CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

One-dimensional fluid dynamical model predicting blood flow and pressure in the systemic arteries at any position along the blood vessels can be used to study the profile of the flow and pressure waves as they propagate along the arteries. Such models of vascular blood flow have previously been developed to model flow through relatively simple geometries by Pedly (1980), Stergiopulos *et al.* (1992), Olufsen (1999), Smith *et al.* (2002). Disruption of blood flow is the major cause of failure of organs in the human system. Diseases, such as stroke, are caused mainly by disruption of flow of blood in the human system. A stroke occurs when a blood vessel in the brain is blocked or bursts. Without blood and the oxygen it carries, part of the brain starts to die. The part of the body controlled by the damaged area of the brain can't work properly. There are two types of stroke; Ischemic and Hemorrhagic stroke. An ischemic stroke develops when a blood clot blocks a blood vessel in the brain while a hemorrhagic stroke develops when an artery in the brain leaks or bursts. This causes bleeding inside the brain or near the surface of the brain, which will lead to death if the situation is not arrested. Another disease that is strongly linked with stroke is diabetes. Individuals diagnosed with Type 2 diabetes are at double the risk of having a stroke compared to those without diabetes (Jerakaathil, 2007). Diabetes is related with imbalance of glucose in the human system. A correct glucose metabolism is one of the key factors in keeping a healthy state in mammals. Among other processes, this is accomplished mostly via regulatory action of hormones released by specific cell population inside the pancreas. A very relevant role is played in this process by the hormone, insulin, synthesized by the pancreatic cells. The normal blood glucose concentration level in humans is in a narrow range (70–110 mg/dl) (Makroglou *et al.*, 2005). Exogenous factors that affect the blood glucose concentration level include food in-take, rate of digestion, exercise, reproductive state, etc. The pancreatic endocrine hormones, insulin and glucagons, are responsible for keeping the glucose concentration level in check.

Computational methods have emerged as powerful tools for modeling blood flow vessel deformation in the cardiovascular system. Application in disease research, medical device design, and surgical planning have required increasingly sophisticated numerical methods ranging from closed-loop lumped parameter models to one-dimensional pulse wave propagation methods applied to fractal trees to three-dimensional computation fluid dynamic and fluid-structure interaction methods. Of these methods, lumped parameter models, based on solving system of ordinary differential equations in time and three-dimensional numerical analysis of blood flow based on solving the incompressible Navier-Stokes equations in rigid domains fail to include flow and pressure wave phenomena, and these are of clinical interest (Vignon and Taylor, 2006).

Blood flow and pressure waves in the cardiovascular system can be modeled solving the governing equations for an incompressible fluid in an elastic viscoelastic domain. At least three different approaches are possible. The first approach, the one-dimensional wave propagation method, involved solving the governing equations of blood flow in a one-dimensional domain and is based on the assumption that the dominant component of blood flow velocity is orientated along the vessel axis and that pressure can be assumed constant over the cross-section of the vessel. For the flow of a Newtonian fluid in a deforming impermeable, elastic domain, these nonlinear partial differential equations consist of the continuity equation, single axial momentum balance equation, a constitutive equation, and suitable initial and boundary condition (Hughes, 1973). The second approach is based on Womersley's solution for pulsatile flow in an elastic vessel (Womersley, 1955, 1957). Under the assumptions of axisymmetry, linear constitutive behaviors, and small perturbations about a constant pressure and zero axial velocity reference state, a system of linear partial differential equations governing the fully developed pulsatile flow in an elastic vessel can be derived and solved analytically. When periodic solutions are desired, a solution can be employed that involves calculating the input impedances of a single segment based on its characteristics and terminal impedances and assembling the vessels to compute the input impedance of an entire vascular tree. In this case, for a prescribed input flow rate, the Fourier coefficients of the input pressure can be determined from the product impedance and the Fourier coefficients of the input flow rate. An inverse Fourier transform can be used to compute the inlet pressure. Pressure and flow rates throughout the vascular tree can be computed by enforcing conservation of mass and continuity of pressure at branch points (Avolio, 1980). While impedance-based linear methods can be used to describe pressure and flow wave propagation in vessels, these models do not incorporate nonlinear advective losses due to branching and stenoses (Stergiopulos *et al.*, 1992; Olufsen, 1999; Wan *et al.*, 2002). This is perhaps the most significant limitation of Womersley's elastic vessel theory, especially as applied to blood flow in the major arteries and in the presence of disease. The third approach is based on numerically solving the governing three-dimensional equations of blood flow in elastic domains (Perktold and Rappitsch, 1995). The three-dimensional methods require boundary conditions to model blood flow; prescribed velocity or pressure outflow boundary conditions are typically applied, this approach is entirely inappropriate when modeling wave propagation phenomena in human arteries, especially for treatment planning where the quantity of blood flow exiting branch vessels is unknown and is part of the desired solution. A better strategy is to use one-dimensional methods to model the downstream vessels and provide boundary conditions for the more computationally intensive, three dimensional methods used for the major arteries (Taylor and Hughes, 1998; Formaggia *et al.*, 2001; Laguna *et al.*, 2002).

