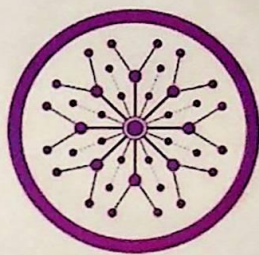


**SONOGRAPHIC EVALUATION OF RENAL CORTICAL
THICKNESS AND RENAL PARENCHYMAL CHANGES
AS A PREDICTOR OF RENAL FUNCTION**



SUPERIOR UNIVERSITY

Thesis Submitted to

The Superior University Lahore

In Partial Fulfillment of the

Requirement for the Degree of

Master of Science in Allied Health Sciences

By

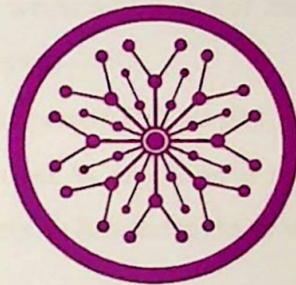
IQRA ABDUL RAZZAQ

Roll No. SU91-MSAHW-S23-039

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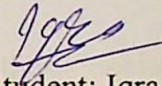
Faculty of Allied Health Sciences

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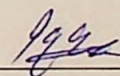
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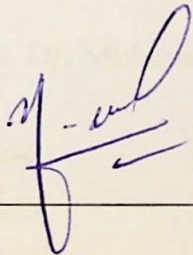


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Supervisor Name: Ms Sadia Sabir

Designation: Lecturer

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This is to certify that the research work presented in this thesis, titled “**Sonographic evaluation of renal cortical thickness and renal parenchymal changes as a predictor of renal function impairment in hypertensive patient's**” was conducted by “**Iqra Abdul Razzaq**” under the supervision of “**Ms. Sadia Sabir**”

No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Faculty of Allied Health Sciences, The Superior University, Lahore in partial fulfillment of the requirements for the degree of Master of Sciences in the field of “**Allied Health Sciences**” in Faculty of Allied Health Sciences at The Superior University, Lahore.

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DEDICATION

I dedicate this thesis to my family, whose unwavering love, patience, and support made this journey possible. To my parents, for their constant encouragement and belief in my abilities. To my advisor, Ms. Sadia Sabir, for their invaluable guidance, insight, and support throughout this research. To all those who believed in me, especially my friends who stood by me in moments of doubt.

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious, the most Merciful.

I am extremely thankful to Almighty 'Allah' Who is the entire source of knowledge and wisdom endowed to mankind, for providing me with the acumen and vision to complete this endeavor.

I would like to express my profound gratitude to my supervisor for his/her wise counsel and encouraging attitude towards this study. I am extremely grateful to him/her for immensely facilitating me during my study period by ensuring the provision of favorable circumstances and conducive environment. This project would not have been possible without his support and expert guidance.

In the end, I would like to extend my deepest gratitude to my family members. Without their encouragement; I would not have been able to complete this endeavor.

Iqra Abdul Razaq

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LIST OF ABBREVIATIONS

LMIC	Low- and middle-income
CT	Computed Tomography
US	Ultrasound
CMD	Corticomedullary distinction
CKD	Chronic kidney disease
GFR	Glomerular Filtration Rate
eGFR	Estimated Glomerular Filtration Rate
RCT	Renal Cortical Thickness
RRI	Renal Resistive Index
BMI	Body Mass Index
DUS	Doppler US
CD	Color Doppler
PD	Power Doppler
LDL	Low-Density Lipoprotein
HDL	High-Density Lipoprotein
TC	Total Cholesterol
TG	Triglycerides

ABSTRACT

Background: Hypertension and the associated risks of renal disease make it a significant global public health concern. Renal sonographic data can be used to indirectly evaluate renal function or status because hypertension can indirectly affect the kidneys. The most frequent causes of acute and chronic renal disorders are renal parenchymal diseases, which, if left untreated, can progress to end-stage renal diseases. **Aim and Objectives:** To assess the diagnostic precision of ultrasound to measure the cortical thickness and renal parenchymal changes and estimate the effect of hypertension on renal function. **Methodology:** Prospective, cross-sectional study was conducted on 100 participants and data was collected from Rashid Hospital Shahkot, Samar diagnostic lab Lahore. Purposive sampling technique (non-Random) was done. Renal Ultrasound was performed by using Toshiba NIMIO 200 convex probe 3-5 MHz and all the collected data was analyzed by using SPSS. **Results:** 100 patients total in which 59 females and 41 male patients with hypertension were added. The frequency and percentage of corticomedullary distinction was intact in 83 percent, lost in 3 patients and was poorly intact in 14 percent of the total cases. The correlation coefficient (R) among the observed and predicted standards of the dependent variable (CGeGFR) is 0.375, indicating a moderate positive correlation between the independent variable and the dependent variable. $R^2 = 0.140$, which means that around 14% of the variance is explained by the independent variable P-value, is 0.000, demonstrating that the model is statistically significant.

