



CLINICAL RESEARCH

**Incidence and risk factors of postoperative visual function impairment in elderly patients undergoing nonocular surgery: a prospective cohort study**

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**KEYWORDS**

Aged;  
Postoperative complications;  
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**Abstract**

**Background:** Elderly patients may present with visual function impairment after surgery, which may increase the incidence of postoperative delirium and falls and decrease their quality of life. The aim of this study was to assess visual function in elderly patients after long-duration nonocular surgery to determine the incidence and risk factors for visual function impairment after surgery.

**Methods:** This prospective and observational study included patients aged between 60 and 80 years who had been scheduled for elective non-ocular surgery expected to last longer than 120 minutes under general anaesthesia. Ocular examinations were performed before surgery, on post-operative day 3 and on post-operative day 21 and consisted of a LogMAR-Snellen chart test, a Jager chart test, biomicroscopy, optical tonometry, ocular motility assessment and funduscopy. Baseline characteristics of all patients as well as intraoperative and postoperative data were collected.

**Results:** A total of 107 patients were included in the final analysis. Visual function impairment was diagnosed in 21 patients (19.6%) at POD 3. Of those, 7 patients (6.5%) still presented with visual changes at POD 21. On POD 3, compared with that at baseline, visual acuity assessed by the Snellen chart test had decreased in these patients. Significant differences regarding

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refraction tests and intraocular pressure measures were also found. Multivariable analysis identified diabetes mellitus, duration of surgery, hypotension during anaesthesia induction, lower peripheral oxygen saturation at the end of the procedure and body mass index as independent risk factors for postoperative visual impairment.

**Conclusion:** In elderly patients undergoing long-duration non-ocular procedures under general anaesthesia, the incidence of visual function impairment was considerably high. Most patients recovered to baseline visual function, but clinically significant visual changes may still be present 3 weeks after surgery. Obesity, diabetes mellitus, and the duration of surgical and anaesthetic techniques appear to increase the risk of visual impairment after surgery.

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## Introduction

Perioperative visual function impairment after non-ocular surgery is a complication of surgery whose incidence, severity and clinical presentation vary among patients. Perioperative Visual Loss (POVL) is the most severe presentation, with increased prevalence after cardiac, spine, head and neck and some orthopaedic procedures.<sup>1,2</sup> Fortunately, this impairment is a very rare complication, and its incidence is approximately 5.4 per 10,000 patients for transient POVL and 0.16 per 10,000 patients for permanent POVL.<sup>3-5</sup> Nevertheless, milder forms of postoperative visual changes may not easily be perceived by clinicians, and the real incidence of perioperative visual changes has not yet been well established. Elderly patients may be at high risk for this complication, which may also increase the incidence of postoperative delirium and the risk of falls, leading to anxiety and decreased quality of life.

Previous studies have attempted to determine the frequency and natural history of perioperative changes in vision. Warner et al.<sup>6</sup> prospectively performed an ocular examination based on accommodation-acuity tests and pupil size measurements in 671 patients undergoing a variety of surgical procedures. The incidence of postoperative changes in accommodation and visual acuity was 4.2%. Unfortunately, the authors could not identify any significant risk factors for this problem. The findings of Warner et al. are not relevant for clinical practice because an ocular examination is not a routine postoperative evaluation, and visual changes may affect postoperative outcomes.

It has been hypothesized that the incidence of perioperative visual changes in elderly patients might be higher than previously perceived. The aim of this study was to determine the incidence of perioperative visual function impairment in elderly patients undergoing non-ocular surgery through a complete ocular examination and to identify risk factors for postoperative visual changes.

