OBSTETRICS

Neonatal morbidity associated with vaginal delivery of noncephalic second twins

Thomas Schmitz, MD, PhD; Diane Korb, MD; Catherine Battie, MD; Anne-Gaël Cordier, MD; Céline de Carne Carnavalet, MD; Céline Chauleur, MD, PhD; Véronique Equy, MD; Bassam Haddad, MD; Delphine Lemercier, MD; Christophe Poncelet, MD, PhD; Luc Rigonnot, MD; François Goffinet, MD, PhD; for the Jumeaux Mode d'Accouchement study group and the Groupe de Recherche en Obstétrique et Gynécologie

BACKGROUND: Management of noncephalic second twin delivery rests on the results of population-based retrospective studies of twin births that have shown higher neonatal mortality and morbidity for second twins with noncephalic, compared with cephalic, presentations after vaginal delivery of the first twin. Because these studies are flawed by data of questionable validity, do not report the obstetrical practices at delivery, and do not allow collection of potential confounding variables, we performed a national prospective study specially designed to evaluate the management of twins' delivery.

OBJECTIVE: We sought to assess neonatal mortality and morbidity according to second twin presentation after vaginal birth of the first twin.

STUDY DESIGN: The Jumeaux Mode d'Accouchement study was a nationwide prospective population-based cohort study of twin deliveries performed in 176 maternity units in France from February 2014 through March 2015. The primary outcome was a composite of intrapartum mortality and neonatal mortality and morbidity. Neonatal outcomes of second twins born ≥32 weeks of gestation after vaginal delivery of the first cephalic or breech twin were compared according to the noncephalic or cephalic second twin presentation. Multivariable logistic regression models controlled for potential confounders. Subgroup analyses were conducted according to the breech or transverse presentation of the noncephalic second twin, and gestational age at delivery, before or after 37 weeks of gestation.

RESULTS: Among 3903 second twins enrolled in the study, 2384 (61.1%) were in cephalic and 1519 (38.9%) in noncephalic presentations, of whom 999 (25.6%) were in breech and 520 (13.3%) in transverse presentation. Composite neonatal mortality and morbidity did not differ between the noncephalic and cephalic group (47/1519 [3.1%] vs 59/2384 [2.5%]; adjusted odds ratio, 1.23; 95% confidence interval, 0.81−1.85). No significant difference between groups was shown for the primary outcome in subgroup analyses according to type of noncephalic second twin presentation or gestational age at delivery. Cesarean delivery rates for the second twin were lower in the breech than in the cephalic group (14/999 [1.4%] vs 75/2384 [3.1%], $P = .003$) and lower in the cephalic than in the transverse group (75/2384 [3.1%] vs 35/520 [6.7%], $P < .001$).

CONCLUSION: Noncephalic and cephalic second twin presentations after vaginal delivery of the first twin ≥32 weeks of gestation are associated with similar low composite neonatal mortality and morbidity. Vaginal delivery of noncephalic second twin is a reasonable option.

Key words: active management of second twin delivery, breech second twin delivery, second twin presentation

Introduction

Shortly after the publication of the results of the international randomized trial (the Twin Birth Study),[1,2] showing comparable neonatal mortality and morbidity rates after planned cesarean and planned vaginal delivery for twin pregnancies, the American Congress of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine recommended that women with either cephalic/cephalic presenting twins or cephalic/noncephalic presenting twins should be counseled to attempt vaginal delivery.[3,4] A large French prospective national cohort study (Jumeaux Mode d'Accouchement [JUMODA]) recently showed higher composite neonatal mortality and morbidity associated with planned cesareans <37 weeks of gestation in an unselected population of women pregnant with twins.[5] These findings strongly support these recommendations.[6]

Nevertheless, a recent survey underlined persistent concerns about managing delivery of noncephalic second twins and reported the reluctance of >40% of US practitioners to perform breech extractions in this situation and their preference for another method of delivery, mainly cesarean.[7] Indeed, large retrospective population-based cohort studies repeatedly report that the delivery of noncephalic second twins after vaginal birth of the first twin is associated with higher neonatal mortality and morbidity than for cephalic second twins,[8] either directly or indirectly, due to increased rates of cesarean for the second twin.[9-13] Together with the conclusions of the Term Breech Trial,[14] these results have progressively led obstetricians to abandon the vaginal route for twin deliveries when the second twin's presentation is noncephalic.[15,16] This result generates a vicious circle in which more and more practitioners are becoming less and less skilled[7,16] and thus further complicates the evaluation of the risks associated with vaginal delivery for these presentations.

Because the management of noncephalic second twin delivery has been influenced by the results of large population-based retrospective studies that are flawed by data of questionable validity, do not report the obstetrical practices at delivery, and do not allow collection of potential confounding

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AJOG at a Glance

Why was this study conducted?

This national prospective study was conducted to assess neonatal mortality and morbidity according to second twin presentation after vaginal birth of the first twin ≥32 weeks of gestation.

Key Findings

Noncephalic and cephalic second twin presentations after vaginal delivery of the first twin ≥32 weeks of gestation are associated with similar low composite neonatal mortality and morbidity.

What does this study add to what is already known?

Our study confirms on a population basis the results of small retrospective hospital studies. It provides further evidence that vaginal delivery of noncephalic second twins is a reasonable option and that the planned mode of delivery of twin pregnancies should not be based any longer on second twin presentation.

variables, we performed the national prospective JUMODA study, specially designed to assess the management of twins' delivery. It enabled an accurate evaluation of the neonatal risks according to well-described and reported obstetrical practices with sufficient statistical power and generated high-quality data. This study was performed in a country where obstetricians are trained in and accustomed to active management of noncephalic second twin deliveries with breech extraction, which is the recommended strategy,[17] because the alternatives, external cephalic version or cesarean for the second twin, are associated with poorer neonatal outcomes.[9-13,18] Therefore, in this planned secondary analysis of the JUMODA cohort, our aim was to assess the neonatal risks associated with different second-twin presentations after vaginal delivery of the first twin: noncephalic (with breech and transverse considered both together and separately) and cephalic.

