

## OBSTETRICS

# Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study



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**BACKGROUND:** To assess both severe maternal and neonatal mortality and morbidity after attempted operative vaginal deliveries by residents under supervision and by attending obstetricians.

**STUDY DESIGN:** Secondary analysis of a 5-year prospective study with cross-sectional analysis including 2192 women with live singleton term fetuses in vertex presentation who underwent an attempted operative vaginal delivery in a tertiary care university hospital. Obstetricians who attempted or performed an operative vaginal delivery were classified into 2 groups according to their level of experience: attending obstetricians (who had 5 years or more of experience) and obstetric residents (who had less than 5 years of experience) under the supervision of an attending obstetrician. We used multivariate logistic regression and propensity score methods to compare outcomes associated with attending obstetricians and obstetric residents. Severe maternal morbidity was defined as third- or fourth-degree perineal laceration, perineal hematoma, cervical laceration, extended uterine incision for cesareans, postpartum hemorrhage >1500 mL, surgical hemostatic procedures, uterine artery embolization, blood transfusion, infection, thromboembolic events, admission to the intensive care unit, or maternal death; severe neonatal morbidity was defined as a 5-minute Apgar score <7, umbilical artery pH <7.00, need for resuscitation or intubation, neonatal trauma, intraventricular hemorrhage greater than grade 2, neonatal intensive care unit admission for more than 24 hours, convulsions, sepsis, or neonatal death.

**RESULTS:** High prepregnancy body mass index, high dose of oxytocin, manual rotation, persistent occiput posterior or transverse positions, operating room delivery, midpelvic delivery, forceps, and

spatulas were significantly more frequent in deliveries managed by attending obstetricians than residents whereas a second-stage pushing phase longer than 30 minutes was significantly more frequent in deliveries managed by residents. The rate of severe maternal morbidity was 7.8% (115/1475) for residents vs 9.9% (48/484) for attending obstetricians; for severe neonatal morbidity, the rates were 8.3% (123/1475) vs 15.1% (73/484), respectively. In the univariate, multivariable, and sensitivity analyses, attempted operative vaginal delivery managed by a resident was significantly and inversely associated with severe neonatal but not maternal morbidity. After propensity score matching, delivery managed by a resident was not significantly associated with severe maternal morbidity (adjusted odds ratio, 0.74; 95% confidence interval, 0.39–1.38) and was no longer associated with neonatal morbidity (adjusted odds ratio, 0.51; 95% confidence interval, 0.25–1.04).

**CONCLUSION:** Management of attempted operative vaginal deliveries by residents under the supervision of attending obstetricians, compared with by the attending obstetricians themselves, does not appear to be associated with either maternal or neonatal morbidity. These reassuring results support the continued use of residency programs for training in operative vaginal deliveries under the supervision of attending obstetricians.

**Key words:** forceps, Kiwi OmniCup vacuum, maternal and neonatal morbidity, operative vaginal delivery, registrars, residents, Thierry's spatula, training, vacuum

Operative vaginal delivery remains a procedure used in daily practice in modern obstetrics, one that all residents should be experienced in or at least comfortable with at the end of their training.<sup>1–3</sup> The goal of operative vaginal delivery is to expedite delivery when the second stage of labor is

excessively prolonged and/or when immediate or potential fetal compromise is suspected, but if and only if the fetal head is engaged in the maternal pelvis.<sup>1–3</sup> Nonetheless, even though the American College of Obstetricians and Gynecologists (ACOG) considers that “forceps and vacuum extractors have low risk of complications and are acceptable for operative vaginal delivery,”<sup>1</sup> they are associated with greater short-term maternal and neonatal morbidity than occurs with spontaneous vaginal delivery; this is especially true for forceps delivery.<sup>1–3</sup> They also may be associated with greater short-term morbidity than cesarean deliveries in some circumstances, depending on indication, fetal

head station, operative instrument, and procedure (rotational and/or sequential instrument use).<sup>4</sup> They may also expose the obstetrician to greater litigation risk,<sup>5</sup> particularly in cases of neonatal trauma or brachial plexus injury,<sup>6</sup> for both of which operative vaginal delivery is a well-known risk factor.<sup>7</sup>

Unsurprisingly, the rates of operative vaginal deliveries have decreased dramatically over the past 2 decades in some parts of the world. In the United States, they have fallen from nearly 10% in 1994 to 3% in 2014<sup>8</sup> for both vacuum and forceps,<sup>9</sup> even though ACOG and the Society for Maternal–Fetal Medicine now advocate increased use of operative vaginal delivery as a strategy for reducing cesarean rates.<sup>10</sup>

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## AJOG at a Glance

**Why was the study conducted?**

This study was conducted to determine whether the maternal or neonatal outcome after an attempted operative vaginal delivery by residents under supervision is poorer than after such deliveries managed by attending obstetricians.

**Key findings**

An attempted operative vaginal delivery managed by an obstetric resident under supervision was not associated with a greater rate of severe maternal and neonatal morbidity than such a delivery managed by an attending obstetrician.

**What does this add to what is known?**

These reassuring results support the continued use of residency programs to provide training for operative vaginal deliveries under the supervision of an attending obstetrician and may participate in a virtuous circle to prevent the ongoing demise of these valuable skills.

Some authors warn that forceps delivery is becoming a “species on the brink of extinction.”<sup>9</sup> Proposals to correct this situation include proactive faculty teaching of this skill,<sup>11</sup> simulators,<sup>12</sup> or both, combined with procedural training<sup>11</sup> to change the trend and increase the ability of future attending obstetricians to use operative vaginal delivery.

One issue related to these deliveries by residents, specifically to forceps training and the transfer of knowledge and skills in delivery rooms under the supervision of an attending obstetrician, is that the teacher is partially blinded to this procedure, does not really control the application of the forceps blade or the force used during traction, and does not see the manipulations performed inside the mother’s body. Under the constraints inherent in stressful emergency situations, it is easy to understand that attending obstetricians may be risk averse and prefer to perform the operative vaginal delivery themselves, especially in cases of known maternal or fetal pathology such as overweight, fetal growth restriction (FGR), macrosomia, or previous cesarean delivery. Consequently, one of the main impediments to the performance of operative vaginal deliveries during residency may be the potentially strong belief of attending obstetricians that such a delivery performed by residents rather than themselves may present a greater risk of maternal and/or neonatal morbidity, although this has never been demonstrated. It is unlikely that it ever

will be demonstrated, because a randomized trial of this question will probably never be conducted, for obvious ethical reasons. Observational studies with prospective data collection and appropriate statistical methods are the best compromise between quality and feasibility to determine whether level of experience affects maternal and neonatal outcomes after this type of delivery.

