ORIGINAL RESEARCH ARTICLE

Perinatal outcome of dichorionic and monochorionic-diamniotic Finnish twins: a historical cohort study

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Abstract

Introduction: Although the perinatal mortality of monochorionic twins has been reported to be higher, the role of chorionicity is debated and data from Finland are still lacking. To examine the effect of chorionicity on the main outcome measures, perinatal and neonatal mortality and neonatal morbidity of Finnish twins, a comprehensive population-based historical cohort study was performed at Helsinki University Hospitals.

Material and methods: All 1034 dichorionic and monochorionic-diamniotic twin pregnancies managed at Helsinki University Hospital area during 2006, 2010, 2014 and 2018 were collected from patient databases. Information on chorionicity was retrieved from ultrasound reports and all relevant clinical information from patient records. Differences in perinatal and neonatal mortality and neonatal morbidity were analyzed by performing group comparisons between the twins and chorionicity. The role of chorionicity was also assessed in logistic regression analyses.

Results: There were 1034 dichorionic-diamniotic (DCDA, $n = 789$, 76.3%, 95% confidence interval [CI] 73.6–78.9) and monochorionic-diamniotic (MCDA, $n = 245$, 23.7%, 95% CI 21.4–26.0) twin pregnancies during the studied years. Most ($n = 580$, 56.1%, 95% CI 52.8–59.2) twins were born at term, but 151 (61.6%, 95% CI 55.8–67.3) of MCDA twins were preterm and had lower birthweight and Apgar scores and higher risk of death of one twin. Perinatal and neonatal mortality did not differ between twins A and B, but the immediate outcome of twin B was worse, with lower arterial pH and Apgar scores and increased need of neonatal intensive care unit treatment.

Conclusions: Chorionicity contributes to the perinatal and neonatal outcome in favor of dichorionic twins. This disadvantage of MCDA twinning is likely explained by earlier gestational age at birth and inequal placental sharing. Irrespective of chorionicity, twin B faces more complications.

KEYWORDS
chorionicity, neonatal, perinatal mortality, pregnancy, twins

1 | INTRODUCTION

The onset of twin pregnancies varies from surprises to acknowledged risks taken with artificial reproductive technology (ART). Due to enhanced use of ART and postponed childbearing, the number of twin pregnancies has increased. Risks related to advanced maternal age and the need for ART result in accumulation of complications in these high-risk pregnancies.[1-3] The incidence of monozygotic twins also appears more common in these groups.[4] Depending on chorionicity, fetal growth restriction complicates 20%–30% of twin pregnancies.[1]

Prematurity is the most important cause of the higher perinatal mortality (PNM) of twins. When adjusted for gestational age (GA), PNM has been reported to be lower among preterm twins than among singletons.[5] However, no distinct difference in morbidity in the late preterm period has been discovered.[6] Depending on chorionicity, the risk of stillbirth and neonatal mortality (NNM) seems to intersect at 36–37 weeks.[7,8] Yet, timing of twin deliveries lacks national standards. As the most favorable neurodevelopmental outcome has been suggested with early-term (37 weeks) deliveries, the definition of term for twins has been challenged.[9]

PNM is more than doubled in monochorionic compared with dichorionic twins, mainly due to problems related to inequal placentation.[10] Also, congenital abnormalities are more common among monozygotic twins with possible effect on PNM.[11]

In Finland, PNM is generally very low, but the discrepancy between twins A and B remains and information on the effect of chorionicity is still lacking.[12] Overall, the role of chorionicity on PNM has been questioned, but we expect monochorionic twins to do worse in Finland as well.[13,14] The aim of this study was to define and report for the first time in Finland the significance of chorionicity on PNM and NNM and morbidity of twins. The data provided may be used to further improve the surveillance and management of twins.

2 | MATERIAL AND METHODS

All twin pregnancies treated in Helsinki University Hospitals during 2006–2018 were searched for from patient databases at 4-year intervals, 2006, 2010, 2014 and 2018, to achieve cross-sections with adequate numbers. Twin deliveries were managed in five of the six delivery units of Helsinki University Hospital, comprising approximately one-third of all twin deliveries in Finland. Data were collected using International Statistical Classification of Diseases and Related Health Problems (ICD-10) and Nordic Medico-Statistical Committee (NOMESCO) Classification on Surgical Procedures (NCSP) assigned on patient documents. Clinical information was retrieved from medical records.

The following information was collected: time and mode of delivery; birthweight (g), height (cm) and head circumference (cm); Apgar scores at 1 and 5 minutes (if available); sex; GA (≥37 weeks of gestation defined as term, <37 as preterm); presentation; umbilical cord arterial and venous pH and base excess. Umbilical artery pH <7.05 or vein pH <7.17 was defined as low.

Key message

Even though the perinatal mortality of Finnish twins is low, monochorionic twins are at higher risk of perinatal morbidity and mortality. Twin B faces more complications irrespective of chorionicity and this difference could and should be narrowed.

