Review

Understanding Drug-Induced Movement Disorders: Causes, Symptoms, and Treatment

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Posted Date: 22 February 2024

doi: 10.20944/preprints202402.1258.v1

Keywords: DIMD; DIP; Review; parkinsonism; DID; dyskinesia; tardive syndromes

 doi:10.20944/preprints202402.1258.v1

Review

Understanding Drug-Induced Movement Disorders: Causes, Symptoms, and Treatment

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Abstract: Drug-induced movement disorders (DIMDs) are a group of neurological conditions caused by the use of certain medications. These disorders can significantly impact a person's quality of life and are essential to recognize and manage. This article provides an overview of the causes, symptoms, and treatment of DIMDs. DIMDs can manifest in various forms, including parkinsonism, tardive dyskinesia, dystonia, and akathisia. They are most commonly associated with medications such as neuroleptics, antidepressants, antipsychotics, antiemetics, and anticonvulsants. Risk factors for developing DIMDs include age, genetics, duration of medication use, and dose of medication. Symptoms of DIMDs can range from mild to severe and may include tremors, rigidity, bradykinesia, and involuntary movements. These symptoms can significantly impact a person's ability to perform daily activities and lead to social isolation and decreased quality of life. DIMD diagnoses are based on clinical evaluation, including a thorough medical history and physical examination. Imaging studies such as MRI or CT scans may also be used to rule out other possible causes of symptoms. Treatment of DIMDs involves the withdrawal of the offending medication if possible. Pharmacological treatments such as anticholinergic drugs, benzodiazepines, and dopamine agonists may also be used to manage symptoms. Non-pharmacological treatments such as physical, occupational, and speech therapy can also be beneficial. DIMDs are necessary neurological conditions that can significantly impact a person's quality of life. Early recognition and management of these disorders are essential for optimizing outcomes. Further research is needed to understand the underlying mechanisms of DIMDs better and to develop more effective treatments.

Keywords: DIMD; DIP; review; parkinsonism; DID; dyskinesia; tardive syndromes

1. Introduction

1.1. Definition of Drug-Induced Movement Disorders (DIMDs)

Drug-induced movement disorders (DIMDs) encompass a broad spectrum of neurological conditions characterized by abnormal, involuntary movements caused by exposure to specific medications [1]. These disorders are often a result of the medication's effects on the central nervous system, particularly on the neurotransmitter systems involved in motor control. DIMDs can significantly impact a person's quality of life and may require prompt recognition and management [2].

One of the most well-known DIMDs is drug-induced parkinsonism, which is characterized by symptoms similar to those of Parkinson's disease, such as tremors, rigidity, bradykinesia (slowness of movement), and postural instability. Drug-induced parkinsonism is most commonly caused by medications that block dopamine receptors in the brain, such as specific antipsychotic medications [3].

Tardive dyskinesia is another common DIMD characterized by involuntary movements, particularly of the face and tongue. These movements can include grimacing, tongue protrusion, and rapid blinking. Tardive dyskinesia is most often associated with long-term use of dopamine receptor-blocking medications, such as certain antipsychotics and antiemetics. It is believed that the relation

 doi:10.20944/preprints202402.1258.v1

with the time of receptor binding neurotransmitter is associated with an increased likelihood of developing dyskinesia, like in cases of liquid versus tablet formulations of levodopa [4]. Another hypothesis could be related to the neuroinflammation Field [5], but this does not entirely explain different presentation [6].

Dystonia is a DIMD characterized by sustained muscle contractions that result in abnormal postures or repetitive movements. Dystonic movements can affect any part of the body and can be painful and disabling [7]. Like other DIMDs, dystonia can be caused by medications that affect dopamine receptor activity in the brain.

Akathisia is a DIMD characterized by a subjective feeling of restlessness and an urge to move. People with akathisia may pace, fidget, or have difficulty sitting still. Akathisia is often associated with medications that block dopamine receptors, such as certain antipsychotics and antiemetics. Various factors, including the type of medication, the dose and duration of medication use, and individual susceptibility, influence the development of DIMDs. Some people may be more predisposed to developing DIMDs due to genetic factors or underlying neurological conditions.

The diagnosis of DIMDs is based on a thorough medical history, physical examination, and evaluation of the timing of symptoms about medication use. Imaging studies such as magnetic resonance imaging (MRI) or computed tomography (CT) scans may be used to rule out other possible causes of symptoms.

Management of DIMDs often involves discontinuing the offending medication if possible. However, this must be done under the supervision of a healthcare professional, as abrupt discontinuation of certain medications can lead to withdrawal symptoms or a worsening of the underlying condition. Switching to a different medication or adjusting the dose may be necessary.

Pharmacological treatments for DIMDs may include anticholinergic medications, which can help reduce tremors and muscle stiffness, or dopamine agonists, which can help restore dopamine activity in the brain. However, the use of these medications must be carefully balanced with the risk of side effects.

Non-pharmacological treatments for DIMDs may include physical therapy, occupational therapy, and speech therapy [8]. These therapies can help improve motor function, reduce muscle stiffness, and improve overall quality of life.

In conclusion, drug-induced movement disorders are a diverse group of neurological conditions that can have a significant impact on a person's quality of life. Prompt recognition and management of these disorders are essential for optimizing outcomes. Further research is needed to understand the underlying mechanisms of DIMDs better and to develop more effective treatments.

1.2. Brief Overview of the Impact and Prevalence of DIMDs

Drug-induced movement disorders (DIMDs) can have a significant impact on affected individuals, leading to a range of physical and psychological symptoms that can impair daily functioning and reduce quality of life. DIMDs can cause a variety of abnormal movements, such as tremors, rigidity, dystonia, and dyskinesia, which can interfere with activities of daily living and reduce mobility and coordination [9].

Some DIMDs, such as dystonia, can cause painful muscle contractions and postures, leading to discomfort and decreased quality of life [10]. The visible nature of many DIMDs, such as facial grimacing or involuntary movements, can lead to embarrassment, social stigma, and isolation. Additionally, the impact of DIMDs on mobility and communication can affect social interactions and relationships. Living with a DIMD can lead to psychological distress, including anxiety, depression, and frustration, mainly if the disorder is chronic or has a significant impact on daily life.

The prevalence of DIMDs varies depending on the specific disorder and the population studied. For example, drug-induced parkinsonism is estimated to occur in 20-30% of patients taking antipsychotic medications, while tardive dyskinesia is estimated to occur in 20-30% of patients treated with antipsychotics for an extended period [11]. Dystonia and akathisia are less common but can still appear with certain medications.

 doi:10.20944/preprints202402.1258.v1

Overall, the impact of DIMDs underscores the importance of careful consideration of medication choices, monitoring for early signs of movement disorders, and prompt management to minimize adverse effects on quality of life.

2. Types of Drug-Induced Movement Disorders

2.1. Parkinsonism

Parkinsonism is a neurological condition characterized by a group of motor symptoms that are similar to those seen in Parkinson's disease. These symptoms include tremors, rigidity, bradykinesia (slow movement), and postural instability. Parkinsonism can be caused by a variety of factors, including certain medications, toxins, and underlying neurodegenerative disorders.

One of the most common causes of drug-induced parkinsonism is the use of dopamine receptor-blocking medications, particularly antipsychotic medications. These medications are used to treat conditions such as schizophrenia, bipolar disorder, and severe depression. However, their use can lead to a reduction in dopamine activity in the brain, resulting in Parkinsonian symptoms.

The symptoms of drug-induced parkinsonism can vary in severity and may develop gradually over time. Sometimes, the symptoms may improve or resolve once the offending medication is discontinued. However, the symptoms may persist in other cases even after the drug is stopped.

