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Mode of delivery of Finnish dichorionic and monochorionic-diamniotic twins: A retrospective observational study including a risk score for intrapartum cesarean birth

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Abstract

Background and Aims: Trial of labor is considered safe also among twins, yet nearly 50% are born via cesarean section in Finland. While planned cesarean births have declined among twins, intrapartum cesarean deliveries have risen, postulating evaluation of criteria for trial of labor. The objective of this study was to create an outline of the mode of delivery of dichorionic and monochorionic-diamniotic Finnish twins. By evaluating risk factors for intrapartum cesarean delivery (CD), we aimed at creating a risk score for intrapartum cesarean birth for twins.

Methods: A retrospective observational study based on a cohort of dichorionic and monochorionic-diamniotic twin pregnancies considered as candidates for trial of labor in 2006, 2010, 2014, and 2018 (n = 720) was performed. Differences between parturients with vaginal delivery and intrapartum CD to identify potential risk factors for intrapartum CD were assessed. Logistic regression analysis (n = 707) was used to further define risk score points for recognized risk factors.

Results: A total of 23.8% (171/720, 95% confidence interval [CI] = 20.7–26.9) of parturients experienced intrapartum CD. Induction of labor, primiparity, fear of childbirth, artificial reproductive technology, higher maternal age, and other than cephalic/cephalic presentation independently associated with intrapartum CD. The achieved total risk score ranged from 0 to 13 points with significantly higher points among the CD group (6.61 vs. 4.42, $p < 0.001$). Using ≥8 points as a cut-off, 51.4% (56/109) were delivered by intrapartum CD (sensitivity = 33.73%, specificity = 90.20%, positive predictive value = 51.38%, negative predictive value = 81.61%). The total risk score had a fair predictive capability for intrapartum CD (area under the curve = 0.729, 95% CI = 0.685–0.773).

Conclusion: Fair-level risk stratification could be achieved with higher maternal age, primiparity, induction of labor, artificial reproductive technology, fear of childbirth, and other than cephalic/cephalic presentation increasing the risk. Parturients with low-risk score (0–7 points) appear to be the best candidates for trial of labor with acceptable CD rates in this group (18.4%).

KEYWORDS
cesarean section, Finland, pregnancy: high-risk, risk factors, trial of labor, twins

1 | INTRODUCTION

Pregnancy and delivery complications are more common when carrying twins, including the risks of intrapartum cesarean delivery (CD) and combination delivery, where one twin is born vaginally and the other by cesarean section.[1–4] In Finland, nearly half of the twins are delivered by CD.[4] With globally rising rates, cesarean birth may be preferred in some countries, even though trial of labor (TOL) is often considered safe also in twin pregnancies.[5–11]

Assisted reproductive technologies (ARTs) and advancing maternal age predispose to multiple pregnancy with implications on CD rate.[12–14] Nulliparity and noncephalic second twin have been identified as potential risk factors for intrapartum CD, but the role of maternal age or ART is less clear.[15,16] Although spontaneous prematurity is common, induction of labor is also often needed before term and depending on chorionicity.[2,4,17,18] Overall, the magnitude of the risk of intrapartum CD after induction of labor among twins is debated.[19–21]

At the time of delivery over half of both twins are in cephalic presentation, yet up to 12% of vertex second twin experience intrapartum presentation change.[22,23] Even though unstable, lie and nonvertex presentation (nonbreech in particular) of the second twin has been suggested as risk factors for CD; TOL seems to be a safe and often successful option.[5,11,15,16,21–24] As vaginal delivery (VD) is generally aimed at in uncomplicated diamniotic twin pregnancies with the first twin in cephalic presentation, more data is needed to define parturients at the highest risk of intrapartum CD.[25–28] With breech-presenting first twin, planned CD is often recommended, but in well-selected patients, TOL may also be considered.[9,11,25,26] Data on the risk of intrapartum CD among twins with the first twin in breech are, however, limited. Regardless of the presentations, managing twin delivery requires experience in handling different VDs.[2]

Individualized risk assessment is necessary in planning the mode of delivery of twins. Here, we aimed to estimate parturients' unique risk for intrapartum CD. To achieve this, an outline of the definitive mode of delivery of Finnish twins considered as candidates for TOL including the first twin in breech presentation was pursued. By identifying possible risk factors for intrapartum CD, a risk score for intrapartum CD was further aimed at using a previously described method.[29]