Maternal information retrieved included parity; body mass index (kg/m^2); smoking status; spontaneous/ART conception; antenatal corticosteroids; onset of delivery (spontaneous/induced, induction method); birth analgesia; mode of delivery (spontaneous vaginal/vacuum/forceps/breech/CS [elective/urgent/emergency] and combination delivery [=twin A born vaginally and B via urgent/emergency CS]); postpartum bleeding (ml). The decision-to-delivery interval was 30 minutes or more in urgent CS and 10 minutes in emergency CS. All diagnoses and treatments of the mother and twins, and neonatal intensive care unit (NICU) admittance were analyzed.

Finnish newborn growth charts adjusted for GA, twin pregnancy, sex and parity available online (https://www.psshp.fi/syntymakokolaskuri) were used to count each newborn's unique birthweight standard deviation (SD), where <−2 SD was small-for-gestational-age (SGA), −2 SD to +2 SD normal and >+2 SD large for GA. The presenting/first born twin was named "A" and the second born "B". Information on chorionicity was gathered from 1st trimester ultrasound reports.

The annual PNM rate was defined as death in the perinatal period (≥22 weeks of gestation up to 6 days postpartum) per 1000 children born and expressed as per thousand (‰). The annual early NNM rate denotes death during the first week of life and total NNM rate death within the neonatal period (<28 days) per 1000 live-born children, counted separately for DCDA and MCDA twins and separating twins A and B.

Twin-to-twin transfusion syndrome, twin anemia-polycythemia sequence and twin oligo-polyhydramnios sequence were analyzed as a group referred to "twin-to-twin transfusion syndrome".

2.1 | Statistical analyses

The data were analyzed using SPSS (IBM SPSS Statistics for Windows, Version 27.0, IBM Corporation). Microsoft EXCEL 2010 and SPSS 27.0 were used to create graphs. Crosstabs, independent samples *t* test and Mann–Whitney U test were performed for independent group comparisons with effect sizes (Cramer's V, Phi, Hedge's g and Eta^2) reported when applicable. For multiple comparisons, Bonferroni correction was used. Twins A and B were compared with related samples *t* test, Wilcoxon and McNemar tests, depending on distributions. To study factors related to PNM of one twin, logistic regression analyses were performed. PNM and NNM comparison were performed on numbers, not rates. A *p*-value <0.05 was considered statistically significant and 95% confidence intervals (CI) were used.

2.2 | Ethical approval

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 18 June 2018).

3 | RESULTS

During the studied years (2006, 2010, 2014 and 2018) there were 1034 twin pregnancies with known chorionicity (range 235–302 per year) of which 789 (76.3%, 95% CI 73.6–78.9) were DCDA and 245 (23.7%, 95% CI 21.4–26.0) MCDA (Figure 1). More than half (56.1%, 95% CI 52.8–59.2) of twins were born at term, with stable numbers

(Figure S1). However, up to 61.6% (95% CI 55.8–67.3) of MCDA twins compared with 38.4% (95% CI 35.4–41.5) of DCDA twins were preterm (p < 0.001). Overall, 23.1% (95% CI 19.4–26.7) of preterm deliveries were induced and 8.4% (CI 6.2–10.6) were planned CS. Corticoid therapy for lung maturation was given in 37.6% (95% CI 34.7–41.6): 33.7% (95% CI 30.8–36.8) among DCDA and 50.2% (95% CI 43.7–55.9) among MCDA pregnancies (p < 0.001).

