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Long-Term Survival After Glaucoma Surgery: A Real-World Retrospective Analysis

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Abstract

Purpose

To evaluate postoperative survival after glaucoma surgery in older adults and to identify age- and comorbidity-related predictors of mortality, in order to assess whether patients live long enough to potentially benefit from surgery.

Methods

We conducted a retrospective observational cohort study including patients aged ≥ 65 years who underwent glaucoma surgery at a tertiary referral hospital between 2015 and 2020. Patients were followed until death or administrative censoring in 2025. Overall survival was estimated using Kaplan–Meier methods and compared across predefined age groups. Cox proportional hazards regression was used to identify predictors of mortality.

Results

Of 639 patients undergoing glaucoma surgery, 390 met inclusion criteria. The mean age at surgery was 75.7 ± 6.5 years, and the median postoperative follow-up was 4.8 years. During follow-up, 45 patients (11.5%) died, with a median time from surgery to death of 3.1 years (IQR 1.4–4.5). The estimated overall survival probability was 95.7% at two years and 88.0% at five years. Survival differed significantly across age groups (log-rank p = 0.0097), with the highest mortality observed in patients aged ≥ 85 years. In multivariable Cox regression analysis adjusting for ASA classification, age ≥ 85 years (HR 2.42, 95% CI 1.04–5.67) and higher perioperative risk (ASA III–IV; HR 2.99, 95% CI 1.64–5.47) were independently associated with increased mortality. Postoperative healthcare utilization within six months did not differ across age groups.

Conclusions

Older patients—including those with advanced age and higher perioperative risk—survived long enough to potentially benefit from glaucoma surgery. While age ≥ 85 years and elevated ASA classification were associated with increased mortality, these factors alone should not preclude surgical intervention.

Key summary points

Aim This study aimed to evaluate long-term postoperative survival and mortality predictors in older adults undergoing glaucoma surgery to assess whether patients, particularly the very old, live long enough to potentially benefit from the intervention.

Findings The analysis revealed high overall survival rates (95.7% at two years and 88.0% at five years), and while patients aged 85 years and those with higher comorbidity burdens had increased mortality risks, their short-term postoperative healthcare utilization did not differ from younger groups.

Message Advanced age and higher perioperative risk should not automatically preclude glaucoma surgery, as the majority of older patients survive long enough to experience the benefits of the procedure without imposing a disproportionate burden of short-term care.

INTRODUCTION

Glaucoma is a leading cause of irreversible vision loss worldwide, and its prevalence rises sharply with advancing age.[1] In geriatric populations, disease progression often coexists with multimorbidity, polypharmacy, frailty, and functional limitations, making the balance between visual benefit and treatment burden particularly challenging.[2] Although surgical intervention can slow glaucomatous damage and help preserve visual function, long-term outcomes depend on remaining life expectancy and on the patient's capacity to engage in the demanding postoperative care that glaucoma surgery typically requires.[3]

From a holistic perspective, quality of life and functional status are central to therapeutic decision-making. Visual impairment in older adults is associated with increased risk of falls, cognitive decline, loss of independence, and higher rates of institutionalization.[4,5] Therefore, interventions that preserve vision may significantly contribute to maintaining autonomy and overall well-being. However, glaucoma surgery does not reverse the loss of vision but only decreases the rate at which it is happening. It does so by decreasing intraocular pressure to a level where this risk factor should no longer aggravate the condition. Therefore, its success would ultimately depend on whether the patient would live long enough to benefit from the difference between the fast rate of disease progression and the – expectedly – slower rate of progression after the procedure. So, not only its success is measured in years, it involves intensive follow-up, frequent clinic visits, strict medication regimens, and ongoing monitoring—factors that may not be appropriate for patients with limited life expectancy, advanced frailty, or social vulnerability.[3]

Previous studies suggest that life expectancy is not always systematically incorporated into the decision to perform glaucoma surgery, particularly in the oldest age groups. This may lead to invasive procedures that provide limited long-term benefit when survival is substantially shortened. Conversely, evidence indicates that carefully selected older adults, even at advanced ages, can achieve meaningful gains in visual function and quality of life when their anticipated survival is sufficient for the benefits of surgery to accrue.[6]

Understanding real-world postoperative survival patterns is therefore essential. Identifying age groups at higher risk of early mortality may inform shared, patient-centered surgical decision-making, allowing clinicians and patients to jointly weigh expected benefits against risks and align treatment choices with

individual goals and preferences, particularly in vulnerable geriatric populations.[7] This study aims to assess postoperative survival after glaucoma surgery in a real-world cohort and explore whether life expectancy may limit the potential long-term visual benefit of surgery in very old patients.