Materials and Methods

The JUMODA study was a national, observational, prospective, population-based cohort study conducted from February 10, 2014, through March 1, 2015, in France. Detailed information regarding the participating women and maternity units has previously been reported elsewhere.[5] This cohort was specially designed to assess the effect of the planned mode of delivery[3] and of delivery management (the present study) on neonatal outcomes in twins.

This planned secondary analysis of the JUMODA cohort focuses on second twins born after vaginal delivery of the first twin ≥32 weeks of gestation, regardless of the first twin's presentation. It excludes pregnancies with either twin stillborn (Figure).

Recruitment and data collection occurred only after women had received information and provided oral informed consent to participate. The National Data Protection Authority (DR-2013-528), the consultative committee on the treatment of information on personal health data for research purposes (13-298), and the committee for the protection of people participating in biomedical research (PP-13-014) approved this study.

Diagnosis of second twin presentation was available before delivery on the last sonography report and always checked clinically after first twin delivery by vaginal examination. In France, guidelines recommend active management of second twin delivery, with immediate total breech extraction for breech presentations, internal version and total breech extraction for transverse or cephalic presentations >0 station, and artificial membrane rupture and pushing

FIGURE
Study flowchart

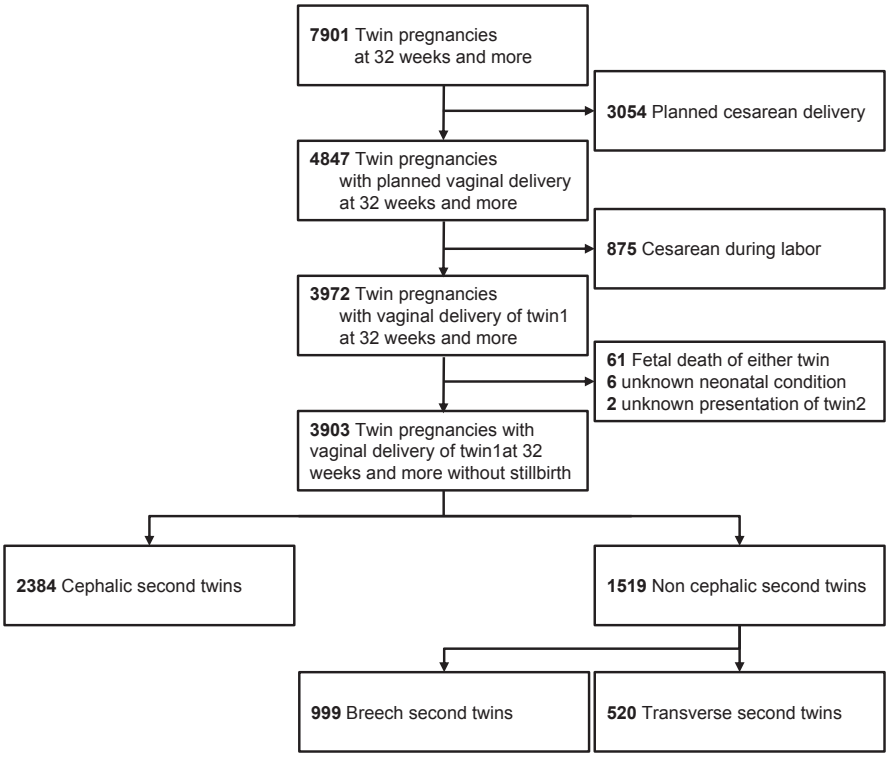

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TABLE 1
Maternal and pregnancy characteristics according to second twin presentation after vaginal birth of first twin

Maternal and pregnancy characteristics	Noncephalic second twin N = 1519	Cephalic second twin N = 2384	*P* value
Age, y, mean ± SD	31.5 ± 5.1	31.0 ± 4.9	.003
<30	516 (34.0)	914 (38.3)	.008
30–39	919 (60.5)	1369 (57.4)	
≥40	84 (5.5)	101 (4.2)	
Occupation			
Managers and higher socioeconomic professions	212 (14.0)	357 (15.0)	.02
Intermediate professions, administrative, sales, and service workers	718 (47.3)	1228 (51.5)	
Crafts workers, storekeepers	43 (2.8)	70 (2.9)	
Farmers, workers	27 (1.8)	38 (1.6)	
Retired or not in labor force	397 (26.1)	515 (21.6)	
Unknown	122 (8.0)	176 (7.4)	
Country of birth			
France	1000 (74.5)	1689 (78.8)	.01
Europe	52 (3.8)	79 (3.7)	
North Africa	175 (12.9)	200 (9.3)	
Africa, other	81 (6.0)	112 (5.2)	
Other	38 (2.8)	63 (2.9)	
BMI before pregnancy, kg/m^{-2}			
<18.5	89 (6.1)	158 (6.9)	.016
18.5–24.9	896 (61.2)	1488 (65.2)	
25–29.9	320 (21.8)	423 (18.5)	
≥30	160 (10.9)	214 (9.4)	
Nulliparous	554 (36.6)	1057 (44.0)	<.001
Smokers	210 (14.4)	330 (14.4)	.98
Previous cesarean	58 (3.9)	69 (2.9)	.11
IVF, ICSI	284 (18.7)	458 (19.1)	.70
First trimester sonography	1377 (95.4)	2175 (96.0)	.38
Fetal reduction at ≥13 wk	18 (1.2)	21 (0.9)	.36
Chorionicity			
Dichorionic	1278 (84.3)	1841 (77.6)	.001[a]
Monochorionic, diamniotic	236 (15.6)	524 (22.1)	
Monochorionic, monoamniotic	1 (<0.1)	6 (0.3)	
Unknown	1 (<0.1)	3 (0.1)	
Pregnancy complications	330 (21.8)	515 (21.7)	.95
Hypertension	61 (4.0)	96 (4.0)	
Preeclampsia	95 (6.3)	139 (5.9)	
Placenta abruptio	2 (0.1)	0 (0.0)	
IUGR	163 (10.8)	255 (10.7)	
Insulin-treated diabetes	49 (3.2)	57 (2.4)	