Twin pregnancies were spontaneous in 72.5% (95% CI 69.8–75.0) and ART-induced in 26.1% (95% CI 23.6–28.7) of cases. Data were not available in 1.4%. Among ART-induced pregnancies, 90.0% (95% CI 85.9–93.4) were DCDA and 10.0% (95% CI 6.6–14.1) MCDA. Maternal characteristics were similar irrespective of chorionicity, but the share of over 35-year-old parturients was higher among DCDA pregnancies (p = 0.044) with no marked temporal change
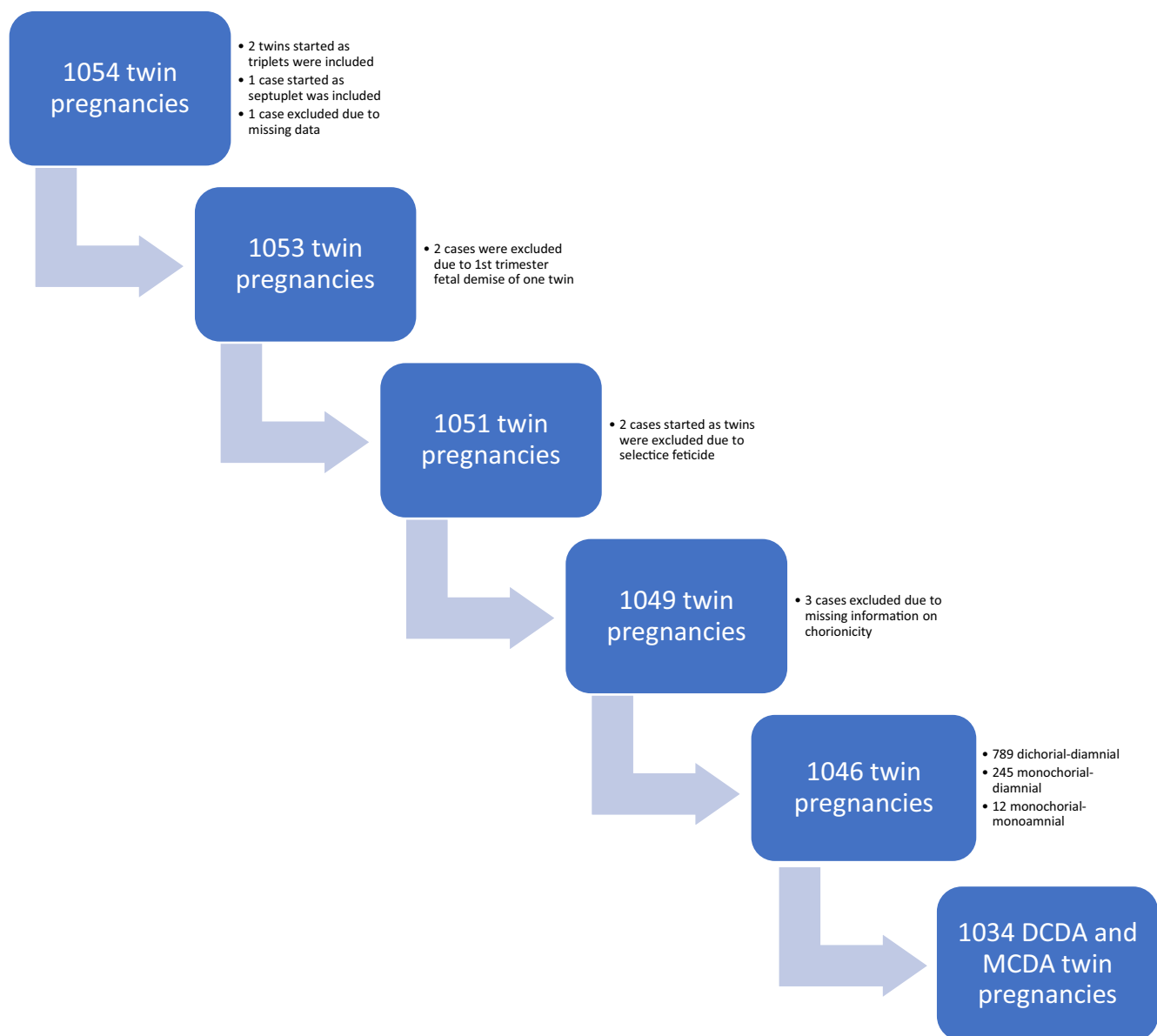

FIGURE 1 Flow-chart of the study with included and excluded cases described. DCDA, dichorionic-diamniotic; MCDA, monochorionic-diamniotic
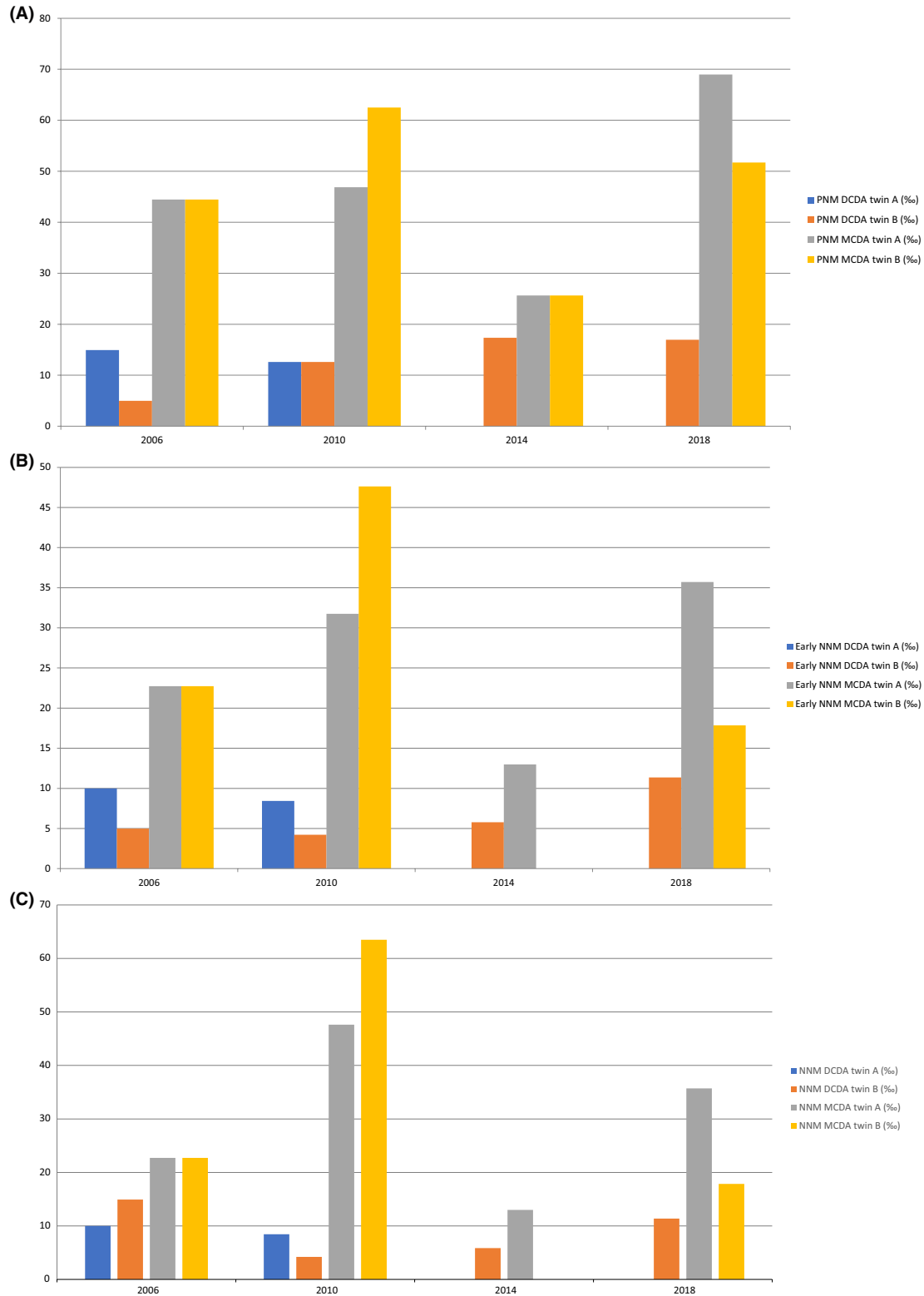
FIGURE 2 (A) Annual perinatal mortality rate (PNM) of Finnish dichorionic-diamniotic (DCDA) and monochorionic-diamniotic (MCDA) twins per 1000 children born, reported for 2006, 2010, 2014 and 2018. (B) Annual early neonatal mortality rate (NNM; death within the first week of life) of Finnish dichorionic-diamniotic (DCDA) and monochorionic-diamniotic (MCDA) twins per 1000 children born alive, reported for 2006, 2010, 2014 and 2018. (C) Annual neonatal mortality rate (NNM; death in the neonatal period) of Finnish dichorionic-diamniotic (DCDA) and monochorionic-diamniotic (MCDA) twins per 1000 children born alive, reported for 2006, 2010, 2014 and 2018

