

Neonatal and Maternal Outcomes With Prolonged Second Stage of Labor

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OBJECTIVE: To assess neonatal and maternal outcomes when the second stage of labor was prolonged according to American College of Obstetricians and Gynecologists guidelines.

METHODS: Electronic medical record data from a retrospective cohort (2002–2008) from 12 U.S. clinical centers (19 hospitals), including 43,810 nulliparous and 59,605 multiparous singleton deliveries at 36 weeks of gestation or greater, vertex presentation, who reached 10-cm cervical dilation were analyzed. Prolonged second stage was defined as: nulliparous women with epidural greater than 3 hours and without greater than 2 hours and multiparous women with epidural greater than 2 hours and without greater than 1 hour. Maternal and neonatal outcomes were compared and adjusted odds ratios calcu-

lated controlling for maternal race, body mass index, insurance, and region.

RESULTS: Prolonged second stage occurred in 9.9% and 13.9% of nulliparous and 3.1% and 5.9% of multiparous women with and without an epidural, respectively. Vaginal delivery rates with prolonged second stage compared with within guidelines were 79.9% compared with 97.9% and 87.0% compared with 99.4% for nulliparous women with and without epidural, respectively, and 88.7% compared with 99.7% and 96.2% compared with 99.9% for multiparous women with and without epidural, respectively ($P < .001$ for all comparisons). Prolonged second stage was associated with increased chorioamnionitis and third-degree or fourth-degree perineal lacerations. Neonatal morbidity with prolonged second stage included sepsis in nulliparous women (with epidural: 2.6% compared with 1.2% [adjusted odds ratio (OR) 2.08, 95% confidence interval (CI) 1.60–2.70]; without epidural: 1.8% compared with 1.1% [adjusted OR 2.34, 95% CI 1.28–4.27]); asphyxia in nulliparous women with epidural (0.3% compared with 0.1% [adjusted OR 2.39, 95% CI 1.22–4.66]) and perinatal mortality without epidural (0.18% compared with 0.04% for nulliparous women [adjusted OR 5.92, 95% CI 1.43–24.51]); and 0.21% compared with 0.03% for multiparous women (adjusted OR 6.34, 95% CI 1.32–30.34). However, among the offspring of women with epidurals whose second stage was prolonged (3,533 nulliparous and 1,348 multiparous women), there were no cases of hypoxic-ischemic encephalopathy or perinatal death.

CONCLUSIONS: Benefits of increased vaginal delivery should be weighed against potential small increases in maternal and neonatal risks with prolonged second stage. (*Obstet Gynecol* 2014;124:57–67)

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LEVEL OF EVIDENCE: II

Historical guidance for the 2-hour rule of the second stage of labor to prevent maternal and neonatal morbidity and mortality was introduced in the mid-1800s by expert opinion and case series publications.¹

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For a list of institutions involved in the Consortium, please see the Appendix online at <http://links.lww.com/AOG/A497>.

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Table 1. Number of Women for Duration of Second Stage by Parity and Epidural Status

Parity	Epidural	Total	Duration From 10-cm Cervical Dilatation to Delivery (h)						
			0 to Less Than 1	1 to Less Than 2	2 to Less Than 3	3 to Less Than 4	4 to Less Than 5	5 to Less Than 6	6–12
Nulliparous	Yes	35,657	15,618 (43.8)*	11,304 (31.7)*	5,138 (14.4)*	2,103 (5.9) [†]	871 (2.4) [†]	356 (1.0) [†]	267 (0.7) [†]
	No	8,153	5,272 (64.7)*	1,738 (21.3)*	662 (8.1) [†]	274 (3.4) [†]	114 (1.4) [†]	36 (0.4) [†]	57 (0.7) [†]
Multiparous	Yes	43,436	38,764 (89.2)*	3,301 (7.6)*	825 (1.9) [†]	301 (0.7) [†]	142 (0.3) [†]	52 (0.1) [†]	51 (0.1) [†]
	No	16,169	15,183 (93.9)*	663 (4.1)	201 (1.2) [†]	65 (0.4) [†]	20 (0.12) [†]	10 (0.06) [†]	27 (0.17) [†]

Data are n (%) unless otherwise specified.

* Women delivering within American College of Obstetricians and Gynecologists guidelines.¹⁵

[†] Prolonged second stage.

Hamilton published findings in which no stillbirths occurred when forceps were used to shorten the second stage and perhaps was the first to publish the 2-hour rule based on his observations.^{2,3} Since that

time, studies have found increased duration to be associated with increased risk of maternal morbidity, primarily hemorrhage, fever or infection, and perineal trauma.^{4–10} The association of neonatal risks with

Table 2. Maternal, Obstetric, and Neonatal Characteristics by Parity and Epidural Status

