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Review Article

THE NEUROBIOLOGICAL CONCEPTS AND TREATMENT REGIMEN OF SCHIZOPHRENIA

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ABSTRACT

Schizophrenia is a complex, chronic psychiatric disorder with a heterogeneous clinical presentation encompassing positive, negative, and cognitive symptoms. Despite over a century of research, its precise etiology remains elusive, though advances in genetic, neurobiological, and neuroimaging studies have significantly enhanced understanding. The disorder's burden is substantial, with rising global prevalence and Disability-Adjusted Life Years (DALYs), highlighting the need for improved diagnosis and therapeutic strategies. Neurobiological underpinnings include polygenic inheritance, neurotransmitter dysregulation—particularly involving dopamine, glutamate, and serotonin—and structural brain abnormalities affecting prefrontal, temporal, and limbic regions. Diagnostic criteria, as per DSM-5, emphasize symptomatology and functional decline, necessitating careful differential diagnosis. Pharmacotherapy remains the cornerstone of management, with first-generation antipsychotics (FGAs) primarily targeting positive symptoms but burdened by extrapyramidal side effects, while second- and third-generation antipsychotics (SGAs and TGAs) offer broader efficacy with improved tolerability. Psychosocial interventions, notably cognitive behavioral therapy (CBTp) and family therapy, augment pharmacological outcomes by addressing functional impairments and relapse prevention. Emerging modalities such as neurostimulation techniques (rTMS, tDCS) and cannabidiol-based therapies present promising adjunctive options. Integrated, multimodal approaches incorporating pharmacotherapy, psychotherapy, skills training, and social support offer the most comprehensive benefit. Personalized medicine, leveraging genetic, neuroimaging, and clinical biomarkers, holds potential for tailoring treatment, improving outcomes, and minimizing adverse effects. Telemedicine has further expanded access to psychiatric care, particularly in underserved regions, although challenges remain. Overall, an integrated, patient-centered, and biologically informed approach is essential to improving the prognosis and quality of life for individuals with schizophrenia. Continued research into the neurobiology, novel therapeutic targets, and personalized interventions is imperative for advancing schizophrenia management.

Keywords: Schizophrenia, Neurobiology, Antipsychotics, Cognitive Behavioral Therapy, Telemedicine, Personalized Medicine

INTRODUCTION

The diagnosis of Schizophrenia has changed a lot since the time when it was first defined. The term "Schizophrenia" was introduced by Eugen Bleuler in 1908 after Kraepelin's previous term, "Dementia Praecox," which he used to categorize early onset, progressive psychotic disorders.[1] Bleuler paid much attention to the disturbed thought process and lack of effect in disorder and named it after the Greek words meaning 'split mind.' Over the course of the twentieth century, the concept of schizophrenia progressed with the development of modern classification systems, ending with DSM-5 criteria. Although the investigation of schizophrenia dates back over a century, its exact cause and mechanism are still unknown, although the advancement in genetic, neurobiological, and neuroimaging research has helped in enhancing the knowledge and current diagnostic and therapeutic management of the disease.

Schizophrenia is a severe mental disorder that manifests itself through positive symptoms such as delusions and hallucinations, negative symptoms such as social withdrawal, and cognitive symptoms such as impaired thought processes. According to DSM-5, for the diagnosis of schizophrenia, positive symptoms include these psychoses along with negative symptoms like affective flattening, anhedonia, apathy, asociality, and cognitive dysfunctioning.[2] However, the classification of schizophrenia is still dynamic in its clinical usage as more findings are discovered about the neurobiology of schizophrenia and its subtypes.

