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REVIEW ARTICLE

IMPORTANCE OF CLINICAL CHEMISTRY IN MEDICAL TREATMENT

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ABSTRACT: Clinical chemistry is a field of study in higher institutions offering laboratory medicine as well as an indispensable section of routine laboratory; it is generally concerned with the analysis of bodily fluids which includes serum, plasma, cerebrospinal fluid, urine etc. It is usually very busy due to the high need of individuals and the large number of tests comprised in it. Clinical chemistry is concerned with the analysis of body fluids to yield timely, relevant, accurate and precise information on clinical status of the human body. Some of the tests involved in Clinical Chemistry include liver function test kidney function test, hormonal assay, enzyme assay, tumor markers etc. The results of these tests help the clinician in treatment for the healthy society.

KEYWORDS: Clinical Chemistry, Importance, Test, Medical Treatment.

INTRODUCTION

In the medical world body clinical chemistry has become an indispensable area of laboratory medicine. Laboratory medicine on its own has proven to be the bedrock of modern medicine; it refers to the discipline involved in the selection, provision and interpretation of diagnostic testing that uses primarily samples from patients. The field includes research, administration and teaching activities and clinical service (Burtis *et al.*, 2008). Clinical chemistry; also known as chemical pathology, clinical biochemistry or medical biochemistry is a field under clinical pathology. It is concerned with the analysis of body fluids to yield timely, relevant, accurate and precise information on clinical status of the human body. It is usually very busy due to the high needs of individuals and the large number of tests comprised in it. Clinical chemistry is a field of study in higher institutions offering laboratory medicine as well as an indispensable section of routine laboratory; it is generally concerned with the analysis of bodily fluids which includes serum, plasma, cerebrospinal fluid etc.

Medical treatment is a fusing of two words "medical and treatment" Medical as a word means of or relating to medicine; the diagnostic, treatment and prevention of disease while treatment is known as therapy which is the attempted remediation of a health problem usually following a diagnosis (Coley, 2004).

Clinical Chemistry and medical treatment are so knit because the former searches the intrinsic and salient corners of human health; also it has developed very deep roots as a vital tool in diagnosis. There are more than a hundred analytes analyzed in clinical chemistry laboratory as well as pathophysiological conditions which are X-rayed too. Clinical chemistry has been an integral part of laboratory medicine as it dates back to as far as 1096 when the study of urine started. Dr. Douglas of university of Michigan opened the first chemical laboratory in 1844. The likes of Rudolph Virchow, Hermann von Fehling., Dr H.William among others (Jeanne, 1992; Dominiczak, 2000). Most routine tests in clinical chemistry were *ab nitio* performed manually but with the advent of automation, test s are performed on extremely sophisticated , computerized machines to detect the cause of some ailments. Hence, accurate Clinical chemistry laboratory diagnosis aids in accurate treatment and recovery of patients. Large amount of

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knowledge generated by clinical biochemistry was now being accepted into clinical practice across medical and surgical disciplines. The practically most important areas were the assessment of water and electrolyte metabolism and hydrogen ion homeostasis, which lead to diagnosis and treatment of an entire range of 'new' clinical disorders. Particularly important was the contribution of clinical chemistry to the diagnosis and monitoring of diabetes (with the introduction of glycated hemoglobin as a measure of time-averaged glycemic control) and the progress in understanding and treatment of diabetic coma (ketoacidosis). The importance of lipids and lipoproteins for public health increased enormously after the results of clinical studies showing the benefit of lipid lowering for cardiovascular risk had been published (Dominiczak, 1999). Finally, clinical chemistry became important contributor to the development and monitoring of intravenous nutrition.

HISTORY OF CLINICAL CHEMISTRY

Generally the beginnings of the hospital laboratory cannot be pinpointed. However; there were many individuals prior to World War I who helped lead the development of the modern clinical laboratory prior to 1990, a lot of individual made landmark invention and contribution to the development and advancement of clinical chemistry. During the middle Ages (1096-1438 AD), the study of urine helped in disease diagnosis as it was found that certain urine samples attracted ants and that such urine has a sweet taste.

