in vivo *38*: 299-307 (2024)
doi:10.21873/invivo.13439

Maternal and Perinatal Outcome After Induction of Labor *Versus* Expectant Management in Low-risk Pregnancies Beyond Term

MATHIEU PFLEIDERER, ELENA GILMAN, BERTHOLD GRÜTTNER, JESSIKA RATIU, PETER MALLMANN, SUNHWA BAEK, DOMINIK RATIU and NINA MALLMANN-GOTTSCHALK

Department of Gynecology and Obstetrics, University Hospital of Cologne, Medical Faculty, Cologne, Germany

Abstract. *Background/Aim: Due to still controversial discussion regarding appropriate termination of low-risk singleton pregnancies beyond term, this retrospective study aimed to evaluate maternal and perinatal outcomes depending on gestational age and obstetric management. Patients and Methods: This is a retrospective cohort analysis including 3.242 low-risk singleton deliveries at the Department of Obstetrics of the University Hospital of Cologne between 2017 and 2022. According to current national guidelines, the cohort was subdivided into three gestational groups, group 1: 40+0-40+6 weeks, group 2: 40+7-40+10 weeks and group 3>40+10 weeks. Results: In our cohort, advanced gestational age was associated with higher rates of secondary caesarean sections, lower rates of spontaneous vaginal deliveries, higher rates of meconium-stained amniotic fluid and depressed neonates with APGAR < 7 after 5 min. Analyzing obstetric management, induction of labor significantly increased the rate of secondary sections and reduced the rate of spontaneous deliveries, while the percentage of assistant vaginal deliveries was independent from obstetric management and gestational age. Induction of labor also significantly enhanced the need for tocolytic subpartu and epidural anesthesia and caused higher rates of abnormalities in cardiotocography (CTG), which also resulted in more frequent fetal scalp blood testing; however, the rate of fetal acidosis was independent of both obstetric management and gestational age. Conclusion: Our study supports expectant management of low-risk pregnancies beyond term, as induction of labor increased the rate of secondary sections and did not improve perinatal outcome.*

Correspondence to: Nina Mallmann-Gottschalk, Department of Gynecology and Obstetrics, University Hospital of Cologne, Kerpener Str. 62, 50137 Cologne, Germany. Tel: +49 2214783440, Fax: +49 2214784929, e-mail: nina.mallmann-gottschalk@uk-koeln.de

Key Words: Low-risk pregnancy, obstetric management beyond term, induction of labor, delivery mode, perinatal outcome, maternal outcome.

The appropriate management of low-risk singleton pregnancies beyond term remains controversial. The prevalence of post-term pregnancies (>42+0 gestational weeks) in European countries ranges from 0.8-8.1% (1), which is due to different policies regarding obstetric management beyond term and variable accuracy in ultrasound-based determination of the gestational age. In Germany, the reported rate of post-term deliveries is approximately 1% (2). In contrast, approximately 33%-48% of pregnancies are not delivered at the estimated delivery date of 40+0 (2); thus, management of singleton low-risk pregnancies beyond term until 42+0 is of particular interest.

Retrospective studies have shown that post-term deliveries are associated with adverse maternal and neonatal outcomes. Increase of dysfunctional labor and post-partum hemorrhage has been reported, and shoulder dystocia and obstetric trauma are related to increased birth weight and macrosomia (3, 4). Post-term newborns have an increased risk of neonatal acidosis, meconium aspiration syndrome, neurological complications, and neonatal sepsis (3-5). Furthermore, there is evidence for strong increase of perinatal mortality in post-term pregnancies (6, 7). However, retrospective data indicate that risk of perinatal morbidity and mortality does not appear rapidly but develops continuously from the 39th gestational week (6, 8-13). Therefore, taking into account additional data from randomized clinical trials (14, 15), several national guidelines implemented recommendations for induction of labor at 41 weeks or even support induction of labor at or beyond 37 gestational weeks (16, 17). In addition to the proposed reduced fetal morbidity and mortality, several studies have also reported a lower caesarean section (C-

section) rate following the induction of labor (18, 19). However, other studies have shown no benefit for induction of labor regarding perinatal mortality (5, 19, 20), whereas others have reported increased c-section rate (10, 21, 22).

Since most of these studies are retrospective and status of included patients as low-risk-pregnancies is debatable, current international guidelines are still discussed and differentially implemented in the respective countries. Furthermore, various policies of fetal monitoring during expectant management beyond term and insufficient accuracy in estimating the delivery date by ultrasound measurement complicate interpretation of the available data. The German dataset from quality assurance indicates that fetal mortality rates in Germany seem to be lower than those in other countries (2, 23) and do not support the recommendation of induction of labor early beyond term due to the lack of proof of benefit (24). Thus, in current national guidelines for singleton low-risk pregnancies induction of labor is highly recommended beyond 42+0, should be recommended beyond 40+10 and can be offered beyond 40+7. At term until 40+7, close fetal and maternal antenatal monitoring is recommended (25).

In the present retrospective study, we assessed the outcomes of low-risk singleton pregnancies beyond term managed in routine clinical practice according to current national guidelines. For this, we analyzed mode of delivery as well as various maternal and perinatal parameters depending on the gestational age beyond term and compared the outcome after induction of labor with expectant management.

