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Departments Visited	**Date**
Clinical Pathology	05/02/2025
Medicine Rheumatology	07/02/2025

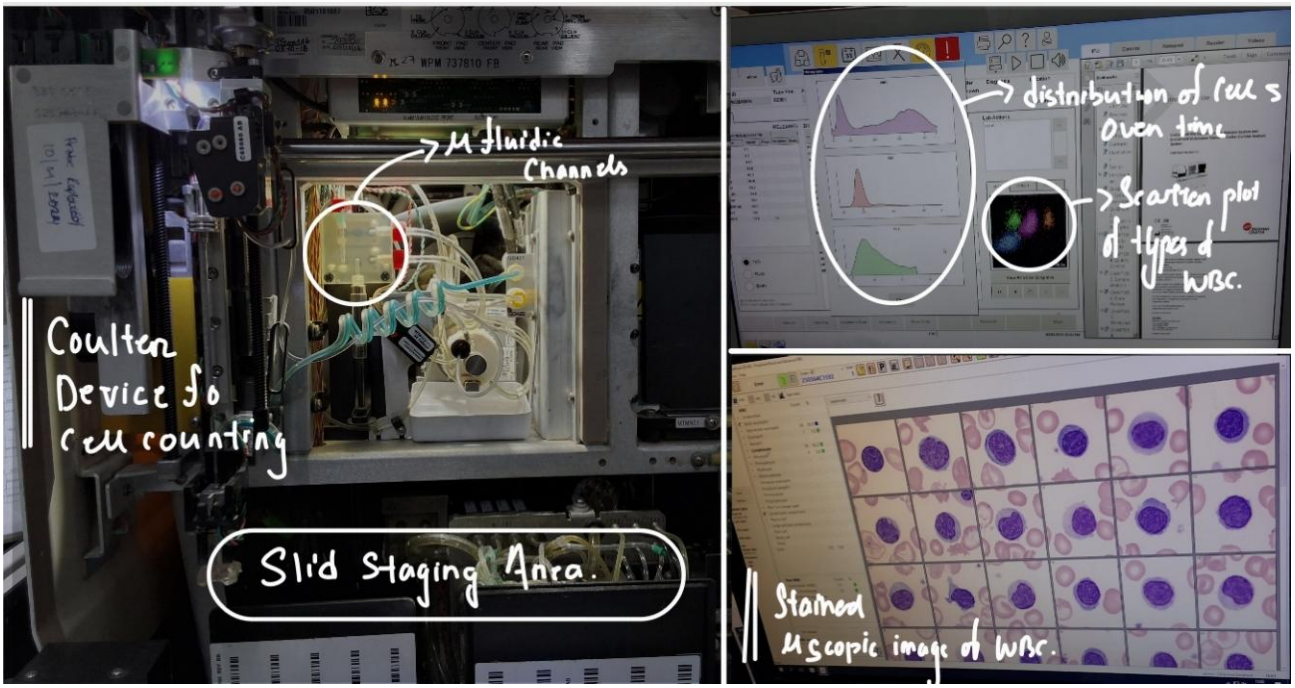
I have attached photos of our visit, which were clicked after permission from the guiding doctor, assistant & patient. The images will only be used for educational Purposes.

Clinical Pathology Department

Start Time: -14:18 | Clinician: - Sukesh Chandran and assistants | End Time: -17:30

