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Perioperative Retinal Artery Occlusion

Risk Factors in Cardiac Surgery from the United States National Inpatient Sample 1998–2013

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Purpose: To study the incidence and risk factors for retinal artery occlusion (RAO) in cardiac surgery.
Design: Retrospective study using the National Inpatient Sample (NIS).
Methods: The NIS was searched for cardiac surgery. Retinal artery occlusion was identified by International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. Postulated risk factors based on literature review were included in multivariate logistic models.
Main Outcome Measures: Diagnosis of RAO.
Results: A total of 5 872 833 cardiac operative procedures were estimated in the United States from 1998 to 2013, with 4564 RAO cases (95% confidence interval [95% CI], 4282–4869). Nationally estimated RAO incidence was 7.77/10 000 cardiac operative procedures from 1998 to 2013 (95% CI, 7.29–8.29). Associated with increased RAO were giant cell arteritis (odds ratio [OR], 7.73; CI, 2.78–21.52; $P < 0.001$), transient cerebral ischemia (OR, 7.67; CI, 5.31–11.07; $P < 0.001$), carotid artery stenosis (OR, 7.52; CI, 6.22–9.09; $P < 0.001$), embolic stroke (OR, 4.43; CI, 3.05–6.42; $P < 0.001$), hypercoagulability (OR, 2.90; CI, 1.56–5.39; $P < 0.001$), myxoma (OR, 2.43; CI, 1.39–4.26; $P = 0.002$), diabetes mellitus (DM) with ophthalmic complications (OR, 1.89; CI, 1.10–3.24; $P = 0.02$), and aortic insufficiency (OR, 1.85; CI, 1.26–2.71; $P = 0.002$). Perioperative bleeding, aortic and mitral valve surgery, and septal surgery increased the odds of RAO. Negatively associated with RAO were female gender (OR, 0.77; CI, 0.66–0.89; $P < 0.001$), thrombocytopenia (OR, 0.79; CI, 0.62–1.00; $P = 0.049$), acute coronary syndrome (OR, 0.72; CI, 0.58–0.89; $P = 0.003$), atrial fibrillation (OR, 0.82; CI, 0.70–0.95; $P = 0.01$), congestive heart failure (OR, 0.73; CI, 0.60–0.88; $P < 0.001$), DM 2 (OR, 0.74; CI, 0.61–0.89; $P = 0.001$), and smoking (OR, 0.82; CI, 0.70–0.97; $P = 0.02$).
Conclusions: Risk factors for RAO in cardiac surgery include giant cell arteritis, carotid stenosis, stroke, hypercoagulable state, and DM with ophthalmic complications; associated with lower risk were female gender, thrombocytopenia, acute coronary syndrome, atrial fibrillation, congestive heart failure, DM 2, and smoking. Surgery in which the heart was opened (e.g., septal repair) versus surgery in which it was not (e.g., CABG) and perioperative bleeding increased the risk of RAO. *Ophthalmology 2016;■:1–8 © 2016 by the American Academy of Ophthalmology*

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Perioperative visual loss is a rare but devastating complication that occurs more frequently in spine and cardiac surgery versus other surgical procedures.[1] Although ischemic optic neuropathy is the most common type of perioperative visual loss after spinal surgery,[2] retinal artery occlusion (RAO) is thought to occur more frequently after cardiac surgery, possibly because of emboli.[3] The existence of retinal microembolization in cardiac surgery is well known[4]; however, long-term outcomes of this phenomena and risk factors for RAO in cardiac surgery have not been quantitated. We recently estimated that RAO after spine fusion surgery occurs at a rate of 0.89/10 000 in the United States,[5] but it may be higher after cardiac surgery according to sparse previous estimates.[6,7] The impact of perioperative RAO on a patient's life is considerable, because the usual outcome includes visual loss and is generally not reversible.[8] With cardiac surgery, one of the most commonly performed in-hospital surgical procedures in the United States,[1] identification of risk factors for perioperative RAO is imperative.

Perioperative RAO is difficult to treat successfully, and understanding its mechanisms may aid in identifying high-risk patients.[9] In turn, this could prompt modification of the informed consent and the surgical planning. Furthermore, perioperative RAO could serve as a model for the study of the natural history of retinal vascular disease because it occurs in the more closely monitored hospital environment.

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Spontaneous nonperioperative RAO is associated with stroke, coronary artery disease, atrial fibrillation, and carotid stenosis, conditions frequently present in patients who require heart surgery, particularly coronary artery bypass grafting (CABG).[3,10,11] Associations also have been documented for spontaneously developing RAO and hypercoagulable state,[12] valvular heart disease,[13] and myxoma.[14,15] Accordingly, we hypothesized that risk factors for RAO after cardiac surgery resemble those of spontaneous RAO.[16] Moreover, a higher risk of RAO would be anticipated in procedures in which emboli are likely to develop, that is, with air emboli when the heart is opened for valve or septal surgery.[17] Embolism also can be due to dislodging of atherosclerotic plaque from the aorta during arterial cannulation for cardiopulmonary bypass or in aortic valve surgery.[18] Another potential cause of perioperative RAO is thrombosis within the arterial circulation due to, for example, a hypercoagulable state, decreased perfusion in the microcirculation, or damaged vascular endothelium, conditions that may occur with cardiac surgery.[19,20] By examining the National Inpatient Sample (NIS), we studied potential risk factors for perioperative RAO in cardiac surgery. Our aims were to determine the trends in incidence and identify the associated patient characteristics, surgical, and perioperative factors.