Dr Douglas at the University of Michigan opened the first Clinical chemical laboratory and began laboratory instruction in 1847. Rudolph Virchow (1821-1902) found the archives of pathology in Berlin in 1847.Hermann van fehling, a German chemist, performal the first quantitative test for urine sugar in 1848 (Lindberg *et al.*, 1984). DR William H.welch taught the first laboratory course in pathology in an American medical school in 1878. He becomes the first professor of pathology at the John Hopkins university in 1885 (Thomas, 1989).

From the year 1900 to world war 11, pathologists and the clinical laboratories played a more major role in health care. Pathologyists learned much from treating the wounded of World War I, and they applied these techniques in civilian hospitals (Wolper and Pena, 1987). During the 1920's and 1930'state societies of clinical pathologists were formed. By 1936 pathologists had established the American Board of pathology, defined the requirements of specialty and were recognized by American Medical Association (AMA).

Post world war 11 advancement of clinical chemistry continued rapidly with new ideas and innovations. In the 1950's almost all clinical chemistry procedures were performed manually. The technologist would assemble a rack of specimen and several racks of empty test tubes. A sectioned drawer in the bench held a collection of pipettes

To process a specimen the Medical Laboratory Scientist reaches for a clear pipette and transferred the appropriate amount of serum to a clean test tube. He often made use of boiling water bath heated by burnsen burner. He then moved to a colorimeter or spectrophotometer and took a reading for each specimen then would record the reading on a log sheet perform the necessary calculations, and notes the results on the log sheet and the patients report (Baer, 1989). Today Medical Laboratory Scientists inspect printed result, record quality control data and perform routine instrument maintenances (Baer, 1989).

Levey and Jennings introduced their quality control chart to clinical chemistry in 1950. In1958, Freier and Rausch presented the first comprehensive daily quality control program for laboratories (Benson, 1989). Chromatography was discovered by Tswett in 1906 and led to the development of gas –liquid chromatography by Martin and James in 1952. Ouchterlong's radial immunodiffusion method in gel was described in 1949. Grabar and Williams used some of these principles to develop immunoelectrophotresis in 1953. In 1966 Laurell introduced "rock" immunoelectrophoresis (Dominiczak, 2011).

In 1957, Technicon introduced the first commercial continuous- flow automatic analyzer, the autoanalyzer designed by Leonard skeggs. This allowed for reliable, rapid analysis of several blood constituents within a reasonable amount of time. Larger multichannel automated instruments soon followed. The first radioimmunoassay method was developed based on the 1960 Berson-Yalow studies on the state of insulin plasma. With radioimmunoassay, concentrations of substances such as hormones, pharmaceutical agents and vitamins could be determined. Better understanding of diabetes mellitus soon followed. Other advances in laboratory medicine in the 1950s and 1960s include absorption spectrophotometry, flame photometry and atomic absorption. Computers became a major part of

clinical chemistry operations chiefly because of advances in technology. Ion-selective electrodes also began to appear in the early 1970s. Na^+ and k^+ electrodes followed in the later 1970s.

The 1990s had the introduction of other automated machines in the operation of the clinical chemistry laboratory. Most tests here have become fully automated, with the laboratorian only functioning to program the particular test to be run at a particular time. More revolutions which will go down in history are still taking place in clinical chemistry.

DIFFERENT APPLICATIONS OF CLINICAL CHEMISTRY

Clinical chemistry is basically applied in medical Science in the diagnosis, prognosis, and management as well as monitoring of diseases and ailments. Many different types of chemicals/analystes aid in the diagnosis of diseases, example creatinine is a waste product excreted by the kidneys. Analysis of this substance can be used to diagnose renal disease , likewise the study of enzymes in cell of different body tissues also can help identify damage or disease of specific organs, for instance, Lactate dehydrogenase (LDH) and creatinine kinase (ck) are enzymes used to identify heart disease and to monitor patients after a heart attack (Jeanne, 1992). The different application clinical chemistry tests are seen in a large array of tests which can be sub- categorized into sub- specialties, they are:

3.1. General or Routine Chemistry

This comprises commonly ordered blood chemistries via:

3.1.1. Liver Function Tests

They are run to check for liver diseases such as jaundice, cirrhosis, and biliary tree obstructions etc. the tests are grouped into enzymatic and non-enzymatic tests. Enzymatic tests include:

