Induction of labor in twin pregnancies – A retrospective cohort study

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Abstract

Objective: The objective of this study was to investigate twin deliveries at St. Olav's Hospital in Trondheim, Norway, with special attention to spontaneous and induced deliveries, , as well as delivery interval and breech-presenting first twins.

Methods: This retrospective cohort study analyzed data from 541 twin deliveries from January 2012 to December 2019. Spontaneous labor onset and induction of labor were compared in women with planned vaginal delivery and gestational age ≥34 weeks. The main outcome was intrapartum cesarean section rates. Secondary outcomes were umbilical arterial pH and five-minute Apgar scores.

Results: Gestational age at delivery was ≥34 weeks in 354 women with planned vaginal delivery. Labor was induced in 229/354(64.7%) women of whom 63/229(27.5%) underwent intrapartum cesarean section vs. 45/125(36.0%) in spontaneous labors (P=0.10). OR for intrapartum cesarean section in induced labors using spontaneous labors as reference was 0.65(95% CI 0.40-1.04) after adjusting for maternal age and parity. One unexpected intrapartum death occurred after induction of labor.

Median umbilical arterial pH was significantly lower in second twins, both in spontaneous and induced labors, P<0.01. pH<7.00 rarely occurred. Second twins born after a delivery interval>30 minutes had a significantly higher frequency of umbilical arterial pH<7.10 than those with a shorter interval, P<0.01. No adverse events were observed in 67 women with planned vaginal delivery and a breech-presenting first twin.

Conclusion: Induction of twin labors was a safe procedure. Intrapartum cesarean section rates were not significantly different in spontaneous vs. induced labors. Delivery interval>30 minutes was associated with a lower umbilical arterial pH in the second twin.

Introduction

Twin pregnancies are classified as risk pregnancies. (1, 2) A rising trend of twin gestations has been linked to assisted fertilization and increasing maternal age. (2, 3) Several studies, the most recognized being The Twin Birth Study, have investigated delivery mode in twin gestations by comparing outcomes in planned cesarean section with planned vaginal deliveries. (1, 4) Due to strict recommendations for gestational length in twin deliveries, induction of labor is common. (5)

The Twin Birth Study from 2013 found no difference in neonatal mortality or adverse neonatal outcome when randomizing 1400 twin gestations with a cephalic-presenting first twin into groups with vaginal delivery or cesarean section. At two years of age, there were no differences in the occurrence of death or delayed neuromotorical development. (4) Despite these results, an increasing trend of cesarean section for twins is seen globally and management of twin deliveries varies greatly. (3, 6)

Contradictory results have been found when studying outcomes of induced twin labors. One study found higher cesarean section rates after induction in twins than in singletons, (7) but others have indicated similar rates between the respective groups. (8) When comparing spontaneous and induced twin deliveries, some studies have found an increased frequency of cesarean section following induction. (5, 9)

Several studies have looked at the effect of delivery interval on the second twin outcome. Prolonged delivery interval has been linked to a lower umbilical arterial pH in the second twin, but there are disagreements regarding clinical relevance. (10, 11) Others have found increased rate of combined delivery following a prolonged delivery interval. (12, 13)

In approximately 20% of twin pregnancies, the first twin presents in breech position. (14) A study conducted in 176 French hospitals found planned vaginal delivery in women with breech-presenting first twins not to be associated with an increased neonatal mortality or

morbidity for either twin when compared to planned cesarean delivery. (15) This study used the same inclusion criteria as the Twin Birth Study, but also included breech-presenting first twins. The results are consistent with several previous studies. (16-18)

We aimed to study twin deliveries at Trondheim University hospital from 2012-2019 with special attention to spontaneous and induced deliveries, as well as delivery interval and breech-presenting first twins.

Methods

In this retrospective cohort study, twin deliveries at Trondheim University Hospital (St. Olav's Hospital), Norway were investigated. Data were prospectively collected between January 1st 2012 and December 31st 2019 using standardized, quality-controlled procedures, and stored in the hospital's electronic birth journal (NATUS). The study population comprises twin deliveries with gestational age ≥23 weeks at delivery and two living fetuses at the start of spontaneous delivery or at induction of labor.

