**DATA EXTRACTION BIOMARKERS**

*Extraction of Data Related to BioMarkers :-*

**Sources :-** [*https://medcraveonline.com/JSRT/emerging-biomarkers-of-congenital-heart-diseases-and-disorders.html*](https://medcraveonline.com/JSRT/emerging-biomarkers-of-congenital-heart-diseases-and-disorders.html)[*https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2773467*](https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2773467)[*https://www.mdpi.com/1422-0067/23/9/4993*](https://www.mdpi.com/1422-0067/23/9/4993)

Types of Biomakers explained in the scientific journal article:-

:- Hemodynamic, Physiological, Genetic, Molecular, Immunological, Clinical and Therapeutic biomarkers  
  
 “*Some of the above are explained below with proper example”*

1. Physiological Biomarkers  
  
Physiological biomarkers are measurable indicators of the body's functions or states, providing valuable information for diagnosing diseases, monitoring treatment response, and assessing overall health. They encompass various types, such as blood markers, genetic markers, imaging markers, and vital signs, enabling objective assessments and personalized healthcare interventions.

| **Biomarker Type** | **Examples** | **Sources** | **Applications** |
| --- | --- | --- | --- |
| Blood Biomarkers | C-reactive protein (CRP), glucose | Blood | Assess organ function, detect inflammation, diagnose diseases |
| Genetic Biomarkers | BRCA1, BRCA2 | DNA | Assess disease risk, personalize treatment plans |
| Imaging Biomarkers | X-rays, MRI, CT, PET | Imaging techniques | Detect abnormalities, assess organ function, monitor treatment |
| Vital Signs | Body temperature, heart rate, blood pressure, respiratory rate | Measurement devices | Assess overall health, detect abnormalities |
| ECG Biomarkers | Heart rate, rhythm, cardiac function | Electrocardiogram | Diagnose heart conditions, monitor heart health |
| Biochemical Biomarkers | Prostate-specific antigen (PSA), neurotransmitters | Bodily fluids (urine, saliva, CSF) | Diagnose diseases, monitor treatment response, measure physiological processes |
| Wearable Device Biomarkers | Activity levels, heart rate, sleep patterns | Wearable devices | Assess overall health, monitor physical fitness, identify trends or abnormalities |

2. Hemodynamic Biomarker

Hemodynamic biomarkers are measurements that provide information about the movement of blood in the body. They help doctors understand how well blood is flowing, how strong the heart is pumping, and if there are any blockages or problems in the blood vessels, which can be important for diagnosing and treating heart conditions.

| **Hemodynamic Biomarker** | **Definition** | **Role** |
| --- | --- | --- |
| Blood Pressure | Force exerted by blood against vessel walls | Indicates workload on the heart and resistance within blood vessels |
| Heart Rate | Number of heartbeats per minute | Reflects cardiac output and can be influenced by various factors |
| Cardiac Output | Volume of blood pumped by the heart per minute | Provides information about the heart's efficiency in delivering oxygenated blood |
| Stroke Volume | Volume of blood ejected from the heart with each beat | Indicates cardiac function and can be influenced by heart size, contractility, and more |
| Central Venous Pressure | Pressure in the central veins | Assesses fluid status and guides fluid management in critical care settings |
| Pulmonary Artery Pressure | Pressure in the pulmonary artery | Evaluates the right side of the heart, pulmonary circulation, and fluid balance |

3. Genetic Biomarkers

Genetic biomarkers are specific variations or patterns in our DNA that can give doctors clues about our risk of developing certain diseases or how we might respond to certain treatments. By studying these genetic markers, doctors can personalize medical care and make more informed decisions about our health.

| **Genetic Marker Type** | **Function** |
| --- | --- |
| Single Nucleotide Polymorphism (SNP) | SNPs are the most common type of genetic variation, where a single nucleotide differs between individuals. SNPs can be associated with disease susceptibility, drug response, and traits. |
| Microsatellites / Short Tandem Repeats (STR) | Microsatellites are short DNA sequences repeated in tandem. They are used for DNA profiling, forensic analysis, and population genetics studies. |
| Variable Number Tandem Repeats (VNTR) | VNTRs are DNA sequences consisting of repeated units of variable lengths. They can be used for genetic mapping and disease diagnosis. |
| Gene Expression Markers | Gene expression markers measure the activity of specific genes. They can indicate disease subtypes, prognosis, and treatment response. |
| Haplotype | A haplotype is a set of genetic variations inherited together. Haplotypes can be associated with disease susceptibility and population genetics studies. |

