Body mass index and labor outcome associated with the level of amniotic fluid lactate. A cross-sectional study of women with labor dystocia

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ABSTRACT

Introduction: Obesity is a globally growing problem. Labor dystocia is associated with obstetric complications, especially among obese pregnant women. Previous studies have shown an association between the level of lactate produced by uterine myocytes during contractions and the level of lactate in the amniotic fluid (AFL). A relationship between a high level of AFL and labor dystocia has also been demonstrated. However, it is still unknown whether the observation applies to all women with labor dystocia, regardless of body mass index (BMI).

Aims: This study investigated whether there was any difference in the level of AFL in the three BMI groups and whether there was a difference in labor outcomes between high and low AFL in the different groups.

Materials and Methods: This cross-sectional study included 1683 women from three different countries. Healthy nulliparous women in active labor were included, and they were grouped according to BMI as normal weighted (<25), overweight (≥25–29), and obese (≥30), respectively. AFL was categorized as high (≥10.1 mmol/l) and low (<10.1 mmol/l). The main outcome was the frequency of cesarean section.

Results: No difference in AFL levels was found between the three BMI groups at delivery (mean values of 8.2 vs. 8.3 vs. 8.4 mmol/l, p = .3). Obese women with high AFL had a higher frequency of cesarean section than normal-weighted women (16.2 vs. 20.7 vs. 29.2%). Other risk factors associated with cesarean section varied among the different BMI groups.

Conclusions: This study showed no difference in the mean level of AFL between women with different BMIs. Further, high AFL was associated with a higher frequency of cesarean section in all three BMI groups, suggesting that the level of AFL can in the future be used as a predictor of labor outcome among women with labor dystocia despite their BMI.

Introduction

Obesity is a globally expanding problem [1]. Labor dystocia is associated with obstetrical issues, especially among obese women [2–5]. The underlying pathophysiology of labor dystocia remains unclear, but high maternal body mass index (BMI) is associated with a higher frequency of prolonged first stage of labor [2–5]. Several studies have shown that a high BMI during pregnancy increases the risk of cesarean section (CS) [2,3,5–7]. A recent Norwegian study reported that the incidence of emergency CS increased with increasing maternal BMI despite parity [7]. Further, being overweight increases, the risk of complications associated with CS, such as excessive postpartum bleeding, thrombosis, infections, and uterine rupture during vaginal delivery after a previous CS. To prevent the risk of CS among women with a high BMI, it is essential to better understand the underlying mechanisms of uterine dysfunction.

The uterus is a large muscle that generates strong and synchronized contractions during active labor (8). As in other smooth muscles, stimulation of the uterus leads to an influx of calcium, causing actin-myosin-based contractions of uterine myocytes [8]. The uterus differs from other muscles because it produces lactate during exertion under aerobic and anaerobic conditions [9,10]. Intermittent production of lactate and acidification of the uterus is caused by transient hypoxia (oxygen deficiency of the uterus), as the blood vessels of the uterus occlude during a contraction [8]. Usually, lactate provides energy for the hard-working uterine muscle [10]. However, prolonged labor is
associated with irregular contractions, which lead to prolonged hypoxia, the accumulation of lactate, and decreasing pH [9,10]. The acidification of the uterus inhibits the influx of calcium in myocytes, resulting in weak contractility and dystocic labor [9]. The level of lactate produced by uterine myocytes during contractions correlates with the level of lactate in the amniotic fluid (AFL) [9]. Earlier studies have shown an association between a high level of AFL and labor dystocia [11,12].

Both labor dystocia and high maternal BMI are severe issues in obstetric care. New methods for the diagnosis and management of labor dystocia are needed to prevent complications and CS. Earlier research suggests that AFL can be used as a predictor of labor outcomes, but it is unknown whether the method applies to all women with labor dystocia, despite their BMI. No previous studies have investigated whether women with high and low BMI differ in AFL levels during labor. A better understanding of the underlying pathophysiology may create better preconditions and labor outcomes for women with obesity.

This study aimed to investigate whether there is any difference in the level of AFL in the three BMI groups and whether there is a difference in labor outcome between high and low AFL in the different groups.

**Materials and methods**

A flowchart of the study design is presented in Figure 1. This cross-sectional multicenter study was performed in delivery wards in Sweden, Switzerland, and France. This is a secondary analysis of the data collected in the main study [13]. Nulliparous women in active labor at the selected study locations were invited to participate. Inclusion criteria were singleton pregnancy, gestational age between 37 and 42 weeks, and no maternal/fetal chronic and/or pregnancy-related conditions. Spontaneous onset of labor, regular contractions, and cervical dilation of at least 3 cm were required before the women were invited to participate in the study. A group of midwives and medical doctors at each clinic assisted with data collection and the enrollment of women in the study.