The practice at St. Olav's Hospital is in line with Norwegian and Nordic guidelines, which recommends twin deliveries to take place in a delivery ward with an experienced obstetrician, a neonatal intensive care unit qualified to handle the given gestational age, sufficient anesthesiological competence, electronic fetal monitoring and possibility for quick conversion to cesarean section. (19)

Gestational age was estimated with eSnurra, using data on biparietal diameter and femur length collected in the second trimester ultrasound examination. (20) The recommended delivery mode depended on the presentation of the first twin, gestational age, estimated birth weight, previous deliveries and complications during the pregnancy. Delivery was discussed with the woman at pre-labor consultations. In accordance with Nordic guidelines, cesarean section was recommended in monoamniotic pregnancies. Vaginal birth

was recommended in uncomplicated monochorionic, diamniotic (MCDA) pregnancies and dichorionic, diamniotic (DCDA) pregnancies with the first twin in cephalic presentation. (19) If the first twin was in breech presentation, vaginal delivery could be considered after a thorough evaluation. Local guidelines for vaginal breech delivery were followed, which suggest a gestational age ≥34 weeks and an estimated birth weight between 2000 and 4500 grams.

In accordance with local, as well as Danish guidelines referred to by The Nordic Federation of Obstetrics and Gynecology, monoamniotic pregnancies should be delivered in week 34, MCDA pregnancies in week 37, and DCDA pregnancies in week 38. (19) Induction of labor was only performed from gestational week 34 and followed the same guidelines as for singleton pregnancies. In women with an unripe cervix, induction began with insertion of a balloon catheter and vaginal administration of misoprostol or dineprostone. In women with a ripe cervix, amniotomy was performed and followed by infusion of oxytocin.

The main outcome was ICS. Secondary outcomes were umbilical arterial pH and five-minute Apgar scores of the newborns.

Statistical analyses

Categorical variables were compared with Chi-squared test or Fisher's exact test, two groups of continuous variables with Mann-Whitney U test and two continuous variables with linear regression. Induced and spontaneous labors were compared in a subgroup of women with gestational age ≥34 weeks at delivery.

The association between ICS and induction of labor was analyzed with logistic regression and results adjusted for parity and maternal age. Trends in cesarean section rates during the study period were investigated with linear-by-linear association. SPSS statistics

(IBM SPSS) version 27.0 was used for data analyses and *P*-values <0.05 were considered significant.

Ethical approval

The Regional Committees for Medical and Health Research Ethics (REK) accepted the study as a quality assurance study on the 22nd of May 2020 with reference 117425, and research authorities at St. Olav's hospital approved the study on August 18th, 2020.

Results

During the study period, 30 849 women delivered at St. Olav's Hospital. There were 570 multiple pregnancies, of whom 15 were triplets and 555 (1.8%) were twins. Figure 1 is a flow chart illustrating the study population, delivery mode and labor inductions. Five pregnancies were excluded from the final study population due to gestational age below 23 weeks at delivery, and nine were excluded due to intrauterine fetal death of one or both fetuses before labor onset. In all, 412/541 (76.2%) were planned vaginal deliveries, and 129/541 (23.8%) were planned cesarean sections. Of the planned vaginal deliveries, 278/412 (67.5%) delivered vaginally, and 134/412 (32.5%) delivered by ICS. No significant change in overall cesarean section or ICS rates was observed during the study period, *P* =0.53 and *P* =0.27, respectively. Umbilical arterial pH was measured in 866/1082 (80.0%) of the newborns. Characteristics of the study population differentiated into planned cesarean section and planned vaginal birth are shown in Table 1.

