The Prevalence of Perioperative Visual Loss in the United States: A 10-Year Study from 1996 to 2005 of Spinal, Orthopedic, Cardiac, and General Surgery

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BACKGROUND: Perioperative visual loss (POVL) accompanying nonocular surgery is a rare and potentially devastating complication but its frequency in commonly performed inpatient surgery is not well defined. We used the Nationwide Inpatient Sample to estimate the rate of POVL in the United States among the eight most common nonocular surgeries.

METHODS: More than 5.6 million patients in the Nationwide Inpatient Sample who underwent principal procedures of knee arthroplasty, cholecystectomy, hip/femur surgical treatment, spinal fusion, appendectomy, colorectal resection, laminectomy without fusion, coronary artery bypass grafting, and cardiac valve procedures from 1996 to 2005 were included. Rates of POVL, defined as any discharge with an International Classification of Diseases, Ninth Revision, Clinical Modification code of ischemic optic neuropathy (ION), cortical blindness (CB), or retinal vascular occlusion (RVO), were estimated. Potential risk factors were assessed by univariate and multivariable analyses.

RESULTS: Cardiac and spinal fusion surgery had the highest rates of POVL. The national estimate in cardiac surgery was 8.64/10,000 and 3.09/10,000 in spinal fusion. By contrast, POVL after appendectomy was 0.12/10,000. Those undergoing cardiac surgery, spinal fusion, and orthopedic surgery had a significantly increased risk of developing ION, RVO, or CB. Patients younger than 18 yr had the highest risk for POVL, because of higher risk for CB, whereas those older than 50 yr were at greater risk of developing ION and RVO. Other significant positive predictors for some diagnoses of POVL were male gender, Charlson comorbidity index, anemia, and blood transfusion. There was no increased risk associated with hospital surgical volume. During the 10 yr from 1996 to 2005, there was an overall decrease in POVL in the procedures we studied.

CONCLUSIONS: The results confirm the clinical suspicion that the risk of POVL is higher in cardiac and spine fusion surgery and show for the first time a higher risk of this complication in patients undergoing lower extremity joint replacement surgery. The prevalence of POVL in the eight most commonly performed surgical operations in the United States has decreased between 1996 and 2005. Increased odds of POVL with male gender and comorbidity index indicate that some risk factors for POVL may not presently be modifiable. The conclusions of this study are limited by factors affecting data accuracy, such as lack of data on the intraoperative course and inability to confirm the diagnostic coding of any of the discharges in the database.

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Perioperative visual loss (POVL) in the setting of nonocular surgery, a rare but potentially devastating complication, is usually the result of cortical blindness (CB), ischemic optic neuropathy (ION), or retinal vascular occlusion (RVO).[1] Many reports of POVL are associated with spinal and cardiac surgery.[2–4] Although studies of 65,000 and 400,000 patients undergoing anesthesia for all types of surgery at two large academic institutions suggested a low prevalence of POVL in surgery other than cardiac and spinal fusion,[5,6] the actual prevalence in the most commonly

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performed operations is not known. Moreover, the rates of POVL in cardiac and spinal surgery are not well defined, because the published data primarily reflect the experiences of single institutions, mostly academic centers.[4,7–9]

It has been difficult to estimate the prevalence of POVL on a national scale. The prevalence would be important to define to provide accurate informed consent and for targeting future clinical studies. We retrospectively reviewed the Nationwide Inpatient Sample (NIS) from 1996 to 2005 to describe the frequency and possible risk factors of POVL among the eight most commonly performed surgical operations. This database is well suited (and has been used in studies of large numbers of patients) to assess national disease prevalence, as well as outcomes after medical and surgical interventions.[10–13] Recently, an earlier version of NIS was used to examine the prevalence of visual loss after spine surgery.[14] We hypothesized that specific patient and surgical characteristics, including age, gender, comorbidities, and types of surgery, were associated with specific varieties of POVL. We extracted surgical, patient, and hospital characteristics and compared patients with visual loss secondary to CB, ION, and RVO to unaffected patients. Clinicians suspect that POVL, particularly ION, prevalence is increasing, which we studied by determining the prevalence of types of POVL over a 10-yr period.

METHODS

Data Sources

NIS, the largest United States all-payer hospital inpatient care database, is a yearly, stratified, random sample of hospitals containing all discharges from each selected hospital. With data from about 1000 randomly selected hospitals, it is an approximately 20% stratified sample of nonfederal hospitals from participating states, including academic and specialty hospitals. NIS, part of the Healthcare Cost and Utilization Project (HCUP), is directed by the Agency for Health Care Research and Quality. Sampled hospitals and discharges are weighted based on the number of hospitals and discharges in the database, enabling determination of national population-based estimates.*

A typical hospital discharge abstract includes demographics, diagnosis (principal and multiple secondary), procedures (principal and multiple secondary), charges, length of stay, and outcomes. Data are coded using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Quality control and reliability of the NIS have been examined each year since 2000 and every other year before 2000.† National estimates of essential health care parameters in NIS were precise and accurate in comparison with data from the American Hospital Association Annual Survey, National Hospital Discharge Survey, and Medicare Inpatient data.‡ Our IRB deemed the study "exempt."

Data Classification

Knee or hip arthroplasty, cholecystectomy, spinal fusion, appendectomy, colorectal resection, surgical treatment for fractured or dislocated hip and femur, laminectomy, and coronary artery bypass grafting (CABG) were the most commonly performed inpatient surgical operations.§‖ To prevent gender bias, obstetric and gynecological surgery, which were among the most commonly performed surgery, was not studied. Clinical Classifications Software (CCS) procedure codes, developed by the Agency for Health Care Research and Quality for ICD-9-CM, identified the target surgical procedures based on the principal procedures. CCS codes are annually updated and broad¶ use of which minimizes error due to more specific coding over time. To prevent potential confounding by a secondary procedure code, if present, only the principal procedure code was used. Because of the potential ambiguity of assessing associated characteristics and the surgical procedure, patients with spinal fusion as a secondary procedure to laminectomy were excluded. Because of their clinical similarities, we grouped together hip replacement with surgical treatment for fractured or dislocated hip and femur. Cardiac valve and CABG operations were classified as cardiac surgery. Our study examined knee arthroplasty (CCS 152), cholecystectomy (CCS 84), hip replacement or hip/femur surgical treatment (CCS 153 and 146), spinal fusion (CCS 158), appendectomy (CCS 80), colorectal resection (CCS 78), laminectomy (CCS 3) without fusion, and CABG and cardiac valve procedure (CCS 44 and 43).

