

The Clinical Characteristics of Amblyopia in Children Under 17 Years of Age in Qassim Region, Saudi Arabia

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Purpose: To provide the clinical characteristics of amblyopia in children under 17 years of age in Qassim Region, Saudi Arabia.

Patients and Methods: The study was a cross-sectional hospital-based, included 121 children with amblyopia aged between 3 and 17 years, referred from 6 hospitals in Qassim region to the paediatric optometry clinic at Qassim University medical city. Demographics and comprehensive ocular examination including visual acuity (VA), assessment of anterior and posterior segment, cycloplegic refraction (RE), angle of deviation, and cause of amblyopia were collected.

Results: The mean age at diagnosis of amblyopia was 8.93 ± 3.67 years. The leading cause of amblyopia was strabismus and anisometropia shared the same percentage at 29.75%, and the combined-mechanism at 18.18%. Amblyopia was more common in males 57.85%, particularly strabismic amblyopia in 66.67% and anisometropic amblyopia in 61.11%, $p = 0.408$. Amblyopia was more predominant in the age group 6- to 9-year-old, particularly, strabismic amblyopia 44.44%, and amblyopia due to a combined mechanism of 36.36%, $p = 0.066$. The degree of hyperopia was not varied by the cause of amblyopia ($P = 0.401$), with slightly high hyperopia found in ametropic and strabismic amblyopia. Conversely, hyperopic astigmatism was significantly associated with amblyopia $P = 0.020$, with a high degree of hyperopic astigmatism found in meridional amblyopia and ametropic amblyopia.

Conclusion: The commonest types of amblyopia in children were attributed to strabismus and anisometropia. Causes of amblyopia differed by age group with strabismus, anisometropia, and combined mechanism accounting for most children aged 6- to 9-years and strabismus for children aged less than 6 years. Hyperopic and myopic astigmatism were significantly associated with anisometropia and meridional amblyopia. Therefore, efforts should be made for early diagnosis and management of childhood amblyopia and uncorrected refractive errors to avoid their impact on quality of life.

Keywords: amblyopia, anisometropic amblyopia, meridional amblyopia, Saudi Arabia, hyperopic astigmatism, uncorrected refractive errors, visual impairment

Introduction

The World Health Organization (WHO) reported that visual impairments (VI) are causing a major public health problem in many countries.¹ Amblyopia is the leading cause of vision impairment in children, with a prevalence of 1.5% to 4%.¹⁻³ Amblyopia is defined as a unilateral or bilateral VI with the best-corrected visual acuity (VA) being poorer than 20/20 in the absence of any obvious structural or pathologic anomalies, nonetheless with one or more of the following disorders happening before the age of 6 years; (1) amblyogenic anisometropia; (2) constant unilateral strabismus; (3) amblyogenic bilateral isometropia; (4) amblyogenic unilateral or bilateral astigmatism; (5) and vision deprivation.⁴

Anisometropia is the most common risk factor for unilateral amblyopia, this tends to occur more often for children with anisometropia associated with hyperopia particularly hyperopic anisometropia of 1 D or more.⁵ Furthermore, anisometropia was found to be associated with unilateral amblyopia in 40% of an amblyopic cohort 3 to 6 years old and 5% of an amblyopic cohort younger than 3 years old.^{6,7} Strabismus, the misalignment of the two eyes, is one of the most critical risk factors for unilateral amblyopia. In 2002, the Pediatric Eye Disease Investigator Group (PEDIG)

investigated the clinical profile of amblyopic children 3 to 6 years old, and they reported that strabismus was associated with 40% of amblyopic children enrolled in the study.⁷ Another study investigated the clinical features of amblyopic children younger than 3 years old, the authors found that strabismus was associated with 82% of amblyopic children who participated in the study.⁶ Both strabismus and anisometropia can co-exist and lead to unilateral amblyopia. In fact, it may be difficult to determine which condition developed first.⁸ For children 3 to 6 years old, strabismus and anisometropia were found to be associated with unilateral amblyopia in 20% of the examined children.⁷ Conversely, in children younger than 3 years old, both mechanisms were related to unilateral amblyopia in 13% of the enrolled children.⁶