Variable	Nulliparous With Epidural (n=35,657)			Nulliparous Without Epidural (n=8,153)		
	Within Guidelines (n=32,124)	Prolonged Second Stage (n=3,533)	P	Within Guidelines (n=7,023)	Prolonged Second Stage (n=1,130)	P
Maternal age (y)	24.7±5.6	27.1± 6.3	<.001	23.8±5.7	26.6±6.2	<.001
BMI at delivery (kg/m ²)	29.5±5.38	30.0±5.4	<.001	29.3±5.4	29.5±5.1	.290
Race or ethnicity			.002			<.001
Non-Hispanic white	17,819 (55.5)	2,077 (58.8)		2,709 (38.6)	564 (49.9)	
Non-Hispanic black	5,206 (16.2)	411 (11.6)		1,867 (26.6)	191 (16.9)	
Hispanic	5,155 (16.1)	570 (16.1)		1,459 (20.8)	161 (14.3)	
Asian or Pacific Islander	1,534 (4.8)	203 (5.8)		401 (5.7)	102 (9.0)	
Other or unknown	2,410 (7.5)	272 (7.7)		587 (8.4)	112 (9.9)	
Insurance			.329			<.001
Private	18,844 (58.7)	2,079 (58.9)		3,659 (52.1)	768 (68.0)	
Public or self-pay	8,438 (26.3)	833 (23.6)		2,614 (37.2)	257 (22.7)	
Other	4,842 (15.1)	621 (17.6)		750 (10.7)	105 (9.3)	
Pregnancy complications						
Gestational diabetes	1,055 (3.3)	137 (3.9)	.063	197 (2.8)	41 (3.6)	.128
Pregestational diabetes	169 (0.5)	45 (1.3)	<.001	42 (0.6)	8 (0.7)	.661
Hypertensive disorder	1,229 (3.8)	116 (3.3)	.109	179 (2.5)	17 (1.5)	.036
Induction of labor	13,500 (42.0)	1,486 (42.1)	.967	1,994 (28.4)	359 (31.8)	.020
Dilation on admission	3 (1, 5)	3 (1, 6.5)	<.001	4 (1, 9)	4 (1, 10)	.093
Effacement on admission	80 (50, 100)	80 (50, 100)	.001	90 (50, 100)	90 (50, 100)	.509
Oxytocin	22,638 (70.5)	2,347 (66.4)	<.001	3,924 (55.9)	708 (62.7)	<.001
Gestational age at delivery (wk)	39.2±1.2	39.5±1.2	<.001	39.2±1.3	39.6±1.2	<.001
Neonatal birth weight (g)	3,282±428	3,446±431	<.001	3,210±424	3,411±426	<.001
Hospital type			.030			<.001
University-affiliated teaching hospital	13,278 (41.3)	1,652 (46.8)		3,643 (51.9)	450 (39.8)	
Teaching community hospital	15,342 (47.8)	1,666 (47.2)		3,185 (45.4)	668 (59.1)	
Nonteaching community hospital	3,504 (10.9)	215 (6.1)		195 (2.8)	12 (1.1)	

BMI, body mass index.

Data are mean±standard deviation, n (%), or median (10th, 90th percentiles) unless otherwise specified.

Hypertensive disorder includes gestational hypertension, preeclampsia, and eclampsia.



a prolonged second stage has been controversial. Recent studies have found an increased risk of Apgar score less than 7,⁹⁻¹¹ neonatal intensive care unit (NICU) admission,^{11,12} birth depression, and minor trauma,¹⁰ whereas other studies have found no differences in neonatal outcomes including more serious complications such as seizures or sepsis.⁴⁻⁸ Rare neonatal morbidities including asphyxia, hypoxic-ischemic encephalopathy, and mortality have been understudied. Therefore, whether the prolongation of the second stage of labor beyond the currently accepted windows to achieve a vaginal delivery (and avoid the risks of cesarean delivery) results in serious neonatal complications has remained unclear. Given the lack of well-powered studies with detailed clinical data as well as the common use of epidural, determination of the optimal length of the second stage is needed.¹³

The aims of this study were to quantitate the chance of vaginal delivery for prolonged second stage and to evaluate both maternal and fetal and neonatal risks associated with such prolongations.

MATERIALS AND METHODS

The Consortium on Safe Labor was conducted by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, National Institutes of Health, to determine the course of labor associated with optimal maternal and neonatal outcomes. The Consortium on Safe Labor was a retrospective study of 208,695 women with 228,438 deliveries from 12 clinical centers and 19 hospitals representing nine American College of Obstetricians and Gynecologists (College) districts from 2002 to 2008.¹⁴ Institutional review board approval was obtained by all participating institutions. Detailed information from the patient

Multiparous With Epidural (n=43,436)			Multiparous Without Epidural (n=16,169)		
Within Guidelines (n=42,088)	Prolonged Second Stage (n=1,348)	P	Within Guidelines (n=15,219)	Prolonged Second Stage (n=950)	P
28.8±5.3	30.1±5.8	<.001	28.4±5.6	29.6±5.9	<.001
30.3±5.7	31.3±6.1	<.001	30.5±5.9	30.7±6.1	.615
		<.001			<.001
25,857 (61.4)	638 (47.3)		5,834 (38.3)	376 (39.6)	
6,094 (14.5)	265 (19.7)		3,833 (25.2)	253 (26.6)	
6,670 (15.9)	282 (21.0)		3,921 (25.8)	172 (18.1)	
1,299 (3.1)	70 (5.2)		629 (4.1)	56 (5.9)	
2,168 (5.2)	93 (6.9)		1,002 (6.6)	93 (9.8)	
		<.001			<.001
26,458 (62.9)	738 (54.8)		7,750 (50.9)	592 (62.3)	
10,943 (26.0)	345 (25.6)		5,837 (38.4)	256 (27.0)	
4,687 (11.1)	265 (19.7)		1,632 (10.7)	102 (10.7)	
1,735 (4.1)	79 (5.9)	.002	596 (3.9)	46 (4.8)	.159
358 (0.9)	17 (1.3)	.038	190 (1.2)	13 (1.4)	.305
863 (2.1)	14 (1.0)	.011	199 (1.3)	13 (1.4)	.812
18,881 (44.9)	506 (37.5)	<.001	3,763 (24.7)	218 (22.9)	.252
3 (1, 6)	4 (1, 10)	<.001	5 (2, 10)	7 (2, 10)	<.001
80 (50, 100)	80 (50, 100)	<.001	80 (50, 100)	90 (50, 100)	.006
29,499 (70.1)	850 (63.1)	<.001	7,592 (49.9)	500 (52.6)	.127
39.0±1.2	39.4±1.2	<.001	39.1±1.2	39.3±1.2	.006
3,380±441	3,547±447	<.001	3,350±448	3,461±467	<.001
		<.001			<.001
14,273 (33.9)	621 (46.1)		7,661 (50.3)	366 (38.5)	
21,111 (50.2)	672 (49.9)		6,727 (44.2)	580 (61.1)	
6,704 (15.9)	55 (4.1)		831 (5.5)	4 (0.4)	