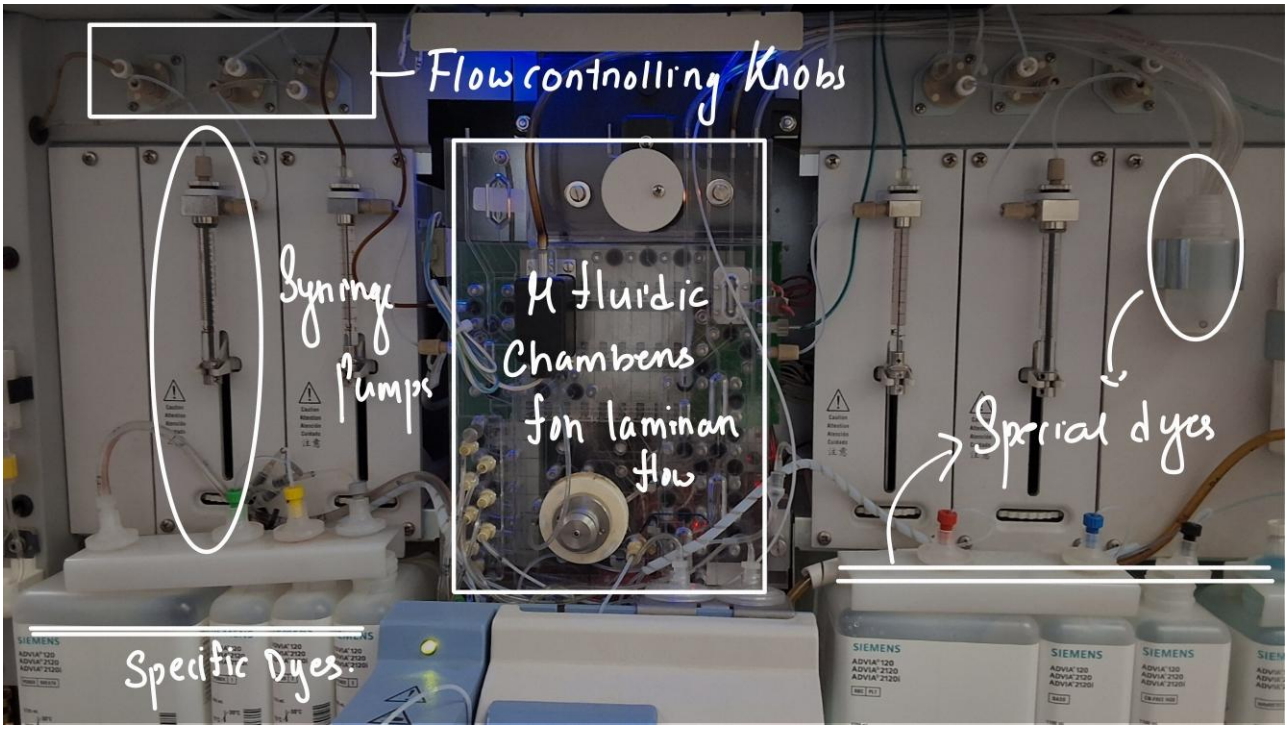
Blood Examination Room.

Clinical pathology involves the study of blood and its components to diagnose diseases, monitor health, and ensure safe medical procedures like blood transfusions. Basic blood investigations include tests for thrombosis (clot formation) and hemostasis (the body's natural process of stopping bleeding). These tests help detect blood clotting disorders, ensuring proper treatment for conditions like hemophilia or deep vein thrombosis. Blood banks play a crucial role in collecting, storing, and distributing blood, and they follow stringent protocols regulated by bodies like the Drug Controller General of India (DGCI). Before any blood transfusion, cross-matching is performed to check donor-recipient compatibility, reducing the risk of transfusion reactions. Advanced screening techniques using electronics and computers help identify blood group antigens, antibodies, and infections, ensuring safe blood donations and transfusions. Additionally, barcode scanning is implemented to maintain accurate tracking of blood samples and patient data.



Blood is composed of various essential components, including plasma, platelets, and clotting factors, which are critical for managing bleeding disorders and emergency transfusions. Tissue

typing, especially Human Leukocyte Antigen (HLA) analysis, is crucial in organ transplants, ensuring donor compatibility and reducing rejection risks. Another important aspect of pathology is blood cell counting, which is performed using the Coulter Principle—a method based on electrical impedance to differentiate blood cells. White Blood Cells (WBCs) play a crucial role in immunity, and their differential analysis helps diagnose infections and blood-related diseases. Meanwhile, Red Blood Cells (RBCs) undergo changes based on their surrounding environment; they swell in hypotonic solutions and shrink in hypertonic solutions, affecting overall blood stability. Additionally, flow cytometry, which utilizes lasers and staining techniques, enables single-cell analysis, making it easier to study blood composition in detail.



