TITLE: Effect of individual-level and socioeconomic factors on long-term survival after cataract surgery over a 30-year period

RUNNING HEAD: Long-term survival after cataract surgery

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ABSTRACT

PURPOSE

The long-term survival probability and the combined effect of individual-level and socioeconomic factors on survival after cataract surgery for the Scottish population are largely unknown. The aim was to evaluate survival and risk of mortality after cataract surgery in relation to individual-level and socioeconomic factors in Scotland over three decades.

SETTING

Hospital episodes, Scotland, United Kingdom.

DESIGN

Retrospective representative population-based study of administrative health care data.

METHODS

A 5% random sample (n=9,228) of Scottish decedents linked to hospital records (1981 to 2012) was analysed. Survival time, survival probability, and determinants of mortality were analysed for first and second recorded hospital episodes for cataract surgery. Cox proportional hazards regression models

were used to assess the effect of individual-level and socioeconomic factors including age, geographic location, socioeconomic status, and comorbidity on mortality.

RESULTS

Mean (±SD) survival time was 2,383±1,853 days. Survival probability decreased from 98% at 90 days post-surgery to 22% at 10 years, 2% at 20 years, and 0% after 30 years. Mean age was 77±9 years and age (HR 3.66, 95% CI 2.97-3.80, p<0.001) and severe comorbidity (HR 1.68; 95% CI 1.47-1.91, p<0.001) were associated with an increased risk of mortality; women had a 20% lower risk than men (HR 0.80; 95% CI 0.76-0.83; p<0.001). Socioeconomic status and rural geographic locations were not linked to mortality.

CONCLUSIONS

Long-term survival after cataract surgery is determined by individual-level characteristics, reflecting mortality patterns of ageing populations. The mortality risk is independent of socioeconomic and geographic factors per se.

INTRODUCTION

Cataract remains a major cause of visual impairment in industrialised countries, ranking third after uncorrected refractive error and macular degeneration.[1] Population ageing has led to an increase in the need for cataract surgery and clinic capacity, and necessitating ophthalmology service adaptation.[2,3]

Survival and the risk of mortality following cataract surgery have been assessed using various study designs.[4-9] A decrease in life expectancy after cataract surgery has been suggested, implying greater risk of mortality.[4] The opposite, namely reduced mortality following cataract surgery, has also been reported.[5] Even though cataract surgery may reduce the risk of mortality up to fifteen years postoperatively,[6,9] follow-up data beyond two decades does not appear to be available and a need for further research, in particular longer-term studies has been highlighted in the literature.[10,11]

With cataract surgery rates varying substantially across geographic areas[2,12,13] and all cause mortality varying by geographic location,[14] greater health inequalities have been reported for populations older than 65 years living in remote rural areas as compared to urban areas.[15] There are also considerable differences in mortality rates, which have been linked to socioeconomic factors, in different geographic areas in Scotland.[16]

The long-term survival probability as well as the combined effect of individual-level and socioeconomic factors on survival after cataract surgery are largely

unknown. This study examined the long-term survival and risk of mortality as a health outcome after cataract surgery. The aim of this study was to assess the effect of individual-level and socioeconomic characteristics on survival following cataract surgery using a large representative sample of the Scottish population over a 31-year period.

MATERIALS AND METHODS

A longitudinal dataset comprising a 5% sample of all Scottish decedents between 1981 and 2012 derived from national mortality data (National Records Scotland, NRS) and randomly drawn by the Information and Services Division (ISD) Scotland was used. These records were linked to inpatient hospital admissions, the Scottish Morbidity Records 01 (SMR01). The SMR patient-level database is a continuously updated database, currently containing > 37 million records. Variables recorded for each hospital episode include patient demographics, socioeconomic status, reason for hospital admission, comorbidity, and medical treatment information.

