Sudan University of Sciences and Technology
College of Graduate Studies

Assessment of the effect of body mass index on common carotid Arteries' Resistive indeces Using Doppler Ultrasound.

تقييم تأثير كتلة الجسم علي مؤشر مقاومة الشريان السباتى بإستخدام موجات الدوبلار

A Research Submitted for partial fulfillment of the Award of Msc. Degree in Diagnostic Medical Ultrasound

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2015

الآية

بسم الله الرحمن الرحيم

(وَعَلَّمَ آَدَمَ الْأَسْمَاءَ كُلَّهَا ثُمَّ عَرَضَهُمْ عَلَى الْمَلائِكَةِ فَقَالَ أَنْبِئُونِي بِأَسْمَاءِ هَؤُلَاءِ إِنْ كُنْتُمْ صَادِقِين(31) *قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا* إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ ((32)

سورة البقرة: الايات (31-32)

DEDICATION

I dedicate this blessed work to my great mother, my devoted wife, my lovely children and to my brother-in-low Mr. Mohammed Abdullah AL Haj and his noble brother Mr. Ayman for their greatness of help during the samples collection , as well as I dedicate this scholarly work to the whole scientific community of radiological sciences college in Sudan university of sciences and technology representatively in its hardworking dean and my supervisor in this research **A. Professor Dr. Mohammed Mohammedomer.**

AKNOWLEDGMENT

Firstly, I thank Almighty Allah for granting me the ability to complete this work. Then my thank to my supervisor **A.professor Dr. Mohamed Mohamedomer** for his assistance and closed guidance during finalization of this research, I have learnt a lot from him. As I am particularly thankful to the whole staff of ultrasound clinic at college of radiological sciences where this study has taken place, in the head of them **Dr. AL Safi Ahmed Abdulla** the former dean of medical radiation college of Sudan university, and I am not going to forget the volunteer students at medical radiation college who have played the major role in the existence of this study by being its population voluntarily, I deeply thank all of them collectively and individually.

Abstract

The purpose of the study was to measure the resistive indeces of common carotid arteries for examining their susceptibility of being changed due to changing in body mass index, gender and age , in addition to its suggested possibility of detecting early atherosclerosis deposit in previous studies by increasing in its numerical value in atherosclerotic artery this study aimed to discover and investigate this privilege. This study was a prospective study conducted in ultrasound clinic of college of radiological sciences in a period of time between October 2014 to August 2015 , The overall sample was 54 subjects their ages ranged between 18 to 24, mean age 21.25 SD 3.65 with body mass index ranged between 18.47 to 43.68, with mean 26.43 SD 5.32. Females were 34 accounted for 63% , males 20 accounted for 37% , divided into three groups, Normal weight subjects were 23 accounted for 42.6%, their BMI below 25, Overweight subjects were 17 accounted for 31.5% their BMI between 25 to 30, Obese subject were 14 accounted for 25.9% their BMI above 30. The mean of RRI for normal weight was 0.75 with SD 0.037 and the mean for over-weight was 0.78 with SD 0.046, the mean for obese was 0.76 with SD 0.059. The mean of LRI for normal weight was 0.76 with SD 0.09, the mean for overweight was 0.78 with SD 0.043, the mean for obese was 0.77 with SD 0.049. The overall mean of RRI and LRI for the whole sample collectively for RRI was 0.76 with SD 0.047, and for LRI was 0.77 with SD 0.045. The study has concluded that, there is no effect for body mass index on resistive indeces of common carotid arteries, and there is a variation in numerical values of resistive indeces of common carotid artery between males and females the mean of RRI for males was 0.77 and of LRI was 0.79, the means for females were 0.76 in both RRI & LRI. In addition to that the study has found linear correlation for left resistive indeces with age.

ملخص البحث

هذه دراسة إستطلاعية أجريت في الفترة بين إكتوبر 2014 إلى أغسطس 2015 في عيادة الموجات فوق الصوتية التابعة لجامعة السودان كلية الأشعة الطبية و ذلك لقياس تأثير كتلة الجسم على القيمة الحسابية لمؤشر المقاومة فى موجات الدوبلار للشريان السباتي العام و لمعرفة تأثير عامل الجنس و العمر على قيمته الحسابية للإستفادة من ذلك في معرفة الفوارق الطبيعية و المرضية في قيمته الحسابية و إقتراح دراسات مستقبلية موسعة لدراسة مدى جدوى إستخدام التغير فى القيمة الحسابية لمؤشر المقاومة فى موجات الدوبلار فى تشخيص الحالات المبكرة لتصلب الشرايين.

أجريت الدراسة علي 54 شخص بينهم 34 إمراة بنسبة 63% و 20 رجلا بنسبة 37% تتراوح أعمار العينة كلها بين 18 إلى 34 بمتوسط 21.25 و إنحراف معياري 3.65 و تراوحت أوزان كتلة إجسامهم من 18.47 إلى 43.68 بمتوسط 26.43 و إنحراف معياري 5.32 . تم تقسيهم إلى ثلاثة مجموعات حسب قيمة مؤشر كتلة الجسم المجموعة الأولي كانت تتكون من اصحاب كتلة الجسم الطبيعة أقل من 25 عددهم 23 بنسبة 42.6% . المجموعة الثانية أصحاب الأوزان الزائدة تتراوح كتلة أجسامهم من 25 إلى 30 عددهم 17 بنسبة 31.5% . المجموعة الثالثة هي المجموعة التي توصف بالسمنة وهم أصحاب كتلة الجسم فوق ال 30 عددهم 14 بنسبة 25.9% . متوسط مؤشر المقاومة للشريان السباتي اليمين للمجموعة الأولي 0.75 بإنحراف معياري 0.037 ولليسار 0.76 بإنحراف معياري 0.09. ومتوسط مؤشر المقاومة للشريان السباتي اليمين للمجموعة الثانية 0.78 بإنحراف معيار 0.046 و لليسار 0.78 بإنحراف معياري 0.043 . و متوسط مؤشر المقاومة للشريان السباتي اليمين للمجموعة الثالثة 0.76 بإنحراف معياري 0.059 و لليسار 0.77 بإنحراف معياري 0.049 . خلصت الدراسة إلى أنه يوجد تأثير إحصائيا لكتلة الجسم على القيمة الحسابية لمؤشر المقاومة لموجات الدوبلار للشريان السباتي العام و أن هنالك تباين فى تلك القيمة بين الرجال و النساء و قد حصل الرجال على متوسط 0.77 للشريان السباتي اليمين و 0.79 لليسار و النساء حصلن على 0.76 للشريانين السباتيين. كما أوضحت الدراسة أن هناك علاقة طردية مهمة إحصائيا لمؤشر المقاومة للشريان السباتي اليسار مع العمر .

List of Abbreviations

US	Ultrasound
BMI	Body Mass Index
CCA	Common Carotid Artery
IMT	Intima-Media Thickness
PSV	Peak Systolic Velocity
EDV	End-Diastolic Velocity
RI	Resistive Index
RRI	Right Resistive Index
LRI	Left Resistive Index
SD	Standard Deviation
P-Value	Probability Value
ANOVA	Analysis of Variance
ECA	External Carotid Artery
ICA	Internal Carotid Artery
PI	Pulsatility Index

Table of Contents

List of Tables

List of Figures

Chapter One

1-1 Introduction

The prevalence of overweight and obesity has recently become a major problem in the developing countries, it causes impaired function of the large arteries , which might become the consequence of metabolic dysregulation, inflammatory pathways, obstructive sleep apnea, and excessive weight considered strong predisposing factor of developing stroke and heart attack if left untreated for long time. As " Obesity increases the risk of cardiovascular disease and premature death". (Gaal et al, 2006)

Overweight becomes obesity when the accumulated fat exceed the extent where it might cause adversely health effects and it is commonly defined by using the equation of body mass index (BMI= kg/square meter) when BMI > 30 .

Weight increasing is thought to be a major risk factor in stroke because of the atherosclerotic deposition, as (J Am. 2008) states , higher BMI is strongly associated with atherogenic progression. Doppler ultrasonography offers noninvasive investigation of hemodynamic of the carotid arteries and has assisted in the diagnosis of stroke. Doppler ultrasound has also been used to predict the likelihood of developing atherosclerosis and other cardiovascular disorders, and common carotid arteries Doppler is well-known exam in detecting risk factor of stroke and heart attack due to high sensitivity and specificity of Duplex ultrasound in evaluating blood flow pattern and quantifying plaque and measuring intima-media thickness (IMT) of common carotid arteries and their branches.

This study took advantage of the advance in duplex ultrasound to investigate the relationship between changing in Body mass index (BMI) and resistivity index of both common carotid arteries, as many studies have shown strong linear relationship between resistive index (RI) of common carotid arteries CCAs and their IMT this suggests the validity of using RI in prediction of stroke and progression of atherosclerosis, since the RI increases when IMT increases.

1-2 The study problem

Increasing weight has been very common among adult nowadays due to the dynamic change in life and the entailed environmental and nutritional changes have played a major role of inducing obesity among the youth, on the other hand and since there are previous studies found a strong linear correlation of increasing weight and obesity with the probability of developing atherosclerotic carotid arteries, this study has investigated the possibility of being at risk of developing atherosclerotic carotid arteries by using the numerical value of resisitive index in doppler ultrasound as an independent predictive parameter to investigate any potential of having early atherosclerosis in the early adulthood life of those over-weighted persons, besides, establishing its relationship with body mass index.

1-3 Study objectives

1-3-1 The general objective of the study :

To assess the effect of body mass index on common carotid arteries' resistive indeces using doppler ultrasound.

1-3-2 Specific objective :

To correlate the effect of age and gender with numerical value of resistive indeces of common carotid arteries, thereby, the variations have to be considered technically.

1-4 Overview of the study

This study consists of five chapters. Chapter one is an introduction includes the introduction of the study, the problem, the study objectives, and the overview of the study. Chapter two contains the background of the study which includes anatomy and pathophysiology besides, previous studies in related topics. Chapter three consists of material and methods used in this study. Chapter four Result of the study, and finally chapter five which includes discussion, conclusion and recommendations.

Chapter two

Literature review

Chapter two

literature review

2-1 A-natomy

The principal arteries of supply to the head and neck are the two common carotids they ascend in the neck and each divides into two branches. The left common carotid artery arises from the aortic arch in front of the trachea and passes across this to lie on its left side in the root of the neck. The right common carotid arises from the brachiocephalic trunk behind the right sternoclavicular joint. From this point the vessels have a similar course. The common carotid artery passes upwards and slightly laterally. It is accompanied by the internal jugular vein on its lateral aspect, with the vagus nerve lying posteriorly between the two. All three structures are invested in the carotid sheath. The common carotid artery bifurcates into internal and external branches at the level of C4. The external carotid artery passes anteriorly and curves slightly posteriorly as it ascends to enter the substance of the parotid gland, where it terminates by dividing into maxillary and superficial temporal arteries. The internal carotid artery continues superiorly from its origin to the base of the skull, maintaining the relationship of the common carotid artery with the internal jugular vein and vagus nerve in the carotid sheath. It has a localized dilatation at its origin called the carotid sinus. It has no branches in the neck. (Ryan et al, 2004).

The thoracic portion of the left common carotid artery ascends from the arch of the aorta through the superior mediastinum to the level of the left sternoclavicular joint, where it is continuous with the cervical portion. (Gray. 1918).

Relations. *In front,* it is separated from the manubrium sterni by the Sternohyoideus and Sternothyreoideus, the anterior portions of the left pleura and lung, the left innominate vein, and the remains of the thymus; *behind,* it lies on the trachea, esophagus, left recurrent nerve, and thoracic duct. To its *right side* below is the innominate artery, and above, the trachea, the inferior thyroid veins, and the remains of the thymus; to its *left side* are the left vagus and phrenic nerves, left pleura, and lung. The left subclavian artery is posterior and slightly lateral to it. (Gray. 1918).

The cervical portions of the common carotids resemble each other so closely that one description will apply to both. Each vessel passes obliquely upward, from behind the sternoclavicular articulation, to the level of the upper border of the thyroid cartilage, where it divides into the external and internal carotid arteries. (Gray. 1918).