Epidemiology and Global Burden

Schizophrenia is one of the major mental disorders that impact millions of people around the globe and which entails substantial economic and social losses. Based on the Global Burden of Disease 2019 report, the trend of prevalence, incidence, and Disability Adjusted life years DALYs of schizophrenia has risen significantly from 14.2 million cases in 1990 to 23.5 million in 2019, and the DALYs related to the disorder also rose from 9.1 million to 15.1 million over the same period.[3]

The trends in the prevalence and the DALYs are higher in high sustainability development index (SDI) countries where both have been on the rise, which may be due to not only improved diagnostic procedures and heightened awareness but also possible because of the environmental and lifestyle changes of the growing industrialized and urbanized population. On the other hand, in low SDI (Sustainability development Index) countries, though the age-standardized incidence of schizophrenia has reduced significantly but the DALYs remain unchanged, which implies that there are problems in proper diagnosis and access to treatment.[3]

As per the report by Solmi and team,[3] the disease of schizophrenia is not distributed randomly across the population; different groups of people are affected in different ways. For instance, the burden of schizophrenia by sex shows that the male-to-female ratio is fairly constant but skewed more towards males in early adulthood and towards females after the age of 65, probably due to differences in age of onset and life expectancy. These demographic differences also indicate that specific approaches and healthcare solutions have to be developed to cater to the needs of the affected groups of people with schizophrenia.

Collectively, schizophrenia not only has a direct effect on sufferers but also has an enormous social and economic cost for families, communities, and healthcare providers. This burden can only be handled through enhanced public health measures, better access to care, and continued research on improved preventive and treatment measures.

Neurobiological Basis of Schizophrenia

Genetic Factors

A recent study by Tanrıkulu and Erbaş in the year 2020 has reported that schizophrenia is increasingly seen as a genetically influenced disease, as illustrated by family clustering and twin studies.[4] Although no specific gene can be named to be solely responsible for causing schizophrenia, many genes are linked to schizophrenia, which proves the fact that it is a polygenic disorder.[2,4] Genome-wide association studies (GWAS) has shown that there are several genetic markers that are linked to an increasing risk of schizophrenia, and many of them are related to neuro-development, synaptic transmission, and neurotransmission.[4]

Furthermore, some specific CNVs and de novo mutations have been found related to schizophrenia, thus suggesting that specific genetic changes are implicated in the development of schizophrenia.[1] However, the research done on the genetic architecture of schizophrenia has shown that the disorder is polygenic; therefore, the disease risk is multi-factorial and involves many genes and their interaction with the environment.[4] Understanding of the hereditary background of schizophrenia could offer substantial meaning for the definition of the disease's etiology and can contribute to the discovery of the new treatment approaches.

Neurotransmitter Imbalance

Schizophrenia has been known to involve abnormalities in neurotransmitter systems and the dopaminergic hypothesis has perhaps received more attention. This hypothesis postulates that the elevation of functioning of dopamine system in the mesolimbic pathway is the cause of the positive symptoms of schizophrenia, such as delusions and hallucinations. On the other hand, hypodopaminergic transmission in the mesocortical DA pathway is thought to underlie negative symptoms such as affective and motor deficit, anhedonia, asociality, and cognitive impairment in memory and executive function.[2]

Schizophrenia is also associated with other neurotransmitters, and thus, the neurochemistry of the disorder is more complicated. L- Glutamate, the

major excitatory neurotransmitter in the brain, is involved through the glutamate hypothesis. The hypofunction of NMDA receptors on glutamatergic neurons leads to a variety of effects on the dopaminergic system, which might relate to positive and negative signs. Some of the facts that may be in support of this hypothesis are the fact that the administration of NMDA receptor antagonists such as ketamine can cause schizophrenia-like psychoses in normal individuals.[4]

Serotonin is also implicated in schizophrenia especially in the modulation of dopamine systems. Serotonergic changes include reduced levels and receptor density in subjects with schizophrenia, and the relationship between serotonin and dopamine is complex.[5] In this regard, it can be attributed to the serotonergic hypothesis since atypical antipsychotics are serotonin-dopamine antagonists. These medications can help with both positive and negative symptoms, which points to serotonin receptors, especially the 5-HT2A receptor, in the disorder.