- Aspartate Transaminase (AST)
- Alanine Transaminase (ALT)
- Gamma – glutamyl Transpeptidase (GGT)
- Alkaline phosphatase (ALP)

And non-enzymatic tests are:

Total protein, which comprises

- Albumin
- Globulins
- Albumin/ Globulin ration
- Protein Electrophoresis
- Urine protein

Bilirubin Estimation, which Comprises

- Total Bilirubin
- Direct Bilirubin
- Indirect Bilirubin

3.1.2. Kidney Function Tests

These are of great importance in checking renal function and diseases for example Glomerular nephritis, kidney stone etc. they test include:

- Creatinine
- Blood Urea Nitrogen (BUN)
- Electrolytes via, Sodium, Bicarbonate, Potassium chloride, and Calcium.

3.1.3. Blood Glucose or Sugar Tests

This estimates the metabolic activities of sugars (carbohydrates) they include:

- Random Blood sugar tests (RBS)
- Fasting Blood sugar tests (FBS)
- 2–hour Post–prandial tests
- Glycated hemoglobin test
- Oral and Intravenous Glucose Tolerance Test (OGTT$ IGTT)

3.2. Special Chemistry

These are not routinely done and they require special equipment and automated machines such as Electrophoresis machines, automatic analyzers etc. Tests here are:

- Hemoglobin genotyping
- Cardiac marker tests via,
  - Troponin
  - Myoglobin
  - Creatine kinase- MB (ck-mg)
  - B-Type natriuretic peptide (BNP)
- Blood Disorders via,
  - Iron
  - Transferring
  - Vitamin B_{12}
  - Total Iron Binding Capacity (TIBC)
  - Folic Acid

3.3. Clinical Endocrinology

Hormonal tests have becomes common now with the advent of automation and immunological techniques. Such tests are carried out to ascertain the deficiency or excess of a single hormone or several hormones. The common tests are:

- Gonadal Hormones:
  - Follicle stimulating hormones (FSH)
  - Luteinizing hormone (LH)
  - Prolactin (Pl)
  - Progesterone
  - Estrogen, Estradiol

Testosterone

- Thyroid Hormones:
  Thyroid stimulating hormone (TSH)
  Thyroxine (T_4)
  Triiodothyronine (T_3)
  Calcitonine

- Prostatic Specific: Antigen (PSA) tests
- Growth hormone test (GH)
- Adrenocorticotropic hormone tests (ACTH)
- Insulin and Glucagon tests

3.4. Toxicology Tests

These tests are carried out to check the presence of drugs of abuse in a human system and for study purposes. Such drugs include Barbiturates, Amphetamine, methamphetamines, Benzodiazepines etc. The analytical methodology used is the Gas chromatography, mass spectrometry, immunoassays etc. Specimens used are Urine, serum, plasma or saliva.

3.5. Therapeutic Drug Monitoring

This is applied in the measurement of therapeutic medications blood levels to optimize dosage. Such drugs include analgesics, anticholinergic drugs, salicylate etc. specimen is usually serum, urine, or plasma and the method of analysis is by chromatography, Immunoassay etc.

3.6. Dipstick Techniques and Strip Tests

This is the quickest semi-quantitative method for analysis of a wide array of diseases. The stick or strip is embedded with reagents for the particular tests to be run. Example of such is the combin-9 or Combi-10. Tests run with this method use urine, serum, plasma, saliva, cerebrospinal fluid and effusions. These tests include

- Urinalysis; This checks for metabolites in a urine sample such as protein, nitrite, urobilinogen etc.
- Pregnancy tests; this checks the presence of an embryo, sample is serum, plasma or urine.
- VDRL testing; this is for the veneral disease syphilis. sample is serum or plasma
- HIV Test; this is for the virus that causes aids. sample used in serum
- *Helicobacter pylori*; this checks for the organism that causes stomach ulcer.
- HbsAg Test; this checks for the Hepatitis B virus in the serum or plasma of the individual

3.7. Serological Tests

These tests are helpful in directing diagnosis, they are almost like dipstick tests sample is serum or plasma the tests include:

- C-reactive protein (CRP)
- Rhematoid factor (RF)
- H. Pylori

3.8. Fecal Analysis

This is mostly for detection of gastrointestinal disorders. The tests include:

- Fecal Occult Blood Test (FOBT)
- Electrolyte estimations.
- Fecal Immunochemical Testing (FIT)
- Fecal Porphyrin Quantitation
- Fecal DNA test

In addition to gastrointestinal disorders, fecal analysis is useful in diagnosing colon and rectal cancers.