Data

Data were available from 1981 to 2012. From these linked data we identified patients with one or more admissions for cataract surgery in the primary diagnostic position (categorised using International Classification of Disease 9 and 10 [ICD-9, ICD-10]) (Box 1). Patients were then followed up from first recorded hospital episode for cataract surgery until death, recording all

hospital admissions. Second recorded episodes were subsequently identified and analysed.

Covariates

The analysis was restricted to patients older than 45 years. Patient characteristics analyzed include: age, gender, socioeconomic status (measured using the Scottish Index of Multiple Deprivation, SIMD deciles), the grouped Charlson Comorbidity Index (CCI), and geographic location. Geographical areas are described using the eight-fold urban-rural classification for Scotland [Information Services Division. http://www.isdscotland.org/Products-and-Services/GPD-Support/Geography/Urban-Rural-Classification/ [accessed 05/03/15]. In this classification areas are defined as shown in Box 1 (supplement 1). For our analysis we ordered the eight-fold urban-rural categorisation in terms of driving time to the next larger settlements as shown in Box 2 (supplement 2).[17]

Comorbidities were identified utilising the primary and up to five secondary diagnostic positions recorded for each hospital admission. Based on these, the CCI, a measure of disease burden,[18] was recorded. For our analyses, we used the grouped CCI, a modified CCI coding algorithm[19] to adjust for comorbidity. The grouped CCI consisted of three categories with “0” representing no comorbidity, “1” representing the presence of one, mild comorbid condition, and “2” representing more than one comorbid disease and/or moderate to severe comorbidities. We controlled for temporal changes

in clinical practice and different time points of study entry by including the year of admission for cataract surgery. Survival time was measured in days and years following the first recorded hospital episode for cataract surgery.

Statistical analyses

Cox proportional hazards regression models were used to estimate the risk of mortality, taking into account individual-level and socioeconomic factors including age, gender, comorbidity, geographic area, socioeconomic status and year of admission. Hazard ratios (HR), 95% confidence intervals (95% CI), and probabilities were generated. Effect modifications (interactions) between CCI and socioeconomic status were analysed by including interaction terms for these two variables. All analyses were undertaken using Stata /SE version 14 software (STATA Corp., TX, USA). A p-value of <0.05 was considered as statistically significant.

RESULTS

We analyzed a representative sample of the Scottish population, consisting of 9,228 hospital episodes for first recorded cataract surgery between 1981 and 2012. The mean age at first recorded hospital episode was 77 ± 9 years (range 45 to 101 years), 62% of the patients were female. Twenty percent of patients lived in the three most deprived areas (deciles 8 to 10), and 38% resided in the three least deprived areas (deciles 1 to 3). The majority of patients resided in large urban or other urban areas (69%), and 11% lived in remote and very remote settings. Thirty-one percent of patients (n = 2,872)

had a grouped CCI indicating no comorbidity, 20% (n = 1,841) showed a mild level of comorbidity, and 49% (n = 4,515) had more severe comorbid disease (Table 1).

First recorded hospital episode for cataract surgery

Survival

Survival following cataract surgery ranged from 2 to 11,342 days (i.e. up to 31.1 years), with a mean (±SD) survival of 2,383 ± 1,853 days (or 6.5 ± 5.1 years). Within the first five years, the probability of survival was high. Survival probabilities at 90, 180, 365 days and five years were 98%, 96%, 91% and 53%, respectively. At 10 years postoperatively, the survival probability was reduced to 22%, to 2% at 20, and 0% at 30 years. The Kaplan Meier survival plot for first recorded hospital episode for cataract surgery is presented in Figure 1 and differences in survival by severity of existing comorbidities are shown in Figure 2.

