Nursing Research • January/February 2007 • Vol 56, No 1, 9–17

Anesthesia Staffing and Anesthetic Complications During Cesarean Delivery

A Retrospective Analysis

Daniel C. Simonson ▼ Melissa M. Ahern ▼ Michael S. Hendryx

Editor's Note

Editor's Note: Materials documenting the review process for this article are posted at http://www.nursing-research-editor.com.

- ***Background:*** Obstetrical anesthesia services may be provided by Certified Registered Nurse Anesthetists (CRNAs), anesthesiologists, or a combination of the two providers. Research is needed to assist hospitals and anesthesia groups in making cost-effective staffing choices.
- ***Objectives:*** To identify differences in the rates of anesthetic complications in hospitals whose obstetrical anesthesia is provided solely by CRNAs compared to hospitals with only anesthesiologists.
- ***Methods:*** Washington State hospital discharge data were obtained from 1993 to 2004 for all cesarean sections, and were merged with a survey of hospital obstetrical anesthesia staffing. Anesthetic complications were identified via International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes. Resulting rates were risk-adjusted using regression analysis.
- ***Results:*** Hospitals with CRNA-only staffing had a lower rate of anesthetic complications than those with anesthesiologist staffing (0.58% vs. 0.76%, $p = .0006$). However, after regression analysis, this difference was not significant (odds ratio for CRNA vs. anesthesiologist complications: 1.046 to 1, 95% confidence interval 0.649–1.658, $p = .85$).
- ***Discussion:*** There is no difference in rates of complications between the two types of staffing models. As a result, hospitals and anesthesiology groups may safely examine other variables, such as provider availability and costs, when staffing for obstetrical anesthesia. Further study is needed to validate the use of ICD-9-CM codes for anesthesia complications as an indicator of quality.

- ***Key Words:*** cost–benefit analysis · obstetrical anesthesia · outcomes research

Anesthesiologists have often complained that there is insufficient reimbursement for obstetrical anesthesia (Bell et al., 2000; Chestnut, 2000; Ciment, 1999; Lagasse & Santos, 1997; Levinson & Shnider, 1986). Hospitals are often forced to subsidize anesthesiology practices in order to obtain coverage for their obstetrical departments (Medical Group Management Association, 2005). Rural hospitals face similar problems in obtaining anesthesiologist coverage for both obstetrical and general surgical needs (Orkin, 1996, 1998). Greater utilization of Certified Registered Nurse Anesthetists (CRNAs) working without anesthesiologist supervision in obstetrical anesthesia may represent a long-term solution for hospitals and anesthesiology groups, both in rural hospitals and in urban hospitals serving large Medicaid populations. Arguments against such increased utilization are often based on speculations about lower quality of care under CRNAs, but the evidence generally does not support this speculation (Smith, Kane, & Milne, 2004).

Nurse anesthetists have administered anesthesia in Washington since 1888. There were few physicians with practices devoted to anesthesia until the advent of third-party reimbursement in the 1950s. As a result, anesthesia was considered a service provided by hospital-employed

Daniel C. Simonson, CRNA, MHPA, is Chief Anesthetist and Managing Partner, The Spokane Eye Surgery Center, Spokane, Washington.

Melissa M. Ahern, PhD, MBA, is Associate Professor, Department of Health Policy and Administration, Washington State University, Spokane.

Michael S. Hendryx, PhD, is Associate Professor, Department of Community Medicine; Research Director, Institute for Health Policy Research, West Virginia University School of Medicine, Morgantown.

CRNAs, with surgeons usually serving as the department heads (Bankert, 1989). For regulatory purposes, supervision was nominally the responsibility of the operating surgeon. With greater numbers of anesthesiologists in the 1970s, this supervisory role was given to anesthesiologists and renamed *medical direction*, in contrast with the less-involved supervision role previously performed by the operating surgeon. Use of this new approach enabled reimbursement to the anesthesiologist for the service. Rural hospitals, which are generally shunned by anesthesiologists, continued using surgeon supervision. Because of high staffing requirements and low reimbursement, obstetrical anesthesia, even in large urban hospitals, is often performed by CRNAs with minimal or no anesthesiologist involvement.

The regulatory model of CRNA practice changed in the 1980s when CRNAs were licensed as Advanced Registered Nurse Practitioners (ARNPs). Washington law does not require CRNAs licensed as ARNPs to be supervised by physicians. Such supervision can, however, be specified by hospital medical staff bylaws. Hospitals now utilize CRNAs and anesthesiologists in a variety of staffing models. Hospitals choose the staffing pattern based on costs and provider availability rather than on patient outcomes data, due to lack of related patient outcomes studies (Bell et al., 2000; Dunbar et al., 1998).