Patients and Methods

Study design and population. In the present retrospective study, data from 3.242 women, who delivered beyond term at the Department of Obstetrics of the University Hospital of Cologne between 2017 and 2022, were analyzed. Only nulliparous or multiparous women with low-risk singleton pregnancies were included. Low-risk pregnancy was defined as presence of fetal cranial position without any fetal malformations or intrauterine growth restriction. Women with primary or pregnancy-induced diseases (*e.g.*, diabetes mellitus, hypertension, renal insufficiency) and prior c-sections were excluded from the study. The calculated gestational age using the last month period was reviewed by measurements of crown-rump-length (CRL) in early pregnancy using ultrasound. Due to current national guidelines a deviation from the due delivery date of at least seven days was corrected (25). For comparative analysis, the cohort meeting the inclusion criteria was subdivided into three groups depending on gestational age at delivery: group 1: 40+0-40+6 weeks, group 2: 40+7-40+10 weeks and group 3: >40+10 weeks, which results from recommendation of current national guidelines (26). Due to the retrospective data collection, the accuracy and quality of the data were dependent on the person responsible for the documentation.

Data analysis. Baseline characteristics as maternal age, parity, number of preventive medical examinations during pregnancy, data of the neonates (weight, length, and head circumference at birth) are shown according to the gestational groups. The mode of delivery was stratified by obstetric management comparing induction of labor and expectant management for each gestational group. Vaginal deliveries, secondary C-sections as well as assisted vaginal deliveries by vacuum extraction or forceps were included, primary C-sections were excluded. Induction of labor followed medical indication. If medical indication was present, women with immature cervix received prostaglandin E1 (misoprostol, oral) or prostaglandin E2 (minprostin or dinoprostone, vaginal) or balloon catheter or a combination of these. All maternal and perinatal parameters [pathological cardiotocography (CTG), tocolysis subpartu, epidural anesthesia, episiotomy, obstetric anal sphincter injuries (OASIS), fetal scalp blood testing, premature rupture of membranes (PROM), shoulder dystocia, meconium-stained amniotic fluid, retained placenta, score for Appearance, Pulse, Grimace, Activity and Respiration (APGAR) 5 min <7 and pH of umbilical artery (UA) <7.20 and duration of birth] considered for analysis were extracted from birth documentation database. Episiotomies usually followed medical indication, whereas prophylactic episiotomies were not performed. Severe perineal laceration (grade 3 and 4) including obstetric anal sphincter injuries (OASIS) were also analyzed. Retained placenta was defined as an absent, delayed and/or incomplete expulsion of the placenta such that the postpartum period was longer than 30 min. Due to the national guidelines (25) different parameters (umbilical artery pH <7.20 and APGAR-Score 5 min <7) defined obstetric quality and assessed perinatal outcome. Other parameters as Bishop-Score and maternal weight at time of birth were not reliably documented and could not be assessed from our dataset.

Statistical analysis. All statistical analyses were carried out using SPSS software version 29 (IBM, International Business Machines Corporation, Armonk, NY, USA). Continuous normally distributed variables are reported as mean and standard deviation. Categorical variables are presented as frequencies and percentages. For categorical data, the statistical tests used were the chi-square test and the Fisher's Exact test. The *t*-test for independent samples was used to compare numeric values between two groups. The assumption for parametric testing was met due to sample size of the groups. A *p*-value below 0.05 was considered statistically significant.

Results

The cohort included 3,242 low-risk-singleton pregnancies beyond term. For comparative analysis, the various parameters defining maternal and perinatal outcomes were analyzed in three subgroups of gestational age at delivery (group 1: 40+0-40+6 weeks, group 2: 40+7-40+10 weeks and group 3: >40+10 weeks). The characteristics of our cohort are summarized in Table I. The mean age was 33 years. Younger women tended to deliver later at advanced gestational age, but the correlation between maternal age and gestational age at birth was inconsistent. Regarding parity, multiparous women delivered significantly earlier than nulliparous women. Due to the guidelines' recommendations for antenatal fetal and maternal monitoring, the number of preventive medical examinations in gravitate significantly increased with advancing gestational age. All three neonatal dimensions at birth (weight, length, and head circumference)

Table I. *Baseline characteristics of the cohort dependent on gestational age.*

		N=3,242	Mean±SD	*p*-Value
Maternal age	40+0-40+6	2,396	33.24±5.26	
	40+7-40+9	628	32.67±4.88	0.040
	≥40+10	218	32.82±4.73	n.s.
	Total	3,242	33.10±5.16	
Gravida	40+0-40+6	2,396	2.08±1.21	
	40+7-40+9	628	1.93±1.16	0.015
	≥40+10	218	1.80±1.22	0.003
	Total	3,242	2.03±1.21	
Para	40+0-40+6	2,396	1.72±0.91	
	40+7-40+9	628	1.59±0.81	0.002
	≥40+10	218	1.50±0.81	0.001
	Total	3,242	1.68±0.88	
Preventive medical examinations during pregnancies (no.)	40+0-40+6	1,821	11.02±2.91	
	40+7-40+9	494	12.03±3.09	<0.001
	≥40+10	172	12.30±3.30	<0.001
	Total	2,487	11.31±3.01	
Fetal weight (g)	40+0-40+6	2,396	3560.88±421.54	
	40+7-40+9	628	3647.24±403.58	<0.001
	≥40+10	218	3709.43±403.23	<0.001
	Total	3,242	3587.60±419.43	
Fetal length (cm)	40+0-40+6	2,386	52.40±2.67	
	40+7-40+9	625	52.89±2.51	<0.001
	≥40+10	217	53.15±4.36	<0.001
	Total	3,228	52.55±2.80	
Fetal head circumference	40+0-40+6	2,384	35.37±1.99	
(cm)	40+7-40+9	625	35.65±1.67	0.007
	≥40+10	217	35.79±3.27	0.011
	Total	3,226	35.45±2.05	