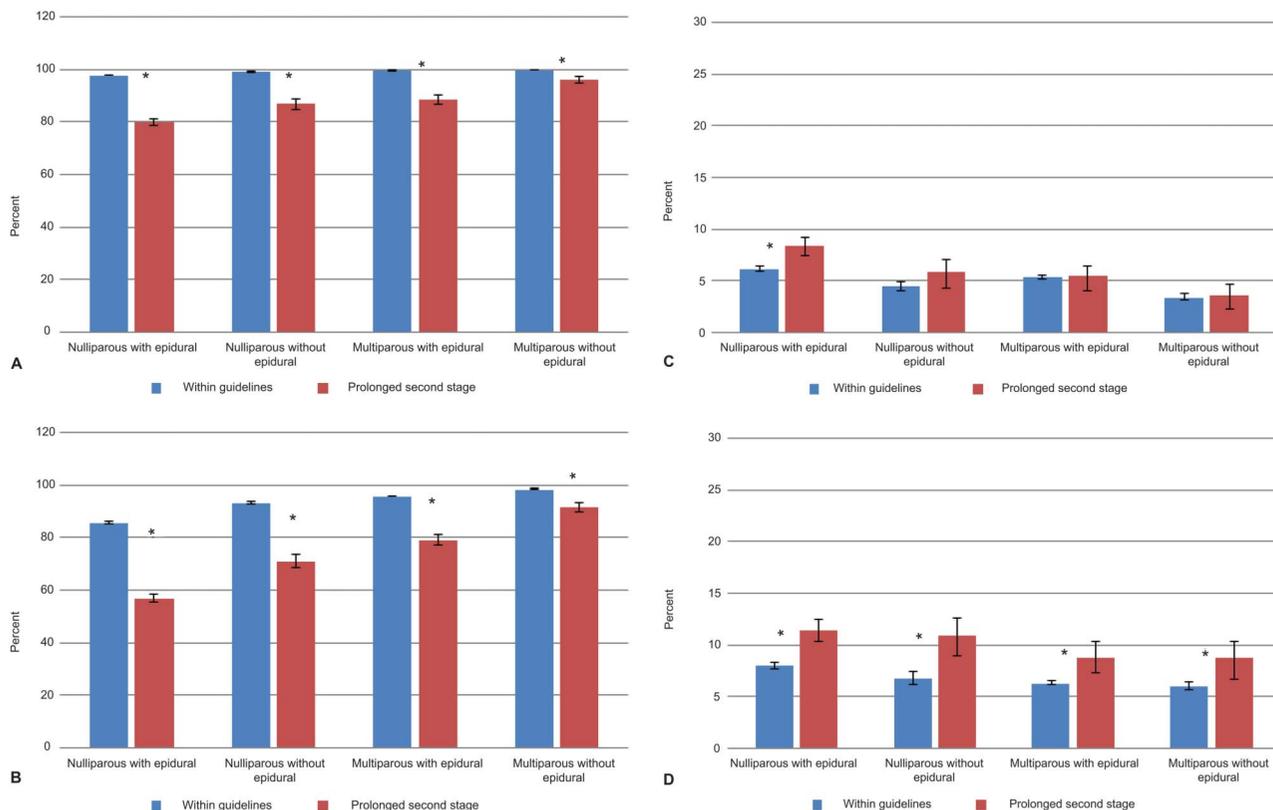


Fig. 1. Mode of delivery and neonatal outcomes according to duration of second stage in women by parity and epidural status. **A.** Vaginal delivery. **B.** Nonoperative vaginal delivery. **C.** Composite maternal morbidity. **D.** Composite neonatal morbidity. Prolonged second stage as per American College of Obstetricians and Gynecologists guidelines was defined as: for nulliparous women greater than 3 hours with epidural or greater than 2 hours without; multiparous women greater than 2 hours with epidural or greater than 1 hour without.¹⁵ Maternal composite morbidity included postpartum hemorrhage, blood transfusion, cesarean hysterectomy, endometritis, or intensive care unit (ICU) admission. Neonatal composite morbidity included shoulder dystocia, 5-minute Apgar score less than 4, need for continuous positive airway pressure resuscitation or higher, neonatal ICU admission, sepsis, pneumonia, hypoxic-ischemic encephalopathy or periventricular leukomalacia, seizure, intracranial hemorrhage or periventricular hemorrhage, asphyxia, or perinatal death. Error bars indicate 95% confidence intervals, and asterisks indicate significance in the unadjusted models. All associations remained significant after controlling for maternal race, body mass index, insurance, and region (note that unadjusted composite maternal morbidity rates were not higher for multiparous women with prolonged second stage, but there were significantly increased odds for multiparous women with epidural after adjustment.).

Laughon. *Prolonged Second Stage*. *Obstet Gynecol* 2014.

electronic medical record was extracted including demographic data and medical, prenatal, and antenatal histories. Labor and delivery information including cervical examinations and timing were obtained. Postpartum maternal and neonatal outcomes were collected along with maternal and newborn discharge summaries. Validation of four key variables was performed, including cesarean delivery for nonreassuring fetal heart rate tracing, asphyxia, NICU admission for respiratory conditions, and shoulder dystocia. The electronic medical records were highly accurate with greater than 91% concordance for all subgroups and greater than 95% for most (see prior publication for more details).¹⁴

The objectives of this study were to quantitate the chance of vaginal delivery once College guidelines for duration of second stage were exceeded and to compare both maternal and fetal and neonatal risks for deliveries within the guidelines with those outside of the guidelines.

