The association between bariatric surgery and cataract: a propensity score-matched cohort study

Theresa Burkard, Ph.D. a, Dag Holmberg, M.D, Ph.D. b, Anders Thorell, M.D., Ph.D. c,d, Farhad Hafezi, M.D., Ph.D. e,f,g,h,i, Andrea M. Burden, Ph.D. a,*

aETH Zurich, Department of Chemistry and Applied Biosciences, Zurich, Switzerland
bUpper Gastrointestinal Surgery, Department of Molecular Medicine and Surgery, Karolinska Institutet, Karolinska University Hospital, Stockholm, Sweden
cDepartment of Clinical Science, Danderyd Hospital, Karolinska Institutet, Stockholm, Sweden
dDepartment of Surgery, Ersta Hospital, Stockholm, Sweden
eLaboratory for Ocular Cell Biology, Center for Applied Biotechnology and Molecular Medicine, University of Zurich, Zurich, Switzerland
fELZA Institute, Dietikon, Switzerland
gUSC Roski Eye Institute, University of Southern California, Los Angeles, California
hFaculty of Medicine, University of Geneva, Geneva, Switzerland
iDepartment of Ophthalmology, University of Wenzhou, Wenzhou, China

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Abstract

Background: Obesity is considered a risk factor for cataracts. The association between weight loss and a cataract among patients with obesity has not been assessed to date.

Objectives: To assess the association between weight loss following bariatric surgery and cataracts.


Methods: We performed a population-based cohort study. Patients aged 40–79 years who underwent bariatric surgery were matched on their propensity score (PS) to up to 2 patients with obesity (“unexposed patients”). Cox proportional hazard regression analyses calculated hazard ratios (HRs) and 95% confidence intervals (CIs) of developing cataracts following bariatric surgery, compared with unexposed patients. Subgroup analyses by age, sex, bariatric surgery type, and duration of follow-up were conducted.

Results: In total, 22,560 bariatric surgery patients were PS-matched to 35,523 unexposed patients. The risk of cataracts was decreased in bariatric surgery patients compared with unexposed patients (HR .71, 95% CI .66–.76). We observed the lowest risk of cataracts among bariatric surgery patients aged 40–49 years (HR .52, 95% CI .44–.75) but a null result for patients aged ≥60 years. Gastric bypass or duodenal switch were associated with decreased risks of cataracts, whereas sleeve gastrectomy yielded a null result. Subgroups of sex and duration of follow-up showed no evidence of effect modification (hazards were proportional throughout follow-up).

*Correspondence: Andrea M. Burden, Ph.D., Pharmacoepidemiology, Institute of Pharmaceutical Sciences, Department of Chemistry and Applied Biosciences, Federal Institute of Technology (ETH) Zurich, Vladimir-Prolog-Weg 1-5/10, CH-8093 Zurich, Switzerland.
E-mail address: andrea.burden@pharma.ethz.ch (A.M. Burden).

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A cataract is a clouding of the lens leading to lens opacity and represents a leading cause of visual impairment and blindness [1, 2]. The prevalence of cataracts in Sweden among individuals aged 65–74 years is 35.2% in women and 26.2% in men and increasing within 5-year age groups [3]. The occurrence of cataracts is multifactorial, with age being the main risk factor [4]. Further risk factors include eye injury, radiation exposure, heritability, glucocorticoid use, metabolic conditions (e.g., diabetes, ischemic ocular conditions), and other ocular conditions (e.g., end-stage glaucoma or high myopia) [4]. Obesity may also increase the risk of age-related cataracts by 34% for cortical cataracts and 52% for posterior subcapsular cataracts, as reported by a meta-analysis of 6 prospective cohort studies [5].

Obesity is further associated with numerous adverse health outcomes [6, 7], but lifestyle interventions are often ineffective to reduce excess body weight [8, 9]. Consequently, bariatric surgery has been a popular procedure since the early 2000s [10]. Depending on the type of surgery, patients typically lose up to 50%–70% of excess body weight within the first 2 years post-surgery [11], with most patients sustaining this weight loss at 10 years postsurgery [12]. The benefit of bariatric surgery in relation to various health outcomes such as type 2 diabetes (T2D) [13, 14], hypertension [13, 14], cardiovascular disease [13, 15], and mortality [13, 16] has been previously demonstrated; however, a benefit has not been established in relation to cataracts. To date, only 1 small prospective study (n = 29) has assessed lens opacity 1 year after bariatric surgery, compared with the bariatric surgery date, and observed no changes [17].

