Risk of Severe Acute Maternal Morbidity According to Planned Mode of Delivery in Twin Pregnancies

*Diane Korb, MD, MPH, Catherine Deneux-Tharaux, MD, PhD, Aurélien Seco, MSc, François Goffinet, MD, PhD, and Thomas Schmitz, MD, PhD, for the JUmeaux MODe d'Accouchement (JUMODA) study group and the Groupe de Recherche en Obstétrique et Gynécologie (GROG)**

OBJECTIVE: To evaluate the association between the planned mode of delivery and severe acute maternal morbidity in women with twin pregnancies.

METHODS: In this planned secondary analysis of the JUmeaux MODe d'Accouchement cohort, a national prospective population-based study of twin deliveries conducted from February 2014 to March 2015 in 176 hospitals performing more than 1,500 annual deliveries in France, we included women with twin pregnancies at 24 weeks of gestation or greater with two live fetuses. Women delivering before 24 weeks of gestation, those with recognized indications for cesarean delivery, and those with severe acute maternal morbidity symptomatic before labor were excluded to limit confounding by indication. The primary outcome was a composite measure of intra- or postpartum severe acute maternal morbidity. Multivariate Poisson regression models and propensity score matching were used to control for potential confounding by indication. Analyses were conducted for the overall study cohort as well as stratified by maternal age in years (younger than 30, 30–34, 35 years or older). No adjustments were made for multiple comparisons.

RESULTS: Among the 8,124 women included in this analysis, 3,062 (37.7%) had planned cesarean deliveries and 5,062 (62.3%) had planned vaginal deliveries, of whom 4,015 (79.3%) delivered both twins vaginally. No significant overall association was found between the planned mode of delivery and severe acute maternal morbidity (6.1% in the planned cesarean delivery group and 5.4% in the planned vaginal group; adjusted relative risk 1.00, 95% CI 0.81–1.24). In women 35 years or older, the risk of severe acute maternal morbidity was significantly higher for those with planned cesarean delivery than planned vaginal delivery (7.8% vs 4.6%, adjusted relative risk 1.44, 95% CI 1.02–2.06). Propensity score and secondary analyses yielded similar results.

CONCLUSION: In twin pregnancies, there is no overall association between planned mode of delivery and severe acute maternal morbidity. Women older than 35 years may be at higher risk of severe acute maternal morbidity after planned cesarean delivery.

(Obstet Gynecol 2018;132:647–55)
DOI: 10.1097/AOG.0000000000002788

Twin pregnancies are increasingly frequent in developed countries and account for approximately 3% of all births in the United States and France.[1–5] The most recent and contributive neonatal data in twin pregnancies do not show differences in morbidity rates according to the planned mode of delivery.[6,7] Based on the available evidence about neonatal outcomes, the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine encourage planned vaginal delivery for twin pregnancies with the first twin in

**For a list of members of the JUMODA and GROG study groups, see Appendix 1 available online at http://links.lww.com/AOG/B133.*

From the INSERM U1153, Obstetric, Perinatal, and Pediatric Epidemiology Research Team (EPOPé), CRESS, DHU Risks in Pregnancy, Paris Descartes University, the Department of Obstetrics and Gynecology, Robert Debré Hospital, APHP, and the Port-Royal Maternity Unit, Cochin Hospital, APHP, Paris, France.

Supported by a grant from the French Ministry of Health (Programme Hospitalier de Recherche Clinique, AOM2012).

Each author has indicated that he or she has met the journal's requirements for authorship.

Received March 26, 2018. Received in revised form May 23, 2018. Accepted June 7, 2018.

Corresponding author: Diane Korb, MD, MPH, 53 Avenue de l'Observatoire, 75014 Paris, France; email: diane.korb@inserm.fr.

Financial Disclosure
The authors did not report any potential conflicts of interest.

ISSN: 0029-7844/18

cephalic presentation.[8] The planned mode of twin delivery may also, however, influence maternal complications, which have thus far been reported in a limited number of studies.[6,9–13]

Two recent large studies have specifically assessed maternal morbidity in twin pregnancies according to the planned mode of delivery. First, the international Twin Birth Study reported no significant difference in serious maternal morbidity between groups.[6] Its randomized design might, however, have been responsible for the selection of a low-risk population of twin pregnancies. Furthermore, the inclusion of events of heterogeneous degrees of severity raises questions about its definition of maternal morbidity. Second, an observational retrospective study in a U.S. hospital found a higher risk of severe maternal morbidity in the planned vaginal than the planned cesarean delivery group.[9] This result may reflect residual confounding by indication and the potential misclassification of planned mode of delivery when performed retrospectively. It thus remains unclear whether the risk of severe maternal morbidity differs according to planned mode of delivery of twins.

Our aim was to assess the association between the planned mode of delivery and severe acute maternal morbidity, a predetermined objective of the JUmeaux MODe d'Accouchement study, the French national prospective population-based study of twin deliveries.