Contrary to the United States, the operative vaginal delivery rate has remained unchanged in France since 1995, at around 12%–14%,<sup>13,14</sup> as in many European countries.<sup>15</sup> Similarly, the cesarean delivery rate has remained stable since 2003 at around 21%.<sup>13,14</sup> These data, taken together, indirectly indicate an ongoing policy of resident training in operative vaginal delivery in France. We aimed to determine maternal and neonatal morbidity according to the managing practitioner—obstetric resident or attending obstetrician—in a large French observational study of attempted operative vaginal deliveries that collected numerous details related to maternal and fetal condition, and clinical decision making. Propensity-score analysis was used to ensure the comparability of the study groups and to minimize selection bias.

**Materials and Methods****Study design and patients**

This is a secondary cross-sectional analysis of data from a prospective study that took place from December

2008 to October 2013 at a French tertiary care university hospital with more than 4000 annual deliveries. Detailed information about the participating women and protocol already has been reported elsewhere.<sup>16–18</sup> This prospective study was primarily designed to assess the effect of fetal head station on short- and mid-term maternal and neonatal morbidity after attempted operative vaginal delivery.<sup>16–18</sup> The number of cases included in this prospective study determined the sample size of this secondary cross-sectional analysis.

This study included all women carrying a live singleton fetus at term ( $\geq 37$  weeks of gestation) who underwent an attempted operative vaginal delivery, defined by the application of at least one blade for forceps or spatula, or a vacuum, regardless of its success. Exclusion criteria were multiple gestations, infants with FGR, defined as weighing less than the 10th percentile for gestational age on Hadlock curves,<sup>19,20</sup> a known congenital anomaly, noncephalic presentation, and missing data for the exposure or adjustment variables.

All women received information about our study and consented to the collection of their data. The Research Ethics Committee of the University of Angers, France, approved the study (no. 2008).

The decision to perform an operative vaginal delivery, the choice of instrument (forceps, Kiwi OmniCup vacuum, or Thierry’s spatulas), and the place of delivery (operating room or not) were left to the attending obstetrician’s discretion. Operative vaginal deliveries were performed by either the attending obstetrician or the obstetric resident under the supervision of an attending obstetrician, who was always present in the delivery room when a resident performed such a delivery. Moreover, attending physicians always chose the instrument used and determined whether they needed to check the instrument placement personally before traction.

All women were offered epidural analgesia. The bladder was emptied by catheter before delivery. In accordance with French guidelines,<sup>3</sup> ultrasound for

assessment of the fetal head position (but not station) was possible in cases of doubts after clinical examination, at the attending obstetrician's discretion; and it was recommended that rotational forceps-assisted deliveries ( $>90^\circ$  rotation) be avoided: only vacuum instruments were recommended for rotation. In the case of a failed operative vaginal delivery, the same resident performed the cesarean under the supervision of the same attending obstetrician.

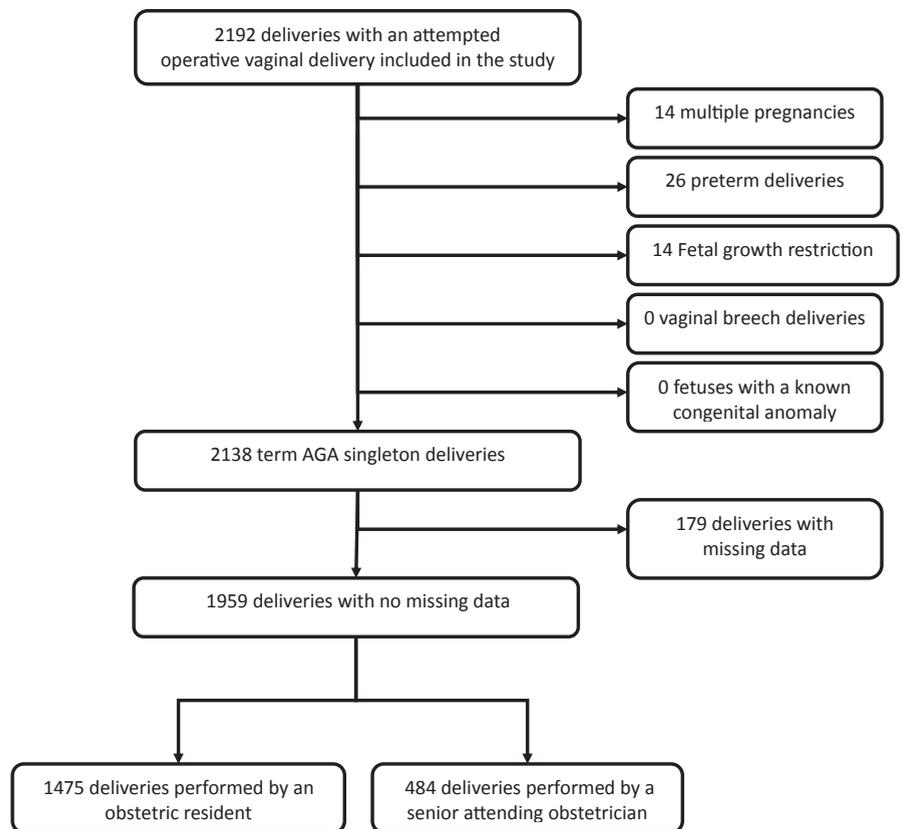
The medical records of women with an attempted operative vaginal delivery were assessed and discussed at the daily morning staff meeting. Attending obstetricians regularly reviewed with residents the ACOG classification of fetal head station,<sup>21</sup> academic knowledge about operative vaginal delivery, and the French National College of Obstetricians and Gynecologists clinical practice guidelines for this type of delivery.<sup>3,22</sup> Indications for attempted operative vaginal delivery included nonreassuring scalp pH and fetal heart rate abnormalities (defined by any of prolonged deceleration, bradycardia, or decreased variability)<sup>23</sup> and/or prolongation of the second-stage pushing phase resulting from inadequate expulsive efforts or failure to progress.<sup>3,22</sup> All women underwent continuous fetal heart rate monitoring. Episiotomy was left to the practitioner's discretion. All episiotomies were mediolateral. A pediatrician examined the newborn in all cases within 2 hours after delivery.