The demand for efficient and accurate software that can deal with the problems faced by hydraulic engineers led to numerous commercial packages. In the past, some of the more sophisticated softwares available required the use of powerful computers and long run times, as a result of the level of complexity involved. However, resolution is in sight with advances in computer hardware. In addition several other areas can be identified where numerical techniques encounter difficulties when applied to blood flow. Firstly, the pulsating flow can lead to problems in producing a computational grid to represent the structure. The occurrence of mixed regions of flow, for example at blockages, leads to problems for some numerical methods resulting in either poor results or failure to produce a solution. All numerical methods are subject to stability constraints which restrict the values allowed for the time step for a given grid. For explicit schemes, this can result in the need to use small time steps which can be computationally expensive. Implicit schemes overcome this difficulty but at the expense of more complex algorithms. To improve this situation, numerical schemes which base their solution on solving a series of Riemann problems were used. Such methods have a number of desirable properties, most noticeably the ability to predict discontinuities in the solution due to the presence of flow transitions, and so were chosen as a focal point for the solution of the blood flow equations in this work. And this will be applied to simulation of stenosis and artherosclerosis, with a view to determine Ischemic or Haemorrhagic stroke situations.

Insulin, the primary anabolic hormone of the human body, has been implicated in the aetiopathogenesis of several non-communicable disease like hypertension, peripheral vascular disease, coronary heart disease and even cancer (Bakari, 2004). Measurement of insulin resistance and glucose disappearance rate has been reported by Mari *et al.* (2001). It will be of interest in clinical investigation of diabetes and hypertension. It was apparent that insulin secretion is associated with energy abundance (Guyton and Hall, 1996). That is, when there is great abundance of energy-giving foods in a diet, especially excess amounts of carbohydrates and proteins, insulin is secreted in great quantity. This is especially true for excess carbohydrates, less for excess proteins, but only slightly even for fats. Although insulin plays a role in carbohydrate, proteins and fats metabolism, this study has been narrowed down to the modeling of glucose (carbohydrate) metabolism, following the short insulin tolerance test (Bonora *et al.*, 1989). Diabetes mellitus is a disease of the glucose- insulin regulatory system (Bergman *et al.*, 2002; Topp *et al.*, 2000), which is referred to as hyperglycemia. Himsworth (1936) identified two different types of diabetes mellitus: Type 1 diabetes, juvenile onset and insulin-dependent, and Type 2 diabetes, adult onset and insulin-independent. Type 1 diabetes is caused by deficiency of circulating insulin due to the loss of insulin producing β-cells in the Langerhans islets of the pancreas (Makroglou *et al.*, 2005), while Type 2 diabetes is caused by the failure of pancreatic beta cells to respond appropriately to the prevailing blood glucose levels (Bakari and Onyemelukwe, 2005). Complications of the disease include retinopathy, nephropathy, peripheral neuropathy and blindness (Derouich and Boutayeb, 2002). The ability of insulin to lower blood glucose is referred to as Insulin Sensitivity (IS), while Glucose Effectiveness (GE) is a measure of the fractional ability of glucose to disappear in plasma or be used up by the body independent of increased insulin (DeFronzo and Ferrannini, 1991).To this day, the standard treatment for Type 1 diabetes mellitus is the administration of exogenous insulin to mimic the normal metabolic regulatory system in healthy subjects.