3.9. Lipid Profile Tests

This is a panel of tests carried out to check if an individual is at risk of cardiovascular diseases such as coronary heart disease; ischemic heart disease, arteriosclerosis. The tests are:

- Total Cholesterol (TC)
- Triglyceride (TG)
- High Density Lipoprotein (HDL)
- Low Density Lipoprotein (LDL)
- Very Low Density Lipoprotein (VLDL)

3.10. Cancer Marker Tests

These tests are run to check the blood, urine or the body tissues of substances that can be elevated in cancer, among other tissues. The tests are used as both diagnostic and monitoring tools. Tests here include:

- Alpha- fetoprotein (AFP)(for ovarian tumor)
- Prostatic-specific Antigen (PSA)(marker for prostate)
- Tumor M2-PK (marker for colorectal cancer)
- CA242 (for pancreatic cancer)
- PCNA (for brain tumor)
- CA19-9 (for pancreatic cancer)
- CA 15-3 (for breast cancer)
- CA -125 (for ovarian cancer) etc.

Clinical chemistry, apart from being so helpful in diagnosis, its use in research and study cannot be over emphasized. This is because many clinical chemists are deeply involved in research and development of new and innovative methods for running tests, as well as manufacturing of reagents and chemicals for running tests.

IMPORTANCE OF CLINICAL CHEMISTRY IN MEDICAL TREATMENT

Once diagnosis is not known, treatment of any sickness of diagnosis is disastrous because it is like the blind leading the blind. Treatment can only come after diagnosis. Therefore, clinical chemistry tests reveal what is hidden and not known to the physician. Without proper diagnosis, an individual may be receiving treatment for a disease not related in any way to the actual ailment. Example, an individual may be suffering from stomach pain or ache unless the right diagnosis is made. Treatment may be given for ulcer while the actual pain is due to hepatitis. In addition, tests here help the physician know the actual medication to administer to patient after tests have been run. It gives hope to both the patient and the physician because some patients suffer from diseases which are not known and because clinical chemistry has a wide array of tests, it shows what is hidden especially if a panel test is ordered. It dispels doubt over or about a particular condition. This is because nothing is hidden and as the tests are run the results are seen. It points the physician to the dose or type of treatment to give, because most of the tests are quantitative, semi-quantitative or qualitative.

CHALLENGES OF CLINICAL CHEMISTRY IN MEDICAL TREATMENT

The changes and advancements occurring in laboratory medicine generally are also causing some challenges in the utilization of clinical chemistry tests in medical treatment. These challenges range from economic to environmental factors, technological advancements etc. On a wider note, these challenges are as follows:

5.1. Economic and Environmental Challenges

- Legislation and regulation
- Personnel shortages
- Aging population
- Wellness concerns.

Clinical chemistry laboratory continues to be affected by many regulations and government legislation because of the all-encompassing and invasive nature of the tests carried out in the laboratory. Example is the enactment of the clinical laboratory Improvement Amendments (CLIA) of 1988, introduction of diagnostic- related groups (DRG) in 1983 amongst others. These actions result to limitations on reimbursement, cost containment, a focus on quality and improved efficiency. Due to the complex and precise nature of tests here, there is limited personnel involvement because a lot of brain-work is involved. Also, clinical chemistry has to adjust to an aging population which has come with an increase in some health conditions which has made wellness of the population a great concern to clinical chemistry (Ehrmeyer, 1990)

5.2. Focus on Quality Assurance

- Consumerism
- Handling of samples
- Test Reagents and kit.

