Paediatric glaucoma in Hong Kong: a multicentre retrospective analysis of epidemiology, presentation, clinical interventions, and outcomes

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ABSTRACT

Purpose: To document the epidemiology, presentation, clinical interventions, and outcomes of paediatric glaucoma in Hong Kong.

Methods: This multicentre territory-wide retrospective study was performed by reviewing charts of patients with paediatric glaucoma in six clusters of the Hong Kong Hospital Authority and The Chinese University of Hong Kong from 2006 to 2015.

Results: This study included 150 eyes of 98 patients with paediatric glaucoma (presenting age: 5.2±5.7 years). Of them, 35 eyes (23.3%) had primary congenital glaucoma, 22 eyes (14.7%) had juvenile open-angle glaucoma, and 93 eyes (62.0%) had secondary glaucoma. The most prevalent types of secondary glaucoma were lens-related after cataract extraction (18.0%), Axenfeld–Rieger anomaly (5.3%), uveitis (5.3%), Sturge–Weber syndrome (4.7%), and traumatic (3.3%). The most common clinical presentations were parental concerns (20.7%) including cloudy cornea (12.7%) and tearing/photophobia (8.0%), followed by poor visual acuity (18.0%), high intraocular pressure (13.3%), and strabismus (6.0%). The follow-up duration was 8.46±6.51 years. Furthermore, 63.2% of eyes with primary glaucoma and 45.2% of eyes with secondary glaucoma were treated surgically. The final visual acuity was 0.90±0.98 LogMAR; intraocular pressure was 18.4±6.6 mm Hg; and number of glaucoma medications was 2.22±1.61.

Conclusion: Primary congenital glaucoma was most prevalent, followed by juvenile open-angle glaucoma and aphakic glaucoma. Most eyes with primary glaucoma required surgical treatment. Parental concerns were important clinical presentations. Basic assessments by healthcare providers to identify glaucoma signs (eg, poor visual acuity, high intraocular pressure, and strabismus) warranted prompt referral to an ophthalmologist.

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New knowledge added by this study

- Primary congenital glaucoma and juvenile open-angle glaucoma are the most prevalent types of paediatric glaucoma in Hong Kong.
- While most patients with primary glaucoma required surgical intervention, most patients with secondary glaucoma were treated medically.
- Parental concerns were a critical factor in obtaining early medical attention. Basic ophthalmic assessments by healthcare providers warranted prompt referral to an ophthalmologist.

Implications for clinical practice or policy

- Parental concerns regarding cloudy cornea, tearing, and photophobia are important clinical manifestations of paediatric glaucoma and are the chief complaints described to paediatricians, family physicians, or nurses.
- Prompt and basic ophthalmic assessments by healthcare providers, which identify signs of paediatric glaucoma (eg, poor visual acuity, ocular asymmetry, strabismus, nystagmus, and leukocoria), warrant early and rapid referral to an ophthalmologist.

Introduction

Paediatric glaucoma affects infants and children and may result in irreversible blindness that substantially diminishes productivity and quality of life over the entire lifetime of affected individuals. Prognosis is largely dependent on early, accurate diagnosis and timely treatment, comprising rigorous intraocular pressure (IOP) reduction to a level at which further progression is unlikely; the prevention of amblyopia is also a critical component of treatment.[1] Paediatric glaucoma is classified as 'primary' when it involves an isolated idiopathic developmental abnormality of the anterior chamber angle, whereas it is classified as 'secondary' when aqueous outflow is reduced because of a congenital or acquired ocular disease or systemic disorder.[2]

Primary paediatric glaucoma includes primary congenital glaucoma (PCG, isolated trabeculodysgenesis) and juvenile open-angle glaucoma. Primary congenital glaucoma is the most common type of glaucoma in infants,[3,4] with a variable incidence reported worldwide. Higher incidences have been observed in inbred populations where parental consanguinity is common.[5-7] Primary congenital glaucoma occurs more frequently in boys than in girls[8-10]; it is bilateral in 70% to 80% of patients.[11,12] Patients with familial PCG tend to have an equal sex distribution.[10,11,13]

