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Review article

A systemic review of evidence for the role of inflammatory biomarkers in bipolar patients

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ABSTRACT

Bipolar disorder (BD) is a neuropsychiatric disorder that is characterized by a phasic course of affective episodes interspersed with a euthymic state. Epidemiological, clinical, genetic, post-mortem and pre-clinical studies have shown that inflammatory reactions and immune modulation play a pivotal role in the pathophysiology of BD. It is conceptualized that biomarkers of inflammation and immune responses should be employed to monitor the disease process in bipolar patients. The objective of this systematic review is to analyse the inflammatory markers involved in human studies and to explore each individual

Abbreviations: ADHD, Attention Deficit Hyperactivity Disorder; ANCOVA, Analysis of Covariance; AITD, Autoimmune Thyroid Disease; α1-AT, α1-Antitrypsin; α1S, α1 Acid glycoprotein; BA, Broadmann's Area; BAD, Bipolar Affective Disorder; BD, Bipolar Disorder; BD+, Bipolar Disorder with subsyndromal symptoms; BD-, Bipolar Disorder without subsyndromal symptoms; BD I and BD Type I, Bipolar Disorder Type I; BD II and BD Type II, Bipolar Disorder Type II; BD-NOS, Bipolar Disorder-Not Otherwise Specified; BDNF, Brain-Derived Neurotrophic Factor; BRMRS, Bech-Rafaelsen Manic Rating Scale; BMI, Body Mass Index; CAD, Coronary Artery Disease; C3C, Complement Component 3; C3, 4, 6, Complement 3, 4 and 6, respectively; CC16, Clara Cell Protein; CCL, Chemokine (C-C motif) Ligand; CD, Cluster of Differentiation; CD40 L, Cluster of Differentiation 40 Ligand; CMI, Cell-Mediated Immunity; CRH, Corticotrophin Releasing Hormone; CRP, C-reactive Protein; CSF, Cerebrospinal Fluid; CVLT, California Verbal Learning Test; CVD, cardiovascular disease; CXCL, Chemokine (C-X-C motif) Ligand; DBP, Diastolic Blood Pressure; DNA, Deoxyribonucleic Acid; EDN1, Endothelin; ELISA, Enzyme-Linked Immunosorbent Assay; FASL, Fas Ligand; FAST, Functioning Assessment Short Test; Fb, Fibrinogen; GAF, Global Assessment of Functioning; GFAP, Glial Fibrillary Acidic Protein; GPx, Glutathione Peroxidase Activity; GM, Grey Matter; GM-CSF, Granulocyte Monocyte-Cerebrospinal fluid; HAM-D, Hamilton Rating Scale for Depression; HC, Healthy Controls; HDL, High Density Lipoprotein; HHV, Human Herpes virus; HPA, Hypothalamus-pituitary-adrenal; Hp, Haptoglobin; Hpx, Haemopexin; hsCRP, high-sensitivity C-reactive Protein; IL- Interleukin: IL-1β, Interleukin-1β; IL-R, Interleukin Receptor; IL-1R, Interleukin-1 Receptor; IL-1Ra, Interleukin-1 Receptor antagonist; IL1RN, Interleukin-1 Receptor Antagonist gene; Ig, Immunoglobulin; IgD, Immunoglobulin D; IgG, Immunoglobulin G; IgG1, Immunoglobulin G1; IgM, immunoglobulin M; IFN-α, Interferon-alpha; IFN-δ, Interferon-delta; IFN-γ, Interferon gamma; iNOS, inducible Nitric Oxide Synthase; LDL, Low Density Lipoprotein; MAPK, Mitogen-Activated Protein Kinase; MCP-1, Monocyte Chemotactic Protein-1; MDD, Major Depressive Disorder; MetS, Metabolic Syndrome; MHC Class II, Major Histocompatibility Complex class II; MIF, Macrophage Inflammatory Factor; MRI, Magnetic Resonance Imaging; mRNA, messenger Ribonucleic Acid; MyD 88, Myeloid Differentiation Factor 88; NF-κB, Nuclear factor kappa B; NLR, Neutrophil-Lymphocyte Ratio; nNOS, neuronal Nitric Oxide Synthase; NR-1, NR-2A, NR-2B, NR-3A, NMDA receptor subunits 1, 2A, 2B, and 3A; NT-3, Neurotrophin 3; OPG, Osteoprotegerin; PAS, Premorbid Adjustment Scale; PANSS, Positive and Negative Syndrome Scale; PBLs, Peripheral Blood Lymphocytes; PBMC, Peripheral Blood Mononuclear Cells; PCC, Protein Carbonyl Content; PCR, Polymerase Chain Reaction; PCR-RFLP, Polymerase Chain Reaction-Restriction Fragment Length Polymorphism; PCT, Procalcitonin; PHA, Phytohemagglutinin; PPI, Protein-Protein Interaction; PTX3, Pentraxin-3; Q-PCR, Quantitative or Qualitative Real Time Polymerase Chain Reaction; RBANS, Repeatable Battery for the Assessment of Neuropsychological Status: RNA; Ribonucleic Acid, RTPCR; Real Time Polymerase Chain Reaction, SBP; Systolic Blood Pressure, sCD4; soluble Cluster of Differentiation 4, sCD8; soluble Cluster of Differentiation 8, sCD14; soluble Cluster of Differentiation 14, sCD40L; soluble Cluster of Differentiation 40 Ligand, SCF; Stem Cell Factor, SCZ; Schizophrenia, SERT; Serotonin Transporter, sIL2R; soluble Interleukin-2 Receptor, sIL-6R; soluble Interleukin-6 Receptor, sP-selectin; soluble P-selectin receptor, SR; Suicide Risk, sST2; IL-33 soluble receptor, sTNF-R1; soluble Tumour Necrosis Factor Receptor 1, sTNF-R2; soluble Tumour Necrosis Factor Receptor 2, TBARS; Thiobarbituric Acid Reactive Substances, TC; Total Cholesterol, TfR; Transferrin-Receptor, TG; Triglycerides, TGF-β; Transforming Growth Factor-beta, TGF-β1; Transforming Growth Factor- β1, Th1; T helper cell Type I, Th2; T helper cell Type 2, Th17; T helper cell Type 17, TIMP-1; Tissue Inhibitor of Metalloproteinases-1, TIMP-2; Tissue Inhibitor of MetalloProteinases-2, TLRs; Toll-Like receptors, tm TNF-α; transmembrane Tumour Necrosis Factor-alpha, sTNF-α; soluble Tumour Necrosis Factor alpha, TNF-α; Tumour Necrosis Factor-alpha, TNF-R1; Tumour Necrosis Factor-alpha Receptor 1, TNF-R2; Tumour Necrosis Factor-alpha Receptor 2, TRAP; Total Reactive Antioxidant Potential, TSST; Trier Social Stress Test, UD; Unipolar Depression, VNTR; Variable Number Tandem Repeat, vWf; von Willebrand factor, WAIS; Wechsler Adult Intelligence Scale, WC; Waist Circumference, WCST; Wisconsin Card Sorting Test, WMS-III; Wechsler Memory Scale III, XCL1; Chemokine (X-C motif) Ligand, YKL-40; Chitinase-3-Like Protein 1, which derived its name from the 3 N-terminal amino acids and its molecular weight; YMRS, Young Mania Rating Scale.