2 | MATERIALS AND METHODS

All twin pregnancies ≥22 + 0 weeks' gestational age (GA) treated in the delivery units in Helsinki–Uusimaa region, Finland during the years 2006, 2010, 2014, and 2018 were searched from patient records to achieve cross-sections with adequate numbers for this retrospective observational study. With an average of 259 twin deliveries annually, one-third of all twin pregnancies in Finland are managed in the Helsinki–Uusimaa region. Data were collected using the International Statistical Classification of Diseases and Related Health Problems (ICD-10) and the Nordic Medico-Statistical Committee (NOMESCO) Classification on Surgical Procedures assigned on patient documents. Relevant clinical information concerning the twin pregnancy and the outcome of the newborns were also manually collected from medical records. All 1034 dichorionic-diamniotic (DCDA) and monochorionic-diamniotic (MCDA) twins were analyzed for the method of delivery. After exclusion of planned CDs and pregnancies where TOL was not designated, 720 twin pregnancies of all GAs were left for further analyses (548 DCDA and 172 MCDA; Figure 1). The primary outcome was to create an outline of the definitive mode of delivery of these twins. The secondary outcome was to define possible risk factors for an intrapartum CD to be included in risk score analysis. Potential risk factors were selected based on clinical experience and earlier literature; data for these were available in 707 cases. Group comparisons to identify potential risk factors for intrapartum CD were performed for the following variables: preterm prelabor rupture of membranes (PPROMs), cervical incompetence, induction of labor, fear of childbirth, hypertensive disorders and diabetes (including pre-existing and gestational conditions), intrahepatic cholestasis of pregnancy, term birth (differences between smaller subgroups, <28, 28–31 + 6, 32–36 + 6, ≥37 weeks were also analyzed and for more detailed distribution of prematurity, <24 weeks and fortnights ≥24 + 0 onwards until 36 + 6 were used), maternal age (categorized to ≤31 and ≥32 years based on the cohort mean), parity, antenatal signs of potential hypoxia, ART, chorionicity, presentation (cephalic/cephalic, cephalic/noncephalic and breech/any presentation), contractions unrelated to delivery <37 weeks (false labor), and categorized birthweight discordance (<15%, 15%–24.9%, ≥25% as compared to the bigger twin). All variables were analyzed as dichotomous (excluding GA subgroups, presentation, and birthweight categories) based on ICD-10 diagnosis codes and clinical notes. Body mass index (BMI, kg/m^2) was not included in the final analyses due to vastly missing data. Regarding intrapartum CD, we could not differentiate whether epidural or spinal analgesia was used for vaginal birth analgesia and this information was thus left out of the analyses. GA ≥37 weeks was defined as term and <37 weeks as preterm. The presentations were reported as they were at the onset of delivery and at the time of decision-making. The presenting/first-born twin was named "A" and the second born "B." Data on chorionicity were retrieved from ultrasound reports; one pregnancy was treated as MCDA, although the newborns represented both sexes.

Antenatal signs of potential fetal distress were identified based on notes in patient records. Suspicious or pathological cardiotocography patterns, signs of placental insufficiency or clinically significant bleeding (antenatal or at the onset of delivery) were all