4. Molecular Biomarkers:-

Molecular biomarkers are specific molecules or substances found in the body that can provide information about the presence, progression, or risk of certain diseases, including congenital heart defects (CHDs). In the context of CHDs, molecular biomarkers can be used to aid in early diagnosis, predict disease severity, monitor treatment response, and assess the overall prognosis of individuals with CHDs.

| **Molecular Biomarker** | **Examples** | **Sources** | **Applications** |
| --- | --- | --- | --- |
| Genetic Markers | GATA4, NKX2.5, TBX5 | DNA (Blood, Tissue) | Assess risk, identify genetic causes, predict disease severity |
| Protein Biomarkers | Troponin T, Brain Natriuretic Peptide (BNP) | Blood, Urine, Tissue | Diagnose CHDs, assess cardiac injury or stress, monitor treatment response |
| MicroRNA | miR-1, miR-133, miR-21 | Blood, Tissue | Predict disease progression, identify subtypes, assess prognosis |
| Metabolomic Markers | Lactate, Glutamate, Citrate | Blood, Urine | Assess metabolic changes, identify biomarkers of disease subtypes |
| Oxidative Stress Markers | Reactive oxygen species (ROS), Malondialdehyde (MDA) | Blood, Tissue | Assess oxidative stress levels, evaluate cardiac damage |
| Inflammatory Markers | C-reactive protein (CRP), Interleukins | Blood, Tissue | Assess inflammation levels, identify immune system activation |

5. Immunological Biomarker:-

Immunological biomarkers in CHDs provide insights into the immune system's role in disease development, progression, and complications. They can help identify immune dysregulation,

inflammation, and autoimmune processes associated with CHDs.

| **Immunological Biomarker** | **Examples** | **Sources** | **Applications** |
| --- | --- | --- | --- |
| Cytokines | Interleukin-6 (IL-6), Tumor Necrosis Factor-alpha (TNF-α) | Blood, Tissue | Assess inflammation, immune response, and cardiac remodeling |
| Chemokines | CXCL8 (Interleukin-8), CCL2 (Monocyte Chemoattractant Protein-1) | Blood, Tissue | Indicate immune cell recruitment and inflammation |
| Autoantibodies | Anti-cardiac myosin antibodies, Anti-endothelial cell antibodies | Blood | Indicate immune responses targeting cardiac tissue |
| Cellular subsets | T-helper cells (Th1, Th2), Regulatory T cells (Tregs) | Blood, Tissue | Assess immune cell profiles and immune regulation in CHDs |
| Inflammatory Markers | C-reactive protein (CRP), Erythrocyte sedimentation rate (ESR) | Blood, Tissue | Indicate systemic inflammation and disease activity |
| Damage-associated molecular patterns (DAMPs) | High-mobility group box 1 (HMGB1), Heat shock proteins (HSPs) | Tissue, Blood | Reflect tissue damage and immune responses in CHDs |

6. Clinical Biomarkers : -

Clinical biomarkers are measurable characteristics or parameters that are directly observable or detectable through medical examinations or tests.