Temperature regulation is vital in blood testing, as improper storage can alter the properties of blood cells. Peltier devices help maintain precise temperatures to ensure sample integrity. Furthermore, hydrodynamic focusing in diagnostic machines ensures accurate blood analysis by aligning cells in a single stream for examination. This method, combined with laminar flow and capacitive changes, helps categorize different blood cells effectively. In clinical pathology, conditions such as postpartum hemorrhage (excessive bleeding after childbirth) are managed through uterine contractions and clotting factors, preventing severe complications. Similarly, allergic reactions involve the release of histamine, which triggers symptoms like swelling and inflammation, countered using antihistamines. The continuous advancements in biomedical sensors, microfluidics, and automated diagnostics are revolutionizing blood analysis, improving accuracy and efficiency in healthcare.

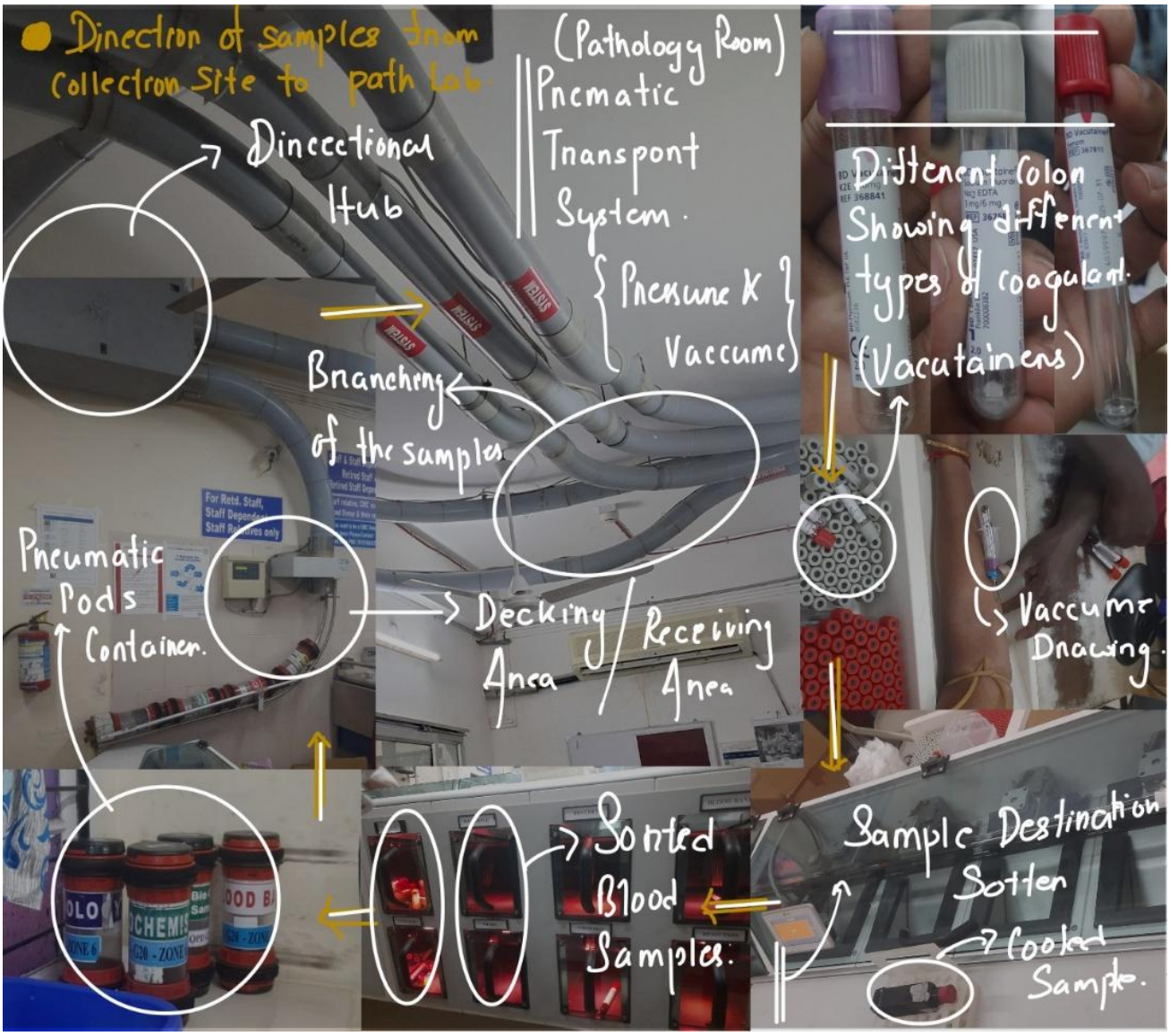
Blood Collection Room.

