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Single Photon Emission Computed Tomography (SPECT) as a Tool for Diagnosis and Treatment Analysis of Mood Disorders

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Systematic Review

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ABSTRACT

Background: The misdiagnosis rate for mood disorders is high. Psychiatric literature is in much need of a more objective and quantitative tool for the investigation of mood disorders. Although SPECT has been previously used in research for the understanding of the neuroscience behind depressive and bipolar disorders, it is a tool that remains underutilized in clinical settings.
Aims: To study the effectiveness of SPECT as a tool for diagnosis and treatment analysis of mood disorders.
Discussion: SPECT provides a significant insight into the neurochemistry of the brain during normal and abnormal functioning. The involvement of regional cerebral blood flow(rCBF) and serotonin transport (SERT) abnormalities as markers of mood disorders are theories that receive backing from single photon emission computed tomography (SPECT).

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Conclusion: This neuroimaging technique may be used a tool for differential diagnosis between mood disorders. Moreover, SPECT may be utilized to evaluate the effectiveness of treatment being provided to patients with mood disorders. Additional research to improve sensitivity and specificity of SPECT may encourage its further usage in clinical settings. The future of SPECT as a tool for diagnosis and treatment analysis of mood disorders looks promising.

Keywords: SPECT; single photon emission computed tomography; mood disorder; major depressive disorder; bipolar I; bipolar II; regional cerebral blood flow; rCBF; serotonin transport; SERT; perfusion.

1. INTRODUCTION

Mood disorders (Classified by ICD-10, F30-F39) are highly prevalent today. Globally, depressive disorders and bipolar disorders totally affect over 310 million people worldwide [1]. Widely accepted methods of diagnosing patients with mental disorders are based on the criteria provided in the Diagnostic Statistical Manual of Mental Disorders, 5th Edition (DSM-V) and International Classification of Diseases (ICD)-10 [2]. However, the rate of misdiagnosis in patients with mood disorders is very high. This may be attributed to the dependance on a clinician's subjective interpretation of the symptoms displayed by the patient for an accurate differential diagnosis [3].

Neuroimaging in outpatient settings could potentially revolutionize the diagnosis of mood disorders. Single photon emission computed tomography (SPECT), a technique used for neuroimaging, helps to identify, and correlate anatomical structures and their functioning in the brain by measuring their regional cerebral blood flow(rCBF) using a radioactive tracer [4,5]. [99mTc] ethyl cysteinate dimer (ECD) may be used as radioactive tracer [6]. The radioactive tracer is injected into the body and as the tracer decays, photons are emitted from the bodies which are picked up by a gamma camera [7]. Using this information, 3-D images of the brain are then to be generated which help locate regions of normal and abnormal perfusion activity [8].

SPECT has been previously used for detection of major depressive disorder and bipolar disorders in clinical trials but its usage for diagnosis of mood disorders in clinical outpatient settings remains limited [9]. SPECT scans, if found consistent in its pathophysiological findings and highly correlative with psychiatric evaluation of patients, can solve the problem of incorrect diagnosis and subsequently delayed effective treatment [10]. With research, it may be possible to explore the neurochemistry behind mood disorders more clearly.

2. AIMS AND OBJECTIVES

This review aims to study the effectiveness of SPECT as a tool for diagnosis and treatment analysis of mood disorders.

3. METHODOLOGY

Search Strategy: A search was performed on Pubmed with the terms: "Single photon emission computed tomography" OR "SPECT" AND "Mood disorders" OR "depressive disorder"[MeSH Terms] OR "bipolar disorder"[MeSH Terms]. Searches cover the period up to 18 April 2021. 104 articles were identified. Upon further review and exclusion of articles not relevant to mood disorders or single photon emission computed tomography, a total of 30 articles were included in the final review.