Given current knowledge, we hypothesized that weight loss might be negatively associated with the incidence or progression of cataracts. Therefore, this investigation aimed to assess the association between weight loss through bariatric surgery and cataract in a secondary care setting.

Methods

Study design and data source

We conducted a propensity score (PS)-matched sequential cohort study using data from the nationwide Swedish healthcare registries, including the Patient Registry (in- and outpatient information), Causes of Death Registry, Prescribed Drug Registry, Cancer Registry, and the Scandinavian Obesity Surgery Registry (SOReg). All individuals born or permanently residing in Sweden are assigned a 10-digit personal code for identification in healthcare registries and allowed for linkage. Bariatric surgery codes have been validated with excellent results, showing high agreement between the Patient Registry, SOReg, and medical records [18]. Thus, we used the Swedish patient registry to identify bariatric surgery patients and SOReg to obtain details on the type of surgery codes and body mass index (BMI) measurements. The Regional Ethical Review Board in Stockholm, Sweden, approved the study (registration number 2020-04112).

Study population

We identified all individuals diagnosed with obesity (ICD10 E66, ICD9 278A/B, ICD8 287,0, ICD7 277,99) aged 40–79 years at any time between January 1, 2006, and December 31, 2019, in the Swedish Patient Registry. According to the date of surgery, we categorized patients who underwent bariatric surgery into one of four 3- to 4-year cohort entry blocks (referred to as cohort entry) (Fig. E1). Unexposed patients were selected as follows. The period during which a patient was unexposed from bariatric surgery (i.e., from ≥40 yr of age until bariatric surgery, exclusion criteria, or loss to follow-up) was assigned 1 random entry date within each cohort entry block. If the patient had a record of obesity, the patient entered the study on this date as an unexposed patient (Fig. E1). For simplicity, we refer to all contributing patients as episodes because patients could contribute 1 episode as an exposed patient but multiple episodes as an unexposed patient throughout the study period if eligibility criteria were fulfilled.

We excluded all episodes with a record of other weight-reducing surgery prior to cohort entry (e.g., jejunooileal bypass). Furthermore, we excluded episodes with a prior eye injury, cataract diagnosis, or primary or revision cataract surgery.

PS matching

We estimated a PS (probability of undergoing bariatric surgery) for each bariatric surgery episode and unexposed episode using multivariable logistic regression. We included medical diagnoses recorded at any time before cohort entry and prescriptions recorded within the 6 months before
cohort entry. Selected diagnoses and prescriptions were either associated with obesity (e.g., T2D, hypertension), associated with undergoing surgery in general (e.g., Royal College of Surgeons Charlson comorbidity score [19]), the risk of developing cataract (e.g., sun exposure approximated by non-melanoma skin cancer), or potential confounders of the association between bariatric surgery and cataract (e.g., age). All covariates were selected a priori based on clinical knowledge (Table 1) [20]. To maximize comparability between matched episodes, we matched bariatric surgery episodes and unexposed episodes separately within each of the 4 cohort entry blocks (to account for time trend bias of exposure and outcome). A greedy 8–1–digit matching algorithm without replacement was applied, excluding those who could not be matched [21]. In a sensitivity analysis, we trimmed our study population asymmetrically at the

### Table 1

Baseline characteristics of bariatric surgery patients and non-bariatric surgery patients (follow-up >365 d) before and after PS-matching

<table>
<thead>
<tr>
<th></th>
<th>Before PS-matching</th>
<th>PS-matched</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposed (n=28,801)</strong></td>
<td><strong>Unexposed (n=211,418)</strong></td>
<td><strong>Exposed (n=22,560)</strong></td>
</tr>
<tr>
<td>Mean age (SD), yr</td>
<td>49.2 (6.5)</td>
<td>57.8 (10.4)</td>
</tr>
<tr>
<td>Mean follow-up (SD), yr</td>
<td>6.4 (3.1)</td>
<td>5.5 (3.2)</td>
</tr>
<tr>
<td>Women</td>
<td>20,867 (72.5%)</td>
<td>121,079 (57.3%)</td>
</tr>
<tr>
<td>Alcohol overconsumption proxy</td>
<td>7934 (27.6%)</td>
<td>90,339 (42.7%)</td>
</tr>
<tr>
<td>Smoking</td>
<td>963 (3.3%)</td>
<td>17,918 (8.5%)</td>
</tr>
<tr>
<td>Median number of hospital contacts ≤1 yr before index date (IQR)</td>
<td>3 (2–4)</td>
<td>0 (0–2)</td>
</tr>
</tbody>
</table>

