Original Research Report

THE ETIOLOGY OF PARALYTIC STRABISMUS AT AN INDONESIAN TERTIARY HOSPITAL FROM 2017 TO 2022

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ABSTRACT

Paralytic strabismus is the most common cause of adult-onset strabismus. It can result from paralysis of the third, fourth, or sixth cranial nerves, either separately or in combination, which are responsible for innervating the ocular motor muscles. Paralysis of these cranial nerves occurs due to congenital disorders, neoplasms, trauma, intracranial processes, idiopathic diseases, and other causes. This study aimed to determine the etiology of paralytic strabismus incidence at the Department of Ophthalmology of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, between 2017 and 2022. This study employed a retrospective methodology and utilized total sampling. The medical records of patients diagnosed with paralytic strabismus were used to collect secondary data. Out of the total of 282 cases, the most common condition was combined ocular motor cranial nerve palsy, which accounted for 102 (36.2%) cases. The main factors contributing to this condition were neoplasms (37.2%), intracranial processes (25.5%), trauma (25.5%), other causes (8.8%), idiopathic diseases (2%), and congenital disorders (1%). The incidence of third cranial nerve palsy and sixth cranial nerve palsy was equally prevalent, each accounting for 86 (30.5%) cases. Meanwhile, fourth cranial nerve palsy was the least frequent with just eight (2.8%) cases. This study concluded that the most frequent etiology of paralytic strabismus was combined ocular motor nerve paralysis, which primarily results from neoplasms.

Keywords: Health risk; paralytic strabismus; third cranial nerve paralysis; fourth cranial nerve paralysis; sixth cranial nerve paralysis

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Highlights:
1. This study investigated the etiology of paralytic strabismus, a condition that requires further research to prevent its incidence, particularly in adults.
2. The findings of this study provided valuable insight into the primary etiology of paralytic strabismus and its underlying factors.

INTRODUCTION

Strabismus, more commonly known as "crossed eyes" or "squint," is a condition characterized by a lack of alignment between the eyes. This condition is visible when either one or both eyes deviate inward or outward. Individuals affected by strabismus may experience diminished self-confidence and social anxiety (Kraus & Kuwera 2023, Kanukollu & Sood 2024).

Race has an impact on the prevalence of strabismus. Hence, the frequency of different types of strabismus differs from one race to another. The global prevalence of strabismus is 1.93%, affecting approximately one out of every 50 individuals.

Strabismus is more common in certain countries and ethnic groups, particularly in Western countries and among white people (Khorrami-Nejad et al. 2018, Hashemi et al. 2019). Strabismus can manifest in individuals of all ages, but it is more prevalent in adults (>20 years old) than children. The prevalence of strabismus in children globally ranges from 0.14% to 5.65%. These cases are associated with several factors, including cesarean delivery, prematurity, low birth weight, nerve disorders, refractive errors, anisometropia, cranial nerve paralysis, advanced maternal age at childbirth, maternal smoking during pregnancy, and a family history of strabismus (Agaje et al. 2020). On the other hand, the prevalence of strabismus in the adult population is not well documented due to limited data availability. The prevalence of strabismus in adults was found to be 1.1% in Denmark. Meanwhile, among Israeli military conscripts, it varied between 0.6% and 1.2% (Fieß et al. 2020).

Paralytic strabismus is an ocular pathology that is caused by dysfunction in one or more cranial nerves responsible for the extraocular muscle innervation. These cranial nerves include the ocular motor nerve (third cranial nerve), trochlear nerve (fourth cranial nerve), and abducens nerve (sixth cranial nerve). Vascular diseases, tumors, and trauma are among the reasons that may contribute to the paralysis of these nerves. In addition to trauma and tumors, paralytic strabismus can also result from other factors such as vasculopathy, increased intracranial pressure, inflammation, and even unknown causes (Ho et al. 2013, Kim & Lew 2022). Paralytic strabismus has been found to be one of the most common types of strabismus. This has been reported in numerous studies, two of which were conducted at Mahatma Eye Hospital in India and Olmsted County, Minnesota, USA (Martinez-Thompson et al. 2014, Rajasekaran et al. 2018).