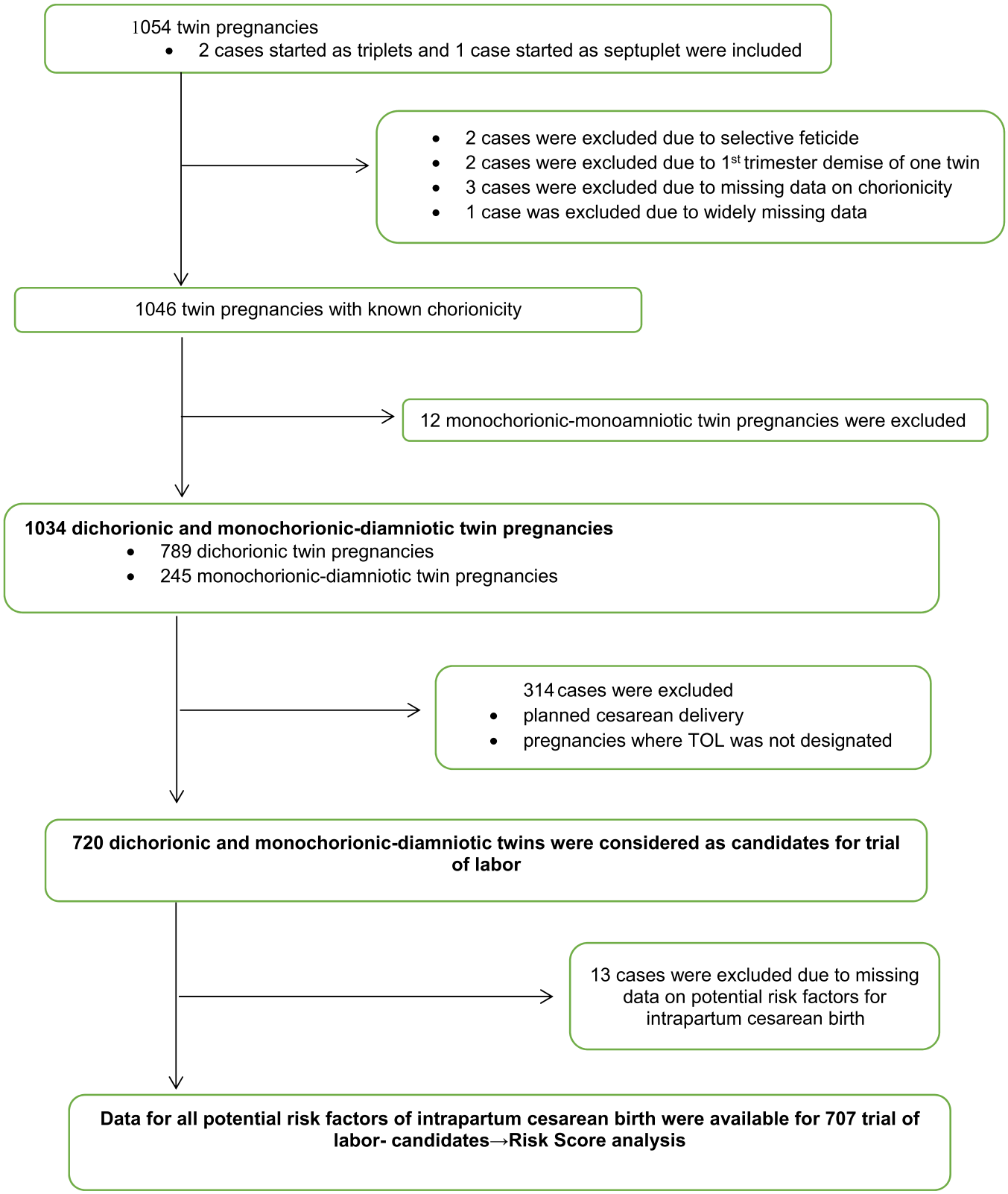

FIGURE 1 Flowchart of the study showing included and excluded cases with final numbers available for the study. TOL, trial of labor.

defined as "antenatal signs of potential fetal distress." All cases with suspected fetal distress were evaluated case by case and only cases that were allowed to enter TOL were included. Twin-to-twin transfusion syndrome or growth restriction were not included in this group unless the before-mentioned features existed. Twin-to-twin transfusion syndrome, twin anemia–polycythemia sequence, and twin oligo-polyhydramnios were analyzed as a group called TTTS.

Suggested core outcomes of maternity care are numerous; here, we report the mode of birth, neonatal death and stillbirth, GA and preterm birth, birth weight, pregnancy-induced hypertension, and type of labor onset.[30] Number of cesarean births after previous CDs and congenital anomalies are also reported.

2.1 | Statistical analyses

The data were analyzed using SPSS (IBM SPSS Statistics for Windows, Version 27.0; IBM Corporation). For continuous variables, means, medians, and interquartile ranges are reported, when appropriate. Independent-samples proportions test and mid-*p*-adjusted binomial paired-samples proportions tests were performed to compare shares. To define group differences, crosstabs with Bonferroni correction for multiple comparisons were used. Pearson's χ^2 and Fisher's exact tests were also performed to select variables to be used in logistic regression with intrapartum CD as the outcome of interest. The forward-conditional method was used to evaluate the risk of multicollinearity with results for enter method for selected variables also reported and used for the final model. The odds ratios (ORs) elicited in the logistic regression model were rounded to the nearest integer to achieve risk score points for all variables. The sum of risk score points formed the individual total risk score of each patient. The capacity of the individual risk score to predict intrapartum CD was analyzed using the receiver-operating characteristic curve. The sensitivity, specificity, and positive and negative predictive values for different risk scores are reported. A *p*-value <0.05 for two-tailed tests was considered statistically significant. As this was a retrospective study, a priori sample size calculations were not performed. We used a 95% confidence interval (CI) to express the amount of uncertainty around the effect estimates, achieved also by boostrapping with 1000 repetitions.

3 | RESULTS

3.1 | Descriptive obstetric and maternal characteristics

During the study years (2006, 2010, 2014, and 2018), there were 720 DCDA and MCDA twins that were considered candidates for TOL (Figure 1). Among these twins, 548 (76.1%, 95% CI = 72.8–79.2) were DCDA and 172 (23.9%, 95% CI = 21.0–26.9) were MCDA. Most twins were born at term (418/720, 58.1%, 95% CI = 54.4–61.4), but MCDA twins were more often preterm (98/172, 57.0% vs. 204/548, 37.2% among DCDA twins, $\varphi = -0.171$, $p < 0.001$, Pearson's χ^2). Most preterm twins were born at 35–36 + 6 GA (129/239, 54.0%, 95% CI = 47.3–60.3 among the VD group, overall GA range 22 + 4–40 + 3 vs. 38/63, 60.3%, 95% CI = 47.4–74.2 among the CD group, overall GA range 25 + 0–41 + 1). Nearly a quarter of twin pregnancies were ART-induced (174/720, 24.2%, 95% CI = 21.4–26.9). Data were not available in 1.1% (8/720) of cases.

