ANESTHESIOLOGY

Anesthesiologist Specialization and Use of General Anesthesia for Cesarean Delivery

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ABSTRACT

Background: Guidelines for obstetric anesthesia recommend neuraxial anesthesia (*i.e.*, spinal or epidural block) for cesarean delivery in most patients. Little is known about the association of anesthesiologist specialization in obstetric anesthesia with a patient's likelihood of receiving general anesthesia. The authors conducted a retrospective cohort study to compare utilization of general anesthesia for cesarean delivery among patients treated by generalist *versus* obstetric-specialized anesthesiologists.

Methods: The authors studied patients undergoing cesarean delivery for live singleton pregnancies from 2013 through 2017 at one academic medical center. Data were extracted from the electronic medical record. The authors estimated the association of anesthesiologist specialization in obstetric anesthesia with the odds of receiving general anesthesia for cesarean delivery.

Results: Of the cesarean deliveries in our sample, 2,649 of 4,052 (65.4%) were performed by obstetric-specialized anesthesiologists, and 1,403 of 4,052 (34.6%) by generalists. Use of general anesthesia differed for patients treated by specialists and generalists (7.3% *vs.* 12.1%; $P < 0.001$). After adjustment, the odds of receiving general anesthesia were lower among patients treated by obstetric-specialized anesthesiologists among all patients (adjusted odds ratio, 0.71; 95% CI, 0.55 to 0.92; $P = 0.011$), and in a subgroup analysis restricted to urgent or emergent cesarean deliveries (adjusted odds ratio, 0.75; 95% CI, 0.56 to 0.99; $P = 0.049$). There was no association between provider specialization and the odds of receiving general anesthesia in a subgroup analysis restricted to evening or weekend deliveries (adjusted odds ratio, 0.76; 95% CI, 0.56 to 1.03; $P = 0.085$).

Conclusions: Treatment by an obstetric anesthesiologist was associated with lower odds of receiving general anesthesia for cesarean delivery; however, this finding did not persist in a subgroup analysis restricted to evening and weekend deliveries.

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EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- Obstetric specialty societies recommend neuraxial anesthesia, when possible, for cesarean delivery
- Current data regarding the association of obstetric anesthesiologist specialization and use of general anesthesia for cesarean delivery remain lacking

What This Manuscript Tells Us That Is New

- Maternal and provider factors are strongly associated with use of general anesthesia for cesarean delivery
- Patients receiving care from obstetric-specialized anesthesiologists are 29% less likely to receive general anesthesia for cesarean delivery

Neuraxial blockade (*i.e.*, spinal or epidural anesthesia) is currently recommended over general anesthesia for most patients undergoing cesarean delivery.[1,2] The American Society of Anesthesiologists and the Society for Obstetric Anesthesiology and Perinatology recommend that providers "consider selecting neuraxial techniques in preference to general anesthesia for most cesarean deliveries."[1] Compared to general anesthesia, neuraxial blockade may reduce the incidence of maternal airway complications,[3] such as difficult ventilation or aspiration,[4–7] and the potential for neonatal compromise.[8] While the majority of U.S. patients undergoing cesarean delivery receive neuraxial anesthesia,[9–12] use of neuraxial anesthesia for cesarean delivery may vary across patient subgroups[13]; selected patient factors known to be associated with increased likelihood of receiving general anesthesia for cesarean delivery include black race, Hispanic ethnicity,[14] and fetal emergencies.[11]

Few data exist to characterize the role of obstetric anesthesiologist specialization in influencing anesthesia choice for cesarean delivery. Two previous studies suggested an association between specialization toward obstetric anesthesiology and lower rates of general anesthesia use for cesarean delivery.[15,16] However, previous work in this area is limited by a lack of adjustment for potential confounders, and by a focus on limited populations of obstetric patients. Better characterizing associations between anesthesiologist specialization and patterns of anesthesia care for cesarean delivery may inform staffing models for obstetric care by individual

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hospitals and health systems, inform accreditation standards by regulators, and potentially influence value-based purchasing approaches by healthcare payers.

In this study, we compared the use of general anesthesia *versus* neuraxial anesthesia for cesarean delivery among generalist *versus* obstetric-specialized anesthesiologists at one major urban teaching hospital. Our hypothesis was that patients treated by obstetric anesthesiologists would be less likely to receive general anesthesia for cesarean delivery compared to patients treated by generalists.

Materials and Methods

Overview

We conducted a retrospective cohort study of patients undergoing singleton cesarean delivery between July 1, 2013, and March 30, 2017, at the Hospital of the University of Pennsylvania (Philadelphia, Pennsylvania), a large urban quaternary care center.