For all included deliveries, a partogram was recorded to monitor the progress of labor. Included clinics used different alert lines of the partogram, as per local guidelines. Still, two criteria for labor dystocia were defined: if the progress of cervical dilation crossed the action line in the partogram used at the clinic, or if labor progress was arrested for two hours or more.

Oxytocin was administered according to local clinical guidelines. The dose of oxytocin added to the infusion did not differ between the included clinics, and a low dose of oxytocin was used (3.3 Mu/min).

BMI was calculated as weight in kilograms divided by height in meters squared (kg/m²) for all women included in the study. BMI was calculated using weight and height documented in every woman’s medical journal by a midwife during the first visit at the maternity clinic in early pregnancy. Based on the level of BMI, the women were divided into three BMI groups: normal BMI (< 25), overweight (25–29), and obesity (≥30), respectively (Figure 1).

**Labor outcomes**

Labor outcomes were categorized as CS or vaginal delivery (spontaneous vaginal, vacuum extraction/forceps). The primary outcome measure in this study was the frequency of CS (Figure 1).

**Definition of AFL**

The AFL cutoff value has, in earlier publications, been defined with a receiver operator characteristic (ROC) curve to discriminate between dystocic and normal labor. The ROC curve was generated in the original study from the data by plotting true positives (sensitivity) against false positives (1-specificity) [13]. A cutoff value of < or ≥10.1 mmol/l for high and low AFL was used, as it was considered to best discriminate between an increased risk of CS or vaginal delivery. Based on the level of AFL, the women in this study were divided into two groups: low and high values of AFL levels (<10.1 and ≥10.1 mmol/l, respectively).

A sample of amniotic fluid (AF) was collected vaginally three times during labor in the main study. Upon arrival at the delivery ward, the membranes were broken when oxytocin stimulation was started (if needed) and within 30 min before delivery. The sample was collected when the amniotic fluid was flowing spontaneously or after amniotomy for augmentation of labor. The membranes were not allowed to rupture for the single purpose of collecting amniotic fluid for the study. A 2-ml standard syringe was used to collect the sample, and 50 μl was required to analyze the value of AFL.

Previous studies have shown that the value of AFL is not affected by meconium, whereas a high concentration of blood (>10%) decreases the AFL value [14].
Therefore, the meconium-contaminated samples were included, but samples intensely colored red by blood were excluded [13].

The last sample, collected just before labor, was used in this subanalysis. A particular device (LMU061, Obstecare AB, Sweden) adapted to measure lactate in amniotic fluid was used. The device measured lactate concentrations between 0.5–25.0 mmol/l. At a lactate concentration of 11 mmol/l, the device had a coefficient of variation of approximately 3% [14]. The lactate recognition system was based on lactate oxidase with amperometric detection of enzymatically produced hydrogen peroxide [14]. The AFL levels were analyzed, blinded, and stored in the device by the midwife.

Figure 1. Flowchart of the study design. BMI: body mass index. AFL: amniotic fluid lactate.

**Type of data**

Materials for the study were recorded in an Internet database (Dystocia) created specifically for the study, available for use by all included clinics, and secured with a password.

- **Maternal background data collected**: maternal age (y), level of education, smoking, BMI, and gestational age (d).
- **Fetal background data collected**: gender (boy or girl), weight (g), height (cm), head circumference (cm), and fetal position.
- **Maternal delivery data**: AFL values (mmol/l), time of latency phase (h), time of active labor (h), active...
time of pushing (min), oxytocin stimulation, use of epidural anesthesia, labor outcome (spontaneous vaginal, vacuum extraction/forceps or CS), indication for CS (labor dystocia, fetal distress, other), and postpartum complications (rupture of sphincter and rectum, bleeding, fever) were retrieved.

Fetal delivery data collected: acid–base status of arterial umbilical cord blood, Apgar score (0–10 in 1, 5, 10 min ago), transport to neonatal intensive care.

Statistical analysis

The data were divided into three groups based on maternal BMI <25, ≥25–29, ≥30. Descriptive analyses were made on all variables. Differences in continuous variables between the groups were studied using an independent sample t-test. The results are presented as means with standard deviations (SD).