Recent outcomes studies in anesthesia have focused on elderly Medicare populations. Large datasets of administrative data, which are data routinely collected by hospitals and payers for the purpose of reimbursement, are used in these studies. The outcomes studied have been limited to death and failure-to-rescue (patients with complications who subsequently die). Although these outcomes are convenient to study due to their accessibility in administrative data, they may have little direct correlation to anesthesia quality (Cohen, Duncan, & Tate, 1988). For example, in a recent study using Medicare administrative data from Medicare for 217,000 cases in 245 Pennsylvania hospitals, a significant increase in the risk of death and failure-to-rescue was found for patients whose anesthesia care was not medically directed by anesthesiologists (Silber et al., 2000). However, in another study replicating Silber in a larger multistate population, no such difference was found (Pine, Holt, & Lou, 2003). In addition, in a systematic search of the literature conducted for the United Kingdom National Health Service, no evidence was found of significant differences in mortality rates by type of anesthesia provider or by type of anesthesia practice within the hospital (Smith et al., 2004). The authors point out the difficulty of using rare events, such as death or failure-to-rescue, as indicators of anesthesia quality.

Researchers at the Agency for Healthcare Research and Quality (AHRQ) developed methods for using administrative data in a more specific, targeted fashion (Romano et al., 2003). They identified 21 patient safety indicators (PSIs). The anesthesia PSI is used to flag cases containing any one of 15 specific International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes potentially associated with anesthesia problems.

Relying on administrative data may not provide an accurate reflection of complications as compared to actual chart review (Iezzoni, 1997; Iezzoni et al., 1994). There may be errors in reporting complications due to errors or omissions on the part of the coding staff (Hsia, Krushat, Fagan, Tebbutt, & Kusserow, 1988). However, there is no reason to suspect that coding for anesthetic complications is systematically different between CRNA-only and anesthesiologist-only hospitals. In a study involving 205,000 records, no difference was found between hospitals for such errors (Dubois, Brook, & Rogers, 1987). The AHRQ has standardized use of these data for quality analysis in the PSIs and inpatient quality indicators (AHRQ, 2004, 2005).

Purpose

The purpose of this study was to evaluate the quality of care provided at hospitals whose obstetrical anesthesia is delivered solely by CRNAs versus care at hospitals employing only anesthesiologists. The study focused on differences in rates of anesthetic complications between these two types of hospitals for cesarean section in Washington for a 12-year period.

Importantly, the difference between two types of hospitals, not between two types of anesthesia provider, was studied. Specifically, the outcomes in the type of hospital that employs only CRNAs to perform obstetrical anesthesia and the type of hospital that employs only anesthesiologists were contrasted. There is a precedent for this type of analysis. In a classic study of anesthesia outcomes, Forrest (1980) used a similar scheme (hospitals with primarily physician providers or hospitals with primarily nurse anesthetist providers) to analyze the differences among 16 randomly chosen hospitals. In that study, no difference was found in outcomes based on the distinction.

The hypothesis was that there would be no difference in anesthetic complication rates between hospitals that rely primarily on CRNA obstetrical anesthesia versus those that rely primarily on anesthesiologists.

Methods

The Washington State University Institutional Review Board approved this investigation, including use of the Comprehensive Hospital Abstract and Reporting System (CHARS) database and hospital survey.

Independent Variables

The main independent variable, type of obstetrical anesthesia staffing (CRNA-only or anesthesiologists-only), was obtained using a survey of 73 hospitals in Washington that provide obstetrical anesthesia services on a routine basis (this number was reduced by the end of the survey period to 68 hospitals). The survey was conducted initially in 1999 and included retrospective descriptions of staffing during 1993–1998; the survey was updated in 2002 and 2004. The survey was completed by anesthesia providers or medical staff administrators at the hospital.

The type of obstetrical anesthesia staffing and the main operating room staffing for each hospital for each year were identified using the survey. Hospitals were asked if they changed obstetrical anesthesia staffing during the year. If so, they were put into the category that represented the majority of the year. Hospital staffing configuration was

categorized based on a criterion of at least 90% of cases under a particular staffing pattern. Because the CRNA-only and the anesthesiologist-only staffing patterns were the most reliable to confirm, only hospitals with these staffing patterns are included in this study.

Additional independent variables that functioned as risk adjusters include hospital characteristics, patient demographic characteristics, and patient comorbidities. Hospital characteristics include *geographic location* (urban, rural), *size* (number of beds), and *teaching status* (teaching, nonteaching). Three anesthesiologist-only hospitals and one CRNA-only hospital were identified as teaching institutions with obstetrical anesthesia training programs. Nine percent of CRNA-only cesarean deliveries were at teaching hospitals; 4% of anesthesiologist-only were at teaching hospitals. Unmeasured provider or hospital-level variables that might impact the delivery of obstetrical anesthesia care adversely, such as provider experience and provider workload, were not available for this study.