showed a significant increase with advancing gestational age. First, we analyzed the mode of delivery according to gestational age and stratified by obstetric management comparing induction of labor and expectant management. For this, 3,005 pregnancies were included; women undergoing primary caesarian sections (c-sections) were excluded. As shown in Table II, the rate of secondary c-sections in the expectant group increased with advancing gestational age. Correspondingly, with advancing gestational age the rate of spontaneous vaginal delivery decreased, while the rate of assisted vaginal delivery remained unchanged. Comparing induction of labor with expectant management, induction of labor led to a significant decrease of spontaneous deliveries in the first group (53.7% *vs*. 65.8% $p<0.001$). Correspondingly, the rate of secondary c-sections was increased significantly (30.2% *vs*. 14.7% $p<0.001$) while the rate of assisted vaginal deliveries remained unaffected. At later gestational weeks (groups 2 and 3) the delivery mode was independent from obstetric management. However, induction of labor still tended to increase the rate of secondary c-section although not statistically significantly. In the second part of our study, we analyzed further maternal parameters depending on gestational age and obstetric management as shown in Table III. In the expectant group, the rate for severe perineal lacerations and anal sphincter injuries (OASIS) increased with advanced gestational age. Similarly, the duration of labor was longer at advanced gestational age (Table IV). All other maternal parameters were independent from gestational age. Evaluating obstetric management, induction of labor enhanced the need for tocolytics subpartu (10.7% *vs*. 6.5% $p<0.001$ in group 1; 14.9% *vs*. 5.4% $p<0.001$ in group 2) and epidural anesthesia (37.1% *vs*. 31.3% $p=0.018$ in group 1; 49% *vs*. 28.2% $p=0.036$ in group 3) and also significantly increased the rate of PROM (30.1% *vs*. 18.8% in group 1) (Table III). Additionally, induction of labor reduced duration of labor, however, statistically significantly only in group 2 (4.74 *vs*. 5.94 $p=0.013$) (Table IV). Regarding the rates of episiotomies in group 1 and 2 and OASIS in all three groups, there was no difference with respect to obstetric management. The abrupt rise of episiotomies in the induction group 3 is likely due to the restricted case number, which might limit the validity of the analysis of this group. The rates of placenta-related complications and rates of shoulder

Table II. *Mode of delivery depending on gestational age (GA) and obstetric management.*

GA	Mode of delivery	Induction of labor	Expectant management	*p*-Value
40+0-40+6	Spontaneous vaginal	417 (53.7%)	935 (65.8%)	<0.001
	Assisted vaginal	133 (17.1%)	251 (17.7%)	0.841
	Secondary caesarean section	226 (30.2%)	236 (14.7%)	<0.001
	Total	N=776 (35.3%)	N=1,422 (64.7%)	
40+7-40+9	Spontaneous vaginal	188 (55.1%)	153 (59.5%)	0.317
	Assisted vaginal delivery	50 (14.7%)	44 (17.1%)	0.429
	Secondary caesarean section	103 (30.2%)	60 (23.3%)	0.064
	Total	N=341 (57.0%)	N=257 (43.0%)	
≥40+10	Spontaneous vaginal	76 (49.7%)	28 (50.0%)	>0.999
	Assisted vaginal delivery	23 (16.9%)	11 (17.2%)	0.407
	Secondary caesarean section	52 (34.3%)	17 (30.4%)	0.740
	Total	N=153 (73.2%)	N=56 (26.8%)	

Table III. *Maternal parameters depending on gestational age (GA) and obstetric management.*

GA	Maternal parameters	Induction of labor	Expectant management	*p*-Value
40+0-40+6	Tocolysis subpartu	83 (10.7%)	101 (6.5%)	<0.001
	Epidural anesthesia	204 (37.1%)	371 (31.3%)	0.018
	Episiotomy	76 (13.8%)	168 (14.2%)	0.882
	OASIS (vaginal birth)	15 (2.7%)	27 (2.3%)	0.615
	PROM	230 (30.1%)	292 (18.8%)	<0.001
	Shoulder dystocia	11 (1.4%)	12 (0.7%)	0.179
	Retained placenta	34 (4.5%)	51 (3.3%)	0.196
40+7-40+9	Tocolysis subpartu	50 (14.9%)	15 (5.4%)	<0.001
	Epidural anesthesia	81 (34.0%)	68 (34.5%)	0.920
	Episiotomy	33 (13.9%)	28 (14.2%)	>0.999
	OASIS (vaginal birth)	3 (1.3%)	8 (4.1%)	0.073
	PROM	68 (20.7%)	50 (18.1%)	0.471
	Shoulder dystocia	3 (0.9%)	2 (0.7%)	>0.999
	Retained placenta	16 (4.8%)	11 (4.0%)	0.696
≥40+10	Tocolysis subpartu	19 (12.4%)	2 (3.3%)	0.070
	Epidural anesthesia	50 (49.0%)	11 (28.2%)	0.036
	Episiotomy	25 (24.5%)	3 (7.7%)	0.032
	OASIS (vaginal birth)	4 (3.9%)	3 (7.7%)	0.396
	PROM	30 (19.9%)	9 (15.3%)	0.555
	Shoulder dystocia	16 (1.2%)	15 (0.8%)	>0.999
	Retained placenta	7 (4.6%)	2 (3.4%)	>0.999

OASIS: Obstetric anal sphincter injuries; PROM: premature rupture of membrane.

dystocia were independent from gestational age and obstetric management. Importantly, the absolute rates of these severe complications were low.