MATERIALS AND METHODS

The JUmeaux MODe d'Accouchement national, observational, prospective, population-based cohort study of the planned mode of delivery of twin pregnancies took place in France from February 10, 2014, through March 1, 2015.[7] All French maternity units performing more than 1,500 annual deliveries were invited to participate, and 176 of the 191 eligible units (92%) agreed. Detailed information about the participating women and maternity units has been reported previously.[7] This cohort was specially designed to assess the effect of the planned mode of delivery on neonatal and maternal outcomes in twin pregnancies at or after 22 weeks of gestation (N=8,823 women).

For this planned secondary analysis of the JUmeaux MODe d'Accouchement cohort, we excluded women for whom the planned mode of delivery was unknown (n=24) and those with in utero fetal death or medical termination of at least one of the two twins (n=215) (Fig. 1). Other exclusion criteria were defined to focus on the population for which there is a real choice between cesarean and vaginal delivery. Therefore, women for whom one mode of delivery is favored or recommended–either vaginal (delivery before 24 weeks of gestation [n=35]) or cesarean (first twin in transverse presentation [n=175], placenta or myoma previa [n=60], or repeat cesarean [n=161]) were excluded. Women with antepartum severe acute maternal morbidity (n=16) as well as those with obstetric conditions that developed during pregnancy and were symptomatic before labor and responsible for a postpartum severe acute maternal morbidity (for example cesarean delivery for placenta abruptio responsible for a severe postpartum hemorrhage) (n=13) were also excluded to limit confounding by indication. The analysis thus included 8,124 women (92.1%).

The primary outcome was a composite of intra- or postpartum severe acute maternal morbidity. This multicriteria definition was developed through a national Delphi formal expert consensus process for another study specifically conducted to study severe acute maternal morbidity. Aiming to include conditions with severe health impairments, it combines diagnoses, organ dysfunctions, and interventions, as recommended by the World Health Organization.[14]

Therefore, severe acute maternal morbidity was defined as one or more of the following: maternal death; severe postpartum hemorrhage (ie, transfusion 4 or more units of red blood cells), uterine artery embolization, vascular ligation, compressive uterine suture, emergency peripartum hysterectomy, or a complication considered severe by the obstetrician; pulmonary embolism; stroke or cerebral transient ischemic attack; severe psychiatric disorder; cardiovascular or respiratory dysfunction, renal dysfunction (creatinine greater than 1.47 mg/dL or oliguria less than 500 mL per 24 hours), neurologic dysfunction (coma whatever the stage and the duration), or hematologic dysfunction (thrombocytopenia less than 50,000/mm^3 in the absence of a chronic disorder or acute anemia less than 7 g/dL); emergency surgery besides the childbirth procedure, eg, secondary hysterectomy, laparotomy for postdelivery complication; or admission to an intensive care unit. We purposely did not include third- and fourth-degree perineal lacerations or cervical lacerations in the composite maternal outcome unless they were associated with another criterion of severe acute maternal morbidity.[15] This primary outcome was treated as a binary variable.

The exposure of interest was the planned mode of delivery, that is, whether a cesarean or vaginal delivery had been planned. Immediately after delivery, obstetricians completed a detailed web-based questionnaire about the planned mode of delivery,

