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Cardiorespiratory Events Associated With Ophthalmic Surgery: A Single-Center, Retrospective Records Review of 130 775 Patients, 1999–2015

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Abstract

Purpose: The most recent study of ophthalmic surgery morbidity and mortality was published in 1995, with a patient study population from 1977 to 1988. The present study reports surgical outcomes from a single-center, retrospective analysis of patient records from 1999 to 2015. **Methods:** Three International Classification of Diseases–9-CM codes for cardiorespiratory events were searched in the discharge diagnoses in an eye hospital over a 16-year period. The overall mortality and preoperative risk factors were analyzed, including the type of anesthetic, type of surgery, medical comorbidities, and bradycardia preceding the cardiac events. **Results:** Between February 1, 1999 and October 1, 2015, a total of 130 775 patients presented for ophthalmic surgery. Fifty-nine patients (0.45 per 1000) experienced a cardiorespiratory event. Of the 59 patients, 14 patients had a cardiorespiratory arrest, 9 of whom died during the perioperative period. Of the remaining 45 patients, 29 had significant adverse events needing some form of advanced monitoring, evaluation, and/or intervention. There was a significantly greater prevalence of diabetes among patients who had a cardiorespiratory event ($P < .001$). **Conclusions:** The major risk factor associated with ophthalmic surgery morbidity and mortality was diabetes with its associated complications of autonomic neuropathy, nephropathy, and retinopathy. Of the 9 patients who died, 8 were diabetic with proliferative diabetic retinopathy and renal insufficiency/failure. The ninth mortality was secondary to a venous air embolism during ocular air infusion. The adage that "the eye is the window to our overall health" seems to be correct.

Keywords

autonomic neuropathy, morbidity and mortality, ophthalmic surgery, perioperative complications

Introduction

Since the publication of Beecher and Todd's classic paper in 1954 consisting of more than 599 000 procedures, perioperative morbidity and mortality for patients undergoing ophthalmic surgery has significantly decreased.[1] According to this paper, after preexisting disease, surgical complications were the most common causes of morbidity and mortality followed by anesthetic complications. Improved surgical techniques, anesthesia, and monitoring have all contributed to this decline.[2] In 1974, Quigley reported 76 deaths that occurred in 47 001 (1.6 per 1000) ophthalmic surgery patients over 20 years.[3] He reported an adjusted mortality of 0.10%, confirming that death was much less common after ophthalmic surgery than after general surgery. The leading cause of death was pulmonary embolism followed by myocardial infarction, cerebrovascular accidents, and anesthesia. The Quigley study analyzed patient outcomes between 1952 and 1972, when cataract surgery was performed under general anesthesia (GA) and associated with inpatient stays of a week or more.

Kelman's[4] phacoemulsification technique transformed cataract surgery, reducing hospital stay and morbidity. In 1980,

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Backer et al[5] published a series of 10 278 ophthalmic surgery patients who underwent surgery between 1962 and 1977. During this period, local anesthesia was commonly used and median hospital stay had decreased to 3 days. Backer et al[5] concluded that ophthalmic surgery had a "trivial" risk. A follow-up study in their institution of vitreoretinal surgery patients under GA found a 1% incidence of major adverse coronary events.[6] In 1971, Machemer et al[7] published their pars plana technique allowing surgical access to the posterior chamber, revolutionizing ophthalmic surgery while introducing a new population of patients, many of whom had significant comorbidities.

Routine preoperative testing has been found ineffective with regard to reducing morbidity and mortality prior to cataract surgery, which presently has a quoted mortality rate of 0.14 per 1000 surgeries.[8] A high proportion of cataract surgery patients are aged 65 years and older. The prevalence of comorbidities is high in this population, and it is therefore believed that this mortality rate may not be lowered further.

The most recent morbidity and mortality series of ophthalmic surgery patients was published in 1995 by Badrinath et al, discussing outcomes from 10 487 patients who underwent surgery between 1977 and 1988.[9] They reported an overall mortality of 1.15 per 1000 surgeries. Approximately half had cataract extractions. Vitreoretinal procedures were associated with a 14-fold increase in perioperative morbidity and mortality compared to other ophthalmic procedures. The authors did not discuss the prevalence of diabetes, although it is well known to increase perioperative morbidity and mortality rates in the context of many types of surgical procedures.[10]

The "triopathy" of diabetes (neuropathy, nephropathy, and retinopathy) in long-term diabetic patients results in 5-year survival rates that are markedly lower than those of nondiabetic patients following vitreoretinal surgery.[11] The poorer outcomes with resuscitation in diabetic patients appear to be the result of multiple organ involvement.[12] Renal failure patients are, additionally, prone to malignant arrhythmias following a triggering event.[13]