In the blood collection room, there were specially designed siting area for the pathologist to collect blood. The prescription has barcode and once scanned will give the exams needed to be conducted and for each exam separate barcodes will be generated with patients ID. Then the pathologist will take different vacutainer with proper color coding and the anticoagulant in it were present. The pathologist used a common syringe with changeable needle to draw the blood directly

into the vacutainer by suction. The amount of vacuum is directly related to the amount of blood needed to be collected. After blood collection a bunch of samples were collected and then were put into a sorting machine where it was sorted into different category based on barcode and then were dropped into separate bags. After that using pneumatic pumps and delivery system the containers were delivered to their desired department. (Pathology, biochemistry etc..). Then after analysis the results were uploaded to the web portal.

Blood Bank.

In the blood bank the donner must fill the forms according to the type of donner. Then the donner must give blood samples for preliminary blood tests. Once the tests are done and the patient passes the test, he/she must go the donner area and must lay down on the couch. Then according to the age weight and height fixed amount of blood Is collected and according to the sampling type either the whole blood or some components of the blood are taken. The blood bag is shaken properly regularly to prevent the coagulation. Then post processing is done to keep the blood samples in good condition and safe.



It also has a pneumatic system to send samples to different department for different tests. They have separate room for blood grouping and blood typing. The bloods after all the exams and tests are packed properly and are frozen till the patient comes.

Pathophysiology of Anemia

Anemia is a condition characterized by a reduced number of red blood cells (RBCs) or decreased hemoglobin levels, leading to inadequate oxygen delivery to tissues. Its pathophysiology involves three main mechanisms: impaired RBC production, increased RBC destruction, and excessive blood loss. Impaired RBC production occurs due to bone marrow failure, nutritional deficiencies like iron, vitamin B12, or folate deficiency, and chronic diseases such as kidney disease or cancer, which disrupt erythropoiesis. Hemolytic anemia results from intrinsic RBC defects, such as sickle cell anemia and hereditary spherocytosis, or extrinsic factors like autoimmune reactions, mechanical destruction, infections, or drug-induced hemolysis. Excessive blood loss, either acute (trauma, surgery, gastrointestinal bleeding) or chronic (heavy menstruation, slow GI bleeding), can also lead to anemia. The reduced oxygen-carrying capacity triggers compensatory mechanisms such as increased cardiac output and tachycardia, leading to symptoms like fatigue, weakness, dizziness, and shortness of breath. If prolonged, anemia can cause organ dysfunction due to persistent hypoxia.

Technology Used

Here the listed technologies were used for diagnostic and treatment purpose in the clinics.