Numerous studies have been conducted on paralytic strabismus abroad. However, research on this subject is still scarce in Indonesia. Information regarding the causes of paralytic strabismus, particularly in Surabaya, Indonesia, is limited. Only one study, conducted in 2015 at Dr. Soetomo General Academic Hospital, Surabaya, Indonesia. has specifically discussed paralytic strabismus in this region (Dharmantara 2015). Additional research is necessary to establish a reliable source of information for minimizing the incidence of paralytic strabismus through effective prevention and treatment. This study aimed to identify the etiology of paralytic strabismus at Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, between 2017 and 2022.

MATERIALS AND METHODS

This study used a descriptive research design with a retrospective approach to investigate the etiology of paralytic strabismus conducted at Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, from 2017 to 2022. This study employed a descriptive method to offer a detailed overview of characteristics according to the collected data. In the meantime, a retrospective approach was used to retrieve historical data through records or interviews (Ranganathan & Aggarwal 2018). This study was exected to provide a comprehensive description of the etiology of paralytic strabismus, including congenital disorders, neoplasms, trauma, intra-cranial processes, idiopathic diseases, and other causes not included in the existing categories.

The study population consisted of all patients with paralytic strabismus who were diagnosed by an ophthalmologist at the Department of Ophthalmo-logy of Dr. Soetomo General Academic Hospital between 2017 and 2022. Individuals with incomplete medical records were excluded from this study. Patients with paralytic strabismus who met the inclusion criteria were gathered using a total sampling technique (Campbell et al. 2020). The secondary data were obtained from the patients' medical records, digitally archived by the Department of Communication and Information Technology Installation at Dr. Soetomo General Academic Hospital. The data were processed and analyzed using Microsoft Word and Microsoft Excel for Mac, version 16.0 (Microsoft Inc., Redmont, WA, USA). These programs were utilized to perform editing, coding, entry, and cleaning processes, which transform raw data into concise information that could be presented in tables for easier understanding (Vetter 2017). The initiation of this research followed the acquisition of permission and approval from the Health Research Ethics Committee of Dr. Soetomo General Academic Hospital, under reference No. 1187/LOE/301.4.2/ I/2023 dated 15/1/2023. This study implemented ethical principles, including confidentiality, anonymity, and beneficiary considerations.

RESULTS

After applying the inclusion and exclusion criteria, the final dataset consisted of 282 samples, which was reduced from the initial set of 518. Out of the 282 patients with paralytic strabismus, 102 (36.2%) individuals had combined ocular motor cranial nerve palsy. The prevalence of third cranial nerve palsy and sixth cranial nerve palsy was identical, with each condition affecting 86 (30.5%) individuals. The remaining patients exhibited fourth cranial nerve palsies, accounting for 8 (2.8%)

individuals.

The proportions of ocular motor cranial nerve paralysis varied between different sex categories. Table 1 reveals that the majority of patients with paralytic strabismus were female, accounting for 149 (52.8%) patients. Moreover, female patients exhibited the highest prevalence of third and sixth cranial nerve paralysis, with 49 (57%) and 47 (54.7%) cases, respectively. However, the occurrences of combined ocular motor cranial nerve paralysis and fourth cranial nerve paralysis were predominant in male patients, with 52 (50.9%) and 5 (62.5%) cases, respectively. The paralytic strabismus patients were divided into two age groups: children aged 0–18 years and adults aged ≥19 years, including those who had passed away. The majority of patients who had cranial nerve paralysis were adults, amounting to a total of 237 (84%) individuals. This included 91 (89.2%) patients with combined ocular motor cranial nerve paralysis, 70 (81.4%) patients with third cranial nerve paralysis, 70 (81.4%) patients with sixth cranial nerve paralysis, and 6 (75%) patients with fourth cranial nerve paralysis.

Table 1. Descriptive characteristics of the sample.