Approximately 80% of diabetic retinal surgery patients have severe autonomic neuropathy, which places them at increased risk of bradycardia and/or sudden death during anesthesia and surgery.[14,15] Abnormalities of parasympathetic and sympathetic autonomic function in diabetic patients are independent predictors of 10-year cardiovascular mortality.[16] Patients with type 2 diabetes have a higher incidence of autonomic neuropathy than patients with type 1; this is likely due to disease progression attributed to diabetes type 2 often being diagnosed later in life.[14]

Many patients with microvascular disease have underlying coronary artery disease, making them more vulnerable to ischemic events. The Detection of Ischemia in Asymptomatic Diabetics (DIAD) study of asymptomatic diabetics who underwent cardiac stress testing with adenosine-sestamibi myocardial perfusion imaging revealed that such stress testing *did not predict* which patients developed a major adverse cardiac event (MACE) or experienced sudden death.[17] In contrast, cardiac autonomic neuropathy (CAN) was found to be predictive of both a MACE and sudden death, confirming findings of older studies.[18] Ophthalmic surgery presently is considered to be very low risk.[19] In the development of the recent "universal" American College of Surgeons National Surgical Quality Improvement Program MACE calculator,[20] ophthalmic surgery was not included for this reason.

There is a lack of recent data regarding morbidity and mortality associated with ophthalmic surgery. The present study was undertaken to assess morbidity and mortality in a recent cohort of ophthalmic patients.

Table 1. Patient Characteristics and Perioperative Data of the 59 Patients Who Had a Cardiorespiratory Event.

Patient or Procedure Characteristics	No. (%)
Age, y	
≥ 50	52 (88)
< 50	7 (12)
Sex	
Male	30 (51)
Female	39 (48)
ASA	
I or II	3 (5.1)
III or IV	56 (94.9)
Comorbidities[a]	
Hypertension	48
Coronary artery disease	29
Diabetes	37
Chronic kidney disease	13
Procedure	
Vitreoretinal surgery	29 (49)
Other	30 (51)
Anesthesia type[b]	
MAC	24 (41)
General	29 (59)
Laryngeal mask airway	5
Endotracheal tube	24
Operative time, h	
> 3	2 (3.4)

Abbreviations: ASA, American Society of Anesthesiologists; MAC, monitored anesthesia care with a combination of sedation and/or retrobulbar block.
[a]Some patients had more than one comorbidity.
[b]Six cases were canceled because of cardiac events before starting procedure.

Methods

Approval was obtained from the institutional review board of the University of Alabama at Birmingham (UAB), as was a waiver for informed consent. The International Classification of Diseases, Ninth Revision (ICD-9) discharge diagnoses for patients who underwent surgery at UAB Callahan Eye Hospital began to be electronically collected March 6, 1988. Retrieval of these discharge diagnoses was facilitated beginning in 1999 with institution of the electronic medical record, Meditech. For this study protocol, data were collected from February 1, 1999 to October 1, 2015, for 1 or more of 3 ICD-9 codes for cardiorespiratory events or arrest. The 3 codes were 997.1 for "cardiac complications, not elsewhere classified," 427.5 for