Secondary paediatric glaucoma is commonly associated with anterior segment dysgenesis; 50% of patients develop glaucoma.[14] Glaucoma associated with aniridia is usually caused by progressive angle closure; it presents often in childhood with an incidence of 6% to 75% in aniridic eyes.[15] Aphakic glaucoma can occur soon or years after initial uneventful cataract extraction surgery in children with congenital cataract; its incidence ranges from 5% to 41%, depending on patient age at the time of surgery, corneal diameter, and surgical techniques.[16-19] Phacomatoses commonly associated with glaucoma include Sturge–Weber syndrome[20] and Klippel–Trenaunay–Weber syndrome. The glaucoma evident in patients with inflammatory disorders is multifactorial, with a reported incidence of up to 38% in children with juvenile idiopathic arthritis.[21]

The primary goal of treatment for both primary and secondary types of paediatric glaucoma is IOP reduction, for which medical treatment is often the first-line approach. Longer-term treatment involves surgery as the definitive approach for IOP control in the vast majority of patients with paediatric glaucoma. Available surgical procedures have various indications, with both advantages and disadvantages, as well as different success rates, among patient populations. Notably, the management approach and success rate also considerably vary among countries worldwide. Paediatric congenital glaucoma is a relatively uncommon disease, such that a consultant ophthalmologist in a general ophthalmology centre in the Western world is estimated to encounter a new patient with PCG approximately once every 5 years.[22] Because of its relative rarity, PCG is sometimes misdiagnosed or not treated appropriately, especially in general ophthalmology centres, leading to irreversible corneal and optic nerve damage, as well as unnecessary irreversible visual loss. Consequently, PCG is present in a disproportionate percentage (up to 18%) of children in institutions for the blind worldwide.[23,24] Furthermore, congenital glaucoma was reportedly present in 30% of paediatric patients attending a university low vision service.[25] Overall, paediatric glaucoma is responsible for 5% of irreversible blindness in children worldwide.[26] However, there is a paucity of contemporary epidemiologic and clinical data regarding paediatric glaucoma in Hong Kong.

We conducted the Hong Kong Paediatric Glaucoma Study as the first territory-wide analysis of the epidemiology, presentation, clinical interventions, and outcomes of paediatric glaucoma in Hong Kong. This study is expected to greatly enhance the understanding of this disease in our local community, while improving our disease management approaches and standards of clinical care. The findings will also provide our colleagues in Paediatrics and Family Medicine with a clearer overview of the clinical presentations of patients with paediatric glaucoma.

香港小兒青光眼：流行病學、表現、臨床干預及結果的多中心回顧分析

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目的：記錄香港小兒青光眼的流行病學、表現、臨床干預和結果。

方法：這項多中心回顧研究，回顧2006年至2015年期間香港醫院管理局的六個醫院聯網和香港中文大學的小兒青光眼患者的病歷。

結果：本研究納入98例小兒青光眼（年齡5.2±5.7歲）共150隻眼。當中，35隻眼為原發性先天性青光眼（23.3%）、22隻眼為青少年開角型青光眼（14.7%），93隻眼為繼發性青光眼（62.0%）。最常見繼發性青光眼類型包括白內障摘除術後晶狀體相關（18.0%）、Axenfeld–Rieger異常（5.3%）、葡萄膜炎（5.3%）、Sturge–Weber綜合症（4.7%）和外傷性（3.3%）。最常見的臨床表現是父母關注（20.7%）、包括角膜混濁（12.7%）和流淚 / 畏光（8.0%），其次是視力欠佳（18.0%）、眼壓高（13.3%）和斜視（6.0%）。隨訪時間為8.46±6.51年。此外，63.2%原發性青光眼和45.2%繼發性青光眼以手術治療。最終視力為0.90±0.98 LogMAR，眼壓為18.4±6.6 mm Hg，青光眼用藥數量為2.22±1.61。

結論：原發性先天性青光眼最為普遍，其次是青少年開角型青光眼和無晶狀體青光眼。大部份原發性青光眼患者需要手術治療。父母關注是重要的臨床表現。 醫療服務提供者進行基本評估後如識別青光眼體徵（例如視力差、眼壓高和斜視）應立即轉介給眼科醫生。

Methods

Study design and ethical approval

This study comprised a retrospective chart review of patients with confirmed paediatric glaucoma who were managed over a 10-year period (January 2006 to December 2015) in the ophthalmology departments of six regional clusters of the Hospital Authority in Hong Kong (ie, Hong Kong East, Kowloon West, Kowloon Central, Kowloon East, New Territories West, and New Territories East) and The Chinese University of Hong Kong. The Hospital Authority in Hong Kong provides a heavily government-subsidised public clinical service to all Hong Kong citizens, while the Hospital Authority ophthalmology service provides more than 90% of all clinical ophthalmology services delivered in Hong Kong. The six hospital clusters participating in this study had a total population of 6 889 400 in 2017, which represented 92.96% of the total population (7 411 300) in Hong Kong at the time of the study.[27] This study was performed in accordance with the 1996 Declaration of Helsinki and ICH-GC; the study protocol was approved by the institutional review boards of all involved clusters.