	Paralytic strabismus			
	CN III palsy (n, %)	CN IV palsy (n, %)	CN VI palsy (n, %)	Combined OMCNP (n, %)
Number of patients	86 (30.5%)	8 (2.8%)	86 (30.5%)	102 (36.2%)
Sex				
Male	37 (43%)	5 (62.5%)	39 (45.3%)	52 (50.9%)
Female	49 (57%)	3 (37.5%)	47 (54.7%)	50 (49.1%)
Age				
Children	16 (18.6%)	2 (25%)	16 (18.6%)	11 (10.8%)
Adults (≥19 y.o.)	70 (81.4%)	6 (75%)	70 (81.4%)	91 (89.2%)
Risk factor				
Hypertension	23 (26.7%)	1 (12.5%)	12 (14%)	23 (22.5%)
Diabetes mellitus	11 (12.8%)	1 (12.5%)	6 (7%)	21 (20.6%)
Hyperlipidemia	3 (3.5%)	1 (12.5%)	6 (7%)	9 (8.8%)

Legends: CN III=third cranial nerve; CN IV=fourth cranial nerve; CN VI=sixth cranial nerve; combined OMCNP= combined ocular motor cranial nerve palsy.

The proportions of ocular motor cranial nerve paralysis varied between different sex categories. Table 1 reveals that the majority of patients with paralytic strabismus were female, accounting for 149 (52.8%) patients. Moreover, female patients exhibited the highest prevalence of third and sixth cranial nerve paralysis, with 49 (57%) and 47 (54.7%) cases, respectively. However, the occurrences of combined ocular motor cranial nerve paralysis and fourth cranial nerve paralysis were predominant in male patients, with 52 (50.9%) and 5 (62.5%) cases, respectively. The paralytic strabismus patients were divided into two age groups: children aged 0–18 years and adults aged ≥19 years, including those who had passed away. The majority of patients who had cranial nerve paralysis were adults, amounting to a total of 237 (84%) individuals. This included 91 (89.2%) patients with combined ocular motor cranial nerve paralysis, 70 (81.4%) patients with third cranial nerve paralysis, 70 (81.4%) patients with sixth cranial nerve paralysis, and 6 (75%) patients with fourth cranial nerve paralysis.

Table 2. Causes of paralytic strabismus among the patients.

	Paralytic strabismus			
	CN III palsy (n, %)	CN IV palsy (n, %)	CN VI palsy (n, %)	Combined OMCNP (n, %)
Number of patients	86 (30.5%)	8 (2.8%)	86 (30.5%)	102 (36.2%)
Causes				
Congenital disorders	4 (4.6%)	1 (12.5%)	2 (2.3%)	1 (1%)
Trauma	31 (36%)	2 (25%)	29 (33.7%)	26 (25.5%)
Neoplasms	24 (28%)	3 (37.5%)	30 (34.9%)	38 (37.2%)
Basilar tumor	3	1	7	3
Intracranial tumor	17	2	21	30
Orbital tumor	4	0	2	5
Intracranial processes	20 (23.2%)	1 (12.5%)	19 (22.1%)	26 (25.5%)
Aneurysm	3	0	0	3
Infection	0	0	2	0
Inflammation	1	0	5	2
Ischemia	6	0	5	11
Migraine	2	0	1	0
Myasthenia gravis	3	0	0	3
Cavernous sinus disease	1	0	1	2
Increased intracranial pressure	0	0	0	0
Neurological disorder	1	0	1	0
Vascular	3	1	4	5
Idiopathic diseases	1 (1.2%)	1 (12.5%)	3 (3.5%)	2 (2%)
Other causes	6 (7%)	0 (0%)	3 (3.5%)	9 (8.8%)

Legends: CN III=third cranial nerve; CN IV=fourth cranial nerve; CN VI=sixth cranial nerve; combined OMCNP= combined ocular motor cranial nerve palsy.

Out of the 282 patients diagnosed with paralytic strabismus, not all exhibited vascular risk factors such as hypertension, diabetes mellitus, and hyperlipidemia. Hypertension was the predominant

risk factor, affecting a total of 59 individuals. Diabetes mellitus and hyperlipidemia were the second and third most common risk factors, affecting up to 39 and 19 individuals, respectively. Among patients with combined ocular motor cranial nerve paralysis, 23 (22.5%) had hypertension, 21 (20.6%) had diabetes mellitus, and 9 (8.8%) had hyperlipidemia. Regarding third cranial nerve paralysis, 23 (26.7%) of the 86 patients exhibited hypertension, whereas 11 (12.8%) had diabetes mellitus, and 3 (3.5%) had hyperlipidemia. Out of the 86 patients with sixth cranial nerve paralysis, 12 (14%) had hypertension, 6 (7%) had diabetes mellitus, and 6 (7%) had hyperlipidemia. In terms of fourth cranial nerve paralysis, each risk factor was present in only 1 (12.5%) out of 8 patients.