**Comorbidities before cohort entry**

- Cholelithiasis/Cholecystitis
- Diabetes Type 2
- Hyperlipidemia
- Hypertension
- GERD
- Glaucoma
- Gout
- Ischemic heart disease
- Menopause
- Migraine
- Pneumonia
- Pregnancy/Delivery
- Rheumatoid arthritis
- Other corticoid “dependent” diseases
- Sleep apnea

**Medications at cohort entry**

- Antibiotics
- Analgesics/Anti-inflammatory drugs
- Antipsychotics
- Antidepressants
- Anxiolytics
- Cardiovascular drugs
- Hypnotics/Sedatives

**Cohort entry date**

- 2006–2008
- 2009–2011
- 2012–2014
- 2015–2018

**c-statistics**

- .90

PS = propensity score; SD = standard deviation; IQR = interquartile range; GERD = gastroesophageal reflux disease; COPD = chronic obstructive pulmonary disease.

† Includes diagnosis of COPD.

‡ Treatment or diagnosis.

§ Further includes myocardial infarctions and angina pectoris.

‡‡ Representing systemic lupus erythematosus, psoriasis/parapsoriasis/pityriasis, ulcerative colitis, myasthenia gravis, dermatomyositis, giant cell arteritis, autoimmune hemolytic anemia.

‡‡‡ Not used for propensity score estimation.
extreme ends of the PS tail (bariatric surgery episodes below the fifth and unexposed episodes above the 95th percentile before matching) to exclude bariatric surgery and unexposed episodes treated contrary to prediction, as those episodes are subject to the highest confounding.

Follow-up

Follow-up started on day 365 after cohort entry (Fig. E1) because no earlier effect of bariatric surgery was expected. Thus, we did not consider 160 cataracts within 364 days after bariatric surgery. We followed bariatric surgery and unexposed episodes in an “as-treated” approach until the first occurrence of cataract or censoring due to onset of an exclusion criterion described above, change of exposure status, loss to follow-up, or end of the study period (December 2019). We performed 2 sensitivity analyses, starting follow-up at day 1 and day 720 after the index date to assess the influence of the run-in periods.

Exposure ascertainment

Exposure was bariatric surgery identified from the Swedish Patient Registry using the following Nordic Medico-Statistical Committee (NOMESCO) codes [22] as of 1997: gastric bypass: JDF10–11; duodenal switch: JFD03–04; others (92.6% sleeve gastrectomy according to SOReg; thus, we further referred to this group as sleeve gastrectomy): JDF00–01, JDF20–21, JDF96–97. When comparing information from the Swedish Patient Registry with SOReg, we observed that 93.0% and 88.0% of patients categorized as having undergone gastric bypass and duodenal switch, respectively, were categorized correctly. Change of exposure status happened if an exposed episode had a reversal code (NOMESCO code JFD23) or an unexposed episode had a bariatric surgery code.

Outcome

The outcome was cataract, defined as a first diagnosis of a cataract recorded as ICD10 code H25, H26.0/9, or H28, or cataract surgery recorded as NOMESCO codes beginning with CJC, CJD, or CJE recorded in the Swedish patient registry. Among unique patients with a cataract diagnosis and surgery, 85.9% of patients had the diagnosis first, 7.8% had the surgery first, and 6.2% had both for the first time on the same day. The median time from diagnosis to surgery was 55 days (interquartile range [IQR]: 5–142 days).

Statistical analysis

After combining all sequential cohorts into 1 cohort, we compared covariate distribution between treatment groups before and after PS-matching by estimating the standardized mean differences. We further estimated pre- and post-matching c-statistics using a logistic regression model including all covariates included into the PS to assess covariate balance. We applied Cox proportional hazard regression and calculated hazard ratios (HR) with 95% confidence intervals (CIs) to evaluate the association of bariatric surgery and cataract.