## Methods

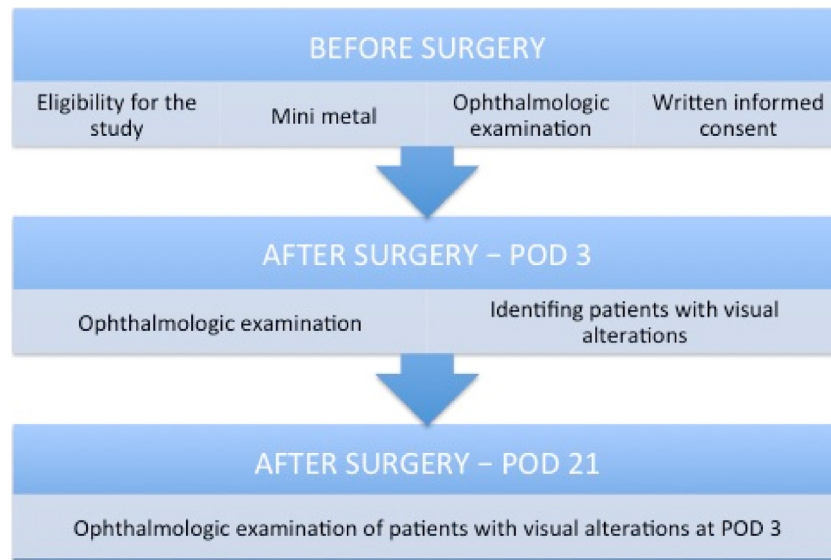
### Study design and setting

This study was a prospective cohort study performed at a university hospital, namely, the of Hospital das Clínicas, Faculdade de Medicina da Universidade de São Paulo, Brazil,

and was carried out between August 2014 and March 2016. The original protocol was approved by the university's Ethics Committee of Hospital das Clínicas, Faculdade de Medicina da Universidade de São Paulo (FMUSP). The study followed the recommendations of the International Conference on Harmonization-Good Clinical Practice Guidelines, and written consent forms were obtained from all patients or their legal guardians.

### Study participants

Patients aged between 60 and 80 years who were scheduled for elective surgery requiring general anaesthesia longer than 120 minutes were included. Patients who were scheduled to undergo cardiac surgery, ophthalmologic surgery, spine surgery, head and neck surgery and otorhinolaryngology surgery were not included. Additionally, patients who were expected to have postoperative mechanical ventilation for more than 24 hours, patients with psychiatric disorders, comprehension deficit, significant preoperative ophthalmologic alterations such as glaucoma, congenital cataract, senile cataract, retinopathy (diabetic, immune, hypertensive), single eye, ocular trauma with unilateral or bilateral blindness, keratoconus and rheumatologic visual alterations were excluded. All patients were submitted to the Mini-Mental State Examination (MMSE) for screening for cognitive alterations, with cut-off points adjusted based on the educational level of the individuals. Only individuals with scores between 18 and 23 on the MMSE scale were included in the project. Due to logistical reasons related to the ophthalmologic examinations, patient recruitment was performed only Mondays after hospital admission. During a pre-anaesthesia evaluation, patients were assessed for eligibility, and after obtaining written consent, they were included in the study and referred for a preoperative ophthalmologic examination by experienced ophthalmologists. Detailed information about participant selection is available in the supplemental material. Surgical and anaesthetic procedures were not standardized for the study and were selected at the discretion of the attending surgeon and anaesthesiologist. Patients were followed up at Post-Operative Day (POD) 3 and at POD 21 for the main outcome.



figure\* 1 Study protocol fluxogram.

### Ophthalmologic examinations

All patients selected for the study were referred to the ophthalmologic clinic located in the outpatient block of the Hospital das Clínicas, Faculdade de Medicina da Universidade de São Paulo (FMUSP), and the following ophthalmologic tests were performed: vision acuity assessment using a Snellen chart and a Jaeger card, bio-microscopy, ocular tonometry, ocular motility and funduscopy. A full description of the ophthalmologic tests is available in the supplemental material. All ophthalmologic tests were performed by or under the supervision of an experienced ophthalmologist. The study patients were examined on the eve of their surgical procedure (baseline test), at POD 3 and at POD 21. Only patients with alterations at POD 3 relative to baseline were scheduled to undergo ophthalmologic tests at POD 21 (Fig. 1). Postoperative visual function impairment was defined as any visual impairment or alteration relative to the baseline examination.