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(continued)

TABLE 1
Maternal and pregnancy characteristics according to second twin presentation after vaginal birth of first twin *(continued)*

Maternal and pregnancy characteristics	Noncephalic second twin N = 1519	Cephalic second twin N = 2384	*P* value
Placenta previa	3 (0.2)	5 (0.2)	
Malformation	26 (1.7)	44 (1.9)	
Twin-to-twin transfusion syndrome	14 (0.9)	36 (1.5)	
Premature rupture of membranes	121 (8.0)	198 (8.3)	.70
Preterm labor	526 (34.7)	878 (36.9)	.17
Antenatal corticosteroids	597 (39.5)	1029 (43.4)	.02

Values are n (%) unless otherwise noted.

BMI, body mass index; *ICSI*, intracytoplasmic sperm injection; *IUGR*, intrauterine growth restriction; *IVF*, in vitro fertilization.

[a] Fisher exact test.

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efforts for cephalic presentation ≤0 station.[17]

Obstetricians completed a detailed web-based questionnaire about the delivery and its management immediately after the birth, before leaving the delivery ward. Research nurses collected data about maternal characteristics, medical history, pregnancy complications, and neonatal health. The primary outcome was a composite of intrapartum mortality and neonatal mortality and morbidity, very similar to the primary outcome of the Twin Birth Study.[1] Neonatal mortality was assessed through the first 28 days of life. Neonatal morbidity was defined as ≥1 of the following: 5-minute Apgar score <4; birth trauma (humerus, femur, or skull fracture, spinal cord injury, or brachial plexus palsy); injury of the phrenic or facial nerve present at 72 hours of age or at hospital discharge; subdural or intracerebral hemorrhage confirmed by ultrasonography, computed tomography, or magnetic resonance imaging); encephalopathy according to the Sarnat classification[19]; seizures on at least 2 occasions within 72 hours after birth; endotracheal ventilation within 72 hours after birth for at least 24 hours; proven neonatal sepsis during neonatal hospitalization, defined by a positive blood culture or cerebrospinal fluid culture; bronchopulmonary dysplasia, defined as the need for supplemental oxygen at a postnatal gestational age of 36 weeks; intraventricular hemorrhage or cystic periventricular leukomalacia confirmed by ultrasonography; and stage II and III necrotizing enterocolitis according to Bell staging. This primary outcome was treated as a binary variable.

We first compared maternal, pregnancy, labor, and neonatal characteristics according to the noncephalic and cephalic presentation of the second twin with Pearson χ^2 test or Fisher exact test when the expected frequency of qualitative items was <5. One-way analysis of variance and *t* tests were used for quantitative variables. In the primary analysis, neonatal outcomes were compared according to whether presentation of the second twin was cephalic or noncephalic.

The proportion of patients with missing data ranged from 0-1%, except for body mass index (4%), deliveries per year per center (8%), and country of birth (10%). Because 15% of the women had at least 1 item of missing data, we used multiple imputation by Monte Carlo Markov chains,[20] generating 15 independent imputed data sets. Multiple imputation allows to keep in the multivariable logistic regression models the other available covariates of the women with missing data, thus preserving from losing both information and statistical power, and finally increasing the accuracy of these models.

The independent effect of the second twin presentation on the primary outcome was tested and quantified with a 2-level multivariable logistic regression with a random intercept to take into account the hierarchical structure of the data, with women clustered according to their center. We adjusted for potential explanatory factors associated with second-twin presentation with a *P* value <.2 in the bivariate analysis. All factors were considered categorical variables (Tables 1 and 2).

We performed a sensitivity analysis after excluding first twins in breech presentation.

For planned subgroup analyses, comparisons were performed according to the breech or transverse presentation of the noncephalic second twin, with the cephalic second twin group as the reference and to gestational age at delivery, before and after 37 weeks of gestation. All tests were 2-sided. *P* values <.05 were considered significant. We used software (Stata 13.1; StataCorp LP, College Station, TX).