Patient population

Using the Hospital Authority's Clinical Data Analysis and Reporting System, we identified patients aged ≤18 years on presentation, all of whom had either undergone glaucoma surgery or been prescribed glaucoma medication(s) continuously for >3 months. Patients identified through the Clinical Data Analysis and Reporting System were then verified through the Clinical Management System, which is an electronic medical records system in use throughout all hospitals and departments under the Hospital Authority in Hong Kong. Hard copies of medical records were also collected and reviewed to ensure the patients met the following criteria:

1. Age ≤18 years at presentation, with a diagnosis of primary or secondary glaucoma;
2. A combination of previous and/or current high IOP (>21 mm Hg), combined with disc cupping >0.3 or disc asymmetry >0.2, as well as one or more of the following signs: progressive disc cupping, buphthalmos (prominent, enlarged eye), enlarged corneal diameter (>11 mm in newborns, >12 mm in children aged <1 year, or >13 mm in children of any age), corneal oedema, Descemet's membrane splitting (Haab's striae), visual field defects, or progressive myopia.

Data collection

Clinical data of all patients who met the above study criteria were retrospectively collected from medical records and the Clinical Management System, using standardised data sheets. The following data were collected: patient demographics including family history of glaucoma and parental consanguinity (defined as a union between two related individuals who were second cousins or closer), type of glaucoma (primary/secondary), presentation of disease/reason for referral, examination findings on presentation, subsequent management (eg, medications, laser interventions, and surgical interventions), and clinical outcomes at the final follow-up. Patients' Hong Kong Identity Card numbers were used to identify duplicate entries at different hospitals; in such instances, the clinical data were combined prior to analysis.

Outcome measures

The primary outcome measures were the epidemiological characteristics and clinical presentations of patients with paediatric glaucoma in Hong Kong. The secondary outcome measures were the subsequent management of these patients and their clinical outcomes at the final follow-up.

Results

Patient characteristics and epidemiological findings

In this study, we identified 98 patients with paediatric glaucoma (150 eyes; 47 boys and 51 girls). Seventy eyes (46.7%) were right eyes, and the mean ± standard deviation (SD) presenting age was 5.2±5.7 years (range, 0-18 years). With the exception of two patients (one Japanese and one from mid-western Asia), all included patients were of Chinese ethnic origin. Three patients (3.1%) had a positive family history of glaucoma, while none had parental consanguinity. The mean ± SD duration of follow-up was 8.46±6.51 years (range, 0.2-25.5 years). While one patient had pigment dispersion syndrome (follow-up duration of 2 months) and one patient had persistent hyperplastic primary vitreous (follow-up duration of 5 months), all other included patients had a minimum follow-up duration of 6 months. The Hong Kong population aged <20 years was 1 378 912 in 2006,[28] and it was 1 174 500 in 2015.[29] The population covered by the involved six Hospital Authority clusters and The Chinese University of Hong Kong eye clinic constituted approximately 93% of the total population.[27] Given that Hospital Authority ophthalmology departments provided services to 90% of our general population, the estimated annual incidence rate of paediatric glaucoma in our Hong Kong was 0.92 per 100 000 population aged <20 years.

Types of glaucoma and presenting symptoms

Among the patients in this study, 57 eyes of 30 patients had primary glaucoma (35 eyes of 18 patients had PCG and 22 eyes of 12 patients had

juvenile open-angle glaucoma). Furthermore, 93 eyes of 68 patients had secondary glaucoma (Table 1). The most prevalent type of secondary glaucoma was lens-related glaucoma after cataract extraction for congenital cataract (27 eyes of 17 patients, 18.0% of all involved eyes), which included aphakic glaucoma (13.3%) and pseudophakic glaucoma (4.7%). Other types of secondary glaucoma were Axenfeld–Rieger anomaly (8 eyes, 5.3%), uveitis (intermediate/anterior, 8 eyes, 5.3%), Sturge–Weber syndrome (7 eyes, 4.7%), and traumatic (5 eyes, 3.3%).