The mean age of the parturients was 31.8 years (median = 32, interquartile range = 6 years): 31.4 years among the VD group (median = 31, interquartile range = 7 years) and 32.9 years among the intrapartum CD group (median = 33, interquartile range = 6 years; Table 1). Data on BMI were available only for 46.4% (334/720) and the majority (186/334, 55.7%) of these were of normal weight (BMI: 18.5–24.9). Most twin parturients had at least one previous delivery (*n* = 428/719, 59.5%, 95% CI = 56.1–63.0, data missing for one case) (Table 1). Of these, 13.8% (59/428) had a previous CD.

Over half of twin deliveries eligible for TOL were induced (*n* = 400/720, 55.6%, 95% CI = 52.1–58.6); a third (*n* = 117, 29.3%) of these resulted in intralabor CD (Table 2). Both twins were delivered vaginally in 76.3% (549/720, 95% CI = 73.6–78.6) and by intralabor CD in 16.8% (121/720, 95% CI = 14.4–19.7). Combination delivery occurred in 6.9% (50/720, 95% CI = 5.3–8.8). Thus, 23.8% (171/720, 95% CI = 20.7–26.9) of parturients experienced intrapartum CD. Vacuum extraction was performed in equal numbers for both twins, but twins A were more often born spontaneously ($p < 0.001$). Correspondingly, twin B experienced urgent and emergency CD as well as breech delivery (or breech extraction) more often ($p < 0.001$).

Twin A was in a cephalic presentation in the majority of cases (cephalic/cephalic 443/716, 61.9%, 95% CI = 58.7–65.1 and cephalic/other 235/716, 32.8%, 95% CI = 29.3–36.3), but 38/716 (5.3%, 95% CI = 3.9-6.7) of twin A were breech (27/38, 71.1% of which were among multiparous parturients and 25/38, 65.8% were preterm). Data were missing for four cases. With cephalic/cephalic presentation, both twins were most likely born vaginally (361/443, 81.5%; Table 2). If twin B was in any other presentation, the numbers were markedly lower (162/235, 68.9%, $p < 0.05$, *z*-test with Bonferroni correction). With twin A in breech presentation, the success rate of VD was similar as with the latter group (25/38, 65.8%) (Table 2). Two first-born twins with a hand presenting next to the head at delivery were coded as cephalic and one premature twin A born vaginally feet first was coded as breech.

3.2 | Descriptive neonatal characteristics

The mean birthweight of twin A was 2566.5 g (median 2636 g, interquartile range = 718 g) and of twin B 2510.1 g (median 2570 g, interquartile range = 708 g). Among vaginally born twins, the corresponding figures were 2538.1 g (twin A, median 2620 g, interquartile range = 725 g) and 2475.9 g (twin B, median 2536 g, interquartile range = 705 g) and among twins born via intrapartum CD 2657.7 g (twin A, median 2712 g, interquartile range = 725 g) and 2619.8 g (twin B, median 2665 g, interquartile range = 745 g). Most twins had <15% weight discordance (407/549, 74.1%, 95% CI = 70.8–77.4 among the vaginally born and 119/171, 69.6%, 95% CI = 62.6–76.0 among the intrapartum CD group) with an average of 205.6 g.

There were 64 newborns diagnosed with any congenital malformation or syndrome at birth, three of which were stillborn. None of the conditions defined the method of delivery, thus included in the study.

TABLE 1 Characteristics of vaginal delivery and intrapartum cesarean delivery (of at least one twin) groups per year.

Vaginal delivery of both twins = VD (reference) group Intrapartum cesarean delivery of at least one twin = intrapartum CD group	Year 2006	2010	2014	2018	Total
Vaginal deliveries, *n* (%)	124 (72.1)	163 (78.0)	149 (81.0)	113 (72.9)	549 (76.3)
Intrapartum CD, *n* (%)	48 (27.9)	46 (22.0)	35 (19.0)	42 (27.1)	171 (23.8)
Preterm (<37 weeks' GA), *n* (%)					
VD group	54 (43.5)	69 (42.3)	65 (43.6)	51 (45.1)	239 (43.5)
Intrapartum CD group	19 (39.6)	16 (34.8)	12 (34.3)	16 (38.1)	63 (36.8)
Chorionicity, *n* (%) DCDA					
VD group	98 (79.0)	124 (76.1)	102 (68.5)	88 (77.9)	412 (75.0)
Intrapartum CD group	41 (85.4)	37 (80.4)	27 (77.1)	31 (73.8)	136 (79.5)
Chorionicity, *n* (%) MCDA					
VD group	26 (21.0)	39 (23.9)	47 (31.5)	25 (22.1)	137 (25.0)
Intrapartum CD group	7 (14.6)	9 (19.6	8 (22.9)	11 (26.2)	35 (20.5)
Mean age (range)					
VD group	31.0 (17-42)	31.2 (19-47)	31.2 (17-42)	32.6 (20-42)	31.4
Intrapartum CD group	34.1 (24-45)	32.6 (19-45)	31.9 (20-42)	32.6 (25-40)	32.9
Nullipara, *n* (%)[a]					
VD group	43 (35.0)	75 (46.0)	46 (30.9)	28 (24.8)	192 (35.0)
Intrapartum CD group	33 (68.8)	25 (54.3)	19 (54.3)	22 (52.4)	99 (57.9)
Hypertension, *n* (%)[b]					
VD group	29 (23.4)	43 (26.4)	17 (11.4)	11 (9.7)	100 (18.2)
Intrapartum CD group	19 (39.6)	16 (34.8)	5 (14.3)	10 (23.8)	50 (29.2)
Diabetes, *n* (%)[b]					
VD group	8 (6.5)	18 (11.0)	43 (28.9)	37 (32.7)	106 (19.3)
Intrapartum CD group	4 (8.3)	8 (17.4)	8 (22.9)	13 (31.0)	33 (19.3)
Cervical incompetence, *n* (%)					
VD group	3 (2.4)	25 (15.3)	16 (10.7)	20 (17.7)	64 (11.7)
Intrapartum CD group	1 (2.1)	2 (4.3)	5 (14.3)	4 (9.5)	12 (7.0)
PPROM, *n* (%)					
VD group	19 (15.3)	33 (20.2)	18 (12.1)	27 (23.9)	97 (17.7)
Intrapartum CD group	6 (12.5)	4 (8.7)	5 (14.3)	8 (19.0)	23 (13.5)
Fear of childbirth, *n* (%)					
VD group	2 (1.6)	5 (3.1)	8 (5.4)	8 (7.1)	23 (4.2)
Intrapartum CD group	1 (2.1)	2 (4.3)	6 (17.1)	6 (14.3)	15 (8.8)
ICP, *n* (%)					
VD group	9 (7.3)	11 (6.7)	11 (7.4)	4 (3.5)	35 (6.4)
Intrapartum CD group	6 (12.5)	3 (6.5)	4 (11.4)	2 (4.8)	15 (8.8)

