eISSN (Online): 2598-0580

Bioscientia Medicina: Journal of Biomedicine & Translational Research

Journal Homepage: www.bioscmed.com

Clinical Characteristics and Management of Steroid-Induced Glaucoma

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ARTICLE INFO

Keywords:
Clinical characteristics
Intraocular pressure
Management
Secondary glaucoma
Steroid-induced glaucoma

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All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.37275/bsm.v9i5.1285

A B S T R A C T

Background: Steroid-induced glaucoma (SIG) is a secondary glaucoma characterized by elevated intraocular pressure (IOP) due to steroid use. This study aimed to analyze the clinical characteristics and management of SIG patients at Dr. M. Djamil General Hospital Padang, Indonesia, from January 2019 to August 2023. **Methods:** A retrospective descriptive study was conducted using medical records of patients diagnosed with SIG. Data collected included age, gender, steroid type, route of administration, duration of use, IOP at diagnosis, underlying diseases, glaucoma stage, and treatment. **Results:** Seventeen patients were diagnosed with SIG. The majority were female (70.58%) and aged 4-39 years (58.83%). The most common underlying diseases were systemic lupus erythematosus (SLE) and allergic conjunctivitis (47%). Oral steroid administration was most frequent (76.4%), with a usage duration of 2-12 months in most cases (70.6%). IOP at diagnosis ranged from 22 to 31 mmHg in most patients (82.3% right eye, 64.7% left eye). Most patients presented with mild glaucoma (70.5%). Topical anti-glaucoma medications were the primary treatment (76.4%), with trabeculectomy performed in some cases (23.6%). **Conclusion:** SIG is a preventable condition. Early detection and appropriate management are crucial to prevent vision loss. The clinical characteristics identified in this study contribute to a better understanding of SIG in our population. Further research on the interplay of risk factors, genetics, and histopathology is needed to enhance our comprehension of SIG.

1. Introduction

Glaucoma, a leading cause of irreversible blindness worldwide, is a group of eye diseases characterized by progressive damage to the optic nerve, the nerve that connects the eye to the brain and transmits visual information. Optic nerve damage in glaucoma is often associated with elevated intraocular pressure (IOP), which is the pressure inside the eye. Glaucoma can be classified as primary or secondary, depending on the underlying cause. Primary glaucoma, such as primary open-angle glaucoma (POAG), is the most common type and has no identifiable cause other than age and genetic predisposition. Secondary glaucoma, on the other hand, arises as a consequence of other ocular or systemic conditions, medications, or trauma. Steroid-induced glaucoma (SIG) is a type of secondary open-angle glaucoma that develops due to the use of corticosteroids, either topical, systemic, or by other routes of administration. Corticosteroids, particularly glucocorticoids, are potent anti-inflammatory agents widely used in the treatment of various ocular and systemic diseases. While corticosteroids are highly effective in managing inflammation, their use is associated with a significant risk of IOP elevation, potentially leading to glaucomatous optic neuropathy and vision loss.[1-4]

The prevalence of SIG remains uncertain due to its frequent underdiagnosis. Studies suggest that a

significant portion of the general population experiences IOP elevation with steroid use, with a smaller percentage developing SIG. The condition can affect individuals of all ages and genders. Risk factors for SIG include a history of POAG, family history of POAG, very young age (<6 years), older age, autoimmune diseases (rheumatoid arthritis, scleroderma, lupus), type 1 diabetes mellitus, and myopia. The pathogenesis of SIG involves steroid-induced changes in the trabecular meshwork (TM), the primary outflow pathway for aqueous humor in the eye. Aqueous humor is a clear fluid that fills the anterior chamber of the eye, providing nutrients and oxygen to the lens and cornea. The TM, located at the angle where the cornea and iris meet, regulates the outflow of aqueous humor from the eye. Steroids bind to glucocorticoid receptors in TM cells, leading to alterations in TM structure, extracellular matrix composition, and gene expression. These changes result in increased resistance to aqueous humor outflow, causing IOP elevation.[5-7]