The main presenting symptoms are summarised in Table 2. Common clinical presentations were parental concerns (31 eyes of 21 patients, 20.7% of all involved eyes) including cloudy cornea (19 eyes of 13 patients, 12.7%) and tearing/photophobia (12 eyes of 8 patients, 8.0%); other presentations that warranted referral to an ophthalmologist included poor visual acuity (27 eyes, 18.0%), high IOP (20 eyes, 13.3%), and strabismus (9 eyes, 6.0%). The mean ± SD IOP on presentation to the attending ophthalmologist was 25.3±10.2 mm Hg (range, 7-53 mm Hg). Notably, one eye had an iris cyst and underwent penetrating keratoplasty; although its IOP was 7 mm Hg, it showed an increased cup-to-disc ratio (0.5) and was therefore included in the cohort. The mean ± SD visual acuity was 0.6±0.7 logarithm of the minimum angle of resolution (LogMAR; range, -0.08 to 3.00), the mean ± SD spherical equivalent was -2.5±5.6 (range, -12.6 to 13.3), and the mean ± SD cup-to-disc ratio was 0.59±0.22 (range, 0.2-1.0).

Glaucoma interventions

Among the 78 eyes which underwent surgical or laser interventions, 38 (48.7%) had primary glaucoma and 40 (51.3%) had secondary glaucoma. The first glaucoma intervention for each eye is indicated in Table 3. The most commonly performed surgery was trabeculectomy with antimetabolites (26 eyes, 33.3%) followed by goniotomy (23 eyes, 29.5%) and glaucoma drainage device implantation (6 eyes, 7.7%). The most commonly performed laser procedure was transscleral cyclophotocoagulation (9 eyes, 11.5%). The mean ± SD number of glaucoma interventions per eye was 1.37±1.90 (range, 0-9). Of the 78 eyes which underwent surgical or laser interventions, 31 (39.7%) received one intervention during the study period while 47 (60.3%) received more than one intervention.

In all, 63.2% of eyes with primary glaucoma were treated surgically during the follow-up period; 54.8% of eyes with secondary glaucoma were treated by medications alone during the follow-up period. Among the 35 eyes of 18 patients with PCG, 23 eyes (66%) were managed surgically and only six of them (17.1%) were medication-free on the final follow-up. Among the 22 eyes of 12 patients with juvenile open-angle glaucoma, 15 eyes (68%) were managed surgically and only six of them (27.3%) were medication-free on the final follow-up. Among the 93 eyes of 68 patients with secondary glaucoma, 40 eyes (43.0%) were managed surgically during follow-up and 14 (15.1%) were medication-free on the final follow-up.

Follow-up findings

The mean ± SD LogMAR visual acuity at the final follow-up was 0.90±0.98 (range, -0.19 to 3.00, ie, no light perception). Among 111 eyes for which

TABLE 1. Diagnostic findings in patients with paediatric glaucoma*

	Patients (n=98)	Eyes (n=150)
Primary		
Primary congenital glaucoma	18 (18.4%)	35 (23.3%)
Juvenile open-angle glaucoma	12 (12.2%)	22 (14.7%)
Secondary		
Lens-related		
Aphakia	13 (13.3%)	20 (13.3%)
Pseudophakia	4 (4.1%)	7 (4.7%)
Phacomatoses		
Sturge–Weber syndrome	6 (6.1%)	7 (4.7%)
Neurofibromatosis	1 (1.0%)	1 (0.7%)
Klippel–Trenaunay–Weber syndrome	1 (1.0%)	2 (1.3%)
Phacomatosis pigmentovascularis	1 (1.0%)	1 (0.7%)
Uveitis		
Uveitis (intermediate/anterior)	5 (5.1%)	8 (5.3%)
Vogt–Koyanagi–Harada disease	1 (1.0%)	2 (1.3%)
Anterior segment dysgenesis		
Axenfeld–Rieger anomaly	6 (6.1%)	8 (5.3%)
Peters anomaly	3 (3.1%)	4 (2.7%)
Aniridia	3 (3.1%)	4 (2.7%)
WAGR syndrome	1 (1.0%)	1 (0.7%)
Others		
Traumatic	5 (5.1%)	5 (3.3%)
Steroid-induced	4 (4.1%)	4 (2.7%)
Persistent hyperplastic primary vitreous	4 (4.1%)	5 (3.3%)
Silicone oil–related	2 (2.0%)	2 (1.3%)
Intracranial vascular malformation	1 (1.0%)	2 (1.3%)
Hurler syndrome	1 (1.0%)	2 (1.3%)
Sclerocornea	1 (1.0%)	2 (1.3%)
Cornea plana	1 (1.0%)	2 (1.3%)
Iris cyst	1 (1.0%)	1 (0.7%)
Iris cyst with penetrating keratoplasty	1 (1.0%)	1 (0.7%)
Pigment dispersion syndrome	1 (1.0%)	1 (0.7%)
Familial exudative vitreoretinopathy	1 (1.0%)	1 (0.7%)