Anesthesia Staffing Model

Attending anesthesiologist coverage for labor and delivery services at the study hospital is provided by both obstetric-specialized and generalist (*i.e.*, nonobstetric specialized) anesthesiologists (table 1). Attending anesthesiologist coverage is provided by a specialized obstetric anesthesia team Monday through Friday from 7:00 AM through 5:30 PM (*i.e.*, daytime). At other times (*i.e.*, "on call"), dedicated coverage is provided by a mix of obstetric-specialized and generalist attending anesthesiologists. In addition to daytime attending anesthesiologist coverage, daytime resident coverage includes two dedicated anesthesiology residents Monday through Friday from 7:00 AM through 5:30 PM, with or without one obstetric anesthesia fellow. During daytime shifts, assigned anesthesiology residents and fellows are available to assist with placing labor epidurals, scheduled cesarean deliveries, add-on urgent or emergent cesarean deliveries, tubal ligations, cervical cerclages, and postpartum dilation and curettages. Obstetric anesthesia fellows assist with resident education and supervision, and coordination of care. Of note, current obstetric anesthesia fellows did not serve as the attending of record for cesarean delivery cases during daytime shifts. However, board-eligible or board-certified obstetric anesthesia fellows were permitted to provide on-call attending coverage.

Table 1. Default Staffing Model for Obstetric Anesthesia Coverage of Labor and Delivery Unit

Shift	Staff Coverage
Daytime: Monday through Friday, 7:00 AM–5:30 PM	One dedicated obstetric-specialized attending anesthesiologist + two dedicated PGY 2–4 anesthesia residents
On-call: Monday through Friday, 5:30 PM–7:00 AM; Friday, 5:30 PM–Monday, 7:00 AM	One dedicated generalist or obstetric-specialized attending anesthesiologist + one dedicated PGY 2–4 anesthesia resident

PGY, postgraduate year.

On-call resident coverage is one dedicated anesthesiology resident. At our institution, certified registered nurse anesthetists and certified anesthesiologist assistants do not provide obstetric anesthesia care, and all obstetric anesthesia providers remain in-hospital during their entire shift. Anesthesia attending, fellow, and residents assigned to labor and delivery have no regular clinical responsibilities other than work on the labor and delivery unit for the duration of their shift. Attending obstetrician staffing consisted of one generalist obstetrician and one maternal fetal medicine specialist providing care on the labor and delivery unit at all times. No changes to the staffing model occurred during the study period.

Data Collection

After approval from the Institutional Review Board at the University of Pennsylvania, we used anesthesia service claims from our department to identify all patients undergoing cesarean delivery using relevant Current Procedural Terminology codes (codes: 59510, 59514, 59515, 59618, 59620, and 59622). All live singleton cesarean deliveries were included in the final cohort. Intrauterine fetal demise patients were excluded. Patients that delivered more than once during the study period were included in the cohort for each cesarean delivery. Patient characteristics and information on members of the care team were extracted from the electronic medical record and *via* manual chart review by one investigator (B.T.C.) and a research assistant using a standardized data collection form. Information on provider characteristics was obtained from departmental records.

Outcome Variables

The primary outcome was receipt of general anesthesia for cesarean delivery, defined as the final anesthesia type recorded in the medical record. Patients who received general anesthesia at any point were classified as having received general anesthesia, regardless of whether a neuraxial block had been performed or attempted before general anesthesia induction. Patients who received epidural, spinal, or combined spinal-epidural anesthesia without general anesthesia were classified as having received neuraxial anesthesia.

Definition of Anesthesia Provider Type

The primary exposure was obstetric specialization of the attending anesthesiologist at the time of induction for cesarean delivery. We defined specialized training in

obstetric anesthesiology as having completed a fellowship in obstetric anesthesiology or having practiced as an attending anesthesiologist for at least 5 yr with at least 33% of full-time anesthesia services dedicated to obstetric anesthesia care. We defined a fellowship in obstetric anesthesiology as completing a formal postresidency curriculum in obstetric anesthesiology, including a minimum of 100 clinical days on the labor and delivery unit under the supervision of obstetric-specialized anesthesiologists. "Generalist anesthesiologists" were defined as attending anesthesiologists who did not have specialized training in obstetric anesthesiology. Obstetric anesthesia fellows who provided on-call attending coverage of the labor and delivery unit, but had not yet completed their fellowship, were classified as generalists; however, we also conducted supplementary analyses to consider current fellows as obstetric specialists to evaluate the robustness of our findings to alternate specifications of our primary exposure variable.

Covariates

Patient-level covariates included age, race (categorized as black, white, or other), Hispanic ethnicity, parity, gestational age at time of delivery, cesarean delivery urgency and indication, cesarean delivery number, history of hypertension or preeclampsia, and history of diabetes. Cesarean delivery urgency was classified as (1) "emergent," indicating a threat to the life of mother or fetus requiring immediate delivery; (2) "urgent," indicating a need for delivery within 30 min in situations where no immediate threat to mother or fetus exists, but maternal or fetal compromise may be expected if spontaneous delivery is awaited; and (3) "elective," indicating that early cesarean delivery is needed, maternal and fetal compromise is absent, and cesarean delivery should be performed at a time to suit to the needs of the patient and labor and delivery staff.[17–19]