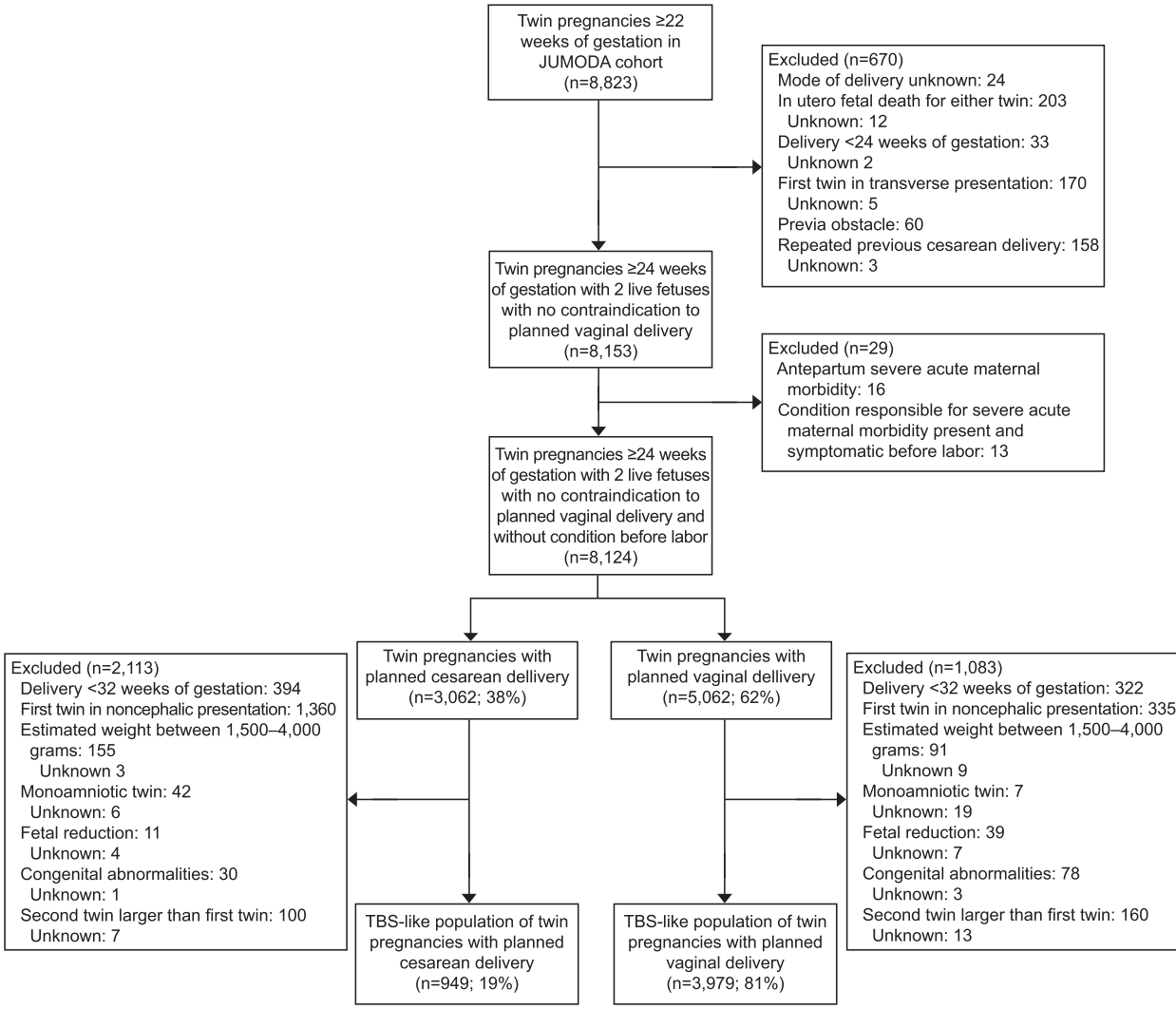

Fig. 1. Flow chart. JUMODA, JUmeaux MODe d'Accouchement; TBS, Twin Birth Study.
Korb. Twins, Cesarean Deliveries, and Severe Maternal Morbidity. Obstet Gynecol 2018.

indications of cesarean deliveries, and details about delivery management; they also classified cases as planned cesarean or planned vaginal deliveries. Research nurses collected data about maternal characteristics, medical history, pregnancy complications, maternal complications, and neonatal health.

Potential confounders determined from previous literature included maternal age, body mass index, parity, and history of previous cesarean delivery; pre-existing diabetes or pre-existing hypertension; characteristics of the current pregnancy, including in vitro fertilization, pregnancy complications (defined as a binary variable by the presence of at least one of the following: hypertension, preeclampsia, placental abruption, insulin-treated diabetes, twin–twin transfusion syndrome), and premature rupture of membranes; and hospital characteristics (annual number of twin deliveries).

We compared the characteristics of the women, pregnancies, labors, neonates, and hospitals according to the planned mode of delivery based on χ^2 or Fisher exact tests for categorical variables and Student or Wilcoxon rank-sum tests for quantitative variables, as appropriate. To assess the relation between the planned mode of delivery and severe acute maternal morbidity, while controlling for confounding by indication, we first used multivariate Poisson regression modeling to estimate the relative risk (RR) and 95% CI and to adjust for prognostic covariates with a random intercept model to take variability between

Analysis method	Planned cesarean n/N (%)	Planned vaginal n/N (%)	RR (95% CI)
Overall			
Crude	186/3,062 (6.1)	272/5,062 (5.4)	1.13 (0.94–1.35)
Adjusted*	186/3,062 (6.1)	272/5,062 (5.4)	1.00 (0.81–1.24)
Propensity score, matching†	94/1,699 (5.5)	94 /1,699 (5.5)	1.01 (0.77–1.34)
<30 years of age			
Crude	51/1,065 (4.8)	108/1,861 (5.8)	0.83 (0.60–1.14)
Adjusted‡	51/1,065 (4.8)	108/1,861 (5.8)	0.73 (0.51–1.05)
Propensity score, matching§	26/573 (4.5)	36/573 (6.3)	0.72 (0.43–1.18)
30–34 years of age			
Crude	63/1,069 (5.9)	104/1,094 (5.5)	1.08 (0.80–1.46)
Adjusted‡	63/1,069 (5.9)	104/1,094 (5.5)	1.00 (0.58–1.71)
Propensity score, matching§	36/591 (6.1)	30/591 (5.1)	1.22 (0.75–1.99)
≥35 years of age			
Crude	72/928 (7.8)	60/1,297 (4.6)	1.68 (1.20–2.34)
Adjusted‡	72/928 (7.8)	60/1,297 (4.6)	1.44 (1.02–2.06)
Propensity score, matching‖	45/522 (8.6)	29/522 (5.6)	1.59 (1.01–2.49)