Length of second stage of labor was determined by subtracting the date and time of delivery from the date and time of 10-cm cervical dilation as recorded in the maternal medical record. Duration of second stage outside College guidelines was designated as prolonged second stage and defined as: for nulliparous women greater than 3 hours with epidural or greater than 2 hours without and multiparous women greater



than 2 hours with epidural or greater than 1 hour without.¹⁵ Otherwise, delivery was designated as within guidelines. Success of any vaginal delivery (including nonoperative and operative) was estimated as well as operative vaginal delivery (forceps, vacuum, forceps and vacuum, or unspecified). Maternal outcomes were explored individually as well as a composite that included postpartum hemorrhage, blood transfusion, cesarean hysterectomy, endometritis, or intensive care unit admission. Postpartum hemorrhage was defined as estimated blood loss greater than 500 mL for vaginal delivery and greater than 1,000 mL for cesarean delivery. Other maternal outcomes included chorioamnionitis, wound infection, wound separation, episiotomy, third- or fourth-degree perineal laceration, cervical laceration, and hospital length of stay. Neonatal outcomes were explored individually as well as a composite that included shoulder dystocia, 5-minute Apgar score less than 4, need for continuous positive airway pressure resuscitation or higher, NICU admission, sepsis, pneumonia, hypoxic-ischemic encephalopathy or periventricular leukomalacia, seizure, intracranial hemorrhage or periventricular hemorrhage, asphyxia, or perinatal death as recorded in the medical record and supplemented with discharge International Classification of Diseases, 9th Revision, Clinical Modification diagnoses. Not all sites reported all of the outcomes, so individual analyses of secondary outcomes were limited to those sites where reported.

We included singleton births ($n=223,394$) delivering 36 weeks of gestation or greater ($n=206,920$). The following were then excluded: nonvertex presentation ($n=26,382$), antepartum stillbirth before the onset of labor ($n=238$), prior uterine scar ($n=21,604$), and congenital anomalies ($n=8,901$). Cervical examinations before vaginal delivery were less than 10 cm for 22,291 and missing for 3,461 deliveries, and cervical examinations before cesarean delivery were less than 10 cm for 13,772 and missing for 6,779 deliveries leaving a total of 103,492 deliveries with a cervical dilation of 10 cm recorded in the medical record. We excluded 77 (0.2%) deliveries with a second stage 12 hours or greater because these were considered most likely to be an error. The final analysis included 43,810 nulliparous and 59,605 multiparous deliveries.

Maternal, obstetric, and neonatal characteristics and outcomes were compared using either linear (continuous or categorical variables) or logistic (binary variables) regression with generalized estimating equations to account for multiple pregnancies contributed by the same woman. Results are presented as *P* values

or odds ratios (ORs). Adjusted ORs for outcomes were also calculated controlling for maternal race, body mass index (calculated as $\text{weight (kg)}/[\text{height (m)}]^2$), insurance, and region. All statistical analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, NC).

RESULTS

Of the 43,810 nulliparous women, 81.4% had an epidural and 10.6% delivered after a prolonged second stage. Of the 59,605 multiparous women, 72.9% had an epidural and 3.9% delivered after a prolonged second stage (Table 1). For the women delivering after a prolonged second stage, the majority delivered within the subsequent hour. Women who delivered after a prolonged second stage on average tended to be older and have a slightly higher body mass index only if they had an epidural (Table 2). A lower proportion of women delivered after a prolonged second stage at nonteaching community hospitals. Women without an epidural presented with more favorable cervical examinations on admission and received less oxytocin (Table 2).

Vaginal delivery after prolonged second stage for nulliparous women with epidural was 79.9% compared with 97.9% for women delivering within guidelines ($P<.001$) and without epidural 87.0% compared with 99.4% for prolonged compared with within guidelines ($P<.001$), which remained significant after adjustment (Fig. 1A). Rates of operative vaginal delivery for women who delivered after a prolonged second stage were at least twofold higher for nulliparous women (with an epidural, prolonged second stage compared with within guidelines 23.0% compared with 12.2%, $P<.001$; adjusted OR 2.23, 95% confidence interval [CI] 2.04–2.45) and without epidural prolonged second stage compared with within guidelines 16.0% compared with 6.2% ($P<.001$; adjusted OR 2.89, 95% CI 2.30–3.63) (Fig. 1B). Cesarean deliveries in the second stage for women after a prolonged second stage were more likely to be performed for indications of dystocia or cephalopelvic disproportion instead of nonreassuring fetal heart rate tracing (Table 3).

Composite maternal morbidity was higher for nulliparous women with an epidural who delivered after a prolonged second stage (8.4% compared with 6.1%, $P<.001$; adjusted OR 1.42, 95% CI 1.25–1.62) (Fig. 1C). Specific morbidities were increased for nulliparous women who delivered after a prolonged second stage with an approximately threefold higher rate of chorioamnionitis as well as increased odds of episiotomy, third- or fourth-degree perineal laceration, and a 1-day longer median hospital stay (Table 3).