Clinical biomarkers for CHDs can include various measurements, imaging findings, and diagnostic tests. These biomarkers are used to assess and diagnose CHDs, monitor disease progression, evaluate treatment response, and determine prognosis.

| **Clinical Biomarker** | **Examples** | **Sources** | **Applications** |
| --- | --- | --- | --- |
| Echocardiographic measurements | Ejection fraction, Cardiac dimensions (e.g., ventricular size), Valve abnormalities | Ultrasound | Assess cardiac structure and function, diagnose specific CHD types |
| Electrocardiogram (ECG) findings | Heart rate, Rhythm abnormalities (e.g., arrhythmias), QT interval | Electrical activity of the heart | Assess cardiac electrical activity, detect conduction abnormalities |
| Oxygen Saturation Levels | Pulse oximetry measurements (SpO2) | Non-invasive device (e.g., finger probe) | Assess blood oxygen levels, screen for cyanotic CHDs |
| Cardiac Imaging Results | X-rays, Magnetic resonance imaging (MRI), Computed tomography (CT) | Imaging techniques | Visualize cardiac structures, detect abnormalities, aid in diagnosis |
| Biomarkers of Heart Failure | B-type natriuretic peptide (BNP), N-terminal pro-B-type natriuretic peptide (NT-proBNP) | Blood | Assess cardiac strain and heart failure severity |

7. Therapeutic biomarkers:-

Therapeutic biomarkers in the context of Congenital Heart Defects (CHDs) are measurable indicators used to guide and optimize treatment strategies for individuals with CHDs. By incorporating therapeutic biomarkers into clinical practice, healthcare providers can optimize treatment decisions and improve patient outcomes in the management of CHDs.

| **Therapeutic Biomarker** | **Examples** | **Sources** | **Applications** |
| --- | --- | --- | --- |
| Genetic Markers | Genetic variants affecting drug metabolism (e.g., CYP2C9, VKORC1) | DNA (Blood) | Personalize medication selection and dosing for optimal response |
| Protein Biomarkers | Brain Natriuretic Peptide (BNP), Troponin T | Blood | Assess cardiac function, guide heart failure treatment |
| Imaging Markers | Echocardiographic response to medication, Cardiac MRI findings | Imaging techniques | Monitor treatment response, assess changes in cardiac structure |
| Biomarkers of Inflammation | C-reactive protein (CRP), Interleukins | Blood, Tissue | Guide anti-inflammatory therapies, assess response to treatment |
| Metabolic Markers | Metabolites indicating drug metabolism or therapeutic efficacy | Blood, Urine | Optimize medication selection, monitor treatment response |
| Cardiac Remodeling Markers | Galectin-3, Matrix metalloproteinases (MMPs) | Blood, Tissue | Assess cardiac remodeling, guide treatment strategies |
| Biomarkers of Oxidative Stress | Reactive oxygen species (ROS), Antioxidant enzyme levels | Blood, Tissue | Evaluate oxidative stress levels, assess response to antioxidants |

List of Other Related Biomarkers Extracted Related to CHDs ➖

| **Biomarker** | **Explanation** |
| --- | --- |
| Cardiac troponins I and T (cTnI and cTnT) | Proteins released into the bloodstream when there is damage to the heart muscle. |
| Natriuretic peptides (BNP and NT-proBNP) | Hormones produced by the heart in response to increased stretching of heart muscle cells. |
| Galectin-3 | A protein involved in inflammation and fibrosis. |
| High-sensitivity C-reactive protein (hs-CRP) | A marker of systemic inflammation. |
| Beta-amyloid (Aβ) | A protein fragment that accumulates in the brain in Alzheimer's disease. |
| Tau protein | A protein involved in stabilizing microtubules in nerve cells. |
| Malondialdehyde (MDA) | A reactive compound formed during lipid peroxidation, indicating oxidative stress. |
| Advanced oxidation protein products (AOPP) | Products formed by the oxidation of proteins, indicating oxidative stress. |
| Isoprostanes | Prostaglandin-like compounds formed by the oxidation of lipids, indicating oxidative stress. |
| Protein carbonyls | Oxidized proteins that serve as markers of oxidative stress. |
| 8-hydroxy-2'-deoxyguanosine (8-OHdG) | A marker of oxidative damage to DNA. |
| C-reactive protein (CRP) | A protein produced by the liver in response to inflammation. |
| Tumor necrosis factor-alpha (TNF-α) | A pro-inflammatory cytokine involved in immune regulation. |
| Interleukin-6 (IL-6) | A pro-inflammatory cytokine involved in immune responses. |
| Interleukin-1 beta (IL-1β) | A pro-inflammatory cytokine involved in immune responses. |