### Data collection

In addition to the data related to the ophthalmologic tests, baseline characteristics of the study patients, such as age, sex, body mass index, previous chronic diseases such as systemic arterial hypertension, diabetes mellitus, tobacco use, chronic obstructive pulmonary disease, atrial fibrillation, hypothyroidism, dyslipidaemia, gastroesophageal reflux disease, chronic hepatitis/liver cirrhosis and chronic kidney disease, were also collected. Further recorded data included a physical status classification based on the American Society of Anesthesiologists, type and duration of the surgical procedure, intraoperative patient position, anaesthetic agents administered, the need for blood transfusion, type and amount of fluids given in the intraoperative period, haemoglobin concentration before and after surgery, and temperature, pulse oximetry, end tidal CO<sub>2</sub>, heart rate, and

arterial blood pressure immediately before and after anaesthesia induction and at the end of the procedure.

### Risk of bias

To minimize the risk of bias, all patients were selected from the same general population using rigorous inclusion and exclusion criteria, and data collection was standardized and blinded. All data was collected prospectively. The preoperative and postoperative ophthalmologic examinations were performed by or under the supervision of an experienced ophthalmologist. Patients who were lost to follow-up were excluded from the final analysis.

### Statistical analysis

Based on the hypothesis that postoperative visual function impairment occurs in approximately 15% of elderly patients and considering a 95% Confidence Interval and an 80% power of analysis for unilateral difference (calculations based on a normal approximation to the binomial distribution), the necessary calculated sample was 95 patients (estimate of 20% for loss of follow-up).

We compared baseline characteristics, follow-up measures and clinical outcomes between the groups (patients with or without postoperative visual impairment). Continuous and semi-continuous variable data were initially compared with the Gaussian curve by means of the Kolmogorov-Smirnov and Shapiro-Wilk tests. Sample means and standard deviations are used to represent data with parametric behaviours, whereas medians and interquartile ranges are used to represent data with nonparametric behaviour. Parametric variables were analysed by the paired Student's *t*-test, whereas non-parametric variables were assessed using the Mann-Whitney *U* test. Categorical data are presented as absolute (n) and percentage (%) values and were analysed using the chi-square test, Fisher's exact test, or a likelihood test. Comparisons of the values obtained from

the visual acuity tests using the Snellen chart, ocular tonometry and the refraction test over time were made using repeated-measures analysis of variance (ANOVA) and the post hoc Tukey's test. Stepwise multiple logistic regression analysis was performed to estimate the predictive factors for postoperative visual function impairment, including risk factors that were first estimated in the univariable analysis ( $p < 0.10$ ). A statistical significance of 5% was adopted ( $p < 0.05$ ).

Calculations were performed using the following software programs: Microsoft Excel for Windows (Microsoft Corp., Redmond, WA, USA), IBM SPSS Statistics 20.0 for Mac (SPSS Inc., Chicago, IL, USA), and GraphPad Prism 4.0 for Windows (GraphPad Software Inc., San Diego, CA, USA).

A one-tailed test was used to calculate the sample because it was expected that visual acuity would worsen in the postoperative period. If visual acuity was expected to have remained unchanged or improved, a two-tailed test would have been used.

## Results

Of a total of 203 patients assessed for eligibility, 110 patients were enrolled in the study. Of those, 107 completed follow-up and were included in the final analysis. Three participants were lost to follow-up due to clinical conditions that precluded them from undergoing the ophthalmologic examination at POD 3 (Fig. 2). The characteristics of the study participants are described in Table 1.

## Outcome data

Patients with postoperative visual alterations presented with a lower body mass index and a higher prevalence of diabetes mellitus, tobacco use, chronic liver disease and gastroesophageal reflux disease than patients without postoperative visual abnormalities. Regarding surgical- and anaesthetic-related variables, patients with postoperative visual alterations required longer surgical procedures, received more fluids, received more blood transfusions, and presented with a lower haemoglobin concentration after surgery. In addition, the intraoperative head-up position was more common among patients with postoperative visual alterations. Intraoperative fentanyl was required significantly more often among patients with postoperative visual impairment. The incidence of hypotension after anaesthetic induction and the need for ephedrine or metaraminol were significantly higher in patients with postoperative visual impairment (Table 2).