Insulin facilitates cellular glucose uptake and stimulates conversion of glucose into glycogen (Gerich, 1993). Several attempts at building a satisfactory model of the glucose-insulin system are recorded in the literature. The minimal model, which is the model currently and mostly used in physiological research on the metabolism of glucose, was proposed in the early eighties for the interpretation of the glucose and insulin plasma concentrations following the Intra-Venous Glucose Tolerance Test (IVGTT) (Shen *et al.*, 1970). Since then, several other methods have been used to quantify insulin action. The tests that have been used to assess insulin sensitivity include: insulinogenic ratio (insulin/glucose) (Gaetano and Arino, 2002), glucose/insulin ratio (Seltzer et al, 1967), glucose clamp technique (DeFronzo *et al.*, 1979), Frequently Sampled Intravenous Glucose Tolerance test (FSIGT) (Kahn *et al.*, 1994) and minimal model technique (Bergman *et al.*, 1987). Another simple and reliable test, the Short Insulin Tolerance Test (SITT), was developed by Bonora *et al.* (1989).

There has been no model study, as far as the authors are aware, on glucose disappearance from blood plasma in Nigerians. However a glucose disappearance study on Nigerians was carried out by Fasanmade (1987) using the short insulin tolerance test. No models were developed in that study and glucose disappearance rate constants were determined using the least square method on patient data.

Bergman's minimal model (1980) is a one compartment model, meaning that the body is described as a compartment/tank with a basal concentration of glucose and another with a basal concentration of insulin. The minimal model actually contains two minimal models, one describing glucose kinetics - how blood glucose concentration reacts to insulin concentration and vice versa. The two models respectively take insulin and glucose data as an input. The two models have mostly been used to interpret the kinetics during the IVGTT test. The Minimal Model (Bergman and Cobelli, 1980) has been widely accepted, but it has the following short comings: the model operates at steady state and describes short-term dynamics of glucose and insulin.

Computer software packages that can assist clinicians in early screening of patients at risk and treatment procedures for stenosed, atherosclerotic and diabetic patients in any crisis situations has been developed here, for the first time, using the developed equations and visual basic application tools. Interfaces that accept simple measurements like doppler and concentration of sugar in the blood created the input. The program takes these inputs and analyses the situation, and the result is then used for diagnosis by the clinician.

So in this work the gut-blood system was modeled as an infinite number of continuous stirred tanks in series, which could be used as simulators of the entire blood glucose-insulin system. Laplace transformation technique was used to solve the equations analytically with a view to determine model parameters and glucose disappearance rate constant in an individual subjected to short insulin tolerance test (SITT). Software was developed which can be used for therapeutic management of stroke and diabetes.

1.2 STATEMENT OF THE PROBLEM

Diabetes is about 4 to 5 times more than HIV and about 250 million diabetic patients all over the world (CDC, 1997; Graham, 2002). Ten percent of Nigerians are diabetic, amounting to 15 million Nigerians. Primary health care system lack experts like dieticians and doctors with expertise on diabetes. There are about twenty to twenty four diabetes experts in Nigeria, between fifteen and twenty reside in Lagos, this figure forms about 80% to 90% of diabetes experts in the country residing in Lagos. Considering the population of diabetic patients in Nigeria, the experts are not enough for this teeming population. Sixty percent (60%) of diabetes mellitus cases die of vascular related diseases like stroke, heart attack, heart failure, leg gangrene, etc. Up to half of stroke cases are secondary to or complicated by diabetes mellitus. About 95% of Diabetic mellitus (DM) cases are type 2, type 1 DM is about 1 - 2% and the rest are gestational, pancreatic or hepatic DM (CDC, 1997; Graham, 2002).