Patient demographic characteristics included age, primary payer (Medicaid, other), type of admission (emergent, urgent, elective), and source of admission (physician referral, clinic referral, HMO referral, emergency room, or hospital transfer). Identification of ICD-9-CM diagnosis codes for comorbidities that could affect the dependent variable was important for developing a proper risk adjustment model. As a result, records that contained such ICD-9-CM codes were flagged as potential risk factors as maternal mortality (Panchal, Arria, & Labhsetwar, 2001).

Dependent Variable: Anesthetic Complications

The dependent variable is the rate of anesthetic complications during labor and delivery (Table 1). Patients were identified as having had an anesthetic complication by the presence of ICD-9-CM codes 668.0 through 668.9. The first three digits (668) represent the category *Complications of the Administration of Anesthetic or Other Sedation in Labor and Delivery*. The fourth digit represents subcategories (0 = *pulmonary*, 1 = *cardiac*, 2 = *central nervous system*, 8 = *other complications*, and 9 = *unspecified complications*). Higher incidence of these codes, in contrast to death rates, allows for greater power in the analysis of relative risk. The incidence of complications measured in this way is consistent with a study of anesthetic quality based on chart review at a hospital in Washington (Posner & Freund, 1999). Results of that study found that the incidence of patient injury for all types of surgical procedures varied from 0.38% to 1.34%.

TABLE 1. Anesthesia Complications

		CRNA-Only (*n* = 33,236)	Anesthesiologist-Only (*n* = 101,570)
Anesthesia Complications			
668.0–668.9: Complications of the administration of anesthetic or other sedation in labor and delivery			
668.0	Pulmonary complications	21	70
668.1	Cardiac complications	10	33
668.2	Central nervous system complications	3	16
668.8	Other complications of anesthesia or other sedation in labor and delivery	134	599
668.9	Unspecified complications of anesthesia and other sedation	4	33
Anesthesia Patient Safety Indicators			
E876: Other and unspecified misadventures during medical care			
E876.3	Endotracheal tube wrongly placed during anesthetic procedure	0	0
E855: Accidental poisoning by other drugs acting on central and autonomic nervous system			
E855.1	Other nervous system depressants	0	2
E930–E949: Drugs … causing adverse effects in therapeutic use			
E938.2	Other gaseous anesthetics	1	0
E938.3	Intravenous anesthetics	0	1
E938.4	Other and unspecified general anesthetics	4	4
E938.5	Surface and infiltration anesthetics	0	1
E938.6	Peripheral nerve and plexus blocking anesthetics	3	6
E938.7	Spinal anesthetics	19	35
968.0–968.7: Poisoning by other central nervous system depressants and anesthetics			
968.3	Intravenous anesthetics	0	1
Total of complications		226	849

Note. CRNA = Certified Registered Nurse Anesthetist.
Source: Comprehensive Abstract and Reporting System dataset, 1993–2004.

Also included are the 15 specific ICD-9-CM codes identified by the AHRQ as part of the anesthesia PSIs. These codes, although not as specific for complications as the 668 category, are more specific than death rates. For example, the anesthesia PSI specifies code E876.3, *Other and Unspecified Misadventures During Medical Care: Endotracheal Tube Wrongly Placed During Anesthetic Procedure.*

In the young, healthy population of women undergoing cesarean section, quantifying the safety and quality of anesthesia services through an analysis of death or failure-to-rescue rates is difficult due to the very small risk of death from direct effects of the anesthesia provider (Cohen et al., 1988). Using these ICD-9-CM codes overcomes that difficulty.

The dependent variable is coded as 1 = *complication*, 0 = *no complication*. In addition to anesthetic complications, death rates were measured also to allow comparison to previous studies.

Patient Data

The type of procedure (cesarean section) the patient underwent was identified using hospital administrative data. All cesarean delivery patients identified in the CHARS database of hospital admissions for Washington State were analyzed for the period 1993–2004. The study involved 134,806 patients, 33,236 patients cared for at hospitals whose obstetrical anesthesia was staffed by CRNAs only and 101,570 cared for at hospitals staffed by anesthesiologists only. Patients were identified as having undergone cesarean delivery if they had any one of the ICD-9-CM procedure codes for cesarean delivery (74.00 to 74.99) in any one of the six procedure fields of the CHARS dataset.

Hospital Data

Hospital data for bed size and location (rural or urban) were obtained from the Washington State Department of Health.

Model Development

Hospitals with CRNA-only and anesthesiologist-only staffing patterns have very different patient profiles. To account for these differences and their possible effects on the incidence of anesthetic complications, hierarchical modeling was used to test individual and community effects on the dependent variable (Bryk & Raudenbush, 1992). A hierarchical approach was chosen because individual patients are nested within hospitals.