TABLE 1 Onset and mode of delivery in DCDA and MCDA twins in Finland during 2006–2018

Year	2006	2010	2014	2018	Total
DCDA twins n	201	238	173	177	789
Spontaneous onset of labor n (%)	80 (39.8)	84 (35.3)	66 (38.2)	58 (32.8)	288 (36.5)
Induction of labor n (%)	63 (31.3)	90 (37.8)	65 (37.6)	69 (39.0)	287 (36.4)
CS without vaginal attempt n (%)	58 (28.9)	64 (26.9)	42 (24.3)	50 (28.2)	214 (27.1)
Planned CS n (%)	28 (13.9)	45 (18.9)	25 (14.5)	29 (16.4)	127 (16.1)
Vaginal delivery of both twins n (%)	98 (48.8)	124 (52.1)	102 (59.0)	89 (50.3)	413 (52.3)
Urgent CS of both twins n (%)	65 (32.3)	57 (23.9)	40 (23.1)	52 (29.4)	214 (27.1)
Combination delivery n (%)	10 (5.0)	12 (5.0)	6 (3.5)	8 (4.5)	36 (4.6)
MCDA twins n	45	64	78	58	245
Spontaneous onset of labor n (%)[*]	22 (48.9)	26 (40.6)	17 (21.8)	13 (22.4)	78 (31.8)
Induction of labor n (%)	12 (26.7)	24 (37.5)	39 (50.0)	24 (41.4)	99 (40.4)
CS without vaginal attempt n (%)	11 (24.4)	14 (21.9)	22 (28.2)	21 (36.2)	68 (27.8)
Planned CS n (%)	3 (6.7)	6 (9.4)	10 (12.8)	10 (17.2)	29 (11.8)
Vaginal delivery of both twins n (%)	26 (57.8)	39 (60.9)	47 (60.3)	25 (43.1)	137 (55.9)
Urgent CS of both twins n (%)	11 (24.4)	17 (26.6)	19 (24.4)	17 (29.3)	64 (26.1)
Combination delivery n (%)	4 (8.9)	2 (3.1)	2 (2.6)	6 (10.3)	14 (5.7)
All twins n	246	302	251	235	1034
Spontaneous onset of labor n (%)[*]	102 (41.5)	110 (36.4)	83 (33.1)	71 (30.2)	366 (35.4)
Induction of labor n (%)[*]	75 (30.5)	114 (37.7)	104 (41.4)	93 (39.6)	386 (37.3)
CS without vaginal attempt n (%)	69 (28.0)	78 (25.8)	64 (25.5)	71 (30.2)	282 (27.3)
Planned CS n (%)	31 (12.6)	51 (16.9)	35 (13.9)	39 (16.6)	156 (15.1)
Vaginal delivery of both twins n (%)	124 (50.4)	163 (54.0)	149 (59.4)	114 (48.5)	550 (53.2)
Urgent CS of both twins n (%)	76 (30.9)	74 (24.5)	59 (23.5)	69 (29.4)	278 (26.9)
Combination delivery n (%)	14 (5.7)	14 (4.6)	8 (3.2)	14 (6.0)	50 (4.8)

Abbreviation: CS, Cesarean section; DCDA, dichorionic-diamniotic; MCDA, monochorionic-diamniotic.