Because the ICD-9-CM procedure codes for spinal fusion included the surgical approach, we separately

*HCUP Nationwide Inpatient Sample (NIS). Healthcare Cost and Utilization Project (HCUP), 1996–2005. Rockville, MD: Agency for Healthcare Research and Quality. Available at: http://www.hcup-us.ahrq.gov/nisoverview.jsp. Accessed May 2008.

†NIS Comparison Reports, 1997–2005. Rockville, MD: Agency for Healthcare Research and Quality. Available at: http://www.hcup-us.ahrq.gov/db/nation/nis/nisrelatedreports.jsp. Accessed May 2008.

‡Whalen D, Houchens R, Elixhauser A. 2004 HCUP Nationwide Inpatient Sample (NIS) Comparison Report. HCUP Methods Series Report #2007-03. Rockville, MD: U.S. Agency for Healthcare Research and Quality, 2007. Available at: http://www.hcup-us.ahrq.gov/reports/methods.jsp. Accessed May 2008.

§Whalen D, Houchens R, Elixhauser A. 2005 HCUP Nationwide Inpatient Sample (NIS) Comparison Report. HCUP Methods Series Report #2008-01. Rockville, MD: U.S. Agency for Healthcare Research and Quality, 2008. Available at: http://www.hcup-us.ahrq.gov/reports/methods.jsp. Accessed May 2008.

‖HCUPnet: National and Regional Statistics from the NIS. Rockville, MD: Agency for Health Care Research and Quality. Available at: http://hcup.ahrq.gov/.

¶Elixhauser A, Steiner C, Palmer L. Clinical Classification Software (CCS). Rockville, MD: U.S. Agency for Healthcare Research and Quality, 2004. Available at: http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp. Accessed May 2008.

categorized procedures into anterior (ICD-9-CM 81.02, 81.32, 81.04, 81.34, 81.06, 81.36), posterior (ICD-9-CM 81.03, 81.33, 81.05, 81.35, 81.08, 81.38), or other (ICD-9-CM 81.01, 81.31, 81.07, 81.37). If anterior and posterior fusion were present in the same discharge, operation was considered posterior. Surgical site (cervical, thoracic, lumbar, or lumbro-sacral) was not specifically examined. Similarly, the specific heart valve operated upon, the number of coronary arteries bypassed, and the laterality of hip or knee arthroplasty were not included. Intraoperative data, e.g., arterial blood pressure, length of surgery, laboratory data, and IV fluids and drugs administered, were not available in the database.

Patients discharged with a principal or secondary diagnostic ICD-9-CM code of sudden visual loss (368.11), ION (377.41), CB (377.75), or RVO (362.3) were considered to have had POVL during the hospitalization.

Patient and Surgical Characteristics

Patient's age and gender, but not race, missing in more than 20% of the records, were used in the statistical analyses. Patient weight was not available. We used the Charlson comorbidity index[15] with Deyo ICD-9-CM modification, which provides a valid and reliable measurement for coexisting morbid conditions in clinical research[16] and has been used and verified in outcome studies.[17–19] We identified patients who had at least one blood transfusion (CCS 222) and patients who were anemic (ICD-9-CM 280 [iron deficiency anemias], 281 [pernicious anemia, vitamin B12 and folate deficiency anemia, and other deficiency anemia], 282 [hereditary hemolytic anemias], 283 [acquired hemolytic anemia], 284 [aplastic anemia], or 285 [other unspecified anemias]).

If admission status was missing, we considered it elective if the admission type was routine and nonelective if otherwise. To evaluate trends in POVL prevalence, we studied each calendar year (1996–2005 inclusive) individually, and to increase the size of the time-related database for study, the database was divided into five 2-yr time periods, e.g., 1996–1997, 1998–1999. To assess impact of surgical volume, we ranked hospitals by total annual volume for each procedure and evenly divided them into quintiles as described by Birkmeyer et al.[20]

Statistics

Analytic Dataset

NIS core datasets for 1996–2005 contained 74,451,816 discharges. Each of the core files for 1996–2002 was merged with the corresponding NIS Trends Supplemental File to obtain trend weights and data elements consistently defined across data years; supplemental files are not needed after 2002.# Data were reduced following the procedure recommended by HCUP when computing contraints prevented use of the entire NIS.** Specifically, for each year, the dataset was condensed to the subpopulation of interest (the above categories of surgical discharges) and augmented with one "dummy" observation for each NIS hospital, for which the survey weight and analytic variables were set to zero. Augmentation ensures that subpopulation analysis in the reduced dataset yields correct standard errors, identical to those that would be obtained from the full dataset. The augmented datasets were merged producing 5,689,335 observations, of which 5,679,422 were in the subpopulation of interest.

Analysis

To strictly protect patients' privacy, HCUP prohibits disclosure of data where the cell size is ≤ 10. Prevalence rates for any POVL and specific types of POVL (CB, ION, RVO) were estimated, overall, and by subgroups defined by patient demographic and clinical characteristics (age group, gender, Charlson index, and presence of anemia), surgical variables (type of procedure, blood transfusion, and elective admission), surgical volume of hospital, and calendar year. Age and calendar year were analyzed as categorical covariates because of nonlinearity of their effects on the continuous scale. Calendar year was fit using 1- and 2-yr intervals, which yielded similar results; results are presented, for simplicity and to yield higher numbers of patients and accuracy for analysis, using 2-yr intervals. Because of an extremely skewed distribution, with only 5.4% of patients having scores >1, Charlson index was categorized as "0," "1," and "2 or more." Because of the low occurrence of POVL in appendectomy, cholecystectomy, and colorectal resection, these surgeries were grouped into one category. Knee arthroplasty, hip replacement or hip/femur surgical treatment, and laminectomy without fusion were designated "nonfusion orthopedic surgery."

Univariate and multivariable logistic regression models were fit to identify potential risk factors for specific POVL diagnoses (CB, ION, and RVO), examining demographics, comorbidities, admission type, surgical variables, surgical volume, and calendar year. Subgroup analyses were conducted for specific surgical categories, i.e., spinal fusion and cardiac surgery (any POVL). Categories of covariates were collapsed for selected analyses when the number of cases was small. Parsimonious models were obtained by backward elimination. Full models included all univariate analysis covariates except surgical volume quintile. Results for full and parsimonious models were similar; therefore, for brevity, only the full models are presented.

#HCUP NIS Trends Supplemental Files Healthcare Cost and Utilization Project (HCUP), May 2008. Rockville, MD: U.S. Agency for Healthcare Research and Quality. Available at: www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp. Accessed August 2008.

**Houchens R, Elixhauser A. Final Report on Calculating Nationwide Inpatient Sample (NIS) Variances, 2001. HCUP Method Series Report #2003-02. Rockville, MD: U.S. Agency for Healthcare Research and Quality. Available at: http://www.hcup-us.ahrq.gov/reports/2003_2.jsp. Accessed August 2008.