Also, the use of other neurotransmitters, including gamma-aminobutyric acid (GABA), acetylcholine, and neuropeptides in schizophrenia, adds to the complexity and the neurochemical perspective of the disorder. It is reported that Impaired GABAergic system during schizophrenia might be due to cognitive impairments and changes in the brain networks. Further, cholinergic dysfunctions are associated with attention and memory impairments, which are cardinal features of the disorder.[6]

These multiple neurotransmitter dysregulations also emphasize the schizophrenia symptomatology's complexity and the need for extensive therapeutic interventions targeting the various neurotransmitter dysregulations.[5,6] Knowledge about these numerous and complex connections between neurochemicals is vital in an effort to create new and more specific approaches to the treatment of schizophrenia that can cause fewer side effects and improve the quality of life for those afflicted with the disorder.

Brain Structure and Function Abnormalities

Neuroimaging literature offers rich information regarding the structural and functional changes in brain of the schizophrenia patients. It has been revealed that a marked decrease in cortical, specifically prefrontal and temporal regions which are implicated in executive functioning, affect regulation and social reasoning.[5-7] Moreover, alterations of the connectivity have been reported, and thus, the neural networks involved in various cognitive and perceptual processes are assumed to be impaired. However, several other regions of the brain are also changed due to schizophrenia. Temporal lobes are generally involved in schizophrenia, especially the hippocampus and the amygdala. Neuroimaging research has also revealed the impaired structure of these regions and that they are less developed than in normal individuals.[6,7] Hippocampus dysfunction is related to memory and spatial impairment, while the amygdala may be involved in affective disturbances and mood changes.

Other sub-cortical areas implicated in schizophrenia include the thalamic nuclei, basal ganglia, and the ventral striatum. These areas are involved in the regulation of sensory input, motor control, and reward pathways. Dysfunction of basal ganglia-thalamo-cortical circuits has been found to be linked with the development of positive symptoms such as hallucinations and paranoid delusions.[8] The parietal lobes are the part of the brain that has a function in sensory integration, spatial orientation, and attention. Reduced parietal cortical function in schizophrenia has been reported and seems to be related to deficits in sensory information processing, visuospatial processing, and attention. The cerebellum is mostly associated with motor functions, yet it is also responsible for cognition and emotion.[6,7] Cerebellum is involved in schizophrenia, and there are structural and functional changes in the cerebellum that are involved in the etiology of the disorder. Discontinuity of the white matter, the fiber tracts, and connections have also been observed in schizophrenia. The Diffusion Tensor Imaging (DTI) analysis, as reported by Chee et al,[7] has revealed the alterations in the principal white matter tracts, including corpus callosum, cingulum bundle, and uncinate fasciculus, that are involved in the inter-hemispheric transfer and connection between the various brain regions.[7]

One of the more prominent neuroanatomical features is the hypofrontality, which is related to the cognitive deficits that are characteristic of schizophrenia. Such structural and functional modifications could be responsible for the several symptoms and the cognitive impairments observed in the disorder (5,6). Moreover, current research has indicated that metabolic disturbances, such as the impaired use of glucose in the specific regions of the brain, are part of schizophrenia's pathology, which enlarges the list of factors that contribute to the neurobiology of the disease.

Clinical Presentation and Diagnosis

Positive, Negative, and Cognitive Symptoms

Schizophrenia can be expressed in three different ways: Positive, Negative, and Cognitive and all these are useful in the diverse forms of schizophrenia. The positive symptoms include delusions, hallucinations, and disorganized speech and behavior; these are the apparent changes that are most likely to lead the affected person to a clinician. However, it is the negative symptoms, such as lack of initiative, loss of interest, and decrease in talk and emotional expression, that are extremely disabling and affect the quality of life by limiting social interactions. Also, there are cognitive impairments that include memory, attention, and executive functioning, which aggravate the disability aspect of schizophrenia and make its treatment and outcome even more challenging.[2,8]