*Proportions between 2006 and 2018 differ significantly, $p < 0.05$.

($p = 0.462$). Cervical incompetence and premature rupture of membranes added to preterm deliveries, but hypertension, diabetes and intrahepatic cholestasis of pregnancy showed insignificant results.

3.1 | Perinatal and neonatal mortality

PNM rate was higher for MCDA (11/245 = 44.9/1000 for both, annual range 25.6‰–69.0‰ for twin A and 25.6‰–62.5‰ for twin B) than DCDA twins (6/789 = 7.6/1000, range 0‰–14.9‰ for twin A and 10/789 = 12.7/1000, 5‰–17.3‰ for twin B) and remained stable over the years for both chorionicities (Figure 2A). Overall, 10 (1.0%, 95% CI 0.6–1.5) twins A died during the early neonatal period and seven (0.7%, 95% CI 0.3–1.1) were stillborn. The difference in PNM between MCDA and DCDA twins A was statistically significant (Phi = 0.125, $p < 0.001$). In addition, two newborns died after the first week of life (0.2%, 95% CI 0.0–0.5), the other during the neonatal period.

For twins B, the numbers were similar, with no significant difference in PNM compared with twins A ($p = 0.541$): 11 (1.1%, 95% CI 0.6–1.6) were stillborn and 10 (1.0%, 95% CI 0.5–1.5) early neonatal

deaths. The difference in PNM between MCDA and DCDA twins B was significant (Phi = 0.097, $p = 0.004$). After the first week of life there were six (0.6%, 95% CI 0.2–1.1) deaths among twins B, half of which happened during the neonatal period.

The overall NNM of twins A and B were similar. With minor correlation for chorionicity, early neonatal death was slightly more common among MCDA twins (Phi = 0.086, $p = 0.014$, twin A; and Phi = 0.063, $p = 0.060$ twin B) (Figure 2B). During the whole neonatal period, monochorionicity contributed significantly only to the NNM of twins A (Phi = 0.099, $p = 0.005$) (Figure 2C).

Twin A was slightly more often a girl (51.1%, 95% CI 48.1–53.8) and twin B a boy (51.5%, 95% CI 48.5–54.6), but sex had no effect on the PNM or early NNM of the twins, irrespective of chorionicity. When common maternal risk factors were analyzed, none of them resulted in significant changes in PNM.

Early NNM was higher among prematurely born twins (Phi = −0.093, $p = 0.003$ for both). Adjusting for chorionicity produced small numbers for comparison, but a subtle difference was seen, as there were no neonatal deaths among term MCDA twins. In addition, chorionicity correlated with GA at birth with MCDA twins born earlier (Cramer's V = 0.243, $p < 0.001$). Early

TABLE 2 Mean birthweight, Apgar scores and umbilical cord pH

ALL	DCDA	MCDA	*p*-value[a]	Effect size for chorionicity[b]	A vs B[c]
Mean birthweight[d] (g)	*n* = 789 (A), *n* = 788 (B)	*n* = 244			
A (2533)	2610	2284	<0.001	Hedge's *g* = 0.522	
B (2471)	2556	2196	<0.001	Hedge's *g* = 0.580	<0.001
SD (mean)[d]	*n* = 788 (A), *n* = 786 (B)	*n* = 241			
A (−0.167)	−0.128	−0.295	0.039	Hedge's *g* = 0.152	
B (−0.365)	−0.292	−0.601	<0.001	Hedge's *g* = 0.256	<0.001
Mean 1-min Apgar score[e]	*n* = 777 (A), *n* = 772 (B)	*n* = 236 (A), *n* = 238 (B)			
A (8.42)	8.58	7.92	<0.001	$\eta^2 = 0.031$	
B (7.80)	7.92	7.42	0.003	$\eta^2 = 0.008$	<0.001
Mean 5-min Apgar score[e]	*n* = 306 (A), *n* = 342 (B)	*n* = 103 (A), *n* = 109 (B)			
A (8.69)	8.90	8.05	<0.001	$\eta^2 = 0.073$	
B (8.43)	8.61	7.84	<0.001	$\eta^2 = 0.030$	0.005
Mean umbilical artery Ph[e]	*n* = 723 (A), *n* = 741 (B)	*n* = 224 (A), *n* = 211 (B)			
A (7.30)	7.30	7.31	0.043	Hedge's *g* = −0.155	
B (7.24)	7.24	7.26	0.002	Hedge's *g* = −0.221	<0.001
Mean umbilical vein Ph[e]	*n* = 37 (A), *n* = 27 (B)	*n* = 9 (A), *n* = 14 (B)			
A (7.33)	7.33	7.34	0.567	$\eta^2 = 0.008$	
B (7.28)	7.29	7.28	0.714	$\eta^2 = 0.004$	0.012

Abbreviations: DCDA, dichorionic-diamniotic; MCDA, monochorionic-diamniotic.