Table 1. Frequency and National Incidence[a] of Perioperative Visual Loss (POVL) by Surgical Procedure for Years 1996–2005

	Frequency		POVL incidence per 10,000[a]	
Procedure	POVL discharges	Total discharges	Estimate	95% CI
Hip/femur treatment	226	1,207,542	1.86	1.61–2.14
Knee replacement	84	771,528	1.08	0.86–1.37
Cholecystectomy	51	796,284	0.66	0.50–0.88
Cardiac surgery[b]	704	815,856	8.64	7.83–9.54
Appendectomy	[c]	550,945	0.12	0.01–0.26
Colorectal resection	69	543,201	1.24	0.97–1.59
Laminectomy without fusion	45	528,721	0.86	0.63–1.16
Spinal fusion	140	465,345	3.09	2.35–4.06
Total	1326	5,679,422	2.35	2.16–2.55

CI = confidence intervals.

[a] Estimates are weighted to account for the differential probabilities of selection in the Nationwide Inpatient Sample (NIS) sampling design.

[b] Cardiac surgery includes valve and coronary artery bypass grafting surgery.

[c] The numerical result when less than 10 may not be reported according to NIS regulations.

Table 2. Frequency of Specific Types of Perioperative Visual Loss (POVL) by Surgical Procedure for Years 1996–2005[a]

Procedure	All POVL	Ischemic optic neuropathy	Cortical blindness	Retinal vascular occlusion	Total discharges
Hip/femur treatment	226	43	68	113	1,207,542
Knee replacement	84	>10[b]	<10	65	771,528
Cholecystectomy	51	<10	<10	34	796,284
Cardiac surgery[c]	704	114	53	541	815,856
Appendectomy	<10	<10	<10	<10	550,945
Colorectal resection	69	>10[b]	<10	43	543,201
Laminectomy without fusion	45	<10	<10	32	528,721
Spinal fusion	140	39	68	32	465,345
Total	1326	245	215	864	5,679,422

[a] The numerical result when less than 10 may not be reported according to Nationwide Inpatient Sample (NIS) regulations.

[b] Count is reported as >10 to avoid indirectly revealing value of count <10 for cortical blindness.

[c] Cardiac surgery includes valve and coronary artery bypass grafting surgery.

Analyses accounted for the survey sampling design by incorporating sampling strata and clusters, as well as weights adjusting for differential probability of selection. Standard errors were computed using Taylor linearization method.[21] Analyses were conducted using survey procedures in Stata 10.0 (Stata Corporation, College Station, TX: StataCorp LP; 2007).

RESULTS

Perioperative Visual Loss in Nonocular Surgery

All Included Surgical Procedures

There were 1326 discharges (2.35/10,000) with a visual loss code among the 5,679,422 eligible discharges from 1996 to 2005 (Table 1). Cardiac surgery had the highest rate (8.64/10,000), spinal fusion rate was 3.09/10,000, and laminectomy without fusion rate was 0.86/10,000. The lowest rate, 0.12/10,000, was for appendectomy. Of the 704 POVL cases in cardiac surgery, the majority (541, 77%, unweighted) had RVO, 114 (16%) had ION, and 53 (8%) had CB (Table 2). With respect to spine surgery, 39 (28%) of 140 POVL cases were diagnosed with ION, 32 (23%) with RVO, and 68 (49%) with CB (Table 2).

Table 3 summarizes patient demographic, clinical, and surgical characteristics and univariate associations with POVL; multivariable associations are in Table 4A. Those patients younger than 18 yr had the highest prevalence of POVL (4.37/10,000) and 18–49 yr had the lowest (0.92/10,000), whereas rates were 2.46–2.87/10,000 among those ≥50 yr ($P < 0.0001$). Men, 45.7% of the database, had greater POVL prevalence than women (3.16 vs 1.68/10,000; odds ratio [OR] 1.88, confidence interval [CI]: 1.67–2.12; $P < 0.0001$). There was a significantly higher prevalence of POVL with Charlson index >0, blood transfusion, anemia, and spinal, orthopedic, or cardiac surgery (by univariate and multivariable analysis). POVL decreased from 3.06/10,000 in 1996–1997 to 2.03/10,000 in 2004–2005 ($P < 0.001$), an effect significant, although attenuated, in multivariable analysis ($P = 0.02$).

Cardiac Surgery

Table 5 reports univariate analysis of POVL among 815,856 cardiac surgery patients; multivariable analyses are in Table 4B. Among men (67.7%), the prevalence was 9.45 vs 6.95/10,000 for women (OR 1.36, CI: 1.15–1.61; $P = 0.0003$). Other factors included Charlson index, blood transfusion, and anemia, all confirmed by multivariable analysis, except anemia. The prevalence decreased from 9.74 in 1996–1997 to 8.30/10,000 in 2004–2005 ($P = 0.002$).

Table 3. Perioperative Visual Loss (POVL) by Patient Demographic, Clinical, and Surgical Characteristics—Incidence and Univariate Associations[a]

Covariates	Covariate levels	Subgroup percent	POVL cases	Incidence per 10,000		Univariate logistic regression		
				Estimate	95% CI	Odds ratio	95% CI	*P*
Overall			1326	2.35	2.16–2.55			
Age group	<18	4.34	107	4.37	2.95–6.46	4.75	3.14–7.18	
	18–49	25.10	128	0.92	0.74–1.14	Referent		<0.0001
	50–64	23.17	323	2.46	2.17–2.79	2.68	2.13–3.37	
	≥65	47.39	768	2.87	2.62–3.14	3.12	2.50–3.89	
Gender	Female	54.34	516	1.68	1.50–1.88	Referent		<0.0001
	Male	45.66	810	3.16	2.87–3.47	1.88	1.67–2.12	
Charlson index	0	79.67	898	2.00	1.82–2.20	Referent		<0.0001
	1	17.61	333	3.33	2.90–3.82	1.66	1.45–1.91	
	≥2	2.72	95	6.15	4.98–7.59	3.07	2.45–3.85	
Blood transfused	No	87.72	1070	2.17	1.98–2.37	Referent		<0.0001
	Yes	12.28	256	3.64	3.13–4.23	1.68	1.43–1.97	
Anemia	No	80.05	947	2.10	1.91–2.31	Referent		<0.0001
	Yes	19.95	379	3.36	2.99–3.77	1.60	1.40–1.82	
Elective admission	No	47.98	563	2.23	1.98–2.52	Referent		0.39
	Yes	52.02	651	2.38	2.13–2.67	1.07	0.92–1.24	
Type of surgery	Abdominal	33.28	127	0.67	0.56–0.81	Referent		<0.0001
	Nonfusion ortho	44.11	355	1.41	1.25–1.59	2.09	1.70–2.58	
	Spinal fusion	8.11	140	3.09	2.35–4.06	4.59	3.29–6.41	
	Cardiac	14.50	704	8.64	7.83–9.54	12.85	10.44–15.83	
Calendar year	1996–1997	18.53	320	3.06	2.57–3.64	1.51	1.20–1.90	
	1998–1999	18.64	273	2.69	2.31–3.13	1.33	1.08–1.63	
	2000–2001	20.11	239	2.08	1.76–2.46	1.03	0.83–1.26	
	2002–2003	21.06	247	2.01	1.72–2.36	0.99	0.81–1.22	
	2004–2005	21.67	247	2.03	1.74–2.35	Referent		0.0003
Surgical volume quintile	1st	1.63	22	2.32	1.52–3.55	Referent		0.46
	2nd	6.08	94	2.77	2.22–3.46	1.19	0.75–1.91	
	3rd	12.90	177	2.41	2.02–2.88	1.04	0.66–1.64	
	4th	24.34	302	2.17	1.88–2.50	0.93	0.60–1.45	
	5th	55.05	731	2.37	2.10–2.67	1.02	0.66–1.58	