The statistic from the US on a Stroke Initiative (1997) by an interdisciplinary research group formed to launch an offensive against brain attack shows that stroke is the leading cause of permanent disability in the U.S. and the third leading cause of death. Each year, 550,000 Americans have stroke. One-third of them die. Many of the survivors, who currently total over 3 millions, have decreased vocational function (71%), of these 16% remain institutionalized, and 31% need assisted care. The personal cost is incalculable; the annual cost for treatment, post-stroke care, rehabilitation, and lost income to victims (but not the family caregivers) is $30 billion. The question that agitates the mind of a group at the Lawrence Livermore National Laboratory's Center for Healthcare Technologies was: Given that both heart attack and strokes result from disruption of blood flow, why are cardiovascular conditions treated with aggressive medical intervention while cerebrovascular conditions usually receive passive intervention with emphasis on rehabilitation? Why is stroke not treated as "brain attack?" The answer they found was not that there is something fundamentally different about the two potentially deadly maladies. Instead what they found was that doctors frequently did not have proper tools to treat stroke as quickly and aggressively as they treat heart attack. What has the collaboration of the multidisciplinary group accomplished? First, they have remedied the paucity of tools for diagnosing and treating stroke: The vision for stroke care does include medical devices for screening people without symptoms for stroke risk. It also places special emphasis on the development of tools for earlier rather than later diagnosis of stroke type and assessment of brain cell damage so that appropriate treatment can be initiated. One has to be realistic in defining the objectives of a bio-medical research group in an environment such as ours. Although we lack access to state-of-the-art facilities for carrying out whatever objectives we may define for ourselves, we can work within a circle of parameters whereby our efforts can be uniquely determined.

Stroke is a situation whereby a blood vessel in the brain is blocked (ischaemia) or burst (haemorrhage). Usually, each and every chamber of the brain co-ordinate particular parts of the body, the part of the brain that fails to receive blood and the oxygen it carries will definitely fail to co-ordinate the part of the body it usually co-ordinates. In some situation, the rupture of the blood carrying vessels results in internal bleeding. The doctors need to identify whether the stroke is due to ischaemia or haemorrhage before they can initiate any treatment. Another disease that is strongly linked with stroke is diabetes. It was reported by Jeerakathil (2007) that individuals diagnosed with Type 2 diabetes are at double the risk of having a stroke compared to those without diabetes. Jeerakathil (2007) indicates it is possible that physicians are undertreating stroke risks because of a prevailing attitude among physicians and patients that the cardiovascular complications of diabetes occur long after diagnosis rather than in the first five years. It is hoped that the findings of Jeerakathil (2007) will help to dispel the notion that the risk of stroke occurs only in the long term and will improve the motivation of both patients and health care providers to aggressively control cardiovascular risk factors soon after diagnosis.

The situation of stroke and diabetes in Nigeria is very bad, and hence this research will establish a model of flow of blood within the arteries, it will also model the description of insulin-glucose system during simple clinical tests such as short insulin and glucose tolerance test. The aim is to quantify in individual patients, macroscopic physiological process that may be associated with the development of diabetic disease, atherosclerosis and stenosis and to explore the possibility of applying the model in clinical studies. It will be useful in primary health care, settings where resources are scarce; the shortage of imaging facilities in resource poor settings, the unavailability of the qualified medical personnel and the low income of families are a great threat to a healthy life. Developed software will greatly assist in places where there are no dieticians, doctors with expertise on diabetes, it will guide the junior doctors, nurses and pharmacist; generally it will help non professionals and practitioners.

1.3 OBJECTIVES OF STUDY

The purpose of this work is;

i) To develop and use a one-dimensional fluid dynamical model to predict blood flow and pressure in the systemic arteries at any position along the blood vessels. Such a model can be used to study the profile of the flow and pressure waves as they propagate along the arteries.

ii) To develop a new approach with which to solve the one-dimensional non-linear equations of blood flow using the Riemann based methods constructed within the finite volume framework and then apply it to blood flow equations.

iii) To develop a mathematical model for the description of insulin-glucose kinetics during simple clinical tests such as short insulin and glucose tolerance test.

iv) To develop a computer software package for the screening of patients at risk and diagnosis of diabetic patients.

v) To develop a computer software package for antithrombotic and therapeutic management of stroke.

1.4 RESEARCH QUESTIONS

The following research questions will guide this research work:

i. What are the current mathematical models describing blood flow and glucose-insulin systems in humans and their shortcomings in terms of describing the actual phenomenon in human systems?
ii. What are the current solution mathematical techniques?
iii. What are the shortcomings of the mathematical techniques in terms of speed, accuracy, good conservation and shock capturing capabilities?
iv. What is the ability of the mathematical model in terms of predicting discontinuities in the solution?
v. How does this present research differ from work of previous researchers?
vi. Are there enough experimental data for the achievement of the research objectives?
vii. Will the developed computer softwares be applicable to all subjects?

viii. How would the performance of the developed softwares compare to the available traditional prescription?