* Data are shown as No. (%)

TABLE 2. Presenting symptoms and signs of potential paediatric glaucoma that merited referral to an ophthalmologist*

	Patients (n=98)	Eyes (n=150)
Parental concerns		
Cloudy cornea	13 (13.3%)	19 (12.7%)
Tearing/photophobia	8 (8.2%)	12 (8.0%)
Referral for ophthalmic management		
Poor visual acuity	15 (15.3%)	27 (18.0%)
High intraocular pressure	12 (12.2%)	20 (13.3%)
Strabismus	6 (6.1%)	9 (6.0%)
Nystagmus	4 (4.1%)	7 (4.7%)
Leukocoria	4 (4.1%)	5 (3.3%)
History of trauma	4 (4.1%)	4 (2.7%)
Incidental	4 (4.1%)	4 (2.7%)
Eye pain	2 (2.0%)	2 (1.3%)
Ocular asymmetry	2 (2.0%)	3 (2.0%)
Cataract	2 (2.0%)	3 (2.0%)
Myopia	2 (2.0%)	4 (2.7%)
Buphthalmos	1 (1.0%)	1 (0.7%)
Increased cup-disc ratio	1 (1.0%)	1 (0.7%)
Uncertain	1 (1.0%)	2 (1.3%)
Referral for systemic association		
Port-wine stain	2 (2.0%)	3 (2.0%)
Neurofibromatosis	1 (1.0%)	1 (0.7%)
Referral from private ophthalmologists	14 (14.3%)	23 (15.3%)

* Data are shown as No. (%)

visual acuity was determined, 10 (9.0%) had no light perception at the final follow-up, four (3.6%) had light perception, five (4.5%) could perceive hand movement, and four (3.6%) could perceive finger counting. The mean ± SD IOP at the final follow-up was 18.4±6.6 mm Hg (range, 6-43 mm Hg), while the mean ± SD number of glaucoma medications at the final follow-up was 2.22±1.61 (range, 0-5). The mean ± SD spherical equivalent was -3.4±6.6 (range, -18.25 to 13.1), whereas the mean ± SD cup-to-disc ratio was 0.68±0.20 (range, 0.3-1.0). Clinical parameters among the different types of glaucoma (ie, PCG, juvenile open-angle glaucoma, and secondary glaucoma) are described in Table 4. As expected, PCG manifested at an earlier age, compared with other types of glaucoma. Patients with secondary glaucoma had a wider range of refraction because some exhibited hyperopia, such as in aphakic glaucoma. Other parameters (eg, IOP, cup-to-disc ratio, number of glaucoma interventions, and number of medications) were similar among the different types of glaucoma.

Discussion

Effects of ethnicity on paediatric glaucoma incidence and type

To our knowledge, this is the first epidemiological report concerning paediatric glaucoma in Hong Kong. Hong Kong had a population of 7.4 million in 2018,[30] of which 92.0% were of Chinese ethnic origin, while there were 2.5% Filipinos, 2.1% Indonesians, and 0.8% Caucasians.[29] In this study, we included

TABLE 3. First glaucoma surgical/laser interventions for paediatric glaucoma*

	Eyes (n=78)	Primary congenital glaucoma (n=23)	Juvenile open-angle glaucoma (n=15)	Secondary glaucoma (n=40)
Surgical intervention				
Trabeculectomy with antimetabolites	26 (33.3%)	5 (22%)	9 (60%)	12 (30%)
Goniotomy	23 (29.5%)	17 (74%)	1 (7%)	5 (13%)
Glaucoma drainage device implantation	6 (7.7%)			6 (15%)
Non-penetrating deep sclerectomy	5 (6.4%)	1 (4%)	1 (7%)	3 (8%)
Trabeculectomy and trabeculotomy	1 (1.3%)			1 (3%)
Laser intervention				
Transscleral cyclophotocoagulation	9 (11.5%)			9 (23%)
Endoscopic cyclophotocoagulation	2 (2.6%)			2 (5%)
Selective laser trabeculoplasty	3 (3.8%)		2 (13%)	1 (3%)
Argon laser trabeculoplasty	2 (2.6%)		2 (13%)	
Laser iridotomy	1 (1.3%)			1 (3%)