The diagnosis of SIG is based on a combination of factors, including a history of steroid use, elevated IOP, characteristic changes in the optic nerve head (cupping), and visual field defects. Gonioscopy, a specialized examination to visualize the angle of the anterior chamber, may reveal an open angle with possible signs of TM dysfunction. Early diagnosis and management of SIG are crucial to prevent irreversible optic nerve damage and vision loss. The primary goal of management is to lower IOP to a level that prevents further optic nerve damage. Treatment options include discontinuation or reduction of steroid use, if possible, and the use of topical anti-glaucoma medications to increase aqueous humor outflow or decrease its production. In cases where medical therapy is insufficient to control IOP, surgical intervention, such as trabeculectomy or glaucoma drainage devices, may be necessary.[8-10] This study aimed to investigate the clinical characteristics and management of SIG patients at Dr. M. Djamil General Hospital Padang, Indonesia, from January 2019 to August 2023.

2. Methods

This research employed a retrospective descriptive study design to investigate the clinical characteristics and management of patients diagnosed with steroid-induced glaucoma (SIG) at the Ophthalmology Clinic of Dr. M. Djamil General Hospital Padang, Indonesia. The study period spanned from January 2019 to August 2023. Ethical approval for this study was obtained from the hospital's ethics committee, ensuring adherence to ethical guidelines and patient confidentiality.

The study population comprised all patients diagnosed with SIG at the Ophthalmology Clinic of Dr. M. Djamil General Hospital Padang during the specified study period. This tertiary care hospital serves a diverse population in the West Sumatra region of Indonesia, providing a representative sample of SIG patients in the area. The Ophthalmology Clinic is a specialized unit within the hospital dedicated to the diagnosis, treatment, and management of various eye conditions, including glaucoma.

To maintain the rigor and focus of the study, specific inclusion and exclusion criteria were established. Patients were included in the study if they met the following criteria; Diagnosis of SIG: Patients must have a documented diagnosis of SIG made by an ophthalmologist at the clinic during the study period. This diagnosis was based on a comprehensive evaluation, including a review of medical history, clinical examination, IOP measurement, and optic nerve assessment; Complete Medical Records: Only patients with complete medical records were included in the study to ensure the availability of all relevant data for analysis. Complete medical records included demographic information, medical history, ophthalmic examination findings, treatment details, and follow-up data; No Prior History of Elevated IOP or Glaucoma-like Symptoms: Patients with a prior history of elevated IOP or glaucoma-like symptoms, such as blurred vision, halos around lights, or eye pain, were excluded from the study. This exclusion criterion aimed to isolate the effects of steroid use on IOP and glaucoma development. In addition to the

inclusion criteria, the following exclusion criteria were applied; Other Secondary Glaucoma Diagnoses: Patients with other secondary glaucoma diagnoses, such as neovascular glaucoma, angle-closure glaucoma, or pigmentary glaucoma, were excluded from the study. This exclusion criterion ensured that the study focused specifically on SIG and not other forms of glaucoma; History of Anti-glaucoma Medication Use: Patients with a history of anti-glaucoma medication use prior to the diagnosis of SIG were excluded from the study. This exclusion criterion aimed to avoid confounding effects of prior glaucoma treatment on the study findings.

Data were collected retrospectively from the medical records of eligible patients. The following information was extracted from the medical records; Demographic Data: Age and gender were recorded as basic demographic information; Steroid Use: The type of steroid used (e.g., dexamethasone, prednisolone), route of administration (e.g., topical, oral, intravitreal), and duration of steroid use were documented. This information provided insights into the potential relationship between steroid type, route of administration, and duration of use with the development and severity of SIG; IOP at Diagnosis: IOP at the time of SIG diagnosis was measured using Goldmann applanation tonometry, the gold standard for IOP measurement. This information provided a baseline IOP value for each patient; Underlying Disease: The underlying disease necessitating steroid therapy was recorded. This information helped to identify potential associations between specific underlying diseases and the development of SIG; Stage of Glaucoma at Diagnosis: The stage of glaucoma at diagnosis was determined based on the cup-to-disc ratio (CDR), a measure of the size of the optic nerve head cupping. The CDR was assessed through a funduscopic examination of the optic nerve head. The stages of glaucoma were classified as mild (CDR < 0.65), moderate (CDR 0.7-0.85), and advanced (CDR > 0.9); Treatment Modalities: The treatment modalities employed to manage SIG were documented. This included topical anti-glaucoma medications, surgical interventions (e.g., trabeculectomy), and any other relevant treatment strategies.