The analysis was done using SUDAAN *Proc Multilog* for categorical-dependent variables. Using this procedure estimates parameters utilizing generalized estimating equations and employs a robust variance estimation method for describing the dependence of responses within clusters (Shah, Barnwell, & Bieler, 1997). During intermediate model fitting, one predictor variable, maternal pulmonary embolism, was eliminated from further consideration due to an F value of less than 1, as this resulted in unstable model estimates. Model fit was estimated using a Wald chi-square statistic with a Satterthwaite correction for numerator degrees of freedom (Shah et al., 1997). The model was adjusted for patient characteristics, patient severity, hospital obstetrical anesthesia staffing characteristics, and other hospital characteristics, to predict obstetrical anesthetic complications.

Results

Obstetrical Anesthesia Staffing

In 2004, of the 94 hospitals in Washington, 68 provided obstetrical anesthesia services (44 urban hospitals and 24 rural hospitals). Twenty-eight hospitals (41%) used anesthesiologist-only staffing and 27 (40%) used CRNA-only staffing. Anesthesiologist-only staffing represented 59% of urban hospitals; CRNA-only staffing represented 79% of rural hospitals (Table 2).

Variation in Demographics of the Cesarean Delivery Population

Hospitals that utilize CRNAs only are different from hospitals that use anesthesiologists only (Table 3). Specifically, hospitals staffed with only CRNAs treated the greatest percentage of rural, teaching, urgent admission, and very young (under 17 years old) patients. Hospitals with anesthesiologist staffing had the greatest percentage of emergency admissions and older mothers (age >35 years).

CRNA-only hospitals tended to be either smaller (<100 beds) or large tertiary-care size hospitals (>200 beds). Anesthesiologist-only hospitals tended to predominate among the midsize community hospitals (100–200 beds). A greater percentage of Medicaid patients were treated in CRNA-only staffed hospitals (43% vs. 30% for anesthesiologist-only).

Transfers of sicker patients to a hospital might affect the number of anesthetic complications. CRNA-only hospitals had a significantly greater percentage (1.44% vs. 0.82%, $p < .0001$) of patients transferred from other hospitals. However, regression analysis did not identify hospital transfer as a significant risk factor for anesthetic complications.

Incidence of Comorbidities Among Types of Obstetrical Anesthesia Staffing

Although the demographics of the two types of hospitals were different, analysis did not provide any indication that either type of hospital treated sicker patients, defined as those with comorbid conditions (Table 4). The 18 individual comorbidity variables varied significantly between the two types of staffing, but there seemed to be no pattern overall. Hospitals with CRNA-only staffing had higher percentages of patients for six of the comorbidity variables and those with anesthesiologist-only staffing had higher percentages for eight of the variables; for four of the variables there was no difference between the types of hospitals.

Anesthetic Complications by Staffing Type

In the sample studied, there were 965 patients identified as having at least one anesthetic complication 17 deaths (Table 5). One hundred patients had more than one of the codes identifying anesthetic complications. Hospitals with CRNA-only staffs had a complication rate of 0.58%, whereas anesthesiologist-only hospitals had a rate of 0.76%. The results are significantly different, $p < .0006$. Only one of the 17 deaths had an ICD-9-CM code associated with an anesthetic complication.

The majority of the 965 cases of obstetrical anesthesia complications were of the less serious, *other* code (76% of all anesthetic complications). *Pulmonary* (9%), *cardiac*

TABLE 2. Obstetrical Anesthesia Staffing by Hospital in Washington State, 1993–2004

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	%[a]
All Hospitals													
MDA	27	27	28	25	25	28	29	31	31	31	28	28	41
CRNA	30	30	29	29	28	28	28	29	29	30	28	27	40
Collaborative	6	7	7	9	9	6	6	5	5	2	2	2	3
Combined	10	9	9	9	10	10	8	7	7	9	10	11	16
None[b]	21	21	21	22	22	22	23	22	22	22	26	26	
Total	94	94	94	94	94	94	94	94	94	94	94	94	
Urban													
MDA	25	25	26	23	23	25	26	28	28	28	26	26	59
CRNA	10	10	9	9	9	9	8	8	8	8	8	8	18
Collaborative	5	6	6	8	8	6	6	5	5	2	2	2	5
Combined	8	7	7	7	7	7	6	6	6	8	8	8	18
None[b]	12	12	12	13	13	13	14	13	13	14	16	16	
Urban total	60	60	60	60	60	60	60	60	60	60	60	60	
Rural													
MDA	2	2	2	2	2	3	3	3	3	3	2	2	8
CRNA	20	20	20	20	19	19	20	21	21	22	20	19	79
Collaborative	1	1	1	1	1	0	0	0	0	0	0	0	0
Combined	2	2	2	2	3	3	2	1	1	1	2	3	13
None[b]	9	9	9	9	9	9	9	9	9	8	10	10	
Rural total	34	34	34	34	34	34	34	34	34	34	34	34	

Note. MDA = anesthesiologist or physician anesthetist; CRNA = Certified Registered Nurse Anesthetist.
Source: Survey Data.
[a]Percentages are of those hospitals with anesthesia services for 2004.
[b]Hospitals labeled "none" were not included in the percentage determinations by category.