Results

During the study period, 7901 women in the 176 participating maternity units gave birth to twins ≥32 weeks of gestation and consent to the study, and 3903 of them had vaginal deliveries of the first twin. Because 109 women were mistakenly not included or refused to participate, this analysis covers 97.3% of the women

TABLE 2
Labor and delivery characteristics of according to second twin presentation after vaginal birth of first twin

Labor and delivery characteristics	Noncephalic second twin N = 1519	Cephalic second twin N = 2384	*P* value
Twin deliveries per center per year			
<50	506 (36.2)	770 (35.2)	.83
50–99	330 (23.6)	529 (24.2)	
≥100	563 (40.2)	886 (40.6)	
Onset of labor			
Spontaneous	847 (55.8)	1332 (55.9)	.76
Induction with oxytocin	467 (30.7)	756 (31.7)	
Induction with prostaglandins	180 (11.9)	258 (10.8)	
Induction with balloon	25 (1.7)	38 (1.6)	
First-twin presentation at delivery			
Cephalic	1410 (92.8)	2274 (95.4)	.001
Breech	109 (7.2)	110 (4.6)	
Analgesia			
None	50 (3.3)	85 (3.6)	.70
Regional	1441 (95.1)	2260 (95.1)	
General	24 (1.6)	31 (1.3)	
Mode of delivery			
Vaginal	1470 (96.8)	2309 (96.9)	.89
Cesarean	49 (3.2)	75 (3.1)	
Delivery by OB/GYN resident	545 (35.9)	843 (35.4)	.74
Intertwin delivery interval (median, Q1–Q3, min)	4 (3–7)	7 (4–11)	<.001
Gestational age at birth			
32 wk 0 d–34 wk 6 d	294 (19.4)	424 (17.8)	.40
35 wk 0 d–36 wk 6 d	455 (30.0)	708 (29.7)	
≥37 wk 0 d	770 (50.7)	1252 (52.5)	
Birthweight			
<10th centile	633 (41.7)	1002 (42.1)	.61
10th–89th centile	862 (56.8)	1351 (56.8)	
≥90th centile	22 (1.5)	26 (1.1)	
g, Mean ± SD	2399 ± 451	2419 ± 416	.17
First twin ≥25% larger than second twin	84 (5.5)	85 (3.6)	.003
Second twin ≥25% larger than first twin	19 (1.3)	47 (2.0)	.09

Values are n (%) unless otherwise noted.

OB/GYN, obstetrics/gynecology; *Q*, quartile.

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having delivered twins in the participating maternity units during the study period (N = 4012). Among these 3903 women, 2384 (61.1%) had a second twin in cephalic presentation, and 1519 (38.9%) in noncephalic presentation, of whom 999 (25.6%) were in breech and 520 (13.3%) in transverse presentations (Figure).

As Table 1 shows, compared to women with a cephalic second twin, those with a noncephalic second twin were older; more often foreigners, unemployed, and overweight; had monochorionic twin pregnancies more often; and received antenatal corticosteroid therapy more frequently. Moreover, their first twin was in breech presentation more often, and their intertwin

TABLE 3
Neonatal outcomes according to second twin presentation after vaginal birth of first twin

	Noncephalic second twin N = 1519	Cephalic second twin N = 2384	OR (95% CI)	aOR (95% CI)[a]
	n (%)	n (%)		
Primary outcome Composite morbidity	47 (3.1)	59 (2.5)	1.27 (0.86–1.88)	1.23 (0.81–1.85)
Death	2 (0.1)	2 (0.1)		
Intrapartum	0 (0.0)	0 (0.0)		
Neonatal	2 (0.1)	2 (0.1)		
Apgar score <4 at 5 min	1 (0.1)	8 (0.3)		
Neonatal trauma	6 (0.4)	4 (0.2)		
Long bone fracture	3 (0.2)	3 (0.1)		
Brachial plexus palsy	1 (<0.1)	1 (<0.1)		
Skull fracture	2 (0.1)	0 (0.0)		
Encephalopathy	1 (<0.1)	5 (0.2)		
≥2 Seizures within 72 h after birth	0 (0.0)	1 (0.1)		
Endotracheal tube for >24 h within 72 h after birth	21 (1.4)	20 (0.8)		
Proven neonatal sepsis	14 (0.9)	22 (0.9)		
Bronchopulmonary dysplasia	7 (0.5)	5 (0.2)		
Intraventricular hemorrhage	4 (0.3)	10 (0.4)		
Grade I–II	4 (0.3)	9 (0.4)		
Grade III–IV	0 (0.0)	1 (<0.1)		
Periventricular leukomalacia	0 (0.0)	1 (<0.1)		
Necrotizing enterocolitis	5 (0.3)	2 (0.1)		

All variables were included in primary outcome except grade I–II intraventricular hemorrhage.

No infant had spinal cord, phrenic, or facial nerve injury.

aOR, adjusted odds ratio; *CI*, confidence interval; *OR*, odds ratio.

[a] Adjustment for maternal age, profession, country of birth, body mass index, nulliparity, previous cesarean, chorionicity, antenatal corticosteroids, first-twin presentation, birthweight, and twin discordance.

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delivery interval shorter (Table 2). Obstetrics residents performed a third of the second-twin deliveries (Table 2). The groups did not differ for second-twin cesarean rates or gestational age at birth (Table 2). Only 4 women had a cesarean for the second delivery due only to this twin's noncephalic presentation. To control for group imbalance and potential confounders, we performed multivariable logistic regression.

The noncephalic group did not differ significantly for composite neonatal mortality and morbidity from the cephalic group (3.1% vs 2.5%, odds ratio [OR], 1.27; 95% confidence interval [CI], 0.86–1.88). This result was unchanged after adjustment for potential confounders (adjusted OR, 1.23; 95% CI, 0.81–1.83) (Table 3). The sensitivity analysis performed after exclusion of the breech-presenting first twins showed similar results (2.9% compared to 2.5%; adjusted OR, 1.18; 95% CI, 0.77–1.83) (Supplementary Table 1).

Rate of cesarean delivery for the second twin was lower in the breech than in the cephalic group (1.4% vs 3.1%, $P = .003$) and lower in the cephalic than in the transverse group (3.1% vs 6.7%, $P < .001$). After adjustment for potential confounders, composite neonatal mortality and morbidity did not differ significantly between the breech and cephalic groups (3.4% vs 2.5%; adjusted OR, 1.34; 95% CI, 0.85–2.12) (Supplementary Table 2) nor between the transverse and cephalic groups (2.5% vs 2.5%; adjusted OR, 0.91; 95% CI, 0.47–1.76]) (Supplementary Table 2).

