-related hypertension; PROM: premature rupture of membranes.
*Statistically significant. †Median (range). ‡Comparison of the neo-metoro group with the mini-metoro group (because all cases in the without metreurynter group were administered oxytocin and induced by the one-day schedule).

treurynter into the closed and firm cervix proves impossible, but this did not occur during the study period. Active labor is often not obtained after metreurynter use, and in such cases, the authors administer oxytocin via an intravenous drip for uterine augmentation.

Here the authors evaluated the effectiveness and safety of methods using neo-metoro or mini-metoro in combination with oxytocin for LI. They also assessed the differences in parturition outcomes according to metreurynter type used at induction initiation.

## Materials and Methods

*Indications and informed consent*

Major indications for LI are premature rupture of membranes (PROM) and post-term pregnancy. Other indications include pregnancy-related hypertension, complications, prevention of precipitate labor, oligohydramnios, fetal abnormality, and societal indications. Anesthesia for labor and delivery (planned or occasional) is not performed at the present institution. In addition, the authors do not handle breech vaginal delivery, twin vaginal delivery, or vaginal delivery after prior cesareans. LI is indicated when spontaneous labor onset does not occur within

Table 2. — *Adjusted odds ratios calculated by multivariate logistic regression analysis assessing the relationship between each factor and VDPS and VDF parturition outcomes.*

| Factors | | *Parturition outcomes* | | | | | |
|---|---|---|---|---|---|---|---|
| | | VDPS AOR | 95% CI | *p* | VDF AOR | 95% CI | *p* |
| Age | Five-year elevating | 0.64 | 0.07–5.2 | 0.68 | 1.3 | 0.69–2.6 | 0.40 |
| Parity | Nulliparous | 0.30 | 0.10–0.85 | 0.024* | N/A† | | |
| Maternal BMI (kg/m2) | < 22 | 1.2 | 0.34–4.9 | 0.76 | 0.87 | 0.11–7.4 | 0.89 |
| | ≥ 29 | 0.87 | 0.23–3.5 | 0.85 | 0.76 | 0.11–5.7 | 0.78 |
| Indication for labor induction | Post-term | 1 | | 1 | | | |
| | PROM | 1.8 | 0.65–5.5 | 0.25 | 1.00 | 0.26–3.9 | 1.0 |
| | Others | 0.73 | 0.22–2.4 | 0.60 | 1.1 | 0.19–7.7 | 0.89 |
| Complications | Yes | 0.74 | 0.28–2.0 | 0.54 | 0.45 | 0.12–1.6 | 0.22 |
| Neonatal birth weight (g) | ≥ 3,500 | 0.53 | 0.16–1.7 | 0.26 | 0.33 | 0.06–1.6 | 0.17 |
| Bishop score | 1–3 | 0.18 | 0.04–0.65 | 0.008* | 0.04 | 0.002–0.33 | 0.002* |
| | 4–5 | 0.66 | 0.21–1.9 | 0.45 | 0.14 | 0.007–0.89 | 0.036* |
| | 6–7 | 1 | | | 1 | | |
| | 8–10 | 0.79 | 0.14–5.1 | 0.80 | N/A‡ | | |
| Metreurynter groups | Mini-metoro | 1 | | | 1 | | |
| | Neo-metoro | 2.2 | 0.85–5.8 | 0.11 | 1.5 | 0.40–5.8 | 0.53 |
| | Without metreurynters | 0.94 | 0.11–7.7 | 0.96 | 0.21 | 0.004–9.6 | 0.40 |

AOR: adjusted odds ratio; BMI: body mass index; CI: confidence interval; N/A: not available; PROM: premature rupture of membranes; VDF: vaginal delivery finally achieved; VDPS: vaginal delivery achieved during the planned schedule.
*Statistically significant. †The VDF rate in the multiparous women was too high to analyze the relation to parity, so the factor of parity was extracted in the multivariate analysis. ‡The VDF rate in the BS8–10 class (which was 100%) was too high to analyze.