At the lower part of the neck the two common carotid arteries are separated from each other by a very narrow interval which contains the trachea; but at the upper part, the thyroid gland, the larynx and pharynx project forward between the two vessels. The common carotid artery is contained in a sheath, which is derived from the deep cervical fascia and encloses also the internal jugular vein and vagus nerve, the vein lying lateral to the artery, and the nerve between the artery and vein, on a plane posterior to both. On opening the sheath, each of these three structures is seen to have a separate fibrous investment. (Gray. 1918).

Relations. At the lower part of the neck the common carotid artery is very deeply seated, being *covered by* the integument, superficial fascia, Platysma, and deep cervical fascia, the Sternocleidomastoideus, Sternohyoideus, Sternothyreoideus, and Omohyoideus; in the upper part of its course it is more superficial, being covered merely by the integument, the superficial fascia, Platysma, deep cervical fascia, and medial margin of the Sternocleidomastoideus. When the latter muscle is drawn backward, the artery is seen to be contained in a triangular space, the carotid triangle**,** bounded behind by the Sternocleidomastoideus, above by the Stylohyoideus and posterior belly of the Digastricus, and below by the superior belly of the Omohyoideus. This part of the artery is crossed obliquely, from its medial to its lateral side, by the sternocleidomastoid branch of the superior thyroid artery; it is also crossed by the superior and middle thyroid veins which end in the internal jugular; descending in front of its sheath is the descending branch of the hypoglossal nerve, this filament being joined by one or two branches from the cervical nerves, which cross the vessel obliquely. Sometimes the descending branch of the hypoglossal nerve is contained within the sheath. The superior thyroid vein crosses the artery near its termination, and the middle thyroid vein a little below the level of the cricoid cartilage; the anterior jugular vein crosses the artery just above the clavicle, but is separated from it by the Sternohyoideus and Sternothyreoideus. *Behind,* the artery is separated from the transverse processes of the cervical vertebræ by the Longus colli and Longus capitis, the sympathetic trunk being interposed between it and the muscles. The inferior thyroid artery crosses behind the lower part of the vessel. *Medially,* it is in relation with the esophagus, trachea, and thyroid gland (which overlaps it), the inferior thyroid artery and recurrent nerve being interposed; higher up, with the larynx and pharynx. *Lateral* to the artery are the internal jugular vein and vagus nerve. (Gray. 1918).

At the lower part of the neck, the right recurrent nerve crosses obliquely behind the artery; the right internal jugular vein diverges from the artery, but the left approaches and often overlaps the lower part of the artery. (Gray. 1918).

Behind the angle of bifurcation of the common carotid artery is a reddish-brown oval body, known as the glomus caroticum (*carotid body*). It is similar in structure to the glomus coccygeum (*coccygeal body*) which is situated on the middle sacral artery. (Gray. 1918).

Peculiarities as to Origin. The *right common carotid* may arise above the level of the upper border of the sternoclavicular articulation; this variation occurs in about 12 per cent. of cases. In other cases the artery may arise as a separate branch from the arch of the aorta, or in conjunction with the left carotid. The *left common carotid* varies in its origin more than the right. In the majority of abnormal cases it arises with the innominate artery; if that artery is absent, the two carotids arise usually by a single trunk. It is rarely joined with the left subclavian, except in cases of transposition of the aortic arch. (Gray. 1918).

Peculiarities as to Point of Division. In the majority of abnormal cases this occurs higher tan usual, the artery dividing opposite or even above the hyoid bone; more rarely, it occurs below, opposite the middle of the larynx, or the lower border of the cricoid cartilage; one case is related by Morgagni, where the artery was only 4 cm. in length and divided at the root of the neck. Very rarely, the common carotid ascends in the neck without any subdivision, either the external or the internal carotid being wanting; and in a few cases the common carotid has been found to be absent, the external and internal carotids arising directly from the arch of the aorta. This peculiarity existed on both sides in some instances, on one side in others (Gray. 1918).

Occasional Branches. The common carotid usually gives off no branch previous to its bifurcation, but it occasionally gives origin to the superior thyroid or its laryngeal branch, the ascending pharyngeal, the inferior thyroid, or, more rarely, the vertebral artery (Gray. 1918).

Collateral Circulation. After ligature of the common carotid, the collateral circulation can be perfectly established, by the free communication which exists between the carotid arteries of opposite sides, both without and within the cranium, and by enlargement of the branches of the subclavian artery on the side corresponding to that on which the vessel has been tied. The chief communications outside the skull take place between the superior and inferior thyroid arteries, and the profunda cervicis and ramus descendens of the occipital; the vertebral takes the place of the internal carotid within the cranium. (Gray. 1918).

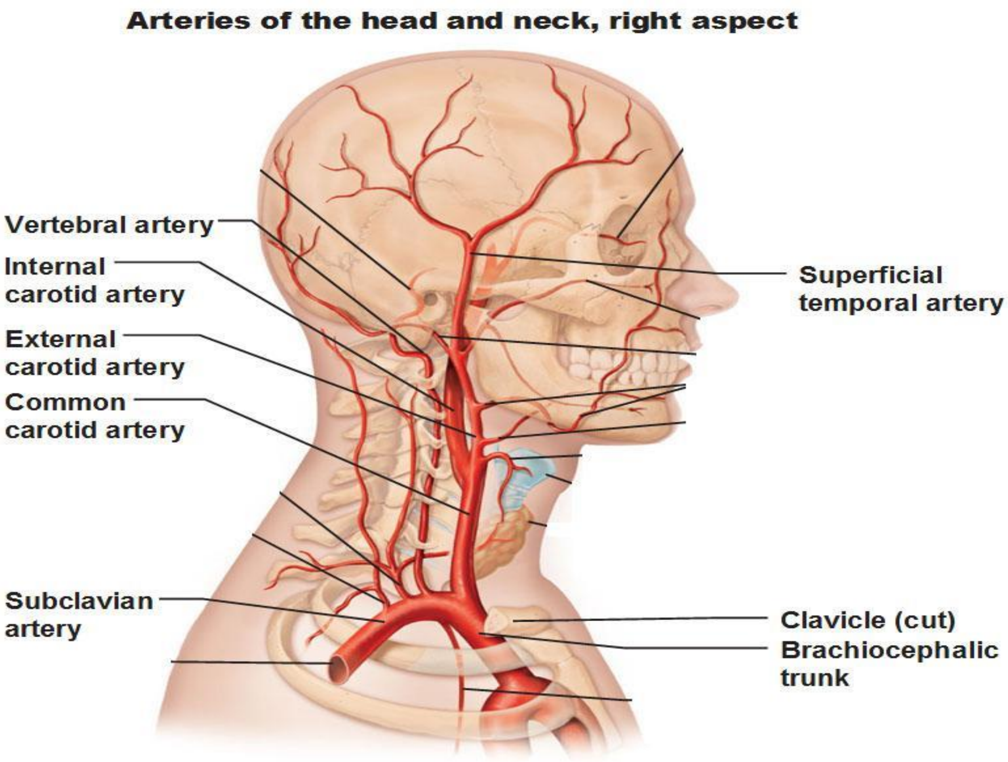

Fig. (2-1) Lateral view of The right common carotid artery

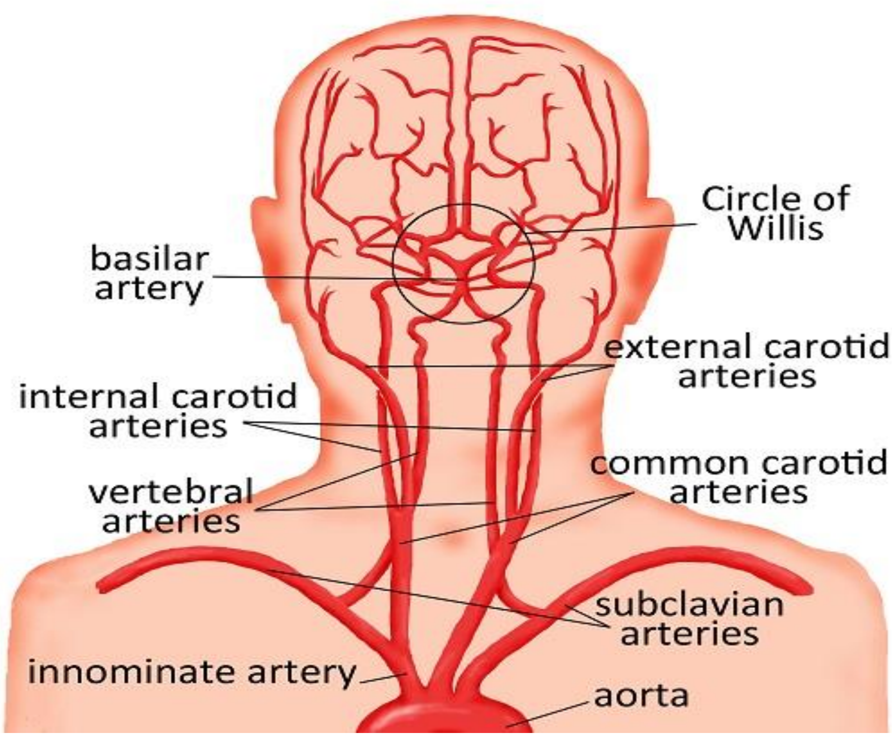

Fig. (2-2) Front view of common carotid arteries

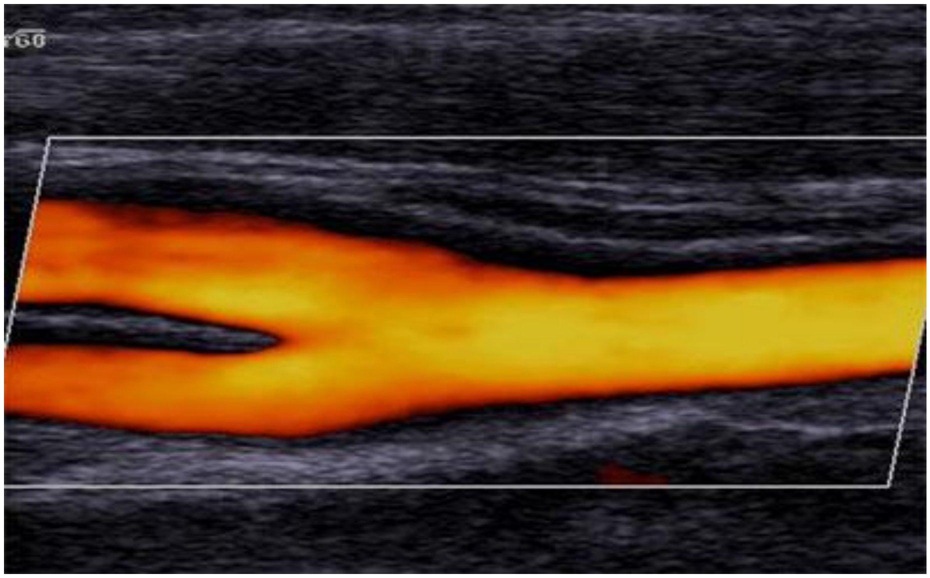

Fig. (2-3) Power Doppler showing Common carotid Artery and Its branching site.

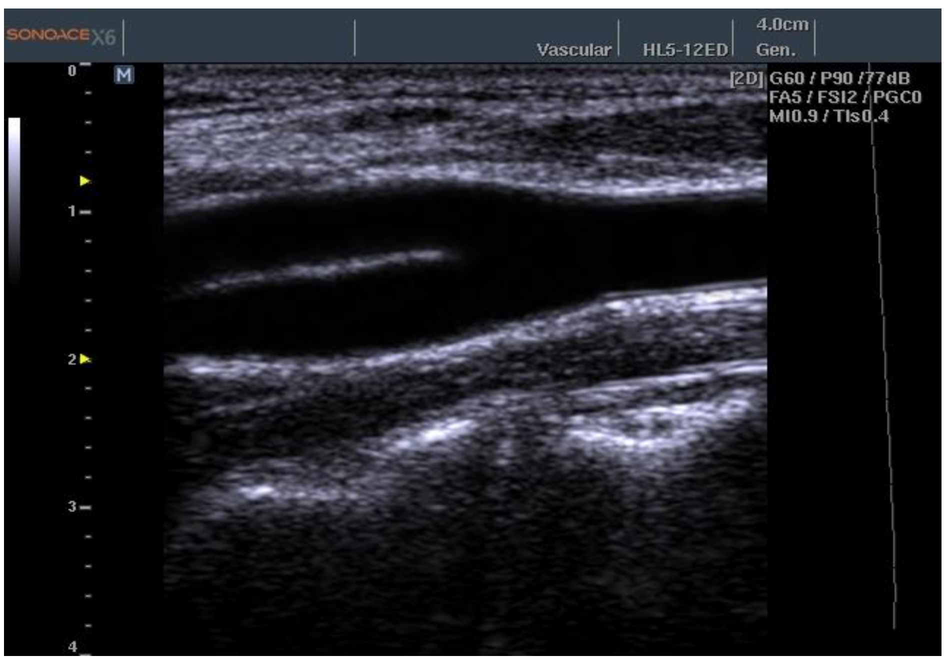

Fig. (2-4) B- Mode Image showing Common Carotid Artery and its branches. ICA, ECA.