Subgroup analysis according to gestational age at delivery showed no significant difference in composite neonatal mortality and morbidity between groups before (5.6% vs 3.9%; adjusted OR, 1.33; 95% CI, 0.83–2.13) (Supplementary Table 3) or after (0.7% vs 1.2%; adjusted OR, 0.53; 95% CI,

0.19−1.48) (Supplementary Table 4) 37 weeks of gestation in the noncephalic compared to the cephalic group.

Comment

Based on this planned secondary analysis on the JUMODA study, we showed that noncephalic second twin presentations are not associated with higher composite neonatal mortality and morbidity than cephalic second twin presentations. Furthermore, a low cesarean rate for breech second-twin presentations is an achievable goal nationwide.

Our results contrast with most of the existing literature. Although underpowered hospital retrospective studies have not observed higher levels of neonatal mortality and morbidity for second twins in breech or transverse compared to cephalic presentations,[21-25] large retrospective population-based cohort studies have reported higher levels of neonatal risks associated with noncephalic presentations and dictated noncephalic second twin delivery management so far.[8-13] A Swedish series of >18,000 consecutive twin deliveries found that breech presentation of the second twin was associated with an 85% increase in neonatal death compared with cephalic presentation.[8] Several factors might explain these discrepancies. First, as reported earlier,[5] patients in the JUMODA study eligible for planned vaginal delivery were carefully selected to reduce potential risks of adverse neonatal outcome associated with vaginal birth. Second, the intertwin delivery interval was <5 minutes in the noncephalic group, and shorter intervals are correlated with better neonatal outcomes.[12,26,27] These shorter intervals are due to the nature of the obstetric interventions recommended in France for noncephalic second twin deliveries.[17] Retrospective cohort studies do not provide information about all of these relevant points. Finally, we report low rates of cesarean for the second twin, an obstetric situation well-known for being associated with increased neonatal mortality and morbidity.[9-13]

Calculated with women having delivered their first twin vaginally as denominator, the rate of cesarean for the second twin was 7.0% in the Twin Birth Study[1] and 24.8% in the study of Yang et al.[13] Cesarean rates for second twins in our study were much lower, around 3%, and did not differ between the cephalic and noncephalic groups. Furthermore, the lowest cesarean rate for second twins was associated with breech presentation and was only 1.4%. Several related reasons may explain our low cesarean rate for breech presenting second twins. First, despite the publication of the results of the Term Breech Trial,[14] vaginal delivery is still proposed to women with fetuses in breech presentation in France, as a national prospective study failed to observe any significant increase in perinatal risks associated with planned vaginal, compared with planned cesarean, deliveries.[28] This continued practice has resulted in maintenance of the skills needed for breech delivery in our country. Second, in France, breech presentation of second twins is generally considered the most favorable situation for their successful vaginal delivery, as others have also suggested.[29] Support for this viewpoint comes from our finding that only 4 women had cesareans for the second twin's delivery only because of its noncephalic presentation. Third, a recent survey of French obstetrics residents showed that >45% of them had performed >5 internal versions followed by breech extractions by the end of their 5-year residency program.[30] Consistently with these results, one third of the second twin deliveries in this nationwide study were performed by residents.

The main clinical implication of our study is that the planned mode of delivery of twin pregnancies should not be based any longer on second twin presentation. Indeed, second twin presentation has a 10-25% chance to change in late pregnancy and during labor,[25,31] so that the decision made before labor on a presumed presentation will not be valid at the time of delivery. Furthermore, as the results of the present study suggest, presentation of the second twin has no influence on neonatal mortality and morbidity or on the rate of cesarean for the second twin.

Future researches will have to focus on how these results could be implemented into clinical practices, that is, how could active management of second twin delivery be taught to future practitioners. Beside simulation programs for twin deliveries,[32] hands-on training should remain the pivotal step of resident training programs ultimately. Therefore, future researches should assess if hands-on training of residents for second twin delivery is possible and evaluate its impact on neonatal outcomes.

The strengths of our study include its population-based cohort design and prospective enrollment of women giving birth in maternity units performing >1500 deliveries annually in France during a 1-year period. The births included in the study account for >70% of all twin births in France each year and >95% of those in maternity units with >1500 annual deliveries.[33] Attending obstetricians prospectively collected the data about delivery management, so that thorough and accurate information was available for the second twin presentation. Furthermore, it provided sufficient statistical power to assess the neonatal risks associated with second twin presentation and ensured high external validity of its results. Nonetheless, our findings are only generalizable to large maternity units accustomed to active management of second-twin delivery, as recommended in France.[17]

As in all observational studies, the main limitation of our study is uncontrolled confounders. Nonetheless, unlike large retrospective cohort studies, our prospective design enabled us to collect data about clinically pertinent factors that were integrated in multivariable logistic regression models to control for these potential confounders and reduce bias as much as possible. Although it is unlikely because of the French point of view regarding noncephalic second twin presentations, the unbalance for maternal, pregnancy, and labor characteristics between the 2 groups might have resulted from different criteria during the selection process for planned vaginal delivery. However, we do not believe this could have compromised the external validity of our study, for several

reasons. First, the JUMODA study recruited nationwide, in the general French population, and there was no exclusion criterion at the time women were recruited. Second, the planned cesarean delivery rate was low, <40%, half of which was explained by the breech presentation of the first twin. Third, our rate of second twins in noncephalic presentation is in accordance with the rates reported in the retrospective literature[29] and in the Twin Birth Study.[1,31]

