·Investigation·

Prevalence and associated factors of corneal blindness in Ningxia in northwest China

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Received:2014-01-04 Accepted:2014-03-01

Abstract

• **AIM: To describe the prevalence and demographic characteristics of corneal blindness in an urban and rural region of Ningxia, located in the northwest part of China.**

• **METHODS: A stratified, randomized sampling procedure was employed in the study, including urban and rural area of all age group. Visual acuity, anterior segment and ocular fundus were checked. Related factor of corneal disease, including age, gender, education status, ethnic group, location and occupation, were identified according to uniform customized protocol. An eye was defined to be corneal blindness if the visual acuity was <20/400 due to a corneal disease.**

• **RESULTS: Three thousand individuals (1290 from urban area and 1710 from rural area) participated in the investigation, with a response rate of 80.380%. The prevalence of corneal blindness was 0.023% in both eyes and 0.733% in at least one eye. The blindness in at least one eye with varied causes was present in 106 participants (3.533%) and in bilateral eyes in 34 participants (1.133%). The corneal diseases accounted for 20.754% of blindness in at least one eye and 20.588% of bilateral blindness. The prevalence of corneal disease was higher in older and Han ethnic group, especially those who occupied in agriculture and outdoor work. People with corneal blindness were more likely to be older and lower education. Rural population were more likely to suffer from bilateral corneal blindness than the urban population in ≥59-year group (χ^2=6.716, P=0.019). Infectious, trauma and immune corneal disease were the three leading causes of corneal disease. Trauma corneal disease was more likely leading to blindness in one eye. However, infectious and immune corneal diseases make more contribution to the bilateral corneal blindness.**

• **CONCLUSION: Corneal blindness is a significant burden of in Ningxia population, encompassing a variety of corneal infections and trauma; the majority of those were avoidable. Health promotion strategies and good hygienic conditions have to be developed.**

• **KEYWORDS:** corneal disease; epidemiology; blindness; infectious keratitis; trauma
DOI:10.3980/j.issn.2222-3959.2014.03.30

Sheng XL, Li HP, Liu QX, Rong WN, Du WZ, Ma L, Yan GH, Ma RQ, Zhang JL, Xu HF, Zou WQ, Bi XJ. Prevalence and associated factors of corneal blindness in Ningxia in northwest China. *Int J Ophthalmol* 2014;7(3):557-562

INTRODUCTION

Sight is an important indicator of health and quality of life. Visual impairment is thought to be an important source of social burden worldwide. According to the most up to date studies, WHO estimates that 285 million people were suffering from visual impairment worldwide[1]. Corneal disease is a major cause of blindness in the world today, second only to cataract in overall importance [1]. In past decades, so much emphasis has been placed on cataract surgery, the corneal blindness were somewhat neglect [2]. The burden of corneal blindness is not just reflected by the prevalence, but also by the life years of blindness, which was known as disability adjusted life years (DALYs). Unlike cataract, blind eye caused by corneal scarring and vascularization usually remained blind throughout the individual's life due to lack materials for corneal transplantation, thus the blind usually last longer. Corneal blindness is complicated and encompasses a wide variety of infective and inflammatory eye diseases that cause corneal scarring and vascularization which leads to functional blindness [3]. About 80% of corneal blindness is avoidable [4]. In past decades, much effort has been made on the trachoma, onchocerciasis and vitamin A deficiency to reduce the corneal blindness [5], but infectious keratitis was still one of the most common causes of corneal blindness [6]. Li *et al* [7] conducted a population-based survey

on corneal blindness in the rural area of southern Harbin, China, which was assessing the burden of corneal blindness, but only rural population was involved in. In this study Keratitis in childhood after exanthematous fever was the dominant cause of corneal blindness (39.6%). The similar founding was display in the study several years later, that the leading cause was keratitis in childhood (40.0%), followed by ocular trauma (33.3%) and keratitis in adulthood (20.0%)[8]. In Henan Province, located in the central China, the infectious keratitis was the most common corneal disease, which was based on the hospital data [9]. But in Northern Nigeria trauma was the leading cause of corneal ulcer [10]. The prevalence of corneal blindness was diverse from different countries and different population. In less developed region of China, limited data available on the situation of corneal blindness. It was estimate that 95% corneal blindness was avoidable[11], so awareness of situation of corneal blindness would be benefit for the government take effective measure to prevent and cure the corneal disease. To investigate the corneal blindness burden and the difference of prevalence and risk factor of corneal blindness between urban and rural population. We conduct a population-based survey from February 2010 to July 2010 on corneal blindness in the urban and rural area in Ningxia, a less developed region located in northwest part of China. This area inhabited by Hui ethnic minority, who adhere to Islamic principles, lifestyle, diet, and culture. But Han ethnic group is still in the majority in this region. Different ethnic groups and population were involved in the study, which would help for comprehensive analysis on the risk factor of corneal disease.