In Saudi Arabia, numerous researchers have reported a higher prevalence of refractive errors among Saudi populations.^{9–13} In 2015, a study by Aldebasi¹⁴ was conducted to determine the prevalence of amblyopia in primary school children in Qassim region, and the study included 5176 children aged 6 to 13 years old. Distance visual acuity was tested monocularly using a log MAR chart with and without correction. Cycloplegic refraction was performed on children with reduced vision. The findings showed that the prevalence of amblyopia was higher in the older age group from 10–13 years compared to the younger age group from 6 to 9 years old. The study showed that the prevalence of unilateral amblyopia of 3.24% was much higher than bilateral amblyopia of 0.66%. Refractive error was reported to be the most common cause of unilateral and bilateral amblyopia with 94.56% of all amblyopic children. The study revealed that 77.72% of unilateral amblyopia was attributed to anisometropia and isometropia was found in 16.84%, while only 5.44% of amblyopia was due to strabismus.

The abovementioned previous study was the only study that investigated amblyopia prevalence in the Qassim region. However, this study's main aim was to report the clinical characteristics of amblyopia in children under 17 years of age in Qassim Region, Saudi Arabia. Thus, this study aimed to report demographics and causes of amblyopia in children 3 to ≤17 years old in the Qassim region.

Materials and Methods

Study Design

This was a cross-sectional hospital-based study of 121 consecutive children with amblyopia aged between 3 and 17 years old who were recruited to participate in the present study. The amblyopic children were referred by optometrists and ophthalmologists from 6 hospitals in Qassim region in the period from April 2021 to April 2022, data were analyzed along with genders, ages, and causes of amblyopia.

Ethical Consideration

Ethical permission for the study was obtained from Qassim University Health Research Ethics Committee under approval number (19–07-06). The study was conducted according to the tenets of the Helsinki Declaration for performing medical research with human participants. Written consent forms were obtained from the parents of the children before the study commencement.

Furthermore, efforts were made to ensure that patients' confidentiality was guaranteed.

Data Collection Procedures

One-hundred and twenty-one amblyopic children were referred to the paediatric optometry clinic at Qassim University medical city to undergo a full comprehensive ocular examination. The assessment of the anterior segment was taken for each child, followed by the fundus examination using direct ophthalmoscopy. The visual acuity (VA) was obtained by using either the Amblyopia Treatment Study (ATS) testing protocol single-surround HOTV optotypes for children <7 years, or the Electronic Early Treatment Diabetic Retinopathy (E-ETDRS) protocol for children ≥7 years.¹⁵

The dry and cycloplegic refractions were measured using both standard retinoscopy and autorefractor (NIDEK AR-310), and the average of 3 static measurements of refractive error were calculated for each eye. Thereafter, a cyclopentolate 1% was instilled 3 times after 5-min intervals, and cycloplegic refraction was assessed for all participants. Ocular alignment was also evaluated using the Simultaneous Prism Cover Test (SPCT) and Hirschberg method at both distance (6 m) and near (40 cm), while children were fully corrected with the distance vision correction.¹⁵

The Characteristics and Types of Amblyopia

All the recruited children who were diagnosed with unilateral or bilateral amblyopia were included in this study. Unilateral amblyopia is defined as amblyopia associated with strabismus (comitant or incommittant), anisometropia, both mechanisms, refractive, or deprivation. For unilateral amblyopia, VA in the amblyopic eye between 20/40 and 20/400 inclusive, visual acuity in the sound eye of 20/32 or better, and inter-eye acuity difference ≥ 2 log MAR lines. For bilateral amblyopia, visual acuity of 20/30 in both eyes after the best-corrected visual acuity, and a high refractive error of $>3D$ (SE).

Criteria for Strabismus

At least one of the following criteria must be met:⁷

- Heterotropia at distance and/or near fixation on examination (with or without spectacles)
- History of strabismus surgery
- Documented history of strabismus which is no longer present (which in the judgment of the investigator could have caused amblyopia)

Criteria for Anisometropia

At least one of the following criteria must be met:⁷

- $>1.00 D$ difference between eyes in spherical equivalent
- $>1.50 D$ difference between eyes in astigmatism in any meridian

For deprivation amblyopia, amblyopia due to media opacities that includes cataract, corneal diseases' complications, ptosis, or any other pathology.