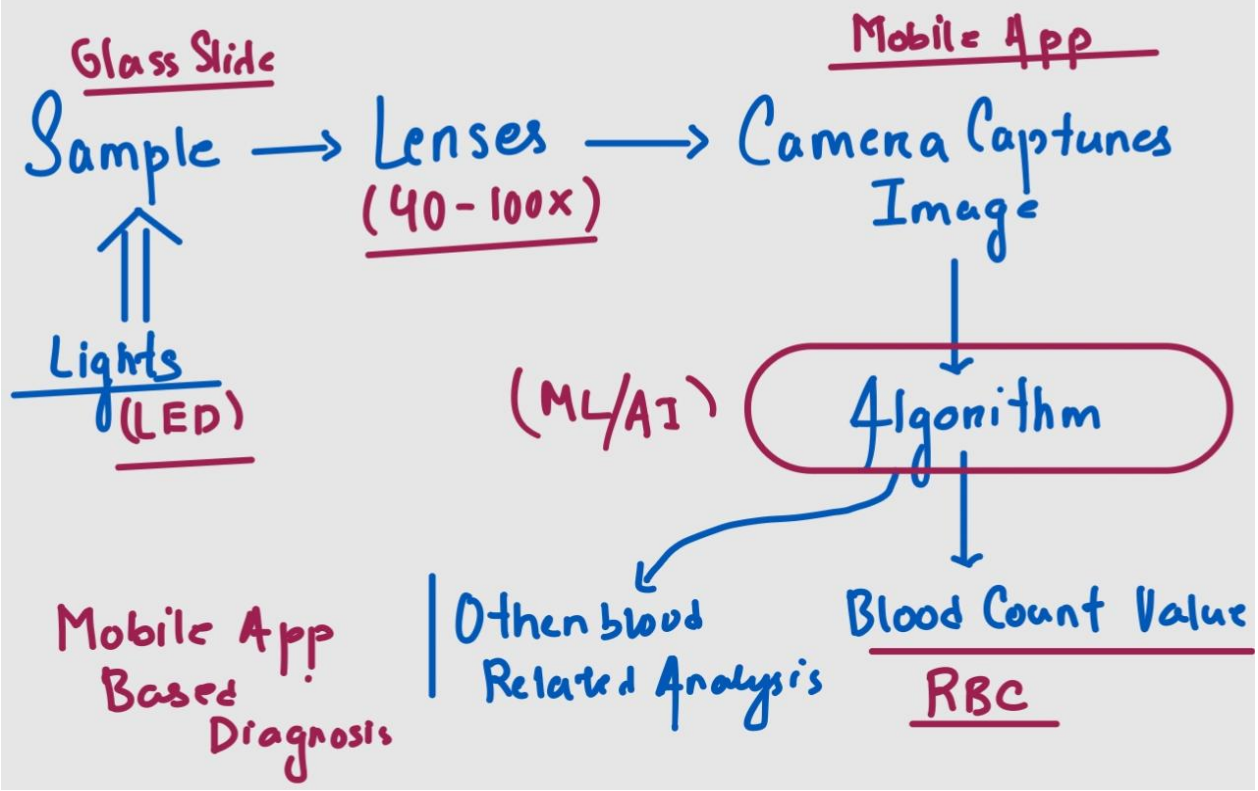
1. ***Pneumatic Pumps***
    a. ***Vacuum & Pressurized pipes***
    b. ***Branching system.***
2. ***Coulter Principle***
3. ***Microfluidics***
4. ***Capillary Action***
5. ***3 Part differential Counter***
6. ***5-part differential counter***

These were the main technologies used in the Clinical Pathology department.