We performed subgroup analyses by sex, age (40–49, 50–59, and 60–79 yr), and bariatric surgery type (sleeve gastrectomy, gastric bypass, duodenal switch), for which we re-matched within subgroups. The proportional hazard assumption was tested using the martingale residual method and held overall and for all subgroups. Nevertheless, we also performed a subgroup analysis by tertials of follow-up (>1–3.5, >3.5–6, and >6–13 yr). Since some patients entered our study cohort more than once, we additionally estimated the robust sandwich estimate for the covariance matrix to consider repeated use of exposed/unexposed episodes (results remained unchanged). For comparative reasons, we also conducted all analyses using multivariable Cox regression in the unmatched cohort, adjusting for all covariates included in the PS.

In post hoc analyses, we compared the cumulative incidence of cataracts among bariatric surgery episodes with those of unexposed episodes. All analyses were performed using SAS statistical software version 9.4.

Results

We identified 28,801 eligible bariatric surgery episodes, of which 22,560 (78.3%) were matched with up to 2 unexposed episodes (i.e., 35,523 episodes among 28,318 unique unexposed patients [79.7%]) (Fig. E2).

Table 1 shows patient characteristics before and after PS-matching. Before PS-matching, compared with unexposed episodes, the mean age of bariatric surgery episodes was lower and the proportion of women was higher. Bariatric surgery episodes had a higher median number of hospital contacts and were less frequently diagnosed with type 2 diabetes, hypertension, ischemic heart diseases, but more frequently using analgesics or anti-inflammatory drugs (Table 1). After PS-matching, covariate balance was achieved with a post-matching c-statistic of .56. Furthermore, all covariates yielded <10% of standardized mean differences between bariatric surgery and unexposed episodes after PS-matching (Fig. E3). Moreover, censoring was comparable between groups after PS-matching (Table E1).

BMI obtained from SOReg at the time of bariatric surgery and during follow-up is provided in eTable 2. Gastric bypass was the most performed bariatric surgery. Episodes with duodenal switch (only 1% of cases) had the highest mean BMI (55.3 kg/m²).

In the PS-matched analysis, we observed an overall decreased risk of cataracts in bariatric surgery episodes when compared with unexposed episodes (HR of 0.71, 95% CI .66–.76) (Table 2). The risk increased slightly with age...
at bariatric surgery – with the lowest risk observed among bariatric surgery episodes aged 40–49 years (HR of .52, 95% CI .44–.75) when compared with unexposed episodes. We observed a null result as of patient aged 60. Gastric bypass or duodenal switch (small sample size) yielded similar to those from PS-matching. Sensitivity analyses of (i.e., hazards were proportional throughout follow-up).

Results from the multivariable adjusted analysis are similar to those from PS-matching. Sensitivity analyses of shortening or prolonging the run-in duration did not change the results. However, trimming tails yielded a slightly higher HR than the overall result (HR of .82, 95% CI .74–.90).

In the post-hoc analyses, the cumulative incidence of cataracts stratified by exposure status over time is described in Fig. 1. The cumulative incidence of cataracts was continuously higher in unexposed episodes than in bariatric surgery episodes aged 40–49 years (HR of .52, 95% CI .44–.75) and .49 (95% CI .20–1.20), respectively, whereas sleeve gastrectomy yielded a null result. No evidence of effect

Discussion

In this large cohort study with a maximum follow-up of 14 years among patients with obesity in the Swedish patient registry, we observed a 29% decreased risk of cataracts following bariatric surgery. Compared with unexposed patients with obesity, the risk of cataracts was lowest in patients aged 40–49 at bariatric surgery (48% decreased risk) and in patients who underwent gastric bypass (32% decreased risk). A null result was observed in patients aged ≥60 years at the time of bariatric surgery and among those undergoing sleeve gastrectomy.