METHODS

Study design and setting

This retrospective observational cohort study was conducted at a tertiary referral hospital in Lisbon, Portugal. Medical records of all patients aged 65 years or older who underwent glaucoma surgery between January 2015, and December 2020 were reviewed. To ensure a minimum postoperative follow-up of five years, only patients with follow-up data available through 2025 were included. Patients younger than 65 years, those lost to follow-up during this period, or those with unconfirmed survival status were excluded. In patients who underwent bilateral glaucoma surgery, only the first surgical procedure was considered for analysis, in order to avoid within-patient correlation and to ensure independence of observations.

Data collection

Data were extracted from the institutional electronic health record (EHR) system with the assistance of the hospital's Information Technology Department. Surgical cases were identified using International Classification of Diseases, Ninth and Tenth Revision (ICD-9 and ICD-10) procedure and diagnosis codes, to ensure comprehensive capture of all glaucoma surgeries performed during the study period. The use of both coding systems reflected the temporal transition in the hospital's clinical information system during the study timeframe. A detailed list of the ICD-9 and ICD-10 codes used for case identification is provided in Supplementary Material 1.

For each patient, demographic data (age at surgery and sex), preoperative anaesthetic risk classification according to the American Society of Anesthesiologists (ASA), the type of glaucoma surgery performed, and postoperative variables, including the number of outpatient visits within six months after surgery, unplanned hospital admissions, and reoperations related to surgical complications, were collected. Vital status was confirmed through the hospital records and cross-checked with the national death registry.

Outcomes

The primary outcome was overall postoperative survival, defined as all-cause mortality occurring within five years after glaucoma surgery. The secondary outcome was early postoperative mortality, defined as death occurring within two years after surgery. This timeframe was chosen because clinically meaningful improvements in visual function and quality of life following glaucoma surgery generally require a minimum of two years of follow-up.[8]

Survival time was calculated from the date of the index glaucoma surgery to the date of death or the last documented follow-up, whichever occurred first.

Survival estimates were stratified by predefined age groups and, where available, by ASA class, to explore differences in postoperative mortality across clinically relevant strata.

Statistical analysis

Descriptive statistics were used to summarize patient characteristics. Continuous variables were expressed as mean ± standard deviation or median (interquartile range), depending on distribution, and categorical variables as frequencies and percentages.

Survival probabilities at 2 and 5 years were estimated using Kaplan–Meier analysis and compared between age groups using the log-rank test. Associations between postoperative mortality and potential predictors (age, ASA classification, and postoperative variables) were assessed using Cox proportional hazards regression models. Cases with missing ASA classification were excluded from analyses involving this variable. The proportional hazards assumption was verified by inspection of log-minus-log survival plots.

All analyses were performed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). A two-tailed p-value < 0.05 was considered statistically significant.

Ethics

The study complied with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the Lisbon Academic Medical Centre (ref n 359/25). The requirement for informed consent was waived due to the retrospective nature of the study.

RESULTS

A total of 639 patients underwent glaucoma surgery between January 2015 and December 2020. After applying the predefined inclusion and exclusion criteria, 390 patients were eligible and included in the final analysis. The median postoperative follow-up time was 4.8 years (interquartile range: 2.6–8.5).

Population characteristics

The mean age at the time of surgery was 75.67 ± 6.45 years. The majority of patients were classified as ASA 2 (72%). ASA classification shifted toward higher-risk categories with increasing age, and its distribution differed significantly across age group ($\chi^2 = 15.7$, $p = 0.015$).

The median number of outpatient visits within six months after surgery was 6 (interquartile range: 4–8), including a median of 4 glaucoma-related visits (interquartile range: 1–6). Despite a higher ASA

classification in older patients, postoperative healthcare utilization within the first six months, including both total outpatient visits and glaucoma-related visits, was similar across age groups (Kruskal–Wallis test, p = 0.088 and p = 0.962, respectively).