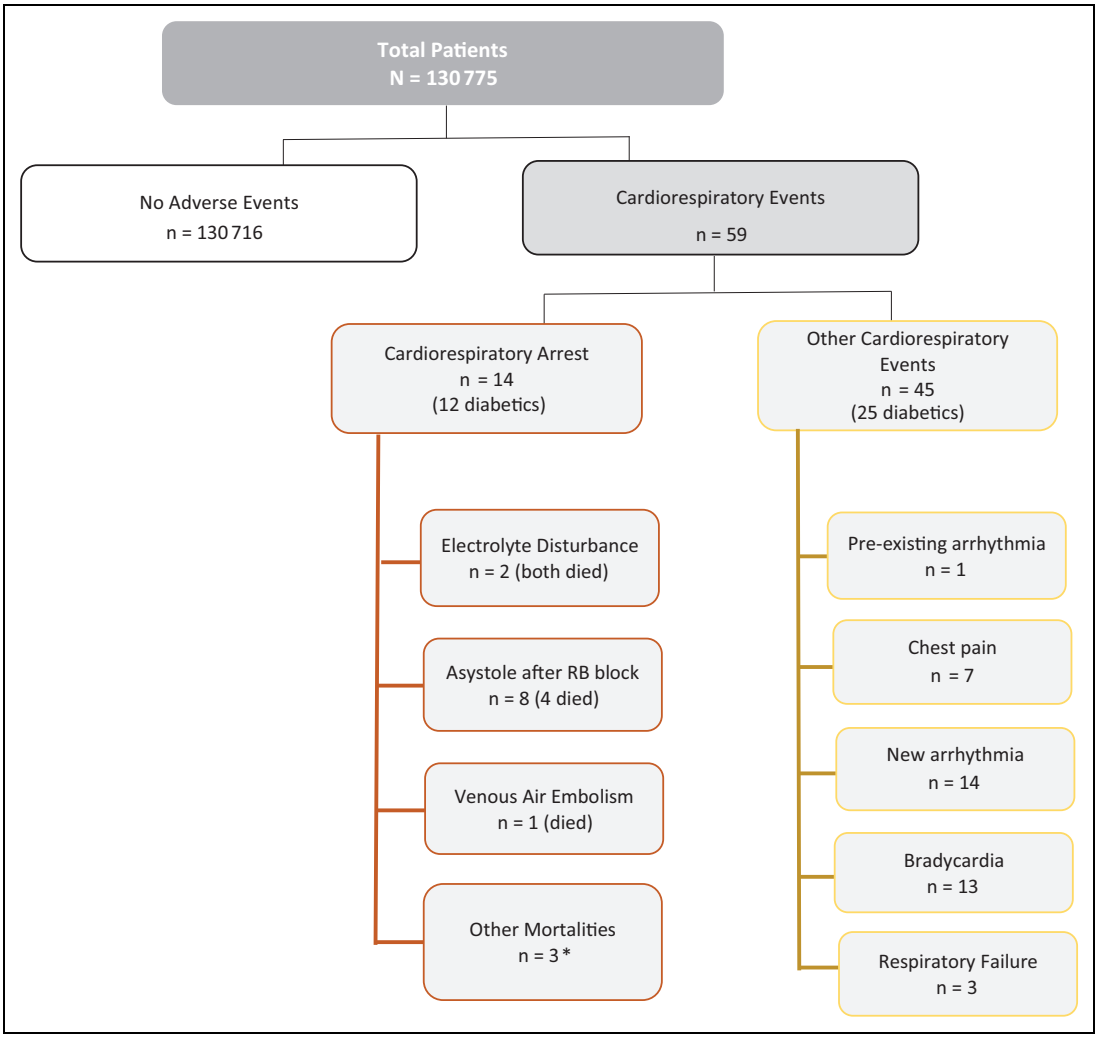

Figure 1. Cardiorespiratory events experienced by the 59 patients in this study. RB indicates retrobulbar block.
[a]Intraoperative morality: All 3 patients were diabetic. Causes of mortality: patient 1, unresponsive bradycardia after sedation; patient 2, bradycardia with induction and unexplained metabolic acidosis; patient 3, unresponsive hypotension with induction.

"cardiac arrest," and 799.1 for "respiratory arrest." ICD-10 coding was instituted in October 2015; patients treated subsequent to this date were excluded from the study.

Information regarding age, sex, type and duration of surgery, medical comorbidities, physician evaluation including history, physical, and ophthalmologic diagnoses, and perioperative laboratory studies were noted. The American Society of Anesthesiologists (ASA) physical status was recorded along with comorbidities like coronary artery disease, hypertension, diabetes, chronic kidney disease, and proliferative diabetic retinopathy (PDR). The preoperative evaluation, anesthetic records, progress notes, and, if applicable, the code records were reviewed by 3 anesthesiologists not involved the particular patient's care. After discussion, a presumptive cause for the cardiorespiratory event was determined. Laboratory results and electrocardiogram (ECG), if performed, were available for interpretation by the 3 anesthesiologists.

Statistical Analysis

Categorical variables are presented as frequency with percentages and continuous variables are presented as means with SD. A chi-square analysis was used to assess for significant differences among categorical variables using SPSS (IBM). This manuscript adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Results

A total of 130 775 patients underwent ophthalmic surgery between February 1, 1999 and October 1, 2015. Approximately 80% of patients received monitored anesthesia care (MAC) and 20% received GA. Over the course of the study period, there was a gradual decrease in the number of physician orders for laboratory testing and ECG the day of surgery. During the study period, the laryngeal mask airway (LMA) replaced

Table 2. Prevalence of Diabetes Among Patients Undergoing Ophthalmic Surgery.