Table 3. — *Multivariate Cox proportional hazards model assessing the effect of each factor on induction-to-delivery interval in 113 women who underwent LI via Schedule A of the two-day induction.*

| Factors | | AOR | 95% CI | *p* |
|---|---|---|---|---|
| Age (years) | Five-year elevating | 0.82 | 0.63–1.07 | 0.14 |
| Parity | Nulliparous | 0.45 | 0.25–0.80 | 0.006* |
| BMI (kg/m$^2$) | < 22 | 0.64 | 0.31–1.3 | 0.20 |
| | ≥ 29 | 0.46 | 0.21–0.92 | 0.027* |
| Indication for labor induction | Post-term | 1 | | |
| | PROM | 1.4 | 0.81–2.4 | 0.22 |
| | Others | 0.94 | 0.47–1.8 | 0.85 |
| Complications | Yes | 0.69 | 0.39–1.2 | 0.18 |
| Neonatal birth weight | ≤ 3,500 g | 0.57 | 0.30–1.03 | 0.063 |
| Bishop score | 1–3 | 0.48 | 0.22–0.96 | 0.038* |
| | 4–5 | 0.76 | 0.46–1.3 | 0.28 |
| | 6–7 | 1 | | |
| | 8–10 | 0.56 | 0.12–1.7 | 0.33 |
| Metreurynter inserted at induction initiation | Mini-metoro | 1 | | |
| | Neo-metoro | 1.5 | 0.89–2.6 | 0.13 |

Calculated hazard ratios were regarded as odds ratios for achieving delivery per unit of time, with higher hazard ratio indicating earlier delivery.
LI: labor inducton; AOR: adjusted odds ratio; BMI: body mass index; CI: confidence intervals; PROM: premature rupture of membranes.
*Statistically significant.

24 hours of PROM. For safety, cesarean is prioritized over LI in cases with severe complications or in cases wherein vaginal delivery seems to be hard to achieve. Induction initiation occurs after careful consideration of maternal condition and provision of informed consent.

*Standard schedules*

The basic procedure for LI is metreurynter insertion in combination with subsequent oxytocin administration. Standard schedules of LI comprise two-day and one-day inductions. Schedule selection depends on cervical maturity at induction initiation. In the two-day induction, in principle, metreurynters are inserted in the afternoon (three to five pm) of the day before the target delivery day (Schedule A); sometimes in the morning of the day before the target delivery day (Schedule B). Moreover, the two-day induction is divided into mini-metoro insertion and neo-metoro insertion at induction initiation. The one-day induction is selected when a woman has a comparatively favorable cervix. Moreover, a neo-metoro is inserted prior to oxytocin if possible (Schedule C); no metreurynter is inserted when the cervix is sufficiently favorable (Schedule D). Inserted metreurynters are removed when extruded through the cervix into the vagina.

If contractions are insufficient in the morning of the target delivery day, oxytocin is administered to obtain active labor. The initial oxytocin dose is two milliunits (mu)/min (12 ml/h of five units oxytocin in 500 ml solution), followed by 3.3 mu/min (20 ml/h of oxytocin solution) 30 min later, with a dose increment of 1.7 mu/min (10 ml/h of oxytocin solution) at least every 30 min; the maximum dose administered is 20 mu/min (120 ml/h oxytocin solution).

Manual cervical dilatation, manual membrane stripping, and artificial amniotomy are administered with discretion. Artificial amniotomy will only be performed when delivery (vaginal or cesarean) will likely be achieved within several hours. If delivery is not foreseen to be achieved by five to seven pm based on labor progress during the afternoon of the target delivery day, oxytocin administration is stopped. At this time, without indications for cesarean delivery and if mother and fetus are considered fit to tolerate further attempts, the authors advise rest before attempting LI the following day.

To monitor fetal heart rate and uterine contractions, the authors use cardiotocography with external transducers at least 20 min before and after metreurynter insertion, intermittently during early labor, and continuously during active labor or oxytocin administration. Recently, the authors continuously monitor fetal heart rate in cases with neo-metoro insertion, in accordance