A total of 21 patients presented with postoperative visual function impairment in at least one of the ophthalmologic tests relative to the baseline examination. Except for the refraction tests, preoperative ophthalmologic test performance was similar between patients with and without postoperative visual alterations. Patients with postoperative visual alterations presented with a better performance in the preoperative refraction tests than patients without postoperative visual alterations. However, at POD 3, visual acuity as assessed by the Snellen chart test was decreased in these patients relative to baseline. Significant differences regarding refraction tests and intraocular pressure measures

were also found (Table 3). Of the 21 patients who presented with visual alterations, 14 fully recovered at POD 21.

Regarding perioperative monitoring variables, patients with postoperative visual alterations presented with lower peripheral oxygen saturation before anaesthetic induction, after anaesthetic induction and at the end of the surgery than patients without postoperative visual alterations. In addition, heart rate was higher after anaesthetic induction and at the end of the surgical procedure among patients with postoperative visual alterations. Additionally, systolic blood pressure was higher before anaesthetic induction but lower after anaesthetic induction and at the end of the surgery among patients with postoperative visual alterations than among patients without postoperative visual alterations (Table 4).

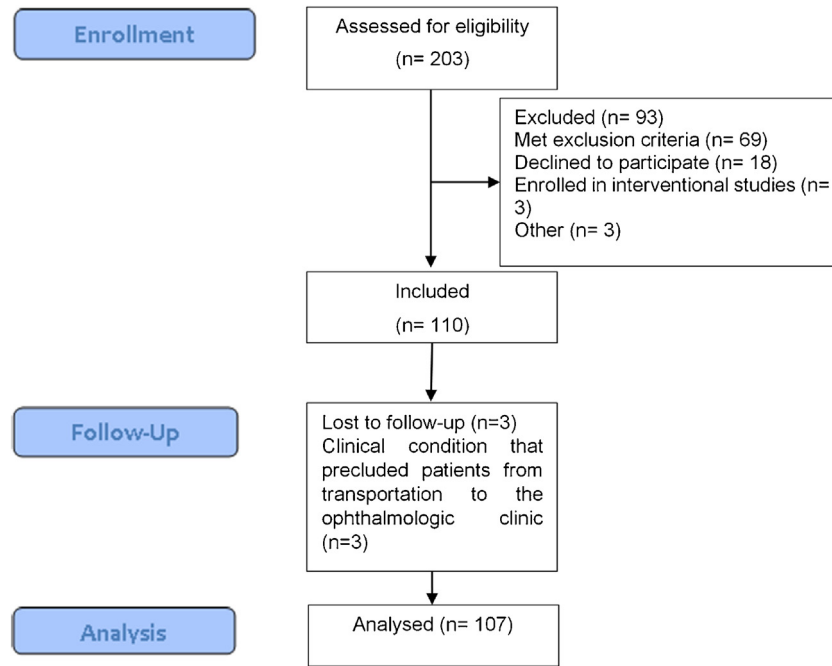
In the multivariable analysis, independent risk factors for postoperative visual alterations were higher body mass index, lower peripheral oxygen saturation at the end of the surgery, higher heart rate and lower systolic blood pressure after anaesthetic induction, and longer duration of surgical procedure (Table 5).

## Discussion

This study found that approximately one in five elderly patients who underwent non-ocular surgery with a duration longer than 2 hours and under general anaesthesia presented with postoperative visual impairment at POD 3. Additionally, one in fifteen of those patients continued presenting with an alteration of visual function as late as 3 weeks after surgery. Lower BMI, higher duration of surgery, lower SBP after anaesthesia induction and lower peripheral oxygen at the end of the surgery were identified as independent risk factors for postoperative visual function impairment in this population.