[a]Mann-Whitney U or independent samples *t*-test for chorionicity comparisons.

[b]Data available for comparisons may slightly differ from the total *N* available for the calculation for means.

[c]Paired samples *t*-test or Related samples Wilcoxon signed-rank test for twin A and B comparisons.

[d]All twins were analyzed.

[e]Live-born twins were analyzed.

NNM remained stable during the study period for both twins and chorionicities.

Neonatal death was caused by a congenital anomaly in four cases, most (three) among DCDA twins. Exclusion of anomalies produced small numbers, but the role of chorionicity on early and total NNM and on PNM, remained similar.

The order of twins was the same antenatally and during delivery except for six cases. The mode of delivery (vaginal/planned CS/unplanned CS) showed no differences in NNM of the twins (Table 1). The early NNM of vaginally born MCDA twins A was, however, slightly higher (4.1%, no deaths in the CS group, *p* = 0.084). There were no neonatal deaths among twins born via combination delivery.

3.2 | Birthweight

Overall, 4.2% (95% CI 3.1–5.4) of twins A and 8.6% (95% CI 6.9–10.2) of twins B were SGA (Tables 2 and 3). At least one twin was SGA in 11.8% (95% CI 10.0–13.4) of cases with a higher proportion among MCDA twins (16.3% vs 10.4%, *p* = 0.014). The association between

SGA and perinatal death of one twin was stronger among MCDA twins (Cramer's V = 0.080, *p* = 0.049, DCDA twins; and Cramer's V = 0.158, *p* = 0.029, MCDA twins). Severe weight discordance (≥25%) and perinatal death of one twin were associated, but significantly so only among DCDA twins (Cramer's V = 0.171, *p* < 0.001).

3.3 | Neonatal morbidity

There were five (0.5%, 95% CI 0.1–1.0) twins A and 44 (4.4%, 95% CI 3.2–5.9) twins B with low umbilical cord pH (*p* < 0.001), with stable numbers during the study period. Low pH did not vary across chorionicities, but there were no first-born MCDA twins with low pH and all neonatal deaths related to it (*n* = 3) occurred among DCDA twins. In general, low pH of one twin was more common among term compared to preterm twins. This difference was explained mainly by DCDA twins B (5.9% vs 2.7%, *p* = 0.042) as first-born twins showed no association between low umbilical cord pH and term birth with insignificant results also for MCDA twins B. For mean Apgar scores and umbilical cord pH, and details on neonatal morbidity, see Tables 2, 4, and S1.

TABLE 3 Birthweight discordance between twins A and B

DCDA twins n = 788		
Mean birthweight discordance (g)	212	
Birthweight discordance category	n (%, 95% CI)	SGA of at least one twin n (%, 95% CI)[*]
<15%	529 (67.1, 63.8, 70.3)	17 (3.2, 1.9–4.6)
15%–24%	160 (20.3, 17.6–22.8)	27 (16.9, 11.6–22.6)
≥25%	99 (12.6, 10.3–14.8)	38 (38.8, 28.8–49.0)
Effect size (Cramer's V)[*]	0.392	
p-value[*]	<0.001	
MCDA twins, n = 243		
Mean birthweight discordance (g)	230	
Birthweight discordance category	n (%, 95% CI)	SGA of at least one twin n (%, 95% CI)[*]
<15%	166 (68.3, 62.6–73.7)	7 (4.3, 1.7–7.3)
15%–24%	39 (16.0, 12.3–20.6)	8 (20.5, 9.1–35.3)
≥25%	38 (15.6, 11.5–19.3)	24 (64.9, 48.6–80.4)
Effect size (Cramer's V)[*]	0.585	
p-value[*]	<0.001	
ALL twins, n = 1031		
Mean birthweight discordance (g)	216	
Birthweight discordance category	n (%, 95% CI)	SGA of at least one twin n (%, 95% CI)[*]
<15%	695 (67.4, 64.6–70.5)	24 (3.5, 2.3–4.8)
15%–24%	199 (19.3, 17.1–21.4)	35 (17.6, 13.1–22.1)
≥25%	137 (13.3, 11.4–15.1)	62 (45.9, 38.5–53.3)
Effect size (Cramer's V)[*]	0.446	
p-value[*]	<0.001	

Abbreviations: DCDA, dichorionic-diamniotic; MCDA, monochorionic-diamniotic.

*Chi-squared test to analyze SGA of one twin across weight discordance category groups.

Only one premature twin A (4.8%) and B (4.0%) diagnosed with patent ductus arteriosus died in the early neonatal period. All neonatal deaths among premature twins A were associated with respiratory distress syndrome, but none were related to it or patent ductus arteriosus among twins born at term. Intracranial hemorrhage was associated with NNM of both twins: 0.3% (n = 3) vs 15.0% (n = 3) for twin A (Phi = 0.267, p < 0.001) and 0.7% (n = 7) vs 20.0% (n = 3) for twin B (Phi = 0.236, p < 0.001). Sepsis did not cause neonatal deaths. Necrotizing enterocolitis was a rare event (two cases for each twin).