CI = confidence intervals.

[a] All estimates, including subgroup percent, are weighted to account for the differential probabilities of selection in the Nationwide Inpatient Sample (NIS) sampling design.

Spinal Fusion

Table 6 reports univariate analysis of POVL among 465,345 spinal fusion patients. Factors that conferred higher odds of POVL included age, anemia, blood transfusion, and posterior approach for surgery. Those patients younger than 18 yr had the highest prevalence (34.5/10,000). Among adults ≥18 yr, POVL increased significantly from 1.16/10,000 among those 18–49 yr to 3.02/10,000 for those ≥65 yr. The prevalence of POVL decreased from 6.30/10,000 in 1996–1997 to 2.79/10,000 in 2004–2005 ($P = 0.045$). The percent of patients undergoing the posterior or anterior approach was nearly the same (46.48% and 45.19%, respectively), but the prevalence of POVL was 5.50/10,000 in posterior, 2.83/10,000 in "other," and 0.66/10,000 in the anterior approach ($P < 0.0001$). The odds of POVL were significantly greater for the posterior or "other" approach compared with those for the anterior (posterior: OR 8.29, CI: 4.32–15.92; other: OR 4.27, CI: 1.80–10.15; $P < 0.0001$).

Multivariable analysis (Table 4C) was confirmatory except for blood transfusion and calendar year, whereas men had higher odds of POVL (1.75, CI: 1.22–2.50; $P = 0.002$). In summary, multivariable models showed that age <18 or ≥65 yr, male gender, anemia, and posterior approach, but not blood transfusion or calendar year, resulted in significantly higher odds of POVL.

Ischemic Optic Neuropathy

Overall, ION rate during 1996–2005 was 0.43 (CI 0.37–0.50) per 10,000 discharges (Table 7A). ION rate was significantly higher in patients aged 50–64 yr (0.63/10,000, OR 2.75, CI: 1.84–4.11) and in those ≥65 yr (0.43/10,000, OR 2.01, CI: 1.35–3.00) compared with <50 yr-of-age (0.23/10,000, $P < 0.0001$). Other factors included male gender, Charlson index >0, anemia, and orthopedic, spinal fusion, and cardiac surgery. Multivariable analysis (Table 8A) upheld results only for age, male gender, and surgery type.

Retinal Vascular Occlusion

Overall, the RVO rate during 1996–2005 was 1.54 (CI 1.41–1.68) per 10,000 discharges (Table 7B) and increased with age ($P < 0.0001$); the highest prevalence was in patients aged >65 yr (2.14/10,000, OR 4.79, CI: 3.55–6.45 vs <50 yr). Men were nearly twice

Table 4. Multivariable Associations of Perioperative Visual Loss (POVL) with Patient Demographic, Clinical, and Surgical Characteristics[a]

Covariates[b]	Covariate levels	Odds ratio	95% CI	*P*
A. All surgical procedures				
Age group	<18	6.91	4.30–11.1	
	18–49	Referent		<0.001
	50–64	1.51	1.18–1.94	
	≥65	1.99	1.55–2.56	
Male		1.32	1.16–1.50	<0.001
Charlson index	0	Referent		<0.001
	1	1.21	1.04–1.39	
	≥2	1.95	1.53–2.50	
Blood transfused		1.23	1.03–1.46	0.02
Anemia		1.28	1.10–1.50	0.002
Type of surgery	Abdominal	Referent		<0.001
	Nonfusion ortho	2.03	1.53–2.69	
	Spinal fusion	5.55	3.81–8.09	
	Cardiac	11.1	8.35–14.7	
Calendar year	1996–1997	1.31	1.04–1.64	
	1998–1999	1.19	0.97–1.46	
	2000–2001	0.94	0.76–1.17	
	2002–2003	0.96	0.79–1.18	
	2004–2005	Referent		0.02
B. Cardiac surgery[c]				
Male		1.34	1.12–1.59	0.001
Charlson index	0	Referent		0.002
	1	1.01	0.84–1.22	
	≥2	1.68	1.26–2.24	
Blood transfused		1.23	0.99–1.53	0.06
Calendar year	1996–1997	1.13	0.81–1.56	
	1998–1999	1.29	1.00–1.68	
	2000–2001	0.85	0.64–1.12	
	2002–2003	0.90	0.69–1.19	
	2004–2005	Referent		0.007
C. Spinal fusion				
Age group	<18	18.3	9.81–34.0	
	18–49	Referent		<0.0001
	50–64	1.65	0.90–3.03	
	≥65	2.07	1.12–3.80	
Male		1.75	1.22–2.50	0.002
Anemia		1.65	1.06–2.59	0.03
Surgical position	Anterior	Referent		0.0001
	Posterior	4.16	2.13–8.13	
	Other	2.69	1.09–6.62	

CI = confidence intervals.

[a] Multivariable logistic regression. Estimates are weighted to account for differential probabilities of selection in the Nationwide Inpatient Sample (NIS) sampling design.

[b] The models include all univariate covariates except surgical volume quintile. Results are shown for effects with $P < 0.10$.

[c] Cardiac surgery includes valve and coronary artery bypass grafting surgery.

as likely as women to develop RVO (2.11 vs 1.07/10,000, OR 1.98, CI: 1.71–2.29; $P < 0.0001$). Other factors included Charlson index >0, blood transfusion, anemia, and orthopedic, spinal fusion, and cardiac surgery. The RVO rate decreased from 2.07 in 1996–1997 to 1.31/10,000 in 2004–2005 ($P = 0.002$). Multivariable analysis (Table 8B) upheld all except for decrease over time.