Differences in categorical variables between the groups were calculated using the Wald Chi-Squared test and Fisher’s exact test for smaller groups with frequencies <5. The results are expressed as proportions with percentages (%). Further, differences in labor outcomes combined with differences in BMI were analyzed and presented in the same way as other categorical variables.

Logistic regression was used to study the associations between possible known risk factors and CS among women with different BMI groups. The associations were analyzed first for each independent factor (univariate) and then adjusted for all the significant factors (multivariate) separately for different BMI. The results are presented as proportions with percentages (%), as well as unadjusted and adjusted odds ratios (OR) with corresponding 95% confidence intervals (CI).

The risk factors for CS reported in previous studies (such as maternal age >30 years, BMI >30, gestational age >280 days, high fetal weight >4000 g, high AFL-level >10.1 mmol/l, and the use of oxytocin (yes/no)) were used as references. Statistical analyses were performed using IBM SPSS Statistics 26.0. P-value <.05 was considered to be statistically significant.

The study was approved by the regional ethics committee of the Karolinska Institute, Stockholm (2010/199-31/1). All the clinics involved added a local addendum from their ethics committee to the original ethical authorization. Written informed consent was obtained from all women before inclusion in the study.

Results

A total of 1683 women from the original study had a BMI noted at the first visit to the maternity center and were included in this study (Figure 1). Table 1 presents the distribution of maternal BMI among the three countries included in the study. Sweden had

| Country | Total (n = 1683) | BMI < 25 (n = 1249) | BMI ≥ 25–30 (n = 324) | BMI ≥ 30 (n = 110) | p-value |
|---------|-----------------|---------------------|---------------------|-------------------|---------|
| Sweden  | 1385            | 1055 (76.2)         | 250 (18.0)          | 80 (5.7)          | <.001*  |
| France  | 37              | 30 (81.1)           | 3 (8.1)             | 4 (10.8)          |         |
| Switzerland | 261          | 164 (62.8)          | 71 (27.2)           | 26 (10.0)         |         |

Table 2. Maternal and fetal background characteristics.

| Background data | BMI < 25 (n = 1249) | BMI 25–29 (n = 324) | BMI ≥ 30 (n = 110) | p-value |
|-----------------|---------------------|---------------------|-------------------|---------|
| Maternal        |                     |                     |                   |         |
| Age (y)         | 30.5 (4.8)          | 30.7 (4.6)          | 30.2 (5.4)        | .06     |
| >30 years (%)   | 756 (60.6)          | 195 (60.6)          | 61 (55.5)         | .6      |
| Gestational age (d) | 281 (7.2)       | 282 (7.1)           | 281 (8.2)         | <.02*   |
| >280 days (%)   | 761 (60.9)          | 221 (68.2)          | 71 (64.6)         | <.05*   |
| Smoking (%)     | 160 (13.1)          | 47 (14.7)           | 35 (32.7)         | <.001*  |
| Highest education (%) | 138 (11.1)    | 50 (15.5)           | 26 (23.6)         | <.001*  |
| Highschool      | 478 (38.5)          | 142 (44.1)          | 56 (50.9)         |         |
| Gymnasium       | 627 (50.4)          | 130 (40.4)          | 28 (25.5)         |         |
| College         |                     |                     |                   |         |
| Fetal           |                     |                     |                   |         |
| Gender, boy (%) | 628 (50.6)          | 159 (49.4)          | 51 (46.4)         | .7      |
| Weight (g)      | 3528 (420)          | 3675 (484)          | 3628 (543)        | <.02*   |
| Newborn > 4kg (%)| 148 (11.9)         | 72 (22.4)           | 29 (26.4)         | <.001*  |
| Newborn < 3kg (%)| 134 (10.8)         | 15 (4.7)            | 13 (11.8)         | <.003*  |
| Height (cm)     | 50.7 (2.0)          | 51.2 (2.0)          | 51.1 (2.2)        | <.001*  |
| Head circumference (cm) | 34.9 (1.4)   | 35.2 (1.5)          | 35.1 (1.4)        | <.008*  |
| Anterior posterior position (%) | 98 (7.9)       | 25 (7.8)            | 10 (9.1)          | .9      |

The deliveries are divided in groups by maternal BMI. The results are presented as means with standard deviations (SD) or proportions with column percentages (%).
significantly fewer obese women than the other two countries (5.7 vs. 10.8 vs. 10.0%, p < .001).