Cesarean delivery indications were classified as (1) "contraindication to labor," indicating a cesarean delivery for reasons that increase the likelihood of morbidity if a vaginal delivery ensued (*i.e.*, active vaginal herpes infection, malpresentation, history of shoulder dystocia, macrosomia, not eligible for trial of labor after cesarean delivery, placenta or vasa previa); (2) "fetal indication," indicating patients that required a cesarean delivery due to category II and III fetal heart tracing (or nonreassuring fetal heart tones/bradycardia), uterine rupture, cord prolapse, or failed external cephalic version; (3) "labor dystocia," defined as patients who required a cesarean delivery due to inadequate uterine contractions, incomplete cervical dilation, arrest of descent, or failed labor induction; (4) "maternal indication," defined as a cesarean delivery that was required due to severe maternal peripartum cardiac, pulmonary, or neurologic comorbidities; (5) "primary cesarean delivery, no other indication listed," defined as a first cesarean delivery with no other primacy indication recorded; and (6) "unknown." We recorded whether the delivering obstetrician had completed a fellowship in maternal fetal medicine. Additionally, we recorded whether the anesthesia induction for cesarean delivery occurred during an on-call (*i.e.*, evening or weekend) shift. Last, we reviewed all general anesthesia case records to identify potential complications related to airway management for patients treated by generalist *versus* obstetric-specialized anesthesiologists. Specifically, we collected data on regurgitation of gastric contents, frank pulmonary aspiration, inability to intubate, inability to ventilate, need for rescue laryngeal mask airway, incidence of needle cricothyroidotomy, and incidence of emergent surgical tracheotomy, and compared the rate of complication by anesthesiologist provider type.

Statistical Analysis

Descriptive statistics were used to compare predelivery characteristics of patients treated by generalist *versus* obstetric anesthesiologists. For continuous variables, means were compared using *t* tests. Categorical variable frequencies were compared using the chi-square test, and ordinal variable frequencies were compared using the Kruskal–Wallis test. Unadjusted bivariable analysis was conducted between patient characteristics and our outcome of general anesthesia for cesarean delivery. Next, we fit logistic regression models to estimate the association of anesthesia provider specialization with the odds of receiving general anesthesia after adjusting for all above covariates among all patients in our study sample. To assess whether any differences in use of general anesthesia between obstetric-specialized and generalist anesthesiologists could be attributed to the difference in proportion of elective cases between provider groups, we conducted a subgroup analysis restricted to patients undergoing urgent or emergent cesarean deliveries. Given that obstetric-specialized anesthesiologists in our sample provided care during the daytime and on-call shifts whereas generalist anesthesiologists provided care only during on-call shifts, we also conducted a subgroup analysis restricted to on-call cesarean deliveries. To test for interactions between the primary exposure (anesthesiologist specialization) and key predictor variables, we also fit separate logistic regression models using the full study sample that incorporated interaction terms for provider specialization with urgent or emergent delivery status and for provider specialization with on-call delivery status.

As our analysis was conducted within a convenience sample at one institution, we did not perform a formal *a priori* power calculation or determine a minimum clinically meaningful effect size in advance. While the principal dataset had been accessed before initiating this analysis for purposes of internal quality reviews, the primary outcome, analytic approach, and subgroup and sensitivity analyses were agreed upon *a priori* by all study authors. Alpha was set at the 0.05 level, and all tests were two-tailed. $P < 0.05$ was

considered significant. Data were analyzed using Stata 15.1 (StataCorp LLC, USA).

Results

Within the study period, 4,217 women underwent cesarean delivery. After exclusion of nonsingleton and intrauterine fetal demise deliveries, we obtained a study sample of 4,052 patients. No patients in the final analysis had missing, lost, or excluded covariate data. The rate of general anesthesia in the sample was 9.0% (n = 363 of 4,052), and the rate of neuraxial anesthesia was 91.0% (n = 3,689 of 4,052). Seven obstetric anesthesiologists performed 2,649 of 4,052 (65.4%) anesthetics for cesarean deliveries. Thirty-three generalist anesthesiologists performed 1,403 of 4,052 (34.6%) anesthetics for cesarean delivery. Obstetric-specialized anesthesiologists performed 193 of 363 (53.2%) general anesthetics, and generalist anesthesiologists performed 170 of 363 (46.8%) general anesthetics. Endotracheal intubation was successful in all cases; no patients were unable to be intubated or ventilated, required a rescue laryngeal mask airway, required needle cricothyroidotomy, required an emergent surgical tracheotomy, or were noted to have frank pulmonary aspiration. One patient under the care of an obstetric-specialized anesthesiologist was noted to have gastric contents in the oropharynx during endotracheal intubation without any mention of the diagnosis of pulmonary aspiration.