The collected data were analyzed using descriptive statistics. Frequencies and percentages were calculated for categorical variables, such as gender, route of steroid administration, underlying disease, and stage of glaucoma at diagnosis. Means and standard deviations were used to summarize continuous variables, such as age, duration of steroid use, and IOP at diagnosis. The results were presented in tables and figures to facilitate interpretation and comparison.

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the hospital's ethics committee prior to the commencement of the study. Patient confidentiality was maintained throughout the study by anonymizing all data and ensuring secure storage of medical records. In conclusion, this retrospective descriptive study aimed to investigate the clinical characteristics and management of SIG patients at Dr. M. Djamil General Hospital Padang, Indonesia. The study employed a rigorous methodology, including well-defined inclusion and exclusion criteria, comprehensive data collection, and appropriate statistical analysis. The findings of this study contribute to a better understanding of SIG in our population and aid in developing strategies for early detection and effective management.

3. Results

Table 1 presents the demographic characteristics of the 17 patients diagnosed with Steroid-Induced Glaucoma (SIG) included in the study. In terms of age, a majority of the patients (58.83%) fell within the 4-39 years age group, with the remaining 41.17% being 40 years or older. This suggests that SIG is prevalent across a wide range of ages, including younger individuals. Regarding gender, a larger proportion of the patients were female (70.58%), compared to 29.42% who were male. This indicates a potential higher susceptibility to SIG in females.

Table 1. Characteristics of SIG patients.

Characteristic	Number (n=17)	Percentage (%)
Age		
4-39 years	10	58.83
≥ 40 years	7	41.17
Gender		
Male	5	29.42
Female	12	70.58

Table 2 illustrates the duration of steroid exposure for the 17 patients diagnosed with Steroid-Induced Glaucoma (SIG). Notably, none of the patients had a steroid exposure duration of less than 2 months. This suggests that short-term steroid use may not be a significant risk factor for developing SIG in this study population. The majority of patients (70.6%) had a steroid exposure duration between 2 and 12 months. This indicates that prolonged steroid use, even within a year, can contribute to the development of SIG. A smaller percentage of patients (29.4%) had a steroid exposure duration of more than 12 months. This suggests that while long-term steroid use may increase the risk of SIG, it is not the sole determinant, as some patients developed SIG with shorter exposure durations.

Table 2. Duration of steroid exposure.

Duration	Number (n=17)	Percentage (%)
< 2 months	0	0
≥ 2 - 6 months	6	35.3
7 - 12 months	6	35.3
> 12 months	5	29.4

Table 3 shows the distribution of the route of steroid administration for the 17 Steroid-Induced Glaucoma (SIG) patients. Most patients (76.4%) received steroids orally. This suggests that systemic steroid use is a major contributor to SIG development in this population. A smaller proportion of patients (23.6%) received topical steroids, indicating that while topical steroids can also cause SIG, they may be less frequently implicated compared to oral administration.

Table 3. Route of steroid administration.

Route	Number (n=17)	Percentage (%)
Oral	13	76.4
Topical	4	23.6

Table 4 presents the intraocular pressure (IOP) at diagnosis for the 17 Steroid-Induced Glaucoma (SIG) patients, measured in both right (OD) and left (OS) eyes. Notably, none of the patients had an IOP less than 21 mmHg in either eye, which is generally considered the upper limit of normal IOP. This indicates that all patients had elevated IOP at diagnosis, consistent with the diagnostic criteria for SIG. The majority of patients (82.3% OD and 64.7% OS) had IOP ranging from 22 to 31 mmHg. This suggests that moderate IOP elevation is common in SIG patients at the time of diagnosis. A smaller

proportion of patients (17.7% OD and 35.3% OS) had IOP greater than 31 mmHg. This indicates that some patients may present with significantly elevated IOP, potentially requiring more aggressive treatment strategies.

Table 4. IOP at diagnosis.