Diagnosis of drug-induced parkinsonism is based on a thorough medical history, physical examination, and evaluation of the timing of symptoms concerning medication use. Imaging studies such as magnetic resonance imaging (MRI) or computed tomography (CT) scans may be used to rule out other possible causes of symptoms.

Management of drug-induced parkinsonism often involves discontinuing the offending medication if possible. However, this must be done under the supervision of a healthcare professional, as abrupt discontinuation of certain medications can lead to withdrawal symptoms or a worsening of the underlying condition. Switching to a different medication or adjusting the dose may be necessary.

Pharmacological treatments for drug-induced parkinsonism may include anticholinergic medications, which can help reduce tremors and muscle stiffness, or dopamine agonists, which can help restore dopamine activity in the brain. However, the use of these medications must be carefully balanced with the risk of side effects.

Non-pharmacological treatments for drug-induced parkinsonism may include physical therapy, occupational therapy, and speech therapy. These therapies can help improve motor function, reduce muscle stiffness, and improve overall quality of life.

In conclusion, drug-induced Parkinsonism is a neurological condition characterized by symptoms similar to those of Parkinson's disease. Prompt recognition and management of drug-induced parkinsonism are essential for optimizing outcomes and minimizing the impact on quality of life.

2.2. Tardive Dyskinesia

Tardive dyskinesia (TD) is a neurological condition characterized by involuntary, repetitive movements of the face, tongue, lips, and other body parts. These movements include grimacing, tongue protrusion, lip smacking, and rapid blinking. TD typically develops after long-term use of dopamine receptor-blocking medications, particularly certain antipsychotic medications used to treat psychiatric disorders such as schizophrenia and bipolar disorder.

The exact mechanism of TD has yet to be fully understood. Still, it is believed to involve alterations in dopamine signaling in the brain, particularly in the basal ganglia, which is implicated in motor control. Prolonged exposure to dopamine receptor-blocking medications can lead to changes in the sensitivity of dopamine receptors, resulting in abnormal movements characteristic of TD.

A gradual onset often characterizes TD and may initially be subtle, making diagnosing it in the early stages challenging. However, over time, the symptoms of TD typically become more

 doi:10.20944/preprints202402.1258.v1

pronounced and may persist even after discontinuation of the offending medication. In some cases, TD can be irreversible, leading to a long-term impairment of motor function.

Diagnosis of TD is based on clinical evaluation, including a thorough medical history and physical examination. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) criteria are commonly used to diagnose TD, which requires the presence of abnormal involuntary movements for a specified duration in patients with a history of exposure to dopamine receptor-blocking medications.

Management of TD can be challenging and often involves a combination of strategies aimed at minimizing symptoms and optimizing quality of life. Sometimes, discontinuing or reducing the offending medication may improve or resolve TD symptoms. However, this must be done under the supervision of a healthcare professional, as abrupt discontinuation of certain medications can lead to withdrawal symptoms or a worsening of the underlying condition.

Pharmacological treatments for TD may include tetrabenazine, deutetrabenazine, and valbenazine, approved by the U.S. Food and Drug Administration (FDA) for treating TD. These medications work by reducing dopamine activity in the brain, which can help alleviate TD symptoms. However, they may also be associated with side effects and must be carefully monitored.

Non-pharmacological treatments for TD may include behavioral therapies, such as biofeedback and relaxation techniques, which can help patients manage the symptoms of TD and improve overall quality of life. Physical and occupational therapy may also be beneficial in some cases, assisting patients to improve motor function and reduce disability associated with TD.

In conclusion, tardive dyskinesia is a neurological condition characterized by involuntary, repetitive movements caused by long-term exposure to dopamine receptor-blocking medications. Prompt recognition and management of TD are essential for minimizing the impact on quality of life and optimizing outcomes for affected individuals.

2.3. Dystonia

Dystonia is a neurological movement disorder characterized by sustained muscle contractions that result in twisting and repetitive movements or abnormal postures. These movements can be painful and can significantly impact a person's ability to perform daily activities. Dystonia can affect any body part, including the arms, legs, trunk, neck, eyelids, face, or vocal cords.

There are several types of dystonia, classified based on the age of onset, body distribution, and underlying cause. Primary dystonia is the most common form and is believed to be caused by a combination of genetic and environmental factors. Secondary dystonia can be induced by underlying neurological conditions, brain injury, or exposure to specific medications [12].

Drug-induced dystonia is a form of secondary dystonia that can occur as a side effect of certain medications, particularly medications that affect dopamine signaling in the brain. These medications include antipsychotics, antiemetics, and certain antidepressants [13]. Drug-induced dystonia typically presents with sudden-onset, involuntary muscle contractions that can be painful and disabling.

The diagnosis of dystonia is based on clinical evaluation, including a thorough medical history and physical examination. [14]. Imaging studies such as magnetic resonance imaging (MRI) or computed tomography (CT) scans may be used to rule out other possible causes of symptoms.

Management of dystonia often involves a multidisciplinary approach, including neurologists, movement disorder specialists, physical therapists, and occupational therapists [15]. The primary goal of treatment is to reduce symptoms and improve quality of life. Anticholinergic medications, such as trihexyphenidyl or benztropine, may be used to decrease muscle contractions and improve dystonia symptoms. Other drugs, such as baclofen [16] or benzodiazepines [17], may also be used to help manage symptoms.

Botulinum toxin injections can be used to temporarily paralyze muscles affected by dystonia, reducing muscle contractions and improving abnormal postures [18]. Repeat injections are typically needed every few months to maintain the effects. DBS is a surgical procedure that involves implanting electrodes in the brain to deliver electrical stimulation to targeted areas. DBS can be an

 doi:10.20944/preprints202402.1258.v1

effective treatment for dystonia in some cases, mainly when other treatments have been unsuccessful [19]. These therapies can help improve muscle strength, flexibility, and coordination, enhancing functional abilities and reducing disability associated with dystonia. Living with dystonia can be challenging, and psychological support from a mental health professional or support group can be beneficial in coping with the emotional impact of the condition [20]. In conclusion, dystonia is a neurological movement disorder characterized by sustained muscle contractions that result in twisting and repetitive movements or abnormal postures. Prompt recognition and management of dystonia are essential for optimizing outcomes and improving the quality of life for affected individuals.

2.4. Akathisia

Akathisia is a movement disorder characterized by a subjective feeling of restlessness and an urge to move [21]. People with akathisia often describe a constant need to shift positions, pace, or fidget. These symptoms can be distressing and significantly impact a person's quality of life.

Akathisia can be a side effect of certain medications, particularly antipsychotic medications and some antidepressants [22]. The exact cause of akathisia has yet to be fully understood. Still, it is believed to involve alterations in dopamine signaling in the brain, particularly in the basal ganglia, which is implicated in motor control [23].

There are two main types of akathisia: acute akathisia, which typically occurs within days to weeks of starting or increasing the dose of a medication, and chronic akathisia, which can persist for months or even years after discontinuation of the offending drug.

Diagnosis of akathisia is based on clinical evaluation, including a thorough medical history and physical examination. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) criteria are commonly used to diagnose akathisia, which requires the presence of subjective restlessness and an urge to move, often accompanied by observable movements such as pacing or fidgeting.

Management of akathisia often involves addressing the underlying cause, such as adjusting the dose of the offending medication or switching to a different medication with a lower risk of causing akathisia. However, this must be done under the supervision of a healthcare professional, as abrupt discontinuation of certain medications can lead to withdrawal symptoms or a worsening of the underlying condition.

Pharmacological treatments for akathisia may include medications such as beta-blockers, anticholinergic drugs, or benzodiazepines, which can help reduce symptoms of restlessness and improve overall comfort. However, the use of these medications must be carefully balanced with the risk of side effects.