Determinants of mortality after cataract surgery

Three factors were associated with risk of mortality. Older age was, as expected, a major determinant of mortality for all age groups, with the hazard of shorter survival time for patients aged 65 to 69 years being 30% greater than that of patients aged 45 to 64 years (HR 1.30; 95% CI 1.18 to 1.43; p<0.001). We observed a consistent gradient for age and the risk of mortality for the oldest age group (>90 years) was four times that of the youngest age group (HR 4.05; 95%CI 3.60 to 4.55; p<0.001). A second factor related to an

increased risk was comorbidity, with patients who had a grouped CCI indicative of mild comorbidity having a risk of mortality that was 1.6 times that of patients with no comorbid conditions (HR 1.59; 95% CI 1.50 to 1.69; p<0.001). Patients with severe comorbid disease showed a hazard that was twice that of patients who had no comorbidity (HR 2.04; 95% CI 1.94 to 2.14; p<0.001). The third determinant of mortality was gender, with women having a 14% lower risk than men (HR 0.86; 95% CI 0.83 to 0.90; p<0.001). Socioeconomic status was not associated with survival in univariate analysis. Geographic location was largely unrelated to survival, with only one category ("remote small town") showing a weak association with the hazard of mortality after first recorded hospital episode for cataract surgery. Year of admission showed a marginal association (HR 1.08; 95%CI 1.07 to 1.09, Table 2).

Multivariable regression analyses

To account for the multifactorial nature of survival time and mortality, we carried out multivariable regression analyses adjusting for all independent variables simultaneously (Table 2). Age retained its association with risk of shorter survival. Severe comorbidity was still associated with an increased risk of mortality (HR 1.68; 95% CI 1.47 to 1.91, p < 0.001) compared with patients who had no comorbidities. Women had a 20% lower risk than men (HR 0.80; 95% CI 0.76 to 0.83; p<0.001) when accounting for individual-level and socioeconomic variables. In line with univariate results, there was no consistent effect of socioeconomic status on survival and risk of mortality. These effects are adjusted for interactions between CCI and SIMD, however, the inclusion of interactions did not alter findings from multivariable regression

without interaction effects. We found no association between geographic location and risk of mortality after the first recorded hospital episode for cataract surgery (Table 2).

Second recorded episode for cataract surgery

Information on second recorded episodes for cataract surgery was available from 4,426 patients, 62% of whom were female. The outcome of the regression analyses confirmed the findings observed for first recorded episode~~s~~, with a similar remaining survival time and the same determinants being associated with increased risk of mortality (Table 3).

DISCUSSION

Cataract surgery is the most common elective procedure carried out and it is therefore of interest to examine the interrelationship between cataract surgery, age at surgery, and survival in ageing populations. Utilising a large, representative 5% sample of the Scottish population, consisting of linked administrative data over a period of 31 years, we identified three main individual-level determinants of survival following cataract surgery, namely age, male gender, and comorbidity. However, socioeconomic factors such as geographic location and level of socioeconomic deprivation were not directly associated with survival. The data presented may provide valuable information for ophthalmologists and health policy makers.

Cataract surgery and survival

Previous studies have considered the association between cataract surgery, survival, and mortality in Australia,[6,7] China,[20,21] Denmark,[22] the United Kingdom,[4,5,11] and the United States.[8,9] Some of these studies analysed data from large, administrative databases,[8,9,22] whereas others were epidemiological or longitudinal studies, [6,7,21] of a cross-sectional nature considering data from a single surgical centre,[4,5] or reviews of the literature.[20] Due to the differences in the study design, the sample size of patients who underwent cataract surgery varied substantially from several hundred[4-7,21] to several thousand surgical episodes included in the analyses.[8,9]

Our results are in agreement with previous reports and confirm that survival after cataract surgery is largely good and mortality, at least initially, low.[8] Our study expands these earlier studies by providing survival probabilities over three decades and by showing a progressive decrease in survival probability, reflecting an increased risk in mortality that is comparable to the general population. Data from the United Kingdom show a mean survival time of 50 months.[4] Our results suggest that the average survival time can be considerably longer (78 months). However, this difference may result from the 10-year follow-up of the previous study.