In the final part of our study, we analyzed various parameters defining the perinatal outcome with respect to the obstetric management for each gestational group (Table V). In the expectant group the rates of meconium-stained amniotic fluid increased depending on advanced gestational age, which also correlated with an increase of the rates of APGAR 5 min <7. However, rates of umbilical artery pH <7.20 were not dependent on gestational age. Compared to expectant management, induction of labor enhanced the rates of pathological CTGs in the first group (20.4% *vs*. 15.2% $p<0.01$) which also resulted in a significantly higher rate of fetal scalp blood testing (9.3% *vs*. 5.3% $p<0.001$ in group 1; 8.7% *vs*. 4.6% $p=0.040$ in group 2). However, in the third group, there was no statistically significant difference between the induction and expectant group regarding these parameters, which may also be due to the small case number in this group. Finally, induction of labor led to an enhanced

Table IV. *Duration of labor dependent on gestation age (GA).*

GA	Parameter	Induction of labor		Expectant management		*p*-Value
		Mean	SD	Mean	SD	
40+0-40+6	Duration of labor (hours)	4.60	5.56	4.80	4.78	0.367
40+7-40+9	Duration of labor (hours)	4.74	5.43	5.94	6.03	0.013
≥40+10	Duration of labor (hours)	5.22	5.65	5.96	6.34	0.444

Table V. *Perinatal parameters depending on gestational age (GA) and obstetric management.*

GA	Perinatal parameters	Induction of labor	Expectant management	*p*-Value
40+0-40+6	Pathological CTG	161 (20.4%)	244 (15.2%)	<0.001
	Fetal scalp blood testing	73 (9.3%)	85 (5.3%)	<0.001
	Meconium-stained amniotic fluid	100 (12.7%)	188 (11.7%)	0.504
	5-min APGAR <7	22 (2.8%)	20 (1.2%)	0.006
	UA pH <7.20	161 (20.5%)	281 (17.6%)	0.093
40+7-40+9	Pathological CTG	81 (23.6%)	49 (17.2%)	0.060
	Fetal scalp blood testing	30 (8.7%)	13 (4.6%)	0.040
	Meconium-stained amniotic fluid	49 (14.3%)	37 (13.0%)	0.727
	5-min APGAR <7	7 (2.0%)	8 (2.8%)	0.354
	UA pH <7.20	72 (21.1%)	62 (21.8%)	0.845
≥ 40+10	Pathological CTG	32 (20.8%)	9 (14.1%)	0.275
	Fetal scalp blood testing	14 (9.1%)	2 (3.1%)	0.159
	Meconium-stained amniotic fluid	31 (20.1%)	17 (26.6%)	0.369
	5-min APGAR <7	4 (2.6%)	2 (3.2%)	0.563
	UA pH <7.20	33 (21.6%)	11 (17.5%)	0.579

CTG: Cardiotocography; APGAR: score for Appearance, Pulse, Grimace, Activity, Respiration; UA: umbilical artery.

rate of depressed neonates in group 1 (APGAR 5 min <7: 2.8% *vs*. 1.2% p=0.006). Importantly, rates of fetal acidosis (UA pH <7.20) did not differ between the induction and expectant group.

Discussion

In the present retrospective study, we analyzed the maternal and perinatal outcomes of singleton low-risk-pregnancies considering differentiated obstetric management beyond term. With respect to different recommendations of current national guidelines depending on the gestational age (26), we analyzed the data within the subgroups 40+0-40+6 weeks, 40+7-40+10 weeks and >40+10 weeks. This classification is also in line with prior national retrospective studies (2, 27) and similar to other international studies (10, 12, 13, 28). The strength of our study is the large number of singleton low-risk pregnancies beyond term which corresponds to a usual cohort in a university perinatal center. A crucial prerequisite for this study was defining the accurate determination of the gestational age. Since there is common consent using last menstruation period date only provides suboptimal estimation of gestational age (29), we matched calculated date by using ultrasound measurements of crown-rump-length (CRL) documented at early pregnancy and adjusted, if indicated, the due date of delivery according to current national guidelines (25).

For the evaluation of the maternal outcomes, we initially analyzed the mode of delivery depending on gestational age. Here, we could show that the rate of secondary c-section increased with advanced gestational age, which is supported by other published studies (3, 12, 28). Corresponding, the rate of spontaneous deliveries decreased whereas the rate of vaginal-operative deliveries remained unchanged. Remarkably, the rate of induction of labor raised from 35.3% up to 73.2% with advanced gestational age. This will likely reflect the implementation of the current national guidelines but also be the result of the increasing risk of failure of spontaneous labor progress at advanced gestational age. Analysis of delivery mode depending on obstetric management indicated that induction of labor enhanced the rate of secondary c-section and significantly decreased the rate of spontaneous deliveries while the rate of