A total of 282 patients admitted to the Department of Ophthalmology at Dr. Soetomo General Academic Hospital were diagnosed with paralytic strabismus. This study identified and classified paralysis of the third, fourth, and sixth cranial nerves, both individually and in combination, into six primary categories: congenital disorders, trauma, neoplasms, intracranial processes, idiopathic diseases, and other causes not falling into the previous categories (Table 2).

Neoplasms were the most common cause of combined paralysis of the ocular motor cranial nerves, accounting for 38 (37.2%) cases. Subsequently, trauma and intracranial processes were observed, each accounting for 26 (25.5%) cases. Other causes contributed to this condition in 9 (8.8%) cases, while idiopathic diseases were found in 2 (2%) instances. The occurrence of congenital disorders was the least frequent, found in only 1 (1%) case (Table 2).

Paralysis of the third cranial nerve was most frequently caused by trauma, occurring in 31 (36%) patients. Neoplasms were the second most common cause, affecting 24 (28%) patients. Paralysis of the third cranial nerve due to intracranial processes was found in 20 (23.2%) patients. The causes of third cranial nerve paralysis were classified into three categories: traumatic, neoplastic, and vascular. The most prevalent causes were traumatic, followed by neoplastic and vascular causes. Congenital, idiopathic, and other causes were the least common, affecting 4 (4.6%), 1 (1.2%), and 6 (7%) patients, respectively (Table 2).

Neoplasms were the leading cause of sixth cranial nerve paralysis in 30 (34.9%) patients. Subsequently, trauma was the second leading cause, accounting for 29 (33.7%) patients. Intracranial processes were the third most common cause of sixth cranial nerve paralysis, affecting 22 (25.6%) patients. Only 3 (3.5%) patients with sixth cranial nerve paralysis had idiopathic diseases or other causes, whereas 2 (2.3%) patients exhibited congenital disorders, indicating that these three causes were the least prevalent. Of the 8 patients diagnosed with fourth cranial nerve paralysis, neoplasms were identified as the primary cause in 3 (37.5%) individuals. Subsequently, trauma was found to be the cause of the condition in 2 out of 8 patients, accounting for 25% of the cases. One patient (12.5%) had congenital disorders, while another patient (12.5%) had an idiopathic disease (Table 2).

DISCUSSION

Distribution of paralytic strabismus according to the patients' characteristics

The results of this study indicated that combined ocular motor cranial nerve palsy was the most common category. The occurrence of third and sixth cranial nerve palsy was equally common, while fourth cranial nerve palsy was the least common. Notably, these results differ from those of a previous study by Kumar et al. (2018), who found that sixth cranial nerve palsy was the most common category (36%) among 50 patients with ocular motor nerve palsy. This was followed by combined ocular motor nerve palsy (34%) and third cranial nerve palsy (30%). Khadka et al. (2020) also reported that out of 167 patients with ocular motor nerve palsy, sixth cranial nerve palsy was the most common (50.3%), followed by third cranial nerve palsy (38.3%), combined ocular motor nerve palsy (6%), and fourth cranial nerve palsy (5.4%). In addition, sixth cranial nerve palsy was the most prevalent among a population of 66 pediatric patients with paralytic strabismus. The pediatric patients showed that 53% of them had sixth cranial nerve palsy, 21.2% had third cranial nerve palsy, 19.7% had fourth cranial nerve palsy, and 6.1% had combined ocular motor nerve palsy (Park et al. 2019b). The discrepancies in the type of paralysis observed might be attributed to various factors, such as sample size, criteria for diagnosing paralytic strabismus, the locations of the causative paralysis, as well as the behavioral patterns and habits of the patients. These factors contribute to the fluctuating incidence of cranial nerve paralysis cases of diverse types.