Conclusion: The assessment of Renal Cortical Thickness and changes in Renal Parenchyma through ultrasound may serve as indicators of renal function deterioration in individuals with hypertension. Research indicates that the predictor Mean Cortical Thickness exhibits a significant correlation with the dependent variable CGeGFR. Therefore, incorporating the evaluation of Renal Cortical Thickness and Renal Parenchymal Changes into routine examinations of hypertensive patients could provide important diagnostic and prognostic insights.

Key words: Hypertension, Ultrasound, Renal Cortical Thickness and Renal Parenchymal Changes

CHAPTER 1

INTRODUCTION

The occurrence of hypertension and the related risks of renal and cardiovascular disease make it a significant global public health concern. It ranks third as a cause of impairment and has been found to be the primary risk factor for mortality [1]. Approximately 60 million Americans suffer from hypertension, which can cause serious morbidity and mortality, such as heart disease and kidney failure. While essential hypertension affects the majority of people, a significant portion (5% to 10%) have a secondary etiology. Renal parenchymal disease and renovascular disease are the most common of these secondary causes [2]. Renal USG data can be used to indirectly evaluate renal function or status because hypertension can indirectly affect the kidneys. In radiology departments, kidney ultrasonography has become the most common investigation. The most frequent causes of acute and chronic renal disorders are renal parenchymal diseases, which, if left untreated, can progress to end-stage renal diseases. If these cases arise, the cost of treating them is high, and ignoring them could be lethal [3]. Hypertension has become more frequent, particularly in low- and middle-income (LMIC) nations. In 2010, an estimated 1.39 billion adults globally, or 31.1% of the total population, suffered from hypertension. Compare to high-income nations (28.5%, 349 million people), the prevalence of adult hypertension was greater in LMICs (31.5%, 1.04 billion people) [4].

Renal disease is now regarded as a serious medical condition. Nearly 7 million individuals need renal replacement, and chronic renal disorders are thought to affect more than 15% of the global population. Furthermore, cardiovascular ailment is the leading cause of death globally, and renal problems increase its frequency [5]. Numerous conditions that impact the renal parenchyma and result in renal failure are referred to as renal parenchymal disorders. The diseases of renal parenchyma were classified by Rosenfield et al. as either type I, which emphasize cortical echoes while preserving or exaggerating the corticomedullary junction, or type II, which distort normal anatomy and either diffusely or focally obliterate the corticomedullary differentiation. In type (i), the renal cortex's echogenicity is on par with or higher than that of the liver or spleen. The accentuation of corticomedullary definition or the disappearance of distinguishable arcuate arteries are examples of minor symptoms. Any mass lesion, such as a cyst, tumor, abscess, or hematoma, can cause focal disruption of normal anatomy in type

(ii) [6]. Common techniques include computed tomography (CT), ultrasound (US), intravenous pyelography, and plain abdominal radiography. For renal imaging, US is a straightforward, affordable, non-invasive technique that is simple to use [7].

1.1: ANATOMY

The kidneys are a pair of organs situated on the posterior abdominal wall retroperitoneally. Every kidney has a distinct shape, with a concave medial border, a convex border positioned laterally, and superior and inferior poles. The renal arteries and renal pelvis are located in the hilum, a prominent dip on the medial edge [8]. The left kidney is bigger than the right in adults, which is consistent with morphometric results for embryonic kidneys. The normal length of the right kidney is 10.97 cm, whereas the average length of the left kidney is 11.21 cm. At the hilum, the mean thickness of the right kidney was 3.21 cm, whereas the mean thickness of the left kidney was 3.37 cm. However, the superior pole (mean = 6.48 cm) is wider than the inferior pole (mean = 5.39 cm) in the same kidney [9].