Table 2 shows characteristics of patients receiving care from generalist *versus* obstetric-specialized anesthesiologists for cesarean delivery. Compared to patients treated by generalist anesthesiologists, those treated by obstetric-specialized anesthesiologists less often received general anesthesia for cesarean delivery (7.3% *vs.* 12.1%; $P < 0.001$). Patients treated by obstetric-specialized anesthesiologists were also older (mean age, 29.5 *vs.* 28.8 yr; $P < 0.001$), less likely to be nulliparous before the index cesarean delivery (38.6 *vs.* 52.0; $P < 0.001$), more likely to be undergoing an elective cesarean delivery (47.6% *vs.* 14.6%; $P < 0.001$), and more likely to have a contraindication to labor (48.1% *vs.* 20.8%; $P < 0.001$). Patients treated by obstetric-specialized anesthesiologists were less likely than those treated

Table 2. Characteristics and Outcomes of Cesarean Delivery Patients Included in the Study Sample, by Anesthesia Provider Type

	Anesthesia Provider Type: Generalist (n = 1,403)	Anesthesia Provider Type: Obstetric-Specialized (n = 2,649)	*P* Value
Patient characteristics			
Age, mean ± SD	28 ± 6.3	29 ± 6.1	< 0.001
Race, number (%)			
White	252 (18.0)	552 (20.8)	0.057
Black	915 (65.2)	1,697 (64.1)	
Other	236 (16.8)	400 (15.1)	
Ethnicity, number (%)			
Non-Hispanic	1,355 (96.6)	2,567 (96.9)	0.576
Hispanic	48 (3.4)	82 (3.1)	
Parity, number (%)			
0	730 (52.0)	1,023 (38.6)	< 0.001
1	351 (25.0)	859 (32.4)	
≥ 2	322 (23.0)	767 (29.0)	
Gestational age at cesarean delivery in weeks, mean ± SD	38.2 ± 3.1	38.2 ± 3.1	0.997
Cesarean delivery urgency, number (%)			
Elective	205 (14.6)	1,257 (47.5)	< 0.001
Urgent	996 (71.0)	1,132 (42.7)	
Emergent	202 (14.4)	260 (9.8)	
Number of previous cesarean deliveries, number (%)			
0 (primary)	988 (70.4)	1,371 (51.8)	< 0.001
≥ 1 (repeat)	415 (29.6)	1,278 (48.2)	
Cesarean delivery indication, number (%)			
Contraindication to labor	292 (20.8)	1,274 (48.1)	< 0.001
Fetal indication	548 (39.1)	624 (23.6)	
Labor dystocia	432 (30.8)	448 (16.9)	
Maternal indication	36 (2.6)	87 (3.3)	
Previous cesarean delivery, no other indication listed	82 (5.8)	163 (6.2)	
Unknown	13 (0.9)	53 (1.9)	
On-call cesarean delivery (yes), number (%)	1,184 (84.4)	1,137 (42.9)	< 0.001
Hypertension/preeclampsia, number (%)	214 (15.3)	411 (15.5)	0.826
Diabetes, number (%)	89 (6.3)	181 (6.8)	0.552
Obstetrician training in maternal-fetal medicine, number (%)	640 (45.6)	1,039 (39.2)	< 0.001
Study outcome: final anesthesia type, number (%)			
Neuraxial (spinal or epidural)	1,233 (87.9)	2,456 (92.7)	< 0.001
General	170 (12.1)	193 (7.3)	

by generalists to have their cesarean delivery performed by a maternal-fetal medicine specialist (39.2% *vs.* 45.7%; $P < 0.001$).

Factors associated with receipt of general *versus* neuraxial anesthesia for cesarean delivery in the overall study sample are listed in table 3. In unadjusted analyses, treatment by an obstetric-specialized anesthesiologist compared to a generalist anesthesiologist was associated with a lower odds of receiving general anesthesia for cesarean delivery (odds ratio, 0.56; 95% CI, 0.45 to 0.70; $P < 0.001$). Patient covariates associated with lower odds of general anesthesia receipt were increasing patient age (odds ratio, 0.97; 95% CI, 0.95 to 0.98; $P < 0.001$), increasing gestational age at time of cesarean delivery (odds ratio, 0.87; 95% CI, 0.85 to 0.90; $P < 0.001$), and repeat cesarean delivery (odds ratio, 0.61; 95% CI, 0.48 to 0.77; $P < 0.001$). We observed an increased odds of receiving general anesthesia among patients of black race (odds ratio, 1.98; 95% CI, 1.43 to 2.74; $P < 0.001$), those with two or more previous deliveries (odds ratio, 1.33; 95% CI, 1.03 to 1.71; $P = 0.024$), and those undergoing urgent cesarean delivery (odds ratio, 1.38; 95% CI, 1.02 to 1.87; $P = 0.032$) or emergent cesarean delivery (odds ratio, 10.8; 95% CI, 7.96 to 14.8; $P < 0.001$). Additional factors associated with increased unadjusted odds of general anesthesia were cesarean delivery for a fetal indication (odds ratio, 3.01; 95% CI, 2.31 to 3.93; $P < 0.001$), cesarean delivery for a maternal indication (odds ratio, 4.18; 95% CI, 2.56 to 6.81; $P < 0.001$), having a cesarean delivery during an on-call shift (odds ratio, 1.77; 95% CI, 1.40 to 2.24; $P < 0.001$), a history of hypertension or preeclampsia (odds ratio, 1.75; 95% CI, 1.35 to 2.27; $P < 0.001$), and delivery by a maternal-fetal medicine specialist (odds ratio, 1.50; 95% CI, 1.21 to 1.87; $P < 0.001$).