(4%), and *central nervous system* (2%) codes represent the most serious complications and were rarely found. Similarly, the majority of the anesthesia PSI complications were also of the least serious type, with drugs causing adverse effects in therapeutic use (8%), compared to misadventure (0%) or poisoning (0.2%).

Risk-Adjusted Rates of Anesthetic Complications

The risk-adjusted odds ratio for anesthetic complications for CRNA-only versus anesthesiologist-only hospitals, along with effects of other variables, are shown in Table 6. Model fit was significant: Satterthwaite adjusted χ^2 = 1,859.7 (df = 6.92), $p < .0001$. After adjusting for covariates, the odds of a patient at a CRNA-only hospital having an obstetrical anesthetic complication as compared to an anesthesiologist-only hospital was not significantly different ($p = .85$).

Three variables were found to have a significant correlation with the incidence of anesthetic complications: *emergency admissions*, *postpartum hemorrhage*, and *other complications of labor and delivery*. Emergency patients had an odds ratio of 1.588 of having an anesthetic complication when compared with elective or urgent patients ($p = .03$). The clinical comorbidities significantly associated with anesthetic complications were *postpartum hemorrhage*, with an odds ratio of 1.804 ($p = .002$) and *other complications of labor and delivery*, with an odds ratio of 1.736 ($p = .002$). *Other complications of labor and delivery* is used to indicate an assortment of serious maternal complications, such as maternal distress, shock, hypotension, and cardiac arrest.

Discussion

After adjusting for comorbidities, hospital size, teaching status, patient transfers, and other potentially confounding variables, no difference was found in anesthetic complication rates in hospitals whose obstetrical anesthesia departments were staffed by CRNAs as compared with those staffed by anesthesiologists. No difference was found in mortality rates either. These findings support the hypothesis that there is no difference in anesthesia outcomes between the two types of hospital staffing.

These study results provide important information for hospitals, anesthesiology practices, and public policymakers. There are currently heated debates in hospitals and state legislatures regarding the safety, efficacy, and cost effectiveness of CRNA-only anesthesia (Abenstein, Long,

TABLE 3. Demographics and Hospital Characteristics of CRNA-Only Hospitals Versus Anesthesiologist-Only Hospitals

	CRNA-Only (*n* = 33,236)		Anesthesiologist-Only (*n* = 101,570)	
	n	%	*n*	%
Age of Mother (years)				
<17	519	2	969	1
17–34	27,797	84	80,341	79
>35	4,920	15	20,260	20
Payment Source				
Other	18,818	57	70,854	70
Medicaid	14,418	43	30,716	30
Admission Type				
Emergency	827	2	6,491	6
Urgent	20,262	61	27,242	27
Elective	12,134	37	67,021	66
Other	13	0	816	1
Admission Source				
Physician referral	30,541	92	95,543	94
Clinic referral	341	1	3,158	3
Health maintenance organization referral	1,203	4	174	0
Hospital transfer	480	1	836	1
Emergency room	648	2	994	1
Other	22	0	865	1
Geographic Location				
Rural	9,952	30	1,989	2
Urban	23,284	70	99,581	98
Hospital Size (no. of beds)				
<100	11,163	34	9,831	10
100–200	2,037	6	56,791	56
>200	20,036	60	34,948	34

Note. CRNA = Certified Registered Nurse Anesthetic.
Source: Comprehensive Abstract and Reporting System dataset, 1993–2004.

McGlinch, & Dietz, 2004; Abouleish, Prough, & Vadhera, 2004). Physician professional associations have identified advanced practice nursing as a target for legislating mandatory supervision by physicians (Croasdale, 2006). Additionally, although hospitals subsidize 60% of anesthesiology services (Medical Group Management Association, 2005), anesthesia providers find it increasingly difficult to provide obstetrical anesthesia services in a cost-effective yet profitable manner (Bell et al., 2000). Despite the heat of the debate, there has been little evidence to justify the claims of either side.