As a result of increasing demands on clinical chemistry tests, there has been a stretch on the ability to satisfy the consumers which flocks in to have tests run. The main focus of these tests is to give the best of quality to the consumers at all cost. Samples from patients and individual which require being transported also pose a major challenge as some most times do not get to the laboratory in the right condition. Sensitivity of test reagents and kit, also affect the operations and running of test in the clinical chemistry laboratory as undue exposure to heat, air or moisture deteriorates them.

5.3. Alternative Site Testing

- Physician's office laboratory
- In-home testing
- Satellite laboratory
- Group- practice settings.

The last few years have seen an increase in the types and number of settings where laboratory tests are performed. Clinical chemistry tests are now performed in a variety of settings as listed above even hospital bedsides and in the home (Crowley and Oliver, 1989). While these alternative testing sites offer several advantages to consumers (e.g convenience, less expense, reduced waiting time), they also present problems. Particularly, there is concern about the quality of testing done at many of these sites (Podell and Zablotney, 1990). Also, the caliber of the personnel or persons handles the test. This has in many occasions resulted to patients been treated for what they are not suffering, some resulting to coma even death.

5.4. Advancement in Technology, Instrumentation and Testing

- Computers
- Robotics
- Nuclear Magnetic resonance
- DNA probes
- Immunoassays.

There is an increasing pressure for clinical chemistry laboratory to be more efficient and productive. However, technology offers a partial solution to this dilemma (Lifshitz and DE-Cresce, 1989). During the past few decades, this field of clinical chemistry has undergone a multitude of exciting changes related to technology. New technologies have been introduced to the clinical chemistry operation; these have not only caused a shift in the procedure for running tests also in the manner diagnostic results are computed. Many of these advancements are related to computer and robotics. Computer technology will continue to have an impact on every area of clinical chemistry operation such as laboratory information systems, diagnostic reports etc. Instead of numeric or textual reports, sophisticated graphic and interpretive reports will be available (Lifshitz and De-cresce, 1989). The use of robotics has also expanded, playing major roles in automating specimen handling processing clinical chemistry laboratory also has undergone additional changes in its many of diagnostic tests with the introduction of new diagnostic procedures such as DNA probe and nuclear magnetic resonance (NMR). These new advances have caused a lot of changes to the clinical chemistry laboratory, personnel and its operations at large (Bishop *et al.*, 1992). Despite all these challenges the clinical chemistry laboratory has brazened itself to meet up with all these advancements. By boosting its personnel, operations, space etc. Challenges are meant to be conquered and clinical chemistry laboratory is thread conquering to meet up with demands, upgrade its operations and not being left behind.

CONCLUSION

Clinical chemistry as a part of laboratory medicine has come to stay likewise the numerous diagnostic and prognostic tests run within its operations into the medical science and have become an indispensable tool in diagnosis. With its wide array of tests, one would see that every part of the human anatomy is touched. Clinical chemistry tests searches out what is hidden in the human because the samples which are used take their roots from the river of life which is the blood. Clinical chemistry tests may appear to be expensive or stretches the pocket, it worth is because what is not known becomes known having faced a lot of challenges, clinical chemistry in the medical field has surmounted and conquered all and is still waxing strong. A lot of care, accuracy, precision, hard work etc. is needed in this field, hence the sound training given to personnel and laboratorian.

The tests run in clinical chemistry laboratory are essential to life and its activities via assessing the functionality and integrity of body tissues, organs and system. Quality assurance is a major focus of clinical chemistry to give the best at any time and point. This is the reason why it is of great importance in medical treatment. The use of clinical chemistry as a diagnostic tool has helped in alleviating a lot of difficulties faced by physicians in administering treatment to patients. This is because most tests were done qualitatively *abinitio* but now with the advancement of technology, the tests now are done quantitatively to ascertain the actual quantity of a particular analyte. When diagnosis is established, this gives the physician the direction to go and the right step. *Abinitio*, some patients suffered from autoimmune diseases like rheumatoid arthritis, scleroderma, systemic lupus erythromatosus etc. since the actual tool for proper diagnosis was lacking, treatment was given blindly but with clinical chemistry and its advanced tests methods, the actual cause and sickness were established which aided treatment. Clinical chemistry is of great importance in medical treatment; it is all encompassing and cannot be over emphasized.

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