SUBJECTS AND METHODS

Subjects A stratified, randomized sampling procedure was employed in the study. Communities larger than 1000 population were subdivided into more than one cluster, and villages smaller than 500 in population were combined. The sampling units were stratified by socioeconomic status. Two urban communities were selected from the Yinchuan city with better economic condition compared to another two rural communities, which were selected from Hongsipu town. According to Ningxia Statistical Data 2009, the annual per capita consumption expenditure of urban residents was 11 455 Yuan in Yinchuan city and 3906 Yuan in Hongsipu Town. In the urban areas, eye care services was at a relatively high standard and in the rural areas, eye care services and a referral system to ophthalmologists were not established very well with less experienced doctor and outdate equipment.

According to the Harbin eye study, the prevalence of bilateral corneal blindness 0.16% was used, within an error bound of 0.16% and 95% confidence interval [7]. Assuming the examination response rate of 80%, a minimum of 2996 individuals were required for the survey. Depending on the percentage of population in urban (43%) and rural area (57%), 1290 urban residents and 1710 rural residents should be included in the study.

Methods Family living in the communities or villages more than 6mo was regard as permanent family unit. The participants who were born before 1st January 2010 would be included in the study. The list of the permanent family unit was obtained and confirmed from the residents committee. Participant families were randomly sampled from the list. All age group was included in the Ningxia study. In China, one family one child policy was not carry out so strictly in ethnic Hui minority as in ethnic Han, especially in rural area. Thus one family usually had two or more children in rural area. Written informed consent was obtained from the participants in the study before the examination. For those participants who could not read and write, the consent was read aloud to them by the receptionist at the examination site in the presence of all the participants on that day. These participants gave their thumb impression after understanding and agreeing with the content of the consent. The study was approved by the Ethics Committee of the Ningxia Hospital. Ophthalmologist staff training was performed three weeks before the formal survey. Sociodemographic feature and ocular status were recorded using a standardized questionnaire.

At the study center, participants underwent an extensive and standardized examination that included visual acuity testing and a detailed clinical slit lamp examination and ocular fundus examination. For each eye, the participant's presenting visual acuity (PVA), was ascertained with participants wearing their habitual optical corrections (spectacles or contact lenses). In the present study, only PVA data were used, as we believe that this acuity gives a more accurate picture of the role of visual acuity in study participants' performance of the activities of daily living. Normal visual acuity was defined as PVA better than 20/60 in both eyes, mild or moderate visual impairment as PVA worse than 20/60 but equal to or better than 20/400. Blindness was defined as PVA worse than 20/400 or had enucleation before. The cause of blindness or visual impairment in each eye was noted by the ophthalmologist examining the subjects. Corneal blindness was considered to have visual acuity in that eye was <20/400 with ulcer or corneal scar as a result of a corneal disease. The corneal diseases were defined and classified using predetermined criteria based on history and the basic clinical eye examination. If corneal disease and another disorder coexisted in one eye, and the cure of the other disorder would not restore vision, the cause of blindness was considered to be the corneal disease.

Statistical Analysis Data were analyzed with commercial software (SPSS, ver. 16.0.1; SPSS Science, Chicago, IL, USA). $P<0.05$ indicated statistical significance. Prevalence

Table 1 Prevalence of corneal disease by age, gender education status ethnic group, area and occupation