The kidney's blood supply is maintained in large part by the renal vessels, which include the renal vein and renal artery [10]. The outside part of the kidney amid the medulla and renal capsule is called the renal cortex. Because nephrons are present, the tissue is granular. It generates erythropoietin, which is required for the creation of new red blood cells, and has blood arteries that are attached to the nephrons [11]. RCT is a significant predictor of the occurrence and course of numerous renal disorders, independent of gender, age, and race. It is a helpful therapeutic metric for the assessment and monitoring of patients with general conditions like diabetes mellitus and hypertension, as well as those with renal parenchymal disorders and recurrent UTIs. Unrestrained high blood pressure over period can lead to the narrowing, hardening, and destruction of the arteries around the kidney. Consequently, based on the severity and length of hypertension, the cortex's size will be affected by progressive renal failure. One early indicator of renal atherosclerotic alterations is cortical size [12]. To the best of our knowledge, ultrasonography has not provided a solid link between cortical size and hypertension. Regular ultrasonography measurements of cortical size in hypertension patients would aid referring physicians in making decisions and enable them to monitor the disease's progression [11].

1.2: BLOOD SUPPLY OF KIDNEY

The renal arteries are two lateral twigs that emerge from the abdominal aorta at the upper lumbar level (L1–L3), beneath the superior mesenteric artery [9]. Each renal artery is divided into anterior and posterior branches around the kidney's hilum. Furthermore, it branched into segmental arteries to stimulate the organ's distinct sections before becoming terminal arteries [13].

One renal vein functions as the kidney's venous drainage system, allowing blood to leave the kidney and enter the IVC. In addition to the vein that exits the organ, the left renal vein receives the left suprarenal and left gonadal veins. The number, source, and course of the renal arteries vary from animal to animal [14].