Maternal and fetal background characteristics are presented in Table 2. The mean age of the included women was 30.5 years (SD 4.8), and the mean gestational age of the pregnancies was 281 days (SD 7.3). A significant difference was seen in gestational age, with postdated pregnancies more common among the overweighted women (p = .05). More smokers were found in the obese group (p < .001), and the included obese women had a lower level of education (p < .001).

Fetal data showed no differences according to gender. More newborns of a large birthweight were found in the obese group; 26.4% gave birth to a fetus >4000 g (p < .001), but 11.8% gave birth to a fetus <3000 g (p < .003, Table 2). Significantly more deliveries ended in a CS in the obese group (9.1 vs. 10.3 vs. 16.4%, p < .001, Table 3), and it was more common for the CS to be performed before the second stage of labor (7.9 vs. 7.8 vs. 15.5%, p = .002, Table 3). More oxytocin was used in the overweighted/obese group than in normal-weighted deliveries (66.1 vs. 74.5 vs. 73.6%, p < .001, Table 3). There was no difference in the AFL values between the groups. Mean values of the AFL analyzed within 30 min before delivery were 8.2 vs. 8.3 vs. 8.4 mmol/l (p = .3), respectively, for the three groups. The number of deliveries with an AFL value \( \geq \)10.1 mmol/l did not differ between the groups (15.9 vs. 17.7 vs. 21.8%, p = .2, Table 3). More cesareans were conducted in the group with an AFL \( \geq \)10.1 mmol/l in all three BMI groups (16.2 vs. 21.1 vs. 29.2%) compared to those with low AFL values (7.8 vs. 7.9 vs. 12.8%).

In the logistical regression analysis, oxytocin was associated with a CS. The risk of having a CS increased 4.6 times (4.6 CI: 2.6–8.3) when oxytocin was used. An AFL value \( \geq \)10.1 mmol/l also had an association with CS; the risk was doubled (2.0 CI: 1.4–3.0). The mother’s age (>30 years [1.9 CI; 1.3–2.8]), and high fetal weight (>4000 g, [1.6 CI; 1.04–2.4]) were also associated with the outcome (Table 4). Subsequently, each BMI group was studied separately. Differences were noted between the groups. In the normal BMI group, the risk factors remained the same as in the entire data. The use of oxytocin and a high AFL value were the factors that most affected the outcome. The maternal age and fetal weight were significant influences (Table 4). Only a high AFL value and maternal age affected the outcome in the overweight group (Table 5). In the obese group, other factors that influenced the outcome were identified, such as maternal level of education (2.9 CI; 1.01–8.3) and postdated pregnancies (5.4 CI; 1.17–24.8). An adjustment analysis revealed that gestational age remained the leading risk factor (5.5 CI: 1.2–26.1) (Table 6).

### Table 3. Maternal and fetal delivery characteristics.

| Delivery data | BMI < 25 (n = 1243) | BMI 25–29 (n = 322) | BMI \( \geq \) 30 (n = 110) | p-value *
|----------------|---------------------|---------------------|---------------------|---------------------|
| **Maternal**   |                     |                     |                     |                     |
| AFL levels at delivery |                     |                     |                     |                     |
| Mean value (mmol/l) | 8.2 (2.1)           | 8.3 (2.0)           | 8.4 (2.0)           | .3                 |
| AFL \( \geq \) 10.1% | 198 (15.9)          | 57 (17.7)           | 24 (21.8)           | .2                 |
| Cervical dilation at inclusion | 7 (2.5)             | 7 (2.6)             | 6 (3.0)             | .04*               |
| Labor outcome (%) |                     |                     |                     |                     |
| Spontaneous vaginal | 925 (74.4)          | 232 (72.1)          | 79 (71.8)           | .6                 |
| Vacuum/forceps | 205 (16.5)          | 57 (17.7)           | 13 (11.8)           | .4                 |
| Cesarean section | 113 (9.1)           | 33 (10.3)           | 18 (16.4)           | .04*               |
| Indication for cesarean (%) |                 |                     |                     |                     |
| Labor dystocia | 78 (69.0)           | 24 (72.8)           | 14 (77.8)           | .6                 |
| Fetal distress | 28 (24.8)           | 8 (24.2)            | 3 (16.7)            | .8                 |
| Other | 7 (6.1)              | 1 (3.0)             | 1 (5.6)             | .9                 |
| The active time of delivery (h) | 8.9 (5.0)           | 10.0 (5.6)          | 9.0 (4.4)           | .2                 |
| Time of pushing (h) | 0.48 (0.4)          | 0.47 (0.4)          | 0.46 (0.5)          | .2                 |
| Cesarean before pushing (%) | 98 (7.9)            | 25 (7.8)            | 17 (15.5)           | .02*               |
| Oxytocin stimulation (%) | 822 (66.1)          | 240 (74.5)          | 31 (73.6)           | <.001*              |
| Epidural anesthesia (%) | 767 (61.7)          | 216 (67.1)          | 76 (69.1)           | .09                |
| Rupture of sphincter and/or rectum (%) | 72 (6.9)            | 21 (7.5)            | 4 (4.6)             | .6                 |
| Postpartum hemorrhage |                     |                     |                     |                     |
| Volume (ml) | 540 (466)           | 569 (454)           | 495 (392)           | .9                 |
| >1000 ml (%) | 86 (10.0)           | 27 (10.3)           | 6 (7.2)             | .7                 |
| Postpartum fever > 38°C (%) | 85 (6.8)            | 26 (8.1)            | 7 (6.4)             | .7                 |
| **Fetal** |                     |                     |                     |                     |
| Arterial umbilical cord blood pH < .10 (%) | 35 (3.2)            | 13 (4.5)            | 4 (4.0)             | .5                 |
| Apgar < 7 at the age of 5 min (%) | 19 (1.5)            | 5 (1.6)             | 2 (1.8)             | .97                |
| Transport to neonatal intensive care (%) | 51 (4.1)            | 18 (5.6)            | 2 (1.8)             | .2                 |