assistant vaginal deliveries remained unaffected. This is in line with some other studies, showing increased c-section rate subsequent to induction of labor beyond term (10, 21, 22, 28, 30, 31). However, published data remain controversial, since other published studies report unchanged rate of c-section due to labor induction (14, 15, 20, 26, 27, 32-34). Prospective data from randomized clinical trials, including data from meta-analysis, show significantly lower rates of c-section after induction of labor (18, 19, 35-38). However, some of these prospective studies also included patients at 39 gestational weeks or even earlier (18, 35-37). Additionally, these conflicting data should be interpreted cautiously, since there are indications that c-section rate is not necessarily influenced by induction of labor itself. Accordingly, in our study, an increase of the secondary c-section rate was also observed in the expectant group in correlation with advanced gestational age. There is consent that there are probably several co-variates which influence c-section rate (39). Among these, one crucial determinant is the increasing risk of cephalopelvic disproportion due to higher fetal weight and labor weakness depending on advanced gestational age (3). Consistent with this published data, the fetal weight in our cohort significantly increased with advanced gestational age, corresponding to the increasing rate of secondary c-section. Furthermore, advanced maternal age is also known to have an impact on the c-section rate (39-41), which was recently confirmed by an own retrospective analysis (42). Compared with the average younger maternal age in other published studies (14, 15, 19, 36), the advanced maternal age in our cohort might have also influenced the rate of c-section. In this context, the high percentage of nulliparous women in our cohort could also be considered as further influencing variable. There is evidence, that the absolute rate of c-section is higher in nulliparous women than in multiparous women. Similarly, the known correlation between maternal age and c-section rate mainly concerns nulliparous women (22, 39, 41). In addition, obesity is also known to be a risk factor for both the induction of labor and subsequent higher c-section rate, especially in nulliparous women (39, 43, 44). Furthermore, the status of Bishop score at the initiation of induction of labor is another parameter influencing c-section rate significantly (30, 39). However, the validity of our study is limited because neither data of maternal weight nor bishop score were available to be included for separate analysis. Further limitation of our study is the single center analysis of one university obstetric department. Due to its retrospective character, the study does not provide any randomized data. Missing data or coding errors might also limit our study.

All other parameters defining maternal outcome in our study stress the favorable maternal outcome in the period under review. In detail, the need for epidural anesthesia and tocolysis subpartu was independent from gestational age, but significantly increased subsequent to the induction of labor, which is consistent with other studies (12, 14, 15, 21, 28, 37, 39). According to published data, induction of labor reduced the duration of labor compared to expectant management (15, 32), which was inconsistent with our study. Similarly to published data (19, 37, 45), the absolute rate of shoulder dystocia in our cohort was low due to the low-risk collective and was not influenced by gestational age or obstetrical management. Placenta-associated complications like retained or incompletely expulsed placenta were rare in our cohort and independent both from gestational age and obstetric management which are similar to those reported by other studies (14, 20). However, there is also indication that the rate of placental retention might be dependent on gestational age (46) and potentially increased after induction of labor (28). Consistent with published data (14, 15, 21, 28, 36), the absolute rate of severe perineal laceration (grade 3 or 4) in our cohort was low. Data from a large retrospective study indicate a decreasing risk for severe laceration (grade 3 or 4) with advancing gestational age (13). In contrast, other studies have not found any correlation with gestational age (37). Other data report an increasing risk depending on advancing gestational age (11), which is inconsistent with our and other studies (28). However, several studies and the data of the current study strongly indicate that the rate of severe lacerations does not differ between the induction and expectant group (14, 15, 18, 20, 28, 36, 37). Compared to international studies, the absolute rate of episiotomy in our study was low (14), which is due to the usually restrictive use of episiotomies in Germany. We did not observe any increase in episiotomies in correlation with gestational age up to 40+9 weeks or a difference between the induction or expectant group which is supported by published data (14, 21). However, the observed abrupt increase in episiotomies in the induction group at >40 + 10 weeks of our study might not be representative due to the low number of cases in this gestational group.

The final analysis of our study showed that perinatal outcomes were generally favorable. The absolute rates of APGAR 5 min <7 and rates of UA pH <7.20 were low, which is similar to those reported in other studies (27, 28, 34). However, in the expectant group of our cohort there were increasing rates of APGAR 5 min <7 and meconium-stained amniotic fluid corresponding to advanced gestational age suggesting enhanced fetal depression. However, the rates of UA pH <7.20 did not increase depending on gestational age correspondingly. Comparing obstetric management, induction of labor resulted in significant higher rate of pathological CTG, which led to significantly more frequent testing of fetal scalp blood. In addition, induction of labor increased the rate of APGAR 5 min <7 in the first group. This is concordant with other published data (10, 28) but also in contrast to other studies (14, 15, 19, 21). In contrast, the rate of meconium-stained amniotic fluid or pH-value of the umbilical cord artery remained unaffected due to labor induction. In summary, induction of labor beyond term did not improve perinatal

outcome, which is supported by other studies (19, 20). Our results are also in accordance with data from prior national analysis and reflect the restrictive national policy of induction of labor until 41 weeks of gestation (23, 26, 27), which is implemented in the current guidelines (25, 26). In contrast, based on the data reporting favorable perinatal outcome subsequent to induction of labor (14, 15), several international guidelines argued for the induction of labor at 41 weeks at latest with respect to the increase of perinatal morbidity and mortality (15-17). However, in our study, perinatal mortality could not be analyzed due to the lack of documented cases. Consistently, even large published prospective studies were not powered to evaluate perinatal mortality as it is a rare event in singleton low-risk pregnancies in absolute terms (47). Unfortunately, we did not obtain any further data regarding complications of the neonatal period. In addition, our study only provides data of short-term perinatal outcome, while long-term consequences of our obstetric management remain unknown. Finally, the clinical policy of antenatal fetal and maternal monitoring beyond term is different between the countries due to missing prospective data. Furthermore, accuracy in reviewing calculated due date of delivery by ultrasound measurements of early pregnancy is different and often not documented in studies sufficiently. Therefore, international recommendations can be transferred to the national situation only to a limited extend.