* Data are shown as No. (%)

TABLE 4. Clinical parameters among different types of paediatric glaucoma*

	Primary congenital glaucoma	Juvenile open-angle glaucoma	Secondary glaucoma
No. of patients	18	12	68
At presentation			
Age, years	2.4 ± 3.8, 0-13	12.4 ± 3.6, 4.5-16	4.7 ± 5.5, 0-18
Sex (M:F)	9:9	7:5	31:37
LogMAR visual acuity	1.06 ± 0.72, 0.15-2.70	0.37 ± 0.76, -0.08 to 3.00	0.59 ± 0.69, 0-2.80
Intraocular pressure, mm Hg	24.4 ± 8.5, 7.4-45	31.5 ± 10.0, 16-46	23.9 ± 10.3, 2-53
Spherical equivalent, dioptre	-4.3 ± 5.2, -12.6 to 2.5	-3.6 ± 6.8, -8.4 to 1.3	-1.8 ± 5.8, -10.0 to 13.3
Cup-to-disc ratio	0.65 ± 0.14, 0.3-0.8	0.68 ± 0.24, 0.2-1.0	0.53 ± 0.22, 0.2-0.95
At final follow-up			
LogMAR visual acuity	0.62 ± 0.59, 0-2.70	0.53 ± 0.93, -0.19 to 3.00	1.10 ± 1.07, 0-3.00
Intraocular pressure, mm Hg	15.8 ± 4.9, 6-27	18.4 ± 6.4, 12-43	19.5 ± 7.0, 9-41
Spherical equivalent, dioptre	-6.6 ± 4.6, -18.3 to -0.3	-4.4 ± 0.2, -4.5 to -4.3	-0.5 ± 7.3, -13.0 to 13.1
Cup-to-disc ratio	0.70 ± 0.20, 0.3-1.0	0.77 ± 0.16, 0.4-1.0	0.62 ± 0.21, 0.3-0.95
No. of glaucoma interventions/eye	2.0 ± 2.3, 0-9	1.5 ± 2.0, 0-8	1.1 ± 1.7, 0-7
No. of glaucoma medications	2.0 ± 1.5, 0-5	2.2 ± 1.7, 0-4	2.3 ± 1.6, 0-5

* Data are shown as mean ± standard deviation or range, except where indicated

patients with confirmed paediatric glaucoma who were managed in the ophthalmology departments of six regional clusters of the Hospital Authority in Hong Kong (Hong Kong East, Kowloon West, Kowloon Central, Kowloon East, New Territories West, and New Territories East) and The Chinese University of Hong Kong. In this study, we estimated the annual incidence rate of paediatric glaucoma in Hong Kong to be 0.92 per 100 000 population <20 years of age. The reported incidence rates have varied among previous studies, presumably because of differences in the ethnicity of the study population. In the British Infantile and Childhood Glaucoma Eye Study, Papadopoulos et al[31] concluded that the incidence of PCG was nearly ninefold greater among children of Pakistani origin, compared with Caucasian children; other groups with high incidences of PCG included those of Bangladeshi and Indian origin. Notably, only one Chinese child (among 99 paediatric patients with newly diagnosed glaucoma) was diagnosed with PCG during the 1-year surveillance period. In total, 67% of all Pakistani children in that study were from consanguineous marriages. Although South Asians remain a minority in Hong Kong, local census data[29] showed that the population increased from 47 505 to 80 028 from 2006 to 2016 (68% increase). Thus, clinicians should be aware of the potential for this condition among babies and children of specific ethnic origins.