The details of the procedures used to manage the labor as well as all clinical outcomes identified during the immediate postpartum period were prospectively collected by the midwife or obstetrician and pediatrician responsible for the delivery and the neonate. Other data were collected by a research assistant, independent of the local medical team, from a prospectively maintained database of women who underwent attempted (or completed) operative vaginal delivery.<sup>16–18</sup>

## Endpoints

The primary and secondary endpoints were composite variables of severe short-term maternal and neonatal morbidity,

**FIGURE 1**  
Study flow chart



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respectively. Severe short-term maternal morbidity was defined by at least one of the following criteria: third- or fourth-degree perineal laceration, perineal hematoma, cervical laceration, extended uterine incision for cesareans, postpartum hemorrhage  $>1500$  mL (blood loss was assessed routinely with a collector bag placed just after birth),<sup>24,25</sup> surgical hemostatic procedures, uterine artery embolization, blood transfusion, infection, thromboembolic events, admission to the intensive care unit, and maternal death.<sup>16</sup>

Severe neonatal morbidity was defined by at least 1 of the following criteria: 5-minute Apgar score  $<7$ , umbilical artery pH  $<7.00$  (umbilical artery blood gas values were routinely measured), need for resuscitation or intubation, neonatal trauma, intraventricular hemorrhage greater than grade 2, neonatal intensive care unit admission

for more than 24 hours, convulsions, sepsis, and neonatal death.<sup>16</sup>

## Exposure variable

In this study, obstetricians who attempted or performed an operative vaginal delivery were classified into 2 groups according to their level of experience: attending obstetricians (who had 5 years or more of experience) and obstetric residents (who had less than 5 years of experience).

## Adjustment variables

All variables that might influence an attending obstetrician's decision to allow a resident to perform the operative vaginal delivery were used as adjustment variables. Thus, maternal and obstetric characteristics used in this study as adjustment variables included maternal age ( $\leq 30$  years or  $>30$  years), prepregnancy body mass index (BMI) based on

TABLE 1

**Maternal and labor characteristics and maternal and neonatal outcomes for operative vaginal deliveries, according to the obstetrician's level of experience (n = 1959)**

Variables	Obstetric resident, n= 1475	Attending obstetrician, n = 484	Pvalue <sup>a</sup>
Maternal and labor characteristics			
Age, y	28 (25, 31)	28 (25, 32)	.06
BMI before pregnancy, kg/m <sup>2</sup>	21.8 (20.0, 24.3)	22.2 (20.3, 25.0)	.01
Nulliparity	1099 (74.5)	358 (74.0)	.86
Previous caesarean delivery	151 (10.2)	54 (11.2)	.63
Previous birthweight >4000 g	14 (3.8)	8 (6.4)	.33
Gestational diabetes mellitus	84 (5.8)	30 (6.2)	.20
Prenatal suspicion of macrosomia <sup>b</sup>	91 (6.2)	31 (6.4)	.94
Gestational age at delivery, wk	40 (39, 4)	40 (39,4)	.88
Induced labor	257 (17.4)	92 (19.0)	.47
Second stage >3 h	197 (13.4)	75 (15.5)	.27
Pushing phase of second stage >30 min	501 (34.0)	125 (25.8)	.001
Dose of oxytocin (milli-international units)	900 (200, 2260)	1110 (248, 2620)	.04
Epidural analgesia	1386 (94.0)	452 (93.4)	.73
Manual rotation	133 (9.1)	80 (16.7)	<.001
Persistent occiput			
Anterior	1324 (89.8)	403 (83.3)	
Posterior	113 (7.7)	65 (13.4)	<.001
Transverse	38 (2.6)	16 (3.3)	
Indication for operative vaginal delivery			
Nonreassuring FHR only	613 (41.6)	221 (45.7)	
Arrested progress only	563 (38.2)	169 (34.9)	.27
Nonreassuring FHR and arrested progress	299 (20.3)	94 (19.4)	
Operative vaginal delivery in the operating room	2 (0.1)	30 (6.2)	<.001
Fetal head station			
Outlet	157 (10.6)	21 (4.3)	
Low	1152 (78.1)	280 (57.9)	<.001
Mid	166 (11.3)	183 (37.8)	
Instrument type			
Vacuum	589 (39.9)	87 (18.0)	
Forceps	34 (2.3)	77 (15.9)	<.001
Spatula	904 (61.3)	345 (71.3)	
Sequential use of 2 instruments	46 (3.1)	24 (5.0)	.08
Rotational forceps delivery	0 (0.0)	2 (0.4)	.10

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019. (continued)

TABLE 1

**Maternal and labor characteristics and maternal and neonatal outcomes for operative vaginal deliveries, according to the obstetrician's level of experience (n = 1959) (continued)**

Variables	Obstetric resident, n= 1475	Attending obstetrician, n = 484	Pvalue <sup>a</sup>
<b>Maternal outcome</b>			
Caesarean delivery after failed operative vaginal delivery	2 (0.1)	30 (6.2)	<.001
Extended uterine incision for caesarean delivery	0 (0.0)	6 (19.4)	.79
Episiotomy	1296 (87.9)	416 (86.5)	.47
Third- or fourth-degree perineal laceration	40 (2.7)	13 (2.7)	1
Perineal hematoma	1 (0.1)	1 (0.2)	.99
Manual removal of retained placenta	164 (19.8)	82 (28.4)	.003
Shoulder dystocia	37 (2.5)	13 (2.8)	.83
PPH (blood loss >500 mL)	232 (15.7)	98 (20.3)	.02
Severe PPH (blood loss >1500 mL)	18 (1.2)	9 (1.9)	.42
Need for an additional uterotonic agent	27 (3.3)	13 (4.5)	.43
Second-line therapies <sup>c</sup>	4 (0.5)	2 (0.7)	1
Blood transfusion	20 (1.4)	16 (3.3)	.01
Infection <sup>d</sup>	19 (1.3)	8 (1.7)	.71
Thromboembolic event	3 (0.2)	1 (0.2)	1
Admission to ICU	2 (0.1)	0 (0.0)	1
Maternal death	0 (0.0)	0 (0.00)	1
Severe maternal morbidity <sup>e</sup>	115 (7.8)	48 (9.9)	.17
<b>Neonatal outcome</b>			
Birth weight ≥4000 g	70 (4.8)	26 (5.4)	.67
5-min Apgar score <7	13 (0.9)	5 (1.0)	.98
pH < 7.00	18 (1.2)	12 (2.5)	.08
Transfer to NICU	61 (4.1)	33 (6.8)	.02
NICU hospitalization >24 h	58 (3.9)	32 (6.6)	.02
Respiratory distress syndrome	49 (3.3)	19 (3.9)	.63
Scalp laceration	66 (4.5)	42 (8.7)	<.001
Scalp hematoma	20 (1.4)	26 (5.4)	<.001
Pain necessitating drugs	134 (9.1)	65 (13.5)	.01
Neonatal trauma <sup>f</sup>	8 (0.5)	4 (0.8)	.72
Fracture of the clavicle	4 (0.3)	2 (0.4)	
Fracture of a long bone	0 (0.0)	0 (0.00)	
Brachial plexus injury	4 (0.3)	2 (0.4)	
Cephalhematoma	5 (0.3)	2 (0.4)	

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019. (continued)

height and the first weight noted in the obstetric record (BMI <25 kg/m<sup>2</sup>, 25 to <30 kg/m<sup>2</sup>, or ≥30 kg/m<sup>2</sup>), and parity

(nulliparous/parous); history of each cesarean delivery, adverse events during previous deliveries (birthweight >4000

g, shoulder dystocia, episiotomy, operative vaginal delivery, or postpartum hemorrhage >1500 mL, preeclampsia,

TABLE 1

**Maternal and labor characteristics and maternal and neonatal outcomes for operative vaginal deliveries, according to the obstetrician's level of experience (n = 1959) (continued)**

Variables	Obstetric resident, n= 1475	Attending obstetrician, n = 484	Pvalue <sup>a</sup>
Intraventricular hemorrhage > grade 2	0 (0.0)	0 (0.00)	1
Need for resuscitation or intubation	8 (0.5)	1 (0.2)	.57
Sepsis	10 (0.7)	9 (1.9)	.04
Seizures	4 (0.3)	0 (0.0)	.57
Neonatal death	0 (0.0)	0 (0.00)	1
Severe neonatal morbidity <sup>g</sup>	123 (8.3)	73 (15.1)	<.001

Data are means (interquartile range) or n (%) unless otherwise specified.