Monochorionic-diamniotic twins and second-born twins were more often admitted to NICU with a longer stay (Tables 4 and S1). The correlation between NICU admittance and NNM was weak, with small numbers (Phi = 0.115, p = 0.001, twin A; and Phi = 0.128, p < 0.001, twin B).

Twin-to-twin transfusion syndrome was diagnosed in 48 (19.6%, 95% CI 15.1–24.4) MCDA pregnancies, resulting in perinatal death of one twin in 11 cases (22.9%, 95% CI 12.5–33.3), all preterm (n = 8, <28 weeks and n = 3, 28+0 to 31+6 weeks of gestation). Both twins died in five cases. Laser ablation was performed in 14 pregnancies, twice in one case. Amnioreduction was executed in four cases (several times in one) as laser ablation was unavailable.

3.4 | Logistic regression analyses

Prematurity, monochorionicity and weight discordance ≥25% were risk factors for perinatal death of one twin (Table S2). Smaller weight discordance (15%–24%) did not contribute significantly. Replacing weight discordance categories with SGA of one twin reduced the effect of chorionicity. These models cannot be used for prediction of PNM. Also, the SD used to define SGA has been adjusted for several factors including GA causing mathematically complex interpretations.

4 | DISCUSSION

In Finland, PNM of both singletons and twins is among the lowest in the world.[12,15] We have previously reported a profound decrease in PNM of both twins from 1987 to 2014, but a significant difference persisting

TABLE 4 Neonatal diagnoses and treatments received by Finnish DCDA and MCDA newborns during 2006–2018 with effect size for chorionicity reported

ALL n (%)	DCDA	MCDA	p-value[*]	Effect size for chorionicity	A vs B[**]
Patent ductus arteriosus	Only premature live-born twins analyzed				
A 21 (4.7)	8 (2.7)	13 (9.1)	0.003	Phi = 0.141	
B 25 (5.7)	12 (4.0)	13 (9.1)	0.031	Phi = 0.103	p = 0.503
Respiratory distress syndrome					
A 111 (25.1)	69 (23.0)	42 (29.4)	0.148	Phi = 0.069	
B 113 (25.6)	74 (24.7)	39 (27.3)	0.569	Phi = 0.027	p = 0.906
Sepsis	All live-born twins included				
A 11 (1.1)	9 (1.1)	2 (0.8)	1.000	Phi = −0.012	
B 14 (1.4)	8 (1.0)	6 (2.5)	0.106	Phi = 0.055	p = 0.664
Intracranial hemorrhage					
A 20 (2.0)	13 (1.7)	7 (3.0)	0.281	Phi = 0.040	
B 15 (1.5)	8 (1.0)	7 (3.0)	0.057	Phi = 0.068	p = 0.189
Neonatal jaundice or phototherapy					
A 263 (25.4)	191 (24.3)	72 (30.4)	0.062	Phi = 0.058	
B 219 (21.5)	147 (18.8)	72 (30.4)	<0.001	Phi = 0.119	p < 0.001
Admitted to NICU					
A 225 (22.0)	139 (17.7)	86 (35.0)	<0.001	Phi = 0.187	
B 251 (24.6)	160 (20.4)	91 (38.2)	<0.001	Phi = 0.175	p = 0.006
NICU stay in days					
A 2.0	1.4	3.8	<0.001	$\eta^2 = 0.036$	
B 2.3	1.5	4.8	<0.001	$\eta^2 = 0.033$	p < 0.001
Respiratory support					
A 201 (19.7)	127 (16.2)	74 (31.0)	<0.001	Phi = 0.157	
B 278 (27.3)	192 (24.6)	86 (36.3)	0.001	Phi = 0.111	p < 0.001
Respiratory support in days					
A 1.80	1.2	3.8	<0.001	$\eta^2 = 0.025$	
B 2.37	1.5	5.1	<0.001	$\eta^2 = 0.015$	p < 0.001

Abbreviations: DCDA, dichorionic-diamniotic; MCDA, monochorionic-diamniotic; NICU, neonatal intensive care unit.

* Chi-squared test or Mann-Whitney U for chorionicity comparisons.; **Related samples Wilcoxon signed-rank test or McNemar test for twin A and B comparisons.

between twin A and B.[12] Although considered a reliable source of information, data on chorionicity have not been available in the Finnish Birth Register until 2020 onwards. In this large twin cohort we looked more deeply into the effect of chorionicity. During the study period 2006–2018, PNM has fluctuated between 0‰ and 17.3‰ in DCDA and 25.6‰–69.0‰ in MCDA twins. The immediate neonatal outcome of twins B is worse and more pronounced in MCDA twins.