Our study showed that PCG was the most prevalent type of glaucoma in our patient population, present in 23.3% of the included eyes; other common types were juvenile open-angle glaucoma (14.7%) and aphakic glaucoma (13.3%). The reported prevalences have varied among types of paediatric glaucoma in previous studies. Taylor et al[3] described a population of Canadian patients with paediatric glaucoma, in which congenital glaucoma was the most common subtype (38% of patients). In the British Infantile and Childhood Glaucoma Eye Study,[31] 45 of 95 patients (47.4%) were diagnosed with PCG during the 1-year surveillance period. In mainland China, two hospital-based studies revealed the epidemiology of paediatric glaucoma in Chinese populations.[32,33] Both studies concluded that congenital glaucoma was the most common subtype. Aponte et al[34] reported the 40-year incidence and clinical characteristics of childhood glaucoma among patients in the region of Rochester, United States. They concluded that acquired and secondary forms of glaucoma were the most common, while congenital and juvenile forms of glaucoma were rare. Thus, we presume that variations in prevalence among different types of glaucoma are related to ethnicity.

Potential mechanisms underlying paediatric glaucoma

Among patients with secondary glaucoma, the most commonly associated conditions were lens-related: aphakia (13.3% of eyes) and pseudophakia (4.7%) after cataract extraction for congenital cataract. Although the exact mechanisms of glaucoma in young patients with aphakia and pseudophakia are not well known, Beck et al[35] suggested the following aetiologies based on their findings in the

Infant Aphakia Treatment Study: congenital angle anomalies, postoperative inflammation leading to angle dysfunction or progressive synechial closure, corticosteroid-induced mechanisms, and some unknown influences of the aphakic state or vitreous interaction with developing angle structures that cause reduced outflow.

Congenital conditions, such as anterior segment dysgenesis (11.4%) and Sturge–Weber syndrome (4.7%), were also associated with glaucoma in our patients. Clinicians could occasionally discern irregular pupils or abnormal red reflex from the fundi in patients with anterior segment dysgenesis; Sturge–Weber syndrome is associated with the presence of a facial port-wine stain.

The mechanisms of uveitic glaucoma are not clearly known, they may involve inflammatory substances/cellular components that cause trabecular damage and blockage, as well as a response to steroid treatment in young patients, which causes high IOP.[36] In addition to uveitis, 2.7% of eyes had steroid-induced glaucoma related to the chronic use of topical steroid treatment for other ophthalmic conditions (eg, allergy and chalazion) or systemic conditions (eg, eczema). Therefore, medication history concerning steroid use is an important consideration in paediatric patients; steroid self-medication and/or long-term steroid use without close IOP monitoring could carry a risk of glaucoma.[37]

Trauma-related glaucoma was also observed in 3.3% of included eyes; four of the five patients with traumatic glaucoma exhibited angle recession. Therefore, IOP should generally be measured in young patients after ocular trauma and the angle structure should be examined via gonioscopy whenever possible.

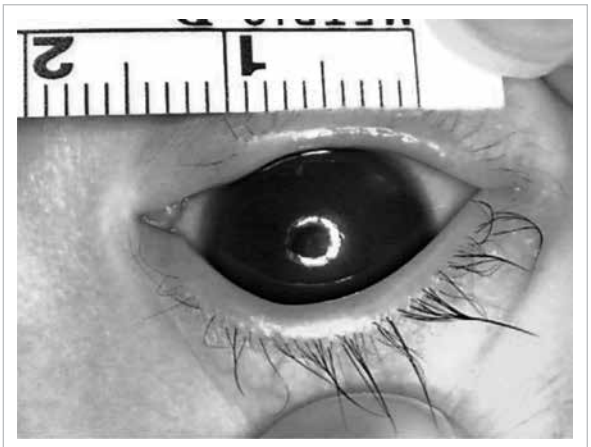

FIG. Photograph showing the surgeon's view of an enlarged cornea (>12 mm), corneal oedema, and conjunctival injection in the right eye of a 4-month-old baby who had primary congenital glaucoma and was undergoing examination under general anaesthesia before goniotomy (Source: Prof Clement CY Tham)

Ophthalmic complaints and early clinical assessments of paediatric glaucoma

Parental concerns of tearing, photophobia, and cloudy cornea comprised approximately 21.5% of the reasons for referral in this cohort (20.7% of total eyes). High IOP comprised only 12.2% of the reasons for referral (13.3% of eyes); other ophthalmic complaints leading to referral included poor visual acuity (18.0% of eyes), strabismus (6.0% of eyes), and nystagmus (4.7% of eyes); these complaints could be related to the presence of unilateral or bilateral amblyopia. Buphthalmia is a finding of glaucoma in infancy as the young eye increases in size from elevated IOP due to corneal and scleral collagen immaturity (Fig).[2] Therefore, a subset of patients presented with ocular asymmetry, buphthalmos, increased or early myopia, or increased cup-to-disc ratio with or without elevated IOP. Furthermore, although visual acuity may not be fully assessed in babies and young children, there is a need to actively screen for and treat amblyopia in this patient group. Amblyopia remains the main cause of poor visual acuity in patients with paediatric glaucoma. Appropriate correction of refractive error and eye patching are essential components of clinical management for these patients.