Cortical Blindness

The rate of POVL due to CB during 1996–2005 was 0.38 (CI 0.29–0.48) per 10,000 discharges (Table 7C). Patients younger than 18 yr had a significantly higher prevalence (4.33/10,000, CI: 2.92–6.42) compared with those >18 yr (0.12–0.25/10,000; $P < 0.0001$). Higher Charlson index, elective admission, and orthopedic, spinal or cardiac surgery were other factors, upheld by multivariable analysis, except for elective admission (Table 8C).

DISCUSSION

POVL prevalence was 0.003%–0.0008% in the general surgical population in two older retrospective single institution studies.[5,6] POVL after cardiac surgery was estimated as high as 1.3%[22] but 0.06% and 0.113% in more recent retrospective studies.[4,23] Visual loss after spine surgery was estimated as high as 0.20%[9] but 0.028% in the most recent largest study (>14,000 patients) at a single hospital.[7] These studies,

Table 5. Perioperative Visual Loss (POVL) for Cardiac Surgery Discharges by Patient Demographic, Clinical, and Surgical Characteristics—Incidence and Univariate Associations[a]

Covariates	Covariate levels	Subgroup percent	POVL cases	Incidence per 10,000		Univariate logistic regression		
				Estimate	95% CI	Ratio	95% CI	*P*
Overall			704	8.64	7.85–9.52			
Age group	<50	10.01	76	9.35	7.16–12.21	Referent		0.74
	50–64	32.74	224	8.34	7.25–9.60	0.89	0.66–1.21	
	≥65	57.26	404	8.69	7.69–9.82	0.93	0.70–1.24	
Age group (excluding <18)	18–49	9.15	71	9.60	7.26–12.69	Referent		0.67
	50–64	32.74	224	8.34	7.25–9.60	0.87	0.63–1.19	
	≥65	57.26	404	8.69	7.69–9.82	0.91	0.67–1.22	
Gender	Female	32.27	185	6.95	5.94–8.12	Referent		0.0003
	Male	67.73	519	9.45	8.50–10.51	1.36	1.15–1.61	
Charlson index	0	66.56	454	8.40	7.57–9.31	Referent		0.001
	1	28.04	189	8.22	6.85–9.87	0.97	0.81–1.18	
	≥2	5.40	61	13.87	10.81–17.80	1.65	1.26–2.16	
Blood transfused	No	83.26	562	8.31	7.46–9.25	Referent		0.03
	Yes	16.74	142	10.31	8.62–12.34	1.24	1.02–1.52	
Anemia	No	76.34	514	8.27	7.41–9.22	Referent		0.045
	Yes	23.66	190	9.86	8.45–11.50	1.19	1.004–1.42	
Elective admission	No	52.13	334	8.39	7.28–9.67	Referent		0.88
	Yes	47.87	301	8.28	7.34–9.35	0.99	0.84–1.17	
Calendar year	1996–1997	22.24	178	9.74	7.76–12.22	1.17	0.88–1.57	
	1998–1999	20.33	170	10.69	9.08–12.58	1.29	1.01–1.65	
	2000–2001	21.42	124	6.99	5.76–8.47	0.84	0.65–1.09	
	2002–2003	19.49	120	7.37	6.04–9.01	0.89	0.67–1.17	
	2004–2005	16.51	112	8.30	6.88–10.02	Referent		0.002
Surgical volume quintile	1st	2.82	19	8.02	5.19–12.41	Referent		0.37
	2nd	8.93	57	7.80	6.02–10.12	0.97	0.59–1.61	
	3rd	14.74	101	8.35	6.82–10.23	1.04	0.64–1.68	
	4th	23.85	147	7.55	6.39–8.93	0.94	0.59–1.50	
	5th	49.67	380	9.44	8.13–10.97	1.18	0.74–1.86	

CI = confidence intervals.

[a] All estimates, including subgroup percent, are weighted to account for the differential probabilities of selection in the Nationwide Inpatient Sample (NIS) sampling design.

however, are limited by the relatively low total number of procedures and POVL cases. It is not known whether the figures merely reflect institutional experience and if they can be generally applied to the US population.

Our national sample analysis showed an overall prevalence of POVL of 2.35/10,000 (0.0235%), and that cardiac surgery and spinal fusion remain the two most likely to be complicated by POVL, with prevalence rates of 0.0864% and 0.0309%, respectively. The rate for spine surgery was lower than that found in the recent NIS 1993–2002 survey (0.094%) by Patil et al.,[14] perhaps because of their inclusion of other causes of noncentral retinal artery occlusion and non-ION visual loss.

We also, for the first time, demonstrated a smaller but nontrivial rate of POVL in two very commonly performed orthopedic surgeries: hip replacement/femur treatment and knee arthroplasty, at 0.0186% and 0.0108%, respectively. In contrast, POVL after cholecystectomy and appendectomy was 1/10–1/2 the prevalence of these procedures, and after laminectomy without fusion, just 0.0086%. Our results for POVL prevalence are higher than in previous studies of nonocular surgery, but for specific surgical procedures, including cardiac and spine fusion, they are in accord with previous estimates from far smaller studies. Our overall estimate may be higher than previously reported by us and others, because approximately 25% of the current database consisted of the highest risk cardiac and spine patients.

Our study suggests that the three major causes of perioperative visual loss, ION, RVO, and CB, share common factors but differ in other important respects. All three, and all causes of POVL overall, occurred with significantly higher rates and odds ratios in orthopedic, spine fusion, and cardiac surgery compared with abdominal surgery. Our data may provide, for the first time, legitimate guidance concerning risks of visual loss for patients undergoing these procedures.