Labor was induced in 229/412 (55.6%) women with planned vaginal delivery. The following indications for induction were registered: multiple pregnancies without spontaneous labor within recommended gestational age (162), hypertensive disorders (14), growth restriction (13), prelabor rupture of membranes (8), maternal request (2),

oligohydramnios (1) and maternal disease (1). In 28 women, the indication was not specified. Induction began by balloon catheter in 125 deliveries, vaginal misoprostol in 86 deliveries, amniotomy in nine, dinoprostone in seven and oxytocin in one.

Table 2 presents labor and birth characteristics differentiated into spontaneous and induced labors, with comparison of the first vs. second twin. Only women with gestational age ≥34 weeks (n =354) were included in these analyses. In all, 45/125 (36.0%) women with spontaneous labor onset were delivered with ICS vs. 63/229 (27.5%) with induced labors (*P* =0.10). The unadjusted OR for an ICS in the group with induced labors was 0.68 (95% CI 0.42-1.08). Neither maternal age nor parity had confounding effect, and adjusted OR was 0.65 (95% CI 0.40-1.04). Combined delivery occurred in 5/125 (4.0%) vs. 7/229 (3.1%) in spontaneous and induced labors, respectively (*P* =0.64). The second twin had significantly lower median umbilical arterial pH than the first twin in both spontaneous and induced labors. The median delivery interval was 8 minutes in the group with spontaneous onset of labor, and 9 minutes in the group with induced labor, (*P* =0.45).

In Table 3, we grouped the twins based on birth order and compared outcomes in spontaneous vs. induced labors in women with gestational age ≥34 weeks. A pH <7.10 rarely occurred in the first twin; 0 cases in the spontaneous group vs. 1 in the induced group. A pH <7.10 in the second twin occurred in 5 (5.1%) of spontaneous labors vs. 12 (5.9%) of induced labors (*P* =0.77). The frequency of five-minute Apgar scores <7 did not differ significantly between the groups.

We found a significant difference in the frequency of second twins with an umbilical arterial pH <7.10 in groups with delivery interval <30 min vs. >30 min, 13/329 (4.0%) vs. 4/18 (22.2%), *P* <0.01, respectively. The association between delivery interval and umbilical arterial pH in the second twin is presented in Figure 2. Pearson correlation coefficient (r) was 0.37 (*P* <0.01), and the linear regression analysis equation was: y=7.29-0.003x.

Of the deliveries with planned cesarean section, 62/129 (48%) of the first twins were in breech presentation. Of the planned vaginal deliveries, 69/412 (17%) of the first twins were in breech presentation, with 37 cephalic-presenting and 32 breech-presenting second twins. Of the planned vaginal deliveries with the first twin in breech presentation, 43/69 (62.3%) were delivered by ICS. Of the 37 women with a breech-presenting first twin and a cephalic-presenting second twin, 26 (70.3%) were delivered by ICS. Of the 32 of planned vaginal deliveries with both twins in breech presentation, 17 (56.7%) were delivered by ICS. One first twin in breech presentation was delivered vaginally in gestational week 33, otherwise, all were in gestational week ≥34. In the planned vaginal delivery group, median umbilical cord pH was 7.31 (7.08 - 7.46) in the first twins with cephalic presentation, and 7.28 (7.10 - 7.45) in the first twins with breech presentation (P =0.01). One of the 26 first twins with vaginal breech delivery had a five-minute Apgar score <7, but a ten-minute Apgar score of 8. There were no cases of locked twins.

In the entire study population of 541 twin pregnancies, ten perinatal deaths were observed. One unexpected intrapartum death occurred in an MCDA pregnancy after induction of labor, but before onset of active labor. The mother was induced in week 37 in accordance with local guidelines. In two cases of DCDA pregnancies, one of the twins had a lethal condition and died shortly after delivery. In three MCDA pregnancies, labor began spontaneously in gestational week 23 and all six children died. In another MCDA pregnancy, one fetus died as expected after delivery due to complications after laser treatment for twin-to-twin transfusion syndrome.