In conclusion, because vaginal delivery is associated with low composite neonatal mortality and morbidity,[1,5] even for noncephalic second twin presentations as reported here, this route of delivery should be encouraged regardless of second twin presentation, as long as the obstetrical skillsets remain available. ■

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Puy-en-Velay (Dr Samuel). **Basse Normandie**: Coordinator: Pr Dreyfus, CHU de Caen (Dr Beucher, Dr Dolley), Clinique du Parc, Caen (Dr Durin), CH d'Avranches (Dr Six), CH de Lisieux (Dr Beniada), CH de Saint-Lô (Dr Balouet), CH de Cherbourg (Dr Desprès, Mme Mathis). **Bourgogne**: Coordinator: Pr Sagot: CHU de Dijon (Dr Yacoub), CH de Chalon-sur-Saône (Dr Bulot), CH d'Auxerre (Dr Dellinger), CH de Mâcon (Dr Spagnolo). **Bretagne**: Coordinator: Pr Poulain: CHU de Rennes (Pr Poulain), Clinique de la Sagesse, Rennes (Dr Moquet, Mme Bourgault), CHP Saint-Grégoire (Dr Seconda), CH de Saint-Brieuc (Dr Moinon), CH de Saint-Malo (Dr Roy-Dahhou), CH Bretagne Sud, Lorient (Dr Pittion), CH Bretagne Atlantique, Vannes (Dr Chauveau), CHU de Brest (Dr Laurent, Dr Lelièvre), CH de Quimper (Dr Bellot), Polyclinique de Keraudren, Brest (Dr Salnelle). **Centre**: Coordinator: Pr Perrotin: CHRU de Tours (Pr Perrotin), CH d'Orléans (Dr Ramos), CH de Blois (Dr Montmasson), CH de Chartres (Dr Ollivier), CH de L'Agglomération Montargoise (Dr Hoock, Dr Ben Romdhane). **Champagne Ardennes**: Coordinator: Pr Graesslin: CHU de Reims (Pr Graesslin), CH de Charleville Mézières (Dr Méreb). **Franche-Comté**: Coordinator: Pr Riethmuller: CHU de Besançon (Pr Riethmuller), CH de Pontarlier (Dr Boyadjian), CH de Dole (Dr Gannard), CH de Belfort (Dr Levy), CH de Lons le Saunier (Dr Reviron). **Haute Normandie**: Coordinator: Pr Marpeau: CHU de Rouen (Pr Verspyck), Clinique Mathilde, Rouen (Dr Durand Reville), CH Le Havre (Dr Talbot), CH d'Elbeuf (Dr Mathieu), CH d'Evreux (Dr Machevin), CH de Vernon (Dr Truong Canh), CH du Belvédère, Mont Saint-Aignan (Dr Guillon). **Ile-de-France**: Coordinator: Pr Schmitz: CHU Robert Debré (Pr Schmitz), CHU Cochin-Port Royal (Dr Ménard), CHU Bichat (Dr Bourgeois Moine), CHU Pitié Salpêtrière (Pr Nizard, Pr Dommergues), CHU Trousseau (Dr De Carné Carnavalet), CHU Necker Enfants Malades (Dr Lemercier), CHU Tenon (Dr Bornes), CHU Lariboisière (Dr Ricbourg), Hôpital 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Léonard), Polyclinique Kennedy, Nîmes (Dr Terschiphorst), CHU de Montpellier (Dr Vintejoux), Clinique Clémentville, Montpellier (Dr Filippi), Clinique Saint-Roch, Montpellier (Dr Rouard), CH de Béziers (Dr Galtier), CH de Carcassonne (Dr Cogan), CH de Perpignan (Dr Koninck). **Lorraine**: Coordinator: Pr Morel: CHU de Nancy (Pr Morel), CH de Metz (Dr Dahlhoff Rodriguez), CH de Thionville (Dr Collin). **Midi Pyrénées**: Coordinator: Pr Parant: CHU de Toulouse (Pr Parant), Clinique Sarrus (Dr Thévenot, Dr Céré). **Nord Pas-de-Calais**: Coordinator: Pr Deruelle: CHRU de Lille (Pr Deruelle, Dr Clouqueur), Polyclinique du Bois, Lille (Dr Pouilly), GHIC Saint-Vincent-de-Paul, Lille (Dr Denoit), CH d'Armentières (Dr Régis, Dr Rivaux), CH de Roubaix (Dr Legoueff), CH de Tourcoing (Dr Jambon), CH de Seclin (Dr Bory), CH de Valenciennes (Dr Sendon, Dr Tillouche), CH de Dunkerque (Dr Boodhun), CH de Lens (Dr Bothuyne), CH de Boulogne-sur-Mer (Dr Sicot), CH d'Arras (Dr Brochot), CH de Calais (Dr 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Sayegh), CH de Montélimar (Dr Dirix), CH de Roanne (Dr Nord), CHU de Saint-Etienne (Pr Chauleur), CH de Bourg-en-Bresse (Dr Hugot, Dr Ferlay), CHU de Grenoble (Dr Equy), Clinique Belledonne, Grenoble (Dr Canonica), CH de Voiron (Dr Gaillard), CH de Chambéry (Dr Dubois), CH de Sallanches (Dr Dujardin), CH d'Annecy (Dr Braig), CH d'Annemasse (Dr Deramecourt), CH de Thonon (Dr Vincent-Génod).