Table 3. Maternal and Neonatal Outcomes According to Duration of Second Stage in Nulliparous Women by Epidural Status

Outcome	Nulliparous With Epidural		P
	Within Guidelines 0 to 3 h or Less	Prolonged Second Stage Greater Than 3 h	
n	32,124 (90.1)	3,533 (9.9)	
Maternal outcomes			
Endometritis	120 (0.4)	42 (1.2)	<.001
Postpartum hemorrhage	1,203 (3.7)	207 (5.9)	<.001
Cesarean hysterectomy	7 (0.02)	1 (0.03)	.807
ICU admission	114 (0.5)	5 (0.2)	.048
Transfusion	1,003 (4.7)	99 (4.4)	.508
Chorioamnionitis	1,285 (4.0)	392 (11.1)	<.001
Wound infection	48 (0.2)	5 (0.2)	.859
Wound separation	5 (0.02)	5 (0.2)	<.001
Episiotomy (%)	12,313 (38.3)	1,193 (33.8)	<.001
3rd- or 4th-degree perineal laceration	1,863 (5.8)	358 (10.1)	<.001
Cervical laceration	265 (0.8)	20 (0.6)	.103
Hospital length of stay (d)	2 (2, 3)	3 (2, 4)	<.001
Neonatal outcomes			
Shoulder dystocia	449 (1.5)	63 (1.9)	.056
5-min Apgar score less than 4	66 (0.2)	18 (0.5)	<.001
Need for CPAP or greater	322 (1.0)	44 (1.2)	.175
NICU admission	1,892 (5.9)	288 (8.2)	<.001
Sepsis	395 (1.2)	92 (2.6)	<.001
Pneumonia	231 (0.7)	24 (0.7)	.790
Hypoxic-ischemic encephalopathy or periventricular leukomalacia	5 (0.02)	0 (0)	
Seizure	35 (0.1)	4 (0.1)	.942
Intracranial hemorrhage or periventricular hemorrhage	50 (0.2)	6 (0.2)	.840
Asphyxia	47 (0.1)	11 (0.3)	.024
Perinatal mortality	10 (0.03)	0 (0)	
NICU length of stay (d)	3.3 (1, 9)	3.0 (1, 9)	.679
Cesarean delivery indication			
Dystocia or cephalopelvic disproportion	406 (60.5)	616 (86.9)	<.001
Nonreassuring fetal heart rate tracing	237 (35.3)	51 (7.2)	<.001

OR, odds ratio; CI, confidence interval; ICU, intensive care unit; CPAP, continuous positive airway pressure; NICU, neonatal intensive care unit.

Data are n (%) or median (10th, 90th percentiles) unless otherwise specified.

Maternal and neonatal composite outcomes include variables listed subsequently. Postpartum hemorrhage defined as estimated blood loss greater than 500 mL for vaginal delivery and greater than 1,000 mL for cesarean delivery. Analyses adjusted for maternal race or ethnicity, body mass index, insurance, and region. Some analyses had too few numbers to calculate adjusted odds ratios.

Nulliparous women with an epidural who delivered after a prolonged second stage had additional increased rates of endometritis (1.2% compared with 0.4%, $P<.001$; adjusted OR 3.21, 95% CI 2.25–4.57), wound separation (0.2% compared with 0.02%, $P<.001$; adjusted OR 12.13, 95% CI 3.63–40.46), and postpartum hemorrhage (5.9% compared with 3.7%, $P<.001$; adjusted OR 1.50, 95% CI 1.27–1.78), but a lower rate of maternal intensive care unit admission (0.2% compared with 0.5%, $P=.048$) that did not remain significant after adjustment (adjusted OR 0.49, 95% CI 0.20–1.21) (Table 2). Nulliparous women without an epidural who delivered with a pro-

longed second stage had a higher rate of postpartum hemorrhage (5.1% compared with 3.9%, $P=.04$) that did not remain significant after adjustment (adjusted OR 1.25, 95% CI 0.87–1.80) (Table 3).

In multiparous women with a prolonged second stage compared with women who delivered within guidelines, vaginal delivery occurred in 88.7% compared with 99.7% ($P<.001$) of women with an epidural and 96.2% compared with 99.9% ($P<.001$) of multiparous women without an epidural, which remained significant after adjustment (Fig. 1A). Rates of operative vaginal delivery for women who delivered after a prolonged second stage were at least