As expected, chorionicity contributed markedly to the morbidity and mortality of twins. The inferiority of MCDA twins is largely related to a common placenta and younger GA at birth, in agreement with our material. The higher PNM among MCDA twins in our study is in line with previous reports.[10,16,17] A fifth of MCDA pregnancies were complicated by twin-to-twin transfusion syndrome, among which total mortality was 22.9%. As chorionicity and GA correlated with MCDA twins born earlier, chorionicity may be considered an indirect cause of higher PNM and morbidity. In fact, 61.6% of MCDA

twins were preterm compared with 38.4% of DCDA twins. Still, over half (56.1%) of all twins were born at term, which is more than previously reported.[18] This may reflect different national policies on delivery timing, as here only 23.1% of premature deliveries were induced.

In Finland, no national guidelines on the management of twin pregnancies and deliveries exist and local protocols are applied. In the delivery units of Helsinki University Hospital, the delivery of uncomplicated MCDA twins is generally aimed at 37–38 weeks and for DCDA twins at 38–39 weeks. This is later than recommended by some obstetric-gynecologic societies.[19,20] In a Japanese population-based study the best child health and neurodevelopmental outcome was achieved for children born at early term.[9] Others have concurred: the risks and benefits are in balance at 36 weeks, suggesting that uncomplicated MCDA twins should be delivered at 36 weeks and DCDA twins at 37 weeks; however, conflicting data also exist.[7,21,22]

Prematurity remains the leading cause of higher PNM and morbidity of twins compared with singletons, with possible long-term sequelae. This applies both to very preterm (<32 gestational weeks) and late preterm (34–36 weeks) children.[22] The reasons behind prematurity are multifactorial and differ from singletons, with reflections on prediction and management.[18,23,24] Antenatal corticosteroids, antibiotics, magnesium-sulfate neuroprotection and tocolysis are equally important and applicable for twins as for singletons.[25] However, no treatment has been shown to reduce preterm birth in asymptomatic twin gestations or the findings are controversial.[26–28] In addition to spontaneous prematurity, up to half of preterm twin deliveries have been induced due to medical reasons.[8] In our material this number is lower, likely due to expectant management of uncomplicated twin pregnancies approximating term.

NNM was expectedly higher among preterm births and slightly higher among MCDA twins, with all neonatal deaths occurring in preterm twins. In previous reports, the effect of chorionicity on NNM has been contradictory and the effect was weak also in our study.[16,17] The NNM of twins A and B did not differ, reflecting the importance of GA at birth.

In our study, weight discordance did not vary across chorionicities, but birthweight (and adjusted birthweight SD) were lower in MCDA twins. Hack et al. have reported similar results.[10] In keeping with previous reports, ≥25% weight discordance was associated with perinatal death of one twin in our study.[14] This association occurred mainly among DCDA twins, possibly reflecting small numbers, but also raising an intriguing question whether different etiology behind weight discordance between chorionicities or difference in monitoring plays an actual role. Furthermore, weight discordance and SGA of at least one twin showed a strong correlation.

Newborn MCDA twins face higher neonatal morbidity than DCDA twins mainly due to earlier GA at birth and lower birthweight.[10] The immediate neonatal outcome was worse among MCDA twins also in our material: Apgar scores were lower, and NICU admittance and respiratory support more common and prolonged. Long (several months) durations of respiratory support may contain inaccuracies. Although low umbilical cord pH was equally rare between chorionicities, all neonatal deaths associated with it occurred among DCDA twins, highlighting the importance of strict surveillance of DCDA twins both antenatally and during delivery, and the different profile of NNM among MCDA twins experiencing earlier GA and inequal placental sharing.

The finding that twin B encounters more complications was anticipated, as similar observations have been made in previous studies, including our register-based report.[12,29] This implies that these high-risk pregnancies are generally well monitored but still require improvement. Despite small numbers, the notion that all three perinatal deaths at term occurred in DCDA twins, raises questions. Compared with MCDA, dichorionic twins are considered as lower risk, even though their PNM is still higher compared with the 3‰–4‰ in singletons in Finland.[12,30] The antenatal follow-up of DCDA twins is less frequent and performed at regular antenatal clinics, whereas MCDA twins are monitored by specialists. Dichorionic twins are also carried to later GA. Even though the PNM of DCDA twins is low, some deaths might be avoided by a more intense follow-up close to term.

This large cohort with well-documented; thorough data enabled comprehensive analysis of several risk factors and outcomes, applicable to other Nordic countries. Sorting by chorionicity is reliable and based on ultrasound reports. The timeline chosen reflects possible alterations during the study period. The generally low PNM and NNM among twins in Finland may limit the statistical power of some analyses and interpretations.

5 | CONCLUSION

The overall PNM and NNM among Finnish twins is low, but national guidelines are needed to standardize the quality of care. The challenges of monochorionicity are well understood and will always account for their higher PNM, but improving the prognosis of the second twin irrespective of chorionicity is attainable and requires adjustment of follow-up and further investigation.

CONFLICT OF INTEREST
None.

AUTHOR CONTRIBUTIONS
A-R.R. and R.J. are responsible for data collection, study design, statistical analyses and the body of the manuscript. M.G., M.N., and I.N. critically revised the manuscript.

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