The deliveries are divided into groups by maternal BMI. The results are presented as means with standard deviations (SD) or proportions with column percentages (%).
New additional methods for the diagnosis and management of labor dystocia are needed to prevent complications and unnecessary CS, especially in deliveries where the mothers are obese. Earlier research suggests that AFL can be used as a predictor of labor outcomes, as it reflects the current metabolic status of the uterus. Still, it is unknown whether the method applies to all women with labor dystocia, regardless of their BMI. This study showed no difference in the mean level of AFL between women with normal weight, overweight, or obesity.

**High BMI and labor dystocia**

The definition of labor dystocia varies in different studies [15], which is problematic, as incorrect diagnosis contributes to increased oxytocin stimulation and an increased risk of a CS. Women in this study were...
diagnosed with labor dystocia based on the partogram, as defined differently in all three countries. This makes the definition not wholly reliable. Further, almost all the women included in this study received oxytocin. A high rate of oxytocin stimulation has been reported in earlier studies [16]. A previous Swedish study showed as the main result that many women receiving oxytocin did not meet the criteria for labor dystocia [17]. In a Cochrane review from 2013, Bugg et al. [18] showed that despite oxytocin stimulation according to guidelines, no more normal deliveries occurred. Time of labor was shorter, but the rate of spontaneous vaginal deliveries did not increase. Earlier studies have also reported that cervical dilation is initially slow until 5 cm, instead of the linear progress presented in the partogram [18]. Such clinical inconsistencies indicate a need for new methods for diagnosing and managing labor dystocia, especially in complicated deliveries, such as those involving maternal obesity. CS in this group of women suggests a higher risk of complications compared to normal-weight women. This information must be included when labor with maternal obesity is handled.

In this study, women with a high BMI had less progress of cervical dilation at inclusion than those with low BMI. These findings follow earlier research suggesting that women with adiposity have a longer duration in the first stage of labor [2–5]. Accepting slower progress among groups such as overweight women instead of following the traditional linear partogram could reduce unnecessary interventions such as a CS. In this study, it seems that the total time of labor was the same among all BMI groups, although women with a high BMI were diagnosed with labor dystocia earlier in cervical progress. The question is whether adiposity is related to an initially slow cervical dilation followed by accelerating progress, or whether women with a high BMI receive the diagnosis of labor dystocia earlier than those with a low BMI in an attempt to avoid possible complications caused by the combination of labor dystocia and a high BMI.

