Risk for Retinal Detachment After Phacoemulsification

A Whole-Population Study of Cataract Surgery Outcomes

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Objectives: To estimate the long-term cumulative incidence of and risk factors for retinal detachment (RD) after phacoemulsification using linked administrative medical data.

Methods: We used the Western Australian Data Linkage System to identify patients who underwent phacoemulsification in Western Australia between January 1989 and December 2001. Retinal detachment cases were those patients requiring admission for RD surgery after phacoemulsification that were validated by medical record review. Kaplan-Meier analysis was used to calculate a cumulative incidence. Cox proportional hazards regression modeling was used to determine the association between RD and risk factors, including patient demographics and operative and hospital factors. Some important risk factors, including axial length and Nd:YAG laser capsulotomy, were not examined.

Results: We identified 237 RD cases following 65,055 phacoemulsification procedures, with a 10-year cumulative incidence of 0.68% (95% CI, 0.56%-0.83%). Significant risk factors were year of surgery (hazard ratio [HR], 0.43; 95% CI, 0.28-0.66 [1999-2001 compared with 1989-1993] for each 5-year period after 1985), age younger than 60 years (3.76; 2.83-5.00), male sex (1.91; 1.45-2.51), and anterior vitrectomy (27.60; 19.27-39.52). Hospital location, patient rural or remote locality, hospital cataract surgery volume, failed intraocular lens insertion, length of stay, and patient insurance status were not significantly associated with RD.

Conclusions: Risk for RD after phacoemulsification has almost halved for each 5-year period since its adoption in the mid 1980s. Younger patient age and male sex at surgery significantly increased risk for RD. Phacoemulsification requiring anterior vitrectomy vastly increased risk for RD.

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RETINAL DETACHMENT (RD) is one of the most frequent sight-threatening complications of modern cataract surgery and complicates approximately 1% of all cataract operations performed in Western countries. Multiple risk factors are implicated, including patient factors (younger age, male sex, and long axial length), operative factors (surgical technique, vitreous loss, and posterior capsule rupture), and postoperative factors (Nd:YAG laser posterior capsulotomy). Operative technique has been implicated as a significant risk factor for subsequent RD, particularly because the abandonment of intracapsular cataract extraction in favor of extracapsular cataract extraction during the late 1970s resulted in a significant decline in the incidence of pseudophakic RD. The subsequent adoption of phacoemulsification cataract surgery as the current procedure of choice has maintained this reduced risk for RD despite initial concerns associated with the surgeon learning curve surrounding its adoption.

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Results of population-based investigations suggest that risk for RD after phacoemulsification may remain increased for 10 years after cataract surgery, yet few studies followed up patients longer than approximately 5 years. The objectives of our study were to explore changes in the long-term risk for RD after cataract surgery over time since phacoemulsification was first introduced and to identify important population-based risk factors for RD after phacoemulsification in the entire Western Australia (WA) population using validated linked health administrative data. Phacoemulsification was widely
adopted in WA during the late 1980s and by the mid 1990s had become the procedure of choice in most cataract surgical procedures.23 The Western Australian Data Linkage System links routinely collected health administrative data sets across the entire WA population, with data sets dating from 1966 onward,24 and provides the unique ability to study long-term postoperative complications of phacoemulsification on a whole-population level.

METHODS

We conducted a whole-population retrospective longitudinal study of RD after phacoemulsification. Linked administrative medical data in WA from January 1989 to December 2001 were used.

STUDY POPULATION

In WA, all cataract and lens-related surgical procedures may only be performed in health facilities licensed with the WA Department of Health. All facilities are required to provide data from all admissions, including patient demographics, comorbidities, primary and secondary diagnoses, and any procedures undertaken or complications arising during the admission. These data, including all admissions from all WA hospitals (public and private), were obtained from the Hospital Morbidity Data Collection, one of the core data sets of the Western Australian Data Linkage System.24

We extracted hospital discharge data from the Hospital Morbidity Data Collection for all patients who underwent phacoemulsification cataract surgery between January 1989 to December 2001. Linkage with the State Mortality Register allowed us to account for follow-up loss caused by patient deaths. Phacoemulsification procedures were identified using the International Classification of Diseases, 9th Revision, Australian Modification (ICD-9-CM)23 codes for procedures 13.41 through 13.43 and the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM)25 codes 42698-02, 42698-03, 42702-04, 42702-05, 42702-06, and 42702-07.