Characteristic	Total	With corneal disease				χ^2	P
		Corneal disease	%	OR	(95%CI)		
Gender						0.173	0.677
M	1424	28	1.966	0.117	0.662-1.885		
F	1576	31	1.970	Reference			
Education						11.492	0.022
No formal education	553	22	3.978	1.516	0.566-4.062		
Primary	907	15	1.654	0.615	0.221-1.715		
High school	855	15	1.754	0.654	0.235-1.821		
Secondary school	172	1	0.581	0.214	0.025-1.851		
College and higher	188	5	2.660	Reference			
Ethnic group						6.682	0.010
Han	1733	46	2.654	2.282	1.221-4.265		
Hui	1241	13	1.048	Reference			
Location						0.549	0.459
Urban	1290	28	2.170	0.817	0.479-1.394		
Rural	1710	31	1.813	Reference			
Occupation						12.411	0.006
Farmer	1000	27	2.700	5.311	2.037-13.849		
Office worker	891	16	1.795	5.072	1.920-13.398		
Outdoor worker	147	11	7.483	5.345	1.421-20.172		
Children and student	962	5	0.520	Reference			

estimates for all outcomes were performed for the overall sample, and then in age-stratified groups. For risk factor analysis, a binary logistic regression model was used to investigate assess associations with each potential vision risk factor. Data are presented as prevalence and odds ratios with corresponding 95% confidence intervals (CIs).

RESULTS

A total of 3000 participants out of 3722 enumerated people of all age accept VA testing, slit-lamp and fundus examination, with an overall response rate of 80.380%. There were 1290 participants from urban area and 1710 participants from rural area. The mean age of urban participants was 37.670 ±21.975y versus 28.340 ±19.607y among rural participants. Among the 3000 participants, 2719 (90.633%) received the VA testing and 281 couldn't cooperate with the testing. Fifty-nine participants (1.967%, CI: 1.470%-2.463%) had corneal disease, and corneal blindness in at least one eye was present in 22 participants(0.733% CI: 0.043%-1.039%) and corneal blindness in both eye was present 7 participants (0.023%, CI: 0.006%-0.041%). Binary logistic analysis was used to estimate the association of corneal disease and corneal blindness with age, gender education status, ethnic group, location and occupation. With the growth of age, the prevalence of corneal disease(χ^2=48.736, P=0.000), corneal blindness in at least (χ^2=24.918, P=0.000) one eye and bilateral corneal blindness (χ^2=10.098, P=0.001) were increasing. Table 1 showed the prevalence of corneal disease and the related factors. Among them the age-adjust odd ratio of corneal disease were analyzed on gender, ethnic group, location and occupation aspects. The prevalence of corneal disease was higher in Han ethnic group, especially those who occupied in agriculture and outdoor work. Table 2 showed the prevalence of corneal blindness. Poor education increases the risk of suffering corneal blindness. Being occupied in farming and outdoor work significantly increases the risk of corneal blindness in at least one eye but has no impact on the bilateral corneal blindness. Gender and ethnic factors play no impact on the prevalence of corneal blindness. Rural population were more likely to suffer from bilateral corneal blindness than the urban population in ≥59-y group (χ^2 = 6.716, P =0.019). The blindness in at least one eye with varied causes were present in 106 participants (3.533% , CI: 2.872% -4.194%) and in bilateral eyes in 34 participants (1.133%, CI: 0.075%-1.512%). Among them, 20.754% (CI: 13.034% -28.475%) of blindness in at least one eye and 20.588% (CI: 6.997%-34.180%) of bilateral blindness resulted from corneal disease.

Infectious corneal disease, trauma and immune corneal disease were the three leading cause of corneal disease. The constitution of corneal disease shows no difference between rural and urban participants (χ^2=7.485, P=0.502, Table 3). Trauma, immune corneal disease and infectious corneal disease were more likely leading to blindness in at least one eye. But infectious corneal disease and immune corneal disease make more contributing to the bilateral corneal blindness (Table 4).

Table 2 Prevalence of corneal blindness by age, gender education status, ethnic group, area and occupation

Characteristic	Total	With bilateral corneal blindness			With corneal blindness at least in one eye		
		n (%)	χ^2	*P*	*n* (%)	χ^2	*P*
Gender			0.006	0.938		0.010	0.921
M	1424	3(0.211)			10(0.702)		
F	1576	4(0.254)			12(0.761)		
Education			4.131	0.042		7.101	0.008
No formal education	553	4(0.723)			9(1.627)		
Primary	907	2(0.221)			8(0.882)		
High school	855	1(0.117)			5(0.584)		
Secondary school	172	0(0.000)			0(0.000)		
College and higher	188	0(0.000)			0(0.000)		
Ethnic group			0.075	0.784		1.070	0.301
Han	1733	4(0.231)			16(0.923)		
Hui	1241	3(0.242)			6(0.483)		
Location			1.785	0.185		0.671	0.413
Urban	1290	2(0.155)			10(0.80)		
Rural	1710	5(0.292)			12(0.702)		
Occupation			3.485	0.062		7.279	0.007
Farmer	1000	5(0.500%)			11(1.100%)		
Office worker	891	2(0.224%)			9(1.010%)		
Outdoor-worker	147	0(0.000%)			2(1.361%)		
Children and student	962	0(0.000%)			0(0.000%)		