Abbreviations: CD, cesarean delivery; DCDA, dichorionic-diamniotic; ICP, intrahepatic cholestasis of pregnancy; MCDA, monochorionic-diamniotic; PPROM, preterm prelabor rupture of membranes; VD, vaginal delivery.

[a]Data were missing for one case.

[b]Including pre-existing and pregnancy-induced conditions.

TABLE 2 Potential risk factors for intrapartum cesarean delivery, results from crosstabs[a] (n = 720) and regression analysis (n = 707) using forced model[b] with enter method.

Variable	Intrapartum CS among negative cases, n (%)[a]	Intrapartum CS among positive cases, n (%)[a]	φ/Cramer's V[a]	p[a]	OR (95% CI)[b]	p[b]	Risk score point[b]
Intrahepatic cholestasis of pregnancy	156/670 (23.3)	15/50 (30.0)	0.040	0.28			
Diabetes[c]	138/581 (23.8)	33/139 (23.7)	0.000	>0.99			
Preterm prelabor rupture of membranes	148/600 (24.7)	23/120 (19.2)	−0.048	0.20			
False labor[d]	128/510 (25.1)	43/210 (20.5)	−0.049	0.19			
Cervical incompetence	159/644 (24.7)	12/76 (15.8)	−0.064	0.09			
Birth weight discordance,[e] 15%–24.9%	119/526 (22.6)	41/145 (28.3)	0.053	0.36			
Birth weight discordance,[e] ≥25%		11/49 (22.4)					
Chorionicity[f]	136/548 (24.8)	35/172 (20.3)	−0.045	0.23			
Term birth (<37 weeks' GA as a reference)	63/302 (20.9)	108/418 (25.8)	0.058	0.12			
Antenatal signs of potential fetal distress[g]	159/687 (23.1)	12/33 (36.4)	0.065	0.08			
Nulliparity[h]	72/428 (16.8)	99/291 (34.0)	−0.198	<0.001	2.56 (1.69-3.87)	<0.001	**3**
Fear of childbirth	156/682 (22.9)	15/38 (39.5)	0.087	0.02	3.16 (1.53-6.53)	0.002	**3**
Presentation cephalic/other[i]	82/443 (18.5)	73/235 (31.1)	0.150	<0.001	2.11 (1.42-3.13)	<0.001	**2**
Presentation breech/[i]		13/38 (34.2)			4.60 (2.09-10.10)	<0.001	**5**
Older age (≥32 years)[j]	66/344 (19.2)	105/376 (27.9)	0.103	0.006	1.67 (1.12-2.48)	0.01	**2**
ART[k]	105/538 (19.5)	64/174 (36.8)	0.174	<0.001	1.93 (1.25-2.97)	0.003	**2**
Induction of labor[l]	54/320 (16.9)	117/400 (29.3)	0.144	<0.001	2.05 (1.36-3.09)	<0.001	**2**
Hypertension or pre-eclampsia[m]	121/570 (21.2)	50/150 (33.3)	0.116	0.002	1.10 (0.70-1.75)	0.67	0

Abbreviations: ART, artificial reproductive technology, any kind; CI, confidence interval; CS, cesarean section; DCDA, dichorionic-diamniotic; GA, gestational age; MCDA, monochorionic-diamniotic; OR, odds ratio.