Very few studies have aimed to describe the frequency and natural history of perioperative visual changes. As previously mentioned, Warner et al.<sup>5</sup> used a limited ocular examination to assess patients after surgery and found an incidence of postoperative visual changes of 4.2%, lower than the incidence found in the current study. However, there are some differences between this study and the study performed by Warner and colleagues. Here, only elderly patients were included, which could explain the higher incidence of postoperative visual alterations, as previous studies have described age as an independent risk factor for ophthalmologic complications, such as ischaemic optic neuropathy.<sup>7</sup> In addition, a more complete ophthalmologic examination was performed in the present study, which may have improved the accuracy of the diagnosis of reduced visual acuity.

Although this study was not designed to provide a mechanistic explanation for postoperative visual impairment, based on the identified risk factors, it was hypothesized that hypoperfusion may have played a major role in its pathogenesis. Hypotension during the surgical procedure may have led to hypoperfusion of structures of the posterior compartment of the eye and caused transient ischaemia of the optic nerve and/or retina. Depending on the severity and duration of the ischaemic insult, patients may present with transient visual impairment or loss, with recovery to normal vision or even permanent blindness. Reduced



figure\* 2 Study flow chart.

Table 1 Baseline characteristics of the study participants.

Variable	Visual function alterations		p-value
	No (n = 86)	Yes (n = 21)	
Age (years)	66 (62–72)	68 (63–74)	0.494 <sup>a</sup>
BMI (kg.m <sup>-2</sup> )	25 (23–27)	22 (21–26)	0.015 <sup>a</sup>
Physical status			
ASA I	8 (9.3%)	2 (9.5%)	1.000 <sup>b</sup>
ASA II	78 (90.7%)	19 (90.5%)	
Comorbidities			
Systemic arterial hypertension	75 (87.3%)	17 (80.9%)	0.488 <sup>b</sup>
Atrial fibrillation	7 (8.5%)	1 (12.5%)	1.000 <sup>b</sup>
COPD	5 (5.8%)	2 (9.5%)	0.621 <sup>b</sup>
Smoking	9 (10.5%)	8 (38.1%)	0.005 <sup>b</sup>
Hypothyroidism	1 (1.2%)	0 (0%)	1.000 <sup>b</sup>
Diabetes mellitus	12 (13.9%)	9 (42.9%)	0.006 <sup>b</sup>
Dyslipidaemia	7 (8.1%)	3 (14.3%)	0.408 <sup>b</sup>
GERD	0 (0%)	2 (9.5%)	0.037 <sup>b</sup>
Hepatitis B	0 (0%)	2 (9.5%)	0.037 <sup>b</sup>
CRF	2 (2.3%)	0 (0%)	1.000 <sup>b</sup>
Procedures			0,012 <sup>d</sup>
Gastrointestinal procedure	20 (23.3%)	11 (52.4%)	
Gynaecologic procedure	11 (12.8%)	1 (4.8%)	
Liver and biliary tract procedure	13 (15.1%)	3 (14.3%)	
Peripheral vascular surgery	11 (12.8%)	5 (23.8%)	
Plastic surgery	1 (1.2%)	0 (0%)	
Urologic procedure	30 (34.9%)	1 (4.8%)	

Data are presented as absolute (n) and relative (%) values or medians and interquartile ranges. BMI, Body Mass Index; COPD, Chronic Obstructive Pulmonary Disease; GERD, Gastroesophageal Reflux Disease; CRF, Chronic Renal Failure.

<sup>c</sup>Chi-Square test.

<sup>a</sup> Mann-Whitney U test.

<sup>b</sup> Fisher's exact test.

<sup>d</sup> Likelihood Ratio.