Table 3 The constitution of corneal disease in urban and rural participants

n (%)

Constitution of corneal disease	Urban	Rural	Total
Infectious corneal disease	5(38.462)	8(61.538)	13(22.034)
Immue corneal disease	4(57.143)	3(42.857)	7(11.864)
Trauma	7(53.846)	6(46.154)	13(22.034)
Post-pterygium surgery	1(16.667)	5(83.333)	6(10.169)
Spheriodal degeneration	2(66.667)	1(33.333)	3(5.085)
Trichiasis	4(66.667)	2(33.333)	6(10.169)
Keratoconus	2(100.00)	0(0.00)	2(3.390)
Trachoma	0(0.00)	1(100.00)	1(1.695)
Undetermined	3(37.500)	5(62.500)	8(13.593)
Total	28(47.458)	31(52.542)	59(100)

Table 4 The constitution of corneal blindness

n (%)

Constitution of corneal blindness	Corneal blindness at least one eye	Corneal blindness in both eyes
Infectious corneal disease	5(4.717)	3(8.824)
Immue corneal disease	5(4.717)	2(5.882)
Trauma	5(4.717)	0(0.00)
Post-pterygium surgery	2(1.887)	0(0.00)
Spheriodal degeneration	0 (0.000)	0(0.00)
Trichiasis	0 (0.000)	0(0.00)
Keratoconus	2(1.887)	0(0.00)
Trachoma	1(0.943)	1(2.941)
Undetermined	2(1.887)	1(2.941)
Total	22(20.755)	7(20.588)

The proportion of corneal blindness in 106 persons suffer from blindness in at least one eye and 34 persons suffer from bilateral blindness.

DISCUSSION

The study aims to provide population-based data on the prevalence and risk factors of corneal blindness and the major sight-threatening corneal diseases for all age groups in urban and rural area in Ningxia. The studies are the basis for appropriate eye health care planning, prioritization of resources and confirm the initial reports that corneal blindness is a public health problem, especially in less developed farming communities. Besides, Ningxia is an area inhabited by ethnic Hui minorities abiding by Islam life style, which is facility to explore the relationship between the prevalence of corneal disease and the life style. The Ningxia Corneal Blindness Study was the comprehensive population-based study conducted on different ethnic group and population.

Data from this survey showed that 1.967% participant had corneal disease and no active corneal disease in this survey. Although the prevalence of corneal disease had no significant associations with gender, location, those who received less education and being occupied in farming and outdoor work would be apt to suffer from corneal disease, especially the older Han ethnic population. The less educated older people often occupied in farming and outdoor work, who had experienced the period of poor living environment and less medical service in their childhood. The lesions of cornea acquired in their past decades accompanied all their life. This reminds us the importance of the prevention of corneal disease. A survey about the knowledge and attitudes about corneal ulceration in China show that little knowledge and awareness about corneal ulceration among residents, especially the older people, farmers and workers, people with lower education [12]. Nowadays, with the economic

development in China, the security-protection consciousness had got obvious increase and the working environment and medical service had improved greatly, therefore, the prevalence of corneal disease was lower in youth group. In the survey, the prevalence of corneal disease in Hui ethic group was much lower than in Han ethnic group. (χ^2=6.682, P=0.010). Islam's washing faith might be benefit for Hui ethnic group to avoid corneal disease. Hui ethnic minorities abide with Islam life style. For pious Muslims, daily five praying were required courses. Before each praying worshipper must take an ablution, washing his face, hands and feet (or, in certain circumstances, washing the whole body known as ghusl). Hence, strengthen the awareness of having a good hygienic habit seems to be helpful for decreasing the prevalence of corneal disease. The further study should be done on the relationship of corneal disease and Islam life style. However our study, at least, gives a hint to explore the protective behavior to avoid suffering from corneal disease.