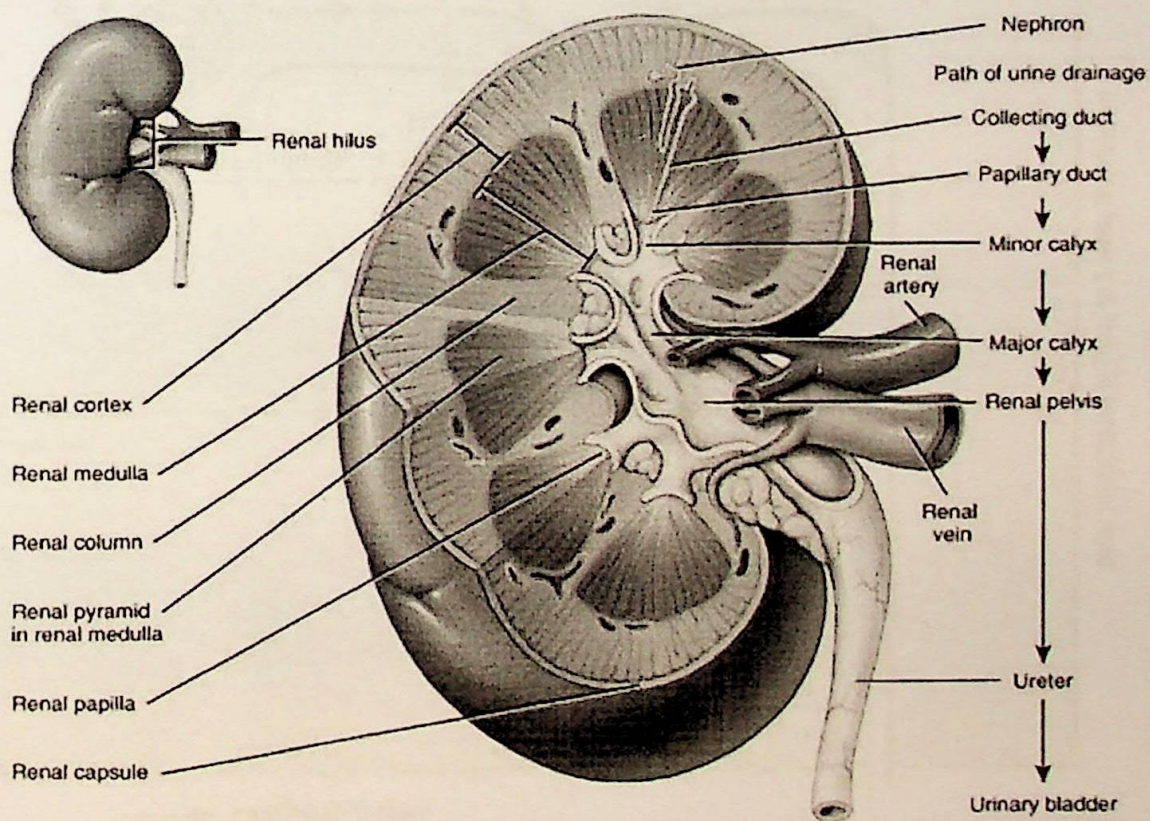


Figure 1.1: Kidney anatomy and pathway of urine drainage [15].

1.3: PHYSIOLOGICAL FUNCTIONS OF KIDNEY

The kidneys perform a number of tasks, including filtering and eliminating waste items from the bloodstream, controlling essential electrolytes, and promoting the creation of red blood cells. Additionally, they manage water reabsorption, maintain the proper pH level, maintain the body's chemical equilibrium, and control blood pressure through the renin-angiotensin-aldosterone system. Additionally, the kidneys reabsorb glucose and amino acids, which may have a role in the regulation of hormone function through the activation of vitamin D, calcitriol, and erythropoietin [16].

Urine is a waste product fashioned by the metabolic procedure of the renal system filtering waste molecules and surplus water. The renal system's major goals are to control blood volume, preserve plasma osmolarity, and get rid of waste through urine, which is principally a practical means of moving out frequent bodily processes [17].