Tabela 1- Baseline characteristics of the study population stratified by age group

Characteristic	Overall (n = 390)	65–74 (n = 171)	75–84 (n = 186)	≥ 85 (n = 33)
Age, years, mean ± SD	75.67 +/- 6.45	69.65 ± 2.91	79.05 ± 2.75	87.79 ± 2.36
Age group, n (%)		171 (43.8)	186 (47.7)	33 (8.5)
ASA classification, n (%)				
ASA I	3 (0.8)	1 (0.6)	2 (1.1)	0 (0)
ASA II	279 (71.5)	134 (78.4)	128 (68.8)	17 (51.5)
ASA III	106 (27.2)	34 (19.9)	56 (30.1)	16 (48.5)
ASA IV	2 (0.5)	2 (1.2)	0 (0)	0 (0)
Outpatient visits ≤ 6 months, median (IQR)	6 (4–8)	6 (4–9)	6 (5–8)	5 (4–6)
Glaucoma visits ≤ 6 months, median (IQR)	4 (1–6)	3 (1–6)	4 (2–5)	4 (1–5)
Survival rate, %				
2 years survival	95.7	97.0	95.6	90.2
5 years survival	88.0	91.5	87.7	72.4

Mortality and survival analysis

During the follow-up period, 45 patients (11.54%) died. The median time from surgery to death was 3.1 years (IQR 1.4–4.5). Notably, nearly half of the cohort remained under follow-up at five years (n = 190; 48.72%).

The overall survival probability was 95.72% at two years (95% CI: 93.1–97.4) and 88% at five years (95% CI: 83.7–91.2). Kaplan–Meier curves showed a significant difference in survival across age groups (log-rank p = 0.0097), with the highest mortality observed in patients aged ≥ 85 years.

Predictors of mortality

In univariable Cox regression analysis, patients aged ≥ 85 years had a significantly higher risk of death compared with those aged 65–74 years (HR 3.34, 95% CI 1.46–7.65; p = 0.004), whereas no significant difference was observed for patients aged 75–84 years. After adjustment for ASA classification, the association between advanced age and mortality remained significant for patients aged ≥ 85 years, although attenuated (HR 2.42, 95% CI 1.04–5.67; p = 0.041). Higher perioperative risk (ASA III–IV) was independently associated with increased mortality (HR 2.99, 95% CI 1.64–5.47; p < 0.001).

DISCUSSION

In this real-world cohort of 390 older adults undergoing glaucoma surgery, overall postoperative survival was high, with estimated survival probabilities of 95.7% at two years and 88.0% at five years. Over a median follow-up of approximately five years, only 45 patients (11.5%) died, with a median time from surgery to death of 3.1 years (IQR 1.4–4.5). Nearly half of the cohort (190/390) remained under follow-up at five years, supporting the robustness of long-term survival estimates.

As expected, survival differed significantly across age groups, with the highest mortality observed among patients aged ≥ 85 years. In Cox regression analysis, age ≥ 85 years was associated with a substantially increased risk of death compared with patients aged 65–74 years, an association that remained significant after adjustment for perioperative risk. By contrast, patients aged 75–84 years did not exhibit a significantly higher mortality risk than younger older adults. In parallel, higher comorbidity burden, reflected by ASA III–IV classification, was independently associated with mortality. Importantly, despite higher ASA classes in older patients, postoperative healthcare utilization within the first six months—including both total outpatient visits and glaucoma-related visits—was similar across age groups, suggesting that advanced age and higher perioperative risk do not translate into increased short-term care burden.

Few studies have specifically examined long-term mortality following glaucoma surgery, as most ophthalmic research has traditionally focused on visual outcomes and intraocular pressure control rather than patient survival. Available evidence addressing postoperative mortality is therefore limited and heterogeneous, particularly in very old or comorbid populations.[8–10]

Historically, very old patients—particularly octogenarians with multiple comorbidities—have frequently been managed conservatively with medical therapy alone, reflecting uncertainty regarding whether the potential benefits of glaucoma surgery outweigh the risks given their perceived limited life expectancy. This conservative approach has been driven not by robust evidence of futility, but rather by the absence of data on survival and the lack of practical tools to integrate life expectancy into clinical decision-making.[2]

Recent data focusing specifically on very old patients provide important context for our findings. A 2025 study of octogenarians undergoing glaucoma surgery reported substantial long-term mortality, with

approximately 28% of patients not surviving beyond five years and more than half dying within nine years postoperatively. In that cohort, visual acuity was also identified as a significant predictor of mortality, suggesting that disease severity and overall health status may be closely intertwined in this population.[2] While these findings underscore the vulnerability of very old patients, they are consistent with our observation of increased mortality among patients aged ≥ 85 years (five-year mortality 27.6%), while also indicating that a substantial proportion survive for several years after surgery.