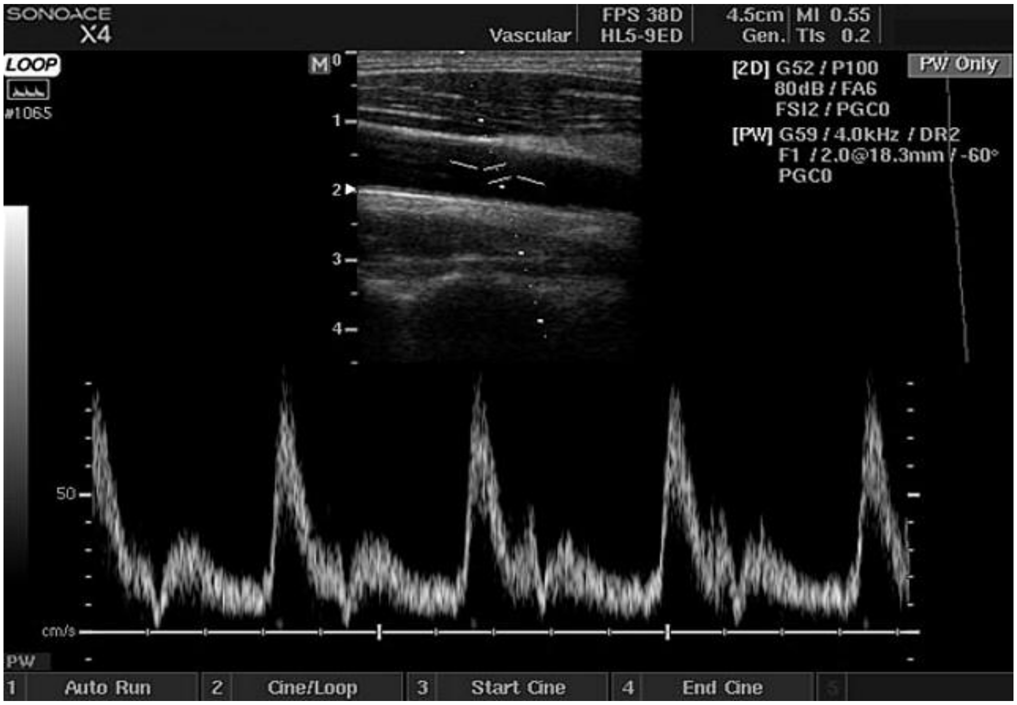

Fig. (2-5) Common Carotid Artery Waveform (Pulsed-Dppler)

2-2 Pathophysiology

The commonest carotid artery disease is a disease in which a waxy substance called plaque builds up inside the carotid arteries. You have two common carotid arteries, one on each side of your neck. They each divide into internal and external carotid arteries.

The internal carotid arteries supply oxygen-rich blood to your brain. The external carotid arteries supply oxygen-rich blood to your face, scalp, and neck. (National heart, lung and blood institute. 2010)

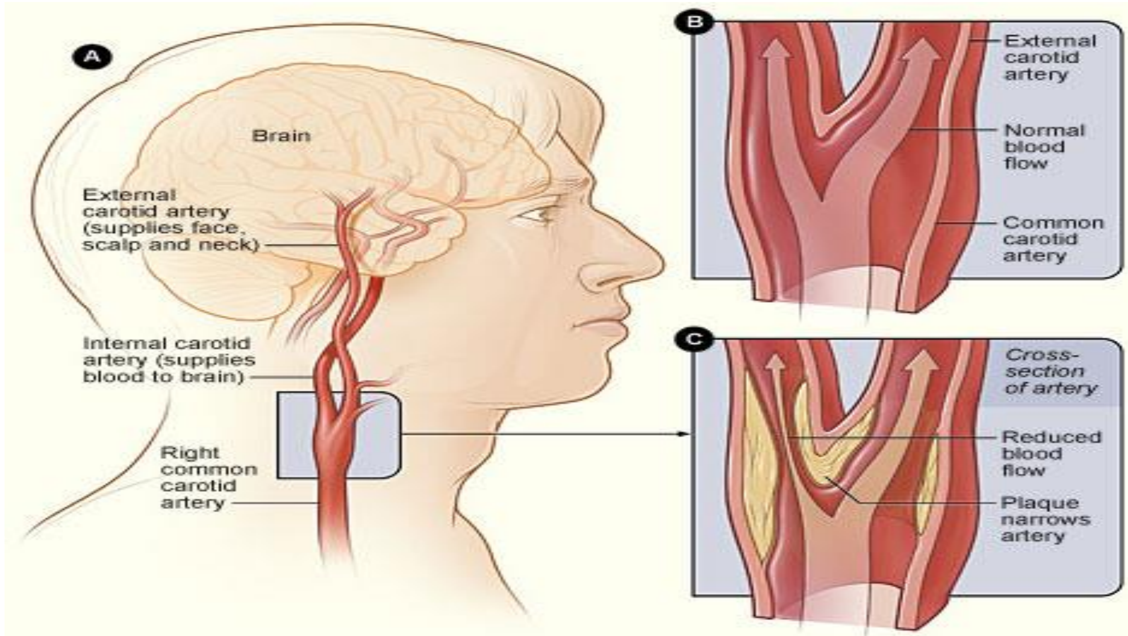

Fig. (2-6) Images of Normal and Atherosclerotic Carotid Arteries

A shows the location of the right carotid artery in the head and neck. B shows the inside of a normal carotid artery that has normal blood flow. C shows the inside of a carotid artery that has plaque buildup and reduced blood flow.

Carotid artery disease is serious because it can cause a stroke, also called a "brain attack." A stroke occurs if blood flow to your brain is cut off.

If blood flow is cut off for more than a few minutes, the cells in your brain start to die. This impairs the parts of the body that the brain cells control. A stroke can cause lasting brain damage; long-term disability, such as vision or speech problems or paralysis (an inability to move); or death. (National heart, lung and blood institute , 2010)

2-2-1 atherosclerosis

If plaque builds up in the body's arteries, the condition is called atherosclerosis . Over time, plaque hardens and narrows the arteries. This may limit the flow of oxygen-rich blood to your organs and other parts of your body.

Atherosclerosis can affect any artery in the body. For example, if plaque builds up in the coronary (heart) arteries, a heart attack can occur. If plaque builds up in the carotid arteries, a stroke can occur.

A stroke also can occur if blood clots form in the carotid arteries. This can happen if the plaque in an artery cracks or ruptures. Blood cell fragments called platelets stick to the site of the injury and may clump together to form blood clots. Blood clots can partly or fully block a carotid artery.

A piece of plaque or a blood clot also can break away from the wall of the carotid artery. The plaque or clot can travel through the bloodstream and get stuck in one of the brain's smaller arteries. This can block blood flow in the artery and cause a stroke.

Carotid artery disease may not cause signs or symptoms until the carotid arteries are severely narrowed or blocked. For some people, a stroke is the first sign of the disease. (National heart, lung and blood institute , 2010)

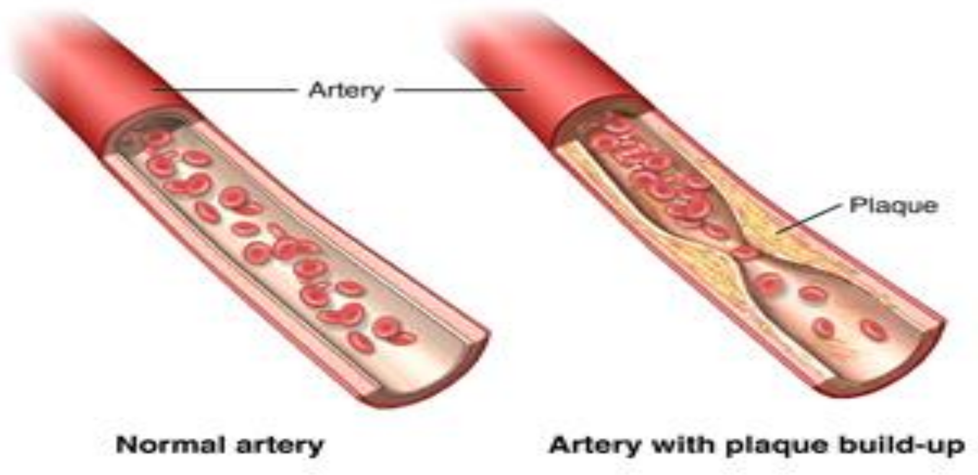

Fig. (2-7) The difference between Normal Artery and Artery with plaque deposition.

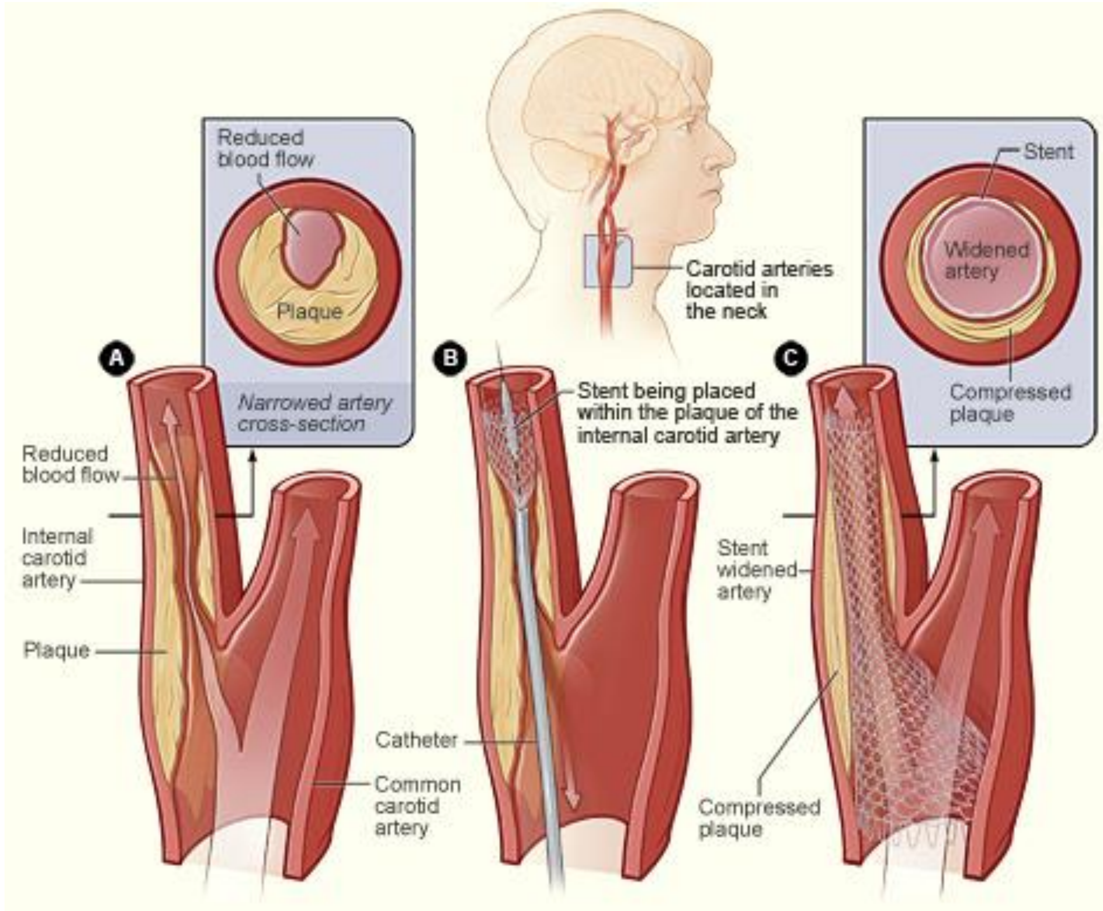

Fig. (2-8) Stent Placement

2-2-2 Carotid artery dissection

Carotid artery dissection begins as a tear in one of the carotid arteries of the neck, which allows blood under arterial pressure to enter the wall of the artery and split its layers. The result is either an intramural hematoma or an aneurysmal dilatation, either of which can be a source of microemboli, with the latter also causing a mass effect on surrounding structures. (Zohrabian, 2014)