BMI, body mass index; FHR, fetal heart rate; ICU, intensive care unit; NICU, neonatal intensive care unit; PPH, postpartum hemorrhage.

<sup>a</sup> Categorical variables were compared with  $\chi^2$  tests and continuous ones with Wilcoxon tests; <sup>b</sup> Prenatal suspicion of macrosomia: fundal height measurement at delivery >37 cm, ultrasonographic fetal abdominal circumference >90th percentile for gestational age on Hadlock curves, or both; <sup>c</sup> Second-line therapies: uterine compression sutures, uterine artery embolization, and peripartum hysterectomy for management of massive primary PPH after failure of uterine massage and uterotonic agents to stop bleeding; <sup>d</sup> Infections were defined by at least 1 of the following: endometritis, episiotomy infection, or wound infection requiring surgery; <sup>e</sup> Severe maternal morbidity was defined by at least 1 of the following criteria: third- or fourth-degree perineal lacerations, perineal hematomas, cervical laceration, extended uterine incision at caesarean delivery, PPH >1500 mL, surgical hemostatic procedure, uterine artery embolization, blood transfusion, infections (endometritis, episiotomy infection, wound infection requiring surgery), thromboembolic event (deep vein thrombophlebitis or pulmonary embolism), admission to intensive care unit, and maternal death; <sup>f</sup> Neonatal trauma was defined by the existence of at least 1 of the following criteria: fracture of the clavicle or a long bone, brachial plexus injury, and cephalohematoma; <sup>g</sup> Severe neonatal morbidity was defined by at least 1 of the following criteria: 5-min Apgar score <7, umbilical artery pH <7.00, need for resuscitation or intubation, neonatal trauma, intraventricular hemorrhage greater than grade 2, admission to the NICU >24 h, convulsions, sepsis, and neonatal death.

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019.

gestational hypertension, or FGR); in this pregnancy, diabetes mellitus during pregnancy (preexisting or gestational), gestational weight gain (>20 kg/≤20 kg), prenatal suspicion of macrosomia (determined by fundal height measurement at delivery >37 cm for all gestational ages, ultrasonographic fetal abdominal circumference >90th percentile for gestational age on Hadlock curves<sup>19,20</sup> or both), gestational age at delivery (determined by craniocaudal length at a first-trimester ultrasound examination or by the date of the last menstrual period, a second or third trimester ultrasonogram, or both if the first-trimester ultrasonogram was not performed),<sup>26</sup> categorized into <39 weeks, 39–40 weeks, and >40 weeks, type of labor (spontaneous or induced by prostaglandins, amniotomy, or oxytocin), second-stage pushing phase, from the beginning of expulsive efforts to birth (>30 minutes/≤30 minutes), epidural analgesia, fetal head position at crowning (occiput posterior or anterior or transverse), indication for attempted operative vaginal delivery (non-reassuring fetal heart rate only, arrested

progress only, or both), fetal head station, defined as the level of the leading bony point of the fetal head in centimeters at or below the level of maternal ischial spines (0 and +1 = midpelvic, +2 and +3 = low, +4 and +5 = outlet),<sup>21</sup> and the instrument type (forceps, Kiwi OmniCup vacuum, Thierry's spatulas, or sequential use of instruments).

### Statistical analysis

Continuous variables were described by their medians and interquartile ranges and compared between groups by a Wilcoxon test. Categorical variables were described by proportions and compared by  $\chi^2$  tests. We used logistic regression models, with multiple adjustments, to estimate crude and adjusted associations between the obstetricians' experience and the composite variables of short-term severe maternal and neonatal morbidity.

Because attending obstetricians' decisions about whether they or the resident should manage the operative vaginal delivery were probably guided by the pregnancy and delivery characteristics rather than by chance, a sensitivity

analysis using propensity scores was conducted to limit potential bias. A 1:1 matching algorithm<sup>27</sup> was used within a caliper of 0.15 standard deviations of the logit of the propensity score to match patients based on maternal age, gestational weight gain, duration of second-stage pushing phase, and epidural use. Exact matching also was performed for parity, persistent occiput position, station at attempted delivery, instrument type, history of cesarean, episiotomy, prepregnancy BMI, suspicion of macrosomia, gestational age, induction of labor, indication for attempted operative vaginal delivery, birthweight, history of adverse events during previous deliveries, diabetes mellitus during pregnancy, and history of preeclampsia, pregnancy-induced hypertension, or FGR. Imbalance after matching was checked. Odds ratios (ORs) were calculated to quantify the association between the obstetrician's experience and the endpoints by using logistic regression fitted by generalized estimating equations to account for paired data.<sup>28</sup>

A second sensitivity analysis was performed with multiple imputation of

**TABLE 2**  
**Univariate and multivariate analysis of severe maternal and neonatal morbidity after attempted operative vaginal delivery (n = 1959)**