CASE VALIDATION

All surgically treated RD cases were identified using specific ICD procedure codes associated with RD repair (ICD-9-CM codes 14.3 through 14.39 and 14.9 and ICD-10-AM codes 42773-00, 42773-01, 42776-00, 42809-01, and 90079-00). Only RD-associated procedures that occurred after the associated phacoemulsification procedure were considered. Potential cases where an RD occurred before the first-ever cataract extraction operation, where eye trauma was involved or where vitreoretinal surgery was performed concurrently were excluded.

As detailed elsewhere,12 all potential cases were validated by reviewing the patient medical record to confirm that the phacoemulsification procedure and RD occurred in the same eye. Other important operative information, such as procedure type, intraocular lens (IOL) insertion, IOL type, and any other concurrent procedures, were recorded.

STATISTICAL ANALYSIS

Age was stratified into 10-year age groups (<50, 50-59, 60-69, 70-79, and ≥80 years). Patient locality was defined as metropolitan, rural, or remote on the basis of residential postcode at the time of surgery. Patient insurance status (public or private) was also recorded. The hospital type was classified as public or private, and the hospital location was classified as metropolitan, rural, or remote. We also considered the cataract surgery volume performed at each hospital during the study period, where in the largest hospitals more than 3000 procedures were performed, in the large hospitals 2000 to 3000 procedures were performed, in the medium hospitals 500 to 1999 procedures were performed, and in the small hospitals fewer than 500 procedures were performed. Length of stay was categorized as follows: day case, overnight, or longer than 1 day. Year of surgery was grouped as follows: 1989 to 1993, 1994 to 1998, or 1999 to 2001.

Kaplan-Meier analysis was used to calculate a cumulative incidence of RD (as a percentage of cataract procedures), whereby patients were censored at the time of death or at the end of the follow-up period. Cox proportional hazards regression modeling was used to calculate hazard ratios (HRs) (95% CIs) for each risk factor examined. Using generalized estimating equations, SEs were adjusted for clustering of procedures around individuals. Important risk factors in Cox proportional hazards regression modeling were selected using a backward stepwise variable selection; all covariates were included in an initial model, and the variable with the highest P value was sequentially removed until the most parsimonious model remained in which the P value for all variables was less than .05. All the statistical analyses were performed using commercially available software (STATA, version 10.0; StataCorp LP).

ETHICAL CONSIDERATIONS

This study was approved by the human research ethics committees at Curtin University (Perth, Australia), the WA Department of Health, and each of the hospitals involved in the study. Data analysis was performed on deidentified data. Patient information for potential cases was provided only for data validation.

RESULTS

In total, 65 055 phacoemulsification procedures were performed on 46 258 patients in WA between January 1989 to December 2001, of which 237 (0.4%) were associated with a subsequent admission for RD surgery (Table). The crude incidence of RD after phacoemulsification declined by a mean of 19% for each year after 1989 (incidence rate ratio, 0.81; 95% CI, 0.77-0.84) (Figure 1 A). The median time to RD after phacoemulsification was 11 months (range, 0.8-4 years), with the cumulative incidence increasing almost linearly from 0.47% (95% CI, 0.41%-0.54%) by 5 years after surgery to 0.68% (0.56%-0.83%) by 10 years after surgery (Figure 1B). Characteristics of the patients undergoing phacoemulsification procedures and those of the RD cases are summarized in the Table.

The mean (SD) age of patients undergoing phacoemulsification procedures was 73.7 (10.3) years (age range, 4-104.4 years). Men were slightly younger than women at the time of surgery (mean difference, 2.4; 95% CI, 2.2-2.6 years; P < .001). Most patients were female (58.4%), lived in a metropolitan locality (83.9%), and had private insurance (63.9%).