Carotid artery dissection is a significant cause of ischemic stroke in all age groups, but it occurs most frequently in the fifth decade of life and accounts for a much larger percentage of strokes in young patients. Dissection of the internal carotid artery can occur intracranially or extracranially, with the latter being more frequent. Internal carotid artery dissection can be caused by major or minor trauma, or it can be spontaneous, in which case, genetic, familial, or heritable disorders are likely etiologies. (Zohrabian, 2014)

Although in practice, dissections are labeled spontaneous in the absence of major blunt or penetrating trauma, when they are associated with minor mechanism trauma they may be caused or influenced by an underlying arteriopathy. Patients can present in a variety of settings, such as a trauma bay with multiple traumatic injuries. (Zohrabian, 2014)

Sophisticated imaging techniques, which have improved over the past 2 decades, are required to confirm the presence of dissection. Most ischemic cerebral symptoms arise from thromboembolic events; therefore, early institution of antithrombotic treatment provides the best outcome. (Zohrabian, 2014)

Once diagnosed and treated, patients with carotid artery dissection require regular follow-up and imaging studies of both carotid arteries because healing usually takes 3-6 months and the incidence of contralateral dissection is higher than in the general population. When the condition is diagnosed early, the prognosis is usually good. A high index of suspicion is required to make this difficult diagnosis. (Zohrabian, 2014) .

2-2-3 Carotid artery vasculitis

Inflammation of the carotid artery, due to an autoimmune condition or an infection. (Webmd, 2014).

2-2-4 Carotid artery stenosis

Narrowing of the carotid artery, usually due to cholesterol plaque buildup, or atherosclerosis. Carotid artery stenosis does not usually cause symptoms until it becomes severe. (Webmd, 2014).

2-2-5 Carotid artery aneurysm

A weak area of the carotid artery allows part of the artery to bulge out like a balloon with each heartbeat. Aneurysms pose a risk for breaking, which could result in stroke or severe bleeding, or hemorrhage. (Webmd, 2014).

2-2-6 Carotid artery embolism

A fragment of cholesterol plaque, or embolus, may break off from the carotid artery wall and travel to the brain, causing a stroke. (Webmd, 2014).

2-2-7 Amaurosis fugax

Temporary blindness in one eye, usually caused by a fragment of cholesterol plaque, or embolus, breaking off from the wall of the carotid artery. The embolus can get stuck in an artery supplying the eye, blocking blood flow. (Webmd, 2014).

2-2-8 Temporal arteritis:

An autoimmune condition in which branches of the carotid artery become inflamed, known as vasculitis. Fever, a severe headache on one side of the head, and jaw pain when chewing can be symptoms. (Webmd, 2014).

2-2-9 Carotid hypersensitivity syndrome

In a few people, applying pressure to the carotid sinus can cause fainting from a sudden drop in blood pressure. Symptoms may occur while shaving or wearing a tight shirt collar. (Webmd, 2014).

2-3 Previous studies

Up to my knowledge so far and after daunting search on many scientific journals websites and universities databases no study has been found on resistivity index relationship with body mass index BMI in this specific topic , but there are many studies explained the validity of using the sole resistive index to investigate the chance of getting atherosclerosis in susceptible subjects without measuring IMT, as measurement of RI is combined with it in all previous studies, here are examples of these studies

"Intima-media thickness (IMT) of the common carotid artery and the resistive index (RI) of the internal carotid artery correlate with the degree of atherosclerosis and are predictors of cardiovascular morbidity and mortality" stated by Heiko et al, (2014).

" Risk factors for atherosclerosis and the percentage of ICA stenosis were independently associated with higher IMT values and an increase in RI. The synergic action of risk factors may cause further deterioration of mechanical forces independent of carotid atherosclerosis". concluded by Vicenzin et al (2006 pp 427-432).

"The resistive index and intima-media thickness (IMT) of the carotid artery are sonographic parameters that depend on the degree of atherosclerosis" quoted from Perumal et al (2015 pp 29-34). Then they decided that evaluation of Carotid arterial resistive index and IMT could be potentially useful diagnostic markers for assessment of atherosclerotic changes and endothelial dysfunction as a consequence of chronic hyperglycemia in diabetic patients. Das et al (2011) state: IMT, RI, PI [pulsatility index] and plaque type are useful diagnostic parameters for acute ischemic stroke and its subtypes. They can be used as noninvasive tools for predicting and preventing ischemic stroke in smokers as well as subjects with DM and hypertension.

Based on the scientific fact of the impact of changes in blood flow pattern on resistive index, and in addition to technical easiness of resistive index (RI) due to being technically independent from Doppler angle which poses the biggest obstacle in getting the other doppler indeces accurately for the privilege of being equal to the peak systolic velocity (PSV) – end diastolic velocity (EDV) divided by end diastolic velocity (EDV), when Doppler angle changes the two velocities change accordingly and the previous equation of RI will stay at one value despite the changes in doppler angle, that is why it has been chosen in this study as a pivotal parameter in studying the effect of body mass index on blood flow pattern and to establish the relationship of BMI with resistivity indeces, and if there is an effect from this kind it could be used also as an indicator for the effect of BMI on other Doppler indeces in an indirect way to suggest other prospective studies on this regard because all Doppler indeces are related to each other.

Frauchiger et al (2001) state: The intima-media thickness (IMT) of the carotid artery is a (morphological) sonographic parameter that depends on the degree of atherosclerosis. In the renal arteries, the value of the (hemodynamic) resistive index (RI) is correlated with the severity of atherosclerosis". They concluded "Although RI reflects the atherosclerotic process in an indirect manner, the correlation between the RI, ICA and the atherosclerosis score as well as the ability to distinguish between low and high-risk patients are comparable to those of the well-known IMT". The relationship between IMT and RI is well-known and established by many other literatures, however using RI independently as a parameter to predict an increase in IMT and thereby and increase in plaque deposition , this has not been discussed in previous study so far up to my knowledge, the other scientific basis of this study is the well-known effect of obesity on developing atherosclerotic arteries.The influence of obesity on atherosclerosis is very complex and varies with gender and age. (Özdemir,et al 2006).

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3-1 Materials

3-1-1 Population of the study

The study was conducted on 54 healthy adult subject of mixed genders , the inclusion criteria were healthy subject adult with free history of cardiovascular diseases and diabetes, both males and females their age ranged between 18 to 35 the whole sample subjects were students in radiological sciences college of Sudan university of Sciences and Technology .

3-1-2 Design of the study

This study was prospective research conducted at Sudan University college of radiological sciences' ultrasound clinic in the period from October 2014 to August 2015, the collected sample was divided into three groups , The first group was the control group consist of (23) classified as normal weight subject their body mass index between 18 to 25 , The second group was group of (17) classified as overweight adults their body mass index between 25 to 30, The third group was group of (14) obese subjects their body mass index over 30.

All of The three groups examined by one ultrasound Doppler technique with one ultrasound machine, performed by one sonographer.

3-1-3 Equipments

General multipurpose-task ultrasound machine brand (ECUBE 7) The type of probes used was linear probe 7.5 m/hrs, others accessories were used such as ultrasound couch with a pillow and sheet besides, revolving chair for the sonographer to sit in, in addition to a bottle of ultrasound gel, meter scale , weight scale and calculator.

3-1-4 Technique

All participants were being well-enlightened on what they would undergo and an informed consent has been given by every single participant. After recording the measurements of the subject's height and weight to get his/her BMI calculated and registered in a master sheet along with the others variables, the selected subject was ordered to lie on ultrasound couch in supine position with a small pillow under his/her neck to accentuate the concerned area. He/She stayed still for a while till Doppler parameters in the machine got set up, then the sonographer put the linear transducer on each side of the subject's neck with slight rotation toward contralateral side starting with the right side then, RRI and LRI were recorded respectively in the meantime. The measurements were taken at 2.5 cm below the bifurcation site.

3-1 Methods

Statistical analysis was done after collecting all relevant data using software program known as statistical package for the Social sciences (SPSS).

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Chapter Four

Results

Chapter Four

Results

4-1 Tables and Figures of the Results

Table No. (4-1)

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
RRI	54	.25	.63	.88	41.44	.7674	.04775	.002
LRI	54	.21	.67	.88	41.78	.7737	.04569	.002
Squired Heights	54	1.30	2.31	3.61	153.41	2.8409	.27524	.076
Age	54	16.00	18.00	34.00	1148.00	21.2593	3.65072	13.328
BMI	54	25.21	18.47	43.68	1427.51	26.4354	5.32948	28.403
Weight	54	95.00	40.00	135.00	4041.00	74.8333	17.39958	302.745
Height	54	38.00	152.00	190.00	9100.00	168.5185	8.10483	65.688
Valid N	54							

Table No. (4-2)

Statistics and central tendency measurements

		Age	Height	Weight	Squired Hights	BMI	RRI	LRI
N	Valid	54	54	54	54	54	54	54
	Missing	0	0	0	0	0	0	0
Mean		21.2593	168.5185	74.8333	2.8409	26.4354	.7674	.7737
Median		20.2500[a]	168.3333[a]	72.6667[a]	2.8300[a]	25.7600[a]	.7717[a]	.7800[a]
Mode		18.00	166.00	70.00[b]	2.75	18.47[b]	.74	.79
Std. Deviation		3.65072	8.10483	17.39958	.27524	5.32948	.04775	.04569
Variance		13.328	65.688	302.745	.076	28.403	.002	.002
Range		16.00	38.00	95.00	1.30	25.21	.25	.21
Minimum		18.00	152.00	40.00	2.31	18.47	.63	.67
Maximum		34.00	190.00	135.00	3.61	43.68	.88	.88
Sum		1148.00	9100.00	4041.00	153.41	1427.51	41.44	41.78

a. Calculated from grouped data.

b. Multiple modes exist. The smallest value is shown

Table No. (4-3)

Gender Statistics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	20	37.0	37.0	37.0
	Female	34	63.0	63.0	100.0
	Total	54	100.0	100.0	

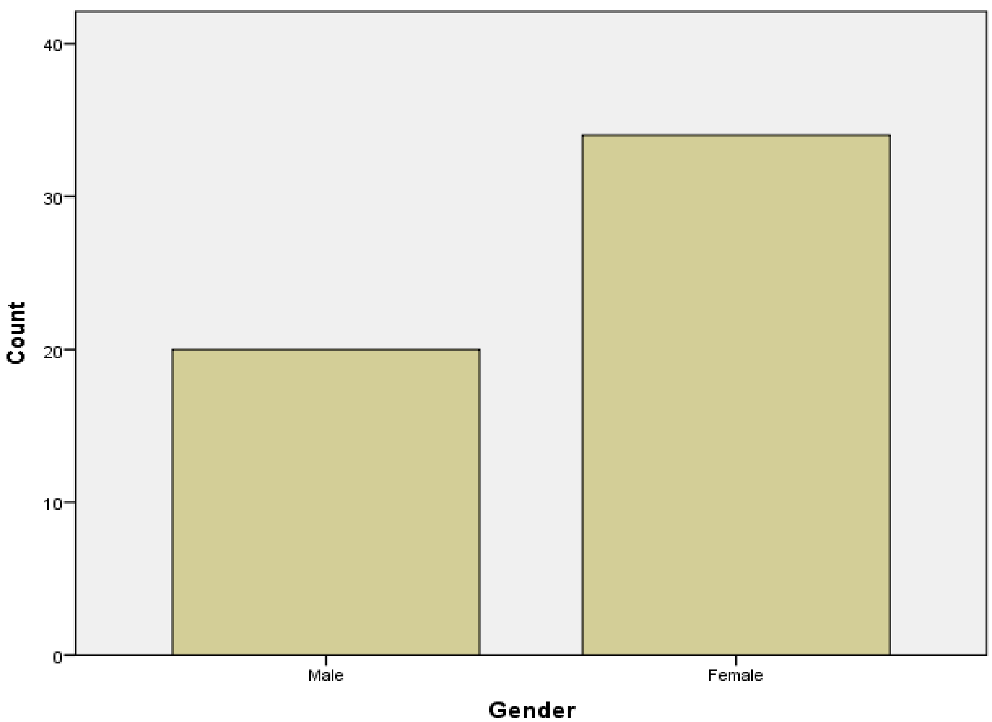

Fig. (4-1) Gender Bar-Chart

Table No (4-4)