Diabetes Status	Patients N = 130 775 No. (%)	Adverse Events n = 59 No. (%)	*P*
Diabetic	38 661 (29.5)	37[a] (62.7)	<.001
Nondiabetic	92 114 (70.4)	22 (37.3)	

[a]Proliferative diabetic retinopathy was present in 21 of 37 diabetic-event patients.

endotracheal intubation as the preferred airway for GA. Monitoring was performed as per ASA standards for all cases. Nasal cannulas with end-tidal CO_2 ($ETCO_2$) monitoring were introduced toward the end of the study period for patients receiving MAC.

A cardiorespiratory event was documented in 59 (0.45 per 1000) patients (Table 1). Sixteen events were deemed insignificant by the reviewing anesthesiologists, whereas 45 required some form of advanced monitoring and/or intervention. Of the 59 patients, 14 (23.7%) had a cardiopulmonary arrest. The root causes for each event are summarized in Figure 1.

Table 3. Clinical Data for 14 Patients With Cardiorespiratory Arrest.

Patient No.	Age, y	Sex	ASA	Comorbidity	Major Surgical Procedure	Anesthesia Type	Cause of Cardiac Arrest	Diabetes	ROSC	Mortality	Transfer to Acute Care Facility
1	64	M	3	HTN, PVD, AS, OA, OSA	Glaucoma shunt	MAC	RBB leading to asystole	+	+	+	+
2	45	M	3	CAD, CVA, PVD, neuropathy, CRF	Vitrectomy	GA-ETT	Reversal leading to ventricular tachycardia (high K preoperatively)	+	+	+	+
3	60	F	3	HTN, CKD, DM, PVD	Retinal detachment repair	MAC	RBB leading to asystole	+	+	+	+
4	56	M	3	HTN, CAD, neuropathy	Glaucoma shunt	MAC	RBB leading to asystole	+	+	Rehab: poor outcome	+
5	62	M	3	HTN, neuropathy, ESRD	Cataract	MAC	Hypoxia/arrhythmia in PACU	+	−	+	−
6	57	F	4	CAD, HTN, asthma, OSA, ESRD, obesity	Vitrectomy	MAC	RBB leading to asystole	+	+	−	−
7	53	M	4	CAD, CRF, HTN, asthma	Vitrectomy	GA-ETT	Bradycardia followed by asystole	+	+	+	+
8	55	M	3	HTN, OA, ESRD, PVD	Ruptured globe repair	GA-LMA	Hyperkalemia leading to PEA arrest next day	+	+	+	+
9	57	M	3	HTN, HLD	Vitrectomy	MAC	RBB leading to asystole	+	+	−	+
10	35	M	3	HTN, CAD, ICD, CHF	Retinal detachment repair	MAC	RBB leading to V tach	+	−	+	−
11	64	M	3	HTN, CAD, TIA, HLD, OSA	Vitrectomy	GA-LMA	Air embolism leading to asystole and death	−	−	+	−
12	46	M	4	HTN, CAD, ESRD	Vitrectomy	GA-LMA	Instrumentation followed by VF arrest	+	−	+	−
13	52	F	2	HTN, OA	Keratoplasty	MAC	RBB leading to asystole	−	+	−	+
14	68	F	3	CHF and/or Hypothyroidism	Vitrectomy	MAC	RBB leading to asystole	+	+	−	+

Abbreviations: AS, aortic stenosis; ASA, American Society of Anesthesiologists; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; CRF, chronic renal failure; CVA, cerebral vascular accident; DM, diabetes mellitus; ESRD, end-stage renal disease; ETT, endotracheal tube; F, female; GA, general anesthesia; HLD, hyperlipidemia; HTN, hypertension; ICD, implanted cardiac defibrillator; LMA, laryngeal mask airway; M, male; MAC, monitored anesthesia care with a combination of sedation and/or retrobulbar block; OA, osteoarthritis; OSA, obstructive sleep apnea; PACU, postanesthesia care unit; PEA, pulseless electrical activity; PVD, peripheral vascular disease; RBB, retrobulbar block; ROSC, return of spontaneous circulation; TIA, transient ischemic attack; UAB, University of Alabama at Birmingham Hospital (an acute care facility); VF, ventricular fibrillation; V tach, ventricular tachycardia.

Diabetes was coded by the ophthalmologist and found to be present in 38 661 (29.5%) of the 130 775 patients. During the course of this study, there was a gradual increase in the number of diabetic patients. Approximately half the patients with cardiorespiratory events were undergoing vitreoretinal surgeries. Table 2 demonstrates the significant relationship between diabetes and cardiorespiratory events. There was a very strong link between cardiorespiratory arrest and diabetes with PDR. Clinical information, including diabetes status, for patients who had a cardiorespiratory event is provided in Table 3.