After adjusting for covariates, treatment by an obstetric-specialized anesthesiologist remained associated with lower odds of receiving general anesthesia for cesarean

Table 3. Unadjusted and Adjusted Predictors of Receiving General Anesthesia for Cesarean Delivery within the Overall Study Sample (N = 4,052)

	Unadjusted			Adjusted		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Principal exposure: anesthesiologist obstetric specialization						
Generalist (nonspecialized; reference)	N/A	N/A	N/A	N/A	N/A	N/A
Obstetric (specialized)	0.56	0.45–0.70	< 0.001	0.71	0.55–0.92	0.011
Additional covariates included in the multivariate regression model						
Age	0.97	0.95–0.98	0.001	0.97	0.95–0.99	0.028
Race						
White (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Black	1.98	1.43–2.74	< 0.001	1.32	0.90–1.94	0.144
Other	1.22	0.79–1.88	0.360	0.96	0.58–1.60	0.897
Ethnicity						
Non-Hispanic (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Hispanic	0.93	0.50–1.75	0.840	1.04	0.48–2.29	0.904
Parity						
0 (reference)	N/A	N/A	N/A	N/A	N/A	N/A
1	0.78	0.59–1.03	0.084	1.04	0.72–1.49	0.820
≥ 2	1.33	1.03–1.71	0.024	1.69	1.17–2.45	0.005
Gestational age at cesarean delivery in weeks	0.87	0.85–0.90	< 0.001	0.91	0.88–0.93	0.001
Cesarean delivery urgency						
Elective (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Urgent	1.38	1.02–1.87	0.032	1.02	0.68–1.53	0.891
Emergent	10.8	7.96–14.8	< 0.001	7.36	4.72–11.4	0.001
Number of previous cesarean deliveries						
0 (primary; reference)	N/A	N/A	N/A	N/A	N/A	N/A
≥ 1 (repeat)	0.61	0.48–0.77	< 0.001	0.86	0.60–1.22	0.402
Cesarean delivery indication						
Contraindication to labor (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Fetal indication	3.01	2.31–3.93	< 0.001	1.21	0.82–1.78	0.320
Labor dystocia	0.94	0.65–1.35	0.763	1.05	0.66–1.68	0.805
Maternal indication	4.18	2.56–6.81	< 0.001	3.18	1.85–5.46	0.001
Previous cesarean delivery, no other indication listed	0.99	0.55–1.77	0.984	0.65	0.33–1.27	0.213
Unknown	1.05	0.37–2.97	0.915	1.07	0.35–3.24	0.897
On-call cesarean delivery (yes)	1.77	1.40–2.24	< 0.001	1.33	1.01–1.75	0.038
Hypertension/preeclampsia	1.75	1.35–2.27	< 0.001	1.24	0.92–1.68	0.148
Diabetes	1.08	0.71–1.65	0.689	1.05	0.65–1.68	0.836
Obstetrician training in maternal-fetal medicine	1.50	1.21–1.87	< 0.001	1.20	0.95–1.53	0.121

N/A, not applicable; OR, odds ratio.

delivery (adjusted odds ratio, 0.71; 95% CI, 0.55 to 0.92; $P = 0.011$). Other factors that remained associated with receipt of anesthesia for cesarean delivery were patient age (adjusted odds ratio, 0.97; 95% CI, 0.95 to 0.99; $P = 0.028$), parity of 2 or greater (adjusted odds ratio, 1.69; 95% CI, 1.17 to 2.45; $P = 0.005$), gestational age at cesarean delivery (adjusted odds ratio, 0.91; 95% CI, 0.88 to 0.93; $P < 0.001$), emergent cesarean delivery (adjusted odds ratio, 7.36; 95% CI, 4.72 to 11.4; $P < 0.001$), cesarean delivery for maternal indication (adjusted odds ratio, 3.18; 95% CI, 1.85 to 5.46; $P < 0.001$), and having a cesarean delivery during an on-call shift (adjusted odds ratio, 1.33; 95% CI, 1.01 to 1.75; $P < 0.038$). We did not find evidence of a statistically significant interaction in separate models incorporating all of the above covariates plus an interaction term between anesthesiologist specialization and on-call delivery status (adjusted odds ratio, 1.54; 95% CI, 0.82 to 2.90; $P = 0.184$), nor between anesthesiologist specialization and urgent/emergent delivery status (adjusted odds ratio, 1.51; 95% CI, 0.86 to 2.63; $P = 0.147$).