In this study, there was no significant difference between the number of male and female paralytic strabismus patients. However, the female patients accounted for a slightly higher proportion (149 individuals, 52.8%) compared to the male patients (133 individuals, 47.2%). In contrast, a study conducted by Niyaz et al. (2015) examined 38 paralytic strabismus patients and found that the proportion of female patients (15 individuals, 39.5%) was not greater than that of male patients (23

individuals, 60.5%). Furthermore, among a population of 153 paralytic strabismus patients in a study by Kim et al. (2018), there were 87 (56.9%) male patients and 66 (44.1%) female patients. This study involved a larger sample size and a longer observation period, which led to differences in the distribution of paralytic strabismus patients according to their sexes.

This study clearly showed that each type of ocular motor cranial nerve paralysis had different predominant sexes. Male patients exhibited the highest prevalence in the category of combined ocular motor cranial nerve paralysis. However, there is a lack of current research that specifically addresses the sex ratio in relation to the prevalence of combined ocular motor cranial nerve paralysis. In general, men tend to have less healthy lifestyles compared to women, including higher rates of alcohol and tobacco consumption. Men also engage in more outdoor activities, which can increase the risk of accidents and trauma. In cases of paralysis of the third and sixth cranial nerves, female patients were found to be more affected than male patients. This aligned with a study by Fang et al. (2017), who observed that out of 145 patients with acquired third cranial nerve paralysis, 87 (60%) were female and 58 (40%) were male. In contrast, slightly different findings were found in eight cases of idiopathic sixth cranial nerve paralysis. Among the 8 patients, 5 (62.5%) were male and 3 (37.5%) were female. Male patients were more prevalent in paralysis of the fourth cranial nerve cases, accounting for 5 (62.5%) individuals (Park et al. 2019a). Another study conducted by Oh & Oh (2020) documented similar findings from the examination of 80 patients diagnosed with fourth cranial nerve paralysis at Samsung Changwon Hospital in Korea. The study found a total of 60 male patients and 20 female patients.

The classification of paralytic strabismus patients in this study revealed that this condition was more prevalent in adults than children. The patients had an average age of 40.9 years. A study conducted by Niyaz et al. (2015) at the Ophthalmology Clinic of Samsun Ondokuz Mayis University in Turkey found that the average age of 38 patients was 25.6 years. The study revealed similar findings to ours, in which the majority of patients with paralytic strabismus in all categories belonged to the adult age group of 19 years or older. A study conducted by Dharmantara (2015) at the Department of Ophthalmology of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, corroborated these findings by revealing that 76 individuals (63.33%) with paralytic strabismus were adults over 20 years old. The occurrence of paralytic strabismus might be attributed to unhealthy adult behaviors such as smoking, poor diet, and unsafe driving.

Out of the 282 paralytic strabismus samples examined in this study, hypertension was identified as the most common risk factor, followed by diabetes mellitus and hyperlipidemia. The results of this study were consistent with several previous studies. In a cohort study conducted by Park et al. (2018), it was found that hypertension and diabetes mellitus were the highest risk factors (30%), along with dyslipidemia (18.5%). Similarly, at the Department of Ophthalmology of Chosun University, Korea, patients diagnosed with ocular motor cranial nerve paralysis had hypertension as the predominant risk factor (63%). Diabetes mellitus (53.7%) and dyslipidemia (24.1%) were the second and third most prevalent risk factors, respectively (Jung & Kim 2015). This study found that adult patients were more likely to have high vascular risk factors. Hypertension, diabetes mellitus, and hyperlipidemia have been identified as vascular risk factors that potentially affect the vasa vasorum of the ocular motor cranial nerves, which can lead to ischemia in the nerve fibers.

This study revealed that hypertension was the predominant risk factor among patients in the combined ocular motor cranial nerve paralysis category. Currently, there is a lack of studies that specifically investigate the risk factors associated with combined ocular motor cranial nerve paralysis. Hypertension was also the most prevalent risk factor among third cranial nerve paralysis patients, followed by diabetes mellitus and hyperlipidemia. In a study conducted at Universiti Sains Malaysia, it was discovered that among a group of 33 patients with third cranial nerve paralysis, 18 individuals (54.5%) exhibited specific risk factors, including diabetes, hypertension, and hyperlipidemia (Nurul-Ain et al. 2022). A separate study conducted by Ramappa et al. (2021) at the Department of Ophthalmology of Krishna Rajendra Hospital in Mysore, India, discovered that diabetes was the primary cause (14) of third cranial nerve paralysis. Furthermore, among 86 patients diagnosed with sixth cranial nerve paralysis, 12 (14%) had hypertension, 6 (7%) had diabetes mellitus, and 6 (7%) had hyperlipidemia. A separate study conducted at Kyung Hee University Hospital in Korea also revealed that hypertension (52%) was the most common risk factor for sixth cranial nerve paralysis, followed by diabetes mellitus (48%) (Kim et al. 2018).