Age Frequencies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18.00	11	20.4	20.4	20.4
	19.00	9	16.7	16.7	37.0
	20.00	10	18.5	18.5	55.6
	21.00	6	11.1	11.1	66.7
	22.00	7	13.0	13.0	79.6
	23.00	3	5.6	5.6	85.2
	25.00	2	3.7	3.7	88.9
	27.00	1	1.9	1.9	90.7
	29.00	2	3.7	3.7	94.4
	30.00	1	1.9	1.9	96.3
	31.00	1	1.9	1.9	98.1
	34.00	1	1.9	1.9	100.0
	Total	54	100.0	100.0	

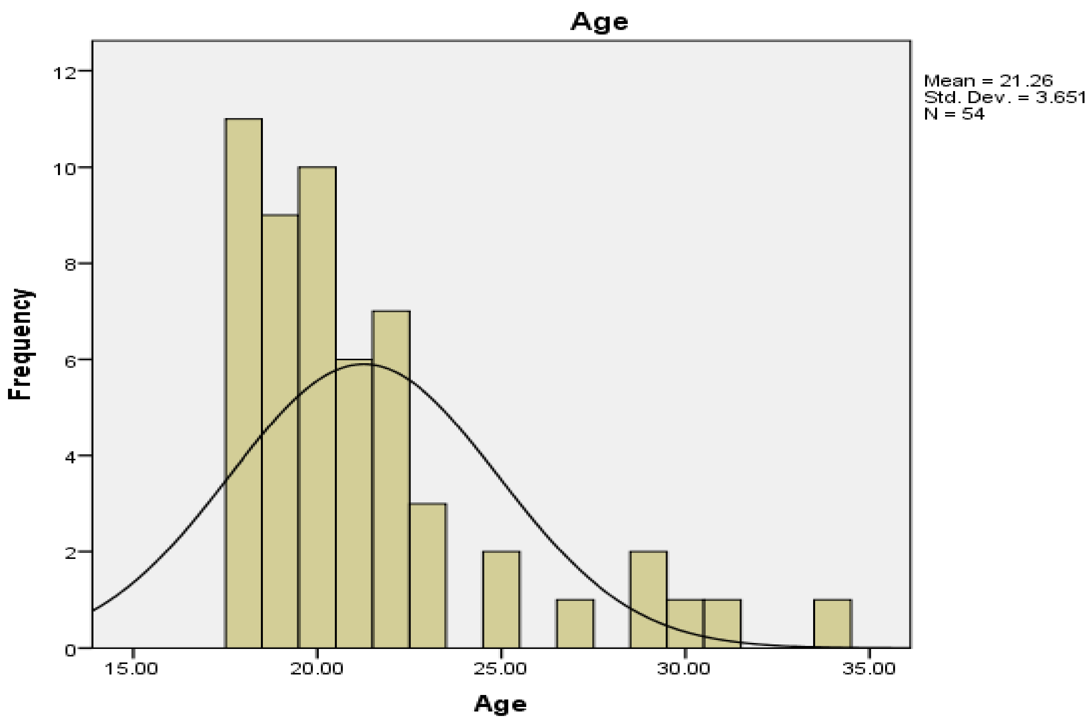

Fig. (4-2) Age Histogram

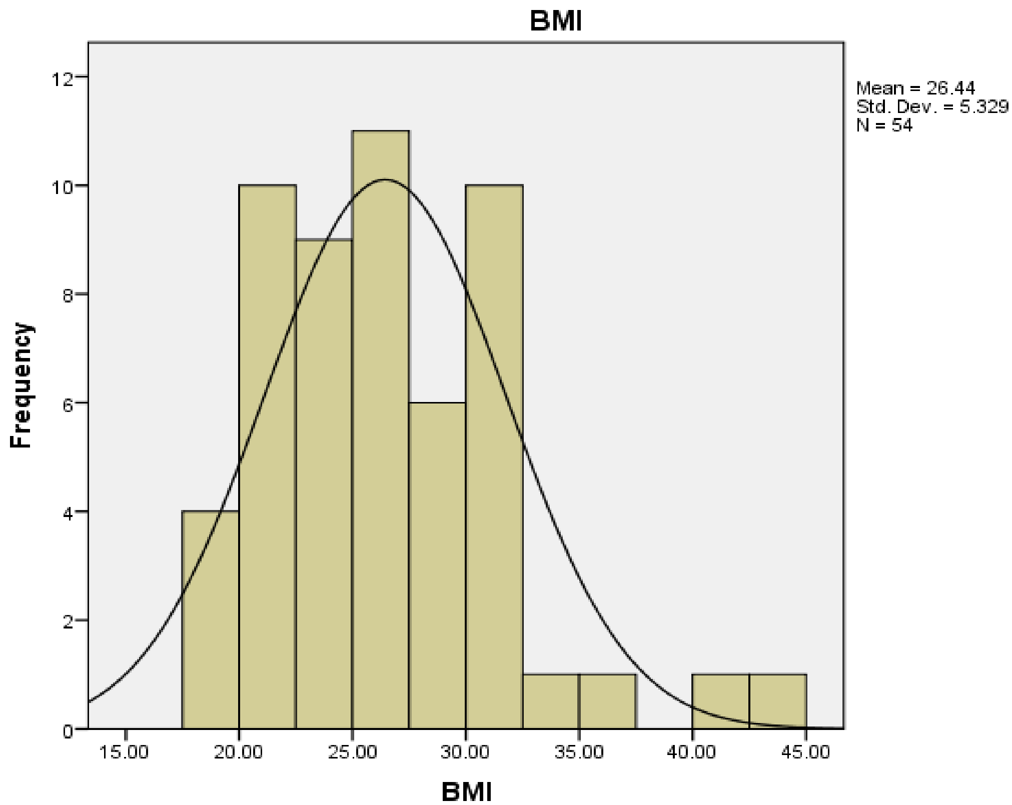

Fig. (4-3). Body Mass Index Histogram

Table No (4-5)

Levels of BMI

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal weight	23	42.6	42.6	42.6
	Overweight	17	31.5	31.5	74.1
	Obese	14	25.9	25.9	100.0
	Total	54	100.0	100.0	

Table No (4-6)

Right Common Carotid Artery Resistive index Frequencies. (RRI)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.63	1	1.9	1.9	1.9
	.68	1	1.9	1.9	3.7
	.70	4	7.4	7.4	11.1
	.71	1	1.9	1.9	13.0
	.72	4	7.4	7.4	20.4
	.73	2	3.7	3.7	24.1
	.74	7	13.0	13.0	37.0
	.75	1	1.9	1.9	38.9
	.76	5	9.3	9.3	48.1
	.77	1	1.9	1.9	50.0
	.78	5	9.3	9.3	59.3
	.79	5	9.3	9.3	68.5
	.80	3	5.6	5.6	74.1
	.81	5	9.3	9.3	83.3
	.82	5	9.3	9.3	92.6
	.83	2	3.7	3.7	96.3
	.84	1	1.9	1.9	98.1
	.88	1	1.9	1.9	100.0
	Total	54	100.0	100.0	

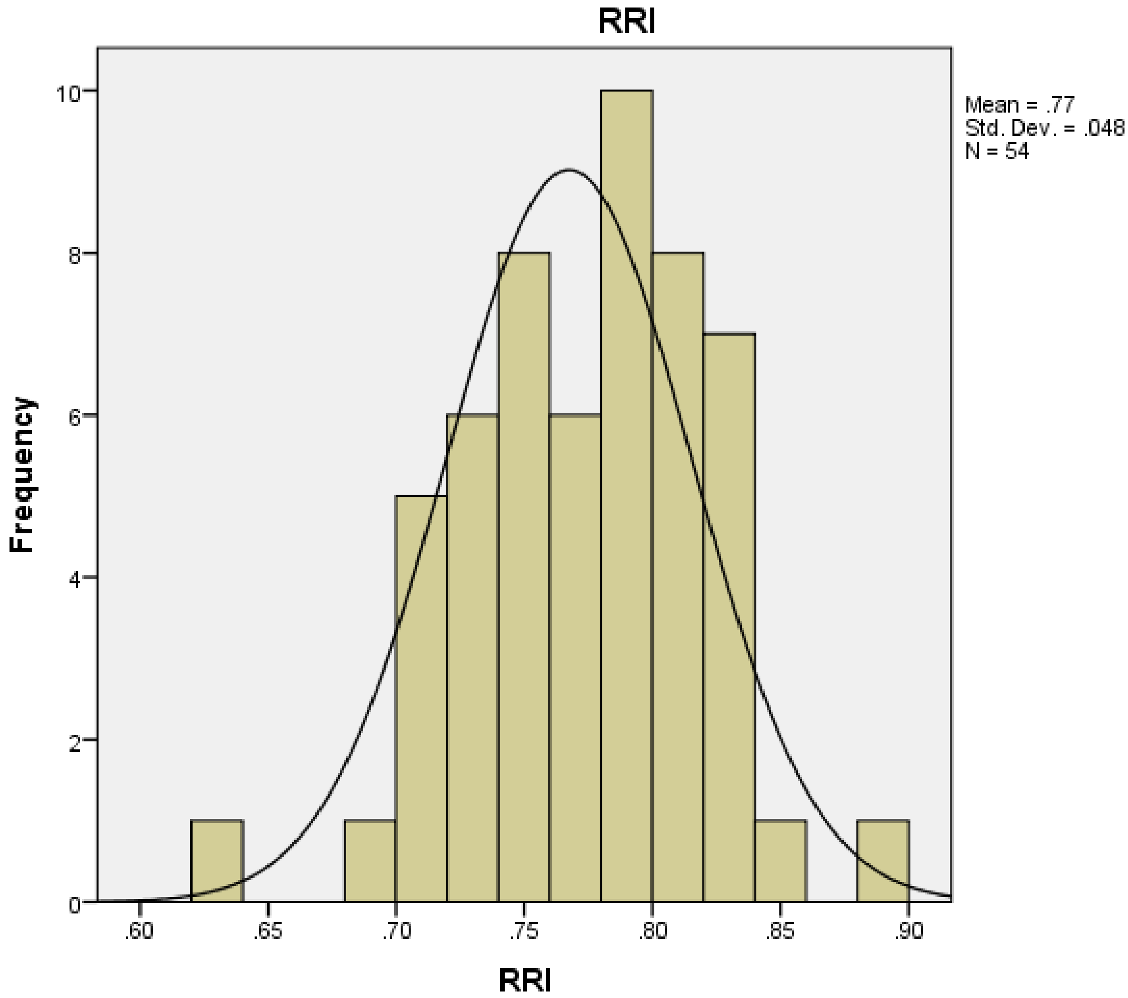

Fig. (4-4). Frequency Histogram of RRI

Table No. (4-7)

LRI Frequencies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.67	1	1.9	1.9	1.9
	.68	2	3.7	3.7	5.6
	.71	2	3.7	3.7	9.3
	.72	4	7.4	7.4	16.7
	.73	4	7.4	7.4	24.1
	.74	3	5.6	5.6	29.6
	.75	1	1.9	1.9	31.5
	.76	4	7.4	7.4	38.9
	.77	4	7.4	7.4	46.3
	.78	4	7.4	7.4	53.7
	.79	8	14.8	14.8	68.5
	.80	1	1.9	1.9	70.4
	.81	5	9.3	9.3	79.6
	.82	6	11.1	11.1	90.7
	.83	2	3.7	3.7	94.4
	.84	1	1.9	1.9	96.3
	.85	1	1.9	1.9	98.1
	.88	1	1.9	1.9	100.0
	Total	54	100.0	100.0	