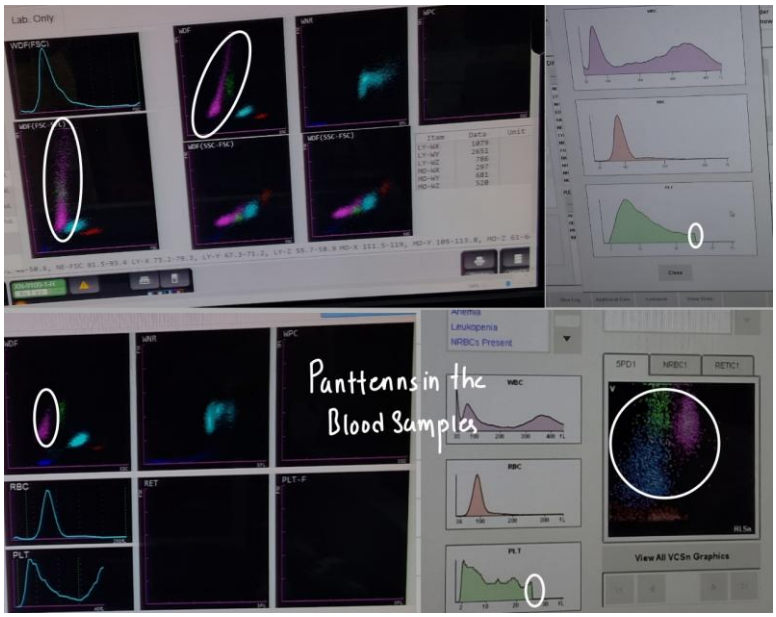
Limitations/Problems and their Solution.

Problem: Anaemia Mukt Bharat is a GOI India project which is to eradicate amimia from India. If we can develop a portable microscope with an Software based processing unit then we can diagnose a lot of patients.

Solution: The diagram illustrates a mobile app-based diagnostic system for blood analysis. A sample is placed on a glass slide and illuminated using LED lights. The image of the sample is magnified using lenses (40-100x) and captured by a camera. The captured image is processed using an algorithm, which incorporates machine learning (ML) or artificial intelligence (AI) techniques. This algorithm extracts relevant blood parameters, such as red blood cell (RBC) count, and may also perform additional blood-related analyses. The processed data is then used for diagnosis via a mobile app, enabling efficient and accessible blood testing.



Problem: The graphs in the cell counter and the different histograms shows some kind of information. Can we do something with it.



Solution: The graphs and histograms generated by cell counters provide valuable insights into blood sample characteristics, including normal and abnormal patterns. These visual representations can be leveraged to develop an AI-based diagnostic tool that predicts potential diseases based on blood sample variations. By collecting and labelling these patterns—such as changes in red blood cell distribution width (RDW), white blood cell (WBC) differentials, platelet counts, or haemoglobin concentration researchers can create a dataset for training machine learning models. Using techniques like image processing, feature extraction, and deep learning algorithms, the model can learn to recognize abnormalities indicative of conditions such as anaemia, leukaemia, or infections. Additionally, integrating this AI-driven analysis into software applications can enhance real-time diagnostics, aiding clinicians in early disease detection and improving patient outcomes. This approach not only automates the interpretation of complex haematological data but also provides a cost-effective and scalable solution for healthcare institutions.

Medicine Rheumatology Department

Start Time: -14:02 | Clinician: - Lokesh, Dr. Josna Joseph | End Time: -16:15

OPD Room.

Autoimmune diseases occur when the immune system mistakenly attacks the body's own cells, leading to organ damage and various disease types. Some common examples include Systemic Lupus Erythematosus (SLE) and Systemic Sclerosis, which can cause symptoms such as joint pain, fever, and skin thickening. Rheumatoid arthritis is another well-known autoimmune condition. Diagnosis is typically lab-based, where specific antibodies are detected using standard tests like ELISA and CLIA. The immune system destroys tissues by producing antibodies, and in severe cases, immunosuppressant drugs are used to slow down its activity. Antiphospholipid Syndrome (APLA) is another autoimmune disorder that leads to blood clot formation, affecting multiple organs. For certain diagnostic procedures, vein detection is used, particularly in nerve biopsies. Additionally, masks are sometimes considered a cost-effective solution in clinical environments.