1.5 THEORETICAL/CONCEPTUAL FRAMEWORK OF STUDY

This research work focuses on the development of suitable mathematical models and computer software for the evaluation of blood flow, stenosis, atherosclerosis and diabetes based on the following theoretical concepts:

(a) The development of mathematical models using Navier Stoke's and Saint Venant's equations of flow. The blood vessels are compliant axisymmetric cylinders and the flow is axisymmetric, incompressible one-dimensional flow situation.

(b) The solution of the developed mathematical model using a new approach, the Riemann based methods constructed within the finite volume framework. The test regarding the occurrence of discontinuities in fluid flow give rise to the hypothesis, that imposing a Roe Riemann which is based on determining the approximate quantities has the effect of determining the position of the discontinuities.

(c) The development of mathematical model equations describing the glucose insulin kinetics during simple clinical tests for insulin and glucose tolerance using a model consisting of three mixed reactors in series. The gut and blood systems are represented as a model of mixed flow tanks in series. The coupling of reaction rates and molecular diffusion and transport is significantly dependent on absorption and diffusion.

(d) The analytical solution of glucose-insulin model using Laplace transformation technique with a view to determine the glucose disappearance rate constant in an individual subjected to short insulin tolerance test (SITT).

(e) The development of a computer software package to assist clinicians in the early screening of patients at risk and diagnosis for stenosed, atherosclerotic, stroke and diabetic patients in any crisis situations.

1.6 SIGNIFICANCE OF WORK

This research work has the following significance:

1. **The development of a mathematical model describing of the blood in distensible blood vessels.**

   A model of one-dimensional non-linear equations of blood flow was developed from Navier-Stokes and Saint –Venant equations. This model can be used to study the profiles of blood flow as they propagate along the arteries, and can used for decision making and therapeutic management.

2. **The development of a numerical model for the solution of the blood flow models.**

   A new approach for the solution of the one-dimensional non-linear equations of blood flow using the Riemann based methods constructed within the finite volume framework was developed and then applied to the blood flow equations. Such methods are noted for their good conservation and shock capturing capabilities and have a number of desirable properties, most noticeably the ability to predict continuities in the solution. Previous models are not well conserved as they could not capture shock and discontinuities. The problem being evaluated is a situation where there is a disruption of blood flow due to blockage or rupture, the previous models cannot account for such disruption in flow.

3. **The development of computer software for detecting artherosclerosis, stenosis and differentiation of haemorrhagic and ischaemic strokes for stroke management from simple measurements.**

   The understanding of atherosclerosis, stenosis and stroke and the management of these diseases. The software developed is capable of computing the Siriraj and the Allen clinical scores. These scores have been proposed to help clinicians in making decisions while waiting for results of computerized tomography, hence clinicians can start anti-thrombotic treatment while waiting for the scan results. The computer software for detecting stenosis was also developed. The software is capable of simulating Stenosis at different position and depth of flow along the arterial length, and can be used for diagnosis. The medical emphasis is on avoiding possible occurrence, every individual can know his status by inputting the required data such as flow and geometry of their arteries into the developed interface and such measurements can be obtained from simple Doppler measurements.

4. **The development of a model for Glucose-Insulin system in Human.**

   A model of the gut and blood stream was developed by describing the body as a compartment/tank with a basal concentration of glucose and insulin by using mathematical equations. The gut-blood system is modeled as an infinite number of continuous stirred tanks in series, which could be used as simulators of the entire blood glucose-insulin system and the pathway for diabetes development. The model makes it possible for the development of software that is used for therapeutic management of patients. The model gives some indicators and parameters regarding the level of development of the diabetes.

5. **The development of software for therapeutic management of diabetes.**

   The software was developed using the model of the gut-blood system proposed. Every individual with or without diabetes can know his diabetes status by inputting the required data such as age, sex, height, weight and the blood glucose concentration through the interface. It is expected that with use of the interface, appropriate management can be initiated in order to prevent other diabetic complications.