IOP (mmHg)	Right eye (OD)	Percentage (%)	Left eye (OS)	Percentage (%)
≤ 21	0	0	0	0
22-31	14	82.3	11	64.7
> 31	3	17.7	6	35.3

Table 5 provides a breakdown of the underlying diseases that necessitated steroid therapy in the 17 Steroid-Induced Glaucoma (SIG) patients. The most common underlying diseases were systemic lupus erythematosus (SLE) and allergic conjunctivitis, each accounting for 23.5% of the cases. This suggests that autoimmune conditions and allergic eye diseases may be significant risk factors for developing SIG, potentially due to the frequent use of steroids in their management. Other underlying diseases included pseudotumor cerebri (17.7%), optic neuritis (11.7%), thyroid eye disease (5.9%), and rheumatoid arthritis (17.7%). These conditions, while less frequent, also highlight the diverse range of medical conditions that may require steroid treatment and subsequently lead to SIG.

Table 5. Underlying diseases.

Disease	Number (n=17)	Percentage (%)
Systemic lupus erythematosus	4	23.5
Pseudotumor cerebri	3	17.7
Optic neuritis	2	11.7
Thyroid eye disease	1	5.9
Allergic conjunctivitis	4	23.5
Rheumatoid arthritis	3	17.7

Table 6 categorizes the 17 Steroid-Induced Glaucoma (SIG) patients based on their stage of glaucoma at the time of diagnosis. The majority of patients (70.5%) presented with mild glaucoma (C/D < 0.65). This suggests that SIG is often detected and diagnosed at an early stage, potentially due to increased awareness and regular eye examinations in patients receiving steroid therapy. A small proportion of patients (5.9%) had moderate glaucoma (C/D 0.7-0.85). This indicates that some patients may progress to a more advanced stage before diagnosis, potentially due to delayed detection or rapid disease progression. A significant proportion of patients (23.6%) presented with advanced glaucoma (C/D > 0.9). This highlights the importance of early diagnosis and prompt treatment to prevent irreversible optic nerve damage and vision loss in SIG patients.

Table 6. Stage of glaucoma at diagnosis.

Stage	Number (n=17)	Percentage (%)
Mild (C/D < 0.65)	12	70.5
Moderate (C/D 0.7-0.85)	1	5.9
Advanced (C/D > 0.9)	4	23.6

Table 7 outlines the treatment modalities used to manage the 17 Steroid-Induced Glaucoma (SIG) patients. Topical anti-glaucoma medications were the primary treatment for most patients (76.4%). This suggests that medical therapy is often effective in controlling IOP and managing SIG. Trabeculectomy, a surgical procedure to improve aqueous humor outflow, was performed in a smaller proportion of patients (23.6%). This indicates that surgical intervention may be necessary in cases where medical therapy is insufficient to control IOP or when advanced glaucoma is present.

Table 7. Treatment.

Treatment	Number (n=17)	Percentage (%)
Topical anti-glaucoma medications	13	76.4
Trabeculectomy	4	23.6

4. Discussion

This study delves into the demographic characteristics of patients diagnosed with steroid-induced glaucoma (SIG), revealing intriguing patterns in gender and age distribution. Understanding these demographic nuances is crucial for identifying at-risk populations, tailoring preventive strategies, and enhancing our comprehension of the factors influencing SIG development. Our study revealed a notable predominance of female patients diagnosed with SIG. Specifically, 70.58% of the SIG patients in our study population were female, contrasting with some previous studies that reported a higher prevalence among males. This discrepancy warrants further exploration and underscores the complexity of gender-related factors in SIG susceptibility. Several hypotheses could potentially explain the observed female predominance in our study. One possible explanation lies in the underlying diseases necessitating steroid use. In our study population, systemic lupus erythematosus (SLE) and allergic conjunctivitis were the most common underlying conditions. Both SLE and allergic conjunctivitis exhibit a higher prevalence in females compared to males. SLE, a chronic autoimmune disease, affects women approximately nine times more frequently than men, particularly during their childbearing years. Similarly, allergic conjunctivitis, an inflammatory condition affecting the conjunctiva, also shows a female predilection. The higher prevalence of these underlying conditions in females could contribute to the increased use of steroids in this demographic, subsequently elevating their risk of developing SIG. Steroids, while effective in managing inflammation, can disrupt the delicate balance of aqueous humor dynamics in the eye, leading to increased intraocular pressure (IOP) and potentially causing glaucomatous optic nerve damage. Another potential factor contributing to the female predominance in SIG could be hormonal influences. Estrogen, the primary female genderhormone, has been implicated in various ocular conditions, including glaucoma. While the exact mechanisms remain unclear, estrogen may influence IOP regulation and optic nerve susceptibility to damage. Further research is needed to fully elucidate the role of gender hormones in SIG development. Estrogen receptors are present in various ocular tissues, including the trabecular meshwork (TM), the primary outflow pathway for aqueous humor in the eye. Estrogen may influence TM cell function and extracellular matrix composition, potentially affecting aqueous humor outflow resistance and IOP. Additionally, estrogen may exert neuroprotective effects on the optic nerve, but these effects may be altered in the presence of elevated IOP or other risk factors for glaucoma. Gender-specific genetic factors could also play a role in SIG susceptibility. Certain genes involved in IOP regulation, TM function, and optic nerve health may exhibit different expression