A prior study conducted by Çolpak & Çağlayan (2019) aligned with the findings of this study, revealing that diabetes mellitus (22 cases), hypertension (19 cases), and hyperlipidemia (10 cases) were the primary risk factors for third cranial nerve paralysis. Additionally, it was discovered that hypertension (25 cases), diabetes mellitus (14 cases), and hyperlipidemia (12 cases) were the

predominant risk factors for sixth cranial nerve paralysis. However, the study identified hypertension (15 cases), diabetes mellitus (9 cases), and hyperlipidemia (5 cases) as the predominant risk factors among patients with fourth cranial nerve paralysis, which deviates from the results of this study. Out of the total of 282 patients with paralytic strabismus in this study, only 8 were identified as having fourth cranial nerve paralysis. Hypertension, diabetes mellitus, and hyperlipidemia were present in only one patient each within this category. The different sample sizes might have resulted in significant variations in the prevalence of risk factors among fourth cranial nerve paralysis patients.

Distribution of paralytic strabismus according to its causes

As indicated by this study, neoplasms were identified as the leading cause of paralytic strabismus at the Department of Ophthalmology of Dr. Soetomo General Academic Hospital. This study additionally revealed that paralytic strabismus could be attributed to trauma, intracranial processes, congenital disorders, idiopathic diseases, and other causes. However, these causes were less prevalent compared to neoplasms. In contrast, a study conducted by Niyaz et al. (2015) reported that congenital disorders accounted for 34.2% of cases of paralytic strabismus. Additional factors that were documented were trauma (26.3%), intracranial lesions (18.35%), infections (7.9%), and idiopathic diseases (13.15%). On the other hand, Kim et al. (2018) discovered that the primary factors contributing to the condition were vascular diseases (54.9%), idiopathic diseases (28.1%), trauma (8.5%), and neoplasms (5.88%). The differences in the results of this study might be due to variations in the ages of the subjects. This included a larger number of adult patients with diverse lifestyles and mental health statuses, potentially leading to the development of neoplasm-related conditions. Moreover, the classification of the causes of paralytic strabismus might have also contributed to the variations observed in the results. It is important to note that Dr. Soetomo General Hospital is a tertiary referral hospital and an oncology referral center, indicating a higher prevalence of neoplasms compared to other hospitals.

Neoplasms were the primary cause of combined ocular motor nerve palsy in this study, with intracranial processes and trauma being the additional causes. Other causes, including idiopathic diseases and congenital disorders, accounted for the remaining cases. These findings slightly differed from those of prior research by Phuljhele et al. (2020), who showed that combined ocular motor nerve paralysis was mainly caused by trauma (66.6%), compressive (16.7%), and inflammatory or infectious diseases. Their findings might indicate poor traffic management and a lack of awareness among road users. Road accidents can be prevented through coordinated efforts among road users and traffic enforcers.

This study identified trauma as the most common cause of third cranial nerve paralysis, followed by intracranial processes, neoplasms, congenital disorders, and idiopathic diseases. These results aligned with those of a study by Ho et al. (2013). According to the study, trauma was the most common cause of third cranial nerve palsy, accounting for 49.35% of cases. Meanwhile, a study conducted by Fang et al. (2017) found that the most common causes of acquired third nerve palsy were microvascular complications (49%), trauma (12%), neoplasms (11%), postoperative complications of neurosurgery (10%), and aneurysms (6%). Damage to the endoneurial sheath of the third cranial nerve may occur due to compression or trauma rather than vascular lesions. Subsequently, compressive or traumatic lesions can result in damage to the third cranial nerve. Additionally, negative processes within the skull can lead to compression of the third cranial nerve.