[b]Intrapartum CS as the outcome of interest.

[c]Including gestational and pre-existing conditions.

[d]Parturients diagnosed with contractions unrelated to delivery before 37 weeks of gestation.

[e]Birth weight discordance was calculated as the intertwin birthweight difference/birthweight of the larger twin. The results are reported for shares (%) with <15% weight discordance as negative cases.

[f]DCDA twins as negative cases and MCDA twins as positive cases.

[g]Changes in cardiotocography or Doppler studies, bleeding before or at the onset of labor. Intrapartum signs of potential hypoxia are part of the reference group.

[h]Data were available for 719 cases.

[i]Cephalic/cephalic as a reference and as negative cases; data were available for 716 cases.

[j]Cut-off chosen based on cohort mean 31.8 years, and ≤31 years as a reference and negative cases.

[k]Twin pregnancies of spontaneous onset as a reference; data were available for 712 cases.

[l]Spontaneous onset of labor as a reference and as negative cases.

[m]Any level, including pre-existing conditions.

During the perinatal period, 12 twins A died, among which six were stillborn. The figures were similar for twins B: 14 died during the perinatal period, including nine stillborn and one case in which the original presenting twin was born second. In addition, two first- and second-born twins died later during the neonatal period. Significant differences between vaginal and intrapartum CD groups were not found, but among both twins, two twins (one A and one B) that were born via intrapartum CD died during the neonatal period. All stillborn babies and their cotwins were delivered vaginally.

3.3 | Factors associated with intralabor CD

In unadjusted analyses, nulliparity, fear of childbirth, other than cephalic/cephalic presentation, older age, ART-onset twin pregnancy, induction of labor, and hypertension were all associated with intralabor CD (Table 2). Using ≥32 years as a cut-off, older parturients were more likely to end up in intrapartum CD (Table 2), but the results remained similar for ≥35-year-old parturients (65/225, 28.9% vs. 106/495, 21.4%, $\varphi = 0.081$, $p = 0.03$, Pearson's χ^2). Among multiparas (≥1 previous delivery), intrapartum CD occurred more often if the parturient had a previous CD (20/59, 33.9% vs. 52/369, 14.1%, $\varphi = 0.183$, $p < 0.001$, Pearson's χ^2). The association of age with parity was also clear ($\varphi = 0.141$, $p < 0.001$, Pearson's χ^2) (Supporting Information: Table S1).

Although intrahepatic cholestasis of pregnancy was more common among the intralabor CD group, the difference was not statistically significant, likely due to small numbers (Table 2). Diabetes was equally common between the groups. Parturients diagnosed with cervical incompetence, false labor, or PPROM delivered both twins more often vaginally than parturients with preterm deliveries in general, but there was no statistical significance. Monochorionicity did not associate with intrapartum CD. Furthermore, statistically significant differences in intrapartum CDs were not discovered between term and preterm deliveries.

Most (42/171, 24.6%, 95% CI = 18.7–31.0) CDs were performed due to imminent hypoxia, but in 21.1% (36/171, 95% CI = 15.2–26.9) multiple reasons contributed to the decision. Failed progress (34/171, 19.9%, 95% CI = 14.6–24.6) and failed induction of labor were reported as indications for CD in corresponding numbers (27/171, 15.8%, 95% CI = 11.1–20.5), followed by presentational reasons (21/171, 12.3%, 95% CI = 8.2–16.4 including eight cases with prolapsed umbilical cord). Maternal request ($n = 4$) or distress ($n = 7$) were rare indications for intrapartum CD.

3.4 | Risk calculator

Primiparity, fear of childbirth, hypertensive disorders, older age, induction of labor, ART, and other than cephalic/cephalic presentations were all defined risk factors for intrapartum CD. With the exception of hypertensive disorders, all other factors remained significant predictors for intrapartum CD in logistic regression analysis and thus contributed to the risk score. Controlling for chorionicity, prematurity, and potential antenatal fetal distress did not change the results, but from the forward conditional model, we could estimate that induction of labor likely caused multicollinearity with respect to term birth and fetal distress (Supporting Information: Table S1). Subgroup analyses resulted in small groups and were thus not eligible for risk score. Using ≥35 years as a cut-off for older age, the overall results remained similar, but the impact of nulliparity on the risk score was slightly reduced (OR = 2.56 → 2.49, $p < 0001$ for both, logistic regression analysis).

Data for all defined risk factors were available in 707 cases, which were included in the risk model. The individual risk scores ranged from 0 to 13 (theoretical maximum total score of 17; Table 2) with significantly higher points among the intrapartum CD group (6.61 vs. 4.42, $p < 0.001$, independent samples Mann–Whitney *U*-test). With 0–7 risk points 18.4% (110/598) resulted in intrapartum CD. Correspondingly, with ≥8 risk points, 51.4% (56/109) were delivered by intrapartum CD (Table 3). The area under the curve (AUC) of the model was 0.729 (95% CI = 0.685–0.773), which may be considered fair. As the performance of the nomogram was slightly better with ≥32 years of age as a cut-off for older age, this age limit was chosen for the final model (AUC = 0.729 vs. 0.724 using ≥35 years). After exclusion of all cases with potential antenatal fetal distress ($n = 675$ left for risk score analysis), the same six risk factors for intrapartum CD were identified. However, the risk effect of nulliparity was minorly reduced (OR = 2.28, $p < 0.001$, logistic regression analysis) with a minimal effect on the performance of the model (AUC = 0.722).