Variable	Severe maternal morbidity (n = 1959)				Severe neonatal morbidity (n = 1959)			
	Crude OR (95% CI)	Pvalue	Adj. OR (95% CI)	Pvalue	Crude OR (95% CI)	Pvalue	Adj. OR (95% CI)	Pvalue
Maternal age, y								
≤30	1.00	—	1.00	—	1.00	—	1.00	—
>30	1.07 (0.76–1.51)	.71	1.02 (0.70–1.48)	.91	0.83 (0.59–1.15)	.26	0.73 (0.51–1.05)	.09
BMI before pregnancy, kg/m <sup>2</sup>								
BMI less than 30	1.00	—	1.00	—	1.00	—	1.00	—
BMI 30 or greater	1.22 (0.67–2.22)	.51	1.30 (0.70–2.41)	.40	1.90 (1.17–3.08)	.01	1.70 (1.02–2.84)	.04
Parity								
Multiparity	1.00	—	1.00	—	1.00	—	1.00	—
Nulliparity	0.96 (0.67–1.38)	.82	1.67 (0.90–3.09)	.11	1.01 (0.72–1.41)	.97	1.13 (0.69–1.87)	.62
History of cesarean delivery								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	1.9 (1.23–2.93)	.004	3.01 (1.50–6.04)	.002	0.97 (0.60–1.58)	.90	1.11 (0.59–2.10)	.75
History of adverse events during delivery <sup>a</sup>								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	0.84 (0.45–1.54)	.56	0.96 (0.49–1.90)	.91	1.57 (0.99–2.48)	.05	1.75 (1.01–3.03)	.04
History of preeclampsia, PIH, or fetal growth restriction								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	1.18 (0.53–2.61)	.69	1.32 (0.57–3.07)	.52	1.45 (0.73–2.88)	.29	1.09 (0.52–2.28)	.82
Diabetes mellitus during pregnancy <sup>b</sup>								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	0.51 (0.23–1.10)	.09	0.49 (0.22–1.09)	.08	1.22 (0.73–2.04)	.45	1.05 (0.61–1.83)	.85
Gestational weight gain >20 kg								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	1.58 (0.93–2.70)	.09	1.59 (0.92–2.75)	.10	1.09 (0.62–1.90)	.77	1.04 (0.59–1.86)	.88
Prenatal suspicion of macrosomia <sup>c</sup>								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	1.74 (1.00–3.01)	.05	1.69 (0.95–3.01)	.07	0.98 (0.53–1.81)	.95	0.91 (0.48–1.73)	.77

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019.

(continued)

**TABLE 2**  
**Univariate and multivariate analysis of severe maternal and neonatal morbidity after attempted operative vaginal delivery (n = 1959) (continued)**

Variable	Severe maternal morbidity (n = 1959)				Severe neonatal morbidity (n = 1959)			
	Crude OR (95% CI)	Pvalue	Adj. OR (95% CI)	Pvalue	Crude OR (95% CI)	Pvalue	Adj. OR (95% CI)	Pvalue
Gestational age, wk								
<39	0.83 (0.53–1.30)	.42	0.82 (0.52–1.30)	.40	2.24 (1.58–3.18)	<.001	2.23 (1.56–3.20)	<.001
39–40	1.00	—	1.00	—	1.00	—	1.00	—
>40	1.4 (0.97–2.02)	.07	1.45 (0.98–2.15)	.06	1.37 (0.95–1.99)	.10	1.26 (0.85–1.87)	.26
Induced labor								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	1.04 (0.69–1.58)	.84	0.89 (0.56–1.41)	.62	1.58 (1.11–2.23)	.01	1.40 (0.94–2.08)	.09
Pushing phase of second stage >30 min								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	1.2 (0.77–1.86)	.43	1.04 (0.65–1.68)	.86	0.68 (0.42–1.10)	.12	0.60 (0.35–1.00)	.05
Epidural analgesia								
No	1.00	—	1.00	—	1.00	—	1.00	—
Yes	0.67 (0.38–1.21)	.18	0.36 (0.19–0.67)	.001	1.61 (0.77–3.35)	.20	1.56 (0.73–3.35)	.25
Persistent occiput position								
Anterior	1.00	—	1.00	—	1.00	—	1.00	—
Posterior	1.27 (0.75–2.12)	.37	1.24 (0.72–2.11)	.43	1.26 (0.78–2.04)	.35	1.02 (0.62–1.69)	.94
Transverse	0.90 (0.32–2.53)	.84	0.92 (0.32–2.63)	.87	1.88 (0.90–3.92)	.10	1.63 (0.76–3.49)	.21
Indication for attempted operative vaginal delivery								
Nonreassuring FHR only	0.65 (0.45–0.93)	.02	0.66 (0.45–0.98)	.04	1.06 (0.75–1.50)	.75	0.94 (0.65–1.37)	.74
Arrested progress only	1.00	—	1.00	—	1.00	—	1.00	—
Nonreassuring FHR and arrested progress	0.85 (0.56–1.31)	.47	0.90 (0.57–1.40)	.63	1.60 (1.09–2.35)	.02	1.46 (0.97–2.19)	.07
ACOG classification								
Mid	1.54 (0.78–3.05)	.21	1.00 (0.46–2.17)	1	1.61 (0.89–2.93)	.11	1.21 (0.61–2.40)	.58
Low	1.22 (0.66–2.26)	.53	0.93 (0.48–1.82)	.83	1.03 (0.60–1.77)	.92	0.94 (0.52–1.68)	.82
Outlet	1.00	—	1.00	—	1.00	—	1.00	—

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019.

(continued)

**TABLE 2**  
**Univariate and multivariate analysis of severe maternal and neonatal morbidity after attempted operative vaginal delivery (n = 1959) (continued)**

Variable	Severe maternal morbidity (n = 1959)			Severe neonatal morbidity (n = 1959)		
	Crude OR (95% CI)	Pvalue	Adj. OR (95% CI)	Crude OR (95% CI)	Pvalue	Adj. OR (95% CI)
<b>Instrument type</b>						
Vacuum	1.00	—	1.00	1.00	—	1.00
Forceps	2.38 (1.19–4.78)	.01	2.52 (1.16–5.46)	2.26 (1.26–4.04)	.006	1.44 (0.75–2.78)
Spatula	1.87 (1.25–2.79)	.002	1.98 (1.25–3.15)	1.11 (0.79–1.56)	.55	0.90 (0.61–1.32)
Sequential use of instruments	1.66 (0.67–4.10)	.28	1.75 (0.69–4.45)	1.94 (0.96–3.91)	.06	1.56 (0.74–3.29)
<b>Level of experience</b>						
Attending obstetrician	1.00	—	1.00	1.00	—	1.00
Obstetric resident	0.77 (0.54–1.09)	.14	0.94 (0.63–1.39)	0.51 (0.38–0.70)	<.001	0.56 (0.39–0.80)

Unadjusted and adjusted logistic regression analyses. All the variables in the table were incorporated in the multivariable logistic models.

ACOG, American College of Obstetricians and Gynecologists; BMI, body mass index; CI, confidence interval; FHR, fetal heart rate; OR, odds ratio; PIH, pregnancy-induced hypertension.

<sup>a</sup> History of birth weight >4000 g, shoulder dystocia, third or fourth perineal laceration, operative vaginal delivery or postpartum hemorrhage; <sup>b</sup> Preexisting or gestational diabetes mellitus; <sup>c</sup> Fetal height measurement at delivery >37 cm, ultrasonographic fetal abdominal circumference >90th percentile for gestational age on Hadlock curves<sup>19,20</sup> or both.