There were two cases of metabolic acidosis, both in second twins in DCDA pregnancies. In one case, umbilical cord prolapse of the second twin occurred after spontaneous labor onset. Umbilical arterial pH was 6.94 and base excess 12.4, but Apgar scores after one, five and ten minutes were 7, 9 and 10, respectively. In the other case, labor

was induced in pregnancy week 37 due to intrauterine growth restriction in both twins. Umbilical arterial pH in the second twin was 6.90 and base excess 12.6, but Apgar scores were 8, 10 and 10, respectively.

A serious event occurred in an induced DCDA pregnancy, probably because of placental abruption. The fetuses were delivered with vacuum extraction due to fetal distress. A case of fetal bleeding occurred in an MCDA pregnancy in week 32, and an emergency cesarean section was performed. In both these deliveries, all the newborns had a very low Apgar score after five and ten minutes, but all four recovered and were discharged from the hospital after a stay at the neonatal intensive care unit.

Discussion

We did not find any significant difference in ICS rates between spontaneous and induced twin pregnancies. The median pH was lower in the second twin than in the first twin in both spontaneous and induced labors, but the frequencies of pH <7.0, metabolic acidosis, and five-minute Apgar scores <7 were low and not significantly different. One unexpected fetal death occurred after induction of labor. A delivery interval >30 minutes was associated with a higher frequency of umbilical arterial pH <7.10 in the second twin. We did not observe any adverse events in planned vaginal deliveries with the first twin in breech presentation.

A Swedish study found an increased risk of ICS following induction of twin pregnancies, (5) but other studies found no significant differences when investigating adverse outcomes following induction. (21, 22) We did not observe any differences in ICS rates, the frequency of low umbilical arterial pH or in low Apgar scores when comparing spontaneous and induced labors.

Despite the exclusion of pregnancies <34 weeks, some factors created dissimilarity between the groups with spontaneous and induced labors. We found a significantly lower

median birth weight and lower gestational age in the group with spontaneous labor onset. The most frequent indication for induction was labor not beginning spontaneously within recommended gestational age. On the other hand, the spontaneous group consisted of a higher number of late preterm labors. The induction group had passed selection criteria and could therefore be considered a relatively healthy group. In addition, term pregnancies considered ineligible for induction were moved to the planned cesarean section group.

Our results support previous findings showing that limiting delivery interval is associated with higher umbilical arterial pH in the second twin. (10-12, 23) One study reported an increased risk of lower pH after 30 minutes, in agreement with our findings. (24) Active management of the second twin has in some studies been shown to reduce the frequency of combined delivery. (13, 25) Some have found lower umbilical arterial pH in the second twin after a prolonged interval but concluded that the difference was too small for clinical relevance. (13, 26)

There is no consensus regarding recommended delivery mode in breech-presenting first twins. American College of Obstetricians and Gynecologists (ACOG) and the National Institute for Health and Care Excellence (NICE) guidelines recommend cesarean section, but a large French study from 2020 found that vaginal delivery can be safe, given certain selection criteria. (15, 27, 28) In our study population, no adverse outcomes occurred in the group with planned vaginal birth and a breech-presenting first twin, but only 26/69 (38%) delivered vaginally.

Locked twins is a rare and hazardous complication, only described in approximately 1/650 - 1/800 of vaginal twin deliveries, which can occur with a breech-presenting first twin and a cephalic-presenting second twin. (19) In our study population, this combination of presentations occurred in 34 pregnancies with planned cesarean section, and in 37 of the

planned vaginal deliveries. No cases of locked twins occurred, however, our study population was too small to investigate this rare complication.

Preterm labor is common in twin gestations, and accounts for several of the associated complications. (13) In our study, 77 (14.8%) women delivered before gestational week 34, and 14 (2.6%) before gestational week 28. Six of the perinatal deaths were related to extreme prematurity. A 2021 article claims that an estimated 15% and 2% of twins are delivered before gestational week 34 and 28 respectively, consistent with our findings. (29)

An increased perinatal risk is also seen late in pregnancy, which has led to earlier recommendations for gestational age at delivery than for singletons. The fetal death in the induced MCDA pregnancy in week 37 could have been avoided with a planned cesarean section. However, this woman did not have any contraindications for vaginal delivery. The other adverse events were related to extreme prematurity or severe malformations in one of the fetuses.