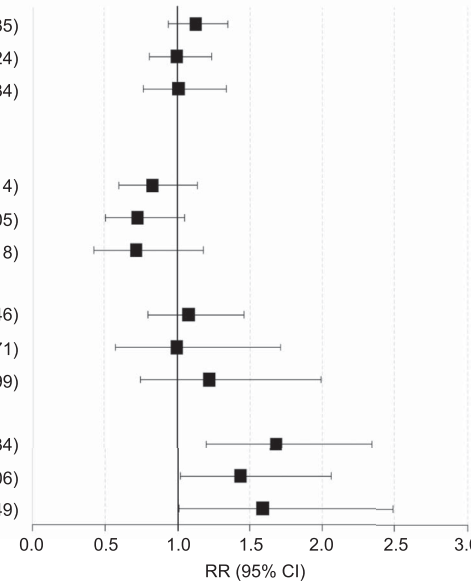

Fig. 2. Association between planned mode of delivery and severe acute maternal morbidity overall and according to maternal age. *Model 1: adjusted for maternal age, body mass index (BMI), parity and previous cesarean delivery, previous diabetes or hypertension, in vitro fertilization, pregnancy complications, premature rupture of membranes, annual number of twin deliveries. †Variables for propensity score estimation in model 1: maternal age, country of birth, BMI, occupation, parity and previous cesarean delivery, smoker, previous diabetes, previous hypertension, in vitro fertilization, chorionicity, pregnancy complications, premature rupture of membranes, preterm labor, first twin presentation, second twin presentation, gestational age at delivery, annual number of twin deliveries, second twin larger than first twin; adjusted for first twin presentation. ‡Model 2: model 1 except no adjustment for maternal age. §Variables for propensity score estimation in model 2: same as in model 1 except no adjustment for maternal age; adjusted for first twin presentation. ‖Variables for propensity score estimation same as in model 2; adjusted for parity, previous cesarean delivery, and first twin presentation. RR, relative risk.

Korb. Twins, Cesarean Deliveries, and Severe Maternal Morbidity. Obstet Gynecol 2018.

centers into account and then conducted a propensity score matching analysis. We tested for clinically relevant interactions between the planned mode of delivery and the covariates considered. Because a significant positive interaction was found with maternal age (P=.009), the analysis was rerun after stratification by maternal age: before 30 years, between 30 and 34 years, and at and after 35 years.

The proportion of women with missing data for any covariate ranged from 0% to 4.0%; there were 7,731 (95.1%) women with full data; their characteristics were similar to those of the women with missing data. We used multiple imputation chained equations to impute missing data and generated five independent imputation data sets.

To control for confounding factors that might influence both the choice of the planned mode of delivery and the occurrence of severe acute maternal morbidity, we used a propensity score approach. A woman's propensity score was defined as her probability of a planned mode of delivery based on her covariates measured before the choice of mode of delivery. A propensity score was estimated for all women by a logistic regression model with planned mode of delivery as the dependent variable in relation to the baseline maternal, obstetric, and maternity unit characteristics (variables listed in the footnote to Fig. 2). For each woman, we calculated first a propensity score in each of the five imputed data sets and then an average propensity score. Exposed (with planned cesarean delivery) and unexposed (with planned vaginal delivery) women were matched with a one-to-one nearest neighbor matching algorithm without replacement by the average propensity score[16] within a caliper of 0.10. Imbalances after matching were checked by propensity score distribution and calculation of standardized mean differences.[17] In the matched set, RRs and their 95% CIs were estimated to quantify the

Table 1. Maternal and Pregnancy Characteristics

Characteristic	Planned Cesarean Delivery (n=3,062)	Planned Vaginal Delivery (n=5,062)	*P*
Age (y)	32±5.6	31.3±5.2	<.001
Younger than 30	1,065 (34.8)	1,861 (36.8)	<.001
30–34	1,069 (34.9)	1,904 (37.6)	
35 or older	928 (30.3)	1,297 (25.6)	
BMI before pregnancy (kg/m^2)	24.4±5.4	23.7±4.7	<.001
Less than 18.5	201 (6.9)	326 (6.7)	<.001
18.5–24	1,660 (56.9)	3,080 (63.4)	
25–29	643 (22.1)	961 (19.8)	
30 or greater	412 (14.1)	493 (10.1)	
Parity and previous cesarean delivery			<.001
Nulliparous	1,553 (50.7)	2,401 (47.5)	
Parous without previous cesarean delivery	890 (29.1)	2,449 (48.5)	
Parous with previous cesarean delivery	618 (20.2)	200 (4.0)	
Smokers	485 (16.4)	708 (14.5)	.024
Previous diabetes	44 (1.4)	25 (0.5)	<.001
Previous hypertension	53 (1.7)	39 (0.8)	<.001
In vitro fertilization	734 (24.1)	1,104 (21.9)	.024
Fetal reduction	23 (0.8)	48 (1.0)	.355
Chorionicity			<.001
Dichorionic	2,418 (79.3)	4,072 (80.7)	
Monochorionic–diamnionic	577 (18.9)	961 (19.1)	
Monochorionic–monoamnionic	54 (1.8)	8 (0.2)	
Pregnancy complications	1,310 (42.9)	1,163 (23.0)	<.001
Hypertension	241 (7.9)	221 (4.4)	
Preeclampsia	444 (14.5)	359 (7.1)	
Placenta abruptio	8 (0.3)	4 (0.1)	
IUGR for either twin	732 (24.0)	541 (10.7)	
Insulin-treated diabetes	137 (4.5)	149 (3.0)	
Placenta previa	15 (0.5)	8 (0.2)	
Malformation for either twin	83 (2.7)	107 (2.1)	
Twin–twin transfusion syndrome	116 (3.8)	65 (1.3)	
Premature rupture of membranes	233 (7.6)	475 (9.4)	.006
Preterm labor	851 (27.8)	1,853 (36.7)	<.001
Antenatal corticosteroids	1,487 (48.7)	2,171 (43.1)	<.001

BMI, body mass index; IUGR, intrauterine growth restriction.
Data are mean±SD or n (%) unless otherwise specified.

association between the planned mode of delivery and severe acute maternal morbidity by generalized estimating equation multivariate Poisson regression with further adjustment for variables with standardized mean differences greater than 15%. The matching was rerun after stratifying by maternal age in each maternal age stratum.