Non-pharmacological treatments for akathisia may include behavioral therapies, such as cognitive-behavioral therapy (CBT), which can help patients manage the psychological aspects of akathisia and improve coping strategies. Physical activity and relaxation techniques may also be beneficial in reducing symptoms of restlessness and enhancing overall well-being.

In conclusion, akathisia is a movement disorder characterized by a subjective feeling of restlessness and an urge to move. Prompt recognition and management of akathisia are essential for minimizing the impact on quality of life and optimizing outcomes for affected individuals.

3. Causes of Drug-Induced Movement Disorders

3.1. Neuroleptic Drugs

Neuroleptic drugs, also known as antipsychotic medications, are a class of medications primarily used to manage psychotic disorders such as schizophrenia, bipolar disorder, and severe depression. These medications work by blocking dopamine receptors in the brain, which helps to alleviate symptoms such as hallucinations, delusions, and disorganized thinking. Neuroleptic drugs are divided into two main classes: typical (first-generation) and atypical (second-generation) antipsychotics. Typical antipsychotics, such as haloperidol and chlorpromazine, primarily block dopamine receptors in the brain's mesolimbic pathway, which is believed to be involved in the

 doi:10.20944/preprints202402.1258.v1

development of psychotic symptoms. Atypical antipsychotics, such as clozapine, risperidone, and olanzapine, are newer medications that also block dopamine receptors but have a broader spectrum of activity, affecting other neurotransmitter systems such as serotonin and norepinephrine. Atypical antipsychotics are often preferred for their reduced risk of side effects compared to typical antipsychotics.

Despite their effectiveness in managing psychotic symptoms, neuroleptic drugs can cause a range of side effects. These include akathisia (restlessness), dystonia (muscle spasms), parkinsonism (tremors, rigidity, bradykinesia), and tardive dyskinesia (involuntary movements) [24]. These side effects are more familiar with typical antipsychotics but can also occur with atypical antipsychotics. Atypical antipsychotics are associated with an increased risk of weight gain, dyslipidemia, and diabetes mellitus, which can lead to long-term health complications. Also, the abnormalities in glucose levels can lead to movement disorders [25]. Some antipsychotic medications can prolong the QT interval, leading to an increased risk of arrhythmias [26]. Antipsychotic drugs can disrupt the normal functioning of the endocrine system, leading to hormonal imbalances and potential complications such as hyperprolactinemia. In rare cases, antipsychotic medications can cause neuroleptic malignant syndrome (NMS), a potentially life-threatening condition characterized by fever, muscle rigidity, and altered mental status.

The choice of antipsychotic medication depends on various factors, including the type and severity of symptoms, the individual's medical history, and the risk-benefit profile of the medication. It is essential for healthcare providers to carefully monitor patients taking neuroleptic drugs for side effects and adjust treatment as necessary to minimize risks and optimize outcomes.

3.2. Antidepressants

Antidepressants are a class of medications used to treat depression [27], anxiety disorders, and other mood disorders [28]. While antidepressants are generally safe and effective, some can potentially cause drug-induced movement disorders (DIMDs) as a side effect [29]. The development of DIMDs with antidepressant use is rare but can occur, particularly with certain classes of antidepressants.

One of the most well-known DIMDs associated with antidepressant use is tardive dyskinesia (TD), which is characterized by involuntary movements, particularly of the face and tongue. TD is more commonly associated with long-term use of dopamine receptor-blocking medications, such as certain antipsychotics, but has also been reported with the use of antidepressants, particularly tricyclic antidepressants (TCAs) and selective serotonin reuptake inhibitors (SSRIs).

Other movement disorders that have been reported with antidepressant use include parkinsonism, dystonia, and akathisia [30]. These movement disorders are less common and are more likely to occur with certain classes of antidepressants, such as TCAs [31] and monoamine oxidase inhibitors (MAOIs).

The exact mechanism by which antidepressants can cause DIMDs is not fully understood but is believed to involve alterations in neurotransmitter systems in the brain, particularly dopamine and serotonin [32]. Antidepressants that affect dopamine and serotonin levels may disrupt the average balance of these neurotransmitters, leading to abnormal movements.

The risk of developing a DIMD with antidepressant use is generally low, and most people can safely take antidepressants without experiencing these side effects [33]. However, certain factors may increase the risk, such as the prolonged use of antidepressants, especially at high doses. Use of multiple medications that affect neurotransmitter systems, such as antipsychotics or antiemetics. Individual susceptibility includes a history of movement disorders or other neurological conditions.

Management of DIMDs associated with antidepressant use involves careful monitoring for symptoms and, if detected, discontinuation of the offending medication. In some cases, switching to a different class of antidepressant or adjusting the dose may be necessary [34]. It is essential for healthcare providers to weigh the risks and benefits of antidepressant treatment and to closely monitor patients for side effects, including movement disorders, to optimize outcomes [35].

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3.3. Antipsychotics

Antipsychotic medications, also known as neuroleptics, are commonly used to treat psychotic disorders such as schizophrenia, bipolar disorder, and severe depression. While effective, antipsychotics can cause a range of side effects, including drug-induced movement disorders (DIMDs). These movement disorders can manifest in various forms, including parkinsonism, tardive dyskinesia, dystonia, and akathisia.

Antipsychotic-induced parkinsonism is characterized by symptoms similar to those of Parkinson's disease, including tremors, rigidity, bradykinesia (slowness of movement), and postural instability. These symptoms are believed to be caused by the blockade of dopamine receptors in the brain. Tardive dyskinesia is a potentially irreversible DIMD characterized by involuntary, repetitive movements, particularly of the face and tongue. These movements can include grimacing, tongue protrusion, and lip-smacking. Tardive dyskinesia is more familiar with long-term use of antipsychotics, especially typical (first-generation) antipsychotics.

Antipsychotic-induced dystonia is characterized by sustained muscle contractions that result in abnormal postures or repetitive movements. Dystonic movements can affect any part of the body and can be painful and disabling. Akathisia is a subjective feeling of restlessness and an urge to move. People with akathisia may pace, fidget, or have difficulty sitting still. Akathisia is believed to be caused by alterations in dopamine signaling in the brain. The risk of developing a DIMD with antipsychotic use varies depending on the type of antipsychotic medication, the dose, and the duration of treatment. Typical antipsychotics, such as haloperidol and chlorpromazine, are more likely to cause DIMDs compared to atypical antipsychotics, such as clozapine and risperidone. However, atypical antipsychotics can also cause DIMDs, particularly at higher doses.

Management of DIMDs associated with antipsychotic use involves careful monitoring for symptoms and, if detected, adjusting the dose or switching to a different medication. In some cases, discontinuation of the offending medication may be necessary, but this must be done under the supervision of a healthcare professional to avoid withdrawal symptoms or a worsening of the underlying condition. Overall, while antipsychotic medications are effective in treating psychotic disorders, the risk of developing DIMDs should be carefully considered, and patients should be monitored closely for side effects to optimize treatment outcomes.

3.4. Antiemetics

Antiemetic medications are used to prevent or treat nausea and vomiting, often associated with chemotherapy, surgery, or motion sickness. While generally safe and effective, some antiemetics can cause drug-induced movement disorders (DIMDs) as a side effect. These movement disorders can manifest in various forms, including parkinsonism, tardive dyskinesia, dystonia, and akathisia. Antiemetic-induced parkinsonism is characterized by symptoms similar to those of Parkinson's disease, including tremors, rigidity, bradykinesia (slowness of movement), and postural instability. These symptoms are believed to be caused by the blockade of dopamine receptors in the brain.