In previous studies, researchers have attempted to impute the quality of anesthesia care based on death and failure-to-rescue rates (Bechtoldt, 1981; Beecher & Todd, 1954; Forrest, 1980; Pine et al., 2003; Silber et al., 2000). Given that the safety of anesthesia care is such that it has been held as a model for the rest of medicine (Institute of Medicine, 1999), such analyses are unconvincing. In this study, a more direct indicator of anesthesia quality was used: the ICD-9-CM codes specifying complications of anesthesia during labor and delivery. Remarkably, there is no similar category directly specifying anesthetic complications anywhere else in the ICD-9-CM codes. There are no codes, for example, for anesthetic complications during cholecystectomy, general surgery, or cardiac surgery. Yet the existence of these codes has gone unnoticed in the anesthetic literature. A better understanding of why these diagnosis codes were placed in the records will help assess the value of these types of studies. Because administrative data are created primarily for reimbursement reasons, it seems probable that these codes were recorded because the complications had some financial impact on the hospital or the patient, perhaps a tray was ordered for an epidural blood patch after a *wet tap*, or the patient had to stay an extra day or receive special medications because of protracted nausea and vomiting. Although these complications are not the life-threatening issues considered when looking at death or failure-to-rescue, they represent real concerns for patients. Macario, Weinger, Carney, and Kim (1999) found that when given a hypothetical $100 to spend on avoiding postoperative complications, more patients "paid" for protection from nausea and vomiting than any other complication. From a quality improvement point of view, obstetrical anesthetists may consider themselves lucky that these codes exist to track their quality efforts because, if used appropriately, they can provide a benchmark for hospitals that allows a wider comparison with other hospitals than any of the measures currently in use.

Safety and Quality of Anesthesia Services

Despite the focus on differences, another important observation from this study is that obstetrical anesthesia, whether provided by CRNAs or anesthesiologists, is extremely safe, and there is no difference in safety between the hospitals that utilize only CRNAs compared with those that utilize only anesthesiologists. The incidence of life-threatening complications was very small for either type of hospital staffing (less than 1 death per 100,000; 0 incidences of misplaced endotracheal tubes). With regard to the codes utilized by the AHRQ's PSI program to identify serious sequelae related to anesthesia, of the 76 anesthesia PSIs found for the 12-year period, 74 were identified by the least serious E-code, for *Adverse Drug Effect*.

Limitations

First, this study was based on administrative data that may not provide an accurate reflection of complications as compared to chart review. Second, this study relied on a survey of hospital staffing patterns that determined whether the hospitals were primarily CRNA-only or anesthesiologist-only. The accuracy of this staffing categorization could be limited by record keeping or by survey respondents' memory of staffing patterns for the 12-year period.

TABLE 4. Incidence of Comorbidities at CRNA-Only Hospitals Versus Anesthesiologist-Only Hospitals

	CRNA-Only (n = 33,236[a])		Anesthesiologist-Only (n = 101,570[a])		
Description	***n***	**Incidence (%)**	***n***	**Incidence (%)**	***p***
Placental abruption, previa, or both	1,520	4.57	4,632	4.56	.9218
Postpartum hemorrhage	793	2.39	1,801	1.77	<.0001*
Pulmonary complications	71	.21	161	.16	.0354*
Maternal obesity	220	.66	944	.93	<.0001*
Maternal diabetes	384	1.16	1,577	1.55	<.0001*
Maternal hypertension	3,437	10.34	10,936	10.77	.029*
Maternal eclampsia	678	2.04	2,040	2.01	.7229
Fetal problems affecting the mother	5,327	16.03	22,118	21.78	<.0001*
Generalized infection during labor	15	.05	18	.02	.0056*
Maternal multiparity	1,752	5.27	9,871	9.72	<.0001*
Fetal heart abnormality	2,994	9.01	9,974	9.82	<.0001*
Uterine rupture	149	.45	376	.37	.0472*
Maternal embolism	8	.02	49	.05	.0628
Obstructed labor	6,162	18.54	24,633	24.25	<.0001*
Prolonged labor	936	2.82	2,887	2.84	.8031
Umbilical cord complications	4,468	13.44	15,156	14.92	<.0001*
Other complications of L&D	875	2.63	1,682	1.66	<.0001*
Insufficient prenatal care	591	1.78	1,520	1.50	.0003*

Note. L&D = Labor and Delivery; CRNA = Certified Registered Nurse Anesthetic.
Source: Comprehensive Abstract and Reporting System dataset, 1993–2004.
[a]Total number of cesarean sections.
*$p < .05$.

Third, the results are unique to studied hospitals in the state of Washington and to a subset of patients—those undergoing cesarean delivery—and thus may not be generalizable to other populations. In their study of anesthesia quality, Pine et al. (2003) found large variability by state in the percentage of patients cared for by the various staffing patterns, and this may reflect underlying differences in statute and practice patterns that would affect these results. Although the pattern of rural hospitals being predominantly CRNA-only holds throughout the United States, in the Midwest, teams of anesthesiologists and CRNAs predominate, and on the East and West coasts, anesthesiologist-only hospitals are the most common. This staffing pattern may reflect underlying economic realities or lifestyle concerns (Orkin, 1996).