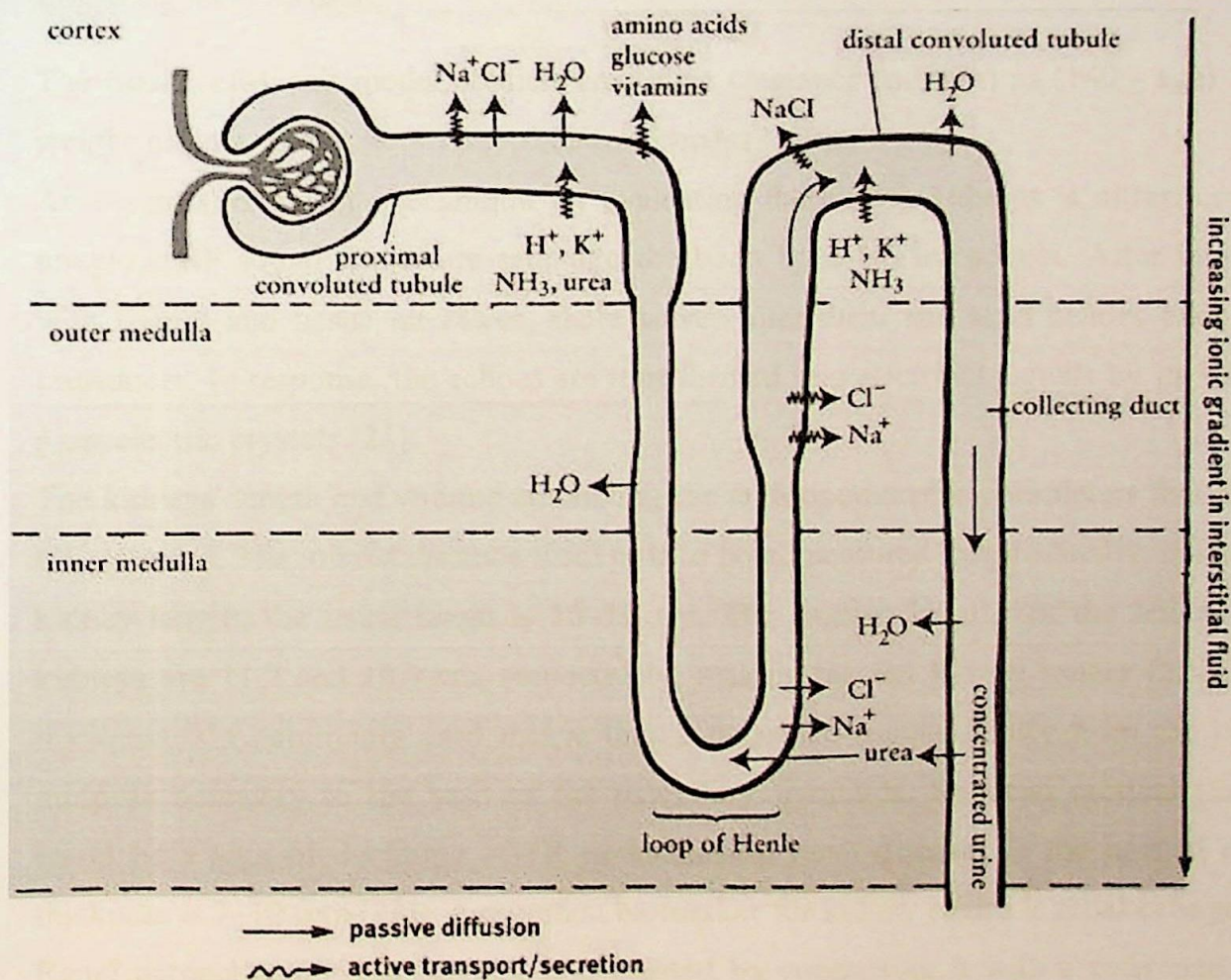


Figure 1.2: The physiological function of kidney and process of urine formation [9].

1.4: CREATININE

It is the endogenous marker utmost regularly used to estimate GFR. A suggestion of GFR is provided by the computed creatinine clearance. Since 24-hour urine collections are incoherent, this process entails collecting urine over a 24-hour time or over accurately scheduled period of 5 to 8 hours [18]. Generally speaking, the kidney completely eliminates creatinine from the blood. Blood creatinine rises as a product of decreased renal clearance. Muscle mass affects the daily production of creatinine. Males and females have distinct creatinine ranges, and toddlers and those with less muscle mass have lower creatinine levels. Creatinine levels are also influenced by dietary variables. Red meat consumption can cause a 30% change in creatinine. Furthermore, renal function might decline by as much as 50% before a rise in serum creatinine is noticed, indicating renal impairment at a rather late stage [19]. For the estimation of creatinine clearance, the following formula is used:

The Cockcroft-Gault model predicts creatinine clearance (ml/min) as $(140 - \text{age}) \times \text{body weight} / \text{plasma creatinine} \times 72$ ($\times 0.85$ for females) [20].

An essential diagnostic technique for evaluating the human kidneys is ultrasound (US) imaging. RF sound waves are sent into the body by a US transducer. After interacting with tissues and tissue interfaces, these waves alter them and send echoes back to the transducer. In response, the echoes are transformed into electrical signals by its vibrating piezoelectric crystals [21].

The kidneys' length and volume are among the anthropomorphic parameters that B-mode US provides. The utmost distance from pole to pole, measured longitudinally, is known as kidney length; the usual range is 10–12 cm. The median lengths of the left and right kidneys are 11.2 and 10.9 cm, respectively, making the left kidney longer [22]. Cortical thickness is a commonly used metric that is measured longitudinally from the kidney's midpole boundary to the base of the medullary pyramids. Reduced cortical thickness could be a sign of declining eGFR or increasing renal disease, as the normal cortical thickness is 7–10 mm [23]. A common biomarker for kidney health is renal echogenicity. Renal parenchyma's echogenicity is evaluated by contrasting it with a reference tissue, like the liver, which ought to be less echogenic. It is simple to compare the echogenicity of the medulla and cortex. The loss of CMD refers to the incapacity to differentiate between them [24].