The discussion highlights the need for better quality masks and improvements in clinical workstations. It mentions self-injectable treatments, which require cold storage and must be administered at specific time intervals. Vasculitis, a condition affecting the lungs and eyes, can lead to vision loss and respiratory issues, with symptoms lasting 5–7 days. A card-based system, such as an umbilical blood test, is mentioned, possibly for diagnostic purposes. Additionally, sample handling and storage efficiency are discussed, with over 10,000 samples being considered for safe storage over time. The document also touches on oxygen concentration monitoring for lifetime use and tracking needles and joint-related treatments.

Clinical Testing Room.

The discussion covers allergic reactions, autoimmune diseases, and immunodeficiency disorders, with a focus on rheumatoid arthritis as a progressive immune disease that can develop over eight years. Early diagnosis is emphasized, particularly through immunological elements such as PCR and next-generation sequencing (NGS) for genotyping. Associative studies link genetic markers to antigen-antibody interactions, forming the basis of disease detection using standard procedures like CLIA and ELISA. The topic also touches on the lack of Indian-specific diagnostic tools and the role of in vitro diagnostics (IVD) in differentiating between positive and negative results, both internally and externally. Additionally, gout and fibrosis are mentioned, with fibrosis being linked to collagen deposition.

The discussion highlights the use of 96-well plate devices in ELISA-based diagnostics, with a focus on indirect ELISA. Key considerations include cost and time efficiency in the process. ELISA techniques are categorized into qualitative and quantitative methods, each serving different diagnostic purposes. Additionally, software plays a crucial role in data interpretation, with an emphasis on interpersonal variability, indicating the need for standardized analysis to ensure accuracy and reliability.

Pathophysiology of Anemia

Autoimmune diseases arise when the immune system mistakenly attacks the body's own tissues, leading to chronic inflammation and organ damage. Genetic factors, such as HLA mutations, and environmental triggers, including infections and toxins, contribute to immune dysregulation. Key mechanisms include molecular mimicry, regulatory T cell dysfunction, and excessive cytokine release. Autoantibodies and autoreactive T cells drive tissue destruction, as seen in rheumatoid arthritis, lupus, multiple sclerosis, and type 1 diabetes. Chronic inflammation results in fibrosis and organ failure over time. Immunomodulatory therapies aim to suppress the overactive immune response, reduce inflammation, and prevent long-term damage, emphasizing the importance of early diagnosis and intervention in disease management.

Technology Used

Here the listed technologies were used for diagnostic and treatment purpose in the clinics.

1. ***PCR (Polymerase Chain Reaction)***
    a. ***RTPCR (Real time PCR)***
2. ***Cryopreservation***
3. ***Co2 Incubator***
4. ***Lateral Flow Assay***
5. ***Polarized Microscope***
6. ***Antigen Antibody Reaction***

These were the main technologies used in the Medicine Rheumatology department.

Limitations/Problems and their Solution.

Problem: Morning Stiffness monitoring.

Solution: Morning stiffness is a significant concern for individuals with rheumatic conditions, affecting mobility and daily activities. A smart wearable system can effectively monitor and manage this issue by integrating motion sensors, temperature detectors, and AI-based analysis. Wearable bands or rings equipped with accelerometers and gyroscopes track joint movement and stiffness levels, while infrared sensors detect localized temperature changes associated with inflammation. Bioimpedance sensors assess swelling, providing valuable data on fluid retention in joints. The device syncs with an AI-powered mobile app that analyses patterns over time, logs pain levels, and offers predictive insights for treatment adjustments. Additionally, built-in vibration therapy and heat stimulation can help improve circulation and reduce stiffness. The system also enables remote monitoring through telemedicine, allowing healthcare providers to adjust medications and recommend personalized exercises. This approach ensures real-time tracking, early intervention, and better management of morning stiffness, enhancing the patient’s quality of life.