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Author and article information

From the Assistance Publique-Hôpitaux de Paris, Hôpital Robert Debré, Service de Gynécologie Obstétrique, Paris (Drs Schmitz and Korb); Université Paris Diderot, Paris (Drs Schmitz and Korb); INSERM (Institut National de la Santé Et de la Recherche Médicale), U1153, Epidemiology and Biostatistics Sorbonne Paris Cité Research Center, Obstetrical, Perinatal, and Pediatric Epidemiology Team, Paris (Drs Schmitz, Korb, and Goffinet); Hospices Civils de Lyon, Hôpital Femme Mère Enfant, Service de Gynécologie Obstétrique, Bron (Dr Battie); Assistance Publique-Hôpitaux de Paris, Hôpital Antoine Béclère, Service de Gynécologie Obstétrique, Paris (Dr Cordier); Université Paris Sud, Le Kremlin Bicêtre (Dr Cordier); Assistance Publique-Hôpitaux de Paris, Hôpital Trousseau, Service de Gynécologie Obstétrique, Paris (Dr de Carne Carnavalet); CHU (Centre Hospitalo-Universitaire) de Saint-Etienne, Service de Gynécologie Obstétrique, Saint-Etienne (Dr Chauleur); Université Jean Monnet, Saint-Etienne (Dr Chauleur); CHU de Grenoble, Service de Gynécologie Obstétrique, Grenoble (Dr Equy); Centre Hospitalier Intercommunal de Créteil, Service de Gynécologie Obstétrique, Créteil (Dr Haddad); Université Paris Est Créteil, Créteil (Dr Haddad); Assistance Publique-Hôpitaux de Paris, Hôpital Necker Enfants Malades, Service de Gynécologie Obstétrique, Paris (Dr Lemercier); Hôpital René Dubos, Service de Gynécologie Obstétrique, Pontoise (Dr Poncelet); Université Paris 13, Bobigny (Dr Poncelet); Centre Hospitalier du Sud Francilien, Service de Gynécologie Obstétrique, Corbeil-Essonnes (Dr Rigonnot); Assistance Publique-Hôpitaux de Paris, Maternité Port-Royal, Paris (Dr Goffinet); Université René Descartes, Paris (Dr Goffinet); and DHU Risques et Grossesse, Paris (Dr Goffinet), France.

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Corresponding author: Thomas Schmitz, MD, PhD. thomas.schmitz@aphp.fr

SUPPLEMENTARY TABLE 1

Neonatal outcomes according to second twin presentation after vaginal birth of first twin—sensitivity analysis after exclusion of first twins in breech presentation

	Noncephalic second twin N = 1410	Cephalic second twin N = 2274	OR (95% CI)	aOR (95% CI)[a]
	n (%)	n (%)		
Primary outcome Composite morbidity	41 (2.9)	56 (2.5)	1.19 (0.79—1.79)	1.18 (0.77—1.83)
Death	2 (0.1)	2 (0.1)		
Intrapartum	0 (0.0)	0 (0.0)		
Neonatal	2 (0.1)	2 (0.1)		
Apgar score <4 at 5 min	1 (<0.1)	7 (0.3)		
Neonatal trauma	6 (0.4)	4 (0.2)		
Long bone fracture	3 (0.2)	3 (0.1)		
Brachial plexus palsy	1 (<0.1)	1 (<0.1)		
Skull fracture	2 (0.1)	0 (0.0)		
Encephalopathy	1 (<0.1)	5 (0.2)		
≥2 Seizures within 72 h after birth	1 (<0.1)	1 (<0.1)		
Endotracheal tube >24 h within 72 h after birth	0 (0.0)	0 (0.0)		
Proven neonatal sepsis	13 (0.9)	21 (0.9)		
Bronchopulmonary dysplasia	6 (0.4)	5 (0.2)		
Intraventricular hemorrhage	2 (0.1)	9 (0.4)		
Grade I—II	2 (0.1)	8 (0.4)		
Grade III—IV	0 (0.0)	1 (<0.1)		
Periventricular leukomalacia	0 (0.0)	1 (<0.1)		
Necrotizing enterocolitis	4 (0.3)	2 (0.1)		

All variables were included in primary outcome except grade I—II intraventricular hemorrhage.

No infant had spinal cord, phrenic, or facial nerve injury.

aOR, adjusted odds ratio; *CI*, confidence interval; *OR*, odds ratio.

[a] Adjustment for maternal age, occupation, country of birth, body mass index, nulliparity, previous cesarean, chorionicity, antenatal corticosteroids, birthweight, and twin discordance.

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SUPPLEMENTARY TABLE 2

Neonatal outcomes according to noncephalic second twin presentation after vaginal birth of first twin

	Cephalic second twin N = 2384	Breech second twin N = 999	OR (95% CI)	aOR (95% CI)[a]	Transverse second twin N = 520	OR (95% CI)	aOR (95% CI)[a]
	n (%)	n (%)			n (%)		
Primary outcome Composite morbidity	59 (2.5)	34 (3.4)	1.41 (0.91–2.13)	1.34 (0.85–2.12)	13 (2.5)	1.02 (0.55–1.89)	0.91 (0.47–1.76)
Death	2 (0.1)	2 (0.2)			0 (0.0)		
Intrapartum	0 (0.0)	0 (0.0)			0 (0.0)		
Neonatal	2 (0.1)	2 (0.2)			0 (0.0)		
Apgar score <4 at 5 min	8 (0.3)	1 (0.1)			0 (0.0)		
Neonatal trauma	4 (0.2)	3 (0.3)			3 (0.6)		
Long bone fracture	3 (0.1)	1 (0.1)			2 (0.4)		
Brachial plexus palsy	1 (<0.1)	1 (0.1)			0 (0.0)		
Skull fracture	0 (0.0)	1 (0.1)			1 (0.2)		
Spinal cord injury	0 (0.0)	0 (0.0)			0 (0.0)		
Encephalopathy	5 (0.2)	1 (0.1)			0 (0.0)		
≥2 Seizures within 72 h after birth	1 (<0.1)	0 (0.0)			1 (0.2)		
Endotracheal tube >24 h within 72 h after birth	20 (0.8)	14 (1.4)			7 (1.4)		
Proven neonatal sepsis	22 (0.9)	11 (1.1)			3 (0.6)		
Bronchopulmonary dysplasia	5 (0.2)	6 (0.6)			1 (0.2)		
Intraventricular hemorrhage	10 (0.4)	3 (0.3)			1 (0.2)		
Grade I–II	9 (0.4)	3 (0.3)			1 (0.2)		
Grade III–IV	1 (<0.1)	0 (0.0)			0 (0.0)		
Periventricular leukomalacia	1 (<0.1)	0 (0.0)			0 (0.0)		
Necrotizing enterocolitis	2 (0.1)	4 (0.4)			1 (0.2)		