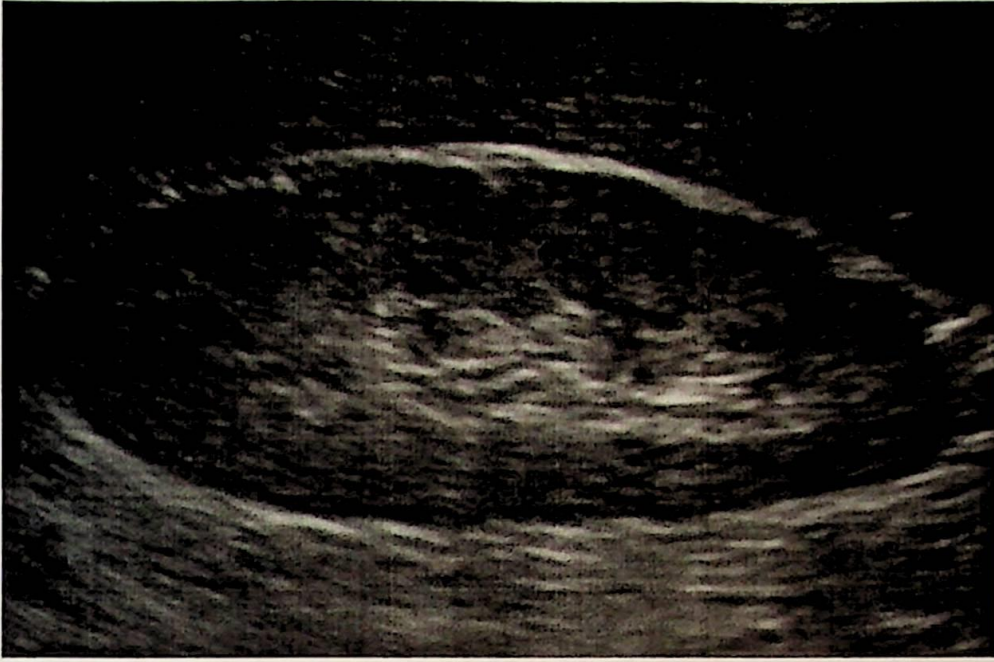


Figure 1.3: The kidney shows parenchymal thickening with compressed renal sinus and hyperechoic renal parenchyma with decreased CMD [25].

One of the many techniques used to assess renal morphology is ultrasound. According to many studies, ultrasonography is the preferred screening and follow-up technique for both patients and healthy individuals. It is also a quick and noninvasive way to diagnose renal disorders [26]. In the practice of urology and nephrology, a patient's kidney size is a useful diagnostic metric. The adult kidney, on the other hand, is described as 12 cm long, 6 cm wide, and 3 cm deep in the main anatomy text. Additional research shows that kidney size changes with co-morbid diseases, pregnancy, body mass index, age, and gender [27].

Renal morphology can be evaluated using a range of metrics that include determining renal length, volume, and cortical thickness. Renal function can also be accessed through renal duration and cortical thickness, and important treatment choices can be made based on this information. To determine if renal disease is severe or normal, serial sonographic tests are also performed. Longitudinal renal length measurements are sufficient in healthy individuals, but renal parenchymal volume is a fairly accurate estimate in patients with CKD [28].