The differential diagnosis of schizophrenia includes the systematic evaluation process that is intended to differentiate the disorder from other mental illnesses that have similar symptoms. The first issue is to

eliminate psychotic disorders secondary to substance use, as a number of substances, both legal and illicit, as well as prescription drugs, may cause symptoms similar to schizophrenia. Schizophrenia-like psychotic disorders include mood disorder with psychotic features, bipolar disorder, and major depressive disorder with psychotic features. Schizo-affective disorder and delusional disorder should be considered for the same reason, as they are also psychotic disorders that share some features of schizophrenia. Hence, neurodevelopmental disorders like ASD may manifest social and communication impairments that resemble negative symptoms of schizophrenia and, therefore, require careful differential diagnosis. Furthermore, one can observe psychotic symptoms in neurodegenerative disorders, brain tumors, autoimmune encephalitis, and so on, so it is crucial to exclude organic causes. Schizophrenia is a complex disorder that requires a differential diagnosis, which involves a comprehensive analysis of the patient's history, psychiatric examination, neuroimaging, and laboratory tests to determine the cause of the disease and the correct therapeutic intervention.[9]

Diagnostic Criteria: DSM-5

The most recent version of the Diagnostic and Statistical Manual of Mental Disorders, the DSM-5, outlines the criteria for schizophrenia and outlines the symptom presentation necessary for classification. In order to be diagnosed, the patient must have at least two of these symptoms within one month. These symptoms include thought disorder, psychosis, disorientation, speech disorder, motor disorder, and others, such as deficit symptoms. However, the diagnostic threshold specifies that at least one symptom must be from delusions, hallucinations, or disorganized speech, which are the key features of the disorder. The DSM-5 criteria highlight the complex clinical picture of schizophrenia: that is why it is crucial to provide a detailed and comprehensive assessment of the patient to understand the peculiarities of the disorder and choose the most suitable treatment strategy.[2]

Pharmacological Treatments

First-Generation Antipsychotics

First-generation antipsychotics (FGAs), which were introduced as a revolution in the management of schizophrenia, marked a new era of drug-based treatment in mental health. This movement was led by such agents as chlorpromazine and haloperidol, which are early FGAs that changed the approach to managing psychotic disorders. These medications work by activating dopamine D2 receptors in such a way that, while reducing the torment of positive symptoms like delusions and hallucinations, they improve the quality of life of those suffering from schizophrenia. However, there is a problem with using FGAs; the appearance of EPS, especially tardive dyskinesia, has limited the application of FGAs. However, the side effects of sedation and anticholinergic effects of these drugs add to the challenges of their use, hence the importance of monitoring and proper dosage. Nevertheless, FGAs were to mark a revolution in psychiatric treatment; they paved the way for the deinstitutionalization of several thousands of patients and helped them to be relocated to the community. However, the introduction of FGAs marked the beginning of a new era in the treatment of schizophrenia that shifted away from the focus on containment to the concept of outpatient treatment and the chance to reintegrate individuals with schizophrenia into society.[10]

Second-Generation Anti psychotics

Second-generation anti psychotics (SGA), which were once believed to be a breakthrough in the pharmacotherapy of schizophrenia, have risen to the expectation of patients and clinicians as a hope for those suffering from the severe manifestations of the disease. These drugs, including clozapine, risperidone, and olanzapine, are good examples of SGAs with different pharmacodynamics and a broader therapeutic spectrum. Unlike the FGAs, the second-generation ones do not solely rely on dopamine blockade and instead incorporate the modulating effect on the serotonin receptors. This expanded receptor involvement makes SGAs the only class of antipsychotics capable of addressing both the positive and negative symptomatology of schizophrenia, which means that they provide a comprehensive treatment for this disorder that goes beyond the scope of pharmacological treatment.