We assessed the association between the planned mode of delivery and severe acute maternal morbidity according to gestational age at delivery (less than 37 weeks of gestation or 37 weeks of gestation or greater) because some authors have reported lower neonatal risks associated with planned cesarean compared with planned vaginal delivery at but not before term.[18,19]

We also assessed the association between the planned mode of delivery and severe acute maternal morbidity after application of the selection criteria of the Twin Birth Study (TBS-like population; Fig. 1) and therefore excluded women with gestational age less than 32 0/7 weeks, first twin in noncephalic presentation, an estimated weight of one of the twins less than 1,500 g or greater than 4,000 g, monoamniotic twins, fetal reduction at 13 or more weeks of gestation, fetal anomaly, or a second twin substantially larger than the first twin.[6] This TBS-like population excluded 3,196 women and included 4,928 (Fig. 1).

All tests were two-sided with P values $\leq$.05 defined as statistically significant. STATA 13 was used for the descriptive and multivariate analyses and its "psmatch2" package for propensity score matching.[20,21] We used the R "forestplot" package to create

Table 2. Labor and Delivery Characteristics

Characteristic	Planned Cesarean Delivery (n=3,062)	Planned Vaginal Delivery (n=5,062)	*P*
Spontaneous labor	784 (25.7)	2,766 (54.7)	<.001
Mode of delivery			<.001
Cesarean delivery for both	3,023 (98.7)	913 (18.0)	
Vaginal delivery and cesarean delivery	4 (0.1)	134 (2.6)	
Vaginal delivery for both	35 (1.1)	4,015 (79.3)	
1st twin in noncephalic presentation	1,509 (49.3)	387 (7.6)	<.001
2nd twin in noncephalic presentation	1,762 (57.7)	2,049 (40.5)	<.001
Gestational age at delivery (wk)	35.4±3.0	36.2±2.6	<.001
Less than 32 0/7	394 (12.9)	322 (6.4)	<.001
32 0/7–36 6/7	1,427 (47.3)	2,186 (43.2)	
37 0/7 or greater	1,221 (39.9)	2,554 (50.4)	
Intertwin delivery interval (min)	1 (1–2)	5 (2–9)	<.001
Analgesia or anesthesia at delivery			<.001
Regional	2,891 (94.4)	4,762 (94.1)	
General	165 (5.4)	118 (2.3)	
None	5 (0.2)	165 (3.3)	
Other	0 (0)	15 (0.3)	
Birth weight of 1st twin (g)	2,257.9±623.6	2,397.8±525.1	<.001
Birth weight of 2nd twin (g)	2,187.1±631.7	2,347.6±517.3	<.001
Hospital characteristics			
Annual no. of twin deliveries			<.001
Less than 50	1,061 (34.7)	1,692 (33.4)	
50–99	952 (31.1)	1,391 (27.5)	
100 or greater	1,049 (34.3)	1,979 (39.1)	
University hospital	1,318 (43.0)	2,409 (47.6)	<.001
Level of care			<.001
I	44 (1.4)	98 (1.9)	
II	1,252 (40.9)	1,848 (36.5)	
III	1,766 (57.7)	3,116 (61.6)	

Data are n (%), mean±SD, or median (quartile 1–quartile 3) unless otherwise specified.

graphics. No adjustments were made for multiple comparisons.

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 of Paris Ile-de-France 7 (PP-13-014) approved this study.

RESULTS

Our study population included 8,124 women: 3,062 (37.7%) had a planned cesarean delivery and 5,062 (62.3%) a planned vaginal delivery (Fig. 1). Women with planned cesarean, compared with vaginal, deliveries were older and more often obese; they also had higher rates of previous cesarean deliveries, preexisting diabetes and hypertension, monochorionic pregnancy, pregnancy complications, and the first and second twins in noncephalic presentation. They also gave birth at an earlier gestational age to neonates of lower birth weight (Tables 1 and 2; Appendices 2 and 3, available online at http://links.lww.com/AOG/B133). In the planned vaginal group, 1,047 (20.6%) had cesarean deliveries (Table 2), and this proportion was highest in the oldest age group: 19.4% for women aged younger than 30 years, 19.2% for women 30–34 years, and 25.0% for those 35 years or older.

The severe acute maternal morbidity rate was 6.1% in the planned cesarean delivery group and 5.4% in the planned vaginal delivery group (crude RR 1.13, 95% CI 0.94–1.35) (Table 3), with severe postpartum hemorrhage the most frequent contributor to severe acute maternal morbidity in both groups. After adjustment for confounding factors, we observed no association between planned mode of delivery and severe acute maternal morbidity (adjusted RR 1.00, 95% CI 0.81–1.24).