patterns or variations in males and females. These genetic differences could contribute to the observed gender-related disparities in SIG prevalence. Lifestyle and environmental factors may also interact with gender-related factors to influence SIG development. For example, certain lifestyle factors, such as smoking and alcohol consumption, have been associated with an increased risk of glaucoma. These factors may exert different effects in males and females due to hormonal or genetic differences. Our study also revealed an interesting pattern in the age distribution of SIG patients. Contrary to previous research indicating a higher prevalence of SIG in older individuals, our study found a higher prevalence in the 4-39 year age group (58.83%). This observation suggests that SIG is not exclusively a disease of the elderly and can affect younger individuals as well. The age distribution observed in our study may be linked to the specific underlying diseases prevalent in our study population. As mentioned earlier, SLE and allergic conjunctivitis were the most common underlying conditions necessitating steroid use. Both SLE and allergic conjunctivitis typically affect younger individuals, potentially explaining the higher prevalence of SIG in this age group. SLE, with its peak incidence between the ages of 15 and 45, can manifest with various ocular complications, including inflammation, dryness, and elevated IOP. Steroid therapy is often employed to manage SLE-related ocular inflammation, inadvertently increasing the risk of SIG development. Similarly, allergic conjunctivitis, a common condition affecting children and young adults, can also lead to steroid use and subsequent SIG development. Allergic conjunctivitis is characterized by inflammation of the conjunctiva, the thin membrane lining the inner surface of the eyelids and covering the white part of the eye. Steroids are often used to alleviate the allergic inflammation, but prolonged or frequent use can disrupt IOP regulation and contribute to SIG. While our study found a higher prevalence of SIG in younger individuals, it is important to note that SIG can still occur in older individuals. Age-related changes in ocular tissues, such as decreased TM outflow facility and increased optic nerve susceptibility to damage, can contribute to SIG development in older individuals, particularly those with other risk factors such as a history of POAG, family history of POAG, or myopia. Another factor to consider in the age distribution of SIG is the cumulative steroid exposure over a lifetime. Older individuals may have a longer history of steroid use for various medical conditions, potentially increasing their risk of developing SIG. However, the duration and intensity of steroid exposure may vary greatly among individuals, making it challenging to isolate the specific contribution of cumulative steroid exposure to SIG development. The demographic characteristics identified in our study have important implications for clinical practice and future research. The female predominance in SIG highlights the need for increased awareness and vigilance among healthcare professionals regarding the potential for SIG development in female patients receiving steroid therapy. Regular IOP monitoring, regardless of the route of steroid administration, is crucial for early detection and prompt intervention. The higher prevalence of SIG in the 4-39 year age group underscores the importance of considering SIG as a potential diagnosis in younger individuals presenting with elevated IOP or suspicious optic nerve changes, especially those with a history of steroid use or underlying conditions associated with steroid therapy.[11-13]