In a subgroup analysis restricted to urgent or emergent cesarean deliveries (table 4), care by obstetric-specialized anesthesiologists compared to generalist anesthesiologists was associated with reduced adjusted odds of general anesthesia for cesarean delivery (adjusted odds ratio, 0.75; 95% CI, 0.56 to 0.99; $P = 0.049$). Other statistically significant factors associated with reduced odds of general anesthesia for cesarean delivery were patient age (adjusted odds ratio, 0.97; 95% CI, 0.95 to 0.99; $P = 0.041$), gestational age at cesarean delivery (adjusted odds ratio, 0.89; 95% CI, 0.85 to 0.92; $P < 0.001$), and a previous cesarean delivery with no other indication listed (adjusted odds ratio, 0.89; 95% CI, 0.85 to 0.92; $P < 0.001$). Additional factors that remained statistically significant with increased odds of receiving general anesthesia for cesarean delivery were parity greater than or

Table 4. Unadjusted and Adjusted Predictors of Receiving General Anesthesia among Patients Undergoing Urgent or Emergent Cesarean Delivery (n = 2,590)

	Unadjusted			Adjusted		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Principal exposure: anesthesiologist obstetric specialization						
Generalist (nonspecialized; reference)	N/A	N/A	N/A	N/A	N/A	N/A
Obstetric (specialized)	0.80	0.62–1.01	0.072	0.75	0.56–0.99	0.049
Additional covariates included in the multivariate regression model						
Age	0.98	0.96–0.99	0.045	0.97	0.95–0.99	0.041
Race						
White (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Black	2.19	1.48–3.26	0.001	1.47	0.92–2.35	0.101
Other	1.29	0.77–2.16	0.317	1.03	0.56–1.91	0.906
Ethnicity						
Non-Hispanic (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Hispanic	0.98	0.48–1.99	0.968	1.14	0.47–2.78	0.760
Parity						
0 (reference)	N/A	N/A	N/A	N/A	N/A	N/A
1	1.29	0.95–1.76	0.100	1.15	0.78–1.71	0.464
≥ 2	2.18	1.64–2.90	0.001	1.72	1.14–2.59	0.010
Gestational age at cesarean delivery in weeks	0.85	0.83–0.88	0.001	0.89	0.85–0.92	0.001
Cesarean delivery urgency						
Urgent (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Emergent	7.82	6.03–10.1	0.001	7.20	5.30–9.76	0.001
Number of previous cesarean deliveries						
0 (primary; reference)	N/A	N/A	N/A	N/A	N/A	N/A
≥ 1 (repeat)	0.98	0.74–1.30	0.898	1.04	0.70–1.53	0.824
Cesarean delivery indication						
Contraindication to labor (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Fetal indication	1.30	0.91–1.85	0.146	1.11	0.72–1.69	0.627
Labor dystocia	0.36	0.23–0.56	0.001	0.93	0.55–1.56	0.794
Maternal indication	2.34	1.24–4.43	0.008	2.64	1.30–5.32	0.007
Previous cesarean delivery, no other indication listed	0.37	0.18–0.76	0.007	0.39	0.17–0.87	0.023
Unknown	1.31	0.43–4.01	0.629	2.29	0.65–8.11	0.196
On-call cesarean delivery (yes)	1.35	1.03–1.78	0.029	1.36	0.99–1.87	0.057
Hypertension/preeclampsia	1.67	1.24–2.25	0.001	1.13	0.80–1.61	0.467
Diabetes	1.03	0.62–1.71	0.904	0.88	0.49–1.57	0.674
Obstetrician training in maternal-fetal medicine	1.29	1.01–1.64	0.039	1.23	0.93–1.61	0.136

N/A, not applicable; OR, odds ratio.

equal to 2 (adjusted odds ratio, 1.72; 95% CI, 1.14 to 2.59; $P = 0.010$), emergent *versus* urgent cesarean delivery (adjusted odds ratio, 7.20; 95% CI, 5.30 to 9.76; $P < 0.001$), and maternal indication for cesarean delivery (adjusted odds ratio, 2.64; 95% CI, 1.30 to 5.32; $P = 0.007$). We obtained similar findings in the overall sample and in both the urgent/emergent and on-call subgroups when alternate specifications considered obstetric anesthesia fellows currently in training as obstetric-specialized *versus* generalist providers for on-call cases where they served as the attending anesthesiologist of record.

In a subgroup analysis restricted to only on-call cesarean deliveries (table 5), care by obstetric-specialized anesthesiologists compared to generalist anesthesiologists did not reach statistical significance with lower adjusted odds of general anesthesia for cesarean delivery (adjusted odds ratio, 0.76; 95% CI, 0.56 to 1.03; $P = 0.085$).