For refractive amblyopia, the magnitude of refractive errors of $>3.00 D$, and inter-eye acuity difference of >3 log MAR lines.

Data Analysis

Data was collected in Excel (Microsoft Corporation, USA) from both eyes, and then statistical analysis was performed using the SPSS software package (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp., USA). The data were analysed descriptively using standard deviations and percentages using the Chi-square test for categorical variables. One-Way ANOVA test was used for means comparison and statistical significance was set at $p < 0.05$.

Results

A total of 121 amblyopic children aged between 3 and 17 years were included in the current study, with a mean age of 8.93 ± 3.67 years, and met the inclusion criteria of the study. One-Sample Kolmogorov–Smirnov Test revealed that the samples for amblyopic children were distributed normally with a $p = 0.766$. The mean and standard deviation of VA right eyes and VA left eyes for the amblyopic children were (0.62 ± 0.33) and (0.59 ± 0.32) , respectively. The mean and standard deviation of hyperopic refractive error for right and left eyes $(3.63 \pm 1.88D)$ and $(4.50 \pm 1.53D)$, respectively. Moreover, hyperopic astigmatism was more common among children with amblyopia for right and left eyes $(3.79 \pm 1.82D)$, and $(4.10 \pm 2.23D)$, respectively, as shown in Table 1.

Demographic Characteristics of Amblyopic Children

The results showed that the leading causes of amblyopia among children were strabismus and anisometropia shared the same percentage of 36 (29.75%), followed by the combined-mechanism of 22 (18.18%) and astigmatism at 14 (11.57%). Amblyopia was more common among males 70 (57.85%), particularly strabismic amblyopia representing 24 (66.67%) and anisometropic amblyopia 22 (61.11%), but the difference was not statistically significant ($p = 0.408$). Most amblyopic children's age ranges from 6 to 9 years 45 (37.19%) followed by the age group 10 to 13 years 35 (28.92%). Furthermore, strabismic amblyopia was commonly found among the age group 6 to 9 years 16 (44.44%), and anisometropic amblyopia

Table 1 Descriptive Statistical Measurements of Clinical Features for Children with Amblyopia

Clinical features	N	Minimum	Maximum	Mean	Std. Deviation
Age (Years)	121	3.00	17.00	8.93	3.67
VAOD(Decimal)	121	0.03	1.00	0.62	0.33
VAOS(Decimal)	121	0.03	1.00	0.59	0.32
Hyperopia OD(D)	16	0.00	+7.25	3.63	1.88
Hyperopia OS(D)	16	+2.00	+7.00	4.50	1.53
Myopia OD (D)	7	-1.00	-4.50	2.75	1.75
Myopia OS(D)	7	-2.75	-4.50	3.33	1.01
Hyper-astigma OD	74	+0.50	+9.75	3.79	1.82
Hyper-astigma OS	74	0.00	+11.25	4.10	2.23
Myopic- astigma OD	24	-0.50	-11.00	4.42	2.91
Myopic- astigma OS	24	0.00	-11.00	4.20	3.48
Anisometropia(D)	121	0.00	11.00	1.51	1.87

Abbreviations: VA, Visual acuity (in decimal); D, Diopter; astigma, Astigmatism.

accounted for 13 (36.11%) of the age group 10 to 13 years. Whereas amblyopia due to combined-mechanism and refractive amblyopia was 8(36.36%) and 5(38.36%), respectively, for the age group 6 to 9 years.

Unilateral amblyopia was more commonly found in 92 (76.03%) children than bilateral amblyopia the difference was statistically significant ($p = 0.003$). The leading causes of unilateral amblyopia were anisometropia 29 (80.56%) followed by strabismus 26 (72.22%). While the common cause of bilateral amblyopia was astigmatism 7(50.50%), followed by hyperopia and myopia 3(23.07%) as shown in Table 2.

Association Between Visual Acuity (VA)and Causes of Amblyopia in Children

Visual acuity was not significantly different for right and left eyes by the causes of amblyopia. However, the poorer VA for the right eyes (0.542 ± 0.286) was associated with strabismic amblyopia compared to slightly good VA (0.764 ± 0.311) for ametropic amblyopia, whereas the worse VA in left eyes (0.521 ± 0.247) was related with anisometropic amblyopia as shown in Table 3.