Analyses according to maternal age showed that the risk of severe acute maternal morbidity was significantly higher after planned cesarean compared with planned vaginal delivery for women aged 35

Table 3. Rate and Components of Severe Acute Maternal Morbidity According to the Planned Mode of Delivery

Outcome	Planned Cesarean Delivery (n=3,062)	Planned Vaginal Delivery (n=5,062)	*P*
Severe acute maternal morbidity	186 (6.1)	272 (5.4)	.18
Death	0 (0)	0 (0)	
Severe postpartum hemorrhage	127 (4.2)	230 (4.6)	
Blood transfusion	34 (1.1)	49 (1.0)	
Uterine artery embolization	18 (0.6)	30 (0.6)	
Vascular ligation, compressive uterine suture	33 (1.1)	36 (0.7)	
Hysterectomy	9 (0.3)	9 (0.2)	
Pulmonary embolism	6 (0.2)	5 (0.1)	
Stroke or cerebral transient ischemic attack	1 (0.03)	0 (0)	
Severe psychiatric disorder	2 (0.1)	1 (0.02)	
Cardiovascular dysfunction	3 (0.1)	3 (0.1)	
Respiratory dysfunction	1 (0.03)	2 (0.04)	
Renal dysfunction	11 (0.4)	16 (0.3)	
Hematologic dysfunction	35 (1.2)	38 (0.8)	
Neurologic dysfunction	0 (0)	0 (0)	
Emergency surgery	45 (1.5)	19 (0.4)	
Admission to intensive care unit	39 (1.3)	49 (1.0)	

Data are n (%).

years or older (7.8% vs 4.6%; adjusted RR 1.44, 95% CI 1.02–2.06) (Fig. 2). The increase in severe acute maternal morbidity for this oldest group was the result of severe postpartum hemorrhage and emergency surgery (data not shown).

In the propensity score analysis, 3,398 women, 1,699 women in each group, could be matched. The matched groups were found to be well balanced (standardized difference less than 15%, Appendices 4 and 5, available online at http://links.lww.com/AOG/B133) except for first-twin presentation (standardized difference 22.5%). This analysis similarly found no association between the planned mode of delivery and severe acute maternal morbidity (5.5% vs 5.5%; adjusted RR 1.01, 95% CI 0.77–1.33) (Fig. 2). Again, however, among this oldest age group, the risk of severe acute maternal morbidity was significantly higher for those in the planned cesarean delivery, compared with planned vaginal delivery, groups (8.6% vs 5.6%; adjusted RR 1.59, 95% CI 1.01–2.49).

Analyses according to gestational age at delivery similarly found no association between the planned mode of delivery and severe acute maternal morbidity in overall (less than 37 weeks of gestation: adjusted RR 0.94, 95% CI 0.71–1.25; 37 weeks of gestation or greater: adjusted RR 1.20, 95% CI 0.93–1.54) and a higher risk of severe acute maternal morbidity associated with planned cesarean delivery in the subgroup of women 35 years or older who gave birth at term (8.8% vs 5.0%; adjusted RR 1.88, 95% CI 1.16–3.06), but this difference was not statistically significant before 37 weeks of gestation (7.0% vs 4.2%; adjusted RR 1.40, 95% CI 0.85–2.30) (Appendix 6, available online at http://links.lww.com/AOG/B133).

In the TBS-like population, 949 (19.0%) women had planned cesarean and 3,979 (81.0%) planned vaginal deliveries (Fig. 1). The severe acute maternal morbidity rate was 7.0% in the planned cesarean delivery group and 5.6% in the planned vaginal delivery group (adjusted RR 1.07, 95% CI 0.81–1.41) (Appendix 7, available online at http://links.lww.com/AOG/B133). After stratification by maternal age, the risk of severe acute maternal morbidity was significantly higher in the planned cesarean delivery than the planned vaginal delivery group for women 35 years or older (9.7% vs 4.6%, adjusted RR 1.80, 95% CI 1.12–2.90) (Appendix 8, available online at http://links.lww.com/AOG/B133). In this oldest cohort, the risk of severe acute maternal morbidity was significantly higher both before 37 weeks of gestation (10.7% vs 4.5%; adjusted RR 1.95, 95% CI 1.05–3.63) and at or afterward (8.7% vs 4.6%; adjusted RR 2.31, 95% CI 1.18–4.53) (Appendix 9, available online at http://links.lww.com/AOG/B133).

DISCUSSION

In this prospective population-based study of twin pregnancies, the overall risk of severe acute maternal morbidity did not differ according to planned mode of delivery. In women 35 years or older, in analyses that

did not account for multiple statistical comparisons, planned cesarean delivery was associated with a nominally significantly higher risk of severe acute maternal morbidity than planned vaginal delivery. The results were consistent across the different statistical methods used to take confounding by indication into account.

