Risk of bilateral visual impairment in individuals with amblyopia: the Rotterdam study

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Background: The excess risk of bilateral visual impairment (BVI; bilateral visual acuity <0.5) among individuals with amblyopia is an argument for screening for amblyopia, but data are scarce.

Methods: The risk was estimated by determining the incidence of BVI in the Rotterdam Study, a population-based cohort of subjects aged 55 years or over ($n = 5220$), including 192 individuals with amblyopia (3.7%). Using a multistate life-table, the lifetime risk and excess period spent with BVI were determined.

Results: The relative risk of BVI for amblyopes was 2.6 (95% confidence interval 1.4–4.5). For individuals with amblyopia, the lifetime risk of BVI was 18%, whereas they lived on average 7.2 years with BVI. For non-amblyopic individuals, these figures were 10% and 6.7 years, respectively.

Conclusion: Amblyopia nearly doubles the lifetime risk of BVI and affected individuals spent an extra six months with BVI. This study provides data for future cost-effectiveness analyses.

The risk of losing vision in the non-amblyopic eye, as well as the social and psychological benefit of binocularity, is an important reason for the prevention and treatment of amblyopia in children. Few data exist on this risk, however, despite a prevalence of amblyopia of approximately 2.5% in the general population.¹ Tommila and Tarkkanen² in Finland identified 35 individuals over a 20-year period with amblyopia who had lost vision in their non-amblyopic eye. Rahi *et al.*³ recently performed a prospective national surveillance among ophthalmologists in the United Kingdom and found 370 cases. According to this study, the projected lifetime risk of vision loss (visual acuity <0.5) for an individual with amblyopia was at least 1.2%. It is possible, however, that both surveillance studies underestimated this risk because the population at risk was not known precisely and elderly patients who did not visit an ophthalmologist may have been underrepresented. A population-based study by Chua and Mitchell⁴ reported a relative risk of 2.7 for the five year risk of bilateral visual impairment (BVI) among individuals with amblyopia. This study did not provide data on the lifetime risk.

We determined the incidence of BVI among individuals with and without amblyopia in a large population-based cohort study and estimated the lifetime risk and expected period living with BVI.

METHODS

Data were derived from the Rotterdam Study, a population-based, prospective cohort study of the frequency and determinants of common cardiovascular, locomotor, neurological and ophthalmological diseases. The study started in 1990 with follow-up examinations in 1993 and 1997.⁵ The eligible population comprised all 10 275 inhabitants aged 55 years or older of a middle-class suburb of Rotterdam, the Netherlands, of whom 7983 (78%) participated. Because the ophthalmological part of the study became operational after the pilot phase had started, 6780 individuals took part in the baseline ophthalmic examinations. Written informed consent was obtained from all participants. The medical ethics committee of Erasmus University approved the study protocol.

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At baseline, participants underwent an interview at their home followed by an extensive general medical and ophthalmological examination at the research centre. Visual acuity was measured monocular at a 3 m distance using a Lighthouse Distance Visual Acuity Test, a modified Early Treatment Diabetic Retinopathy Study chart.⁶ To evaluate best-corrected visual acuity, optimal refraction was obtained subjectively after objective autorefraction. Individuals reporting an amblyopic eye were selected ($n = 137$), as well as those with a unilateral visual acuity less than 1.0 as a result of amblyopia according to a trained examiner ($n = 97$). The diagnosis of amblyopia was assumed to be correct when one of the following criteria was present ($n = 185$): a unilateral visual acuity of 0.5 or less and (history of) strabismus, or anisometropia greater than 1 dioptre, or hypermetropia greater than 3 dioptres in the least hypermetropic eye, or astigmatism greater than 1.5 dioptres, and no other explanation for unilateral visual acuity of 0.5 or less. Eight individuals with a possible history of amblyopia who did not match the criteria were re-examined in person by an ophthalmologist; the diagnosis was confirmed in seven.

BVI was defined as a best-corrected visual acuity less than 0.5 in the better eye, without improvement at subsequent examinations. This cut-of value is in accordance with the United States criteria for visual impairment and is the same as that used in the Rahi study.³ The age-specific incidence rate of BVI was determined by dividing the number of incident cases by the number of person-years within an age category. A Poisson model was fitted to the data to model the age-dependent prevalence and incidence of BVI. Next, a Markov multistate life-table was constructed with transition probabilities from the Poisson model. Mortality rates were taken from the Dutch national database for statistics. From this analysis the age-specific prevalence rates, the cumulative (lifetime) incidences, and the remaining years with BVI were obtained.

RESULTS

The study cohort consisted of 5220 individuals with complete data on visual acuity and amblyopia status at baseline and follow-up (77.0% of baseline). Mean age was 67.4 (range 55–95) years. Amblyopia was diagnosed in 192 individuals, resulting in a prevalence of 3.7%. Median follow-up time was 6.5 years with a range of 0.3–9.7 years. After this period, 173 out of 5220 participants (3.3%) were identified with incident BVI. For the non-amblyopic population, the 5-year cumulative incidence of BVI was 0.3% for individuals aged 55–64 years, 1.2% for individuals aged 65–74 and 5.0% for those aged 75–84 years. These figures were 1.4%, 4.8% and 13.3% for individuals with amblyopia, respectively (fig 1). The relative risk of BVI for amblyopic individuals was 2.6 (95% confidence interval 1.4–4.5). In fig 2, the age-specific prevalence derived from the Markov life-table is compared with the age-specific prevalence at baseline within the Rotterdam Study for individuals with and without amblyopia. According to the life-table, the estimated lifetime risk of BVI for non-amblyopic individuals

Abbreviation: BVI, bilateral visual impairment

Figure 1 Age-specific five-year cumulative incidence of bilateral visual impairment (BVI) for individuals with and without amblyopia as observed within the Rotterdam Study.

was 10%, versus 18% for amblyopic individuals. Once affected, individuals lived on average 6.7 and 7.2 years with BVI, respectively. When lifetime risk and period with BVI are multiplied, the average period with BVI for the population can be calculated. For non-amblyopic individuals, this period was 10% times 6.7 years making 0.7 years. For individuals with amblyopia, the average period with BVI was 18% times 7.2 years making 1.3 years. This means that for the population of amblyopic individuals, the average period of their life spent with BVI was six months longer than those without amblyopia.