Nonetheless, the rise of SGAs is not without its problems: despite their proven efficacy, these medications are not without their issues, primarily metabolic side effects. The risk of weight gain, development of diabetes, and dyslipidaemia are looming large. Hence, careful monitoring of these patients and timely implementation of preventive measures are the need of the hour to prevent the emergence of these undesired metabolic complications. However, these are great challenges that have to be faced when identifying the value of SGAs in the treatment of schizophrenia. The introduction of SGAs has indeed offered patients of schizophrenia a new hope for better prognosis and quality of life. However, the use of SGAs marks the beginning of a new generation of schizophrenia pharmacotherapy that is grounded on the more profound knowledge of the disease's etiology and focuses on the individualized approach to the treatment of schizophrenia.[11]

Newer anti-psychotics such as aripiprazole, brexpiprazole and cariprazine are part of the third-generation anti-psychotics and can be considered a major improvement in the pharmacological management of schizophrenia. These medications are characterized by their mechanism of action, which is mainly based on dopamine D2 receptor partial agonists, which means that they do not completely block dopamine, as in the case of first- and second-generation anti-psychotics.[11] This partial agonism assists in the treatment of both positive symptoms like hallucinations and delusions and the negative symptoms like social isolation and apathy, as well as

limiting the extra-pyramidal side effects that were characteristic of the first-generation anti-psychotics.[10] Also, third-generation anti-psychotics are reported to have a better metabolic effect and a lesser chance of causing significant weight gain and metabolic issues that are common with second-generation drugs.[11] These drugs are beneficial in making long-term management of schizophrenia more effective and tolerable to patients, thus improving the overall prognosis and quality of life for the patients.

[Figure 1] depicts a schematic algorithm for the treatment of schizophrenia.[9,10] This provides a structured approach to the treatment of schizophrenia, emphasising initial assessment, sequential treatment steps, consideration of treatment-resistant options, and the importance of personalized and adjunctive treatments. Regular monitoring and adjustments are crucial to ensure the best outcomes for patients.

Psychosocial Interventions

Cognitive Behavioural Therapy

Cognitive Behavioural Therapy for psychosis (CBTp) is a specific, brief psychotherapy for schizophrenia that focuses on the patient's cognition and behavior and aims at assisting the patient in differentiating between what is real and what is perceived. CBT aims to modify thought processes that underlie emotions and behavior; patients are encouraged to replace negative thoughts. Because cognitive distortions are a central tenet of CBT, this treatment approach can successfully lessen distress triggered by hallucinations and delusions and teach patients new, less distressing ways to interpret these experiences.

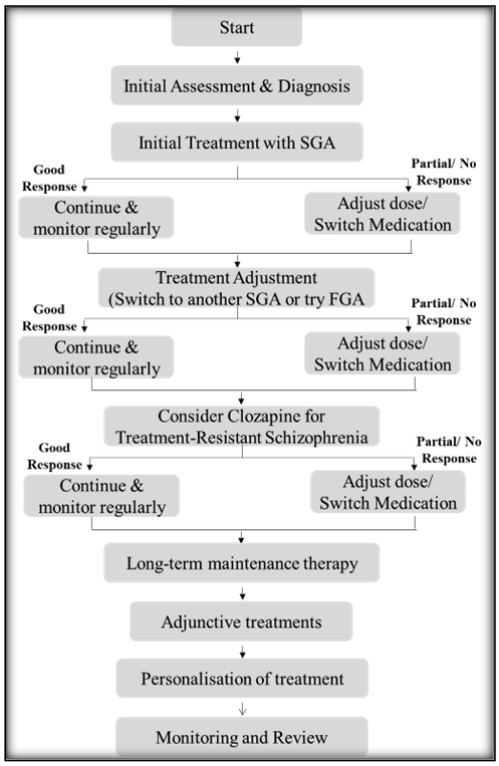

Figure 1. Algorithm for Schizophrenia Treatment (9, 10)

While the impact on the primary positive symptoms, such as hallucination and delusion, is relatively small, CBTp reduces the suffering associated with these symptoms. CBTp with pharmacotherapy has been demonstrated to increase overall functioning, so patients are better able to perform basic as well as social tasks. Research has shown that even a small recovery in the QoL and daily functioning is possible, and it is sustained even after the completion of treatment.[12] While the effect size for the treatment of core schizophrenia symptoms may not be large, the reduction in distress level and the improvement in functional outcome underline the importance of CBTp as a part of the treatment.