The prevalence of corneal blindness was 0.733% (CI: 0.043%-1.039%) in at least one eye, which was lower than that in Liz's study (0.949%) in Harbin[7] and identical with the report in the southern Indian study (0.66%)[13]. This may be the age structures in our study including all age group, but Liz's data was based on adult population[7]. The prevalence of bilateral corneal blindness was 0.023% (CI: 0.006%-0.041%), which belongs to the lower level. Global regional estimates the bilateral corneal blindness ranged from 0.02% to 0.14% [14]. According to the World Health Organization's data, it is estimated that there are currently 45 million people worldwide who are bilaterally blindness, of which 6 to 8 million (13.3%-17.8%) are blindness due to corneal disease [3]. In Sichuan province southwest of China, the corneal disease was accounted for 6.5% visual disability, 5.8% in Shanghai located east of China and 26.3% in remote rural areas in Yunnan province[15-17]. In our study, corneal disease was found to be responsible for more than 20% of blindness, a little higher than worldwide average rate. About 30.8% persons who occupied in agriculture had corneal injure and 37.1% persons with visual impairment [18]. More effort should be made on labor protection in rural area. But in Tibet autonomous region 5.3% blindness result from corneal blindness, where was the highest altitude on earth. So not only the occupation but also the altitude affect the appearance of corneal lesion.

The prevalence of corneal blindness in older group was also taken consideration. Of 402 participants aged ≥60y in our study, 12 (2.985% CI: 1.322%-4.649%) and 4 (0.100% CI: 0.025%-1.965%) had corneal blindness in at least one eye and in both eyes respectively. According to the Beijing Eye Study [19] in 2006 and Chongqing study [20] in 2007, the prevalence of corneal blindness in the better eye was 0.46% in the more than 40 years old group and 0.21% in more than 50-year group. The corneal visual impairment status in Ningxia was more serious than that in above mentioned two cities. Our study provides broad and conclusive evidences that corneal blindness is associated not only with older age, but also with the lack of education and being occupied in farming and out-doors working. The study suggested that greater attention and more eye care service should be taken to the prevention of corneal blindness in Ningxia, especially the outdoor worker and farmer with less education. In our study, it would be an encouraging results that rural population showed no significant difference with urban population in corneal blindness in all age groups except for ≥60-year group (χ^2=6.716, P=0.019) , that would be benefit from increasing awareness of medical and protecting consciousness of visual health in rural area.

In our survey, corneal disease due to infection, immune and trauma was the main contributor to the increase in the prevalence of corneal blindness. However the infectious corneal disease, the main contributor of bilateral blindness, was more serious than others corneal diseases, especially those suffered from exanthematous fever in childhood. Incomplete immunization was supposed to be significantly associated with microbial keratitis in pre-school children [21]. In northern India, corneal infection was also the leading cause of bilateral corneal blindness [22]. In southern India APEDS [13], the most frequent causes of corneal blindness in at least one eye included keratitis during childhood (0.234%), trauma (0.185%), and keratitis during adulthood (0.116%). Although this study did not further classify the infectious keratitis, the exanthematous fever and trauma are also the main causes of corneal blindness. The prevalence of infectious corneal blindness couldn't compare with the APEDS, owing to the different age distribution and classification in the cause of corneal blindness. Infection, immune reaction and trauma were also the major causes of corneal blindness based on our data[13]. The infectious corneal disease (8.824% CI: 0.000%-18.358%) and immune corneal disease (5.882% CI: 0.000%-13.792%) make more contributing to the bilateral corneal blindness. It was interesting that the lower education status and the occupation of farmer and worker significantly increased the risk of corneal blindness in at least one eye, but had no impact on the bilateral corneal blindness. This would be that the industry makes urban participants apt to suffer from trauma, which is usually leading to unilateral blindness, but infectious corneal disease was more common in rural participants, which is more likely leading to bilateral blindness.

In conclusion, there is a significant burden of corneal blindness in Ningxia population, encompassing a variety of

corneal infections and trauma; the majority of those were avoidable. Health promotion strategies and a good hygienic condition have to be developed. The relationship between Islam custom and corneal disease should be further explored.

ACKNOWLEDGEMENTS

The authors acknowledge Professor Li Xinxie in Shandong Eye Institute for study design and diagnosis of complex cases.

Foundation: Supported by Consultation Program of Chinese Academy of Engineering (No.2009-77); Research Program of Ningxia Science and Technology Department (No. NKJ2010-168)

Conflicts of Interest: Sheng XL, None; **Li HP,** None; **Liu QX,** None; **Rong WN,** None; **Du WZ,** None; **Ma L,** None; **Yan GH,** None; **Ma RQ,** None; **Zhang JL,** None; **Xu HF,** None; **Zou WQ,** None; **Bi XJ,** None.

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