Tardive dyskinesia is a potentially irreversible DIMD characterized by involuntary, repetitive movements, particularly of the face and tongue. These movements can include grimacing, tongue protrusion, and lip-smacking. Tardive dyskinesia is more familiar with long-term use of dopamine receptor-blocking medications, such as certain antiemetics. Antiemetic-induced dystonia is characterized by sustained muscle contractions that result in abnormal postures or repetitive movements. Dystonic movements can affect any part of the body and can be painful and disabling. Akathisia is a subjective feeling of restlessness and an urge to move. People with akathisia may pace, fidget, or have difficulty sitting still. Akathisia is believed to be caused by alterations in dopamine signaling in the brain. The risk of developing a DIMD with antiemetic use varies depending on the type of antiemetic medication, the dose, and the duration of treatment. Antiemetics that block dopamine receptors in the brain, such as metoclopramide and prochlorperazine, are more likely to cause DIMDs compared to other antiemetics.

Management of DIMDs associated with antiemetic use involves careful monitoring for symptoms and, if detected, adjusting the dose or switching to a different medication. In some cases,

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discontinuation of the offending medication may be necessary, but this must be done under the supervision of a healthcare professional to avoid withdrawal symptoms or a worsening of the underlying condition. Overall, while antiemetic medications are effective in preventing or treating nausea and vomiting, the risk of developing DIMDs should be carefully considered, and patients should be monitored closely for side effects to optimize treatment outcomes.

3.5. Anticonvulsants

Anticonvulsant medications [36], also known as antiepileptic drugs (AEDs), are used to treat epilepsy and various other neurological conditions [37], including neuropathic pain, bipolar disorder [38], and mood disorders [39]. While generally safe and effective, some anticonvulsants can cause drug-induced movement disorders (DIMDs) and several cosmetic abnormalities [40], such as alopecia [41], as a side effect. These movement disorders can manifest in various forms, including parkinsonism, tardive dyskinesia, dystonia, and akathisia. Anticonvulsant-induced parkinsonism is characterized by symptoms similar to those of Parkinson's disease, including tremors, rigidity, bradykinesia (slowness of movement), and postural instability [42]. These symptoms are believed to be caused by the blockade of dopamine receptors in the brain. Interestingly, some auras can present similar to movement disorders [43].

Tardive dyskinesia is a potentially irreversible DIMD characterized by involuntary, repetitive movements, particularly of the face and tongue [44]. These movements can include grimacing, tongue protrusion, and lip-smacking. Tardive dyskinesia is more familiar with long-term use of dopamine receptor-blocking medications, such as certain anticonvulsants. Anticonvulsant-induced dystonia is characterized by sustained muscle contractions that result in abnormal postures or repetitive movements. Dystonic movements can affect any part of the body and can be painful and disabling. Akathisia is a subjective feeling of restlessness and an urge to move. People with akathisia may pace, fidget, or have difficulty sitting still. Akathisia is believed to be caused by alterations in dopamine signaling in the brain [45]. Some antiseizure medications can cause cerebellar atrophy [46] and contribute to the development of cerebellar signs and symptoms [47]. However, some new antiseizure medications [48] have yet to be associated with movement disorders [49].

The risk of developing a DIMD with anticonvulsant use varies depending on the type of anticonvulsant medication, the dose [50], and the duration of treatment [51]. Anticonvulsants that affect dopamine receptors in the brain [52], such as valproate [53] and carbamazepine [54], are more likely to cause DIMDs than other anticonvulsants [55]. Interestingly, valproate is also associated with the dose-dependent pancytopenia [56]. Management of the DIMDs related to anticonvulsant use involves careful monitoring for symptoms and, if detected, adjusting the dose or switching to a different medication [57]. In some cases, discontinuation of the offending medication may be necessary, but this must be done under the supervision of a healthcare professional to avoid withdrawal symptoms or a worsening of the underlying condition. Overall, while anticonvulsant medications are effective in treating epilepsy and other neurological conditions, the risk of developing DIMDs should be carefully considered, and patients should be monitored closely for side effects to optimize treatment outcomes [58].

3.6. Other Medications

In addition to the classes of medications mentioned previously (neuroleptics, antidepressants [59], antiemetics, and anticonvulsants), several other medications can potentially cause drug-induced movement disorders (DIMDs) as a side effect. Besides neuroleptics and antiemetics, other medicines that block dopamine receptors in the brain can also cause DIMDs. These may include certain anti-nausea medications, such as metoclopramide and prochlorperazine, and some medications used to treat gastrointestinal disorders [60]. Some antiarrhythmic medications, such as amiodarone and procainamide, can cause movement disorders, including tremors, dystonia, and parkinsonism. These effects are believed to be related to the medications' effects on neurotransmitter systems in the brain [61]. Certain calcium channel blockers, such as flunarizine [62], have been associated with movement disorders, including parkinsonism and tardive dyskinesia. The exact mechanism by which these

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medications cause DIMDs is not well understood but may involve alterations in dopamine signaling [63]. Also, some fluoroquinolones are associated with DIMDs [64]. In particular, ciprofloxacin [65] is commonly associated with myoclonus, and the term "ciproclonus" was already reported in [66].

Lithium, commonly used to treat bipolar disorder, can cause a range of movement disorders, including tremors [67], dystonia, and parkinsonism [68]. These effects are more likely to occur with long-term use or at higher doses. Some antihistamine medications, particularly older, first-generation antihistamines such as diphenhydramine, can cause movement disorders, including dystonia and akathisia [69]. These effects are believed to be related to the medications' effects on dopamine receptors in the brain [70]. Certain stimulant medications used to treat attention-deficit/hyperactivity disorder (ADHD), such as methylphenidate [71] and amphetamine derivatives, can cause movement disorders, including chorea and tics [72].

Management of DIMDs associated with these medications involves careful monitoring for symptoms and, if detected, adjusting the dose or switching to a different medication. In some cases, discontinuation of the offending medication may be necessary, but this must be done under the supervision of a healthcare professional to avoid withdrawal symptoms or a worsening of the underlying condition.

4. Risk Factors for Developing DIMDs

4.1. Age

Age is a significant risk factor for the development of drug-induced movement disorders (DIMDs) [44]. Older adults are more susceptible to DIMDs due to age-related changes in pharmacokinetics and pharmacodynamics, as well as increased vulnerability to medication side effects [73]. Several factors contribute to this increased risk in older adults. As people age, there are changes in how medications are absorbed, distributed, metabolized, and excreted by the body [74]. These changes can affect drug levels in the body and increase the risk of side effects, including DIMDs.

Age-related changes in neurotransmitter systems, particularly dopamine, can affect the response to medications that act on these systems [75]. Older adults may be more sensitive to the effects of dopamine receptor-blocking medications, increasing the risk of DIMDs. Older adults are more likely to take multiple medications, raising the risk of drug interactions and side effects. The use of various medications that can cause DIMDs can further increase the risk in this population. Older adults are more likely to have underlying health conditions that can raise the risk of DIMDs. These conditions may affect how medications are metabolized or increase vulnerability to medication side effects.

Older adults with cognitive impairment, such as dementia, may be at higher risk of DIMDs due to difficulties in recognizing and reporting symptoms [76]. Also, some individuals can have genetic syndromes like Fahr's disease [77], leading to a challenging diagnosis of dementia and movement disorder [78]. Caregivers and healthcare providers may need to be more vigilant in monitoring for DIMDs in this population. Frail older adults may be more susceptible to the effects of medications, including DIMDs, due to decreased physiological reserve and increased vulnerability to side effects [79]. Noteworthy, some anticholinesterase inhibitors commonly used in dementia are associated with DIMDs [80].