Senittles et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. Am J Obstet Gynecol 2019.

missing data<sup>29</sup>; it considered all adjustment variables, the 2 primary outcomes, and the obstetrician's training level. This imputation used a bootstrap + Expectation-Maximization algorithm as implemented in the Amelia R package (Foundation for Statistical Computing; Vienna, Austria) and generated 20 independent imputed data sets. A multivariate model was estimated for each imputed data set. The resulting estimates were pooled according to the Rubin rule.<sup>2</sup>

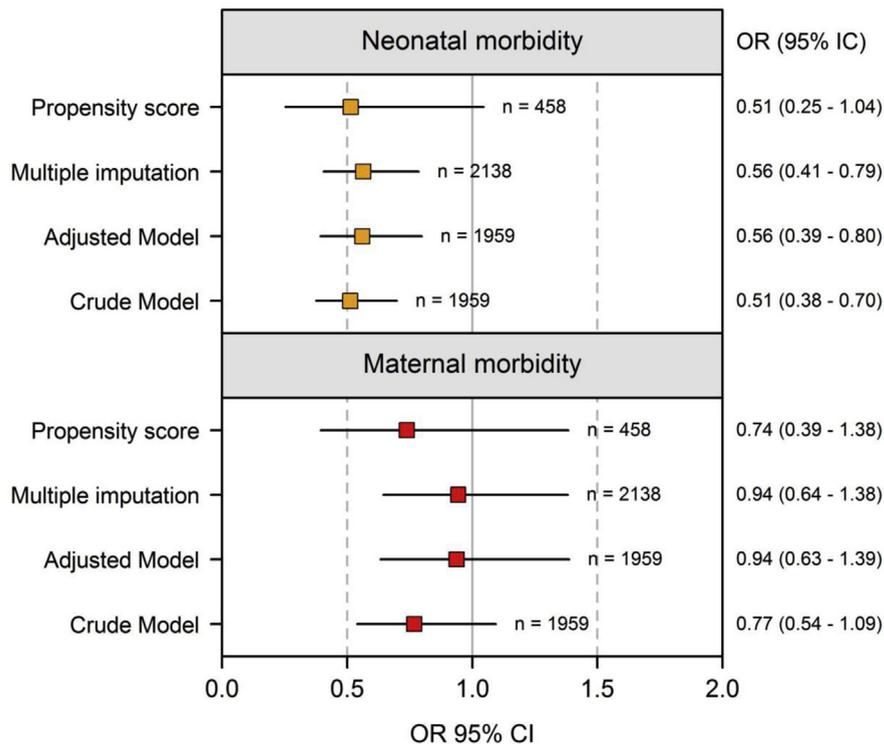
## Results

During the study period, the hospital had 19,786 deliveries: 15,836 (80.0%) were vaginal, including 2153 (13.6%) successful operative vaginal deliveries, and 3950 (20.0%) were cesareans, including 39 (0.2% of all deliveries and 1% of all cesareans) after failed operative vaginal delivery. This study analyzed the 2192 deliveries with an attempted operative vaginal delivery, both the successes (98.2%) and failures (1.8%). Among these deliveries, however, the 28 twins (n = 14 women) and 26 preterm (<37 weeks) and 14 infants with FGR were excluded. Moreover, 179 deliveries had missing data for the exposure variable (n = 26) and/or for the adjustment variables (n = 157). A more detailed description of the patterns in the missing data is given in supplementary materials (Appendix 1). Therefore, our final sample for the main analysis comprised 1959 births with an attempted operative vaginal delivery: 1475 were performed by obstetric residents and 484 by attending obstetricians (Figure 1).

Table 1 details the maternal and labor characteristics and maternal and neonatal outcomes according to the obstetricians' level of training. High pre-pregnancy body mass index, high dose of oxytocin, manual rotation, persistent occiput posterior or transverse positions, operating room delivery, midpelvic delivery, forceps, and spatulas were significantly more frequent in deliveries managed by attending obstetricians than residents whereas a second-stage pushing phase longer than 30 minutes was significantly more frequent in deliveries managed by residents.

FIGURE 2

Severe maternal and neonatal morbidity after attempted operative vaginal delivery according to the obstetrician's level of experience (reference: attending obstetrician)



CI, confidence interval; OR, odds ratio.

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019.

The rate of severe maternal morbidity after attempted operative vaginal delivery was 7.8% ( $n = 115$ ) for residents and 9.9% ( $n = 48$ ) for attending obstetricians and did not differ significantly between the 2 groups (Table 1). Delivery managed by residents was not significantly associated with severe maternal morbidity in either the univariate analysis (Table 2) (crude OR, 0.77; 95% confidence interval [CI], 0.54–1.09,  $P = .144$ ) or the multivariable logistic regression analysis, which was adjusted for potential confounders (adjusted OR, 0.94; 95% CI, 0.63–1.39,  $P = .746$ ). The sensitivity analysis based on multiple imputation was consistent with this primary analysis (adjusted OR, 0.94; 95% CI, 0.64–1.38) (Figure 2).

The rate of severe neonatal morbidity after attempted operative vaginal delivery was 8.3% ( $n = 123$ ) for residents

and 15.1% ( $n = 73$ ) for attending obstetricians and differed significantly between the 2 groups ( $P < .001$ ) (Table 1). Delivery managed by obstetric residents was significantly and inversely associated with severe neonatal morbidity in the univariate (crude OR, 0.51; 95% CI, 0.38–0.70,  $P < .001$ ) and the multivariable logistic regression analyses, the latter adjusted for potential confounders (adjusted OR, 0.56; 95% CI, 0.39–0.80,  $P = .001$ ). The sensitivity analysis based on multiple imputation was consistent with this primary analysis (adjusted OR, 0.56; 95% CI, 0.41–0.79) (Figure 2).

The propensity score matching process produced 458 cases that could be analyzed: 229 matched deliveries in each group, including 15.5% of the deliveries managed by residents and 47.3% of those managed by attending obstetricians. The two matched groups were well

balanced for all the variables we studied (Table 3). After propensity score matching, delivery managed by obstetric residents was not significantly associated with severe maternal morbidity (adjusted OR, 0.74; 95% CI, 0.39–1.38) and was no longer associated with severe neonatal morbidity (adjusted OR, 0.51; 95% CI, 0.25–1.04).

## Comment

### Principal findings

In our study, attempted operative vaginal deliveries managed by supervised obstetric residents were not associated with a greater rate of severe maternal and neonatal morbidity than such deliveries managed by attending obstetricians.

### Meaning of the findings/clinical implications

Our findings have potentially important implications. In a retrospective cohort study in the United States, Epstein et al previously demonstrated what seems intuitively obvious—that senior obstetricians' experience matters. As doctors gained years of experience, their maternal complication rates decreased for vaginal, cesarean, and overall deliveries.<sup>30</sup> It is thus easy to speculate that attending obstetricians may feel uncomfortable letting obstetric residents attempt to manage an operative vaginal delivery and may feel conflict between their responsibilities: toward the woman and child, who may be losing an opportunity for the best possible care, and toward the resident they are supposed to be training. The apparent divergence of our results and those of Epstein et al may be explained by a fundamental difference between these studies. In ours, residents were never alone to manage an attempted operative vaginal delivery; it was always performed under the supervision of the attending obstetrician in the delivery room. Moreover, the attending obstetrician was always the person who decided whether operative vaginal delivery should be attempted and who should do it (and always the only person legally responsible under French law).