1.7 LIMITATION OF SCOPE OF RESEARCH WORK

This research work is limited to the development of novel systems for the screening, evaluation and treatment procedures for atherosclerosis, stenosis and diabetes diseases. The research study is covered within the scope presented below:

1. Detailed literature review of stroke, atherosclerosis, stenosis and diabetes diseases.
2. Mathematical models development of blood flow and glucose-insulin systems.
3. Numerical solution of the mathematical models.
4. Validating of theoretical models with data from real life scenarios.
5. Development of computer software from the developed models, parameters and physiological data.

1.8 DEFINITION OF OPERATIONAL TERMS

Anticoagulant

Substances used to prevent the formation of blood clots or to break up clots in blood vessels in such conditions as thrombosis and embolism.

Arteries

Blood vessels carrying blood away from the heart. All arteries except the pulmonary artery carry oxygenated blood. The walls of arteries contain smooth muscles fibres which contract or relax under the control of sympathetic nervous system.

Arterioles

A small branch of an artery leading into many smaller vessels ‘the capillaries’. By their construction and dilation, under the regulation of the sympathetic nervous system, arterioles are the principal controllers of blood flow and pressure.

Atheroma

Degeneration of the walls of the arteries due to the formation of fatty plaques and scar tissues. This limit blood circulation and predisposes to thrombosis.

Atherosclerosis

Stiffening or hardening of the blood vessel.

Body Mass Index

Is the weight of a person in (kg) divided by the square of the height of that person (in meters), used as an indicator of whether not a person is over or underweight.

Cerebral Haemorrhage

Bleeding from a celebral blood vessel into the tissue of the brain.

Cerebrovascular

Cerebrovascular disease is any disease of the blood vessels, of the brain and its covering membranes.

Cardiovascular

The heart together with two networks of blood vessels: Systemic circulation and the pulmonary circulation. The cardiovascular system affects the circulation of blood around the body which brings about transport of nutrients and oxygen to the tissues and the removal of waste products.

Clinician

A medical doctor, psychologist etc. who has direct contact with patients.

Computerized Tomography (CT) scan

Examination of the body using computerized tomography.

Demography

The study of population on a national, regional or local basis in terms of age, sex and other variables including patterns of migration and survival.

Diabetes

If the blood-glucose concentration falls below 5 mmol/L, neurological and other symptoms may result. Conversely, if the blood-glucose level is raised above its normal level, to 10 mmol/l, the condition of hyperglycaemia develops. This is a symptom of diabetes.

Diabetic

A person who suffers from diabetes.

Diagnosis

The process of determining the nature of a disorder by considering the patients sign, symptoms and medical background; and when necessary the result of laboratory tests and x-ray examinations.

Doppler Ultrasound

A diagnostic technique that utilizes the fact that frequency of ultrasound waves changes when they are reflected from a moving surface. It is used to study the flow in blood vessels and the movement of blood in the heart.

Electrocardiogram (ECG)

A recording of the electrical activity of the heart on a moving paper strip. The ECG tracing is recorded by means of apparatus called an electrocardiograph.

Epidemiological studies

The study of the occurrence, distribution and control of infectious and non-infectious diseases in population which is a basic part of public health medicine.

Epilepsy

A disorder of brain function characterized by recurrent seizures that have a sudden onset.

Etiology

The study or science of the causes of disease or the cause of a specific disease.

Exogenous

Originating outside the body or part of the body; applied particularly to substance in the body that are derived from diet rather than built up by the body's own processes of metabolism.

Glucose

A simple sugar containing six carbon atoms (hexose). Glucose is an important source of energy in the body and the sole source of energy for the brain. Glucose is stored in the body in the form of glycogen. The concentration of glucose in the blood is maintained at around 5 mmol/L by a variety of hormones, principally insulin and glucagon.

Haemorrhagic stroke

Results from rupture of an artery wall. Prolonged reduction of blood pressure may result in a more diffuse brain damage, as after cardio-respiratory arrest.

Hyperglycaemia

An excess of glucose in the blood stream. It may occur in a variety of diseases, most notably in diabetes mellitus due to insufficient insulin in the blood and excessive intake of carbohydrates.

Hyperinsulinism

Metabolic disturbance due to excessive administration of insulin or too much secretion of hormone insulin by the islet cells of the pancreas.

Hypertension

High blood pressure, i.e. elevation of the arterial blood pressure above the normal range expected in a particular age group.