Family Therapy

Schizophrenic family therapy is the integration of the family members in the treatment process with the main goal of enhancing the general living conditions of the patient. This therapeutic approach involves focusing on the family and especially the interaction that may.

SGA: Second-generation antipsychotics; FGA: First-generation antipsychoctics be influencing the patient's condition. Family therapy helps develop a favourable environment of communication among family members. Enhanced communication ability enables the family members to appreciate the situation that the patient goes through and the assistance that they require so that there is less conflict between the family members.

Another advantage of family therapy is its effectiveness in decreasing the rates of relapse. When families are educated about schizophrenia, patients' problem-solving skills are enhanced, and critical or hostile communication is minimized, the frequency of relapses and hospitalizations is reduced. Parental participation in therapy has been associated with compliance with the medication and other treatment schedules. When family members are more supportive, patients are more likely to adhere to the treatment recommendations, meaning that symptoms will be less severe and the prognosis will be better.[13] In conclusion, incorporating family therapy into the patient's treatment plan not only benefits the patient but also enhances the role of family members as active participants in the healing process and helps create a healthier environment in the home.

Neurostimulation Techniques

Among other neurostimulation procedures, repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS) are gradually recognized as additional therapies for schizophrenia. These non-invasive interventions present potential approaches to treat negative and cognitive symptoms by regulating neural activity and the brain's connectivity and functioning. Studies regarding rTMS have established that it has an impact on reducing the negative symptoms of schizophrenia, like withdrawal from society and lack of motivation, and at the same time, has a positive influence on cognitive abilities like memory and other higher

cognitive functions. This technique involves the use of magnetic fields to activate certain parts of the brain. Transcranial direct current stimulation (tDCS) uses a low-voltage electrical current to modulate the identified areas in schizophrenia. Researchers indicate that tDCS can improve cognition and decrease negative symptoms through the facilitation of neuroplasticity and the regulation of aberrant neural circuits. Altogether, these neurostimulation techniques seem to emerge as beneficial supplements to pharmacotherapy, contributing to alleviation of symptoms and, likely, enhancing the overall functional recovery in schizophrenia.[13]

Cannabinoids in Treatment

Cannabinoids (CBD), which is one of the cannabinoids, have attracted interest as a possible antipsychotic medication. Initial research shows that CBD might alleviate some of the symptoms of schizophrenia with fewer side effects. This study indicates that CBD might alleviate psychotic signs and boost cognitive performance in contrast to conventional antipsychotic drugs with significant side effects. This includes the degree of thought disorder, delusional beliefs, and social adjustment. CBD is relatively safe, and it has been reported to have fewer side effects than the conventional antipsychotic drugs. This characteristic may make it attractive for patients who get side effects from traditional treatments. However, these early results need to be viewed with caution because the literature on CBD's effectiveness and safety in relation to typical antipsychotics is still rather scarce. Further, it is possible to conduct larger and more methodologically sound clinical trials that would support these initial observations and investigate the mechanisms of CBD's action in schizophrenia.[14]

Integrated Treatment Approaches

Multimodal Treatment Programs

Such treatment programs are comprehensive in an attempt to address schizophrenia because the disorder is complex. These programs do not only focus on the pharmacological management of the patient, but also, use a combination of therapeutic approaches to manage the different facets of schizophrenia in the identified clients. Medication management in these programs is not only limited to administering antipsychotic medications but also entails the evaluation of the drug's efficacy and making any necessary changes to the dosage or administration to reduce the side effects and to achieve the best results. Psychotherapy is a significant component, and effective treatments include cognitive-behavioural therapy and cognitive remediation therapy aimed at helping the patients cope with the symptoms, recognize and dispute the maladaptive beliefs, and develop strategies for dealing with the difficulties in daily life. Moreover, skills training programs aim at improving interpersonal and vocation skills in order to help the patients to manage their interpersonal relationships, education, and employment as well as to be independent. Social support is another important factor; family therapy sessions, support groups, and the availability of resources enable the patient to find support during the difficult periods of the disease and avoid social isolation. Along similar lines, Vancamport and group underline the importance of multimodal treatment programs that are more individualized and comprehensive in their approach and can result in substantial changes in the symptoms, functional status, as well as quality of life of schizophrenic patients.[11]

