Cannabidiol provides viable treatment opportunity for multipleneurological pathologies of autism spectrum disorder

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Abstract

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental disorder affecting over 1% of the general population. While it is well established that ASD stems from a combination of genetic and environmental factors, there are no defined mechanisms of pathogenesis, rendering curative therapy very difficult to establish. No effective therapy exists for ASD, presenting an urgent clinical need for better control of common core pathologies of ASD regardless of its etiology. Cannabidiol (CBD), a major phytocannabinoid constituent of the cannabis plant, is gaining significant attention in both the media and in medicine for its antiepileptic, anxiolytic, and antipsychotic properties. Recent anecdotal reports, accumulating preclinical and clinical data, and mechanistic insights suggest that CBD provides a viable treatment opportunity for patients with ASD.

Introduction

Autism spectrum disorder (ASD), often characterized by impaired social interaction and communication, as well as repetitive and stereotypic behaviors, is one of the most common (~1/64 at births in US) and fastest-growing neurodevelopmental disabilities. The basic symptoms of ASD are often accompanied by other neurological deficits including, but not limited to: anxiety, mood disorder, sleep disturbance, as well as seizures. These medical conditions associated with ASD interact with each other and result in difficulty of any single symptomatic relief of ASD. Many patients must undergo a series of therapies, medications, and clinical visits in an attempt to alleviate some of the symptoms, which often causes economic and personal stress on the patient and their family. For this reason there is urgent clinical need to better manage multiple neurological pathologies of ASD simultaneously, and in so doing improve the quality of life of ASD individuals and their caregivers.

Cannabis has demonstrated its potential for the therapeutic treatment of a variety of ailments and diseases. The naturally grown plant contains over 80 different biochemical compounds called cannabinoinds, many of which share very similar chemical structures and active properties [1]. Cannabinoinds are often classified into three sub-groups: Phytocannabinoids, endocannabinoids, and synthetic cannabinoids. Phytocannabinoids are the cannabinoids that are found naturally in the cannabis plant, of which cannabidiol (CBD) is the 2nd most naturally abundant in the plant. CBD has been gaining increasing worldwide attention because of its broad therapeutic potential for providing neuroprotective, anti-inflammatory, anti-psychotic, anxiolytic, and anticonvulsant effects in both clinical and preclinical studies [2-8]. Recent anecdotal reports, accumulating animal and human research suggest that CBD provides a viable treatment opportunity for diverse developmental disorders, including ASD. Therefore, CBD holds the potential to simultaneously ameliorate seizures, anxiety, and motor behavioral deficits that are prevalent in ASD (Figure 1). In an open-label FDA expanded access study, Anderson et al. [9] showed that CBD was not only effective in treating seizures, but also had positive effects on measures of behavior, in a cohort of children with ASD [9].

Mechanism of action of CBD

Though the mechanism underlying the beneficial effects of CBD is still largely unknown, converging lines of evidence suggest dysregulated cannabinoid signaling likely could play a critical role in the pathophysiology of social functioning deficits in ASD [10]. Unlike psychoactive phytocannabinoid delta-9-tetrahydrocannabinol (THC), CBD displays low affinity but unexpectedly high potency as an antagonist of cannabinoid receptor 1/2 (CB1/CB2) in vitro, which likely accounts for its lack of psychotropic activity [11,12]. Contradictorily, CBD can exhibit an indirect effect on the CB1 receptors by inhibiting the degradation of the endocannabinoid anandamide [13]. However, the broad CNS benefits of CBD are likely a result of its complex pharmacological mechanisms. Besides cannabinoid receptors, CBD also interacts with many other, non-endocannabinoid signaling systems, including theequilibrium nucleoside transporter, the orphan G-protein-coupled receptor GPR55, the transient receptor potential of melastatin type 8 channels, the 5-HT1a receptor, the a3 and a1 glycine receptors, and the transient receptor potential of ankyrin type 1 channel [14]. The multiple mechanistic-targets of CBD make it a unique candidate for treating complex symptoms associated with a

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number of disorders, including ASD [15].