Association Between Different Types of Refractive and Cause of Amblyopia in Children

The degree of the hyperopic refractive error (RE) was not varied by the cause of amblyopia in the right eyes ($P = 0.401$), with a slightly high amount of hyperopia found among ametropic and strabismic amblyopia ($+4.22 \pm 1.67D$) and ($+4.08 \pm 1.88D$),

Table 2 Clinical Characteristics for Amblyopic Children

Characteristics	Type of Amblyopia					Total N (%)	P-value
	Strabismic N (%)	Anisometropia N (%)	Refractive N (%)	Meridional N (%)	Combined-Mechanism N (%)		
Male	24 (66.67)	22 (61.11)	7 (53.85)	8 (57.14)	9 (40.90)	70 (57.85)	0.408
Female	12 (33.33)	14 (38.89)	6 (46.15)	6 (42.86)	13 (59.10)	51 (42.15)	
Less than 6 years	12 (33.33)	5 (13.89)	4 (30.77)	0 (0.00)	4 (18.18)	25 (20.66)	0.066
6–9 Years	16 (44.44)	10 (27.78)	5 (38.46)	6 (42.86)	8 (36.36)	45 (37.19)	
10–13 Years	8 (22.22)	13 (36.11)	3 (23.08)	6 (42.86)	5 (22.72)	35 (28.92)	
14–17 Years	0 (0.00)	8 (22.22)	1 (7.69)	2 (14.8)	5 (22.72)	16 (13.22)	
Unilateral	26 (72.22)	29 (80.56)	10 (63.92)	7 (50.50)	20 (90.90)	92 (76.03)	0.003
Bilateral	10 (27.78)	7 (19.44)	3 (23.07)	7 (50.50)	2 (9.10)	29 (23.97)	
Total	36 (29.75)	36 (29.75)	13 (10.74)	14 (11.57)	22 (18.18)	121 (100)	

Table 3 Association Between Visual Acuity and Causes of Amblyopia in Children

		Mean	Std. Deviation	95% C for the Mean		Minimum	Maximum	
				Lower Bound	Upper Bound			
	Causes	Visual acuity (VA) in Decimal						P-value
VAOD	Strabismic	0.5419	0.28634	0.4451	0.6388	0.10	1.00	0.084
	Anisometropia	0.5456	0.35460	0.4256	0.6655	0.03	1.00	
	Combination	0.6945	0.30828	0.5579	0.8312	0.05	1.00	
	Ametropic	0.7642	0.31154	0.5760	0.9525	0.03	1.00	
	Meridional	0.5529	0.22089	0.4253	0.6804	0.10	1.00	
VAOS	Strabismic	0.6543	0.34941	0.5361	0.7725	0.03	1.00	0.750
	Anisometropia	0.6463	0.37112	0.5207	0.7718	0.03	1.00	
	Combination	0.6277	0.33486	0.4793	0.7762	0.05	1.00	
	Ametropic	0.5212	0.24713	0.3718	0.6705	0.03	1.00	
	Meridional	0.5793	0.26260	0.4277	0.7309	0.10	1.00	

respectively. However, for left eyes, a high degree of hyperopia was found in ametropic amblyopia ($+4.75 \pm 1.42D$) ($P = 0.261$). The degree of myopic RE was no significant difference by the cause of amblyopia for the right and left eyes with a high degree of myopia found in ametropic amblyopia ($-3.63 \pm 1.24D$). While, hyperopic astigmatism was a significant difference by the cause of amblyopia for left eyes $P = 0.020$, with a high degree of hyperopic astigmatism found among meridional amblyopia ($2.52 \pm 1.75D$), followed by ametropic amblyopia ($1.25 \pm 1.06D$). Conversely, myopic astigmatism was a significant difference by the cause of amblyopia for left eyes $P = 0.008$, with a high degree of myopic astigmatism found in anisometropic amblyopia ($-3.22 \pm 1.5D$), followed by meridional amblyopia ($-2.88 \pm 0.32D$) as shown in Table 4.