Beyond single-center clinical cohorts, population-based analyses offer a complementary perspective on mortality in elderly patients undergoing glaucoma surgery. In a large nationwide Korean cohort (n = 16,210), Lee et al. reported a 30% higher risk of death among elderly patients who underwent glaucoma surgery compared with those managed without surgery.[9] However, such findings likely reflect residual confounding and indication bias, as patients selected for surgery may represent a clinically more severe or vulnerable subgroup rather than a direct effect of the surgical intervention itself.

Emerging evidence further underscores the relevance of frailty-based assessment in older patients with glaucoma.[2,11] Recent electronic health record–based studies have shown that patients with glaucoma are more likely to be frail or pre-frail than glaucoma suspects, and that frailty—rather than the glaucoma diagnosis itself—is a stronger determinant of adverse outcomes such as acute healthcare utilization for injurious falls or fractures.[11] These findings reinforce the concept that vulnerability in older glaucoma patients is driven primarily by systemic health status rather than ophthalmic diagnosis alone.

Although formal frailty assessment and comprehensive geriatric evaluation were not routinely available in our retrospective cohort, the observed survival patterns suggest that chronological age alone is an insufficient criterion for surgical decision-making. As already established in non-ophthalmic surgical fields—such as oncogeriatrics and orthogeriatrics[12,13]— incorporating geriatric principles, including assessment of physiological reserve, functional status, comorbidity burden, and patient goals, may enable more individualized and appropriate surgical selection. This approach is also consistent with international healthy ageing frameworks, including the World Health Organization Integrated Care for Older People (ICOPE) strategy, which advocate for function-oriented, person-centered care rather than decisions based solely on chronological age or single-disease metrics.[14–16]

Notably, despite a higher comorbidity burden and increased mortality risk among the oldest patients, postoperative healthcare utilization within the first six months did not differ across age groups. This finding indicates that advanced age does not translate into increased short-term outpatient care requirements following glaucoma surgery. From a clinical standpoint, these observations challenge the assumption that advanced age or high perioperative risk necessarily limits the usefulness of glaucoma surgery. The high survival probabilities observed suggest that most older patients live long enough to experience meaningful visual and quality-of-life benefits. Together, these findings support a shift from age-based decision-making toward a personalized approach that integrates life expectancy, disease severity, and patient preferences.[7]

Several strengths of this study strengthen the interpretation of these findings. Key strengths of this study include the long follow-up period of at least five years, allowing robust estimation of mid- and long-term mortality, and the use of electronic health records cross-checked with the national death registry, ensuring reliable survival data. The inclusion of a large, consecutive real-world cohort from a tertiary care center provides a realistic picture of glaucoma surgery outcomes in routine clinical practice. Additionally, the combined assessment of survival and postoperative healthcare utilization offers a broader perspective on the feasibility of surgery in older and higher-risk patients.

This study has limitations inherent to its retrospective, single-center design, which may limit generalizability. Selection bias cannot be excluded, as patients deemed unfit for surgery —particularly those with extreme frailty or very high perioperative risk — may not have been referred for or offered surgical intervention. At the same time, patients who are sufficiently fit to attend regular hospital outpatient visits may represent an appropriate target population for surgical consideration, reflecting real-world clinical decision-making rather than arbitrary selection.

Frailty and functional status were not systematically assessed, as validated geriatric instruments were not routinely used during the study period; instead, ASA classification was used as a pragmatic proxy for comorbidity burden, which may not fully capture physiological vulnerability. Visual outcomes and patient-reported measures were not evaluated, precluding direct linkage between survival and functional benefit. Finally, although five-year survival estimates were robust, longer-term estimates are based on fewer patients at risk. Nevertheless, the choice of these outcome measures relates to the clinical utility – as age, and ASA would be something to be easily retrievable in any surgical center, thus allowing future benchmarking or data pooling if needed.

The absence of formal frailty and functional assessment also highlights the potential value of multidisciplinary collaboration in the care of older patients with glaucoma. In other surgical specialties, geriatrician involvement and team-based approaches have been shown to improve risk stratification, perioperative management, and alignment of treatment decisions with patient goals.[17,18] A similar collaborative model may be particularly relevant in glaucoma surgery, where the anticipated benefit depends on long-term survival and functional outcomes rather than immediate symptom relief. Moreover, older patients with glaucoma are at increased risk of geriatric syndromes, including falls, depression, dementia and frailty, which may further influence postoperative outcomes and long-term quality of life.[11,19,20]

Future prospective and clinical studies should incorporate comprehensive geriatric assessments[21], including frailty, functional status, and quality-of-life measures, to better stratify older patients beyond age and ASA classification. Integrating survival data with visual and patient-reported outcomes may help identify which patients derive the greatest benefit from surgery and support the development of decision-support frameworks that promote individualized, patient-centered care.