All variables were included in primary outcome except grade I–II intraventricular hemorrhage.

No infant had phrenic or facial nerve injury.

aOR, adjusted odds ratio; *CI*, confidence interval; *OR*, odds ratio.

[a] Adjustment for maternal age, occupation, country of birth, body mass index, nulliparity, previous cesarean, chorionicity, antenatal corticosteroids, first-twin presentation, birthweight, and twin discordance.

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SUPPLEMENTARY TABLE 3

Neonatal outcomes according to second twin presentation after vaginal birth of first twin <37 weeks of gestation

	Noncephalic second twin N = 749	Cephalic second twin N = 1132	OR (95% CI)	aOR (95% CI)[a]
	n (%)	n (%)		
Primary outcome Composite morbidity	42 (5.6)	44 (3.9)	1.47 (0.95–2.27)	1.33 (0.83–2.13)
Death	2 (0.3)	2 (0.2)		
Intrapartum	0 (0.0)	0 (0.0)		
Neonatal	2 (0.3)	2 (0.2)		
Apgar score <4 at 5 min	0 (0.0)	4 (0.4)		
Neonatal trauma	4 (0.5)	2 (0.2)		
Long bone fracture	2 (0.3)	2 (0.2)		
Brachial plexus palsy	1 (0.1)	0 (0.0)		
Skull fracture	1 (0.1)	0 (0.0)		
Encephalopathy	0 (0.0)	3 (0.3)		
≥2 Seizures within 72 h after birth	0 (0.0)	1 (0.1)		
Endotracheal tube >24 h within 72 h after birth	20 (2.7)	17 (1.5)		
Proven neonatal sepsis	13 (1.7)	16 (1.4)		
Bronchopulmonary dysplasia	7 (0.9)	5 (0.4)		
Intraventricular hemorrhage	4 (0.5)	10 (0.9)		
Grade I–II	4 (0.5)	9 (0.8)		
Grade III–IV	0 (0.0)	1 (0.1)		
Periventricular leukomalacia	0 (0.0)	1 (0.1)		
Necrotizing enterocolitis	5 (0.7)	2 (0.2)		

All variables were included in primary outcome except grade I–II intraventricular hemorrhage.

No infant had spinal cord, phrenic, or facial nerve injury.

aOR, adjusted odds ratio; *CI*, confidence interval; *OR*, odds ratio.

[a] Adjustment for maternal age, occupation, country of birth, body mass index, nulliparity, previous cesarean, chorionicity, antenatal corticosteroids, first-twin presentation, birthweight, and twin discordance.

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SUPPLEMENTARY TABLE 4

Neonatal outcomes according to second twin presentation after vaginal birth of first twin ≥37 weeks of gestation

	Noncephalic second twin N = 770	Cephalic second twin N = 1252	OR (95% CI)	aOR (95% CI)[a]
	n (%)	n (%)		
Primary outcome Composite morbidity	5 (0.7)	15 (1.2)	0.54 (0.20–1.49)	0.53 (0.19–1.48)
Death	0 (0.0)	0 (0.0)		
Intrapartum	0 (0.0)	0 (0.0)		
Neonatal	0 (0.0)	0 (0.0)		
Apgar score <4 at 5 min	1 (0.1)	4 (0.3)		
Neonatal trauma	2 (0.3)	2 (0.2)		
Long bone fracture	1 (0.1)	1 (<0.1)		
Brachial plexus palsy	0 (0.0)	1 (<0.1)		
Skull fracture	1 (0.1)	0 (0.0)		
Encephalopathy	1 (0.1)	2 (0.2)		
≥2 Seizures within 72 h after birth	1 (0.1)	1 (<0.1)		
Endotracheal tube >24 h within 72 h after birth	1 (0.1)	3 (0.2)		
Proven neonatal sepsis	1 (0.1)	6 (0.5)		
Bronchopulmonary dysplasia	0 (0.0)	0 (0.0)		
Intraventricular hemorrhage	0 (0.0)	0 (0.0)		
Grade I–II	0 (0.0)	0 (0.0)		
Grade III–IV	0 (0.0)	0 (0.0)		
Periventricular leukomalacia	0 (0.0)	0 (0.0)		
Necrotizing enterocolitis	0 (0.0)	0 (0.0)		

All variables were included in primary outcome except grade I–II intraventricular hemorrhage.

No infant had spinal cord, phrenic, or facial nerve injury.

aOR, adjusted odds ratio; *CI*, confidence interval; *OR*, odds ratio.

[a] Adjustment for maternal age, occupation, country of birth, body mass index, nulliparity, previous cesarean, chorionicity, antenatal corticosteroids, first-twin presentation, birthweight, and twin discordance.

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