**Table 2** Postoperative clinical and laboratory data of the study participants.

Variable	Visual function alterations		p-value
	No (n = 86)	Yes (n = 21)	
Duration of anaesthesia (min)	160 (140–240)	260 (170–340)	0.005 <sup>a</sup>
Duration of surgery (min)	140 (125–200)	220 (148–310)	0.007 <sup>a</sup>
Fluid therapy and blood transfusion			
Crystalloids (mL)	1500 (1500–3000)	3000 (1550–3500)	0.001 <sup>a</sup>
Red blood cell transfusion	0 (0%)	2 (9.5%)	0.037 <sup>b</sup>
Preoperative Hb (g.dL <sup>-1</sup> )	13 (12–13)	13 (11–13)	0.818 <sup>a</sup>
Postoperative Hb (g.dL <sup>-1</sup> )	12 (11–13)	10 (10–12)	0.001 <sup>a</sup>
Surgical position			
Head-up	6 (6.9%)	6 (28.6%)	0.004
Trendelenburg	54 (62.8%)	14 (66.7%)	0.137
Anaesthetic agents			
Remifentanyl	12 (13.9%)	3 (14.3%)	1.000 <sup>b</sup>
Succinylcholine	1 (1.2%)	1 (4.8%)	0.355 <sup>b</sup>
Etomidate	1 (1.2%)	0 (0%)	1.000 <sup>b</sup>
Fentanyl (mcg)	250 (250–300)	350 (275–500)	0.002 <sup>a</sup>
Propofol (mg)	150 (140–166)	160 (140–170)	0.660 <sup>a</sup>
Cisatracurium (mg)	16 (0–20)	12 (0–20)	0.531 <sup>a</sup>
Midazolam (mg)	2 (0–5)	0 (0–4)	0.418 <sup>a</sup>
Rocuronium (mg)	50 (50–50)	50 (0–50)	0.515 <sup>a</sup>
Vasopressor agents (ephedrine and metaraminol)	16 (18.6%)	12 (57.1%)	<0.001 <sup>c</sup>
Vasopressor agents (ephedrine and metaraminol)	0 (0–0)	5 (0–5)	0.001 <sup>a</sup>

Data are presented as absolute (n) and relative (%) values or as medians and interquartile ranges. Hb, Haemoglobin.

<sup>a</sup> Mann-Whitney *U* test.

<sup>b</sup> Fisher's exact test.

<sup>c</sup> Chi-Square test.

**Table 3** Patient results from preoperative and postoperative day 3 visual acuity tests and intraocular pressure measurements.

Variable	Total (n = 107)			No visual alteration (n = 86)			Visual alteration (n = 21)			p <sup>c</sup>
	Mean	SD	p <sup>a</sup>	Mean	SD	p <sup>b</sup>	Mean	SD	p <sup>b</sup>	
LogMAR Snellen – right eye										
Preoperative	0.28	0.19		0.29	0.20		0.23	0.14		0.189
POD 3	0.31	0.21	0.001	0.29	0.21	0.233	0.39	0.19	<0.001	0.035
LogMAR Snellen – left eye										
Preoperative	0.28	0.20		0.29	0.20		0.23	0.15		0.237
POD 3	0.31	0.21	0.001	0.29	0.21	0.235	0.40	0.21	<0.001	0.022
IOP – right eye										
Preoperative	14.55	1.75		14.59	1.74		14.38	1.80		0.621
POD 3	14.77	1.79	0.001	14.56	1.75	0.320	15.62	1.77	<0.001	0.014
IOP – left eye										
Preoperative	14.58	1.81		14.63	1.82		14.38	1.80		0.578
POD 3	14.79	1.88	0.001	14.59	1.82	0.320	15.57	1.96	<0.001	0.032
Refraction test – right eye										
Preoperative	1.67	0.59		1.73	0.63		1.43	0.35		0.004
POD 3	1.72	0.58	<0.001	1.73	0.63	–	1.68	0.32	<0.001	0.600
Refraction test – left eye										
Preoperative	1.62	0.59		1.68	0.59		1.37	0.52		0.031
POD 3	1.67	0.57	<0.001	1.69	0.58	0.159	1.61	0.52	<0.001	0.556

SD, Standard Deviation; POD 3, Postoperative Day 3; IOP, Intraocular Pressure.

<sup>a</sup> Student's *t* test.

<sup>b</sup> Repeated-measures analysis of variance (ANOVA): preoperative vs. postoperative.

<sup>c</sup> Repeated-measures ANOVA: no visual alteration vs. visual alteration.