4 | DISCUSSION

In this population-based retrospective observational study, nulliparity, other than cephalic/cephalic presentation, fear of childbirth, induction of labor, maternal age ≥32, and ART were identified as risk factors for intrapartum CD. Based on these variables, a risk score to stratify parturients' individual risk of intrapartum CD was created and a fair prediction capacity (AUC = 0.729) was achieved.

Our finding of the association of nulliparity with intrapartum CD supports earlier notions.[15,16] In this material, noncephalic presentation of twin B was another risk factor for intrapartum CD. Previously, conflicting reports existed.[15,16,21,22] Since the presentation of the second twin may change during delivery in up to 12%, TOL should be considered also when twin B is noncephalic.[22,23] Data on VD of twin A presenting breech are scarce, yet a success rate of 60% has been reported with corresponding neonatal outcomes.[9,16] In our material, the breech presentation of the first twin increased the risk of intrapartum CD (OR = 4.60, $p < 0.001$). Still, VD was achieved in 81.5% of cephalic/cephalic, 68.9% of cephalic/noncephalic, and 65.8% of breech/any presentations (A/B). These results implicate satisfactory patient selection for twin VD, even if the first twin is breech, but selection bias is also a limitation of the study as 65.8% of breech-presenting twins A were preterm and 71.1% of these

TABLE 3 Prediction of intrapartum cesarean delivery by total risk score (n = 707), with proportion (%), sensitivity (%), specificity (%), positive and negative predictive values (%), and 95% CI of each risk score point reported.

Risk score	Proportion, *n* (%)	Sensitivity (%, 95% CI)	Specificity (%, 95% CI)	Positive predictive value (%, 95% CI)	Negative predictive value (%, 95% CI)
≥0	707 (100)	100 (97.80–100)	0 (0.00–0.68)	23.48 (23.48–23.48)	NA
≥1	662 (93.6)	97.59 (93.95–99.34)	7.58 (5.49–10.14)	24.47 (23.85–25.10)	91.11 (78.84–96.57)
≥2	662 (93.6)	97.59 (93.95–99.34)	7.58 (5.49–10.14)	24. 47 (23.85–25.10)	91.11 (78.84–96.57)
≥3	544 (76.9)	91.57 (86.25–95.31)	27.54 (23.82–31.51)	27.94 (26.56–29.36)	91.41 (86.36–94.71)
≥4	509 (72.0)	89.76 (84.11–93.92)	33.46 (29.49–37.61)	29.27 (27.67–30.93)	91.41 (86.98–94.43)
≥5	375 (53.0)	80.12.(73.23–85.90)	55.27 (50.97–59.51)	35.47 (32.76–38.27)	90.06 (86.87–92.54)
≥6	275 (38.9)	66.27 (58.53–73.41)	69.50 (65.43–73.36)	40.00 (36.06–44.07)	87.04 (84.34–89.33)
≥7	209 (29.6)	53.01 (45.12–60.79)	77.63 (73.88–81.08)	42.11 (37.03–47.35)	84.34 (81.99–86.43)
≥8	109 (15.4)	33.73 (26.59–41.47)	90.20 (87.38–92.58)	51.38 (43.10–59.58)	81.61 (79.86–83.23)
≥9	88 (12.4)	29.52 (22.70–37.08)	92.79 (90.28–94.82)	55.68 (46.14–64.82)	81.10 (79.50–82.60)
≥10	30 (4.2)	10.24 (6.08–15.89)	97.60 (95.93–98.71)	56.67 (39.35–72.50)	77.99 (77.07–78.89)
≥11	22 (3.1)	8.43 (4.69–13.75)	98.52 (97.11–99.36)	63.64 (42.76–80.39)	77.81 (76.98–78.62)
≥12	4 (0.6)	2.41 (0.66–6.05)	100 (99.32–100)	100	76.96 (76.53–77.38)
≥13	1 (0.1)	0.60 (0.02–3.31)	100 (99.32–100)	100	76.63 (76.42–76.84)

Abbreviations: CI, confidence interval; NA, not available; OR, odds ratio.

parturients were multiparous. Yet, the perinatal mortality of twins is low in Finland.[17,31] With twin A in breech, careful consideration is, however, required as CD is commonly recommended.[25,26] Even though the numbers are small, our results for breech presenting twin A add to the little existing data.