This section delves into the intricate relationship between steroid exposure and intraocular pressure (IOP) elevation, a critical factor in the pathogenesis of steroid-induced glaucoma (SIG). Our findings corroborate existing research, highlighting the significant impact of oral steroid use, particularly over extended durations, on IOP. We also explore the underlying mechanisms by which steroids disrupt the delicate balance of aqueous humor dynamics in the eye, leading to elevated IOP and potentially causing glaucomatous optic nerve damage. Our study revealed that the majority of patients diagnosed with SIG (76.4%) had received oral steroids. This finding aligns

with previous research indicating that systemic steroid use, particularly for prolonged periods, can lead to significant IOP elevation. Oral steroids, such as prednisone and dexamethasone, are potent anti-inflammatory agents widely used in the treatment of various systemic conditions, including autoimmune diseases, allergic reactions, and inflammatory disorders. While oral steroids are highly effective in managing inflammation, their use is associated with a significant risk of ocular complications, including SIG. The exact mechanisms by which oral steroids elevate IOP are not fully understood, but several hypotheses have been proposed. One hypothesis suggests that oral steroids may alter the composition and production of aqueous humor, the clear fluid that fills the anterior chamber of the eye and provides nutrients to the lens and cornea. Steroids may increase the production of aqueous humor or decrease its outflow, leading to an accumulation of fluid in the eye and subsequent IOP elevation. Another hypothesis proposes that oral steroids may induce changes in the trabecular meshwork (TM), the primary outflow pathway for aqueous humor in the eye. The TM, located at the angle where the cornea and iris meet, regulates the outflow of aqueous humor from the eye. Steroids may bind to glucocorticoid receptors in TM cells, leading to alterations in TM structure, extracellular matrix composition, and gene expression. These changes can result in increased resistance to aqueous humor outflow, causing IOP elevation. The pharmacokinetics and pharmacodynamics of oral steroids also play a role in IOP elevation. Oral steroids are absorbed from the gastrointestinal tract and distributed throughout the body, including the eye. The concentration of steroids in the eye can vary depending on the dosage, the frequency of administration, and individual factors such as metabolism and clearance. Steroids exert their effects by binding to glucocorticoid receptors in various tissues, including the eye. The binding of steroids to these receptors triggers a cascade of cellular events, leading to changes in gene expression and protein synthesis. These changes can affect various aspects of ocular physiology, including aqueous humor dynamics, TM function, and optic nerve health. It is important to note that there is significant individual variability in the response to oral steroids. Some individuals may experience significant IOP elevation with even short-term steroid use, while others may tolerate long-term steroid use without any significant IOP changes. This variability is likely due to a combination of genetic, environmental, and individual factors, such as age, gender, and pre-existing ocular conditions. The duration of steroid exposure plays a crucial role in the extent of TM remodeling and subsequent IOP elevation. Our study found that none of the patients had a steroid exposure duration of less than 2 months, suggesting that short-term steroid use may not be a significant risk factor for developing SIG. However, prolonged steroid use, particularly between 2 and 12 months, was prevalent in our study population, highlighting the importance of considering the duration of steroid exposure as a potential risk factor for SIG. The longer the duration of steroid exposure, the greater the likelihood of steroid-induced changes in the TM and subsequent IOP elevation. This is because the TM undergoes a gradual remodeling process in response to steroid exposure, with progressive changes in cell function, extracellular matrix composition, and outflow resistance. The time course of IOP elevation in response to steroid exposure can vary depending on the individual, the type of steroid used, the dosage, and the route of administration. In some individuals, IOP elevation may occur within days or weeks of starting steroid therapy, while in others, it may take months or even years to develop. The initial IOP elevation in response to steroids is often transient and may resolve with discontinuation of the medication. However, in some individuals, the IOP elevation may persist or even worsen over time, leading to glaucomatous optic nerve damage and vision loss. The cumulative steroid exposure over a lifetime may also contribute to the risk of SIG development. Individuals with a history of multiple courses of steroid therapy or long-term steroid use may be at increased risk of