**Table 4** Perioperative monitoring data of the study participants.

Monitoring variable	Visual function alterations		p-value
	No (n = 86)	Yes (n = 21)	
Temperature (°C)			
Before induction	36 (36–36)	36 (35–36)	0.062
After induction	35 (35–36)	35 (35–36)	0.751
At the end of surgery	35 (35–36)	35 (35–36)	0.984
SpO <sub>2</sub> (%)			
Before induction	99 (98–99)	97 (96–99)	<0.001
After induction	99 (99–99)	99 (98–99)	0.003
At the end of surgery	99 (99–99)	97 (96–99)	<0.001
ETCO <sub>2</sub> (mmHg)			
Before induction	42 (39–42)	42 (39–44)	0.344
After induction	35 (35–35)	35 (31–36)	0.207
At the end of surgery	39 (38–40)	39 (37–42)	0.864
HR (bpm)			
Before induction	73 (64–80)	70 (66–81)	0.832
After induction	65 (59–72)	72 (61–80)	0.041
At the end of surgery	66 (60–73)	72 (70–85)	0.001
SBP (mmHg)			
Before induction	130 (124–136)	140 (130–140)	0.008
After induction	100 (100–112)	90 (85–110)	0.002
At the end of surgery	125 (120–130)	124 (115–130)	0.568
DBP (mmHg)			
Before induction	80 (67–85)	80 (65–85)	0.686
After induction	55 (45–60)	50 (45–60)	0.207
At the end of surgery	65 (60–74)	70 (60–83)	0.320
Diuresis (mL)	400 (328–500)	500 (300–650)	0.225

Data are presented as the median and interquartile range. SpO<sub>2</sub>, Peripheral Oxygen Saturation; ETCO<sub>2</sub>, End-Tidal Carbon Dioxide; HR, Heart Rate; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure.

**Table 5** Multivariable analysis of predictive factors for postoperative visual function alteration.

Variable	OR	95% CI		p-value
BMI (kg.m <sup>-2</sup> )	0.627	0.459	0.858	0.030
SpO <sub>2</sub> at the end of surgery (%)	0.142	0.053	0.382	<0.001
HR after induction (bat/min)	1.175	1.057	1.306	0.003
SBP after induction (mmHg)	0.848	0.767	0.938	0.001
Duration of surgery (min)	1.025	1.010	1.041	0.001

OR, Odds Ratio; CI, Confidence Interval; SpO<sub>2</sub>, Peripheral Oxygen Saturation; HR, Heart Rate; SBP, Systolic Blood Pressure.

blood flow in the vertebrobasilar system and posterior visual sensory pathways and visual cortex dysfunction may also be involved in the pathogenesis of postoperative visual dysfunction.<sup>8–11</sup> Elderly patients are more susceptible to eye hypoperfusion due to a higher prevalence of diabetes, cardiac arrhythmia, atherosclerosis and arterial stenosis of the great vessels. However, classical findings of ischaemic optic nerve and retinal ischaemia, such as optic disc oedema, retinal microaneurysms, cotton wool spots, flame or blot retinal haemorrhages, were not found in our patients on postoperative fundoscopy.<sup>9,10</sup> Nevertheless, such findings are normally described in severe ischaemia of the retina or optic nerve, and the clinical presentation is visual loss, which is a rare ophthalmologic condition and is often associated with circulatory shock or vascular occlusive phenomena leading to complete interruption of blood supply to the eye. Our

patients may have experienced mild ischaemia of the retina or optic nerve, which is characterized with transient visual alterations, blurred vision, or reduced visual acuity, but it could not be perceived on fundoscopy examination.