Age was a factor in all causes but in a strikingly differing pattern. Consistent with previous case reports, we found that patients aged 50 yr and older were more likely to develop ION and RVO than patients in the 18–34 yr age range.[9] It has been proposed that elderly patients may experience POVL more frequently, possibly because they are more likely to have systemic vascular occlusive disease.[24] However, patients younger than 18 yr had the greatest risk of developing POVL, and CB in particular, among all age groups. But the impact of age on POVL also

Table 6. Perioperative Visual Loss (POVL) for Spinal Fusion Discharges by Patient Demographic, Clinical, and Surgical Characteristics—Incidence and Univariate Associations[a]

Covariates	Covariate levels	Subgroup percent	POVL cases	Incidence per 10,000		Univariate logistic regression		
				Incidence	95% CI	Odds ratio	95% CI	*P*
Overall			140	3.09	2.36–4.04			
Age group	<18	3.89	61	34.46	22.59–52.53	29.8	17.2–51.9	
	18–49	46.38	23	1.16	0.73–1.84	Referent		<0.0001
	50–64	30.04	28	2.06	1.36–3.12	1.78	0.98–3.24	
	≥65	19.69	28	3.02	2.08–4.39	2.61	1.43–4.77	
Gender	Female	53.07	66	2.80	1.97–3.98	Referent		0.25
	Male	46.93	74	3.43	2.58–4.55	1.23	0.87–1.73	
Charlson index	0	85.71	120	3.09	2.29–4.17	Referent		0.99
	≥1	14.3	20	3.10	2.02–4.76	1.01	0.60–1.68	
Blood transfused	No	90.26	108	2.62	1.98–3.48	Referent		<0.0001
	Yes	9.74	32	7.41	4.92–11.17	2.83	1.89–4.22	
Anemia	No	87.29	97	2.44	1.78–3.34	Referent		<0.0001
	Yes	12.71	43	7.56	5.44–10.52	3.10	2.12–4.54	
Elective admission	No	13.70	15	2.63	1.60–4.32	Referent		0.53
	Yes	86.30	118	3.17	2.33–4.32	1.21	0.67–2.17	
Calendar year	1996–1997	10.20	28	6.30	4.01–9.89	2.26	1.25–4.10	
	1998–1999	15.99	20	2.93	1.63–5.27	1.05	0.54–2.04	
	2000–2001	20.43	26	2.83	1.63–4.89	1.01	0.59–1.75	
	2002–2003	25.36	30	2.44	1.55–3.84	0.88	0.53–1.44	
	2004–2005	28.03	36	2.79	1.90–4.09	Referent		0.045
Surgical volume quintile	1st–3rd	15.22	29	4.21	2.54–6.96	Referent		0.26
	4th	22.84	40	3.67	2.08–6.46	0.87	0.51–1.48	
	5th	61.94	71	2.60	1.96–3.45	0.62	0.35–1.10	
Surgical position	Anterior	45.19	13	0.66	0.36–1.22	Referent		<0.0001
	Posterior	46.48	116	5.50	4.08–7.40	8.29	4.32–15.92	
	Other	8.33	11	2.83	1.48–5.42	4.27	1.80–10.15	

CI = confidence intervals.

[a] All estimates, including subgroup percent, are weighted to account for the differential probabilities of selection in the Nationwide Inpatient Sample (NIS) design.

depended upon the surgical procedure. Patients younger than 18-yr-of-age undergoing spine, but not cardiac surgery, were at higher risk of POVL. Pediatric POVL cases have been reported rarely in the literature.[7,25] The origin of this heightened risk in the <18 yr old surgical population is not clear. CB is generally associated with stroke or embolic phenomena.[26] The former would be distinctly unusual in children and the latter a more plausible mechanism, but one that cannot be confirmed using the NIS database. It is possible that CB actually represented misdiagnosed ION, but this explanation is questionable because ION has also been uncommonly reported in children. Further studies in the pediatric population are needed to follow-up upon this disconcerting finding.

Gender was a common factor in POVL overall, in ION, and RVO. Men constituted a smaller percentage of the patients undergoing spine fusion, yet in the multivariable analysis had 1.3 times higher odds ratio of visual loss than women, twice the odds ratio of developing ION, and 1.33 times higher odds ratio of developing RVO (again despite being a smaller % of the surgical population for ION and RVO as well), in comparison with women. Higher Charlson comorbidity index, a composite of a collection of preexisting medical conditions, was associated with greater odds of developing POVL, and specifically, RVO and CB, but not ION. It was also a factor in POVL in cardiac but not spine fusion surgery. The index does not address any one specific medical condition and thus cannot be used to ascribe a causative link between a particular preexisting disease and the development of POVL. The factors of age, gender, and comorbidities suggest that there are specific patient susceptibilities to some types of POVL that are independent of the surgical procedure or the population undergoing the surgery.

It has been proposed that intraoperative anemia, or acute blood loss during the operation, predisposes a patient to POVL.[24] Patients who had a blood transfusion during the hospitalization were found to be at increased risk of developing POVL, but only RVO in particular. Anemia increased the odds ratio of POVL in spine but not cardiac surgery. The limitation of these data is that it is unknown at what point in relation to the surgery and to what degree the patient was anemic, or when patients were transfused and with how many units.

Given the devastating nature of POVL, it is natural to ask whether surgical experience[20] or the nature of the admission play any role in its unfortunate occurrence. In this study, surgical volume and type of elective or nonelective surgery had no impact. These findings seem to reinforce the clinical impression that the development of POVL remains unpredictable in many instances and is not related to any particular hospital characteristic or degree of surgical experience.

Table 7. Specific Types of Perioperative Visual Loss (POVL) by Patient Demographic, Clinical, and Surgical Characteristics—Incidence and Bivariate Associations[a]