Conclusion

Our study shows that induction of labor in low-risk singleton pregnancies beyond term did not improve perinatal outcome compared to expectant management with serial antenatal monitoring. Indeed, induction of labor resulted in adverse maternal outcome by significantly increasing rates of secondary c-sections, especially in our first gestational group. For this, our data supports the restrictive policy of induction of labor in low-risk pregnancies until 41 gestational weeks as implemented in the current national guidelines. However, further large prospective cohort studies should not only concentrate on short-term maternal and perinatal outcome but also consider long-term consequences of the obstetric management beyond term.

Conflicts of Interest

The Authors have no conflicts of interest to declare regarding this study.

Authors' Contributions

MP performed the data collection and contributed to the draft of the manuscript. EG performed the statistical analysis. BG was involved in conceptualizing the study. JR contributed to the collection and analysis of data. PM approved the final version. DR conceptualized the study and contributed to the final version of the manuscript. NMG conceptualized the study, supervised the project, and wrote the final manuscript.

Acknowledgements

The Authors thank all patients participating in this study.

References

1 Zeitlin J, Blondel B, Alexander S, Bréart G, PERISTAT Group: Variation in rates of postterm birth in Europe: reality or artefact? BJOG 114(9): 1097-1103, 2007. DOI: 10.1111/j.1471-0528.2007.01328.x

2 Weiss E, Krombholz K, Eichner M: Fetal mortality at and beyond term in singleton pregnancies in Baden-Wuerttemberg/Germany 2004-2009. Arch Gynecol Obstet 289(1): 79-84, 2014. DOI: 10.1007/s00404-013-2957-y

3 Olesen AW, Westergaard JG, Olsen J: Perinatal and maternal complications related to postterm delivery: A national register-based study, 1978-1993. Am J Obstet Gynecol 189(1): 222-227, 2003. DOI: 10.1067/mob.2003.446

4 Vayssière C, Haumonte JB, Chantry A, Coatleven F, Debord MP, Gomez C, Le Ray C, Lopez E, Salomon LJ, Senat MV, Sentilhes L, Serry A, Winer N, Grandjean H, Verspyck E, Subtil D, French College of Gynecologists and Obstetricians (CNGOF): Prolonged and post-term pregnancies: guidelines for clinical practice from the French College of Gynecologists and Obstetricians (CNGOF). Eur J Obstet Gynecol Reprod Biol 169(1): 10-16, 2013. DOI: 10.1016/j.ejogrb.2013.01.026

5 Hovi M, Raatikainen K, Heiskanen N, Heinonen S: Obstetric outcome in post-term pregnancies: time for reappraisal in clinical management. Acta Obstet Gynecol Scand 85(7): 805-809, 2006. DOI: 10.1080/00016340500442472

6 Smith GC: Life-table analysis of the risk of perinatal death at term and post term in singleton pregnancies. Am J Obstet Gynecol 184(3): 489-496, 2001. DOI: 10.1067/mob.2001.109735

7 Chantry AA, Lopez E: [Fetal and neonatal complications related to prolonged pregnancy]. J Gynecol Obstet Biol Reprod (Paris) 40(8): 717-725, 2011. DOI: 10.1016/j.jgyn.2011.09.007

8 Rosenstein MG, Cheng YW, Snowden JM, Nicholson JM, Caughey AB: Risk of stillbirth and infant death stratified by gestational age. Obstet Gynecol 120(1): 76-82, 2012. DOI: 10.1097/AOG.0b013e31825bd286

9 Reddy UM, Ko CW, Willinger M: Maternal age and the risk of stillbirth throughout pregnancy in the United States. Am J Obstet Gynecol 195(3): 764-770, 2006. DOI: 10.1016/j.ajog.2006.06.019

10 Ravelli ACJ, van der Post JAM, de Groot CJM, Abu-Hanna A, Eskes M: Does induction of labor at 41 weeks (early, mid or late) improve birth outcomes in low-risk pregnancy? A nationwide propensity score-matched study. Acta Obstet Gynecol Scand 102(5): 612-625, 2023. DOI: 10.1111/aogs.14536

11 Andersson CB, Petersen JP, Johnsen SP, Jensen M, Kesmodel US: Risk of complications in the late vs early days of the 42nd week of pregnancy: A nationwide cohort study. Acta Obstet Gynecol Scand 101(2): 200-211, 2022. DOI: 10.1111/aogs.14299

12 Ren H, Zuo Q, Pan Y, Zhu X, Yin T, Zhang M, Yin Y, Ge Z,

Jiang Z, Lu H: Whether induction of labor ahead in low-risk women improves pregnancy outcomes?: A retrospective cohort, observational study. Medicine (Baltimore) 102(14): e33426, 2023. DOI: 10.1097/MD.0000000000033426

13 Vilchez G, Nazeer S, Kumar K, Warren M, Dai J, Sokol RJ: Risk of expectant management and optimal timing of delivery in low-risk term pregnancies: a population-based study. Am J Perinatol 35(03): 262-270, 2018. DOI: 10.1055/s-0037-1607042

14 Keulen JK, Bruinsma A, Kortekaas JC, van Dillen J, Bossuyt PM, Oudijk MA, Duijnhoven RG, van Kaam AH, Vandenbussche FP, van der Post JA, Mol BW, de Miranda E: Induction of labour at 41 weeks *versus* expectant management until 42 weeks (INDEX): multicentre, randomised non-inferiority trial. BMJ 364: l344, 2019. DOI: 10.1136/bmj.l344