Personalized Medicine in Schizophrenia

It can be regarded as a shift from the conventional uniform method of treatment of schizophrenia to patient-specific treatment. Personalized medicine, then, stems from the understanding that schizophrenia is a heterogenous disorder that presents clinically and has variable treatment responses and prognoses among patients. Genotyping has become one of the significant factors in this approach, where clinicians can determine the genetic factors that may be linked to the response to particular treatments or the ability to tolerate certain side effects.

Some clinicians, like Jameei et al,[6] are able to use a patient's genetic makeup to determine which antipsychotic medication will most likely be effective and have minimal side effects in that particular patient. Neuroimaging findings and blood biomarkers provide further information on disease progression and treatment response and help in the management of the patient. Clinical severity which takes into account factors like symptoms, duration of a disease, and presence of other diseases, adds to the specificity of treatment by matching it to the patient's clinical characteristics. With the ongoing development of the concept of personalized medicine, new insights into the genetics of schizophrenia, innovative neuroimaging techniques, and the possibilities of big data analysis in the near future may further refine the treatment of schizophrenia and increase the quality of care for people with this severe disorder.[10]

Emerging Role of Telemedicine in Schizophrenia

There are a number of factors that make it difficult for people with schizophrenia to access health care, these include; geographical access, cost and social or cultural access. These challenges mean that patients receive their diagnosis later; they have fewer treatment choices and cannot effectively manage symptoms, all of which worsen the disease's impact. It is with regard to telemedicine as a solution to these barriers to access and to enhance the delivery of care for the patients with schizophrenia.[15] In reaching out to patients through consultations, assessments, prescription of drugs, and even individual and group therapy sessions through technology, telemedicine provides more comfort, mobility, and access to mental health care. Also, telemedicine can reach out to individuals in remote or hard to reach areas where there may be a lack of access to psychiatric services. In the same regard, Sharma & Devan,[16] suggest that telemedicine can help to eliminate the social prejudices towards mental health treatment because

the individual can attend the session from the comfort of their home. Nevertheless, some issues are still present, such as patient's data confidentiality and protection, technology-related issues, and the therapeutic relationship in online practice.[17] Nevertheless, the use of telemedicine in schizophrenia care is a promising approach for delivering adequate care, increasing the efficacy of the treatment, and increasing the quality of life of the patients with this severe and frequently disabling condition.

CONCLUSION

All in all, schizophrenia is a poly-etiological and heterogenetic disease that is dispositional to multiple genetic, neurochemical, and psycho-social factors. At present, the origin and the mechanisms of schizophrenia are still unknown, although more than one hundred years of research have been conducted on this disorder, which again underlines the necessity of further research and the development of new diagnostic methods and treatment strategies. Recent research in genetics, neuroimaging, and neurotransmitters has provided a greater insight into the neurobiology of schizophrenia, providing evidence of the genetic vulnerability, neurotransmitter dysregulation, and structural and functional brain anomalies in the etiology of the disease.

Schizophrenia is characterized by positive, negative, and cognitive symptoms that are all features of the illness, which adds to the complexity of diagnosis and differential diagnosis of the condition. The pharmacological treatments, such as first- and second-generation antipsychotics, provide only symptomatic relief but with considerable side effects; therefore, there is a need for individualized and comprehensive treatment strategies for patients with schizophrenia.

As for the current approaches, psychosocial interventions, neurostimulation techniques, cannabinoids, and personalized medicine seem to have the potential for bettering the clients' outcomes and increasing the overall level of care for individuals with schizophrenia. In the future, a more effective and coordinated approach to schizophrenia, which integrates new findings and follows the principles of personalized medicine, will improve the outlook and quality of life for people suffering from this severe psychiatric disorder.

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