Given the increased risk of DIMDs in older adults, healthcare providers should carefully consider the choice of medications, monitor for side effects, and adjust doses as necessary to minimize the risk of DIMDs in this population [81]. Close monitoring and regular review of drugs can help to optimize outcomes and improve the quality of life for older adults.

4.2. Genetics

Genetics plays a significant role in the development of drug-induced movement disorders (DIMDs). Genetic factors can influence an individual's susceptibility to DIMDs by affecting how medications are metabolized, how they interact with neurotransmitter systems in the brain, and the likelihood of developing side effects. Genetic variations in enzymes that metabolize medications,

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such as cytochrome P450 enzymes, can affect how medications are broken down in the body [82]. Differences in metabolism can lead to variations in drug levels and the risk of side effects, including DIMDs. Genetic variations in genes that encode neurotransmitter receptors and transporters can affect how medications interact with these systems. For example, variations in dopamine receptor genes may influence the risk of developing DIMDs in response to drugs that block dopamine receptors. Some individuals may have genetic predispositions that make them more susceptible to specific side effects of medications, including DIMDs. For example, genetic variations in the HLA-B*1502 gene have been associated with an increased risk of developing certain types of drug-induced movement disorders, such as Stevens-Johnson syndrome and toxic epidermal necrolysis, in response to specific medications [83]. Also, this can lead to harmful levels of medications, causing abnormal movements [84]. Genetic factors can also influence an individual's medication response, including the likelihood of developing DIMDs. Variations in genes that affect drug metabolism, neurotransmitter systems [85], and other pathways involved in drug response can contribute to differences in susceptibility to DIMDs among individuals, like in cases of glutaric aciduria type 1 [86].

While genetics play a significant role in developing DIMDs, they are only one piece of the puzzle [87]. Environmental factors, such as medication use, medical conditions, and lifestyle factors, are essential in determining an individual's risk of developing DIMDs. Understanding the complex interplay between genetics and other factors can help healthcare providers better predict, prevent, and manage DIMDs in clinical practice.

4.3. Duration of Medication Use

The duration of medication use is an essential factor in the development of drug-induced movement disorders (DIMDs). DIMDs are more likely to occur with long-term use of certain medications, particularly those that affect dopamine signaling in the brain. The risk of developing a DIMD generally increases with the duration of medication use, although individual susceptibility can vary.

TD is a DIMD that is mainly associated with long-term use of dopamine receptor-blocking medications, such as antipsychotics and some antiemetics. The risk of developing TD increases with the duration of treatment, especially with typical (first-generation) antipsychotics. Drug-induced parkinsonism can occur with prolonged use of medications that block dopamine receptors in the brain, such as certain antipsychotics. The risk of parkinsonism is generally higher with typical antipsychotics and increases with long-term use. Antipsychotic-induced dystonia is more likely to occur early in treatment but can also develop with long-term use. The risk of dystonia may be higher with certain antipsychotics, particularly at higher doses. Akathisia is more common early in treatment but can persist with long-term use of certain medications. The risk of akathisia may be higher with drugs that affect dopamine signaling in the brain.

The exact mechanism by which long-term use of medications leads to DIMDs is not fully understood but is believed to involve alterations in dopamine signaling and changes in the sensitivity of dopamine receptors in the brain. Individual susceptibility to DIMDs can vary, and not everyone who takes these medications long-term will develop a DIMD. To minimize the risk of DIMDs, healthcare providers often prescribe the lowest effective dose of medication for the shortest duration necessary. Regular monitoring for symptoms of DIMDs is essential, especially in patients who are taking medications long-term. If DIMDs develop, adjustments to the medication regimen may be necessary, including dose reduction, switching to a different medication, or discontinuation of the offending medication.

4.4. Dose of Medication

The dose of medication is a critical factor in the development of drug-induced movement disorders (DIMDs) [88]. DIMDs can occur when medications that affect dopamine signaling in the brain are used at high doses. The risk of developing a DIMD generally increases with higher doses of these medications, although individual susceptibility can vary, including during pregnancy. The

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levels of medications should be mainly assessed; in those cases, cerebrovascular disorders can present as abnormal movements [89].

TD is associated with the use of dopamine receptor-blocking medications, such as antipsychotics and some antiemetics [90]. The risk of developing TD is higher with higher doses of these medications, especially with typical (first-generation) antipsychotics. Drug-induced parkinsonism can occur with the use of drugs that block dopamine receptors in the brain, such as certain antipsychotics. The risk of parkinsonism is generally higher with higher doses of these medications. Antipsychotic-induced dystonia is more likely to occur at higher doses of medication. The risk of dystonia may be dose-dependent, with higher doses of certain antipsychotics carrying a higher risk. Akathisia is more common at the beginning of treatment but can also occur at higher doses of medications that affect dopamine signaling. The risk of akathisia may increase with higher doses of these medications.

Individual susceptibility to DIMDs can vary; not everyone taking these medications at higher doses will develop a DIMD [91]. However, healthcare providers often prescribe the lowest effective dose of drugs to minimize the risk of DIMDs. Regular monitoring for symptoms of DIMDs is essential, especially in patients taking medicines at higher doses. If DIMDs develop, adjustments to the medication regimen may be necessary, including dose reduction, switching to a different medication, or discontinuation of the offending drug.

5. Symptoms of Drug-Induced Movement Disorders

5.1. Motor Symptoms

Motor symptoms are a crucial feature of drug-induced movement disorders (DIMDs). These symptoms can vary widely depending on the specific type of DIMD and the underlying mechanism of action of the medication involved. Tremors are rhythmic, involuntary movements affecting various body parts, including the hands, arms, legs, and head. Tremors can be a common side effect of certain medications, particularly those that affect dopamine signaling in the brain. Rigidity refers to stiffness or inflexibility of the muscles. It can make movement difficult and may be accompanied by muscle pain or discomfort. Rigidity is often seen in conditions such as parkinsonism, which certain medications can cause. Bradykinesia refers to slowness of movement and is a hallmark feature of Parkinsonism. It can affect tasks such as walking, writing, and other activities of daily living. Bradykinesia can be a side effect of medications that block dopamine receptors in the brain.

Dystonia is characterized by sustained muscle contractions that result in abnormal postures or repetitive movements [92]. Dystonia can affect any part of the body and can be painful and disabling. It is often seen as a side effect of certain medications, particularly antipsychotics. Akathisia is a subjective feeling of restlessness and an urge to move. People with akathisia may pace, fidget, or have difficulty sitting still. Akathisia can be a side effect of medications that affect dopamine signaling in the brain. Tardive dyskinesia is a potentially irreversible DIMD characterized by involuntary, repetitive movements, particularly of the face and tongue. These movements can include grimacing, tongue protrusion, and lip-smacking. Tardive dyskinesia is more familiar with long-term use of dopamine receptor-blocking medications, such as certain antipsychotics.

It is essential to recognize and monitor for motor symptoms in patients taking medications that can cause DIMDs. Early detection and management of DIMDs can help minimize the impact on quality of life and optimize treatment outcomes. Management strategies may include adjusting the dose or switching to a different medication, but this must be done under the supervision of a healthcare professional.

5.2. Non-Motor Symptoms

In addition to motor symptoms, drug-induced movement disorders (DIMDs) can also cause a range of non-motor symptoms. These non-motor symptoms can vary depending on the specific type of DIMD and the underlying mechanism of action of the medication involved [93]. DIMDs, particularly those that affect dopamine signaling in the brain, can sometimes cause cognitive

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impairment, including problems with memory, attention, and executive function. Some DIMDs can exacerbate psychiatric symptoms, such as anxiety, depression, psychosis [94], or mood swings [95], or even worsen patients with previous movement disorders [96]. DIMDs can disrupt standard sleep patterns, leading to insomnia or excessive daytime sleepiness. DIMDs can affect the autonomic nervous system, leading to symptoms such as changes in blood pressure, heart rate, and sweating [97]. Some DIMDs can cause gastrointestinal symptoms, such as nausea, vomiting, or constipation. DIMDs can sometimes lead to sexual dysfunction, including decreased libido, erectile dysfunction, or difficulty achieving orgasm. Some medications that can cause DIMDs are also associated with weight gain, which can have a range of health implications.