Both maternal and fetal complications should be considered when discussing planned cesarean section or planned vaginal birth. We observed two women with postpartum hemorrhage >3000ml after a planned vaginal birth, but median blood loss was higher in the group with planned cesarean section. The frequency of sphincter ruptures was very low. Risks related to subsequent deliveries should also be considered, but this was not a part of our study.

The main strength of our study is the large size of the study population. Additional strengths are a high level of experience with vaginal twin deliveries among the hospital staff, and a systematic collection of data. First trimester ultrasound was not implemented as routine pregnancy care in Norway during the study period. Thus, we lack a reliable classification of chorionicity in the population. This is a major limitation, but our study focuses on the labors and not on pregnancy-related complications. Another limitation is the study design. A

randomized controlled trial would have produced stronger results, with more equal and unbiased groups. However, given international and national recommendations for gestational age at delivery, randomization would be unethical. Other limitations include missing data regarding umbilical cord arterial pH and body mass index, and a lack of long-term follow-up and registration of transfer to a neonatal intensive care unit.

Conclusions

Our results support induction of twin labors as safe. However, careful fetal surveillance is crucial due to the added risk associated with twin labors. We found no association between ICS and induction. There was an association between a prolonged delivery interval and low umbilical arterial pH in the second twin. No adverse events occurred in vaginal deliveries with a breech-presenting first twin.

Contributors

IM and AJ declare that they contributed equally to the study. They wrote the protocol, did statistical analyses and wrote the manuscript, and declare that they have seen and approved the final version. They have no conflicts of interest.

CT was responsible for data collection, and participated in all parts of the study. TME was the main supervisor and responsible for all parts of the study. They declare that they have seen and approved the final version. They have no conflicts of interest.

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TABLE 1 Characteristics of the study population differentiated into planned cesarean section and planned vaginal birth

	n (%) or median (range)					
	Planned vaginal delivery			Planned cesarean section		
	n = 412			n = 129		p-value
Maternal Characteristics						
Nulliparous	203 (49.3)			65 (50.4)		0.83
Maternal age (years)	31 (18 - 50)			31 (21 - 49)		0.70
Pre-pregnant body mass index (n=196)	23.6 (14.3 - 39.6)			23.3 (18.4 - 41.5)		0.91
Gestational diabetes	9 (2.2)			7 (5.4)		0.06
Pre-eclampsia, mild	17 (4.1)			6 (4.7)		0.80
Pre-eclampsia, severe	13 (3.2)			5 (3.9)		0.69
Pre-pregnancy risks	209 (50.7)			76 (58.9)		0.10
Birth characteristics						
Gestational age at delivery (days)	261 (164 - 283)			260 (197 - 279)		0.60
Gestational age < 34 weeks	58 (14.1)			19 (14.7)		0.85
Gestational age < 28 weeks	14 (3.4)			0		0.03
Postpartum hemorrhage (ml)	500 (150 - 4800)			600 (300 - 2500)		<0.01
Postpartum hemorrhage > 500 ml	170 (41.3)			70 (54.3)		<0.01
Postpartum hemorrhage > 1500 ml	24 (5.8)			5 (3.9)		0.39
Postpartum hemorrhage > 3000 ml	2 (0.5)			0		1.00[a]
Characteristics of the new-born	*Twin 1*	*Twin 2*	*p-value*	*Twin 1*	*Twin 2*	*p-value*
Birthweight (g)	2650 (500 - 3730)	2595 (330 - 3830)	0.24	2590 (990 - 3630)	2505 (865 - 3550)	0.15
Apgar score	*n = 408*	*n = 405*		*n = 127*	*n = 126*	
< 7 after 5 minutes	19 (4.7)	25 (6.2)	0.34	7 (5.5)	5 (4.0)	0.56
pH in umbilical artery	*n = 310*	*n = 342*		*n = 107*	*n = 106*	
Median (range)	7.31 (7.08 - 7.46)	7.28 (6.90 - 7.48)	< 0.01	7.30 (7.14 - 7.39)	7.29 (7.07 - 7.39)	0.39
pH < 7.10	1 (0.3)	17 (5.0)	< 0.01	0	1 (0.9)	0.32[a]
pH < 7.05	0	11 (3.2)	< 0.01	0	0	
pH < 7.00	0	4 (1.2)	0.13[a]	0	0	
Metabolic acidosis	0	2 (0.6)	0.50[a]	0	0	