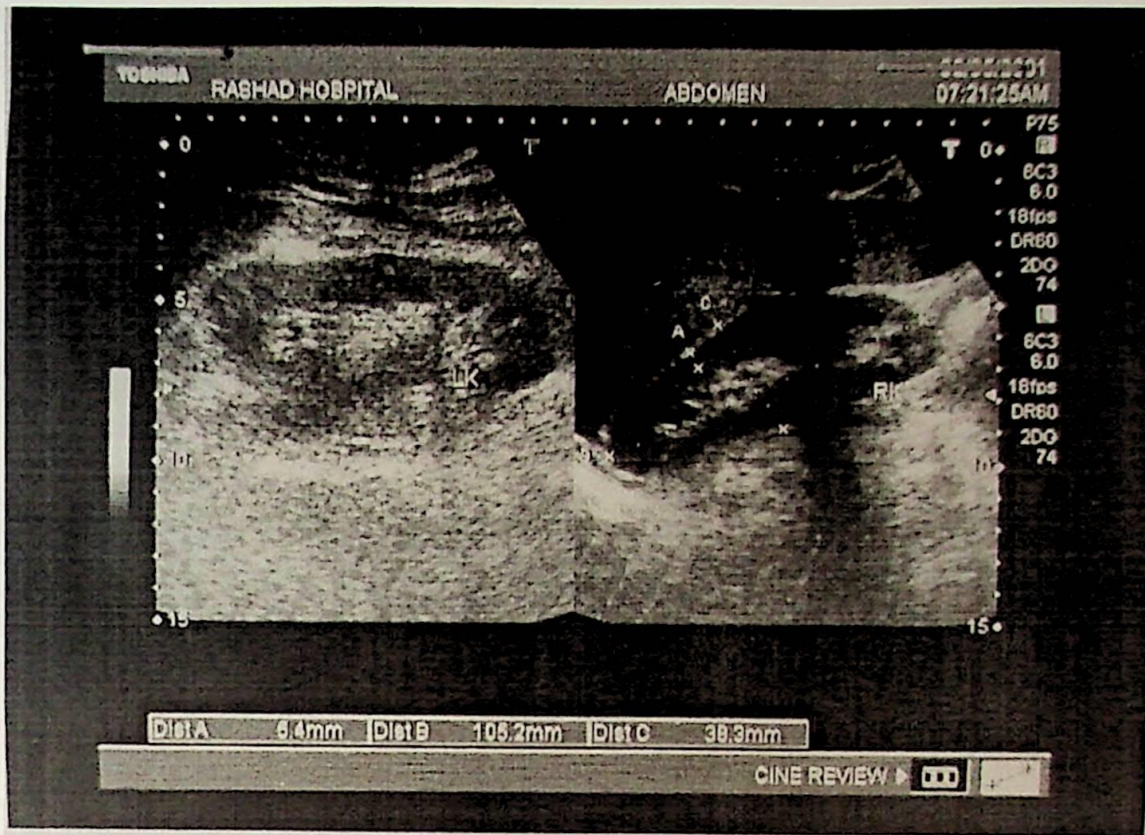


Figure 1.4: Left renal increased parenchymal echogenicity.

According to a more recent study, kidney length has a low specificity for expecting renal destruction, although kidney volume and length have a substantial correlation with e GFR in the old. It is challenging to determine the actual kidney volume with ultrasound, though. The ellipsoid formula can be used to estimate volume, but this approach has a flaw in that the kidney is not ellipsoid in reality. Furthermore, the central sinus fat, which varies from patient to patient and does not contain functional renal tissue, would be included in the ellipsoid volume. These elements most likely influenced the results of a recent study that found a weak but favorable correlation between several GFR indices and kidney volume as measured by sonography. Further research has demonstrated the association between renal function and total renal volumes measured at CT. Nevertheless, there are disadvantages to CT, such as higher expenses and radiation exposure. Furthermore, recent research revealed a strong relationship between renal length as evaluated by ultrasound and renal volume as determined by CT. Renal cortical echogenicity raises during ultrasonography in CKD patients [29].