Discussion

Among 4,052 women who underwent cesarean delivery at one urban academic medical center, patients treated by obstetric-specialized anesthesiologists experienced a 29% lower adjusted odds of receiving general anesthesia compared to patients treated by generalist anesthesiologists. We observed similar patterns within a subgroup restricted to patients undergoing urgent or emergent cesarean delivery; for these patients, treatment by an obstetric-specialized anesthesiologist was associated with a 20% lower adjusted odds of receiving general anesthesia. These findings persisted after adjusting for a range of patient, provider, and system-level factors that could potentially confound the association between anesthesiologist training and use of general anesthesia for cesarean delivery. We did not observe a statistically significant association between anesthesiologist

Table 5. Unadjusted and Adjusted Predictors of Receiving General Anesthesia among Patients Undergoing Urgent or Emergent Cesarean Delivery On-call (n = 2,321)

	Unadjusted			Adjusted		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Principal exposure: anesthesiologist obstetric specialization						
Generalist (nonspecialized; reference)	N/A	N/A	N/A	N/A	N/A	N/A
Obstetric (specialized)	0.77	0.59–1.01	0.061	0.76	0.56–1.03	0.085
Additional covariates included in the multivariate regression model						
Age	0.96	0.94–0.98	0.003	0.96	0.94–0.99	0.021
Race						
White (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Black	2.17	1.43–3.27	0.001	1.45	0.89–2.36	0.131
Other	1.38	0.81–2.35	0.231	1.04	0.54–1.97	0.902
Ethnicity						
Non-Hispanic (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Hispanic	1.19	0.58–2.44	0.617	1.39	0.55–3.51	0.480
Parity						
0 (reference)	N/A	N/A	N/A	N/A	N/A	N/A
1	1.01	0.73–1.41	0.915	1.09	0.71–1.68	0.667
≥ 2	1.61	1.18–2.19	0.002	1.62	1.03–2.56	0.035
Gestational age at cesarean delivery in weeks	0.85	0.82–0.88	0.001	0.89	0.85–0.93	0.001
Cesarean delivery urgency						
Urgent (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Emergent	10.2	6.72–15.5	0.001	8.51	4.83–15.0	0.001
Number of previous cesarean deliveries						
0 (primary; reference)	N/A	N/A	N/A	N/A	N/A	N/A
≥ 1 (repeat)	0.72	0.53–0.96	0.028	0.99	0.64–1.52	0.969
Cesarean delivery indication						
Contraindication to labor (reference)	N/A	N/A	N/A	N/A	N/A	N/A
Fetal indication	2.25	1.61–3.15	0.001	1.15	0.72–1.83	0.551
Labor dystocia	0.66	0.42–1.03	0.072	1.05	0.60–1.83	0.857
Maternal indication	2.75	1.46–5.17	0.002	2.32	1.15–4.66	0.018
Previous cesarean delivery, no other indication listed	0.65	0.30–1.40	0.275	0.47	0.19–1.13	0.092
Unknown	0.78	0.18–3.39	0.748	0.73	0.14–3.73	0.708
Hypertension/preeclampsia	1.74	1.27–2.38	0.001	1.34	0.93–1.95	0.112
Diabetes	1.09	0.67–1.78	0.714	1.09	0.62–1.91	0.753
Obstetrician training in maternal-fetal medicine	1.22	0.94–1.59	0.124	1.07	0.80–1.44	0.615

N/A, not applicable; OR, odds ratio.

training and the odds of receiving general anesthesia in a subgroup analysis restricted to on-call cesarean deliveries. Airway-related complications such as aspiration of gastric contents or inability to intubate were rare among the 363 patients who underwent general anesthesia in our sample and did not differ between obstetric-specialized and generalist anesthesiologists.

Our study builds on previous work comparing differences between obstetric-specialized and generalist anesthesiologists' care for obstetric surgery. Previous studies by Riley and Papasin[15] and Campbell and Tran[16] examined anesthesia care for patients receiving epidural analgesia for labor who subsequently underwent cesarean delivery. In both studies, treatment by a generalist anesthesiologist *versus* an obstetric-specialized anesthesiologist was associated with a greater likelihood of receiving general anesthesia for cesarean delivery in unadjusted analyses. Our analysis expands on these previous studies by considering a mixed population of patients undergoing cesarean delivery, not restricted to those receiving epidural analgesia for labor. As such, our results offer new insight on the potential impact of obstetric anesthesiologist specialization on overall patterns of utilization of general anesthesia for cesarean delivery within one hospital and how other patient- and provider-level factors compare in magnitude to anesthesia provider specialization for cesarean delivery performed with general anesthesia. Additionally, our findings persisted in models that accounted for a range of potential confounders and in a subgroup analysis restricted to urgent or emergent deliveries. However, our subgroup analysis of on-call cesarean deliveries did not show a statistically significant association between obstetric-specialized anesthesiologists' and generalist anesthesiologists' practice patterns; reasons for this may include not enough power to detect a statistical difference between groups or a lack of difference between provider groups when compared within a similar staffing context. Further research is needed to evaluate this potential association between anesthesia provider types caring for patients on the labor and delivery unit with similar staffing domains.