Mann-Whitney U test, chi-squared test, logistic regression or Fisher's exact test[a] were used for data comparison

TABLE 2 Comparison of spontaneous and induced onset of labor, and of the first and second twins, in twin gestations ≥34 weeks with planned vaginal delivery.

	n (%) or median (range)					
	Spontaneous onset of labor			**Induction of labor**		
	n = 125			**n = 229**		**p-value**
Maternal Characteristics						
Nulliparous	53 (42.4)			103 (45.0)		0.64
Maternal age (years)	31 (19 - 46)			32 (18 - 50)		0.59
Pre-pregnant body mass index	23.7 (18.0 - 38.6)			23.4 (14.3 - 39.6)		0.82
Labor characteristics						
Epidural analgesia	54 (43.2)			153 (66.8)		<0.01
Oxytocin augmentation	64 (51.2)			161 (70.3)		<0.01
Birth characteristics						
Gestational age at delivery (days)	257 (238 - 280)			263 (241 - 283)		<0.01
Delivery interval (min)	8 (0 - 91)			9 (0 - 165)		0.45
Postpartum hemorrhage (ml)	500 (150 - 2500)			500 (150 - 3500)		0.05
Postpartum hemorrhage > 500 ml	44 (35.2)			106 (46.3)		0.04
Postpartum hemorrhage > 1500 ml	5 (0.4)			16 (7.0)		0.26
Postpartum hemorrhage > 3000 ml	0			1 (0.4)		1.00[a]
3rd and 4th degree anal sphincter tears	0			1 (0.4)		1.00[a]
Delivery mode	*Twin 1*	*Twin 2*	*p-value*	*Twin 1*	*Twin 2*	*p-value*
Spontaneous cephalic delivery	57 (45.6)	38 (30.4)	0.01	134 (58.5)	88 (38.4)	<0.01
Cesarean section	40 (32.0)	45 (36.0)	0.50	56 (24.5)	63 (27.5)	0.46
Operative delivery	15 (12.0)	12 (9.6)	0.54	27 (11.8)	23 (10.0)	0.55
Vaginal breech delivery	13 (10.4)	30 (24.0)	<0.01	12 (5.2)	55 (24.0)	<0.01
Characteristics of the new-born						
Birthweight (g)	2580 (1605 - 3730)	2585 (1705 - 3575)	0.68	2780 (1535 - 3650)	2730 (1785 - 3830)	0.16
Apgar score	*n = 124*	*n = 124*		*n = 228*	*n = 227*	
< 7 after 5 minutes	1 (0.8)	6 (4.8)	0.06	6 (2.6)	7 (3.1)	0.77
pH in umbilical artery	*n = 85*	*n = 98*		*n = 184*	*n = 202*	
Median (range)	7.32 (7.16 - 7.42)	7.28 (6.94 - 7.43)	<0.01	7.29 (7.08 - 7.45)	7.27 (6.90 - 7.48)	<0.01
pH < 7.10	0	5 (5.1)	0.06[a]	1 (0.5)	12 (5.9)	<0.01
pH < 7.05	0	4 (4.1)	0.13[a]	0	7 (3.5)	0.02[a]
pH < 7.00	0	2 (2.0)	0.50[a]	0	2 (1.0)	0.50[a]
Metabolic acidosis	0	1 (1.0)	1.00[a]	0	1 (0.5)	1.00[a]