It is essential to recognize and monitor for non-motor symptoms in patients taking medications that can cause DIMDs [10]. Early detection and management of these symptoms can help minimize the impact on quality of life and optimize treatment outcomes. Management strategies may include adjusting the dose or switching to a different medication, but this must be done under the supervision of a healthcare professional.

5.3. Impact on Quality of Life

Drug-induced movement disorders (DIMDs) can have a significant impact on quality of life due to their physical, emotional, and social effects. The severity of the impact can vary depending on the type of DIMD, the underlying cause, and individual factors. DIMDs can cause a range of physical symptoms, including tremors, rigidity, dystonia, and other involuntary movements. These symptoms can be painful uncomfortable, and interfere with daily activities such as walking, eating, and writing. DIMDs can affect motor function, coordination, and balance, leading to difficulties in performing tasks requiring fine motor skills and coordination. This can impact a person's ability to work, drive, and engage in leisure activities. DIMDs can be emotionally distressing, causing feelings of embarrassment, frustration, and self-consciousness [98]. These feelings can lead to social withdrawal and isolation. DIMDs can affect social interactions and relationships, as people may feel self-conscious about their movements and may avoid social situations. This can lead to feelings of loneliness and isolation. DIMDs can contribute to or exacerbate mental health conditions such as anxiety and depression [99]. The emotional and physical toll of living with a DIMD can take a significant toll on mental well-being. DIMDs can negatively impact self-esteem and self-image, mainly if the movements are visible and challenging to control. This can lead to feelings of inadequacy and low self-worth. DIMDs can make it difficult to perform everyday tasks such as dressing, grooming, and eating. This can lead to increased dependence on others and a loss of independence.

Management of DIMDs typically involves a multidisciplinary approach, including medication management, physical therapy, occupational therapy, and psychological support [100]. Treatment aims to reduce symptoms, improve function, and enhance quality of life. Healthcare providers must work closely with individuals affected by DIMDs to develop a treatment plan that addresses their needs and goals.

6. Diagnosis of Drug-Induced Movement Disorders

6.1. Clinical Evaluation

Clinical evaluation of drug-induced movement disorders (DIMDs) involves a comprehensive assessment to determine the presence, type, and severity of movement abnormalities. This evaluation is essential for accurate diagnosis and appropriate management. A thorough medical history is obtained to identify any underlying medical conditions, previous medication use, family history of movement disorders, and other relevant factors that may contribute to the development of DIMDs. A comprehensive physical examination assesses movement abnormalities, muscle tone, coordination, and other neurological signs that may indicate a DIMD. As many medications that can cause DIMDs are used to treat psychiatric disorders, a psychiatric evaluation is often conducted to assess for symptoms of psychiatric illness and to evaluate the impact of DIMDs on mental health. A

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review of current and past medication use is performed to identify any medications that may be contributing to the development of DIMDs. This includes both prescription and over-the-counter drugs, as well as herbal supplements. Laboratory tests may be ordered to rule out other medical conditions that mimic or contribute to developing DIMDs, such as thyroid dysfunction or vitamin deficiencies [101].

In some cases, neuroimaging studies such as magnetic resonance imaging (MRI) or computed tomography (CT) scans may be performed to rule out structural abnormalities in the brain that may be causing or contributing to the development of DIMDs [102]. Various rating scales may be used to assess the severity of DIMDs and monitor changes over time. These scales can help guide treatment decisions and evaluate the effectiveness of interventions. Regular follow-up visits are essential to monitor for changes in symptoms, adjust medication regimens as needed, and provide ongoing support and education to individuals with DIMDs. Overall, a thorough clinical evaluation is essential for the accurate diagnosis and management of DIMDs [103]. This evaluation should be conducted by healthcare providers with expertise in movement disorders, such as neurologists or psychiatrists, and should consider the individual's unique clinical presentation and needs.

6.2. Differential Diagnosis

The differential diagnosis of drug-induced movement disorders (DIMDs) involves distinguishing them from other movement disorders and conditions that can cause similar symptoms. This process requires a thorough clinical evaluation, including a detailed medical history, physical examination, and, in some cases, additional tests like basic metabolic panel and TSH. There are some case reports of hypothyroidism associated with catatonia [104] that can be difficult to differentiate from the partial description of parkinsonism [105]. Other reports of limb shaking can be easily confounded with some primary movement disorders [106].

Parkinson's disease is a neurodegenerative disorder characterized by tremors, rigidity, bradykinesia, and postural instability [107]. It is essential to differentiate drug-induced parkinsonism from Parkinson's disease, as the management and prognosis differ [108]. Essential tremor is a common movement disorder characterized by involuntary trembling or shaking, typically in the hands. It is crucial to differentiate essential tremors from tremors caused by medications, such as beta-blockers or stimulants. Dystonia is a movement disorder characterized by sustained or repetitive muscle contractions that result in abnormal postures or movements [109]. It can be primary (idiopathic) or secondary to medications, such as antipsychotics [110]. Huntington's disease is a genetic neurodegenerative disorder characterized by involuntary movements (chorea), cognitive decline, and psychiatric symptoms [111]. It is essential to differentiate drug-induced chorea from Huntington's disease, as the management and prognosis differ. Wilson's disease is a rare genetic disorder characterized by copper accumulation in the body, leading to neurological and psychiatric symptoms. It can present with movement disorders such as tremors, dystonia, and chorea. Certain metabolic disorders, such as hyperthyroidism and hypocalcemia, can cause movement disorders that may mimic DIMDs. These conditions can be identified through laboratory testing. Some psychiatric disorders, such as schizophrenia and bipolar disorder, can present with movement abnormalities that may be mistaken for DIMDs. A careful psychiatric evaluation is essential to differentiate these conditions. Some medications can cause movement abnormalities that are not classified as DIMDs, such as serotonin syndrome, which can occur with certain antidepressants and other drugs [112]. Another possible differential diagnosis is electrolyte abnormalities [113], such as hypokalemic paralysis [114] or copper deficiency [115]. However, one should always consider stroke [116], for which imaging can help differentiate between peripheral and central causes.

The differential diagnosis of DIMDs requires a systematic approach and careful consideration of the clinical presentation, medical history, and response to treatment [103]. Collaboration between healthcare providers with expertise in movement disorders, such as neurologists or psychiatrists, is often necessary to arrive at an accurate diagnosis and develop an appropriate treatment plan.

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6.3. Imaging Studies

Imaging studies are sometimes used in the evaluation of drug-induced movement disorders (DIMDs) to help assess the underlying brain changes and rule out other potential causes of movement abnormalities. While imaging studies are not typically required for all cases of DIMDs, they can be helpful in certain situations, such as when the diagnosis is unclear or when there is concern for an alternative explanation for the symptoms.