4. RESULTS AND DISCUSSION

Studies show that SPECT can be used as a tool for objectively measuring depression severity by studying the rCBF activity using radioactive tracers such as, but not limited to; [99mTc] ethyl cysteinate dimer (ECD) and ([^{123}I]-labeled((2-dimethylamino) methyl) phenyl)thio-5-iodophenylamine) etc. Observation of right hemisphere dominance in hypoperfused regions and slight left hemisphere dominance in hyperfused regions in studies provide clinical evidence for presence of depressive symptoms that correlate with the psychiatric evaluations made using Hamiltonian Rating Scale for Depression (HRSD) [11].

SPECT demonstrates a noteworthy relationship between the severity, duration and separate domains of symptoms of depressive disorders with specific rCBF patterns [12]. Comparison has also been established between perfusion levels in first depressive episodes versus recurrent

depressive episodes, the latter displaying notably more hypoperfusion in the same regions [13]. SPECT goes on to further extend its utility in the identification and differentiation of rCBF patterns associated in patients with MDD with and without psychotic features. Patients of MDD with psychotic features were found to have decreased rCBF in the right inferior frontal cortex as compared to that of patients with MDD without psychotic features [14]. Patterns of lower perfusion have been not only been identified for specific regions in depressive disorders but also for bipolar disorder mainly in anterior temporal regions bilaterally and left parietal area [15]. Additionally, SPECT can successfully differentiate between depression and cognitive disorders like dementia and those with both the comorbidities [16].

Comparison between positron emission tomography (PET) scan and SPECT scan on patients with depressive disorders has shown that 5-hydroxy tryptamine transporter (5-HTT) ligands tend to have low specific binding for SPECT [17]. PET scans may have an edge over SPECT scan in this matter owing to its higher specificity and sensitivity. Conversely, SPECT is seen to be particularly useful in that it presents gamma rays with longer half-lives and hence allows for longer periods of in vivo observations stretching up to a few days after the introduction of the radioactive tracer [18-19]. Additionally, it does not require a cyclotron for the generation of 3D images. Owing to these factors, it proves to be more cost effective than PET, increasing its potential as a viable option for clinical outpatient settings [20].

SPECT may also be used as a marker of the efficacy and mechanism of action of the treatment being provided as in the case of cognitive therapy and happiness training, transcranial magnetic stimulation (TMS), medications and electroconvulsive therapy (ECT) [21]. Further, SPECT may serve as a guide for deciding the site of stimulation for TMS for better and more precise treatments. SPECT findings have also led to focus on the role of serotonin transporter (SERT) as a potential biomarker for differential diagnosis between bipolar I and bipolar II and for diagnosis of MDD. Lower SERT distribution volume ratio (DVR) findings in the midbrain, medial temporal lobe, and the left and right basal ganglia confirm association of SERT binding in depressive disorders [22-26].

5. CONCLUSIONS AND RECOMMENDATIONS

Mood disorders are quite complex in their pathophysiology and response to treatment is inconsistent. More research is required to develop better clarity on the neurochemistry behind mood disorders. Neuroimaging techniques like SPECT may prove to be the required tool for this very research. SPECT has helped identify that rCBF and SERT DVR are important highlighters of the normal or abnormal functioning of the brain. Common patterns indicating the presence of mood disorders have been detected. This may serve as a tool to reduce the high misdiagnosis rate of mood disorders as it provides a more objective and quantitative perspective on the state of the patient.

Neuroimaging with the help of SPECT has the capability to not only diagnose individuals with mood disorders but also be a marker of the efficacy of treatment being prescribed to them. It has proved its mettle as a tool for diagnosis for depressive disorders as well as bipolar disorders. It also aids in differential diagnosis between MDD with psychotic features and MDD without psychotic features, bipolar I and bipolar II, first depressive episodes and recurrent depressive episodes. It has also helped in analyzing changes in the brain upon various modalities of treatment such as cognitive therapy, TMS, drug-based medications and electroconvulsive therapy. Further modifications and advancements in SPECT to increase its capacity for sensitivity and specificity may make it a more efficient tool for clinical settings by providing enhanced neuroimaging. Its relative low cost and availability increases its prospect of usage in clinical settings in the near future.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Ethical clearance taken from institutional ethics committee

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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