Family doctors and paediatricians are usually the first clinicians to examine paediatric patients with suspected glaucoma in the healthcare setting in Hong Kong. Early detection and diagnosis are important for preventing the loss of vision. Appropriate referral is based on the detection of signs and symptoms of paediatric glaucoma. Clinical signs include epiphora, conjunctival erythema, corneal enlargement, corneal clouding, Haabs striae, abnormally deep anterior chamber, myopia and/or astigmatism, and enlarged optic nerve cupping. The classic triad of epiphora, photophobia, and blepharospasm is usually evident in patients with congenital glaucoma. Other symptoms of paediatric glaucoma often include a cloudy and enlarged cornea or large eye, ocular asymmetry (ie, one eye larger than the other), blurring, frequent eye rubbing, pain and discomfort; moreover, the child may become irritable and fussy, and may exhibit a poor appetite. Family doctors and paediatricians may assess vision in older babies or young children; measure IOP using non-contact tonometry in older children (although there is no established range of normal IOP in paediatric patients, an IOP ≥21 mm Hg would merit referral to an ophthalmologist); and may detect manifestations of strabismus, nystagmus, ocular asymmetry, cloudy cornea, irregular pupil, and/or conjunctival injection. Prompt and early referrals are important for minimising visual loss and preventing amblyopia.

Limitations

This study had some notable limitations. First, paediatric glaucoma is a rare and diverse condition with heterogeneous manifestations. Thus, there are no widely established diagnostic criteria and no standardised management protocol in use among different hospitals. Second, clinical data were collected retrospectively from the patients' medical records in this study. Because the ophthalmology departments in most Hospital Authority service clusters have not fully implemented the use of electronic medical records for both out-patients and in-patients, the retrospective collection of handwritten clinical data from hard-copy medical records might have led to the unintentional exclusion of patients or data. Furthermore, missing data and recall bias may have influenced the findings, especially with respect to symptom presentation at the first clinical visit. Among patients who had not received surgical interventions, diagnostic information might have been omitted for some patients in some clusters. Finally, patients with paediatric glaucoma managed in the Hong Kong West Cluster and in the private sector were not included in this study; thus, the findings may not have been entirely representative of the whole territory, although this remains the largest cohort study of patients with paediatric glaucoma in Hong Kong.

Conclusion

Paediatric glaucoma remains an important and irreversible blinding eye disease among children. Children are often unable to complain of specific symptoms and the signs of paediatric glaucoma are often subtle; thus, parents, family doctors, and paediatricians should be familiar with the common manifestations of this disease. Family doctors and paediatricians should have a very high level of suspicion for paediatric glaucoma, combined with a lower threshold for referring patients to ophthalmologists for further evaluation and early treatment. Among the known types of paediatric glaucoma, PCG is the most common. Children with unexplained cloudy corneas, tearing, photophobia, diminished visual acuity, and signs of squinting should be promptly referred for further assessment.

Author contributions

Concept or design: NB Baig and CC Tham.
Acquisition of data: JJ Chan, JC Ho, GC Tang, S Tsang, KH Wan, WK Yip.
Analysis or interpretation of data: NB Baig and CC Tham.
Drafting of the manuscript: NB Baig and CC Tham.
Critical revision of the manuscript for important intellectual content: NB Baig and CC Tham.

All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

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Ethics approval

The study obtained ethics approval from the following ethics committees:

- Research Ethics Committee (Kowloon Central/Kowloon East) (Ref: KC/KE-15-0013/ER-2);
- Research Ethics Committee, Kowloon West Cluster (Ref: KW/EX-15-056[85-09]);
- Joint Chinese University of Hong Kong–New Territories East Cluster Clinical Research Ethics Committee (Ref: 2015.100);
- New Territories West Cluster Clinical & Research Ethics Committee (Ref: NTWC/CREC/15010);
- Hong Kong East Cluster Research Ethics Committee (Ref: HKEC-2015-033).

The participants (or a legal guardian) gave informed consent before the study.

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