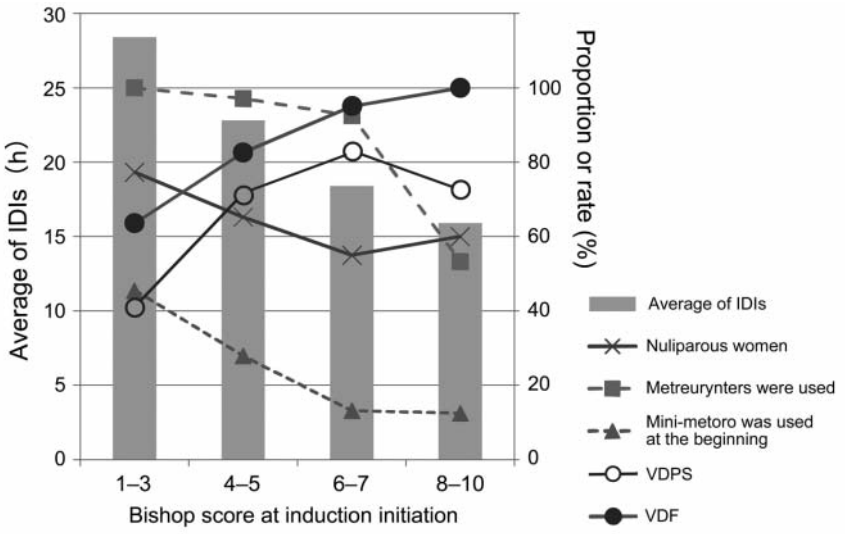


Figure 1. — Relationship between BS and average IDI, VDPS, VDF, and characteristic factors in the 146 women.

with JSOG recommendations when using a transcervical balloon catheter inflated to 41 ml or more [4].

In addition, antibiotics are administered when metreurynters are inserted, PROM occurs, Group B streptococcus has been detected, and prevention of infection is indicated. Broad-spectrum penicillins such as piperacillin sodium are often administered intravenously at the present institution.

*Methods*

The authors retrospectively reviewed 146 consecutive women with live singleton pregnancies, cephalic presentation, no prior cesarean sections, and who underwent LI at the present institution. They obtained characteristic factors, parturition outcomes, and adverse events from the obstetric database and the medical records.

To estimate LI efficacy, the authors defined parturition outcomes as vaginal delivery achieved within the planned schedule (VDPS), vaginal delivery finally achieved (VDF), and induction-to-delivery interval (IDI). VDPS included women who achieved vaginal delivery, including vacuum-assisted or forceps deliveries, by six pm of the target delivery day. VDF included women who eventually achieved vaginal delivery, including vacuum-assisted or forceps deliveries, however excluding cesarean section. Cesarean delivery was considered as failed induction. IDI was defined as the interval in hours from induction initiation to delivery, including cesarean delivery. Induction initiation was defined as the time of metreurynter insertion or oxytocin administration in women where metreurynters were not used. Women were divided into the following three groups according to metreurynter use at induction initiation: the neo-metoro group, the mini-metoro group, and the "without metreurynters" (WOM) group.

Bishop score (BS), measured upon metreurynter insertion or oxytocin initiation, was used to judge cervical maturity at induction initiation. Women were divided into BS1–3, BS4–5, BS6–7, and BS8–10 classes for analysis and interpretation of results. The following three adverse events were assessed: low Apgar score (≤ 7 at one or five min), admission to a neonatal intensive care unit, and maternal fever during induction (≥ 38°C).

The relationship of metreurynter groups with characteristic factors, parturition outcomes, and adverse events were assessed using the Chi-square ($\chi^2$), Student's *t*-test, and Mann–Whitney *U* test. To assess the effect of each factor on VDPS and VDF, the authors used multivariate logistic regression analysis.

IDI was assessed in 113 women who underwent LI via Schedule A. The authors constructed Kaplan–Meier survival curves and analyzed using univariate log-rank tests separately for nulliparous and multiparous women. Moreover, they used the multivariate Cox proportional hazards model to assess the effect of each factor on IDI. Calculated hazard ratios were regarded as odds ratios for achieving delivery per unit time, with higher hazard ratio indicating earlier delivery.

Statistical analyses were performed using JMP 8 and all tests were two-tailed. A $p < 0.05$ was considered statistically significant.

## Results

LI was conducted by the two-day induction in 86% (125/146) women and by the one-day induction in 14% (21/146). Furthermore, 77% (113/146) underwent LI via Schedule A [56% (82/146) with neo-metoro, 21% (31/146) with mini-metoro], 8% (12/146) via Schedule B, 6% (9/146) via Schedule C, and 8% (12/146) via Schedule D. Therefore, some metreurynter was used for LI in 92% (134/146).