TABLE 3

Comparison of spontaneous and induced onset of labor in first twins and second twins.

	n (%) or median (range)					
	Twin 1			**Twin 2**		
	n=412			**n=412**		
	Spontaneous onset of labor	*Induced labor*	*p-value*	*Spontaneous onset of labor*	*Induced labor*	*p-value*
Delivery mode	n = 125	n = 229		n = 125	n = 229	
Spontaneous cephalic presentation	57 (45.6)	134 (58.5)	0.02	38 (30.4)	88 (38.4)	0.13
Cesarean section	40 (32.0)	56 (24.5)	0.13	45 (36.0)	63 (27.5)	0.10
Operative delivery	15 (12.0)	27 (11.8)	0.95	12 (9.6)	23 (10.0)	0.89
Breech presentation	13 (10.4)	12 (5.2)	0.07	30 (24.0)	55 (24.0)	1.00
Characteristics of the new-born						
Birthweight (g)	2580 (1605-3730)	2780 (1535-3650)	<0.01	2585 (1705-3575)	2730 (1785-3830)	<0.01
Apgar score	*n = 124*	*n = 228*		*n = 124*	*n = 227*	
< 7 after 5 minutes	1 (0.8)	6 (2.6)	0.43[a]	6 (4.8)	7 (3.1)	0.41
pH in umbilical artery	*n = 85*	*n = 184*		*n = 98*	*n = 202*	
Median (range)	7.32 (7.16-7.42)	7.29 (7.08-7.45)	<0.01	7.28 (6.94-7.43)	7.27 (6.90-7.48)	0.24
pH < 7.10	0	1 (0.5)	1.00[a]	5 (5.1)	12 (5.9)	0.77
pH < 7.05	0	0		4 (4.1)	7 (3.5)	0.79
pH < 7.00	0	0		2 (2.0)	2 (1.0)	0.60[a]
Metabolic acidosis	0	0		1 (1.0)	1 (0.5)	0.55[a]

Mann-Whitney U test, chi-squared test, logistic regression or Fisher's exact test[a] were used for data comparison