Based on the present analysis, we cannot determine the specific reasons underlying the differences we observe between obstetric-specialized and generalist anesthesiologists in use of general anesthesia for cesarean delivery. However, we posit that several potential mechanisms may explain our findings. Differences in knowledge regarding current guidelines between obstetric-trained providers and generalists may make obstetric-specialized anesthesiologists more likely to avoid general anesthesia for cesarean delivery; similarly, differences in skills related to placement and management of neuraxial blocks between provider types may lead to differences in the extent to which they are able to avoid general anesthesia. Specifically, for patients without indwelling epidural catheters, obstetric-specialized anesthesiologists may be more likely than generalists to attempt and successfully place neuraxial blocks for cesarean delivery; for patients receiving epidural analgesia for labor who require conversion to cesarean delivery, obstetric anesthesiologists may be more likely than generalists to avoid general anesthesia through differences in epidural catheter management or use of adjunctive sedation in selected patients.[20] Conversely, if generalists more than obstetric specialists employ general anesthesia in their overall clinical practice, such additional experience may lead to a higher degree of comfort with general anesthesia and airway management in the context of obstetric surgery. Importantly, while encouraging use of neuraxial anesthesia for cesarean delivery, the American Society of Anesthesiologists also recommends that "the decision to use a particular anesthetic technique for cesarean delivery should be individualized" based on patient factors and provider judgment.[1] Given this, we cannot conclude based on this analysis alone the extent to which providers' management of patients in any given case aligned with or diverged from guideline recommendations.

Beyond differences in knowledge or skill between providers, differences in practice between obstetric specialists and generalists may relate to differences in communication with other members of the care team; specifically, trust between providers related to established, working relationships with obstetric-specialized attending anesthesiologists, obstetricians, and nursing staff may contribute to differences in collaborative decision-making around the time of cesarean delivery, with potential impacts on care. Understanding the role of these or other mechanisms in explaining differences in care between providers with different levels of training in obstetric anesthesia may be considered a target for future qualitative and quantitative research.

Notably, our analysis also identified several patient- and provider-level factors that had a greater magnitude of association with receipt of general anesthesia than did anesthesia provider specialization. For example, in adjusted models, emergency cesarean delivery was associated with a greater than 7-fold increase in the odds of receiving general anesthesia compared to elective cesarean delivery, potentially due to differences in the amount of time available for a neuraxial block placement in emergent *versus* elective cesarean deliveries. We also observed maternal indications for cesarean delivery, such as severe maternal cardiac, pulmonary, or neurologic disease, to be associated with a greater than 3-fold increase in the odds of receiving general anesthesia, which could relate to provider or patient concerns regarding potential adverse hemodynamic or neurologic sequalae of neuraxial anesthesia in certain contexts. We observed cesarean delivery patients treated during on-call shifts to have a 33% greater adjusted odds of receiving general anesthesia compared to daytime cesarean delivery patients, which could relate to the differences between daytime and on-call anesthesia staffing models or a greater propensity for emergent cesarean deliveries to occur during on-call shifts. Beyond providing insight into the multiple potential determinants of general anesthesia receipt for cesarean delivery,

these observations may be useful for placing our findings regarding provider type in a broader clinical context for health policy and informed decision-making.

Our work should be interpreted in the context of limitations. As a single-center study, our work may not be generalizable to other settings that differ in terms of patient population, local standards of practice, or staffing models for obstetric anesthesia services. As a retrospective analysis, our findings cannot support conclusions regarding causal effects of anesthesiologist specialization in obstetric anesthesia on care processes for cesarean delivery; specifically, while we accounted for a wide array of factors that could confound the association between anesthesiologist specialization and use of general anesthesia, it remains possible that patients treated by generalist *versus* specialist anesthesiologists could differ in ways not captured by the variables considered here. Similarly, it is possible that our findings could reflect unmeasured differences in anesthesia providers not related to obstetric anesthesia training *per se*. Finally, as this study did not explicitly consider maternal or neonatal outcomes after cesarean delivery under general *versus* neuraxial anesthesia, we cannot assess the downstream safety implications of the differences in care we observed between obstetric-specialized and generalist anesthesiologists.

Nonetheless, our work has important implications for clinical practice and health policy. The American Society of Anesthesiology's task force on obstetric anesthesia released practice guidelines explicitly stating anesthesia providers should "consider selecting neuraxial techniques in preference to general anesthesia for most cesarean deliveries."[1] As such, our finding that treatment by an obstetric-specialized anesthesiologist is associated with lower odds of receiving general anesthesia argues that increasing patient access to obstetric-specialized anesthesiologists may represent one route for promoting an increase in utilization of neuraxial anesthesia in this context. For hospitals that prioritize limiting the use of general anesthesia for cesarean delivery, our findings may be taken to support specialized staffing models for obstetric anesthesia care. Finally, at the level of the individual patient, our work highlights the potential value of providing information to patients to inform their hospital selection for obstetric care, particularly for patients with established preferences regarding anesthesia type for cesarean delivery.

In conclusion, we observed utilization of general anesthesia for cesarean delivery to differ between obstetric-specialized anesthesiologists and generalist anesthesiologists, with patients receiving care from a generalist experiencing approximately a 29% increase in the odds of receiving general anesthesia for cesarean delivery. Future studies should focus on confirming these findings in other settings, and on characterizing the specific variations in care processes and decision-making between obstetric-specialized and generalist anesthesiologists that underlie the differences in practice patterns we observe here.

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Competing Interests

The authors declare no competing interests.

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