Table 1 shows the relationship of metreurynter groups with characteristic factors, parturition outcomes, and adverse events in the 146 women. With regards to characteristic factors, nulliparity, late gestational age, and post-term pregnancy were higher and PROM and BS were lower in the mini-metoro group than other two groups. Completely opposite characteristics were evident in the WOM group, while intermediate characteristics were observed in the neo-metoro group. With regards to parturition outcomes, IDI in the mini-metoro group was longer than that in the neo-

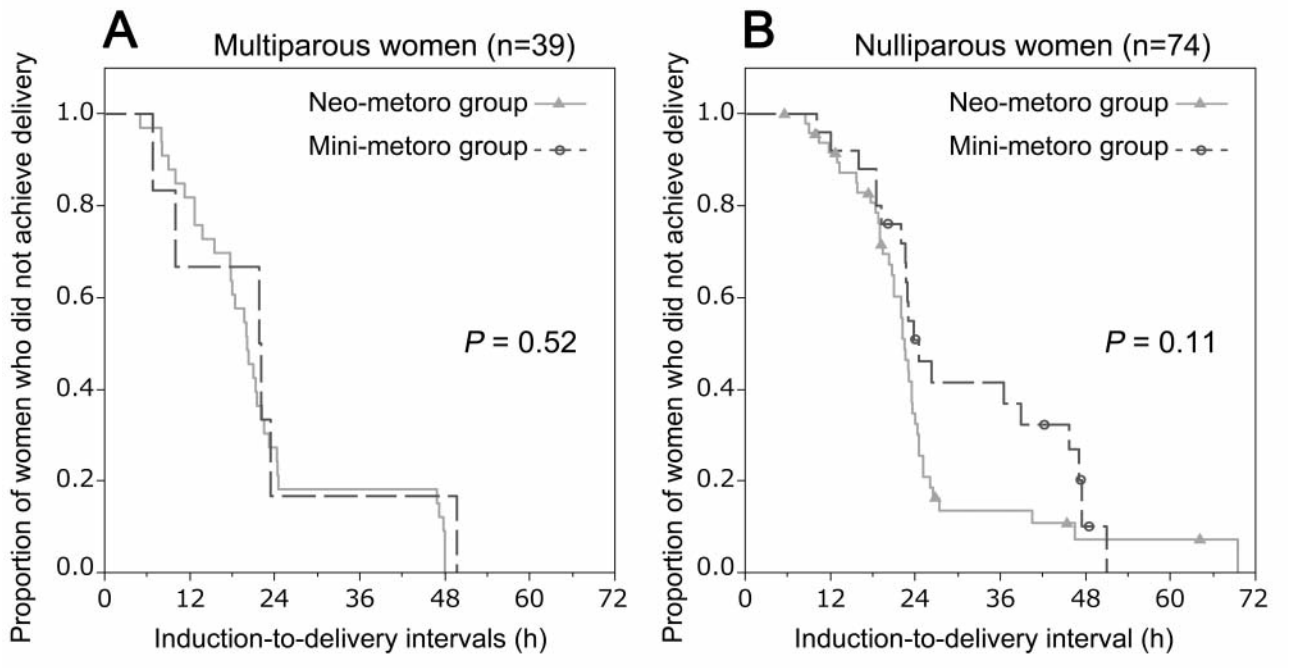


Figure 2. — Kaplan–Meier survival curve and log-rank test assessment of IDI in 113 women who underwent LI via Schedule A of the two-day induction. Markers (triangles/circles) indicate cesarean delivery, considered censored cases in the analyses. (A) multiparous women ($n$ = 39); (B) nulliparous women ($n$ = 74).

metoro group. The VDPS rate was highest in the neo-metoro group, followed by that in the WOM and mini-metoro groups. The VDF rate in the mini-metoro group was lower than that in the other two groups, but the difference was not significant. Adverse events were observed in each group but the differences were not significant. Severe incidents, such as severe neonatal asphyxia, neonatal death, uterine rupture, or umbilical cord prolapse, were not observed in this study.