MRI uses magnetic fields and radio waves to create detailed brain images. MRI can help identify structural abnormalities in the brain that may contribute to the movement disorder, such as tumors, strokes, or other lesions [117]. CT scans use X-rays to create cross-sectional images of the brain. CT scans are less detailed than MRI but can help identify specific structural abnormalities, such as hemorrhages or hydrocephalus, especially when other drugs that are associated with pseudotumor cerebri are involved [118]. PET scans can be used to assess brain function by measuring metabolic activity. PET scans can help differentiate between different types of movement disorders and may be used to evaluate the effects of medications on brain function. SPECT scans can also assess brain function by measuring blood flow [119]. SPECT scans can help identify areas of the brain affected by the movement disorder and may be used to guide treatment decisions, especially in individuals with dementia [120]. DaTscan is a SPECT scan that looks explicitly at dopamine transporter levels in the brain[121]. DaTscan can help differentiate between Parkinson's disease and other causes of parkinsonism, including drug-induced parkinsonism. In some cases, using I123-cardiac MIBG can help distinguish between secondary and primary parkinsonism [122].

Imaging studies are only sometimes necessary to evaluate DIMDs, as the diagnosis is often based on clinical findings and medication history. However, in some instances, imaging studies can provide valuable information that can help guide treatment decisions and improve outcomes for individuals with DIMDs.

7. Treatment of Drug-Induced Movement Disorders

7.1. Withdrawal of Offending Medication

Withdrawal of the offending medication is often the first step in the management of drug-induced movement disorders (DIMDs), especially when the symptoms are mild to moderate and reversible [123]. The process of withdrawing the medication should be done gradually and under the supervision of a healthcare professional to minimize the risk of withdrawal symptoms and to ensure the underlying condition is managed appropriately.

When withdrawing the medication, healthcare providers may consider some key points. The drug is gradually tapered off over some time to minimize the risk of withdrawal symptoms and to allow the body to adjust to the change. During the tapering process, the individual is closely monitored for any changes in symptoms and for the development of withdrawal symptoms. Depending on the type and severity of the DIMD, symptomatic treatment may be initiated to help manage symptoms during the withdrawal process. This may include medications to help control tremors, muscle stiffness, or other symptoms. After the drug has been withdrawn, the individual is reevaluated to assess for any residual symptoms and to determine if further treatment is necessary.

In some cases, withdrawal of the offending medication may lead to improvement or resolution of the DIMD. However, in other cases, symptoms may persist or worsen despite discontinuation of the drug. Additional treatments may be necessary, such as switching to a different medication or initiating symptomatic treatment to help manage symptoms.

It is essential for healthcare providers to carefully consider the risks and benefits of withdrawing the medication and to tailor the management approach to the individual's specific needs and circumstances. Close monitoring and regular follow-up are essential to ensure the best possible outcomes for individuals with DIMDs.

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7.2. Pharmacological Treatments

Pharmacological treatments for drug-induced movement disorders (DIMDs) aim to manage symptoms and improve quality of life. Treatment choice depends on the type and severity of the DIMD and the underlying cause.

Anticholinergic medications, such as benztropine or trihexyphenidyl, are often used to treat drug-induced parkinsonism and dystonia. These medications can help reduce muscle stiffness and tremors by blocking the action of acetylcholine in the brain. Dopamine agonist medications, such as pramipexole or ropinirole, may be used to treat drug-induced parkinsonism or restless legs syndrome. These medications work by mimicking the effects of dopamine in the brain, which can help improve motor symptoms. Benzodiazepines, such as clonazepam or diazepam, may be used to treat drug-induced dystonia or akathisia. These medications can help reduce muscle spasms and anxiety associated with these conditions. Beta-blockers, such as propranolol, may be used to treat drug-induced tremors. These medications work by blocking the action of adrenaline, which can help reduce tremors. Clozapine is an atypical antipsychotic medication that may be used to treat drug-induced tardive dyskinesia [124]. Clozapine is effective in decreasing the symptoms of tardive dyskinesia in some individuals. Amantadine is an antiviral medication that has also been used to treat drug-induced Parkinsonism but has also been associated with myoclonus [125]. It increases dopamine release in the brain and may help improve motor symptoms. In some cases of drug-induced dystonia [126], botulinum toxin injections may help relax muscles and reduce abnormal postures or movements, especially in oromandibular dystonia [127].

It is important to note that pharmacological treatments for DIMDs should be carefully considered and monitored by a healthcare professional [128]. The choice of medication, dose, and duration of therapy should be tailored to the individual's specific needs and circumstances. Close monitoring and regular follow-up are essential to ensure the best possible outcomes for individuals with DIMDs.

7.3. Non-Pharmacological Treatments

Non-pharmacological treatments for drug-induced movement disorders (DIMDs) focus on symptom management, improving quality of life, and maximizing function. These treatments can be used alone or in combination with pharmacological interventions.

Physical therapy can help improve muscle strength, flexibility, and coordination, benefiting individuals with DIMDs [129]. Specific exercises and techniques can be tailored to address the individual's unique needs and symptoms. Occupational therapy can help individuals with DIMDs improve their ability to perform activities of daily living, such as dressing, grooming, and eating. Occupational therapists can provide strategies and adaptations to help individuals overcome movement difficulties and improve independence. Speech therapy can benefit individuals with DIMDs that affect speech and swallowing. Speech therapists can provide exercises and techniques to enhance speech clarity and swallowing function. Assistive devices, such as braces, splints, or walking aids, can help individuals with DIMDs improve mobility and function. These devices can provide support and stability, making it easier to perform daily activities. Botulinum toxin injections can treat focal dystonias and other movement disorders affecting specific muscle groups [130]. The toxin works by blocking the release of acetylcholine, which can help reduce muscle spasms and improve function. DBS is a surgical treatment involving implanting brain electrodes to deliver electrical impulses. DBS can be effective in treating certain types of DIMDs, such as Parkinson's disease or tremors. Counseling and support groups can be valuable for individuals with DIMDs and their families [131]. These resources can provide emotional support, education, and coping strategies for living with a DIMD.

Individuals with DIMDs need to work closely with a healthcare team that includes specialists in movement disorders, such as neurologists, physical therapists, and occupational therapists, to develop a comprehensive treatment plan that addresses their specific needs and goals.

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8. Prevention of Drug-Induced Movement Disorders

8.1. Monitoring for Early Signs

Monitoring for early signs of drug-induced movement disorders (DIMDs) is crucial for early detection and intervention. Since DIMDs can vary widely in presentation and severity depending on the type of medication and individual factors, close monitoring is essential.

Healthcare providers should regularly assess movement and neurological function in individuals taking medications that cause DIMDs. These assessments can help detect early signs of DIMDs before they become more severe. Patients should be encouraged to report any changes in movement or symptoms to their healthcare provider. Educating patients about the signs and symptoms of DIMDs can help them recognize potential issues early on. Healthcare providers may use objective rating scales, such as the Abnormal Involuntary Movement Scale (AIMS) for tardive dyskinesia or the Barnes Akathisia Rating Scale for Akathisia, to assess for DIMDs and monitor changes over time. Since DIMDs can affect multiple aspects of health and well-being, collaboration with other healthcare providers, such as psychiatrists, physical therapists, and occupational therapists, can help ensure comprehensive monitoring and management. Regular review of medication regimens can help identify any potential culprits for DIMDs. Healthcare providers should assess the necessity and appropriateness of each medication and consider alternatives if necessary. Educating healthcare providers, patients, and caregivers about the risk factors, signs, and symptoms of DIMDs can help improve early detection and intervention.

By implementing these monitoring strategies, healthcare providers can improve the early detection of DIMDs and initiate appropriate interventions to minimize their impact on patient's quality of life.

8.2. Dose Optimization

Dose optimization is a critical aspect of managing drug-induced movement disorders (DIMDs), as it can help minimize symptoms while maintaining the therapeutic effects of the medication. The goal of dose optimization is to find the lowest effective dose of drugs that provides symptom relief with the fewest side effects.