The induction rate of twin pregnancies was high, 55.6% in this study. The association of induction of labor with intrapartum CD rate among twins is still debated, also when compared to singletons.[15,16,19–21] Here, induction of labor increased the risk of intrapartum CD (OR = 2.05, $p < 0.001$) and 15.8% of intrapartum CDs were performed due to failed induction. Overall, 70.7% of induced deliveries were vaginal, slightly lower than previously reported.[16,19] Induction of labor likely cancelled the effects of potential fetal distress and term birth in regression analysis and thus the role of these factors could not be reliably analyzed. This treatment paradox is a possible limitation of the study.[32] Yet, exclusion of cases with potential antenatal fetal distress resulted in the same six risk factors for intrapartum CD. Generally, uncomplicated DC twins are delivered at 38–40 weeks' GA and MCDA twins at 37–38 weeks' GA at the study institutions, but due to the lack of national guidelines, some variation may exist.

Advanced maternal age has been associated with CD, particularly due to failed induction or labor arrest, but not in all studies.[13–16] We found higher maternal age related to intrapartum CD even though we used a lower-than-customary cut-off age of 32 years. Despite this finding, ART (including any form) remained a significant risk factor for intrapartum CD in adjusted analyses. Ylilehto et al.[16] noted a similar association between in vitro fertilization and unsuccessful vaginal twin delivery, but the statistical significance was lost in multivariate analyses. Possibly parturients with ART-induced twin pregnancies are more anxious about the pregnancy outcome with reflection on intrapartum CD rates. Comparable explanations are likely behind the higher CD rate of parturients diagnosed with fear of childbirth. To our knowledge, the association of fear of childbirth with intrapartum CD among twin parturients considered as candidates for TOL is a new finding. As the antenatal management of parturients with a fear of childbirth has been congruent, a true discovery is possible. The numbers were, however, small.

Birth weight discordance with a markedly larger second twin has been reported to associate with an increased intertwin delivery interval with a possible indirect effect on intrapartum CD rates.[33] However, birth weight discordance is not considered a significant risk factor for intrapartum CD, supported by our notions.[15,16] Similarly, marked chorionicity-dependent differences between VD and intrapartum CD groups were not discovered, but small differences existed in more detailed analyses: both DCDA twins were more likely to be delivered via urgent CD, but MCDA twins experienced emergency CD more often. Problems related to monochorionicity and estimated fetal weight discordance may have warranted planned CD, but chorionicity as such does not define the mode of delivery in Finland. Overall, our high success rate in delivering twins vaginally regardless of GA supports the notion that TOL is a safe option in uncomplicated twin pregnancies.[5,7,9,22,34,35]

Reasons for intrapartum CD are often multifactorial, also in 21.1% of our CD group. Although it is hard to accomplish accurate risk scores, they have gained ground also in obstetrics.[32,36] To avoid

unnecessary CDs, high specificity and positive predictive value are required. With the tool provided, 100% specificity and positive predictive value were accomplished at ≥12 points, but only 0.6 (n = 4) yielded such a high score. Using a cut-off of ≥8 points, 90.2% specificity, 51.4% positive predictive value, 33.7% sensitivity, and 81.6% negative predictive value were attained. For individualized risk assessment, also including fetal features, different cut-offs may be chosen.

This may be the first time a risk score for intrapartum CD of twins is suggested. Yet to be externally validated, the score may be used to distinguish low-risk-profile twin parturients for consideration of TOL with acceptable intrapartum CD rates. The large and homogenous cohort with congruent management protocols and thorough data collection are the strengths of this study, but the retrospective study design with possible selection bias causes limitations. Larger data sets are needed for subgroup analyses and rarer potential risks including data on neonatal outcomes.

5 | CONCLUSION

Primiparity, maternal age ≥32, induction of labor, ART, fear of childbirth, and other than cephalic/cephalic presentation were independent risk factors for intrapartum CD. We achieved fair-level risk stratification with the risk score presented, but analyses separating preterm and term births with larger data sets are needed before the nomogram can be externally validated and used in practice. The presented data may help in the planning and management of these high-risk deliveries.

AUTHOR CONTRIBUTIONS

Annu-Riikka S. Rissanen: Conceptualization; formal analysis; funding acquisition; methodology; visualization; writing—original draft. **Mikko Loukovaara**: Formal analysis; methodology; supervision; writing—review and editing. **Mika Gissler**: Supervision; writing—review and editing. **Irmeli K. Nupponen**: Writing—review and editing. **Mika E. Nuutila**: Supervision; writing—review and editing. **Riina M. Jernman**: Conceptualization; formal analysis; methodology; writing—original draft.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on reasonable request from the corresponding author with the permission of the Ethics Committee. The data are not publicly available due to privacy and ethical restrictions.

ETHICS STATEMENT

This study was conducted with the permission of Helsinki University Hospital and Helsinki University Hospital Ethics Committee (TMK03 162, 300/13/03/03/2015, final changes accepted June 18, 2018). Informed consent was not required for this historical cohort study, since the participants were not contacted.

TRANSPARENCY STATEMENT

The lead author Annu-Riikka S. Rissanen affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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