Although we observed an increased risk of severe acute maternal morbidity for the oldest group of women in the planned cesarean delivery group, this risk does not differ according to planned mode of delivery in the overall population, consistent with the results of the Twin Birth Study.[6] Those results, however, are difficult to generalize. The first problem of generalization stems from the design of this randomized trial, which necessarily selected its study population, one that appears to have been at low risk compared with the general population of twins and thus required further confirmation in a larger population. The second problem involves its use of a composite definition of maternal morbidity that included items of varying levels of severity. In particular, it included third- and fourth-degree lacerations. These perineal lesions, although serious maternal complications after vaginal delivery, in our minds do not reach the degree of severity necessary to classify these events as severe acute maternal morbidity. The panel of experts who defined severe acute maternal morbidity by a Delphi method did not retain this item for this specific reason. In any case, using the definition of the Twin Birth Study for maternal morbidity would not have modified our finding that women 35 years or older from the planned cesarean delivery group were at a higher risk of maternal morbidity than those in the planned vaginal delivery group (data not shown).

On the other hand, our results contradict those of Easter et al.[9] Because intrapartum cesarean deliveries are known to be associated with a higher risk of severe acute maternal morbidity than antepartum cesarean deliveries,[22] these discrepant results are likely explained by the difference in the rates of cesarean deliveries in the planned vaginal delivery groups in the two studies (26% in their study vs 18% in ours). These differences may well influence the result obtained for the association between the planned mode of delivery and severe acute maternal morbidity. Similarly, the cesarean delivery rate for second twins after vaginal delivery of the first twin was higher in the study by Easter et al than in the JUmeaux MODe d'Accouchement study (9% vs 2.6%). The association between cesarean delivery for the second twin and severe acute maternal morbidity remains to be defined.

An original finding is that the risk of severe acute maternal morbidity associated with planned cesarean delivery is associated with maternal age. This result is important to consider because women 35 years or older account for a large proportion of pregnant women with twins: 24.7% in the United States and 36.1% in France in 2016.[3–5] A physiologic hypothesis that might explain this result is that aging is responsible for poorer adaptation both to physiologic changes and to the stress of cesarean delivery as well as for the greater likelihood of evolution toward severe morbidity and death.[23–26] We cannot rule out that this finding may be spurious, because of multiple statistical comparisons; however, this result was consistently found in the different analyses conducted.

Our results have implications for clinical practice and may be useful in choosing the planned mode of delivery. Because of the absence of excess risk of either neonatal or maternal morbidity with planned vaginal compared with planned cesarean delivery, encouragement of planned vaginal delivery should continue because cesarean delivery is associated with more long-term maternal morbidity.[27,28]

Our study has several strengths. It was population-based, which enabled us to consider the diversity of practices and of women's characteristics. Attending obstetricians prospectively collected the data about the planned mode of delivery so that thorough and accurate information was available for the planned mode of delivery. The analysis of severe acute maternal morbidity was planned during the design of the JUmeaux MODe d'Accouchement study, so the data to characterize severe acute maternal morbidity were defined in advance and collected prospectively. The study design allowed the collection of numerous covariates and potential confounding factors often absent from routine hospital databases. The confounding by indication inherent to this type of observational study was also taken into account by diverse statistical approaches; we made rigorous adjustments for confounding factors, performed a propensity score analysis, and defined a low-risk population to minimize the likelihood of incorrectly attributing any risk of severe acute maternal morbidity to planned cesarean delivery.

The main limitation of this study lies in its observational design. Accordingly, despite the number of covariables available and the different statistical methods used, we cannot rule out the presence of possible unmeasured residual confounding. It nonetheless appears unlikely that it would explain the strength of the association found here. Furthermore, the JUmeaux MODe d'Accouchement cohort

included only those maternity units performing more than 1,500 annual deliveries. Although the number of twin deliveries include in the JUmeaux MODe d'Accouchement study still accounts for 75% of all twin deliveries in France, this could potentially limit the generalizability of our results to the smallest hospitals. This, however, seems unlikely because a previous study reported no association between the twin delivery volume and severe maternal morbidity.[29]

In conclusion, the overall risk of severe acute maternal morbidity did not differ according to planned mode of delivery. In women 35 years or older, planned cesarean delivery was associated with a higher risk of severe acute maternal morbidity than planned vaginal delivery.