When initiating a medication that can cause DIMDs, it is often recommended to start with a low dose and gradually increase the dose as needed while monitoring for side effects. Close monitoring of symptoms is essential during dose optimization to assess the effectiveness of the medication and identify any emerging side effects or movement abnormalities. Dose optimization should be tailored to the individual's specific needs and response to the medication. Age, weight, comorbidities, and other medications should be considered when determining the optimal dose. Individuals with certain risk factors, such as older age, previous history of movement disorders, or use of high-risk medications, may require more careful dose optimization to minimize the risk of DIMDs. Dose optimization should be a collaborative effort between the individual and their healthcare provider. Open communication and regular follow-up are crucial to achieving the optimal dose. When adjusting the dose of a medication, it is important to titrate the dose gradually to minimize the risk of withdrawal symptoms or rebound effects.

Similarly, when discontinuing a medication, tapering the dose slowly can help reduce the risk of withdrawal symptoms. If dose optimization does not adequately control symptoms or intolerable side effects, alternative treatments should be considered. This may include switching to a different medication, adding a second medication, or exploring non-pharmacological therapies.

Overall, dose optimization is essential to managing DIMDs and should be approached carefully, considering the individual's unique circumstances and needs. Close monitoring and regular follow-up are necessary to ensure the optimal dose while minimizing the risk of side effects.

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9. Prognosis and Complications of Drug-Induced Movement Disorders

9.1. Long-Term Effects

The long-term effects of drug-induced movement disorders (DIMDs) can vary depending on the type of DIMD, the underlying cause, and individual factors. TD is a potentially irreversible DIMD characterized by involuntary, repetitive movements, particularly of the face and tongue. In some cases, TD may persist even after discontinuing the offending medication. Long-term effects of TD can include social embarrassment, functional impairment, and reduced quality of life. Drug-induced parkinsonism can occur with certain drugs and is characterized by symptoms similar to Parkinson's disease, such as tremors, rigidity, bradykinesia, and postural instability.

In some cases, drug-induced parkinsonism may resolve after discontinuation of the offending medication, but in other cases, it may persist and require long-term management. Drug-induced dystonia is characterized by sustained or repetitive muscle contractions that result in abnormal postures or movements. The long-term effects of dystonia can include pain, functional impairment, and psychosocial difficulties. Akathisia is characterized by a subjective feeling of restlessness and an urge to move. Long-term effects of akathisia can include anxiety, agitation, and sleep disturbances. Some medications that can cause DIMDs may also affect cognitive function over the long term. Mental effects can include memory problems, attention deficits, and executive dysfunction. DIMDs can have psychiatric effects, including anxiety, depression, and other mood disorders. These effects can impact quality of life and may require long-term management. DIMDs can significantly affect quality of life, including physical, emotional, and social aspects. Long-term management may be necessary to address these effects and improve quality of life.

Individuals with DIMDs need to work closely with their healthcare providers to manage their symptoms and monitor for any potential long-term effects. Regular follow-up and adjustments to treatment, as required, can help minimize the impact of DIMDs and improve overall quality of life.

9.2. Complications of Severe Cases

Severe cases of drug-induced movement disorders (DIMDs) can lead to several complications, which can significantly impact an individual's quality of life and functional abilities. Severe DIMDs, such as drug-induced parkinsonism or dystonia, can cause significant impairment in mobility, coordination, and fine motor skills. This can make it challenging to perform activities of daily living and may require assistance or accommodations.

Severe DIMDs can cause pain and discomfort due to muscle stiffness, spasms, or abnormal postures. This can affect physical comfort and overall well-being. DIMDs can have a profound psychosocial impact, causing embarrassment, social isolation, and difficulties in interpersonal relationships. This can lead to feelings of depression, anxiety, and low self-esteem. Some medications that can cause DIMDs may also affect cognitive function, leading to memory problems, attention deficits, and other cognitive impairments. This can further impact an individual's ability to function independently. The medications used to treat severe DIMDs may themselves cause side effects and complications, mainly if used long-term or at high doses. These complications can include metabolic changes, cardiovascular effects, and neurological symptoms. Severe DIMDs can increase the risk of falls and injuries due to impaired balance, coordination, and muscle control. This can further reduce mobility and independence. Overall, severe DIMDs can have a profound impact on quality of life, affecting physical health, emotional well-being, and social functioning. Effective management and treatment are essential to minimize complications and improve outcomes for individuals with severe DIMDs.

Individuals with severe DIMDs need to receive comprehensive care from a multidisciplinary team, including neurologists, psychiatrists, physical therapists, and occupational therapists. Treatment should be tailored to the individual's needs and may include a combination of medications, therapy, and other interventions to manage symptoms and improve quality of life.

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9.3. Impact on Mental Health

Movement disorders are the most minor group in the burden of neurological disorders in India and the global [132]. However, they still correspond to 0.06 to 1.8% of the neurological burden for most countries [133]. Drug-induced movement disorders (DIMDs) can have a significant impact on mental health due to their physical symptoms, psychosocial implications, and effects on overall well-being. The impact on mental health can vary depending on the type and severity of the DIMD, as well as individual factors.

The physical symptoms of DIMDs, such as tremors, muscle stiffness, and involuntary movements, can be distressing and may lead to feelings of anxiety and apprehension. DIMDs can contribute to or exacerbate feelings of depression, mainly if the symptoms are severe or if they significantly impact daily functioning and quality of life. The physical symptoms of DIMDs, such as abnormal movements or postures, can be socially stigmatizing and may lead to social withdrawal and isolation. DIMDs can impact self-esteem and self-image, mainly if the symptoms are visible and challenging to control. This can lead to feelings of inadequacy and low self-worth. The physical and psychosocial effects of DIMDs can significantly impair quality of life, affecting relationships, work, and overall well-being. Managing the symptoms of DIMDs, along with the challenges of daily life, can be stressful and may contribute to feelings of stress and overwhelm [134]. DIMDs can impact daily functioning, making it difficult to perform tasks that require fine motor skills, coordination, and balance. This can lead to frustration and feelings of helplessness.

Individuals with DIMDs need to receive comprehensive care that addresses both the physical and mental health aspects of the condition. This may include medication management, therapy, and support services to help manage symptoms and improve quality of life. Open communication with healthcare providers and a strong support network can also be beneficial in addressing the mental health impact of DIMDs.

10. Conclusion

In conclusion, drug-induced movement disorders (DIMDs) are a group of iatrogenic conditions that can have a significant impact on individuals' quality of life and mental health. These disorders can result from the use of various medications, including antipsychotics, antidepressants, and antiemetics, among others. DIMDs can manifest as a range of motor and non-motor symptoms, including tremors, rigidity, dystonia, and akathisia, which can vary in severity and duration. Management of DIMDs involves a multidisciplinary approach, including medication management, physical therapy, occupational therapy, and psychological support. Treatment goals are to minimize symptoms, improve function, and enhance quality of life. Dose optimization, withdrawal of the offending medication, and consideration of alternative treatments are essential strategies in managing DIMDs. Close monitoring for early signs and complications is crucial for timely intervention and optimal outcomes. DIMDs can also have a significant impact on mental health, leading to anxiety, depression, social withdrawal, and decreased self-esteem. It is essential for healthcare providers to consider the mental health implications of DIMDs and to provide comprehensive care that addresses both the physical and psychological aspects of the condition. Managing DIMDs requires a personalized approach considering the individual's unique symptoms, medical history, and care goals. By working closely with healthcare providers and receiving appropriate treatment, individuals with DIMDs can improve their symptoms, enhance their quality of life, and better cope with the challenges of living with these disorders.

Author Contributions: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision, project administration, funding acquisition performed E.R.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

 doi:10.20944/preprints202402.1258.v1

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest.

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