Nulliparous With Epidural		Nulliparous Without Epidural			Unadjusted OR (95% CI)
Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Within Guidelines 0 to 2 h or Less	Prolonged Second Stage Greater Than 2 h	P	
		7,023 (86.1)	1,130 (13.9)		
3.21 (2.25–4.57)	3.52 (2.44–5.06)	26 (0.8)	9 (0.7)	.047	2.16 (1.01–4.62)
1.60 (1.37–1.86)	1.50 (1.27–1.78)	271 (3.9)	58 (5.1)	.044	1.35 (1.01–1.80)
1.30 (0.16–10.56)	—	1 (0.01)	1 (0.1)	.196	6.22 (0.39–99.51)
0.40 (0.17–0.99)	0.49 (0.20–1.21)	10 (0.2)	1 (0.1)	.750	0.72 (0.09–5.60)
0.93 (0.75–1.15)	1.03 (0.83–1.29)	77 (2.2)	8 (1.4)	.232	0.64 (0.31–1.33)
3.00 (2.66–3.37)	3.01 (2.65–3.43)	128 (1.8)	63 (5.6)	<.001	3.18 (2.34–4.33)
1.09 (0.43–2.73)	1.12 (0.45–2.79)	5 (0.1)	1 (0.2)	.694	1.54 (0.18–13.20)
10.43 (3.02–36.05)	12.13 (3.63–40.46)	1 (0.02)	0 (0)		
0.82 (0.76–0.88)	0.83 (0.76–0.90)	2,171 (30.9)	459 (40.6)	<.001	1.53 (1.34–1.74)
1.83 (1.63–2.06)	1.80 (1.58–2.05)	409 (5.8)	112 (9.9)	<.001	1.78 (1.43–2.22)
0.68 (0.43–1.08)	0.77 (0.49–1.23)	61 (0.9)	2 (0.2)	.026	0.20 (0.05–0.83)
		2 (1, 3)	3 (2, 4)	<.001	
1.30 (0.99–1.69)	1.33 (0.99–1.78)	82 (1.2)	16 (1.5)	.500	1.20 (0.70–2.07)
2.49 (1.48–4.19)	2.71 (1.49–4.93)	30 (0.4)	4 (0.4)	.724	0.83 (0.29–2.35)
1.25 (0.91–1.71)	1.27 (0.90–1.79)	32 (0.5)	7 (0.6)	.461	1.36 (0.60–3.09)
1.42 (1.25–1.61)	1.39 (1.20–1.60)	356 (5.1)	97 (8.6)	<.001	1.76 (1.39–2.22)
2.15 (1.71–2.70)	2.08 (1.60–2.70)	76 (1.1)	20 (1.8)	.049	1.65 (1.00–2.71)
0.94 (0.62–1.44)	1.05 (0.68–1.63)	29 (0.4)	10 (0.9)	.037	2.15 (1.05–4.43)
		1 (0.01)	1 (0.1)	.196	6.22 (0.39–99.51)
1.04 (0.37–2.93)	0.85 (0.25–2.95)	2 (0.03)	2 (0.2)	.068	6.22 (0.88–44.23)
1.09 (0.47–2.55)	0.67 (0.21–2.16)	4 (0.1)	3 (0.3)	.044	4.67 (1.04–20.90)
2.13 (1.10–4.11)	2.39 (1.22–4.66)	8 (0.1)	4 (0.4)	.064	3.12 (0.94–10.36)
		3 (0.04)	2 (0.18)	.119	4.15 (0.69–24.86)
		3 (1, 8)	2 (1, 7)	.951	
4.32 (3.31–5.65)	4.53 (3.35–6.13)	19 (43.2)	119 (81.0)	<.001	5.59 (2.71–11.54)
0.14 (0.10–0.20)	0.13 (0.09–0.19)	27 (61.4)	20 (13.6)	<.001	0.10 (0.05–0.21)

threefold higher (with an epidural, prolonged second stage compared with within guidelines 9.5% compared with 3.8%, $P<.001$; adjusted OR 3.26, 95% CI 2.66–3.99, and without epidural, prolonged second stage compared with within guidelines 4.6% compared with 1.4%, $P<.001$; adjusted OR 3.20, (95% CI 2.12–4.83) (Fig. 1B).

Composite maternal morbidity rates were not higher for multiparous women with a prolonged second stage overall, but there was an increased odds for multiparous women with an epidural after adjustment (adjusted OR 1.52, 95% CI 1.17–1.97) (Fig. 1C). Multiparous women who delivered with a prolonged second stage regardless of epidural status had higher rates of chorioamnionitis and higher odds of postpartum hemorrhage and third- or fourth-degree perineal laceration after adjustment.

Overall, composite neonatal morbidity rates for deliveries with prolonged second stage were 11% for nulliparous women and 9% for multiparous women, which were approximately 2–3% higher absolute rates compared with deliveries within guidelines (Fig. 1D). Neonates born after a prolonged second stage were also 1.35- to 1.85-fold more likely to be admitted to the NICU (Tables 3 and 4). Rates of neonatal sepsis were approximately double for nulliparous women with a prolonged second stage regardless of epidural. Additionally, for deliveries with a prolonged second stage, neonates had an approximately 2.5-fold increased odds of 5-minute Apgar score less than 4 for nulliparous women and multiparous women with an epidural (Tables 3 and 4). In multiparous women without an epidural, shoulder dystocia was higher (2.2% compared with



Table 4. Maternal and Neonatal Outcomes According to Duration of Second Stage in Multiparous Women by Epidural Status

Outcome	Multiparous With Epidural			Unadjusted OR (95% CI)
	Within Guidelines 0 to 2 h or Less, n (%)	Prolonged Second Stage Greater Than 2 h, n (%)	P	
n	42,088 (96.9)	1,348 (3.1)		
Maternal outcomes				
Endometritis	55 (0.1)	3 (0.1)	.369	1.70 (0.53–5.46)
Postpartum hemorrhage	985 (2.3)	45 (3.3)	.018	1.44 (1.07–1.96)
Cesarean hysterectomy	10 (0.02)	1 (0.1)	.278	3.12 (0.40–24.42)
ICU admission	113 (0.3)	4 (0.4)	.603	1.30 (0.48–3.54)
Transfusion	1,687 (5.7)	28 (4.2)	.092	0.74 (0.52–1.05)
Chorioamnionitis	315 (0.7)	52 (3.9)	<.001	5.31 (3.94–7.16)
Wound infection	32 (0.1)	1 (0.1)	.771	1.35 (0.18–9.86)
Wound separation	6 (0.02)	0 (0)		
Episiotomy (%)	7,431 (17.7)	259 (19.2)	.159	1.10 (0.96–1.27)
3rd- or 4th-degree perineal laceration	325 (0.8)	40 (3.0)	<.001	3.92 (2.82–5.47)
Cervical laceration	165 (0.4)	5 (0.4)	.903	0.95 (0.39–2.31)
Hospital length of stay (d)	2 (1, 3)	2 (2, 4)	<.001	
Neonatal outcomes				
Shoulder dystocia	761 (1.9)	28 (2.2)	.410	1.17 (0.80–1.72)
5-min Apgar score less than 4	72 (0.2)	6 (0.4)	.024	2.61 (1.13–6.01)
Need for CPAP or greater	253 (0.6)	11 (0.8)	.320	1.36 (0.74–2.49)
NICU admission	1,736 (4.1)	84 (6.2)	<.001	1.55 (1.23–1.94)
Sepsis	271 (0.6)	16 (1.2)	.018	1.85 (1.11–3.07)
Pneumonia	191 (0.5)	7 (0.5)	.725	1.15 (0.54–2.44)
Hypoxic-ischemic encephalopathy or periventricular leukomalacia	1 (0)	0 (0)		
Seizure	16 (0.04)	1 (0.1)	.517	1.95 (0.26–14.73)
Intracranial hemorrhage or periventricular hemorrhage	32 (0.1)	2 (0.1)	.359	1.95 (0.47–8.16)
Asphyxia	39 (0.1)	2 (0.1)	.516	1.60 (0.39–6.64)
Perinatal mortality	12 (0.03)	0 (0)		
NICU length of stay (d)	3.8 (1, 11)	2.5 (1, 8)	<.001	
Cesarean delivery indication				
Dystocia or cephalopelvic disproportion	54 (44.6)	118 (77.6)	<.001	4.31 (2.55–7.27)
Nonreassuring fetal heart rate tracing	53 (43.8)	21 (13.8)	<.001	0.21 (0.11–0.37)