The mean (SD) age of RD cases was 64.4 (12.9) years (age range, 24-93 years), and 62.4% were male. Younger patient age and male sex were significantly associated with an increased risk for RD identified in the univariate and multivariate Cox proportional hazards regression models (Figure 2A and B). Compared with those 60 years or older, patients younger than 60 years had almost a
4-fold increased risk for RD (HR, 3.76; 95% CI, 2.83-5.00; P < .001). Compared with women, men were approximately twice as likely to have an RD following their cataract surgery (HR, 1.91; 95% CI, 1.45-2.51; P < .001). Among RD cases, age was not significantly different between the sexes (P = .21). No other patient factors, including locality and insurance status, were independently associated with risk for RD.

An IOL was not inserted in 432 phacoemulsification procedures (7%). In the univariate model, failed IOL insertion was associated with an almost 5-fold increased risk for subsequently having an RD (HR, 4.86; 95% CI, 2.57-9.20; P < .001) and with more than twice the risk after adjustment for all other risk factors in the multivariate model (2.28; 1.06-4.93; P = .04). However, failed IOL insertion was not significant in the backward stepwise method (excluded at P = .06).

Anterior vitrectomy was performed in 643 phacoemulsification procedures (1.0%) and in 48 RD cases (20.3%). The 5-year cumulative incidence of RD after phacoemulsification in which anterior vitrectomy was performed was 8.31% (95% CI, 6.14%-11.20%) and increased to approximately twice as likely to have an RD following their cataract surgery (HR, 1.91; 95% CI, 1.45-2.51; P < .001). Among RD cases, age was not significantly different between the sexes (P = .21). No other patient factors, including locality and insurance status, were independently associated with risk for RD.

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The crude incidence of anterior vitrectomy during cataract surgery declined in the first few years of phacoemulsification adoption in WA and leveled off thereafter at a rate of 10 per 1000 phacoemulsification procedures per year. The incidence of anterior vitrectomy in the first few years was significantly higher than in subsequent years.

The crude incidence of retinal detachment per 1000 cataract procedures was significantly increased in surgeries associated with anterior vitrectomy. The hazard ratio (HR) for RD in surgeries with anterior vitrectomy was 28.96 (95% CI, 20.43-41.05; P < .001) compared to surgeries without anterior vitrectomy.

The cumulative incidence of retinal detachment by patient age, sex, and year of surgery is shown in Figure 2. The incidence of RD was significantly higher in surgeries with anterior vitrectomy compared to those without.

The cumulative incidence of retinal detachment by year of surgery is shown in Figure 1. The incidence of RD declined in the first few years of phacoemulsification adoption and leveled off thereafter.

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formed (Figure 3). The crude incidence of RD after cataract surgery showed a similar decline early in the study period and has continued to decline, despite the rate of anterior vitrectomy remaining constant.

Most phacoemulsification procedures (90.1%) were performed in metropolitan hospitals, and 6.4% were in private hospitals. Two hospitals in WA performed more than 10,000 phacoemulsification procedures, accounting for 37.9% of all phacoemulsification procedures performed in the state. Twenty-three hospitals performed fewer than 500 phacoemulsification procedures, which accounted for less than 5% of the total cohort; 14 of these hospitals were in rural or remote areas. A significant proportion (83.0%) of phacoemulsification procedures involved day case or overnight admissions. No hospital variable (location, cataract surgery volume, or public vs private status) was significantly associated with risk for RD in the univariate model or in the multivariate model (Table).

Most phacoemulsification procedures (50.3%) were performed between 1999 and 2001. Approximately a 50% reduction in the incidence of RD was observed for each subsequent year group, from a high of 0.96% from 1989 to 1993 to a low of 0.25% from 1999 to 2001 (Figure 2C). After adjustment for all significant variables in the multivariate model, year of surgery remained significantly associated with risk for RD, such that the HR was 0.43 (95% CI, 0.28-0.66; P<.001) by 1999 to 2001 compared with 1989 to 1994.