DISCUSSION

This study showed that the estimated lifetime risk of BVI is nearly doubled by the presence of amblyopia. In addition, we calculated that the average period living with BVI when affected was increased by six months.

Although the diagnosis of amblyopia in patients aged 55 years or older is more complex than in children, we think we ruled out most other causes of visual impairment at old age, such as age-related macular degeneration, cataract and glaucoma. These diseases were diagnosed in a standardised and thorough procedure and were excluded in amblyopia cases. Moreover, measured refraction may not be equal to the refraction at the time of amblyopia genesis. We think that this potential random measurement error would have a small effect on amblyopia case definition. The prevalence of amblyopia in our cohort was similar to that reported in the literature.¹ In all likelihood, none of our amblyopes had been subjected to occlusion therapy, as this treatment was introduced nationally in the Netherlands after the second world war. The age-specific prevalence of BVI among non-amblyopes as predicted by our Poisson model was in accordance with prevalence data from eight population-based studies in the United States, Australia, and Europe.⁷

As far as we know, the lifetime risk of visual impairment within the general population has never been described in the

literature. Klein *et al.*⁸ studied the 10-year risk of visual acuity loss in the Beaver Dam Eye Study cohort and found that 12.2% of subjects lost vision to 20/40 in the better eye. The mean age of that cohort at baseline was, however, 58.7 years compared with 67.4 years in the Rotterdam Study. Considering that most causes of visual loss act at ages above 70 years, the lifetime risk will be higher than their reported 10-year risk.

Compared with the study of Rahi *et al.*,³ the lifetime risk of BVI among individuals with amblyopia in our population was considerably higher; 18% instead of 1.2%. There are a few possible explanations for this difference. First, in the surveillance study of Rahi *et al.*³ the population at risk was not known precisely, making incidence estimations less robust. Furthermore, because the ascertainment of eligible cases was probably incomplete, the authors stated that minimum estimates were reported. Rahi *et al.*³ relied on reports from ophthalmologists, thereby possibly foregoing patients who did not consult an ophthalmologist, e.g. older, less mobile patients. Our study did include these age categories by modelling the incidence of BVI until the end of life. On the other hand, individuals with traumatic loss of their non-amblyopic eye below the age of 55 years were not included in our data, but this group is small compared with those affected by age-related disorders.

One can calculate the number of individuals needed to treat to prevent one case with a particular outcome by taking the inverse of the difference in absolute risk.⁹ In this case, the number of individuals with amblyopia needed to treat successfully to prevent one case of BVI can be estimated by taking the difference in the lifetime risk of BVI between individuals with and without amblyopia. The inverse of the difference between 18% and 10% is 12.5. Therefore, 12.5 individuals with amblyopia need to be treated successfully to prevent one case of BVI. These data are obligate for a cost-effectiveness analysis.

In conclusion, the lifetime risk of BVI is nearly doubled by the presence of amblyopia, whereas the expected period living with BVI when affected is on average extended from 0.7 to 1.3 years.

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REFERENCES

- 1 Attebo K, Mitchell P, Cumming P, *et al.* Prevalence and causes of amblyopia in an adult population. *Ophthalmology* 1998;**105**:154-9.
- 2 Tommila V, Tarkkanen A. Incidence of loss of vision in the healthy eye in amblyopia. *Br J Ophthalmol* 1981;**65**:575-7.
- 3 Rahi JS, Logan S, Timms C, *et al.* Risk, causes, and outcomes of visual impairment after loss of vision in the non-amblyopic eye: a population-based study. *Lancet* 2002;**360**:597-602.
- 4 Chua B, Mitchell P. Consequences of amblyopia on education, occupation, and long term vision loss. *Br J Ophthalmol* 2004;**88**:1119-21.
- 5 Hofman A, Grubbe DE, de Jong PTVM, *et al.* Determinants of disease and disability in the elderly: the Rotterdam Elderly Study. *Eur J Epidemiol* 1991;**7**:403-22.
- 6 Klaver CCW, Wolfs RC, Vingerling JR, *et al.* Age-specific prevalence and causes of blindness and visual impairment in an older population: the Rotterdam Study. *Arch Ophthalmol* 1998;**116**:653-8.
- 7 The Eye Diseases Prevalence Research Group. Causes and prevalence of visual impairment among adults in the United States. *Arch Ophthalmol* 2004;**122**:477-85.
- 8 Klein R, Klein BEK, Lee KE. Changes in visual acuity in a population over a 10-year period. The Beaver Dam Eye Study. *Ophthalmology* 2001;**108**:1757-66.
- 9 Laupagis A, Sackett DL, Roberts RS. An assessment of clinically useful measures of consequences of treatment. *N Engl J Med* 1988;**318**:1720-7.

Figure 2 Prevalence of bilateral visual impairment for individuals with and without amblyopia. Squares represent observed prevalence data at baseline of the Rotterdam Study; lines represent predicted prevalence based on Poisson and Markov model.