OR, odds ratio; CI, confidence interval; ICU, intensive care unit; CPAP, continuous positive airway pressure; NICU, neonatal intensive care unit.

Data are n (%) or median (10th, 90th percentiles) unless otherwise specified.

Maternal and neonatal composite outcomes include variables listed subsequently. Postpartum hemorrhage defined as estimated blood loss greater than 500 mL for vaginal delivery and greater than 1,000 mL for cesarean delivery. Analyses adjusted for maternal race or ethnicity, body mass index, insurance, and region. Some analyses had too few numbers to calculate adjusted odds ratios.

1.7%, adjusted OR 1.78, 95% CI 1.02–3.09). The rates of intracranial hemorrhage or periventricular hemorrhage were increased for nulliparous women who delivered after a prolonged second stage without an epidural (0.3% compared with 0.1%, $P=.044$; OR 4.67, 95% CI 1.04–20.90), although the outcome was too rare for an adjusted analysis. Asphyxia rates were increased for nulliparous women who delivered after prolonged second stage with an epidural (0.3% compared with 0.1%, $P=.024$; adjusted OR 2.39, 95% CI 1.22–4.66). Asphyxia rates were not different for multiparous women who delivered outside the guidelines, regardless of epidural status.

Perinatal mortality was a rare outcome and for deliveries with an epidural was not different for women after a prolonged second stage for either parity. For deliveries without an epidural, perinatal mortality was increased for women after a prolonged second stage in both nulliparous women (0.18% compared with 0.04%, adjusted OR 5.92, 95% CI 1.43–24.51) and multiparous women (0.21% compared with 0.03%, adjusted OR 6.34, 95% CI 1.32–30.34).

In an analysis limited to nulliparous women with an epidural with a nonoperative vaginal delivery, for women who delivered with a prolonged second stage, we observed results in the same direction, although not



Multiparous With Epidural		Multiparous Without Epidural			
Adjusted OR (95% CI)	Within Guidelines 0 to 1 h or Less, n (%)	Prolonged Second Stage Greater Than 1 h, n (%)	P	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
	15,219 (94.1)	950 (5.9)			
1.74 (0.53–5.64)	14 (0.1)	0 (0)			
1.50 (1.07–2.10)	423 (2.8)	36 (3.8)	.070	1.38 (0.97–1.95)	1.78 (1.18–2.69)
—	3 (0.02)	0 (0)			
0.75 (0.28–2.02)	36 (0.3)	1 (0.2)	.537	0.53 (0.07–3.91)	0.52 (0.07–4.03)
—	227 (3.2)	4 (1.0)	.184	0.48 (0.16–1.42)	0.76 (0.23–2.45)
4.78 (3.46–6.61)	62 (0.4)	9 (0.9)	.018	2.34 (1.16–4.72)	—
1.09 (0.13–9.24)	10 (0.1)	0 (0)			
	1 (0.01)	0 (0)			
1.44 (1.21–1.70)	1,591 (10.5)	183 (19.3)	<.001	2.03 (1.72–2.41)	1.86 (1.46–2.36)
3.85 (2.65–5.60)	108 (0.7)	18 (1.9)	.001	2.70 (1.63–4.47)	3.20 (1.71–5.99)
0.75 (0.27–2.02)	69 (0.5)	2 (0.2)	.284	0.46 (0.11–1.89)	0.25 (0.03–1.77)
	2 (1, 3)	2 (1, 3)	<.001		
1.04 (0.66–1.62)	246 (1.7)	20 (2.2)	.294	1.28 (0.81–2.03)	1.78 (1.02–3.09)
2.52 (1.01–6.30)	43 (0.3)	7 (0.7)	.019	2.62 (1.18–5.84)	2.46 (0.93–6.47)
1.30 (0.68–2.48)	61 (0.4)	6 (0.6)	.287	1.58 (0.68–3.66)	2.53 (1.06–6.05)
1.57 (1.22–2.03)	606 (4.0)	55 (5.8)	.007	1.48 (1.11–1.97)	1.35 (0.93–1.96)
1.73 (0.99–3.05)	109 (0.7)	11 (1.2)	.128	1.62 (0.87–3.03)	1.84 (0.89–3.82)
1.27 (0.55–2.92)	46 (0.3)	5 (0.5)	.238	1.75 (0.69–4.40)	1.66 (0.51–5.41)
	0 (0)	0 (0)			
2.07 (0.24–17.82)	7 (0.05)	1 (0.1)	.439	2.29 (0.28–18.63)	—
—	4 (0.03)	0 (0)			
2.34 (0.56–9.85)	10 (0.1)	1 (0.1)	.653	1.60 (0.20–12.53)	—
	5 (0.03)	2 (0.21)	.025	6.45 (1.26–33.07)	6.34 (1.32–30.34)
	3 (1, 11)	2 (1, 15)	.831		
4.76 (2.54–8.95)	3 (17.6)	24 (66.7)	.002	9.33 (2.24–38.87)	23.88 (1.55–366.83)
0.15 (0.08–0.31)	11 (64.7)	10 (27.8)	.013	0.21 (0.06–0.72)	0.04 (0.00–0.38)