The analysis of the literature suggests that it remains unknown how exactly cataract surgery and mortality are linked. Some studies have reported cataract surgery to be associated with lower mortality or better survival.[6,7,9] Ten-year data from the US shows that cataract surgery can be associated with a long-term reduction in mortality, with an overall lower HR for mortality in

patients who underwent cataract surgery, which translated to an approximately 30% lower risk.[9]

A contrasting perspective has also been provided.[20,21] A systematic review of the literature indicated that cataract extraction was not associated with mortality risk.[20] In another report covering a 10-year period, cataract surgery was not associated with better survival once confounding factors had been accounted for.[21] Our study confirms previous reports on Caucasian patients, which have shown that women have a lower mortality risk following cataract surgery than men.[22]

Comorbidity and socioeconomic status

Multimorbidity is associated with age and socioeconomic disadvantage and in Scotland, nearly one quarter of patients registered with a general practitioner are suffering from more than one morbidity.[23] With high levels of socioeconomic deprivation being present in Scotland and these being linked to poorer health outcomes,[16] socioeconomic deprivation was considered as a possible confounding factor, however, no direct link to mortality after cataract surgery was observed. With a growing inequality in primary eye care in the UK suggested,[24] this finding may have relevance in the wider health care delivery context.

Rurality

Previous research has shown differences in mortality in relation to geographic location.[14,25] Even though a substantial proportion of the Scottish population

lives in rural or remote locations, geographic location was not associated with any substantial differences in survival and risk of mortality. This finding suggests that people living in more remote areas are not any more likely to have a higher risk of mortality following cataract surgery than patients residing in urban localities who have easier access to health services. Earlier reports have used gross region of residence as a marker for geographic location.[9] Our study extends these analyses by providing a detailed breakdown of varied Scottish geography using an eight-fold rural-urban classification system.

Strengths and limitations of this study

Strengths of this study include the random, representative sample from the Scottish population over three decades, the controlling for confounding factors and effect modifiers, and the consideration of patient-level, socioeconomic, and geographic factors. With data originating from a predominantly Caucasian population, our results are likely generalizable to other Caucasian cohorts. The study is potentially limited by the unavailability of visual acuity data and possible errors in data recording, which is a limitation that is shared with other studies using administrative health care data.

CONCLUSIONS

This study shows that individual-level characteristics, namely age, severe comorbidity, and male gender, but not socioeconomic factors per se, determine survival after cataract surgery. The findings indicate that when survival and risk of mortality is used as health outcomes, the presence of

comorbid disease and their severity may be the most useful decision criteria when assessing patients for cataract surgery. In future studies, it would be of interest to estimate variations in costs of eye care services between geographic areas, and compare these for different health outcome measures.

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WHAT WAS KNOWN

- Lower socioeconomic status has been linked with poorer health outcomes.
- Survival and mortality can be used as health outcomes in the context of cataract surgery, but the literature indicates uncertainty as to how cataract surgery and mortality are linked and what the determinants of survival are.

WHAT THIS PAPER ADDS

- This is the first study that uses this large administrative dataset in the context of cataract surgery (and possibly ophthalmology).
- The study contributes to the literature by i) using a long-term perspective over three decades; ii) analysing a large, representative sample of high quality data on the Scottish population; and iii) considering the effect of individual-level and socioeconomic factors on survival.

- In Scotland, socioeconomic status and rurality as such are not determinants of survival after cataract surgery.

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FIGURE LEGENDS

Figure 1: Kaplan-Meier survival estimates after first recorded hospital episode for cataract surgery.

Figure 2: Kaplan-Meier survival estimates after first recorded hospital episode for cataract surgery by CCI.

TABLE LEGENDS

Table 1. Descriptive Statistics

Table 2. Results for univariate and multivariable Cox proportional hazards regression – First recorded hospital episode for cataract surgery

Table 3. Results for univariate and multivariable Cox proportional hazards regression – Second recorded hospital episode for cataract surgery

SUPPLEMENTARY MATERIAL

Box 1. ICD Codes

Box 2. Eight-fold urban-rural categorisation