We found that the cumulative incidence of RD after phacoemulsification was almost 0.2% at 1 year (Figure 1B). By comparison, the annual incidence of rhegmatogenous RD in the general population of similar age is reported to be between 22 and 49 cases per 100,000 population.27-29 Although these measures are not directly comparable, it suggests a substantially increased risk for RD after phacoemulsification above the baseline risk in the general community.

Our findings are comparable with the incidence of RD after phacoemulsification reported elsewhere.1-11,14,16,19,20 Many of these studies were limited by their smaller sample sizes,4,7-11,16,19,20 involved single clinical centers,4,7-11,16,19,20 or had short follow-up periods (<5 years).5,10,16,19,20 Our whole-population study captured the entire cohort of patients undergoing phacoemulsification in a well-defined population of 2.2 million people that is representative of the Australian context.30,31 The WA population has comparatively low out-of-state emigration rates, representing a stable population for longitudinal observation.31 In addition, a major limitation of previous research using administrative medical data is the inability to confirm that the eye that had the RD was the same eye that underwent cataract surgery.1,3,5,6 We manually validated all potential RD cases using medical record review and are confident in the details of not only the complication but also the associated surgical procedure.

We found that the cumulative incidence of RD after phacoemulsification continued to increase up to 10 years after surgery. Long-term follow-up data for cataract surgery outcomes on a population-based level are lacking. A population-based study with a long follow-up period (>20 years) by Erich et al2 reported that the cumulative incidence of RD after extracapsular cataract extraction (including phacoemulsification) was 0.71% at 5 years and 1.23% at 10 years for all the surgical procedures performed between 1980 and 2004 in Olmstead County, Minnesota. Although their cohort also included patients undergoing extracapsular cataract extraction, the authors reported no significant difference in the probability of RD compared with that associated with phacoemulsification. In contrast, risk for RD in our study (cumulative incidence, 0.47% and 0.68% at 5 and 10 years, respectively) was substantially lower than that reported by these authors and may be because of the later time frame of our study.

The incidence of RD after phacoemulsification in WA decreased significantly over time, with a steady decline in the 5-year cumulative incidence from 0.96% from 1989 to 1993, to 0.43% from 1994 to 1998, to 0.25% from 1999 to 2001. This reduction remained significant after adjustment for patient sociodemographic, surgical, and hospital factors. The large fall in incidence from the period representing the adoption of phacoemulsification into routine clinical practice in WA (1989-1993) to plateau thereafter is likely due to surgeon learning curve, although other unmeasured factors, such as improvement in surgical technique and advances in equipment technology, may have contributed to this result.

Less than 1% of phacoemulsification procedures in our cohort involved an anterior vitrectomy, and failed IOL insertion occurred in 0.7%. Although we were unable to confirm every case of posterior capsule rupture that occurred, the data provided for this study allowed us to identify every case of anterior vitrectomy. Our rate of anterior vitrectomy during cataract surgery herein is within the range of other contemporary studies.32,33 The 5-year cumulative incidence of RD after phacoemulsification in which anterior vitrectomy was performed was 8.31% in our study, with a relative risk approaching 30 times higher than that in surgical procedures in which no anterior vitrectomy was performed.

Many studies2,6,11,13,17,18,34 demonstrated an increased risk for RD (range, 4.5-19.9 times higher) after surgical procedures documenting posterior capsule rupture with...
or without vitreous loss, although a few studies\textsuperscript{1,4,35} found no change in risk. Anterior vitrectomy is generally performed only in cataract surgery in which a posterior capsule rupture has occurred with vitreous loss. Similarly, failed IOL insertion would occur in situations of complicated surgery in which capsule support is compromised. Both events could be regarded as a surrogate marker for complicated surgery involving posterior capsule rupture and vitreous loss. These findings highlight the importance of close follow-up monitoring in patients whose cataract surgery has been complicated by posterior capsule rupture because of significant risk for RD that may extend many years after surgery.