In this study, paralysis of the sixth cranial nerve most frequently occurred due to neoplasms. In addition, the patients experienced paralysis due to trauma, intracranial processes, idiopathic diseases, and congenital disorders. These results were similar to those of a study conducted by Sekeroglu (2014) in Turkey. They found that the most common cause of sixth cranial nerve paralysis was trauma, accounting for 54.4% of all cases. The sixth cranial nerve has complex anatomical features. It is vulnerable to injury due to its long and tortuous shape (Wang et al. 2018). The results of a study conducted by Oh (2022), however, showed that microvascular complications (46.16%) were the most common cause of acquired sixth cranial nerve palsy among 156 patients. Neoplasms (16.03%) were identified as the third-most common cause in the study. Moreover, a study by Jung et al. (2019) exhibited that vascular diseases and neoplasms were among the most common causes of cranial nerve paralysis. The variations in the results could be due to the different criteria used in classifying the causes of sixth cranial nerve palsy. This study did not consider microvascular risk factors (e.g., hypertension, diabetes mellitus, and dyslipidemia) as the causes of sixth cranial nerve palsy.

In eight patients diagnosed with fourth cranial nerve paralysis, it was found that neoplasms were the predominant cause. Additional factors that resulted in the occurrence of the condition were trauma, congenital disorders, and idiopathic diseases.

According to a study by Dosunmu et al. (2018), congenital disorders were responsible for 49% of fourth cranial nerve paralysis cases. This discovery contradicted the results of this study. Additionally, Ho et al. (2013) found that the occurrence of fourth cranial nerve paralysis was mainly caused by trauma (36.84%). In a Turkish strabismus clinic, it was observed that the primary cause of fourth cranial nerve paralysis was congenital disorders, with a total of 39 cases. It was additionally found that the occurrence of the condition was attributed to undetermined causes (27 cases), trauma (13 cases), vascular diseases (13 cases), and other causes (10 cases) (Sekeroglu 2014). The discrepancies observed between this study and other previous studies might be attributed to the different sample sizes, resulting in significant variations in the identified causes.

Strength and limitations

This study, conducted at Dr. Soetomo General Academic Hospital from 2017 to 2022, provides valuable insights into the diverse etiologies of paralytic strabismus. The strength of this study lies in its comprehensive analysis of 282 cases, along with the categorization of the causes into six distinct groups. Additionally, this study contributes significant clinical knowledge by identifying the most prevalent causes of paralytic strabismus. These causes include trauma in cases of third cranial nerve paralysis, as well as neoplasms in cases of combined ocular motor cranial nerve paralysis and paralyses of both the sixth and fourth cranial nerves. However, this study was constrained by the changes in the hospital's medical record storage system, which imposed limitations throughout the retrieval of data from patients' medical records. Further research is required to examine a broader range of variables, such as the degree of eye deviation, the specific eye affected by paralytic strabismus, and other risk factors that may influence the occurrence of paralytic strabismus. Additionally, more comprehensive documentation of medical records is necessary to facilitate efficient data collection.

CONCLUSION

The causes of paralytic strabismus are classified into six categories: congenital disorders, neoplasms, trauma, intracranial processes, idiopathic diseases, and other causes not covered by the preceding five categories. Neoplasms and trauma are the primary causes that commonly lead to paralytic strabismus. Neoplasms are the probable etiology for combined ocular motor cranial nerve paralysis, as well as the paralyses of both the sixth and fourth cranial nerves. In the meantime, trauma is the potential cause of third cranial nerve paralysis. Idiopathic diseases are responsible for just a few cases where the causes are unknown or undetermined.

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Conflict of interest

None.

Ethical consideration

This study acquired permission and approval from the Health Research Ethics Committee of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, with reference No. 1187/LOE/301.4. 2/I/2023 on 15/01/2023.

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Author contribution

ARNA designed and conceptualized the study, analyzed and interpreted the data, drafted the article, provided the study materials and patients, provided administrative, technical, and logistic support, and collected and assembled the data. RL designed and conceptualized the study, drafted the article, offered final approval of the article, and provided the study materials, patients, and funding. HBH critically revised the article for important intellectual content and gave final approval of the article. IW and LRW also offered their final approval of the article.

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