Discussion

Amblyopia is a unilateral or bilateral condition that results in poorer vision in the absence of any structural or pathologic abnormalities; it is a functional decrease in the visual functions of an eye caused by disuse during a sensitive period of visual development.^{16,17} Amblyopia was considered the major cause of childhood VI worldwide; however, timely diagnosis and treatment of amblyopia in childhood could significantly improve visual functions. Conversely, if this condition is not treated during the development of visual system, unfortunately, it permanently causes VI. The clinical feature of amblyopia varies from one community to another and it is essential to understand the frequency of the different types of amblyopia among Saudi individuals who seek eye care. Therefore, the present study was performed to describe the clinical characteristics of amblyopic children attending hospitals in the Qassim region.

Our findings revealed that the mean age at diagnosis of amblyopia was 8.93 ± 3.67 years. The leading cause of amblyopia was strabismus and commonly diagnosed in children aged less than 6 years. This result agreed with Birch and Holmes,⁶ who reported that strabismic amblyopia was detected much more commonly than anisometropic or amblyopia due to the combined mechanism in children. In the present study, the data showed that only 13.89% of children aged less than 6 years were diagnosed with anisometropic amblyopia. This could be due to under-referral of anisometropic children, because a much larger number of children with anisometropia may have slightly good vision in one eye and this led to delays for seeking eye care. Furthermore, the probable reason for the finding of a lower percentage of anisometropic amblyopia in children aged less than 6 years is that anisometropia may need a longer period of time compared to the strabismus in causing amblyopia.^{18,19} Amblyopia was more common among males, predominantly strabismic amblyopia and anisometropic amblyopia, $p = 0.408$. Amblyopia was more prevalent in the age group 6- to 9-year-old, particularly, strabismic amblyopia and amblyopia due to combined mechanism $p = 0.066$. Our finding agreed with the Paediatric Eye Disease Investigator Group's (PEDIG) description of childhood amblyopia, which reported that amblyopia was commonly due to strabismus and anisometropia. They also found that about a quarter of the children have elements of both or a combined mechanism such as strabismus and uncorrected refractive errors.⁷ Flom and Neumaier²⁰

Table 4 Association Between Different Types of Refractive and Causes of Amblyopia in Children

		Mean	Std. Deviation	95% C for the MEAN		Minimum	Maximum	
				Lower Bound	Upper Bound			
	Causes	Refractive error (Hyperopia in Diopter)						P-value
VAOD	Strabismic	4.0833	1.87639	-0.5779	8.7445	2.25	6.00	0.401
	Anisometropia	2.5000	2.27303	-1.1169	6.1169	0.00	5.50	
	Combination	2.0000	0.00	0.00	0.00	2.00	2.00	
	Ametropic	4.2188	1.66603	2.8259	5.6116	2.00	7.25	
VAOS	Strabismic	3.8333	1.75594	-0.5287	8.1953	2.00	5.50	0.261
	Anisometropia	3.8750	1.31498	1.7826	5.9674	2.00	5.00	
	Combination	7.0000	0.00	0.00	0.00	7.00	7.00	
	Ametropic	4.7500	1.42051	3.5624	5.9376	2.75	7.00	
	Causes	Refractive error (Myopia in Diopter)						P-value
VAOD	Anisometropia	1.0000	0.00	0.00	0.00	1.00	1.00	0.333
	Ametropic	3.6250	1.23744	-7.4929	14.7429	2.75	4.50	
VAOS	Anisometropia	2.7500	0.00	0.00	0.00	2.75	2.75	0.667
	Ametropic	3.6250	1.23744	-7.4929	14.7429	2.75	4.50	
	Causes	Refractive error (Hyperopic astigmatism in Diopter)						P-value
VAOD	Strabismic	1.1339	0.91409	-1.4884	-0.7795	3.75	1.50	0.082
	Anisometropia	1.2738	0.78224	-1.6299	-0.9177	2.75	0.00	
	Combination	0.8077	1.40369	-1.6559	0.0406	4.00	2.00	
	Ametropic	2.1250	2.65165	-25.9491	21.6991	4.00	1.25	
	Meridional	2.0500	1.52206	-3.1388	-0.9612	5.00	1.5	
VAOS	Strabismic	1.3929	0.84555	-1.7207	-1.0650	3.25	0.50	0.020
	Anisometropia	1.2738	1.04255	-1.7484	-0.7992	-3.75	0.00	
	Combination	1.0385	0.95113	-1.6132	-0.4637	-3.75	0.00	
	Ametropic	1.2500	1.06066	-10.7797	8.2797	-2.00	0.50	
	Meridional	2.5250	1.73385	-3.7653	-1.2847	-6.50	0.75	
	Causes	Refractive error (Myopic astigmatism in Diopter)						P-value
VAOD	Strabismic	-2.1250	1.23744	-13.2429	8.9929	-3.00	-1.25	0.008
	Anisometropia	-3.2222	1.48137	-4.3609	-2.0835	-5.00	-1.25	
	Combination	-1.1875	0.34718	-1.4778	-0.8972	-1.75	-0.75	
	Meridional	-2.8750	0.32275	-3.3886	-2.3614	-3.25	-2.50	
VAOS	Strabismic	-0.7500	1.06066	-10.2797	8.7797	-1.50	0.00	0.579
	Anisometropia	-2.0278	2.32327	-3.8136	-0.2420	-5.50	0.00	
	Combination	-1.5625	0.71651	-2.1615	-0.9635	-2.50	-0.25	
	Meridional	-2.8750	0.72169	-4.0234	-1.7266	-3.75	-2.00	