Methods

The NIS is an approximately 20% stratified sample of nonfederal inpatient hospital discharge data, maintained by the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. Patient information includes demographics, diagnoses (principal and secondary), procedures (principal and secondary), charges (US dollars), length of stay (in days), discharge status, outcomes, and medical diagnoses. There are no specific patient identifiers. Therefore, the Institutional Review Boards of the University of Chicago and the University of Illinois deemed this study "exempt."

Discharge data in the NIS from 1998 to 2013 were studied. Starting in 2012, to improve accuracy of national estimates, all hospitals were included. Thus, we used Agency for Healthcare Research and Quality 1998−2013 "trend weights" (hcupnet.ahrq.gov) to ensure accurate weighting,[21] as previously described.[5] The "Survey" function (StataCorp LP, College Station, TX) was used for patient-level analyses. Diagnoses and procedures are coded using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM; http://www.cdc.gov/nchs/icd/icd9cm.htm).

Data Classification

Discharges including ICD-9-CM codes for CABG, valve replacement or repairs adjacent to valves, left ventricular assist device, heart transplant, ventricular or atrial septal repairs, cardiopulmonary bypass, and pericardiectomy were evaluated (Table S1, available at www.aaojournal.org). Among these, CABG and pericardiectomy do not necessitate opening of the heart. To ensure complete coverage, ICD-9-CM codes were confirmed against Current Procedural Technology (Table S1, available at www.aaojournal.org) cardiac surgery codes using EncoderPro.com (Optum, Salt Lake City, UT). Patients discharged with a primary or secondary diagnostic ICD-9-CM code for RAO (362.30−34) and a relevant cardiac surgical procedure code were considered to have developed RAO during the hospitalization.

Missing Data

To account for missing data in the multivariate analysis, multiple (10) imputations by chained equations were performed using Stata.[22] Gender, age, race, and type of admission were included in the imputation model. Discharge status was not included in the regression analysis, because it was deemed improbable to affect development of RAO.

Patient Characteristics

Patient characteristics analyzed included age (years, continuous variable), gender, length of hospital stay (days), yearly inflation-adjusted total hospital charges (both as continuous variables), type of admission (elective vs. nonelective), discharge status (routine, short-term hospital, home healthcare, died, other), and race. For age, 10-year epochs were used (i.e., 18−30 years, 31−40 years). Previous studies have suggested that cardiopulmonary bypass is a significant factor for RAO; however, there are no comprehensive studies on perioperative RAO in cardiac surgery.[23] Therefore, we identified potential risk factors for RAO on the basis of previous case series, large database reviews, and case reports on spontaneous RAO as recommended in the Strengthening the Reporting of Observational Studies in Epidemiology statement.[24] Medical diagnoses (ICD-9-CM codes in Table S2, available at www.aaojournal.org) studied were coronary artery disease,[11] carotid artery stenosis,[10,11] diabetes mellitus (DM) type 1 and 2 without complications,[3] DM with complications (ophthalmic, renal, or neurologic),[25] hypertension,[10] hypertension with cardiac complications,[26] obesity,[10] peripheral vascular disease, smoking,[27] myxoma,[14,15] congestive heart failure, atrial fibrillation,[11] giant cell arteritis,[28] acute coronary syndrome,[29] ventricular septal defect,[30] atrial/mitral stenosis and/or insufficiency,[13] cardiomyopathy, thrombocytopenia, and hypercoagulable state (including primary and secondary hypercoagulable states, homocystinuria, and presence of antiphospholipid antibodies).[12,31,32] Hospital conditions included anemia, transfusion, cardiogenic shock, and postoperative bleeding. Stroke was included as embolic, thrombotic, transient ischemia, and "other."[33]

Analysis

Patient characteristics, surgical factors, and RAO from 1998 to 2013 were tabulated using national estimates. Multivariate logistic regression was conducted with RAO as the dependent variable and risk factors and surgery types as independent variables. We included discharges in which a patient underwent 2 or more cardiac operative procedures during the hospitalization (e.g., CABG and valve). Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A second multivariate model was conducted in the same manner, but eliminated from analysis were discharges in which 2 cardiac operative procedures were performed on the same subject (i.e., an alternate "single procedure" model).

The proportions of patients affected by RAO as a function of the surgical procedure (CABG vs. valve vs. septal surgery) were compared using the chi-square test. To further examine the influence of opening of the heart as a risk for RAO, incidence was compared using chi-square, among patients undergoing CABG alone with those undergoing patent foramen ovale closure and CABG (ICD-9-CM: 35.71). Because CABG was a common feature, it could be assumed that the comparison at least partially adjusted for severity of underlying illness.

A P value < 0.05 was considered significant. The variance inflation factor examined for collinearity; variance inflation factor <10 indicates lack of collinearity.[5] Stata v14.0-MP (StataCorp LP)