We confirm findings in previous large studies\textsuperscript{1,3,8,11} of RD after cataract surgery that younger patient age and male sex are significant risk factors for RD. Decreased risk for RD with age is contrary to that in the general community, where risk increases significantly with age.\textsuperscript{27-29} In our study, patients younger than 60 years undergoing phacoemulsification were almost 4 times more likely to have an RD compared with those who were 60 years or older. Several theories have been postulated for why younger patients are more likely to experience RD following phacoemulsification. One relates to vitreous changes after cataract surgery. Ripandelli et al\textsuperscript{19} found that posterior vitreous detachment occurred following cataract surgery in 75.8% of patients without a history of posterior vitreous detachment or lattice degeneration. Given that 10% to 15% of posterior vitreous detachment occurrences are associated with a retinal tear, older patients may be protected from posterior vitreous detachment because they are more likely to have already had phakic posterior vitreous detachment, which tends to occur in individuals 60 years or older.\textsuperscript{15,36} Younger eyes are also more likely to be abnormal in their development of cataract (eg, traumatic cataract), and this may predispose these eyes to pseudophakic RD.

Compared with women, men undergoing phacoemulsification were almost twice as likely to have an RD. The increased risk for RD in men has been reported elsewhere. In a population-based cohort similar to ours, Sheu et al\textsuperscript{11} found that men had a 2.43 times higher risk for RD after phacoemulsification than women. Although men in our study were younger on average than women, the observed sex difference remained after adjusting for age. Sex differences in the anatomy of the eye and vitreous have been postulated as potential contributing factors. Men tend to have longer axial length,\textsuperscript{37} while women tend toward earlier posterior vitreous detachment.\textsuperscript{38} This may confer a protective effect on women for subsequent RD after cataract surgery. Men may also be more likely to experience traumatic injury or to engage in activities where eye trauma is more likely owing to their occupation or lifestyle, placing them at higher risk for pseudophakic RD.

Our study has some limitations. Because all RD cases in the study were identified based on readmission to the hospital for surgery, we likely underestimated the true number of cases in the population. In WA, the standard practice for RD cases during the study period was repair as an inpatient procedure. Procedures that may be performed in an outpatient setting (eg, pneumatic retinopexy) and were not captured were nonstandard and rarely practiced. Even so, not all patients with RD will undergo surgery (eg, the patient may refuse further surgery), or they may have an RD treated outside of WA and as such would not be captured in the data set. We believe that this number is likely small and that any resultant bias is minimal.

Additional important risk factors for RD after cataract surgery identified in other studies include axial length and the use of Nd:YAG posterior capsulotomy. Axial length of at least 25 mm has been significantly associated with increased relative risk for RD after cataract surgery, approaching 6 times that of eyes with shorter axial length.\textsuperscript{14,15} In their population-based study, Ninn-Pedersen and Bauer\textsuperscript{4} found that for every 1-mm increase in axial myopia, the associated relative risk for RD was 1.3. Similarly, Nd:YAG laser posterior capsulotomy was associated with increased risk for RD, with a relative risk of 4.9 documented in their study.\textsuperscript{4} Unfortunately, it was not possible to analyze these factors in our study because neither characteristic is recorded in the Hospital Morbidity Data Collection.

A strength of our study is its population-based design that includes a widely representative population, identifies most complications, and covers 12 years. Some limitations exist surrounding the use of routinely collected administrative medical data whose main purpose is not for clinical research.\textsuperscript{39} The accuracy of such administrative data is dependent on the quality of data processes and systems that create these databases. However, the Western Australian Data Linkage System is a well-established and validated resource that has been used extensively in population-based health research.\textsuperscript{50,60} We further added to the quality of data in our study by careful validation of RD via medical record review.

In conclusion, the incidence of pseudophakic RD has declined markedly since the adoption of phacoemulsification cataract surgery in WA. As identified in previous studies, we confirm that younger patient age and male sex are important risk factors for subsequent RD. Complicated operations necessitating anterior vitrectomy carry significantly increased risk for RD. Knowledge about the importance of such risk factors is important for physicians to guide preoperative counseling and postoperative review with patients.

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