Thus, our study may have assessed the attending obstetricians' performance as medical educators, or even indirectly

**TABLE 3**  
**Matched covariates before and after propensity score matching**

Variable	Overall cohort (n = 1959)			Matched cohort (n = 458)		
	Obstetric resident	Attending obstetrician	Sd. difference, %	Obstetric resident	Attending obstetrician	Sd. difference, %
<b>Maternal age &gt;30 y</b>						
No	1054 (71)	317 (65)	13	171 (75)	174 (76)	3
Yes	421 (29)	167 (35)	13	58 (25)	55 (24)	3
<b>BMI before pregnancy, kg/m<sup>2</sup></b>						
BMI <25	1378 (93)	449 (93)	2.6	227 (99)	227 (99)	0
BMI ≥25	97 (7)	35 (7)	2.6	2 (1)	2 (1)	0
<b>Parity</b>						
Parity	376 (25)	126 (26)	1.2	33 (14)	33 (14)	0
Nulliparity	1099 (75)	358 (74)	1.2	196 (86)	196 (86)	0
<b>History of cesarean delivery</b>						
No	1324 (90)	430 (89)	3	214 (93)	214 (93)	0
Yes	151 (10)	54 (11)	3	15 (7)	15 (7)	0
<b>History of adverse events during delivery<sup>a</sup></b>						
No	1357 (92)	434 (90)	8.3	222 (97)	222 (97)	0
Yes	118 (8)	50 (10)	8.3	7 (3)	7 (3)	0
<b>History of preeclampsia, pregnancy-induced hypertension, or fetal growth restriction</b>						
No	1423 (96)	463 (96)	4.3	228 (100)	228 (100)	0
Yes	52 (4)	21 (4)	4.3	1 (0)	1 (0)	0
<b>Diabetes mellitus during pregnancy<sup>b</sup></b>						
No	1357 (92)	449 (93)	2.9	225 (98)	225 (98)	0
Yes	118 (8)	35 (7)	2.9	4 (2)	4 (2)	0
<b>Gestational weight gain &gt;20 kg</b>						
No	1371 (93)	448 (93)	1.5	219 (96)	216 (94)	6
Yes	104 (7)	36 (7)	1.5	10 (4)	13 (6)	6
<b>Prenatal suspicion of macrosomia<sup>c</sup></b>						
No	1384 (94)	453 (94)	1	225 (98)	225 (98)	0
Yes	91 (6)	31 (6)	1	4 (2)	4 (2)	0
<b>Gestational age, wk</b>						
<39	306 (21)	99 (20)	0.7	43 (19)	43 (19)	0
39 to < 41	819 (56)	269 (56)	0.1	142 (62)	142 (62)	0
>41	350 (24)	116 (24)	0.6	44 (19)	44 (19)	0
<b>Induced labor</b>						
No	1218 (83)	392 (81)	4.1	212 (93)	212 (93)	0
Yes	257 (17)	92 (19)	4.1	17 (7)	17 (7)	0

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019.

(continued)

their clinical performance (although we can assume that their poorer performance is due to their choosing to

manage the most difficult situations themselves), rather than the impact of level of experience on maternal and

neonatal outcome. The key point, however, is that our study provides reassuring evidence that neither maternal nor

**TABLE 3**  
**Matched covariates before and after propensity score matching** (continued)

Variable	Overall cohort (n = 1959)			Matched cohort (n = 458)		
	Obstetric resident	Attending obstetrician	Sd. difference, %	Obstetric resident	Attending obstetrician	Sd. difference, %
Pushing phase of second stage longer than 30 min						
No	1278 (87)	409 (85)	6.2	209 (91)	206 (90)	4.5
Yes	197 (13)	75 (15)	6.2	20 (9)	23 (10)	4.5
Epidural analgesia						
No	89 (6)	32 (7)	2.4	8 (3)	8 (3)	0
Yes	1386 (94)	452 (93)	2.4	221 (97)	221 (97)	0
Persistent occiput position						
Anterior	1324 (90)	403 (83)	20.1	210 (92)	210 (92)	0
Posterior	113 (8)	65 (13)	20.1	16 (7)	16 (7)	0
Transverse	38 (3)	16 (3)	4.5	3 (1)	3 (1)	0
Indication for attempted operative vaginal delivery						
Non-reassuring FHR only	613 (42)	221 (46)	8.3	111 (48)	111 (48)	0
Arrested progress only	563 (38)	169 (35)	6.7	82 (36)	82 (36)	0
Non-reassuring FHR and arrested progress	299 (20)	94 (19)	2.1	36 (16)	36 (16)	0
ACOG classification						
Mid	166 (11)	183 (38)	69.4	50 (22)	50 (22)	0
Low	1152 (78)	280 (58)	45.7	174 (76)	174 (76)	0
Outlet	157 (11)	21 (4)	21.9	5 (2)	5 (2)	0
Instrument type						
Vacuum	548 (37)	68 (14)	49.8	36 (16)	36 (16)	0
Forceps/spatula	881 (60)	392 (81)	44.6	188 (82)	188 (82)	0
Sequential use of instruments	46 (3)	24 (5)	9.9	5 (2)	5 (2)	0

ACOG, American College of Obstetricians and Gynecologists; BMI, body mass index; FHR, fetal heart rate; Sd., standard.

<sup>a</sup> History of birth weight >4000 g, shoulder dystocia, episiotomy, operative vaginal delivery, or postpartum hemorrhage; <sup>b</sup> Preexisting or gestational diabetes mellitus; <sup>c</sup> Fundal height measurement at delivery >37 cm, ultrasonographic fetal abdominal circumference >90th percentile for gestational age on Hadlock curves<sup>19,20</sup> or both.

Sentilhes et al. Outcomes of operative vaginal delivery managed by residents under supervision and attending obstetricians: a prospective cross-sectional study. *Am J Obstet Gynecol* 2019.

neonatal morbidity is increased when attending obstetricians decide that maternal and obstetric conditions allow them to let residents attempt the operative vaginal delivery under their supervision. This important finding may encourage attending obstetricians to continue or resume participation in residency programs for training in operative vaginal deliveries.