Figure 1 illustrates the relationship of BS classification with parturition outcomes and characteristic factors in the 146 women. As BS increased, average IDI decreased ($p$ = 0.011) and the VDF rate increased ($p$ = 0.003). Metreurynter use was lowest in women belonging to the BS8–10 class ($p < 0.001$), and the most of the women in the mini-metoro group belonged to the BS1–3 class ($p$ = 0.037).

There is an obvious relationship between parturition outcome and parity. The overall VDPS rate was 71% (103/146) and was higher in multiparous than in nulliparous women [81% (43/53) vs 65% (60/93); $p$ = 0.035]. Furthermore, the overall VDF rate was 85% (124/146) and was higher in multiparous than in nulliparous women [96% (51/53) vs 78% (73/93); $p$ = 0.004].

Table 2 shows the results of multivariate logistic regression analysis used to assess the relationship between factors, VDPS, and VDF. The VDF rate in multiparous women was too high to analyze its relationship with parity, and hence, parity was excluded from multivariate analysis. The significant adjusted odds ratio (AOR) for VDPS was 0.30 in nulliparous women and 0.18 in women belonging to the BS1–3 class. AOR for VDPS in the neo-metoro group was 2.2, indicating an insignificant positive tendency. The significant AOR for VDF was 0.04 in women belonging to the BS1–3 class and 0.14 in women belonging to the BS4–5 class. With regards to VDF, no advantage of neo-metoro use was evident.

IDI was assessed in 113 women who underwent LI via Schedule A. Kaplan–Meier curves for multiparous women ($n$ = 39, Figure 2A) were identical between the neo-metoro and mini-metoro groups. In contrast, Kaplan–Meier curves for nulliparous women ($n$ = 74, Figure 2B) showed that the proportion of women who did not achieve delivery within 24 hours of induction initiation differed between the neo-metoro and mini-metoro groups (68% vs 49%), but this difference demonstrated not to be significant by log-rank test. To assess the effect of each factor on IDI, AOR for achieving delivery per unit time was calculated by Cox proportional hazards model (Table 3). Significant AOR was 0.45 in nulliparous women, 0.46 in obese women (whose body mass index at induction initiation was $\geq 29$ kg/m$^2$), and 0.48 in women belonging to the BS1–3 class. The AOR of the neo-metoro group was 1.5, indicating insignificant advantage of neo-metoro use for reducing IDI.

In the 113 women who underwent LI via Schedule A,

VDPS and VDF rates were 73% (83/113) and 88% (100/113), respectively. The VDPS rates were 69% and 82% in nulliparous and multiparous women ($p$ = 0.18); 47%, 75%, 87%, and 75% in women belonging to the BS1–3, BS4–5, BS6–7, BS8–10 classes ($p$ = 0.025); and 78% and 61% in the neo-metoro and mini-metoro groups, respectively ($p$ = 0.095). The VDF rates were 82% and 100% in nulliparous and multiparous women ($p$ = 0.004); 74%, 87%, 100%, and 100% in women belonging to the BS1–3, BS4–5, BS6–7, BS8–10 classes, ($p$ = 0.034); and 90% and 84% in the neo-metoro and mini-metoro groups, respectively ($p$ = 0.34).

## Discussion

In the present study, the authors evaluated and showed the effectiveness and safety of methods using neo-metoro or mini-metoro metreurynters in combination with subsequent oxytocin for LI. They also assessed the differences in parturition outcomes according to metreurynter type used at induction initiation; neo-metoro use at induction initiation might shorten IDI relative to mini-metoro use.

The overall VDF rates were 78% and 96% in nulliparous and multiparous women, respectively. In a previous study at this institution ($n$ = 315) [7], vaginal delivery rates in women with spontaneous labor onset were 91% and 97% in nulliparous and multiparous women, respectively. Therefore, in nulliparous women who underwent LI, vaginal delivery rate was lower than in women who experienced spontaneous labor onset ($p < 0.01$). In contrast, there was no difference in vaginal delivery rates between multiparous women who underwent LI and those who experienced spontaneous labor onset. These results indicate that nulliparous women attempting LI have an approximately a two-fold higher risk of cesarean delivery, consistent with other studies [8, 9].