Hypoglycaemia

Deficiency of glucose in the blood stream, causing muscular weakness and in-coordination, mental confusion and sweating. Hypoglycaemia most commonly occurs in diabetes mellitus as a result of insulin over dosage and insufficient intake of carbohydrates.

Impedance

A measurement of the total resistance of a piece of electrical equipment to the flow of an alternating current.

Infarction

The death of part or the whole of an organ that occur when the artery carrying its blood supply is obstructed by a blood clot (thrombus) or an embolus.

Insulin

A protein hormone, produced in the pancreas by the beta cells of the islets of langerhans that is important for regulating the amount of sugar (glucose) in the blood.

Intermittent Claudication

It is a cramping pain, induced by exercise and relieved by rest that is caused by an inadequate supply of blood to the affected muscles.

Ischaemic Stroke

Occurs when the flow of blood is prevented by clotting or by a detached clot, either from the heart or a large vessel (such as carotid artery) that lodges in an artery.

Laser Energy

Laser is a device that produces a very thin beam of light in which high energies are concentrated. (The word derives from light amplication by stimulated emission of radiation).

Lipoprotein

One of a group of compounds, found in blood plasma and lymph each consisting of a protein.

Medical Assistant

A health service worker who is not a registered medical practitioner (often a nurse or an ex-service man with experience as a senior medical orderly) working in association with a doctor to undertake minor treatment and preliminary assessments.

Magnetic Resonance Imaging (MRI)

A diagnostic technique based on analysis of the absorption and transmission of high-frequency radio waves by the hydrogen in water molecules and other components of tissues placed in a strong magnetic field.

Metabolism

Metabolism involves the breakdown of complex organic constituents of the body with the liberation of energy which is required for other process and the building up of complex substances, which form the material of the tissues and organs from simple ones.

Myocardial Infarction

Death of a segment of heart muscle which follows interruption of its blood supply, myocardial infarction is usually confined to the left ventricle.

Nephropathy

Disease of the kidney. Diabetes nephropathy is the progressive damage to the kidneys seen in some people with long standing diabetes.

Pathological

Relating to or arising from disease.

Peripheral Neuropathy

Any of a group of disorders affecting the sensory and/or motor nerves in the peripheral nervous system. They tend to start distally in the fingers and toes and progress proximally. The most common causes of peripheral neuropathy are diabetes, and injection of certain drugs.

Physician

A medical doctor especially one who is a specialist in general medicine and not surgery.

Plasma Concentration

Plasma (blood plasma) is the straw coloured fluid in which the blood cells are suspended. It consists of a solution of various inorganic salts of sodium, potassium, calcium etc, with a high concentration of protein (approx. 70 g/l) and a variety of trace substances.

Post Mortem

After death or dissection, an examination of a body after death in order to determine the cause of death or the presence of disease processes.

Retinopathy

Any of various disorders of the retina resulting in impairment or loss of vision. It is usually due to damage to the blood vessels of the retina occurring as a complication of long standing diabetes.

Scanning

Scan is the examination of the body or a part of the body using ultrasonography or computerized tomography (CT).

Software

The programs used to operate computer hardware application/system software.

Stenosis

The abnormal narrowing of a passage or opening, such as a blood vessel or heart valve.

Stent

A tube placed inside a duct or canal to re-open it or keep it open. It may be a simple tube, usually plastic or an expandable, usually sprung mesh metal tube.

Stroke (apoplexy)

A sudden attack of weakness affecting one side or whole of the body. It is the consequence of an interruption to the flow of blood to the brain.

Subarachnoid Haemorrhage

Sudden bleeding into the subarachnoid space surrounding the brain which causes severe headache with stiffness of the neck.

Symmetry (in anatomy)

The state of opposite parts of an organ or parts at opposite side of the body corresponding to each other.

Therapeutic Management

Therapeutic is something designed to help treat an illness.

Thrombolytic

Describing an agent that breaks up blood clots (thrombi)

Tomography

The technique of rotating a radiant detector around the patient so that the image obtained gives additional three dimensional information.

Type I Diabetes

Type I Diabetes develops when the body's immune system destroys pancreatic beta cells. These are the only cells in the body that make the hormone insulin which regulates blood glucose.

Type II Diabetes

Refer to a condition characterized by insulin resistance and relative rather than absolute insulin deficiency.