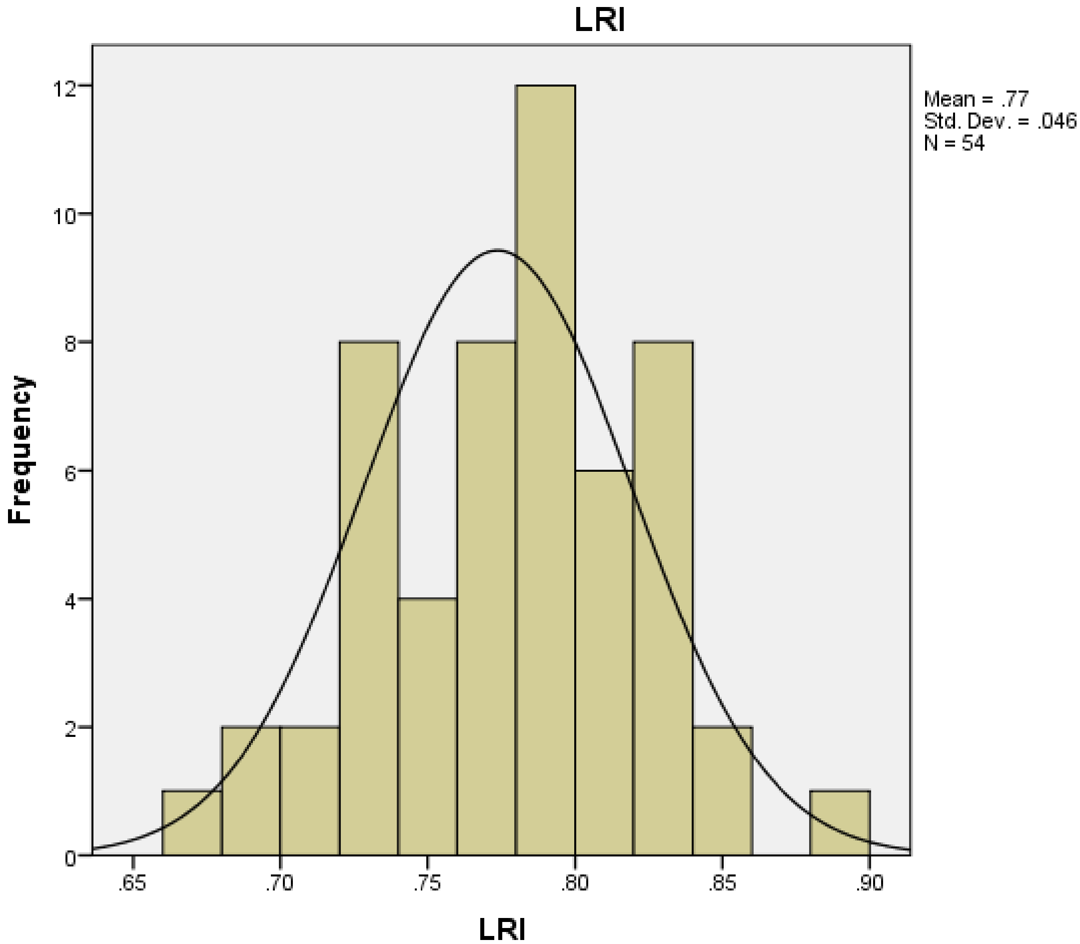

Fig. (4-5) Histogram of LRI Frequencies

4-2 Significance tests

4-2-1 Independent samples t-tests.

These t-tests are conducted to determine whether the means of RRI & LRI of the males and females have a statistically significant difference or the difference between the means might have happened due to chance , the result of this t-tests are displayed in table (4-8) and table (4-9) .

Table No. (4-8)

Independent samples Statistics

Gender		N	Mean	Std. Deviation	Std. Error Mean
RRI	Male	20	.7790	.04424	.00989
	Female	34	.7606	.04905	.00841
LRI	Male	20	.7940	.04477	.01001
	Female	34	.7618	.04246	.00728

Table No. (4-9)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
RRI	Equal variances assumed	.282	.598	1.380	52	.174	.01841	.01334	-.00836	.04519
	Equal variances not assumed			1.418	43.361	.163	.01841	.01298	-.00777	.04459
LRI	Equal variances assumed	.076	.783	2.641	52	.011	.03224	.01221	.00774	.05673
	Equal variances not assumed			2.604	38.259	.013	.03224	.01238	.00718	.05729

4-2-2 One Way ANOVA test.

This significance test is conducted using one way ANOVA to detect whether there is statistically significant difference between the mean scores of RRI & LRI between the three groups normal weight, overweight and obese or the differences between them have happened due to chance, Before ANOVA was conducted means comparison was obtained in table (4-10) to evaluate the difference between group descriptively, then, the result of this t-tests are shown in tables (4-11) & (4-12). The mean plot of RRI and LRI in figures (4-6) & (4-7) respectively.

Table No (4-10)

Means Comparison

Levels of BMI		RRI	LRI
Normal weight	Mean	.7561	.7604
	N	23	23
	Std. Deviation	.03799	.04322
	Sum	17.39	17.49
	Median	.7500	.7700
Overweight	Mean	.7859	.7876
	N	17	17
	Std. Deviation	.04651	.04323
	Sum	13.36	13.39
	Median	.7900	.7900
Obese	Mean	.7636	.7786
	N	14	14
	Std. Deviation	.05917	.04959
	Sum	10.69	10.90
	Median	.7750	.7800
Total	Mean	.7674	.7737
	N	54	54
	Std. Deviation	.04775	.04569
	Sum	41.44	41.78
	Median	.7750	.7800

Table No. (4-11)

One Way ANOVA Descriptive Data

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
RRI	Normal weight	23	.7561	.03799	.00792	.7397	.7725	.70	.83
	Overweight	17	.7859	.04651	.01128	.7620	.8098	.68	.88
	Obese	14	.7636	.05917	.01582	.7294	.7977	.63	.84
	Total	54	.7674	.04775	.00650	.7544	.7804	.63	.88
LRI	Non-overweight	23	.7604	.04322	.00901	.7417	.7791	.67	.82
	Overweight	17	.7876	.04323	.01049	.7654	.8099	.71	.85
	Obese	14	.7786	.04959	.01325	.7499	.8072	.68	.88
	Total	54	.7737	.04569	.00622	.7612	.7862	.67	.88

Table No. (4-12)

One Way ANOVA Test

		Sum of Squares	df	Mean Square	F	Sig.
RRI	Between Groups	.009	2	.004	2.041	.140
	Within Groups	.112	51	.002		
	Total	.121	53			
LRI	Between Groups	.008	2	.004	1.903	.159
	Within Groups	.103	51	.002		
	Total	.111	53			

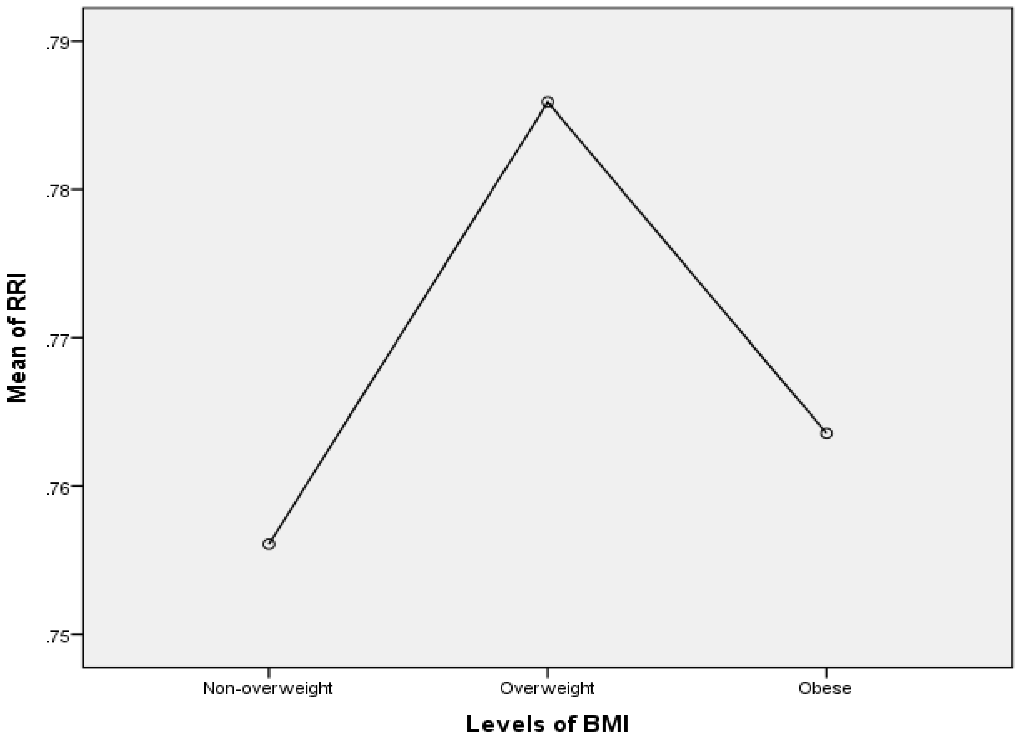

Fig. (4-6) Means Plot of RRI for the Levels of BMI

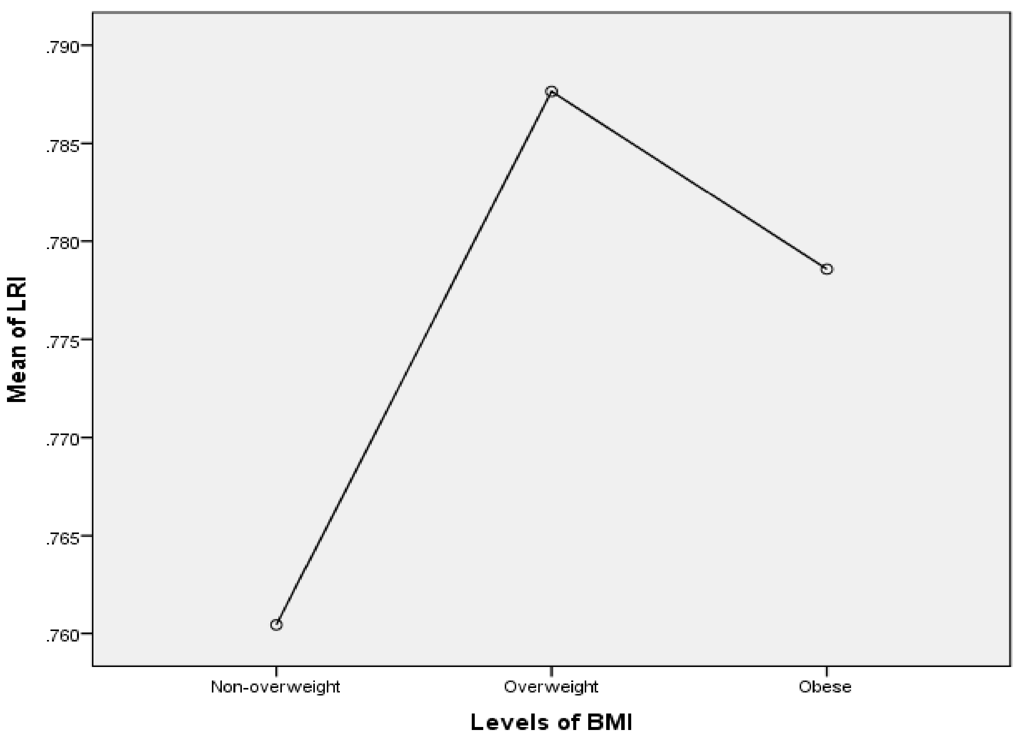

Fig. (4-7) Means Plot of LRI for the Levels of BMI

4-3 Bivariate Correlation tests

Pearson correlation tests are conducted to determine the type of relationship between age , BMI and resistive indeces of CCA RRI & LRI, the result of the correlation between age and resistive indeces of CCA RRI & LRI is shown in table (4-13) and their scatter plot in Fig. (4-8) and Fig. (4-9) respectively. The result of the correlation between BMI and resistive indeces of CCA is shown in table (4-14) and their scatter plot in Fig. (4-10) and Fig. (4-11) respectively.