15 Wennerholm UB, Saltvedt S, Wessberg A, Alkmark M, Bergh C, Wendel SB, Fadl H, Jonsson M, Ladfors L, Sengpiel V, Wesström J, Wennergren G, Wikström AK, Elden H, Stephansson O, Hagberg H: Induction of labour at 41 weeks *versus* expectant management and induction of labour at 42 weeks (SWEdish Post-term Induction Study, SWEPIS): multicentre, open label, randomised, superiority trial. BMJ 367: l6131, 2019. DOI: 10.1136/bmj.l6131

16 Coates D, Homer C, Wilson A, Deady L, Mason E, Foureur M, Henry A: Induction of labour indications and timing: A systematic analysis of clinical guidelines. Women Birth 33(3): 219-230, 2020. DOI: 10.1016/j.wombi.2019.06.004

17 Middleton P, Shepherd E, Morris J, Crowther CA, Gomersall JC: Induction of labour at or beyond 37 weeks' gestation. Cochrane Database Syst Rev 7(7): CD004945, 2020. DOI: 10.1002/14651858.CD004945.pub5

18 Sotiriadis A, Petousis S, Thilaganathan B, Figueras F, Martins WP, Odibo AO, Dinas K, Hyett J: Maternal and perinatal outcomes after elective induction of labor at 39 weeks in uncomplicated singleton pregnancy: a meta-analysis. Ultrasound Obstet Gynecol 53(1): 26-35, 2019. DOI: 10.1002/uog.20140

19 Hannah ME, Hannah WJ, Hellmann J, Hewson S, Milner R, Willan A: Induction of labor as compared with serial antenatal monitoring in post-term pregnancy. A randomized controlled trial. The Canadian Multicenter Post-term Pregnancy Trial Group. N Engl J Med 326(24): 1587-1592, 1992. DOI: 10.1056/NEJM199206113262402

20 Heimstad R, Skogvoll E, Mattsson LA, Johansen OJ, Eik-Nes SH, Salvesen KA: Induction of labor or serial antenatal fetal monitoring in postterm pregnancy. Obstet Gynecol 109(3): 609-617, 2007. DOI: 10.1097/01.AOG.0000255665.77009.94

21 Bodner-Adler B, Bodner K, Pateisky N, Kimberger O, Chalubinski K, Mayerhofer K, Husslein P: Influence of labor induction on obstetric outcomes in patients with prolonged pregnancy. Wien Klin Wochenschr 117(7-8): 287-292, 2005. DOI: 10.1007/s00508-005-0330-2

22 Heffner LJ, Elkin E, Fretts RC: Impact of labor induction, gestational age, and maternal age on cesarean delivery rates. Obstet Gynecol 102(2): 287-293, 2003. DOI: 10.1016/s0029-7844(03)00531-3

23 Schwarz C, Weiss E, Loytved C, Schäfers R, König T, Heusser P, Berger B: [Foetal mortality in singleton foetuses at and beyond term - an analysis of German perinatal data 2004-2013]. Z Geburtshilfe Neonatol 219(2): 81-85, 2015. DOI: 10.1055/s-0034-1398659

24 Schwarz C, Schäfers R, Loytved C, Heusser P, Abou-Dakn M, König T, Berger B: Temporal trends in fetal mortality at and beyond term and induction of labor in Germany 2005-2012: data from German routine perinatal monitoring. Arch Gynecol Obstet 293(2): 335-343, 2016. DOI: 10.1007/s00404-015-3795-x

25 Kehl S, Hösli I, Pecks U, Reif P, Schild RL, Schmidt M, Schmitz D, Schwarz C, Surbek D, Abou-Dakn M: Induction of Labour. Guideline of the DGGG, OEGGG and SGGG (S2k, AWMF Registry No.015-088, December 2020). Geburtshilfe Frauenheilkd 81(8): 870-895, 2021. DOI: 10.1055/a-1519-7713

26 Kehl S, Kupprion C, Weiss C, Temerinac D, Sütterlin M: Impact of a guideline for management of pregnancy beyond term and its influence on clinical routine. Z Geburtshilfe Neonatol 219(2): 87-91, 2015. DOI: 10.1055/s-0034-1390415

27 Pretscher J, Weiss C, Dammer U, Stumpfe F, Faschingbauer F, Beckmann MW, Kehl S: Induction of labour in nulliparous women beyond term in a low-risk population. Z Geburtshilfe Neonatol 223(1): 33-39, 2019. DOI: 10.1055/a-0664-9135

28 Zenzmaier C, Leitner H, Brezinka C, Oberaigner W, König-Bachmann M: Maternal and neonatal outcomes after induction of labor: a population-based study. Arch Gynecol Obstet 295(5): 1175-1183, 2017. DOI: 10.1007/s00404-017-4354-4

29 Pearl M, Wier ML, Kharrazi M: Assessing the quality of last menstrual period date on California birth records. Paediatr Perinat Epidemiol 21 Suppl 21(s2): 50-61, 2007. DOI: 10.1111/j.1365-3016.2007.00861.x

30 Johnson DP, Davis NR, Brown AJ: Risk of cesarean delivery after induction at term in nulliparous women with an unfavorable cervix. Am J Obstet Gynecol 188(6): 1565-1572, 2003. DOI: 10.1067/mob.2003.458

31 Alexander JM, MCIntire DD, Leveno KJ: Prolonged pregnancy: induction of labor and cesarean births. Obstet Gynecol 97(6): 911-915, 2001. DOI: 10.1016/s0029-7844(01)01354-0

32 Chanrachakul B, Herabutya Y: Postterm with favorable cervix: is induction necessary? Eur J Obstet Gynecol Reprod Biol 106(2): 154-157, 2003. DOI: 10.1016/s0301-2115(02)00243-9

33 Briscoe D, Nguyen H, Mencer M, Gautam N, Kalb DB: Management of pregnancy beyond 40 weeks' gestation. Am Fam Physician 71(10): 1935-1941, 2005.