investigated amblyopic children from kindergarten to the sixth grade, and their results indicated that all children with amblyopia had either strabismus 38%, 1 dioptre (D), or more of anisometropia 34%, or both conditions 28%. The present study showed that the leading causes of unilateral amblyopia were strabismus and anisometropia. These results agreed with PEDIG⁷ findings, which reported that strabismus and anisometropia were found to be associated with unilateral amblyopia in 20% of the examined children.

This study showed that the degree of the hyperopia was not varied by the cause of amblyopia ($P = 0.401$), with slightly high hyperopia found in ametropic and strabismic amblyopia. Our findings are in line with Ansons and Davis,¹⁶ revealing that amblyopia occurs in association with high bilateral hyperopia. This cannot be compensated by

accommodation, and causes blurred image present at all distances. Scheiman⁴ stated that the primary factor causing amblyopia is an uncorrected refractive error which does not allow clear retinal images of equal size or shape, or both, in each eye, and this would not create a suitable stimulation for the normal development of the visual system and thus leading to the development of amblyopia. Conversely, hyperopic astigmatism was a significant difference by the cause of amblyopia for eyes $P = 0.020$, with a high degree of hyperopic astigmatism found in meridional amblyopia and ametropic amblyopia. Astigmatism may be an even greater deterrent to fusion than hyperopic anisometropia, uncorrected astigmatism of 1.50 D or more may cause enough image blur resulting in amblyopia since accommodation is also unable to compensate for this refractive error.^{21,22} Peters²³ reported that astigmatic differences between the eyes can contribute to the development of amblyopia, the decrease of VA for a given amount of uncorrected astigmatism is usually less than what would occur with an equal amount of spherical hyperopic anisometropia. These results agreed with our findings that the poorer VA was associated with strabismus amblyopia compared to slightly good VA for meridional amblyopia.

The present study has some limitations. Firstly, its cross-sectional nature did not report the improvement in VA after amblyopia therapy. Secondly, the study used an age group stratification result in a difference in the stratification of age groups, with the age group 6–9 years being dominant in the study might produce discrepancy from others. Thirdly, participants came from different hospitals in Qassim region and this may not reflect the demographics of the general Saudi population. The measurements of the visual function for preverbal children may be difficult to be assessed compared to the assessment of older age groups. Nevertheless, despite the limitations mentioned above, the current study provides important information regarding the clinical feature of amblyopic children in Qassim region, Saudi Arabia.

Conclusion

The most common causes of amblyopia were strabismus and anisometropia. The causes of amblyopia differed by age groups with strabismus, anisometropia, and combined mechanism accounting for most children aged 6- to 9-years and strabismus for children aged less than 6 years. Uncorrected hyperopia was commonly found in ametropic and strabismic amblyopia, whereas hyperopic astigmatism was associated with meridional and ametropic amblyopia. Moreover, myopic astigmatism was significantly associated with anisometropic and meridional amblyopia. Therefore, efforts should be made for early diagnosis and management of childhood amblyopia and uncorrected refractive errors to avoid their impact on quality of life. Future work is also required to examine the long-term effect of amblyopia treatment and eye practitioners should consider the different types of amblyopia while applying the treatment plan for amblyopic children.

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