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Mania
Depression
Biomarkers

marker for its potential clinical application and summarize evidence regarding their role in BD. A systematic review of human studies to measure inflammatory markers was conducted, and the studies were identified by searching PubMed/MEDLINE, PsycINFO, EMBASE, and Web of Science databases for peer-reviewed journals that were published until September 2015. In this review, we included peripheral markers, genetic, post-mortem and cell studies with inflammatory biomarker analysis in BD. One hundred and two (102) papers met the inclusion criteria. The pro-inflammatory cytokines were elevated and the anti-inflammatory cytokines were reduced in BD patients, particularly during manic and depressive phases when compared to the controls. These changes tend to disappear in euthymia, indicating that inflammation may be associated with acute phases of BD. Even though there are promising findings in this field, further clinical studies using more established detection techniques are needed to clearly show the benefit of using inflammatory markers in the diagnosis, follow-up and prognosis of patients with BD.
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1. Introduction

1.1. Bipolar disorder

Bipolar Disorder (BD) is a chronic, multifactorial and debilitating illness that is characterized by episodic illness with symptomatic recovery between episodes (Cetin et al., 2012). It has a global prevalence of 1.5–3% (Li et al., 2015). Although BD is a disabling mental disorder, not much is known about its pathophysiology. The current biological hypotheses on bipolar disorder in relation to pathophysiological processes come from genetics, systems of neurotransmitter and neurotrophic factors, neuro-inflammation, autoimmunity, cytokines, stress axis activity, chronobiology, oxidative stress, and mitochondrial dysfunctions (Sigitova et al., 2017). However, an increasing amount of data supports the involvement of immune and inflammatory pathways in BD. These pathways not only impact BD, but they also affect other neuropsychiatric disorders such as major depressive disorder (MDD), schizophrenia (SCZ), panic disorder and obsessive compulsive disorder (OCD) (Ortiz-Dominguez et al., 2007). Several lines of evidence confirm the role of pro-inflammatory cytokines in SCZ and MDD. In MDD, the most recent meta-analysis of serum pro-inflammatory cytokines confirmed that the soluble interleukin (IL)-2 receptor, IL-6 and tumour necrosis factor-alpha (TNF-α) levels are increased in MDD patients (Liu et al., 2012). The other cytokine meta-analysis for SCZ that accounted for antipsychotics showed that TNF-α, interferon gamma (IFN-γ), IL-12 and sIL-2R are consistently elevated in chronic schizophrenia independent of the

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