34 Gelisen O, Caliskan E, Dilbaz S, Ozdas E, Dilbaz B, Ozdas E, Haberal A: Induction of labor with three different techniques at 41 weeks of gestation or spontaneous follow-up until 42 weeks in women with definitely unfavorable cervical scores. Eur J Obstet Gynecol Reprod Biol 120(2): 164-169, 2005. DOI: 10.1016/j.ejogrb.2004.08.013

35 Wood S, Cooper S, Ross S: Does induction of labour increase the risk of caesarean section? A systematic review and meta-analysis of trials in women with intact membranes. BJOG 121(6): 674-685, 2014. DOI: 10.1111/1471-0528.12328

36 Grobman WA, Rice MM, Reddy UM, Tita ATN, Silver RM, Mallett G, Hill K, Thom EA, El-Sayed YY, Perez-Delboy A, Rouse DJ, Saade GR, Boggess KA, Chauhan SP, Iams JD, Chien EK, Casey BM, Gibbs RS, Srinivas SK, Swamy GK, Simhan HN, Macones GA, Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network: Labor induction *versus* expectant management in low-risk nulliparous women. N Engl J Med 379(6): 513-523, 2018. DOI: 10.1056/NEJMoa1800566

37 Souter V, Painter I, Sitcov K, Caughey AB: Maternal and newborn outcomes with elective induction of labor at term. Am J Obstet Gynecol 220(3): 273.e1-273.e11, 2019. DOI: 10.1016/j.ajog.2019.01.223

38 Wennerholm U, Hagberg H, Brorsson B, Bergh C: Induction of labor *versus* expectant management for post-date pregnancy: Is there sufficient evidence for a change in clinical practice? Acta Obstet Gynecol Scand 88(1): 6-17, 2009. DOI: 10.1080/00016340802555948

39 Lee HR, Kim MN, You JY, Choi SJ, Oh SY, Roh CR, Kim JH: Risk of cesarean section after induced *versus* spontaneous labor at term gestation. Obstet Gynecol Sci 58(5): 346-352, 2015. DOI: 10.5468/ogs.2015.58.5.346

40 Ecker JL, Chen KT, Cohen AP, Riley LE, Lieberman ES: Increased risk of cesarean delivery with advancing maternal age: Indications and associated factors in nulliparous women. Am J Obstet Gynecol 185(4): 883-887, 2001. DOI: 10.1067/mob.2001.117364

41 Marconi AM, Manodoro S, Cipriani S, Parazzini F: Cesarean section rate is a matter of maternal age or parity? J Matern Fetal Neonatal Med 35(15): 2972-2975, 2022. DOI: 10.1080/14767058.2020.1803264

42 Ratiu D, Sauter F, Gilman E, Ludwig S, Ratiu J, Mallmann-Gottschalk N, Mallmann P, Gruttner B, Baek S: Impact of advanced maternal age on maternal and neonatal outcomes. In Vivo 37(4): 1694-1702, 2023. DOI: 10.21873/invivo.13256

43 Ferrazzi E, Brembilla G, Cipriani S, Livio S, Paganelli A, Parazzini F: Maternal age and body mass index at term: Risk factors for requiring an induced labour for a late-term pregnancy. Eur J Obstet Gynecol Reprod Biol 233: 151-157, 2019. DOI: 10.1016/j.ejogrb.2018.12.018

44 Dammer U, Bogner R, Weiss C, Faschingbauer F, Pretscher J, Beckmann MW, Sütterlin M, Kehl S: Influence of body mass index on induction of labor: A historical cohort study. J Obstet Gynaecol Res 44(4): 697-707, 2018. DOI: 10.1111/jog.13561

45 Newman RB, Stevens DR, Hunt KJ, Grobman WA, Owen J, Sciscione A, Wapner RJ, Skupski D, Chien EK, Wing DA, Ranzini AC, Porto M, Grantz KL: Fetal growth biometry as predictors of shoulder dystocia in a low-risk obstetrical population. Am J Perinatol, 2022. DOI: 10.1055/a-1787-6991

46 Treger M, Hallak M, Silberstein T, Friger M, Katz M, Mazor M: Post-term pregnancy: should induction of labor be considered before 42 weeks? J Matern Fetal Neonatal Med 11(1): 50-53, 2002. DOI: 10.1080/jmf.11.1.50.53

47 Alkmark M, Keulen JKJ, Kortekaas JC, Bergh C, van Dillen J, Duijnhoven RG, Hagberg H, Mol BW, Molin M, van der Post JAM, Saltvedt S, Wikström AK, Wennerholm UB, de Miranda E: Induction of labour at 41 weeks or expectant management until 42 weeks: A systematic review and an individual participant data meta-analysis of randomised trials. PLoS Med 17(12): e1003436, 2020. DOI: 10.1371/journal.pmed.1003436

Received October 6, 2023
Revised November 3, 2023
Accepted November 6, 2023