Covariates	Covariate levels	Subgroup percent	POVL cases	Incidence per 10,000		Univariate logistic regression		
				Estimate	95% CI	Odds ratio	95% CI	*P*
A. Ischemic optic neuropathy (ION)								
Overall			245	0.43	0.37–0.50			
Age group	<50	29.44	36	0.23	0.16–0.33	Referent		<0.0001
	50–64	23.17	85	0.63	0.50–0.79	2.75	1.84–4.11	
	≥65	47.39	124	0.43	0.38–0.57	2.01	1.35–3.00	
Age group (excluding <18)	18–49	25.10	36	0.27	0.19–0.38	Referent		0.0001
	50–64	23.17	85	0.63	0.50–0.79	2.35	1.58–3.47	
	≥65	47.39	124	0.43	0.38–0.56	1.71	1.16–2.54	
Gender	Female	54.34	77	0.25	0.20–0.32	Referent		<0.0001
	Male	45.66	168	0.65	0.54–0.78	2.60	1.95–3.46	
Charlson index	0	79.67	180	0.40	0.33–0.47	Referent		0.03
	≥1	20.33	65	0.56	0.43–0.75	1.42	1.04–1.93	
Blood transfused	No	87.72	204	0.41	0.35–0.49	Referent		0.06
	Yes	12.28	41	0.57	0.42–0.77	1.38	0.99–1.94	
Anemia	No	80.05	176	0.39	0.32–0.47	Referent		0.003
	Yes	19.95	69	0.60	0.47–0.78	1.55	1.16–2.08	
Elective admission	No	47.98	96	0.38	0.30–0.48	Referent		0.08
	Yes	52.02	134	0.49	0.40–0.60	1.30	0.97–1.75	
Surgery	Abdominal	33.28	24	0.12	0.001,0.18	Referent		<0.0001
	Nonfusion ortho	44.11	68	0.27	0.21–0.34	2.24	1.39–3.61	
	Spinal fusion	8.11	39	0.88	0.60–1.30	7.34	4.14–13.0	
	Cardiac	14.50	114	1.39	1.11–1.74	11.57	7.13–18.8	
Calendar year	1996–1997	18.53	57	0.54	0.40–0.75	1.52	0.97–2.37	
	1998–1999	18.64	50	0.48	0.36–0.65	1.35	0.89–2.04	
	2000–2001	20.11	48	0.43	0.31–0.58	1.19	0.77–1.83	
	2002–2003	21.06	46	0.37	0.25–0.54	1.02	0.62–1.68	
	2004–2005	21.67	44	0.36	0.26–0.49	Referent		0.28
Surgical volume quintile	1st–2nd	7.71	<10[b]			Referent		0.07
	3rd	12.90	29	0.38	0.26–0.55	1.57	0.75–3.31	
	4th	24.34	51	0.36	0.27–0.49	1.50	0.74–3.07	
	5th	55.05	155	0.50	0.41–0.62	2.10	1.07–4.12	
B. Retinal vascular occlusion (RVO)								
Overall			864	1.54	1.41–1.68			
Age group	<50	29.44	73	0.45	0.33–0.60	Referent		<0.0001
	50–64	23.17	220	1.70	1.47–1.96	3.80	2.78–5.19	
	≥65	47.39	571	2.14	1.94–2.37	4.79	3.55–6.45	
Age group (excluding <18)	18–49	25.10	72	0.52	0.39–0.69	Referent		<0.0001
	50–64	23.17	220	1.70	1.48–1.95	3.28	2.41–4.46	
	≥65	47.39	571	2.14	1.94–2.36	4.13	3.08–5.54	
Gender	Female	54.34	327	1.07	0.94–1.21	Referent		<0.0001
	Male	45.66	537	2.11	1.89–2.35	1.98	1.71–2.29	
Charlson index	0	79.67	568	1.28	1.16–1.41	Referent		<0.0001
	1	17.61	233	2.32	1.99–2.70	1.82	1.55–2.12	
	≥2	2.72	63	4.17	3.23–5.37	3.26	2.48–4.29	
Blood transfused	No	87.72	685	1.40	1.26–1.54	Referent		<0.0001
	Yes	12.28	179	2.56	2.18–3.02	1.84	1.53–2.20	
Anemia	No	80.05	603	1.34	1.21–1.49	Referent		<0.0001
	Yes	19.95	261	2.33	2.04–2.67	1.74	1.50–2.02	
Elective admission	No	47.98	394	1.57	1.37–1.80	Referent		0.33
	Yes	52.02	397	1.45	1.29–1.63	0.92	0.78–1.08	
Type of surgery	Abdominal	33.28	81	0.44	0.35–0.55	Referent		<0.0001
	Nonfusion ortho	44.11	210	0.84	0.72–0.97	1.91	1.48–2.49	
	Spinal fusion	8.11	32	0.69	0.49–0.98	1.57	1.03–2.40	
	Cardiac	14.50	541	6.67	6.01–7.41	15.2	11.8–19.6	
Calendar year	1996–1997	18.53	215	2.07	1.68–2.56	1.58	1.21–2.06	
	1998–1999	18.64	172	1.71	1.43–2.05	1.31	1.03–1.66	
	2000–2001	20.11	154	1.33	1.11–1.61	1.02	0.80–1.30	
	2002–2003	21.06	164	1.35	1.15–1.59	1.03	0.82–1.29	
	2004–2005	21.67	159	1.31	1.11–1.54	Referent		0.002

(*Continued*)

Table 7. Continued

Covariates	Covariate levels	Subgroup percent	POVL cases	Incidence per 10,000		Univariate logistic regression		
				Estimate	95% CI	Odds ratio	95% CI	P
Surgical volume quintile	1st	1.63	14	1.47	0.86–2.52	Referent		0.072
	2nd	6.08	70	2.10	1.64–2.69	1.43	0.79–2.58	
	3rd	12.90	114	1.58	1.29–1.94	1.07	0.60–1.90	
	4th	24.34	188	1.37	1.17–1.60	0.93	0.53–1.62	
	5th	55.05	478	1.54	1.35–1.77	1.05	0.60–1.83	
C. Cortical blindness (CB)								
Overall			215	0.38	0.29–0.48			
Age group	<18	4.34	106	4.33	2.92–6.42	35.7	21.3–59.9	
	18–49	25.10	18	0.12	0.001–0.22	Referent		<0.0001
	50–64	23.17	22	0.17	0.11–0.25	1.36	0.67–2.78	
	≥65	47.39	69	0.25	0.20–0.33	2.10	1.13–3.91	
Gender	Female	54.34	109	0.36	0.26–0.48	Referent		0.38
	Male	45.66	106	0.40	0.31–0.53	1.13	0.85–1.51	
Charlson index	0	79.67	149	0.33	0.24–0.45	Referent		<0.0001
	1	17.61	45	0.45	0.33–0.62	1.39	0.94–2.06	
	≥2	2.72	21	1.33	0.84–2.10	4.07	2.35–7.05	
Blood transfused	No	87.72	180	0.36	0.28–0.47	Referent		0.11
	Yes	12.28	35	0.50	0.33–0.75	1.38	0.93–2.04	
Anemia	No	80.05	166	0.37	0.28–0.49	Referent		0.43
	Yes	19.95	49	0.42	0.31–0.58	1.15	0.81–1.64	
Elective admission	No	47.98	68	0.26	0.20–0.35	Referent		0.02
	Yes	52.02	123	0.45	0.31–0.67	1.71	1.08–2.70	
Type of surgery	Abdominal	33.28	20	0.10	0.001–0.16	Referent		<0.0001
	Nonfusion ortho	44.11	74	0.29	0.22–0.39	2.79	1.63–4.79	
	Spinal fusion	8.11	68	1.50	0.91–2.46	14.36	7.32–28.2	
	Cardiac	14.50	53	0.63	0.48–0.84	6.07	3.57–10.3	
Calendar year	1996–1997	18.53	46	0.43	0.29–0.61	1.22	0.68–2.18	
	1998–1999	18.64	52	0.51	0.36–0.74	1.46	0.84–2.57	
	2000–2001	20.11	37	0.32	0.19–0.54	0.92	0.55–1.53	
	2002–2003	21.06	37	0.30	0.18–0.48	0.84	0.51–1.39	
	2004–2005	21.67	43	0.35	0.22–0.55	Referent		0.50
Surgical volume quintile	1st–2nd	7.71	22	0.47	0.28–0.78	Referent		0.40
	3rd	12.90	33	0.44	0.26–0.75	0.95	0.49–1.86	
	4th	24.34	61	0.43	0.29–0.65	0.92	0.49–1.74	
	5th	55.05	99	0.32	0.25–0.42	0.70	0.39–1.24	

CI = confidence intervals.