There is evidence of weaker uterus contractility among women with a high BMI [8,19,20], but the complex mechanisms underlying prolonged labor due to adiposity remain unclear. Some studies suggest that an increasing level of adiposity markers, such as cholesterol, LDL, and leptin, inhibits calcium influx in uterine myocytes [21,22], resulting in opposing effects on oxytocin and ineffective contractions. However, in these cases, one can assume that women should show a higher level of AFL in their uterus. This is not the case in this study. However, we can speculate whether these factors are essential to the development of dystocic labor. Even women with normal body weight can have high levels of, for example, cholesterol and LDL, although such findings are more common among obese women. Earlier research has also indicated that adiposity is associated with decreased expression of

| Maternal age (y) >30 years | Cesarean section / n/total (%) | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---------------------------|-------------------------------|------------------------|----------------------|
| No                        | 4/49 (8.2)                    | Ref                    | Ref                  |
| Yes                       | 14/61 (23.0)                  | 3.4 (1.02–10.95)*      | 2.8 (0.8–9.9)        |
| Smoker                    |                               |                        |                      |
| Yes                       | 10/72 (13.9)                  | Ref                    |                      |
| No                        | 6/35 (17.1)                   | 1.3 (0.43–3.87)        |                      |
| Collage educated          |                               |                        |                      |
| No                        | 10/82 (12.2)                  | Ref                    | Ref                  |
| Yes                       | 8/28 (28.6)                   | 2.9 (1.01–8.3)*        | 2.2 (0.7–6.9)        |
| Gestational age >280 days |                               |                        |                      |
| No                        | 2/39 (5.1)                    | Ref                    |                      |
| Yes                       | 16/71 (22.5)                  | 5.4 (1.17–24.8)*       | 5.5 (1.2–26.1)*      |
| Fetal weight (g) >4000 g  |                               |                        |                      |
| No                        | 12/81 (14.8)                  | Ref                    |                      |
| Yes                       | 6/29 (20.7)                   | 1.5 (0.5–4.5)          |                      |
| Fetal weight < 3000 g     |                               |                        |                      |
| Yes                       | 0/13 (0)                      | Ref                    |                      |
| No                        | 18/97 (18.6)                  | –                      |                      |
| AFL >10.1 mmol/l          |                               |                        |                      |
| No                        | 11/86 (12.8)                  | Ref                    |                      |
| Yes                       | 7/24 (29.2)                   | 2.8 (0.95–8.3)         |                      |
| Oxytocin                  |                               |                        |                      |
| No                        | 1/29 (3.5)                    | Ref                    |                      |
| Yes                       | 17/81 (21.0)                  | 7.4 (0.94–58.7)        |                      |

The associations are adjusted for significant factors. The results are presented as proportions with row percentages (%) and unadjusted and adjusted odds ratios (OR) with a corresponding 95% confidence interval.
oxytocin receptors, which evolves resistance to oxytocin stimulation [20]. If there is resistance, it makes the management of labor dystocia particularly challenging among women with a high BMI [19]. Thus, future studies on the pathophysiology of dysfunctional labor and oxytocin stimulation in women with high BMI are of high priority.

**High AFL and labor outcomes**

Previous studies suggest that a high AFL can predict whether a CS is needed among women with labor dystocia [14,16]. However, no earlier studies have investigated whether the observation applies to all women with labor dystocia, regardless of BMI. An analysis of the AFL and labor outcomes for the entire study population in this study revealed that those with high AFL had a higher frequency of CS. These results confirm the findings from previous studies. Further, the results from this study showed no difference in the mean level of AFL between women with high and low BMI, indicating that they equally develop an accumulation of lactate in the uterus during labor dystocia and that AFL can be used as a predictor of labor outcome among women with labor dystocia, regardless of their BMI.

**Strengths and limitations**

A strength of this study is that it was performed in different European countries, hence the inclusion of women with different socioeconomic backgrounds. Another strength is that the level of AFL was analyzed with a unique device adapted for the measurement of lactate in amniotic fluid, which made the measurement objective. We also analyzed the associations between several possible risk factors and CS, and the results were adjusted for all the significant factors separately for low and high BMI.

One limitation of this study is that there were several criteria for diagnosing labor dystocia, making the definition quite broad. The study included women in need of oxytocin stimulation based on the clinical assessment of the obstetrician or midwife, even if the partogram of cervical dilation had not crossed the action line. Therefore, there is a risk that some of the women classified as dystocic in this study did not have labor dystocia. As discussed earlier, the lack of general criteria for diagnosing labor dystocia is problematic, and consensus on a definition is missing. There is a need for new additional methods for the diagnosis and management of these labors.

**Conclusions**

The results from this study showed no difference in the mean level of AFL between women with high and low BMI, indicating that they equally develop an accumulation of lactate in the uterus during dystocic labor. Further, high AFL was associated with a higher frequency of CS in all three BMI groups, suggesting that the level of AFL can in the future be used as a predictor of labor outcome among women with labor dystocia, regardless of their BMI.

**Disclosure statement**

The authors of the article report no conflicts of interest.

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