REFERENCES

1. Prunet C, Goffinet F, Blondel B. Medical care and perinatal health in twin pregnancies: situation in 2010 and recent trends in France [in French]. J Gynecol Obstet Biol Reprod (Paris) 2015;44:184–93.
2. Wilcox LS, Kiely JL, Melvin CL, Martin MC. Assisted reproductive technologies: estimates of their contribution to multiple births and newborn hospital days in the United States. Fertil Steril 1996;65:361–6.
3. Blondel B, Coulm B, Bonnet C, Goffinet F, Le Ray C; National Coordination Group of the National Perinatal Surveys. Trends in perinatal health in metropolitan France from 1995 to 2016: results from the French national perinatal Surveys. J Gynecol Obstet Hum Reprod 2017;46:701–3.
4. Martin JA, Hamilton BE, Osterman MJ. Three decades of twin births in the United States, 1980-2009. NCHS Data Brief 2012: 1–8.
5. Martin JA, Hamilton BE, Osterman MJ, Driscoll AK, Drake P. Births: final data for 2016. Natl Vital Stat Rep 2018;67:1–55.
6. Barrett JF, Hannah ME, Hutton EK, Willan AR, Allen AC, Armson BA, et al. A randomized trial of planned cesarean or vaginal delivery for twin pregnancy [published erratum appears in N Engl J Med 2013;369:2364]. N Engl J Med 2013;369: 1295–305.
7. Schmitz T, Prunet C, Azria E, Bohec C, Bongain A, Chabanier P, et al. Association between planned cesarean delivery and neonatal mortality and morbidity in twin pregnancies. Obstet Gynecol 2017;129:986–95.
8. Safe prevention of the primary cesarean delivery. Obstetric Care Consensus No. 1. American College of Obstetricians and Gynecologists. Obstet Gynecol 2014;123:693–711.
9. Easter SR, Robinson JN, Lieberman E, Carusi D. Association of intended route of delivery and maternal morbidity in twin pregnancy. Obstet Gynecol 2017;129:305–10.
10. Wenckus DJ, Gao W, Kominiarek MA, Wilkins I. The effects of labor and delivery on maternal and neonatal outcomes in term twins: a retrospective cohort study. BJOG 2014;121:1137–44.
11. Ylilehto E, Palomäki O, Huhtala H, Uotila J. Term twin birth–impact of mode of delivery on outcome. Acta Obstet Gynecol Scand 2017;96:589–96.
12. Haest KM, Roumen FJ, Nijhuis JG. Neonatal and maternal outcomes in twin gestations > or =32 weeks according to the planned mode of delivery. Eur J Obstet Gynecol Reprod Biol 2005;123:17–21.
13. Schmitz T, Carnavalet Cde C, Azria E, Lopez E, Cabrol D, Goffinet F. Neonatal outcomes of twin pregnancy according to the planned mode of delivery. Obstet Gynecol 2008;111: 695–703.
14. Say L, Pattinson RC, Gülmezoglu AM. WHO systematic review of maternal morbidity and mortality: the prevalence of severe acute maternal morbidity (near miss). Reprod Health 2004;1:3.
15. Prevention and management of obstetric lacerations at vaginal delivery. Practice Bulletin No. 165. American College of Obstetricians and Gynecologists. Obstet Gynecol 2016;128:e1–15.
16. Mitra R, Reiter JP. A comparison of two methods of estimating propensity scores after multiple imputation. Stat Methods Med Res 2016;25:188–204.
17. Austin PC. Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. Stat Med 2009;28:3083–107.
18. Goossens SMTA, Ensing S, van der Hoeven MAHBM, Roumen FJME, Nijhuis JG, Mol BW. Comparison of planned caesarean delivery and planned vaginal delivery in women with a twin pregnancy: a nation wide cohort study. Eur J Obstet Gynecol Reprod Biol 2018;221:97–104.
19. Roberts CL, Algert CS, Nippita TA, Bowen JR, Shand AW. Association of prelabor cesarean delivery with reduced mortality in twins born near term. Obstet Gynecol 2015;125:103–10.
20. Garrido MM, Kelley AS, Paris J, Roza K, Meier DE, Morrison RS, et al. Methods for constructing and assessing propensity scores. Health Serv Res 2014;49:1701–20.
21. Leuven E, Sianesi B. PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. Available at: http://ideas.repec.org/c/boc/bocode/s432001.html. Retrieved July 19, 2018.
22. Villar J, Carroli G, Zavaleta N, Donner A, Wojdyla D, Faundes A, et al. Maternal and neonatal individual risks and benefits associated with caesarean delivery: multicentre prospective study. BMJ 2007;335:1025.
23. Ohkuchi A, Onagawa T, Usui R, Koike T, Hiratsuka M, Izumi A, et al. Effect of maternal age on blood loss during parturition: a retrospective multivariate analysis of 10,053 cases. J Perinat Med 2003;31:209–15.
24. Ananth CV, Wilcox AJ, Savitz DA, Bowes WA Jr, Luther ER. Effect of maternal age and parity on the risk of uteroplacental bleeding disorders in pregnancy. Obstet Gynecol 1996;88: 511–6.
25. Arrowsmith S, Robinson H, Noble K, Wray S. What do we know about what happens to myometrial function as women age? J Muscle Res Cell Motil 2012;33:209–17.
26. Elmes M, Szyszka A, Pauliat C, Clifford B, Daniel Z, Cheng Z, et al. Maternal age effects on myometrial expression of contractile proteins, uterine gene expression, and contractile activity during labor in the rat. Physiol Rep 2015;3. pii:e12305.
27. Al-Zirqi I, Stray-Pedersen B, Forsén L, Vangen S. Uterine rupture after previous caesarean section [published erratum appears in BJOG 2010;117:1041]. BJOG2010;117:809–20.
28. Fitzpatrick KE, Kurinczuk JJ, Alfirevic Z, Spark P, Brocklehurst P, Knight M. Uterine rupture by intended mode of delivery in the UK: a national case-control study. PLoS Med 2012;9: e1001184.
29. Easter S, Robinson J, Carusi D, Little S. The U.S. twin delivery volume and association with cesarean delivery rates: a hospital-level analysis. Am J Perinatol 2018;35:345–53.