Regarding the limitations of the study, it can be stated that due to logistic limitations of the ophthalmologic clinic, the ophthalmologic examinations could only be performed on Mondays and Fridays. Therefore, we were only able to assess patients at POD 3, and whether other factors related to the postoperative period could be involved in the visual function impairment of the patients cannot be excluded. Additionally, for the same reason, the ophthalmologic examinations could not be performed for all patients included in the study at POD 21, only for those who presented with visual alteration at POD 3. In addition, we did not assess the long-term patient outcomes regarding their visual func-

tion. Consequently, we could not precisely describe the real incidence and natural history of the postoperative visual alterations since complete follow-up patient data were only available for postoperative day 3. Additionally, none of the patients were assessed through a more accurate diagnostic method, such as fluorescein angiography or optical coherence tomography, which could have provided more information about the pathogenesis of the reduced visual acuity.<sup>12</sup> Nonetheless, it is worth mentioning that a detailed description of the incidence and natural history of visual function of patients undergoing non-ocular surgery would require a complete ophthalmologic follow-up, which would be extremely costly and unfeasible. The study was a single-centre study performed at a university hospital, and almost 50% of patients assessed for eligibility were not included due to a higher incidence of exclusion criteria. Therefore, the generalization of the findings is limited.

## Conclusions

In elderly patients undergoing long-duration non-ocular procedures under general anaesthesia, the incidence of visual function impairment was considerably high (19,6%). Most patients recovered to baseline visual function. Lower BMI, SpO<sub>2</sub> at the end of surgery, SBP after induction and higher heart rate after induction, duration of surgical and anaesthetic technique appeared to increase the risk of visual impairment after surgery.

## Ethics approval

The protocol and consent procedures were approved by the institutional review board of the university. The project was approved by the Ethics Committee for Analysis of Research Projects (CAPPesq) of Hospital das Clínicas, Faculdade de Medicina da Universidade de São Paulo (FMUSP) under project number NUSP7307172.

## Authors contributions

GB, MB, MA and MC helped to create the study design. GB, JA, MB, MC and MA were responsible for conceiving of the article, interpreting the results, and drafting and revising the manuscript. JK helped to conduct statistical analyses and to revise the manuscript. FC, MT, CH, AA, MA, AF and LF helped to collect the data and draft the manuscript. All authors read and approved the final manuscript and take full responsibility for all aspects of the study.

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This study was performed at the of Hospital de Clínicas, Faculdade de Medicina da Universidade de São Paulo (FMUSP), São Paulo, Brazil. There was no external funding source for this study.

## Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Conflicts of interest

The authors declare no conflicts of interest.

## References

1. Roth S. Perioperative visual loss: what do we know, what can we do? *Br J Anaesth.* 2009;103 Suppl 1:i31–40.
2. Lee LA. Perioperative visual loss and anesthetic management. *Curr Opin Anaesthesiol.* 2013;26:375–81.
3. American Society of Anesthesiologists Task Force on Perioperative Visual Loss. Practice advisory for perioperative visual loss associated with spine surgery: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Visual Loss. *Anesthesiology.* 2012;116:274–85.
4. Newman NJ. Perioperative visual loss after nonocular surgeries. *Am J Ophthalmol.* 2008;145:604–10.
5. Shen Y, Drum M, Roth S. The prevalence of perioperative visual loss in the United States: a 10-year study from 1996 to 2005 of spinal, orthopedic, cardiac, and general surgery. *Anesth Analg.* 2009;109:1534–45.
6. Warner ME, Fronapfel PJ, Hebl JR, et al. Perioperative visual changes. *Anesthesiology.* 2002;96:855–9.
7. Postoperative Visual Loss Study Group. Risk factors associated with ischemic optic neuropathy after spinal fusion surgery. *Anesthesiology.* 2012;116:15–24.
8. Grover V, Jangra K. Perioperative vision loss: a complication to watch out. *J Anaesthesiol Clin Pharmacol.* 2012;28:11–6.
9. Luneau K, Newman NJ, Biousse V. Ischemic optic neuropathies. *Neurologist.* 2008;14:341–54.
10. Mizener JB, Podhajsky P, Hayreh SS. Ocular ischemic syndrome. *Ophthalmology.* 1997;104:859–64.
11. Nenekidis I, Pournaras CJ, Tsironi E, et al. Vision impairment during cardiac surgery and extracorporeal circulation: current understanding and the need for further investigation. *Acta Ophthalmol.* 2012;90:e168–72.
12. Chan NCY, Chan CKM. The use of optical coherence tomography in neuro-ophthalmology. *Curr Opin Ophthalmol.* 2017;28:552–7.