Table No. (4-13)

Correlation Test of Age with RIs

		Age	RRI	LRI
Age	Pearson Correlation	1	.113	.300*
	Sig. (2-tailed)		.415	.028
	N	54	54	54
RRI	Pearson Correlation	.113	1	.556**
	Sig. (2-tailed)	.415		.000
	N	54	54	54
LRI	Pearson Correlation	.300*	.556**	1
	Sig. (2-tailed)	.028	.000	
	N	54	54	54
*. Correlation is significant at the 0.05 level (2-tailed).				
**. Correlation is significant at the 0.01 level (2-tailed).				

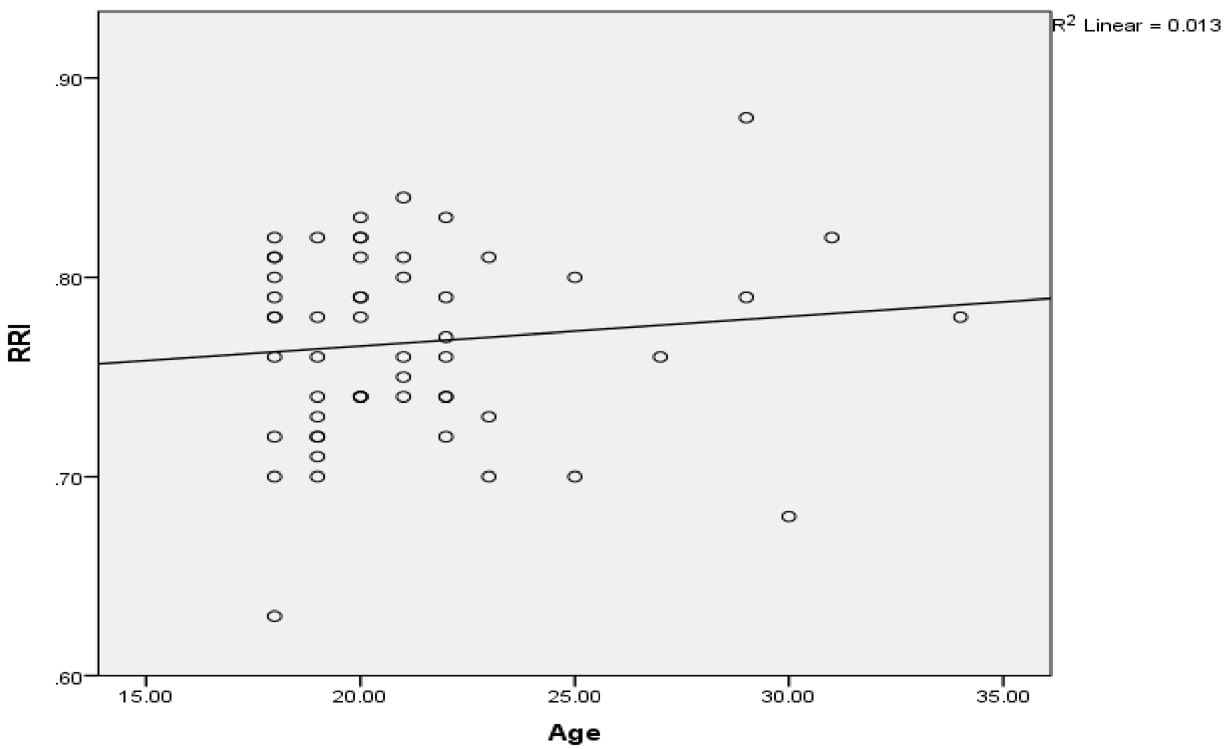

Fig. (4-8) Scatter plot of RRI with Age

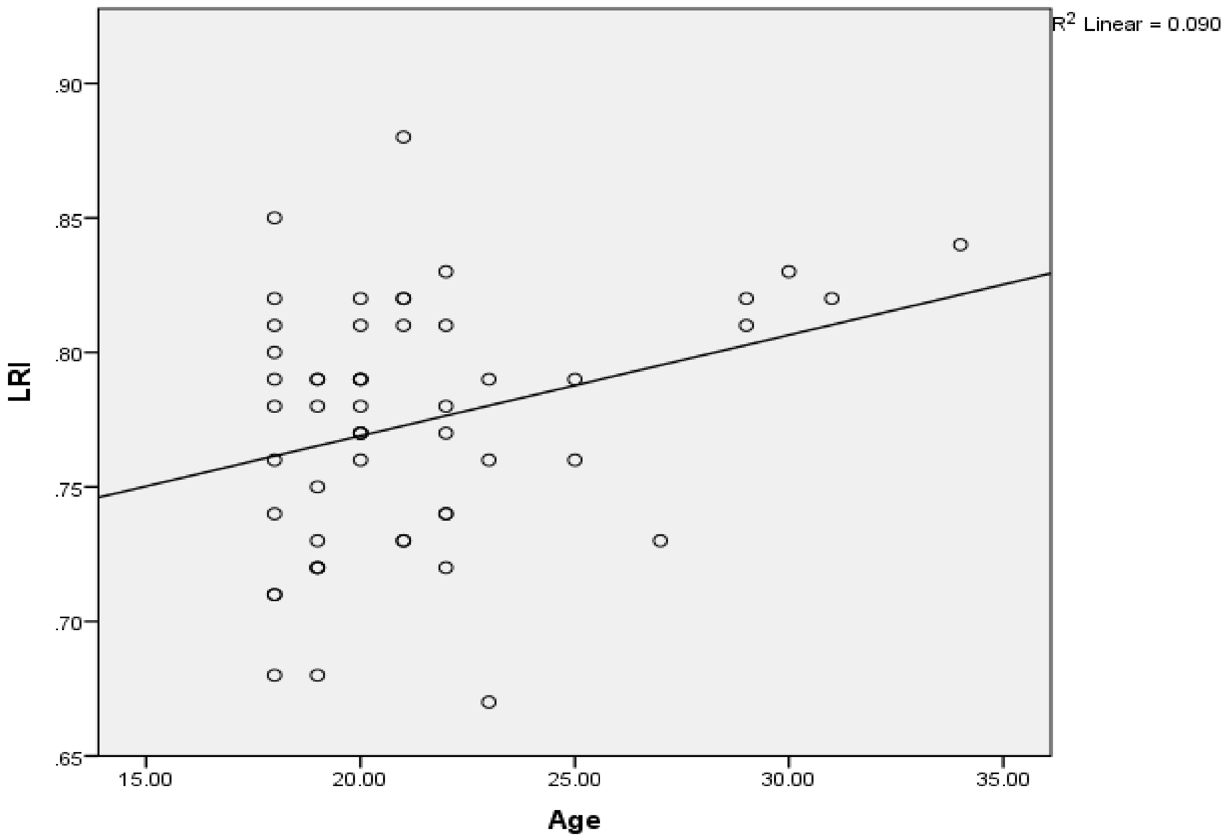

Fig. (4-9) Scatter plot of LRI with Age

Table No. (4-14)

Correlation Test of BMI with RIs

		BMI	RRI	LRI
BMI	Pearson Correlation	1	.029	.053
	Sig. (2-tailed)		.836	.706
	N	54	54	54
RRI	Pearson Correlation	.029	1	.556**
	Sig. (2-tailed)	.836		.000
	N	54	54	54
LRI	Pearson Correlation	.053	.556**	1
	Sig. (2-tailed)	.706	.000	
	N	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