all associations remained significant in this subset of women (maternal composite outcome adjusted OR 1.23, 95% CI 0.99–1.46; endometritis adjusted OR 2.30, 95% CI 1.27–4.15; postpartum hemorrhage adjusted OR 1.45, 95% CI 1.15–1.83; chorioamnionitis adjusted OR 2.63, 95% CI 2.19–3.15; third- or fourth-degree laceration adjusted OR 1.97, 95% CI 1.64–2.37 as well as neonatal composite outcome adjusted OR 1.39, 95% CI 1.17–1.65; shoulder dystocia adjusted OR 1.62, 95% CI 1.17–1.65; 5-minute Apgar score less than 4 adjusted OR 2.58, 95% CI 1.07–6.17; NICU admission adjusted OR 1.25, 95% CI 1.02–1.53; and neonatal sepsis adjusted OR 2.01, 95% CI 1.39–2.91). These results suggest that increased morbidity with a prolonged second stage was not fully explained by the mode of delivery.

DISCUSSION

In this large, U.S. multicenter cohort study, we found that maternal morbidity was increased for deliveries with a prolonged second stage. Given the large sample size in our study with detailed clinical data, we were also able to demonstrate an increased risk in neonatal morbidity in all deliveries, most concerning for a 0.2% absolute increased risk of neonatal asphyxia in nulliparous women with an epidural and an increase risk in perinatal mortality of 0.14% for nulliparous woman and 0.18% for multiparous women in deliveries without an epidural.

The vaginal delivery rates that we observed in deliveries for prolonged second stage duration were similar to previously reported success rates from single institutions of 83%⁹ and 93%¹¹ of nulliparous women



delivered vaginally within 3 hours and 90%¹⁶ of multiparous women delivered vaginally within 1–2 hours, although were not directly comparable because those studies did not stratify by epidural status. Our vaginal delivery rates were also similar to a secondary analysis of a clinical trial of fetal pulse oximetry trial in which 88% of nulliparous women delivered within 3 hours, regardless of epidural status.¹²

Increased maternal morbidities were generally consistent with reports from previous studies including postpartum hemorrhage, maternal febrile morbidity or infection, and perineal trauma.^{4–10} It was reassuring that we did not observe significantly increased risks for other serious maternal complications including need for blood transfusion, cesarean hysterectomy, or intensive care unit admission. Specific neonatal risks associated with a prolonged second stage, similar to previously reported, included an increased risk of 5-minute Apgar score less than 4 (except nulliparous women without an epidural; note Apgar score less than 7 in the literature) and NICU admission.^{9–12} In contrast to studies that found no differences in neonatal outcomes including more serious complications such as seizures or sepsis,^{4–8} we observed a doubling of the rates of neonatal sepsis (except in multiparous women without an epidural). Novel findings included an increased risk of neonatal asphyxia for second stage of labor that exceeded College guidelines in nulliparous women and a sixfold increase in perinatal mortality for deliveries without an epidural although overall absolute rates for both outcomes were low (less than 0.5%).

The mechanism for increased morbidity cannot necessarily be attributed to the duration of second stage, because the underlying reasons for longer duration may also contribute to morbidity. For example, chorioamnionitis and increased fetal size are associated with both longer labor duration and increased maternal and neonatal morbidity.^{17–19} Complications may also have been partly the result of the increase in operative vaginal delivery, but our findings in a sensitivity analysis that morbidity was increased even among nulliparous women with a nonoperative delivery indicates that prolonged duration of second stage may be an independent risk for morbidity.¹⁵ The reason that perinatal mortality was increased only in deliveries without an epidural is also unknown, but perhaps a prolonged second stage attributed to epidural use is associated with less risk than a prolonged second stage resulting from other pathways.

Our study was limited by lack of data on delayed compared with active pushing, which has been

shown to have a mean increase of 57 minutes in the second stage in a meta-analysis; however, delayed pushing has been associated with increased maternal febrile morbidity and decreased umbilical cord pH in some studies indicating that duration itself may be important.²⁰ A randomized controlled trial of delayed compared with active pushing would be useful to study the effect of duration of second stage on maternal and neonatal outcomes. There is also the possibility that some of our findings were false-positives given the large number of comparisons. Caution is also warranted given the retrospective data and lack of information on long-term maternal outcomes including incontinence and childhood neurologic impairment. Nonetheless, the major strength of our study was the large numbers from multiple institutions across the United States with rich patient-level data allowing us to investigate rare neonatal morbidities at term.

We found that a prolonged second stage was associated with highly successful vaginal delivery rates but with small increases in maternal and serious neonatal morbidity as well as perinatal mortality in deliveries without an epidural. However, it was reassuring that for mothers with an epidural who comprised the large majority of our cohort, there was no increased risk of perinatal death or hypoxic-ischemic encephalopathy in association with a prolonged second stage. Benefits of vaginal delivery need to be weighed against increased maternal and neonatal risks when considering duration of second stage outside College guidelines.

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