Anticonvulsant effect of CBD

Epilepsy is common (20-30%) in ASD and is more prevalent in individuals with autistic-like behavior resulting from particular genetic predisposition (e.g. Angelman syndrome, Rett syndrome, Dup15q syndrome, etc.). Animal models, possessing such genetic modifications, also exhibit CNS hyperexcitability, enhanced seizure susceptibility and/or spontaneous recurrent seizures. CBD exhibits potent anti-epileptic features in both clinical and preclinical studies [8,16-21]. Notably, CBD significantly reduced the frequency of total seizures of all types in a recent clinical trial for the treatment of drug-resistant seizures in Dravet syndrome [8]. The antiepileptic mechanisms of CBD are still unclear, but may involve multiple targets [14], which renders it an appealing candidate for complex and refractory epilepsy in ASD. Importantly, the anticonvulsant effects of CBD may be useful in suppressing explosive rage and calming severe anxiety. It is hypothesized that unrecognized partial complex seizures, which cause changes in consciousness but not muscular convulsions, are one source of autistic behavior disturbances [22].

Anxiolytic effect of CBD

Of children with ASD, 40% had at least one comorbid diagnosed anxiety disorder [23], which interacts with and exacerbates the other symptoms of ASD. Anxiety negatively impacts quality of life of ASD individuals and is associated with higher health care usage and other social costs [24]. Studies using a wide range of animal models of anxiety suggest an anxiolytic-like effect of CBD [2,4]. Interestingly, CBD reduced general anxiety in a bell-shaped dose-response curve, with anxiolytic effects observed at moderate but not higher doses [25-27]. CBD also alleviated stress-induced anxieties in mice. Acute administration of CBD reduces anxiety induced by restraint, re-exposure to a context that previously paired with foot shocks or predator stress [28-31]. Evidence from human studies also strongly supports the potential for CBD as a treatment for anxiety disorders. CBD reduced anxiety in a group of social anxiety disorder patients and was shown to regulate cerebral blood flow in limbic and paralimbic brain areas [4]. CBD also reduced anxiety induced by simulated public speaking in both healthy volunteers and patients with social anxiety disorders [32,33]. Consistent with animal studies, acute administration of CBD induced anxiolytic effects in healthy subjects with moderate (300 mg), but not lower (100 mg) or higher (900 mg) doses [34]. CBD can also attenuate anxiety related to sleep problems. Animal studies revealed microinjection of CBD into the central nucleus of the amygdala blocks repeated combination tests-induced rapid eye movement sleep suppression, probably through its anxiolytic effect [35]. A case study reported CBD decreased anxiety and improved the quality and quantity of sleep of a ten-year-old girl diagnosed with post-traumatic stress disorder (PTSD) [36]. The broad anxiolytic effects of CBD provide a unique treatment opportunity for the diverse anxiety phenotypes in ASD.

Wide-spectrum behavioral benefits of CBD

Animal studies suggest that CBD has a broad spectrum of behavioral benefits. CBD administration was found to rescue reserpine-induced motor and cognitive impairments, normalize MK-801-induced social deficits and hyperactivity, and attenuate THC-induced reduction in social interaction in rats [37-40]. Acute CBD treatment also protected against hippocampal cell death and improved cognition in mouse models of ischemia and cerebral malaria [41,42]. CBD can also reduce learned fear by decreasing fear expression, disrupting memory reconsolidation, and enhancing extinction in contextual fear memory paradigm as shown in a study involving mice [43]. These findings suggest CBD holds therapeutic potentials for ASD-related behavioral abnormalities.

Concluding remarks

Individuals with ASD typically face many challenges that worsen their quality of life, create a host of social and behavioral problems, can force their families into a reduced socioeconomic lifestyle, and potentially increase their risk of death. These individuals and their families currently have no available options to alleviate the devastating toll that this experience can have on them. It is for these reasons that there is a great need to find effective treatment options and explore the safety, efficacy, and tolerability, of this promising drug, CBD, for these desperate patients. Establishing, in a preclinical and clinical setting, the quality of life and other daily function changes that CBD could be causing in social behavior, cognition, or motor skills is important. Introduction of CBD into a regular treatment regimen could lead to significant reductions in their otherwise untreated symptoms. The evaluation of changes examined in sophisticated studies while participants are receiving CBD treatment is an important step in therapeutic testing of the drug and in understanding its potential.

Collectively, the pharmacologically broad-spectrum of CBD covers diverse neurological pathologies of ASD, thereby providing a unique and viable therapeutic opportunity to alleviate multiple core ASD symptoms simultaneously. The increasing interest and attention of its beneficial effects in controlling seizures, behavioral and mood disturbances of autism spectrum disorder (ASD) and other neuropsychiatric disorders highlights the potential of CBD as a multifaceted therapeutic candidate for these challenging conditions.
abnormalities in ASD call for systematic preclinical and clinical studies to reveal the mechanisms, efficacy, therapeutic spectrum and safety of CBD in ASD.

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