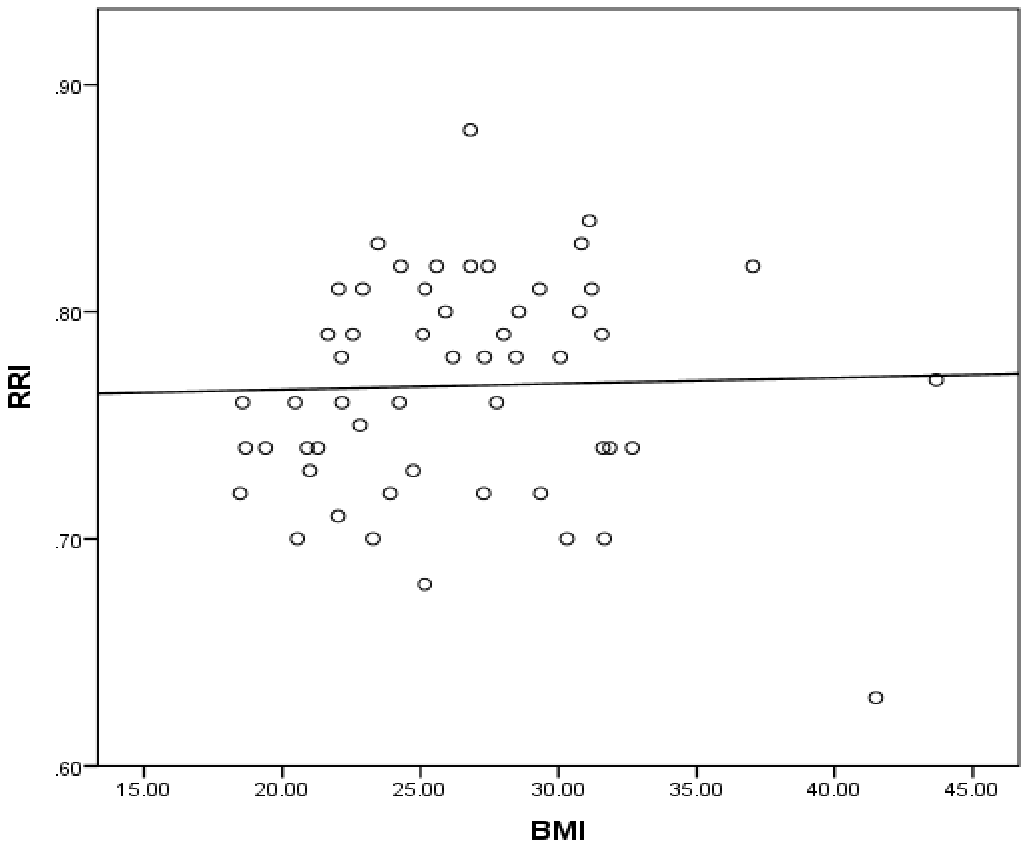

Fig. (4-10) Scatter plot of RRI with BMI

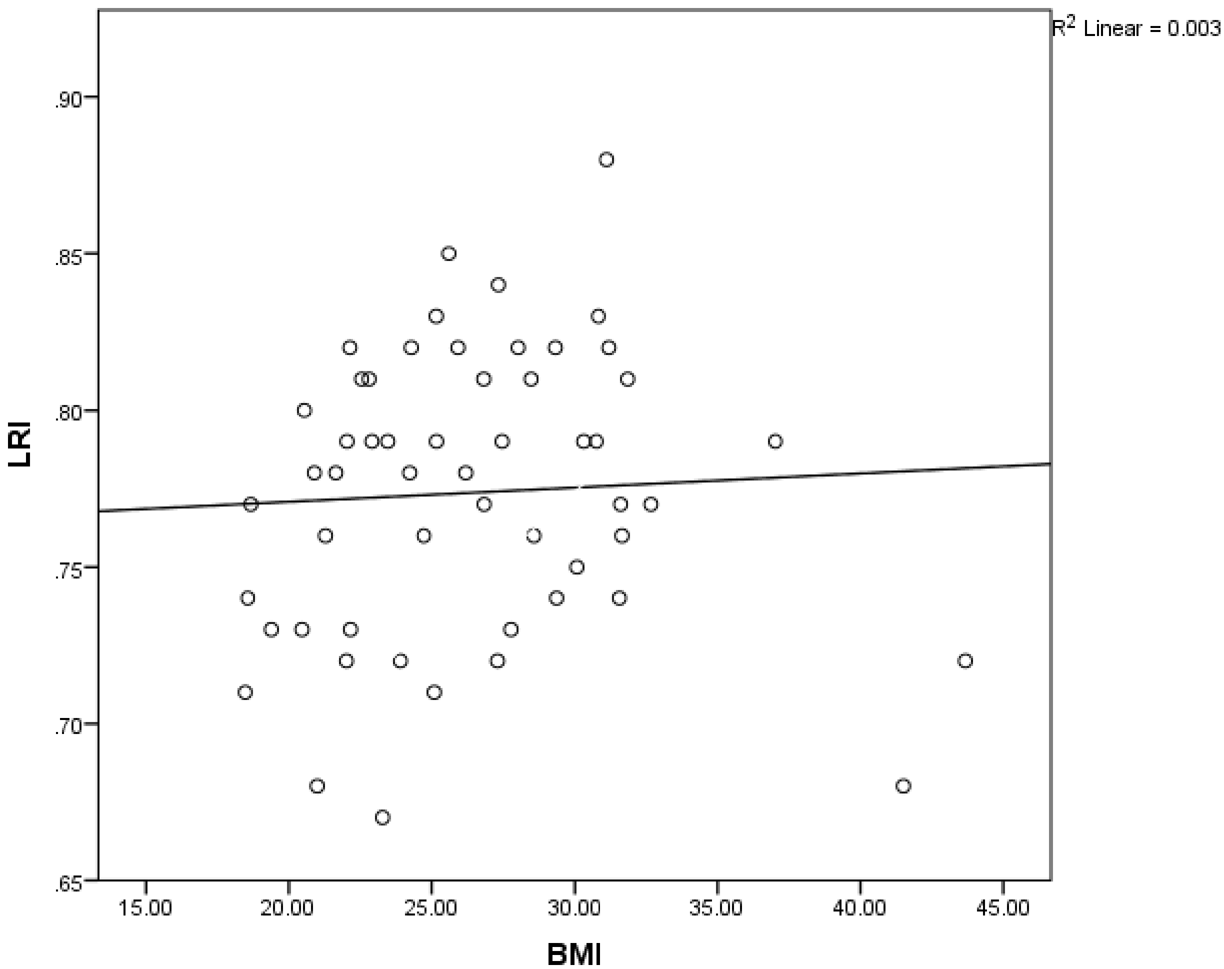

Fig. (4-11) Scatter plot of LRI with BMI

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recomendation

5-1 Discussion

One of the restrictive limitations of this study as we notice clearly was the limited number of subjects particularly in overweight and obese groups and the limited number of subjects was remarkably notable in obese group that might explain its lower mean 0.77 which was lower than the mean of over-weight group 0.78 therefore the effect of this limitation on the significance and correlation tests is inevitable. Another limitation was the restriction to specific ages ranged between 18 to 35 with very small SD 3.65 and more than 70% of participated ages between 18 to 23 this definitely makes it unreliable to generalize the results of this study on the whole population and this explains the small differences in the means of RRI & LRI between the three groups. One last limitation of this descriptive data was there was no balancing between sexes the females number greatly outweighed the males number.

One way ANOVA test has shown no statistically significant difference between independent variables means [the three groups of BMI levels] for p-value = 0.14 and 0.15 of RRI & LRI respectively. Although, This study demonstrates there is no effect of body mass index of the three groups on resistive indeces of both right and left common carotid arteries, this result is considered restricted to this study alone and cannot be generalized because of its obvious restrictive limitations.

Independent samples t-test for RRI has shown no statistically significance difference between the males and females means for p-value = 0.17, the difference between mean was very small = 0.018 , the population mean of confidence interval 95% falls between - 0.0083 and 0.0541 , this result demonstrates clearly that gender has no effect on the numerical value of resistive index of right common carotid arteries. However, the males have scored slightly higher mean than females in RRI mean of males 0.77 and for females was 0.76 and this difference was not statistically significant. Conversely, the difference is higher and statistically significant in LRI for p-value = 0.01 and its mean was 0.79 and for the females still 0.76 the same as in RRI. This result clearly demonstrates there is an effect of gender on the numerical value of left common carotid artery's resistive index and the resultant means values have to be used as standard within the same rang of adult age between 18 to 35 for males and females. The anatomical position of left common carotid artery can be the main reason that may explain its higher resistive index due to its coursing via two anatomical parts, thoracic and neck while in the case of right common carotid artery there is only neck part.

Bivariate correlation test between independent variable age and RRI has shown pearson correlation value of 0.113 and p-value = 0.415 both displayed in table (4-6) indicates there is no relationship between age and RRI, this clearly demonstrated on its scatter plot which has shown random distribution around regression line in Fig. (4-3) . For relationship between age and LRI, pearson value was (0.300) and p-value (0.028) displayed in table (4-6) explaining there is a weak positive linear correlation between LRI and age and the scatter plot has shown this weak relationship as well in Fig. (4-4).

Bivariate correlation test between independent variable BMI and RRI has shown pearson correlation value of 0.029 and p-value = 0.836 indicates there is no relationship between BMI and RRI. Likewise there is no relationship between BMI and LRI for pearson value of 0.053 and p-value = 0.706. Their scatter plots have shown random distributions around regression line indicating there is no relationship between BMI with RRI & LRI in Fig (4-5) ,and Fig (4-6) respectively.

5-2 Conclusion

This study has concluded that there is no effect of BMI on numerical value of resistive indeces of common carotid arteries, Although, due to the aforementioned limitations of this study, the study has resulted in small and weak effect of BMI on Common Carotid Arteries' resistive indeces suggesting that, this small difference in the means of the three levels of BMI which are normal weight, overweight and obese can be increasing if a study of a large sample is conducted. The study has concluded also there was no relationship between overall BMI of 54 subject and resistive indeces of common carotid arteries right and left. Likewise there was no relationship found between age and the value of resistive indeces of CCAs , but the study has proved significant correlation test of age with LRI without RRI being involved in the significant correlation with age despite its very close scatter plot to the scatter plot of LRI. On the other hand the study has discovered there is a significant statistical difference between males and females means for LRI .

5-3 Recommendation

What is extrapolated and concluded from this study is strongly prompt the researchers for the urge and need for other large and wide-ranged studies in the same topic, because this study has come out with a positive results regarding the effect of body mass index and gender on the numerical value of resistive indeces of common carotid artery in spite of the obvious limited sample of 54 subjects only and restricted and narrow age range, besides the disproportionate gender participation 34 females and only 20 males. Therefore, The results of this study despite its limitations expose the explicit need for other prospective studies in this regard and those studies have to avoid or to minimize any limitations' influence.

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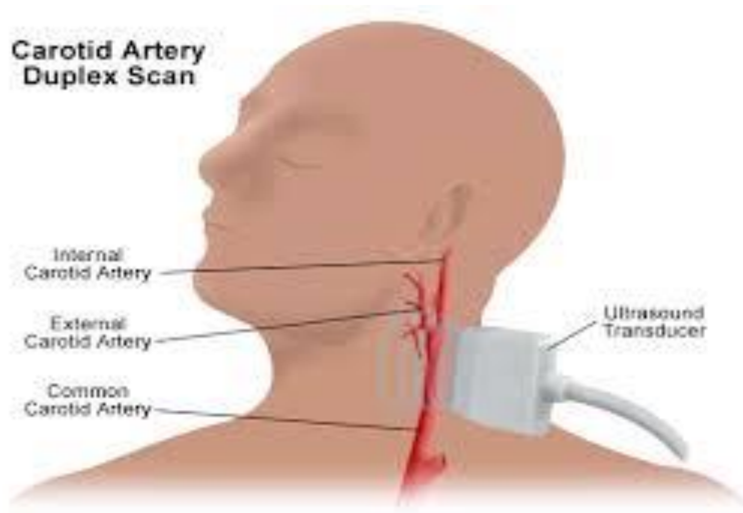
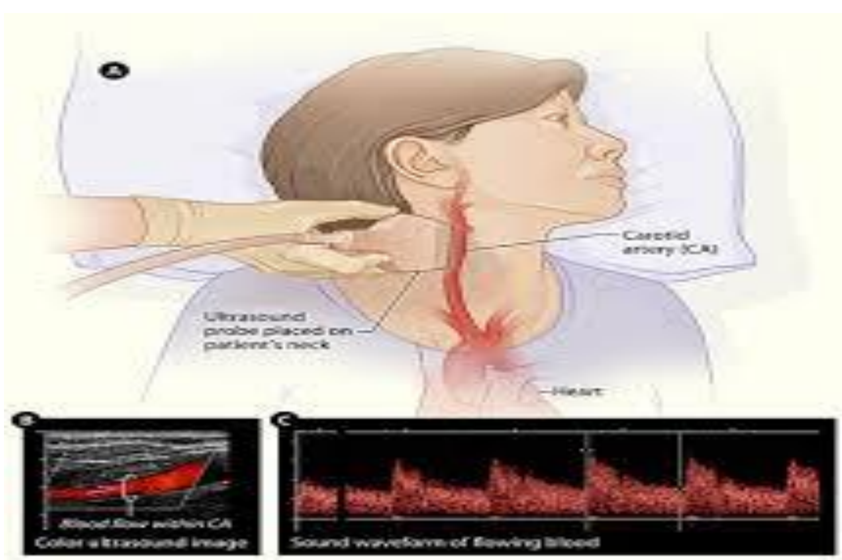
Appendices

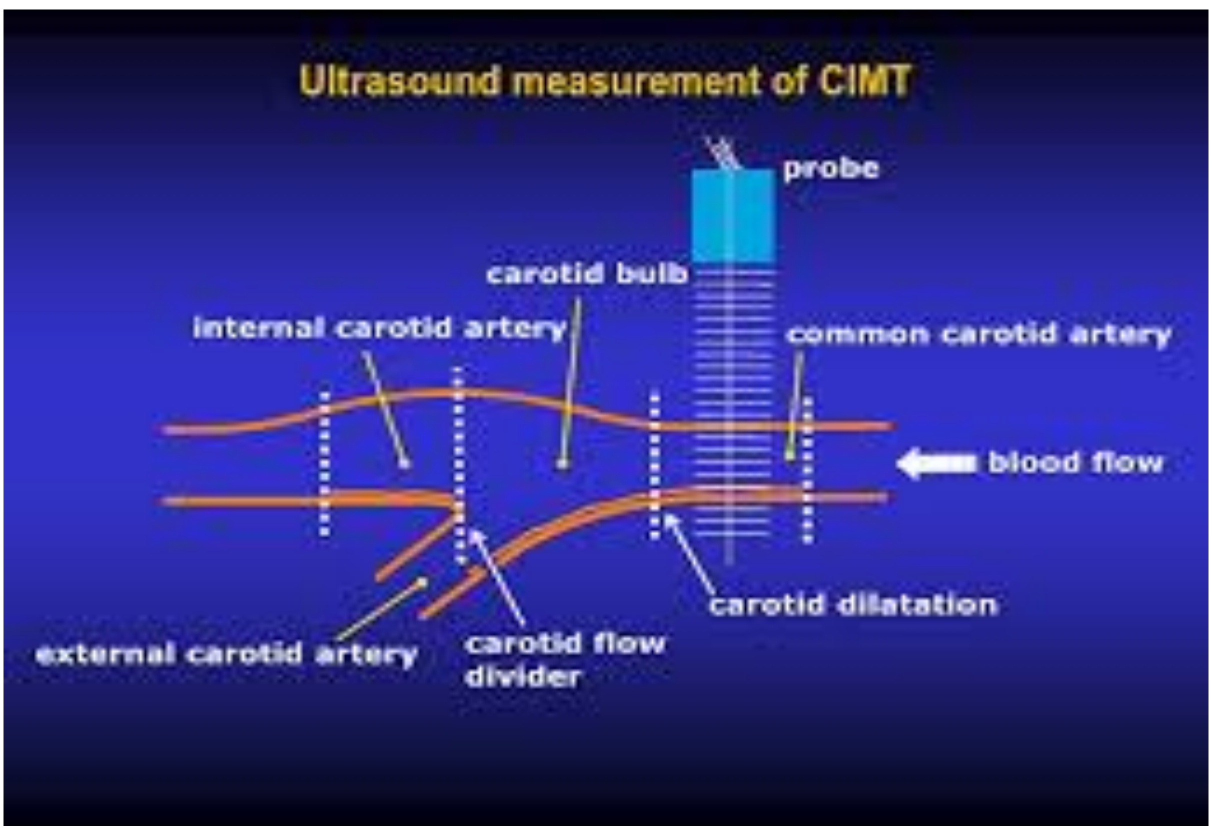
Master Sheet - EMPTY

Master Sheet - FULL


CCA PW doppler


Carotid Artery
Duplex Scan
Internal
Carotid Artery
External
Carotid Artery
Common
Carotid Artery
Ultrasound
Transducer


Carotid
artery (CA)
Ultrasound
probe placed on
patient's neck
Heart
Blood flow within CA
Color ultrasound image
Sound waveform of flowing blood



Ultrasound measurement of CIMT
probe
carotid bulb
internal carotid artery
common carotid artery
blood flow
carotid dilatation
external carotid artery
carotid flow
divider