Moreover, Epstein et al also demonstrated that initial skills matter: variation in the overall quality of future attending obstetricians is determined far more by

their initial skills than by the number of deliveries they have managed.<sup>31</sup> It is therefore essential that the initial performance and learning of obstetric residents should be the best possible so that the complications related to their future operative vaginal deliveries are as low as possible.<sup>31</sup> Intuitively, one might expect that the more confident and comfortable these current residents feel in handling operative vaginal deliveries, the more they often they will use these skills when necessary as attending obstetricians in the future. This in turn should ensure

that they maintain their skills in and acceptable rates of operative vaginal deliveries and thus lower cesarean rates.<sup>32</sup> Our results may participate in a virtuous circle to prevent the ongoing demise of these valuable skills.<sup>8</sup>

Finally, as Asch et al reported, medical training programs play a determinant role in the complication rates of their residents' future patients.<sup>33</sup> In France, including at the university where this study was conducted, there are no formal training programs for operative vaginal deliveries but only lectures; in particular,

routine simulation training and a simulation-based curriculum for operative vaginal deliveries are in their early stages and not yet universally available.<sup>11</sup> Nevertheless, French residency programs are successfully training residents, based on the medieval apprentice—journeyman—master training sequence, as recently demonstrated in a national prospective study related to twin deliveries.<sup>34</sup> This point should be underlined, as it may contribute to our positive results.

### Strengths and weaknesses

Our study presents several strengths. First, the data, including numerous details relevant to maternal, obstetric, and clinical decision characteristics (which are often unavailable in large retrospective population-based studies), came from a large prospective study performed in a center with a policy of planned vaginal delivery, demonstrated indirectly by its rates of operative vaginal (13.6%) and cesarean (20%) deliveries, and a policy of teaching residents to manage operative vaginal deliveries (around 75% of attempted operative vaginal deliveries were performed by residents). Second, these data are robust: a collector bag was routinely used to estimate blood loss after delivery, all neonates were routinely examined by a qualified neonatologist after delivery, and previous results have been consistent with other well-established findings in the literature, in particular regarding short- and mid-term severe maternal morbidity and short-term neonatal morbidity after delivery with forceps or vacuum.<sup>16–18</sup>

Third, we studied all attempted operative vaginal deliveries, including those that failed, for their exclusion might mask a possible negative effect. Fourth, as in all observational studies, the main limitation of ours is uncontrolled confounders, particularly indication bias, as demonstrated in our univariate analysis: attending obstetricians attempted operative vaginal deliveries in the most difficult and risky conditions, and residents undertook less-complicated deliveries involving women and babies at lower risk.

Moreover, confounders may persist after multivariable analyses,<sup>35</sup> as our results suggest: there is no plausible or biological explanation for the finding that severe neonatal morbidity is significantly inversely associated with delivery managed by an obstetric resident. To control for the indication bias, we performed propensity score analysis and made rigorous adjustments for confounding factors, specifically for 19 maternal and obstetric characteristics, to minimize the likelihood of incorrectly attributing any association to operative vaginal delivery managed by attending obstetricians. This allowed us to eliminate these potential persisting confounders. Fifth, operative vaginal deliveries were attempted only in compliance with the prerequisites specified in most guidelines.<sup>1–3,10,36</sup> In particular, ultrasonography was used restrictively, limited to the cases in which the provider had a doubt regarding the fetal head position after clinical examination, as no evidence has demonstrated that the routine use of ultrasonography before attempting operative vaginal delivery affects maternal or neonatal outcomes.<sup>3,22,36</sup>

Nevertheless, we must acknowledge some limitations. First, despite our careful statistical approaches, including sensitivity, multivariate, and propensity score analyses, hidden confounders that were unfortunately not recognized may still be present. It is undeniable that a randomized controlled trial would be the best study design to determine the impact of the level of training on maternal and neonatal outcomes after attempted operative vaginal delivery, but the feasibility and rationale of such a trial appears very doubtful. Second, no prespecified sample size for the endpoints of this secondary analysis was formally calculated. Due to the sample size of our propensity score analysis ( $n = 458$ ), some might argue that it is underpowered. To quantify this problem, a post-hoc calculation determined that with a sample size of 458 patients, 8%–15% of deliveries with adverse maternal or neonatal outcomes and around 75% of deliveries managed by residents, there would have been a power of 80% and an alpha risk of 0.05, so that

an OR  $>2$  would have been detected in univariate logistic regression. This result seems to confirm that our study was correctly powered to identify strong associations between the obstetrician training level and short-term neonatal or maternal outcomes. Third, the study reflects the experience of one tertiary university hospital that uses Thierry's spatulas extensively, and its results can be generalized only to maternity units with similar policies (policy of vaginal birth and proactive training of residents based on continuing close but slowly decreasing supervision by skilled obstetricians, senior supervising staff, daily morning staff meetings) and facilities (university referral center). Fourth, we must underline that maternal and labor characteristics in our study differed significantly according to the obstetricians' level of training. This finding indirectly suggests that attending obstetricians allowed the residents to perform the operative vaginal delivery under their supervision in selected and likely easier cases. Fifth, our results are limited to short-term maternal and neonatal morbidity.

### Conclusion with Future Research Implications

These limitations notwithstanding, attempted operative vaginal delivery managed by an obstetric resident under supervision was not associated in this study with a greater rate of severe maternal and neonatal morbidity than attempted operative vaginal delivery managed by an attending obstetrician. These reassuring results support the continued use of residency programs to provide training for operative vaginal deliveries under the supervision of an attending obstetrician. ■

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## APPENDIX 1

Number and percentage of missing data items in the 2138 term singleton attempted operative vaginal deliveries<sup>a</sup>

Variable	Missing data n (%)
Maternal age	0 (0%)
Prepregnancy BMI	18 (0.8%)
Parity	0 (0%)
History of cesarean delivery	0 (0%)
History of adverse events during delivery <sup>b</sup>	0 (0%)
History of preeclampsia, pregnancy-induced hypertension, or fetal growth restriction	0 (0%)
Diabetes mellitus during pregnancy <sup>c</sup>	0 (0%)
Gestational weight gain >20 kg	97 (4.5%)
Prenatal suspicion of macrosomia <sup>d</sup>	24 (1.1%)
Gestational age	0 (0%)
Induced labor	1 (0%)
Pushing phase of second stage >30 min	2 (0.1%)
Epidural analgesia	1 (0%)
Persistent occiput position	9 (0.4%)
Indication for attempted operative vaginal delivery	0 (0%)
ACOG classification	0 (0%)
Instrument type	23 (1.1%)
Obstetrician's level of experience	26 (1.2%)
Severe short-term neonatal morbidity	0 (0%)
Severe short-term maternal morbidity	0 (0%)

ACOG, American College of Obstetricians and Gynecologists; BMI, body mass index.

<sup>a</sup> In all, 14 women had more than 1 missing data item for the exposure or adjustment variables; <sup>b</sup> History of birth weight >4000 g, shoulder dystocia, episiotomy, operative vaginal delivery, or postpartum hemorrhage; <sup>c</sup> Preexisting or gestational diabetes mellitus; <sup>d</sup> Fundal height measurement at delivery >37 cm, ultrasonographic fetal abdominal circumference >90th percentile for gestational age on Hadlock curves, or both.

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