developing SIG, even if the individual courses of treatment were short-term. IOP at diagnosis ranged from 22 to 31 mmHg in most patients (82.3% right eye, 64.7% left eye). This emphasizes the importance of regular IOP monitoring in patients receiving steroid therapy, regardless of the route of administration. Early detection of IOP elevation allows for prompt intervention and prevents progression to glaucomatous optic neuropathy. Elevated IOP is a major risk factor for glaucoma, a leading cause of irreversible blindness worldwide. Glaucoma is characterized by progressive damage to the optic nerve, the nerve that connects the eye to the brain and transmits visual information. The optic nerve damage in glaucoma is often associated with elevated IOP, which can compress and damage the delicate nerve fibers. Early detection and treatment of elevated IOP are crucial to prevent or slow the progression of glaucoma and preserve vision. In patients receiving steroid therapy, regular IOP monitoring is essential to identify early signs of IOP elevation and initiate appropriate interventions. The target IOP for SIG patients may vary depending on the individual's risk factors, the severity of IOP elevation, and the stage of glaucoma. In general, the goal is to lower IOP to a level that prevents further optic nerve damage and vision loss. The frequency of IOP monitoring in SIG patients may also vary depending on the individual's risk factors and the stability of their IOP. In general, more frequent monitoring is recommended for patients with higher IOP, those with pre-existing risk factors for glaucoma, and those receiving higher doses or longer durations of steroid therapy. While our study focused primarily on oral steroid use, it is important to acknowledge that other routes of steroid administration, such as topical, inhaled, and intravitreal, can also lead to IOP elevation and SIG development. The risk of IOP elevation varies depending on the route of administration, the type of steroid used, the dosage, and the duration of treatment. Topical steroids, such as eye drops and ointments, are commonly used to treat ocular inflammation and allergies. While topical steroids are generally considered safer than systemic steroids in terms of IOP elevation, they can still cause significant IOP increases in some individuals, particularly those with pre-existing risk factors for glaucoma. Inhaled steroids, such as those used to treat asthma and chronic obstructive pulmonary disease, can also lead to IOP elevation, although the risk is generally lower than with oral or topical steroids. Intravitreal steroids, injected directly into the vitreous cavity of the eye, are used to treat various retinal conditions, such as macular edema and uveitis. Intravitreal steroids can cause significant IOP elevation, particularly with repeated injections or in individuals with pre-existing risk factors for glaucoma. Topical steroids are the most commonly used route of steroid administration in ophthalmology. They are available in various formulations, including eye drops, ointments, gels, and suspensions. The choice of formulation depends on the specific ocular condition being treated and the desired duration of action. The risk of IOP elevation with topical steroids varies depending on the potency of the steroid, the frequency of application, and the duration of treatment. More potent steroids and more frequent applications are associated with a higher risk of IOP elevation. Inhaled steroids are commonly used to treat asthma and chronic obstructive pulmonary disease. They are delivered directly to the lungs, where they exert their anti-inflammatory effects. However, some of the inhaled steroid may be absorbed into the systemic circulation and reach the eye, potentially causing IOP elevation. The risk of IOP elevation with inhaled steroids is generally lower than with oral or topical steroids. However, it is still important to monitor IOP in patients receiving inhaled steroids, particularly those with pre-existing risk factors for glaucoma. Intravitreal steroids are injected directly into the vitreous cavity of the eye to treat various retinal conditions. They provide high concentrations of steroid directly to the target tissue, minimizing systemic side effects. However, intravitreal steroids can cause significant IOP elevation, particularly with repeated injections or in individuals with pre-existing risk factors for glaucoma. The risk of IOP elevation

with intravitreal steroids varies depending on the type of steroid used, the dosage, and the frequency of injections. More potent steroids and more frequent injections are associated with a higher risk of IOP elevation.[14-17]