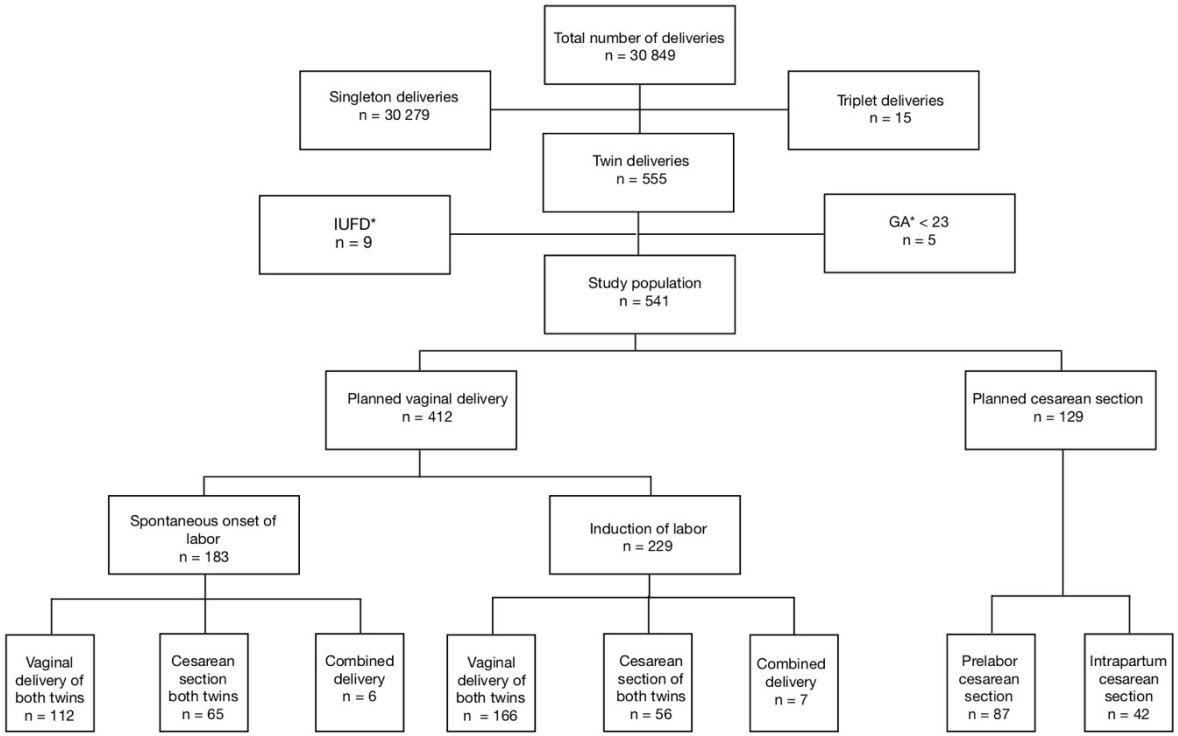

FIGURE 1: Study population flow chart

*IUFD: Intrauterine fetal death, GA: Gestational age

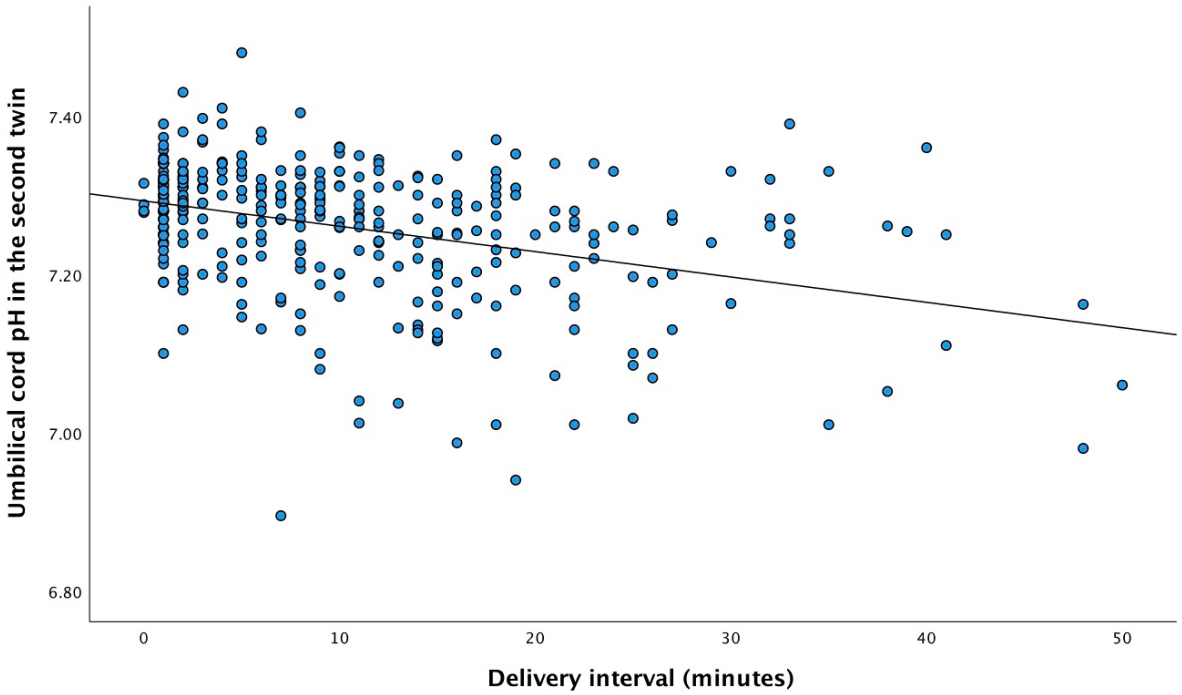

FIGURE 2: Scatter plot illustrating the association between delivery interval and umbilical arterial pH in the second twin, with linear regression analysis equation y=7.29-0.0