Our observed 29% decreased risk of cataracts following bariatric surgery compared with unexposed patients with obesity is in line with our hypothesis that weight loss would decrease the formation or progression of a cataract. No other study has assessed this association before. However, 1 small prospective study assessed lens opacity through the Lens Opacities Classification System III (LOCS) among 29 patients who underwent bariatric surgery [17]. A total of 8 patients had a cataract at bariatric surgery, and no change in lens opacity was observed at the 1-year follow-up examination [17]. Thus, bariatric surgery may neither trigger nor resolve cataracts. However, cataracts have risk factors [23–25] other than obesity [3], such as increased levels of triglycerides, HbA1C (glycated hemoglobin), and blood pressure, which in turn are beneficially influenced by bariatric surgery [26]. The influence of these risk factors may explain the potential dose-response relationship between weight loss and cataracts observed in our analysis, as evidenced by the decreased risk of cataracts following gastric
bypass or duodenal switch but not following sleeve gastrectomy. Gastric bypass and duodenal switch yielded more weight loss than sleeve gastrectomy and were previously reported to have a stronger impact on lipid levels [27], blood pressure, and blood glucose levels [28]. Our findings are plausible, but we can only speculate about the detailed pathway between weight loss and cataracts that may further include decreased levels of oxidative stress [29], systemic inflammation [30], or change in gut microbiota [31]. Thus, the observed decreased risk of cataracts in bariatric surgery patients may be further due to accompanying remission of cardiovascular or metabolic diseases but also other physiologic changes affecting overall health.

Furthermore, although women were reported to have a higher risk of developing cataracts than men [32], our findings suggest no difference between sexes in the decreased risk of developing a cataract following bariatric surgery. Lower weight loss among men following bariatric surgery [33] may make up for a generally higher cataract disease burden among women. Concerning age, we observed that bariatric surgery did not influence cataract risk if bariatric surgery was carried out as of age 60. This may imply that processes are involved that cannot be reversed after a certain age, potentially owing to the amount of partially unfolded crystalline before bariatric surgery [4].

Preserving vision is essential, and a potential delay in cataract development following bariatric surgery, as observed in this study, may be valuable information for patients with obesity in decision-making about bariatric surgery. Moreover, cataract surgery is often more challenging in patients with obesity [34] and diabetes [35]. Furthermore, bariatric surgery was reported to decrease the risk of other ophthalmologic complications such as diabetic retinopathy, as recently reported [36]. Given the population-based approach, our results are generalizable to patients with obesity undergoing bariatric surgery in Scandinavia and other countries with a similar population and health care system (e.g., Germany, Italy, or Canada).

However, despite the rigorous methodology of this study, our results must be interpreted in the context of several limitations. First, data on BMI were only available from SOReg for bariatric surgery patients and thus were unavailable in unexposed patients with obesity. Missing BMI in unexposed patients raises 2 questions: whether unexposed patients may have lost the same amount of weight as bariatric surgery patients and whether BMI was balanced between groups at cohort entry. There is ample evidence that other means to lose weight are most often ineffective, suggesting that the observed decreased risk of cataracts is likely the result of bariatric surgery [8,9]. Moreover, since all risk factors associated with obesity were balanced (e.g., T2D, hypertension, cardiovascular disease) after PS-matching, we assume that BMI was similar among exposed and unexposed patients. However, in the scenario that BMI was not balanced after PS-matching, it was likely higher in unexposed patients, given the covariate distribution before PS-matching. This
may have slightly overestimated the association between bariatric surgery and cataracts (i.e., the obtained HR may be falsely low). Second, while glucocorticoid use is associated with an increased risk of cataracts and would be a confounding factor in this study, we could not control for it in our analysis as it is not available in the existing data set, which was established for other purposes. However, given that rheumatoid arthritis and other corticoid dependent diseases, as well as analgesic/anti-inflammatory drug use, were balanced after PS-matching, we expect that the use of glucocorticoids was likely also balanced. Finally, this study was neither designed nor equipped to assess potential mediators (e.g., inflammatory markers or remission of diabetes) of the association between bariatric surgery and cataract. Thus, we suggest this analysis be carried out in future investigations in a suitable database.

Conclusion

Our findings from this nationwide cohort study suggest that substantial weight loss is associated with a decreased risk of cataracts, especially when bariatric surgery was performed before age 60. This decreased risk of cataracts is an additional benefit to the multitude of positive effects weight loss has on eye health. Furthermore, given the decreased risk of cataracts following gastric bypass or duodenal switch but not following sleeve gastrectomy, our results suggest a potential dose-response relationship between weight loss and cataracts. This evaluation strengthens the evidence that obesity is potentially involved in cataract development or progression and that weight loss may help to delay early cataract formation.

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Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

Supplementary materials

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