This section focuses on the stage of glaucoma at diagnosis and the treatment modalities employed in managing steroid-induced glaucoma (SIG) patients. Understanding the stage of glaucoma at presentation is crucial for determining the appropriate treatment strategy and prognosis. Our findings highlight the importance of early detection and intervention to prevent irreversible vision loss in SIG. Our study found that the majority of patients (70.5%) presented with mild glaucoma (C/D < 0.65), suggesting relatively early detection and intervention. This observation is encouraging and may be attributed to several factors, including increased awareness among healthcare professionals regarding the potential for SIG development in patients receiving steroid therapy. Additionally, regular eye examinations and IOP monitoring in at-risk individuals may contribute to early detection and diagnosis. Early detection of SIG allows for prompt intervention, which can help to prevent or slow the progression of the disease and preserve vision. However, a significant proportion of patients (23.6%) presented with advanced glaucoma (C/D > 0.9), indicating the need for further improvement in early detection and management strategies. Advanced glaucoma is characterized by significant optic nerve damage and visual field loss, which can lead to irreversible blindness if left untreated. The late presentation of SIG in these cases may be due to several factors, including delayed diagnosis, lack of awareness among patients and healthcare providers, and rapid disease progression in some individuals. Additionally, some patients may not experience any symptoms in the early stages of glaucoma, leading to delayed presentation and diagnosis. The primary goal of SIG management is to lower IOP to a level that prevents further optic nerve damage and vision loss. The choice of treatment modality depends on various factors, including the severity of IOP elevation, stage of glaucoma, individual patient characteristics, and the underlying cause of steroid use. In some cases, it may be possible to discontinue or reduce the use of steroids, which can help to lower IOP. However, in many cases, medical or surgical treatment is necessary to control IOP and prevent further damage to the optic nerve. Topical anti-glaucoma medications were the primary treatment modality in our study, with 76.4% of patients receiving these medications. Topical anti-glaucoma medications work by increasing aqueous humor outflow or decreasing aqueous humor production, thereby lowering IOP. Several classes of topical anti-glaucoma medications are available, each with its own mechanism of action and potential side effects. Prostaglandin analogs, such as latanoprost and bimatoprost, are often the first-line treatment for glaucoma due to their efficacy and once-daily dosing. They work by increasing uveoscleral outflow, an alternative pathway for aqueous humor outflow. Beta-blockers, such as timolol and betaxolol, decrease aqueous humor production by inhibiting beta-adrenergic receptors in the ciliary body. Carbonic anhydrase inhibitors, such as dorzolamide and brinzolamide, also decrease aqueous humor production by inhibiting the enzyme carbonic anhydrase. Alpha-adrenergic agonists, such as brimonidine and apraclonidine, decrease aqueous humor production and increase uveoscleral outflow. Rho kinase inhibitors, such as netarsudil and ripasudil, increase trabecular outflow by relaxing the trabecular meshwork. The choice of topical anti-glaucoma medication depends on various factors, including the patient's individual needs and preferences, the severity of IOP elevation, and the presence of any contraindications or potential side effects. Trabeculectomy, a surgical procedure to improve aqueous humor outflow, was performed in some cases (23.6%) where medical therapy was insufficient to control IOP. Trabeculectomy involves creating a new drainage pathway for aqueous humor to flow out of the eye, bypassing the trabecular meshwork. Trabeculectomy is typically reserved for

patients with advanced glaucoma or those who have failed medical therapy. It is a more invasive procedure than topical medications, but it can be highly effective in lowering IOP and preventing further optic nerve damage. Other treatment modalities for SIG may include laser trabeculoplasty, a laser procedure that improves aqueous humor outflow by creating small burns in the trabecular meshwork, and glaucoma drainage devices, which are surgically implanted devices that shunt aqueous humor from the anterior chamber to a reservoir outside the eye. The choice of treatment modality depends on various factors, including the patient's individual needs and preferences, the severity of IOP elevation, the stage of glaucoma, and the presence of any contraindications or potential side effects.[18-20]

5. Conclusion

This study examined the clinical characteristics and management of Steroid-Induced Glaucoma (SIG) patients at Dr. M. Djamil General Hospital Padang, Indonesia, from January 2019 to August 2023. The majority of the 17 patients diagnosed with SIG were female (70.58%) and aged 4-39 years (58.83%). The most common underlying diseases were systemic lupus erythematosus (SLE) and allergic conjunctivitis. Oral steroid administration was most frequent (76.4%), with a usage duration of 2-12 months in most cases (70.6%). IOP at diagnosis ranged from 22 to 31 mmHg in most patients (82.3% right eye, 64.7% left eye). Most patients presented with mild glaucoma (70.5%). Topical anti-glaucoma medications were the primary treatment (76.4%), with trabeculectomy performed in some cases (23.6%). SIG is a preventable condition. Early detection and appropriate management are crucial to prevent vision loss. The clinical characteristics identified in this study contribute to a better understanding of SIG in the population studied. Further research on the interplay of risk factors, genetics, and histopathology is needed to enhance our comprehension of SIG.

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