Conclusions

Analysis of the incidence of anesthetic complications in 134,806 cesarean sections over 12 years suggests that hospitals that utilize CRNAs to provide their obstetrical anesthesia have no difference in rate of obstetrical anesthesia complications from those that use anesthesiologists.

TABLE 5. Rates of Anesthetic Complications

Type of OB Anesthesia Staffing	CRNA-Only	Anesthesiologist-Only	Total	*p*
No. of cesarean deliveries	33,236	101,570	134,806	
Anesthetic complications	192	773	965	
% Anesthetic complications	0.58	0.76	0.72	.0006
Deaths	4	13	17	.9143

Note. OB = Obstetrical; CRNA = Certified Registered Nurse Anesthetic.
Source: Comprehensive Abstract and Reporting System dataset, 1993–2004.

TABLE 6. Risk-Adjusted Odds Ratio of Anesthetic Complications

Variable	Odds Ratio Estimates of Anesthetic Complication			
	Point Estimate	95% CL		*p*
Intercept	10.618	4.387	25.701	.001
CRNA vs. anesthesiologist staffing	1.046	0.649	1.685	.85
Hospital bed size	1.002	0.999	1.004	.16
Teaching hospital	1.486	0.830	2.658	.17
Urban location	1.290	0.682	2.440	.43
Emergency admission	1.588	1.035	2.437	.03
Postpartum hemorrhage	1.804	1.229	2.649	.002
Fetal problems	1.106	0.927	1.319	.25
Maternal multiparity	1.041	0.858	1.262	.68
Prolonged labor	1.268	0.929	1.730	.13
Other complications of labor/delivery	1.736	1.239	2.432	.001

Note. CL = confidence limits; CRNA = Certified Registered Nurse Anesthetist.
Model Fit: Satterthwaite adjusted χ^2 = 1,859.7 (df = 6.92), $p < .0001$.
Source: CHARS dataset, 1993–2004.

These findings demonstrate support for the safety and quality of care provided by CRNAs working without anesthesiologist involvement. For both types of hospitals, the rate of complications was low and well within the range found at a major teaching institution in Washington for all types of anesthetics (Posner & Freund, 1999). The conclusion supports the concept that the decisions about type of anesthesia staffing can be reasonably based on considerations other than safety or quality, such as availability of the type of provider, hospital budgets, or percentage of Medicaid patients cared for at the hospital.

Further studies are needed to validate these observations. Such studies might validate the use of ICD-9-CM codes for anesthesia complications as an indicator of quality, identify any practice differences between CRNA-only hospitals and anesthesiologist-only hospitals that might account for these findings, and quantify the extent to which anesthetic complications in labor and delivery are indicative of the quality of anesthetic care. ▼

Accepted for publication September 17, 2006.

Corresponding author: Daniel Simonson, CRNA, MHPA, The Spokane Eye Surgery Center, 2607 S. Manito Blvd. Spokane, WA 99203 (e-mail: dsimonson@mac.com).

References

Abenstein, J. P., Long, K. H., McGlinch, B. P., & Dietz, N. M. (2004). Is physician anesthesia cost-effective? *Anesthesia and Analgesia*, *98*(3), 750–757.

Abouleish, A. E., Prough, D. S., & Vadhera, R. B. (2004). Influence of the type of anesthesia provider on costs of labor analgesia to the Texas Medicaid program. *Anesthesiology*, *101*, 991–998.

Agency for Healthcare Research and Quality. (2004). AHRQ quality indicators—Guide to inpatient quality indicators: Quality of care in hospitals—Volume, mortality, and utilization, Revision 4 (December 22, 2004).

Agency for Healthcare Research and Quality. (2005). Patient safety indicators overview. Retrieved December 27, 2005, from http://www.qualityindicators.ahrq.gov/psi_overview.htm.

Bankert, M. (1989). *Watchful care: A history of America's nurse anesthetists*. New York: Continuum Publishing.

Bechtoldt, A. A., Jr. (1981). Committee on Anesthesia study. Anesthetic-related deaths: 1969–1976. *North Carolina Medical Journal*, *42*, 253–259.

Beecher, H. K., & Todd, D. P. (1954). A study of the deaths associated with anesthesia and surgery: Based on a study of 599,548 anesthesias in ten institutions, 1948–1952, inclusive. *Annals of Surgery*, *140*, 2–35.