[a] All estimates, including subgroup percent, are weighted to account for the differential probabilities of selection in the Nationwide Inpatient Sample (NIS) sampling design.

[b] The numerical result when less than 10 may not be reported according to NIS regulations.

Contrary to clinical impression, this study showed that the prevalence of POVL has remained relatively constant or has declined. These trends were present despite significant increases in the volume of the procedures performed with the exception of CABG, which decreased 38%, and cholecystectomy, which was nearly constant during this time period.†† POVL overall, and in the setting of cardiac surgery, and RVO in all procedures, showed significant decreases (it should be noted, however, that the diagnostic coding does not distinguish the cause of RVO, i.e., embolism versus direct compression). Decreases in POVL with successive years for spinal fusion and for RVO in all procedures were not verified by multivariable analysis, and thus should be regarded only as tentative conclusions. These trends are reassuring to clinicians, who must, however, remain vigilant to the possibility of POVL in high-risk surgery, such as cardiac and spine fusion.

There are other important limitations of the study. Because of the nature of the NIS, no data are available on the anesthetics and details of the events in the perioperative period. Verification of each POVL case is not possible. We therefore relied on exclusive and specific ICD-9-CM codes to define POVL. Although diagnostic codes recorded on discharge records are taken to reflect those acquired during the hospitalization, it is possible that some of the codes in some discharges were preexisting. If this were the case, the rate of POVL might be overestimated. A means to assess this possibility is to compare our results with the prevalence of visual loss in the general population, but there are few studies in the U.S. Johnson and Arnold surveyed ophthalmologists in Missouri and in Los Angeles County, California in 1991–1992. They found that the incidence of nonarteritic anterior ischemic optic neuropathy was 0.23/10,000.[27] This figure

††National Statistics, HCUPnet Trend Information for 1996–2005, HCUP Quality Control Procedures. Rockville, MD: U.S. Agency for Healthcare Research and Quality. Available at: http://hcupnet.ahrq.gov/HCUPnet.jsp. Accessed December 2008.

Table 8. Multivariable Associations of Specific Types of Perioperative Visual Loss (POVL) with Patient Demographic, Clinical, and Surgical Characteristics[a]

Covariates[b]	Covariate levels	Odds ratio	95% CI	*P*
A. Ischemic optic neuropathy (ION)				
Age group	<50	Referent		0.04
	50–64	1.75	1.13–2.71	
	≥65	1.65	1.05–2.60	
Male		2.04	1.47–2.82	<0.001
Type of surgery	Abdominal	Referent		<0.001
	Nonfusion ortho	1.89	1.09–3.27	
	Spinal fusion	6.96	3.80–12.8	
	Cardiac[c]	8.04	4.57–14.2	
B. Retinal vascular occlusion (RVO)				
Age group	<50	Referent		<0.001
	50–64	1.87	1.31–2.66	
	≥65	2.54	1.79–3.60	
Male		1.27	1.09–1.48	0.003
Charlson index	0	Referent		<0.001
	1	1.14	0.97–1.35	
	≥2	1.81	1.35–2.43	
Blood transfused		1.26	1.04–1.53	0.02
Anemia		1.30	1.09–1.54	0.003
Type of surgery	Abdominal	Referent		<0.001
	Nonfusion ortho	1.44	1.06–1.94	
	Spinal fusion	1.83	1.17–2.84	
	Cardiac[c]	9.72	7.22–13.1	
C. Cortical blindness (CB)				
Age group	<18	64.0	35.9–114.0	
	18–49	Referent		<0.001
	50–64	0.87	0.40–1.90	
	≥65	1.49	0.77–2.90	
Elective admission		1.44	0.95–2.19	0.09
Charlson index	0	Referent		<0.001
	1	2.18	1.49–3.19	
	≥2	5.71	3.27–9.95	
Type of surgery	Abdominal	Referent		<0.001
	Nonfusion ortho	5.42	2.73–10.7	
	Spinal fusion	19.1	9.62–38.0	
	Cardiac[c]	12.7	6.43–25.0	

CI = confidence intervals.

[a] Multivariable logistic regression. Estimates are weighted to account for differential probabilities of selection in the Nationwide Inpatient Sample (NIS) sampling design.

[b] The model includes all univariate covariates except surgical volume quintile. Results are shown for effects with $P < 0.10$.

[c] Cardiac surgery includes valve and coronary artery bypass grafting surgery.

approximates that estimated in nonspinal or cardiac surgery patients in this study. However, it should be kept in mind that most cases of ION reported after surgical procedures have involved posterior ION, a far less common diagnosis overall than anterior ischemic optic neuropathy.[3,28,29] The incidence of central retinal artery occlusion in the United States is not known. In a Croatian study in 1991 of more than 465,000 patients based upon census data, the incidence was 0.07/10,000, but higher in the 60–69 yr old age group (0.38/10,000).[30] The latter figure is close to what we estimated in abdominal surgery, but in our study, the prevalence in that figure included all ages and would not be expected to be that high based upon the overall data in the Croatian study. There are no studies in the literature estimating CB not associated with surgery. According to these incidence figures in the population, it appears that our NIS data are not significantly confounded by preexisting visual loss diagnostic codes.

Several quality control measures and independent quality reviews ensure accuracy of data entry in NIS.‡‡ In general, hospital discharge databases appear to be more reliable and accurate than survey data. Diagnoses and procedures are obtained directly from providers; therefore, data are unaffected by recall bias and may be of higher quality than self-reported survey data.[31]

In conclusion, a review of 10 yr of recent NIS data showed that spinal fusion, cardiac, and nonspinal orthopedic surgery had the highest rates of POVL. Prevalence estimates were 8.64/10,000 in cardiac surgery, 3.09/10,000 in spinal fusion (5.36/10,000 with the posterior approach), 1.08 and 1.86/10,000 in knee and hip surgery, respectively, and 0.12/10,000 in appendectomy. Patient age, gender, and comorbidities

‡‡HCUP Quality Control Procedures. Rockville, MD: U.S. Agency for Healthcare Research and Quality. Available at: http://www.hcup-us.ahrq.gov/db/quality.jsp. Accessed May 2008.

are associated factors in some instances. The overall yearly prevalence for POVL in the most commonly performed inpatient surgical procedures in the United States has been decreasing.

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