Conclusions

Beecher and Todd concluded that preexisting disease was the largest contributor to surgical morbidity and mortality.[1] Our results similarly demonstrated that diabetes was the preeminent contributor. Compared to the study by Backer et al.[5] wherein only 18% of patients were diabetic, 28% of patients in our study cohort were diabetic. In our study, the incidence of cardiorespiratory events for diabetic patients was 0.11%, compared to less than 0.03% for nondiabetic patients ($P < .001$). Although diabetic patients are well known to have increased rates of perioperative morbidity and mortality,[11] it was striking to find that 8 of 9 patients who died had PDR with renal involvement.

Ophthalmic surgeries frequently involve the use of local anesthetic blocks. Sub-Tenon and retrobulbar blocks (RBBs)/peribulbar blocks are used depending on the experience and preference of providers. Brainstem anesthesia is one of the major risks involved with RBB, with an incidence of approximately 0.3% to 0.8%.[21] All nondiabetic patients who suffered presumed brainstem anesthesia in this series survived the event with no deficits. In contrast, all 4 PDR patients died. One mortality patient with PDR had a normal stress test the week before ophthalmic surgery. The cause of his arrest was believed by the reviewers to be brainstem anesthesia complicated by a difficult intubation. Because of CAN-induced neural destruction found in more than 80% of diabetic patients undergoing vitreoretinal surgery,[14] these patients may not respond to vagolytic drugs like glycopyrrolate and atropine. Ciccarelli et al[15] emphasized the importance of autonomic neuropathy in diabetic renal failure patients who are prone to bradycardia unresponsive to atropine. Since their report, we have used dilute solutions of epinephrine during surgery multiple times in diabetic patients on dialysis during surgery. Epinephrine, in small doses of 10 to 20 μg, can be titrated successfully for these not unexpected events in PDR patients.

There was one death due to ocular venous air embolism (OVAE) during the air/fluid exchange (AFX) performed for a recurrent retinal detachment repair with scleral buckle placement. There have been 13 OVAE case reports[22] as well as experimental evidence in both the laboratory[23] and an in vivo porcine model of OVAE[24] during AFX. Ophthalmic anesthesia providers should to be aware of the possibility of OVAE and vigilantly observe the $ETCO_2$ during the AFX, allowing them to diagnose OVAE early and request that the surgeon immediately cease the air infusion. The risk factors for OVAE are choroidal trauma, including preexisting and endoresection of tumor, as well as slippage of the air infusion cannula from the vitreous cavity into the suprachoroidal space.

There was a decrease in coded cardiorespiratory events in the latter part of this study despite an increased prevalence of diabetes in the study population. One contributing factor may be surgeon preference for sub-Tenon block, with its lower risk of brainstem anesthesia.[25] In addition, the lower incidence of cardiorespiratory arrest is believed to be attributed to having a dedicated ophthalmic team in which all clinicians are familiar with the high incidence of severe autonomic dysfunction in diabetic vitreoretinal surgery patients, the potential occurrence of brainstem anesthesia with RBB, and potential OVAE during the AFX. Knowledge of these 3 risk factors for morbidity and mortality may prompt early intervention and appears critical in decreasing the severity of outcomes, particularly in patients with PDR. As Albin wrote, "Pramonitus, Pramunitus—forewarned is forearmed."[26] The adage learned in medical school that "the eye is the window to our overall health" is certainly borne out in this study of ophthalmic surgery mortality. All patients with PDR should be recognized as having a higher risk of perioperative morbidity and mortality.

Authors' Note

Author contributions include the following: Vinodkumar Singh helped with developing the methodology of study, collecting data, analyzing and interpretation of the data, and manuscript writing and preparation. Marc A. Rozner helped with developing the study design, collecting data, and interpretation of the data. Ayesha S. Bryant helped with data analysis and interpretation, and manuscript writing and preparation. Matthew Hull, Robin Walters, Jason Skelley, and R. Clark Cross helped with conducting the study, collection and review of the data, and interpretation of the findings. Gwendolyn L. Boyd helped with study design, conducting the study, collecting and analyzing the data, and manuscript writing.

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Ethical Approval

The University of Alabama at Birmingham Institutional Review Board granted approval for this study.

Statement of Informed Consent

The University of Alabama at Birmingham Institutional Review Board granted a waiver for informed consent for this study.

Declaration of Conflicting Interests

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