Bell, E. D., Penning, D. H., Cousineau, E. F., White, W. D., Hartle, A. J., Gilbert, W. C., et al. (2000). How much labor is in a labor epidural? Manpower cost and reimbursement for an obstetric analgesia service in a teaching institution. *Anesthesiology*, *92*(3), 851–858.

Bryk, A. S., & Raudenbush, S. W. (1992). Hierarchical linear models: Applications and data analysis methods. Newbury Park: Sage.

Chestnut, D. H. (2000). How do we measure (the cost of) pain relief? *Anesthesiology*, *92*(3), 643–645.

Ciment, J. (1999). US women asked to pay for epidurals in advance. *BMJ*, *318*(7187), 828.

Cohen, M. M., Duncan, P. G., & Tate, R. B. (1988). Does anesthesia contribute to operative mortality? *JAMA*, *260*(19), 2859–2863.

Croasdale, M. (2006, February 13). Physician task force confronts scope-of-practice legislation. *American Medical News*, *49*, 1–2.

Dubois, R. W., Brook, R. H., & Rogers, W. H. (1987). Adjusted hospital death rates: A potential screen for quality of medical care. *American Journal of Public Health*, *77*(9), 1162–1166.

Dunbar, P. J., Mayer, J. D., Fordyce, M. A., Lishner, D. M., Hagopian, A., Spanton, K., et al. (1998). Availability of anesthesia personnel in rural Washington and Montana. *Anesthesiology*, *88*(3), 800–808.

Forrest, W. (1980). Outcome: The effect of the provider. In R. Hirsh & W. Forrest (Eds.), *Health care delivery in anesthesia* (pp. 137–142). Philadelphia: George F. Stickley Company.

Hsia, D. C., Krushat, W. M., Fagan, A. B., Tebbutt, J. A., & Kusserow, R. P. (1988). Accuracy of diagnostic coding for Medicare patients under the prospective-payment system. *New England Journal of Medicine*, *318*(6), 352–355.

Iezzoni, L. I. (1997). Assessing quality using administrative data. *Annals of Internal Medicine*, *127*(8 Pt 2), 666–674.

Iezzoni, L. I., Daley, J., Heeren, T., Foley, S. M., Fisher, E. S., Duncan, C., et al. (1994). Identifying complications of care using administrative data. *Medical Care*, *32*(7), 700–715.

Institute of Medicine. (1999). *To err is human: Building a safer health system*. Washington, DC: National Academy Press.

Lagasse, R. S., & Santos, A. C. (1997). Obstetric anesthesia coverage. The problem in perspective. *Anesthesiology*, *87*(1), 4–5.

Levinson, G., & Shnider, S. N. (1986). Obstetric anesthesia coverage—A continuing problem. *Anesthesiology*, *65*(3), 245–246.

Macario, A., Weinger, M., Carney, S., & Kim, A. (1999). Which clinical anesthesia outcomes are important to avoid? The perspective of patients. *Anesthesia and Analgesia*, *89*(3), 652–658.

Medical Group Management Association. (2005). *Cost survey for anesthesia practices*. Denver, CO: Author.

Orkin, F. K. (1996). Why do anesthesiologists shun rural hospitals? *Anesthesia and Analgesia*, *82*, S348.

Orkin, F. K. (1998). Rural realities. *Anesthesiology*, *88*, 568–571.

Panchal, S., Arria, A. M., & Labhsetwar, S. A. (2001). Maternal mortality during hospital admission for delivery: A retrospective analysis using a state-maintained database. *Anesthesia and Analgesia*, *93*(1), 134–141.

Pine, M., Holt, K. D., & Lou, Y. B. (2003). Surgical mortality and type of anesthesia provider. *AANA Journal*, *71*(2), 109–116.

Posner, K. L., & Freund, P. R. (1999). Trends in quality of anesthesia care associated with changing staffing patterns, productivity, and concurrency of case supervision in a teaching hospital. *Anesthesiology*, *91*(3), 839–847.

Romano, P. S., Geppert, J. J., Davies, S., Miller, M. R., Elixhauser, A., & McDonald, K. M. (2003). A national profile of patient safety in U.S. hospitals. *Health Affairs (Millwood)*, *22*(2), 154–166.

Shah, B., Barnwell, B., & Bieler, G. (1997). *SUDAAN user's manual, release 7.5*. Research Triangle Park, NC: Research Triangle Institute.

Silber, J. H., Kennedy, S. K., Even-Shoshan, O., Chen, W., Koziol, L. F., Showan, A. M., et al. (2000). Anesthesiologist direction and patient outcomes. *Anesthesiology*, *93*, 152–163.

Smith, A. F., Kane, M., & Milne, R. (2004). Comparative effectiveness and safety of physician and nurse anaesthetists: A narrative systematic review. *British Journal of Anaesthesia*, *93*(4), 540–545.