Among the 113 women who underwent LI via Schedule A of the two-day induction using neo-metoro or mini-metoro prior to oxytocin, the VDF rates were 82% and 100% in nulliparous and multiparous women, respectively. Levy *et al*. [10] reported LI using a Foley balloon catheter prior to oxytocin ($n$ = 203) similarly to the present method. In their study, vaginal delivery rates were 78% and 99% in nulliparous and multiparous women, respectively. The authors of this study believe that their results showed similar efficacy of the Lavy's method.

With regards to parturition outcomes, the advantages of each metreurynter used at induction initiation were unclear. However, both the overall AOR for VDPS and the AOR for achieving delivery per unit time in the 113 women via Schedule A of the two-day induction showed the tendency that the neo-metoro group tended to achieve earlier delivery than the mini-metoro group. Kaplan-Meier analysis of nulliparous women via Schedule A showed the same tendency. Therefore, for achieving early delivery, neo-metoro use might confer an advantage to mini-metoro use in induction initiation. On the other hand, regarding VDF, no advantage of neo-metoro use over mini-metoro use was evident. In their randomized controlled study, Levy *et al*. [10] compared the efficacy of 30 and 80 ml balloons for cervical ripening during LI. In their study, no difference in cesarean rate was evident between the two volumes. However in their subgroup analysis, in nulliparous women, delivery rate within 24 hours was higher and IDI was shorter in the 80 ml than in the 30 ml group. Such tendencies were not observed in multiparous women of their study. Therefore, the present authors consider that neo-metoro (which has a larger balloon than mini-metro) use at induction initiation will not affect cesarean rate; however, neo-metoro use at induction initiation, especially in nulliparous women, may shorten IDI relative to mini-metoro use.

In the present study, lower BS at induction initiation was associated with lower VDPS and VDF rates and longer IDI. Failed induction is recognized to occur more often in women with an unfavorable cervix. In their prospective study ($n$ = 134), Reis *et al*. [11] suggested that unfavorable cervical maturity (gauged by abbreviated BS) at admission for LI correlates with not achieving delivery within 24 hours in nulliparous and multiparous women. In the present study, the authors showed that IDI in women with a BS $\leq 3$ is longer than in women with a BS $\geq 6$ (Table 3). In their prospective study of 1,389 nulliparous women who underwent spontaneous labor onset or LI, Vrouenraets *et al*. [8] suggested that a BS of $\leq 5$ was a risk factor for cesarean delivery (AOR 2.3) compared with a BS of $\geq 6$. In the present study, the authors showed that in nulliparous women who underwent LI, a BS of $\leq 5$ was a risk factor for failed induction (cesarean delivery), and that a BS of $\leq 3$ greatly increased this risk (Table 2).

No differences were apparent in adverse events rates between the metreurynter groups. Moreover, severe adverse incidents were not observed in this study. Concerning methods of cervical ripening and LI, it is recognized that transcervical Foley balloon catheters have a lower risk of uterine hyperstimulation but a slower effect on labor than vaginal prostaglandins [2, 12]. The authors did not directly examine rates of uterine hyperstimulation and non-reassuring fetal status in this study. Moreover, this study might be too small to evaluate the adverse events that would occur during labor and delivery. However, overall rates of the three adverse events which were assessed in this study were acceptably low and no differences in adverse events rates with metreurynter usage were evident. Therefore, the authors do not believe that metreurynter use will raise the risks of adverse events. Actually, in their experience of LI, severe incidents were rarely observed. In contrast, many Japanese obstetricians recognize that metreurynter use can cause umbilical cord prolapse [4]. In a retrospective observational study of 766 term women with cephalic presentation who underwent LI, Hirashima *et al*. [5] showed that a spherical metreurynter inflated with 200 ml or more caused

umbilical cord prolapse more often than 150 ml or less. In their case-controlled study including 370 women with LI using neo-metoro plus oxytocin, Maruyama *et al*. [6] reported a case with umbilical cord prolapse and subsequent neonatal death in the LI group. However, no well-designed studies address whether transcervical balloon catheters cause umbilical cord prolapse. The present authors believe that balloon catheters, especially neo-metoro and mini-metoro metreurynters which are used for balloons inflated with 100 ml or less, are sufficiently safe to mature the cervix and induce labor.

In this study, the authors presented an example of the methods for LI using modified metreurynters and oxytocin in Japan. They hope this paper will form the basis of further studies to solve the controversial and unsolved problems of LI in Japan.

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