In summary, in this real-world cohort, most older patients — including those with advanced age and higher perioperative risk — survived long enough to potentially benefit from glaucoma surgery. While age ≥ 85 years and elevated ASA classification were associated with increased mortality, these factors alone should not preclude surgical intervention.

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Figures

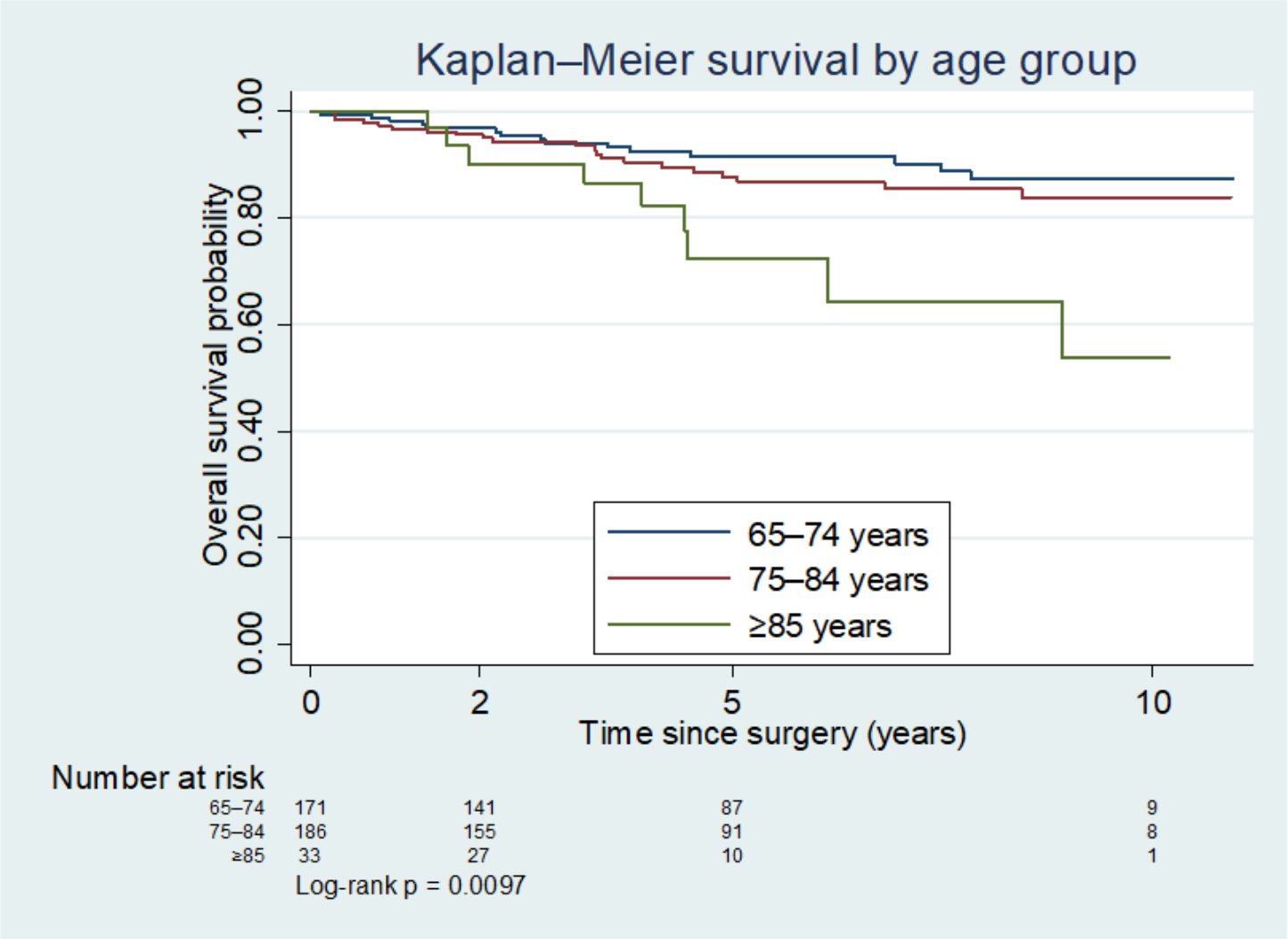


Figure 1

Overall postoperative survival after glaucoma surgery stratified by age group.

Supplementary Files

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