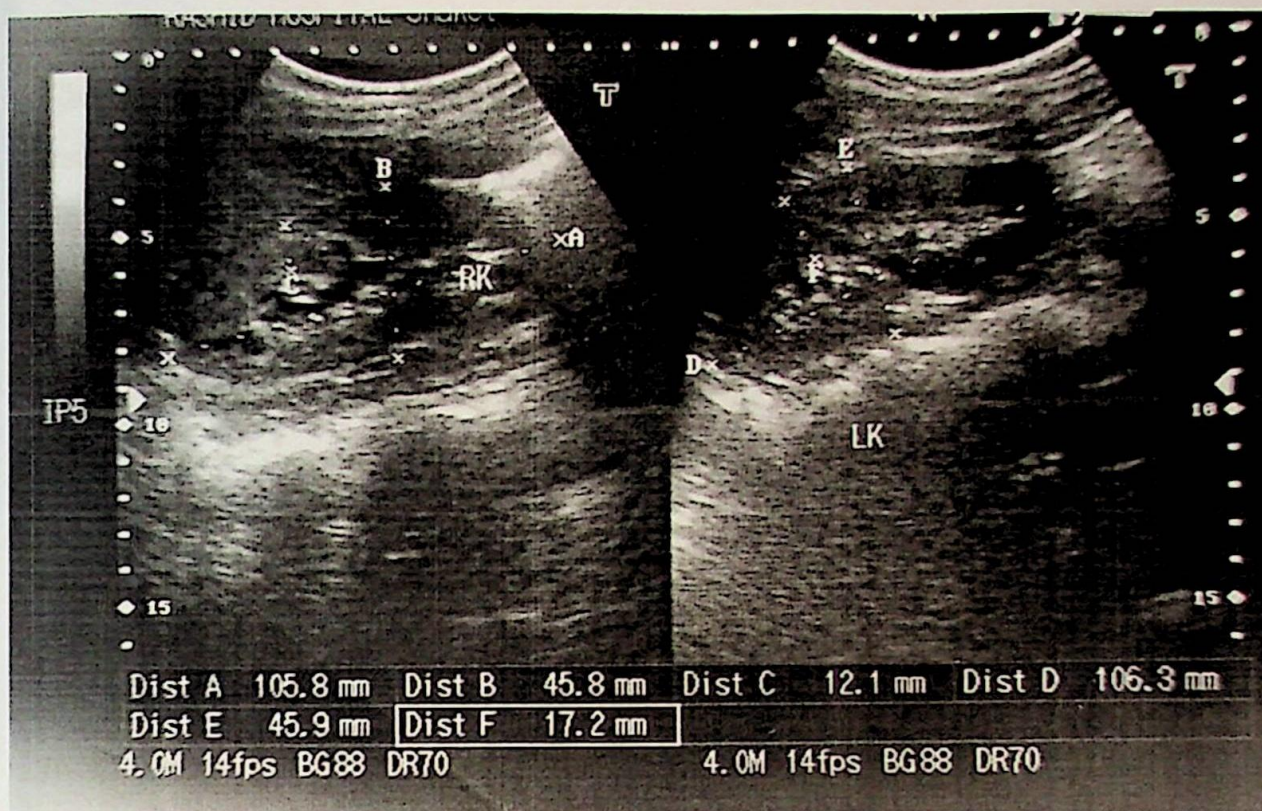


Figure 1.5: Mild increased parenchymal echogenicity bilaterally with right sided mild fullness of collecting system.

A precise and repeatable method for measuring cortical thickness is essential since treatment options for hypertension are often dependent on the results of RCT. Furthermore, it is essential to comprehend the mention value of normal cortical largeness in order to evaluate deviations from these standards. It has been demonstrated that in patients with chronic renal illness brought on by hypertension, RCT decreases early. Additionally, renal parenchymal thickness has been measured and found to have a strong correlation with renal function. It has been discovered that hypertension alters renal size; one study indicated that renal size increases in the early stages of the disease and decreases as it advances [30].

When assessing patients who may have renal disease, renal size measurement by ultrasound is crucial. It does, however, necessitate prior knowledge of the group under study's real normal kidney size. Renal ultrasound is a low-interobserver variability, straightforward, and affordable procedure that may be performed at the patient's bedside to give the physician vital kidney anatomy. Both renal length and cortical thickness are crucial criteria that should be within regular ranges previous to the surgery, making it a necessary step when performing renal biopsies on adults or children. USG is a well-

established diagnostic technique that is safe [31].

Changes in serum creatinine levels are always delayed in reaction to GFR changes, usually occurring 48–72 hours after the GFR fall. Because serum creatinine and other formulas provide a more accurate representation of GFR in patients with constant renal function, they are predominantly used as diagnostic tools in patients with normal renal function or chronic renal insufficiency. However, in critically ill patients, factors such as low nutritional status, decreased muscle mass, high metabolic states, and the little amount of creatinine secreted by the renal tubules severely impair the accuracy of serum creatinine as a renal function evaluation tool. When assessing patients who may have renal disease, renal size measurement by ultrasound is crucial [32]. Even in the absence of renal disease, senescence is expected to cause a significant reduction in renal function. It has also been suggested that confounding variables like atherosclerosis or hypertension may contribute to the irregular aging-related changes in renal function [33].

In order to measure renal function impairment in individuals with hypertension, this study aims to analyze the predictive significance of renal cortical thickness (RCT) and parenchymal changes. Reduced cortical thickness, structural renal alterations, and the advancement of chronic kidney disease (CKD) have all been strongly linked in the literature to date. The usefulness of ultrasonography (USG) as a non-invasive method to measure RCT and identify parenchymal alterations, particularly in hypertensive individuals, is still noticeably lacking, nevertheless. This study is to clarify the relationship between USG findings pertaining to cortical dimensions and parenchymal integrity and deteriorating renal function in hypertension patients in order to aid in early diagnosis and better therapeutic management.

OBJECTIVES

1. To access the diagnostic accuracy of ultrasound to measure the cortical thickness and renal parenchymal changes in hypertension.
2. To estimate the effect of hypertension on renal function.

CHAPTER 2

REVIEW OF LITERATURE

Schmidt Jet al., (2023) conducted a study in which they involved 199 patients in total. USG was used to assess the cortical, parenchymal, and renal fat thicknesses after the fact. Serum GFR readings were taken the same day and compared. The study participants had a 63% chance of getting renal failure. For patients with a ratio between 0.4 and 0.5, the chance rose virtually linearly from 65% to 85%, and for those with a ratio >0.5 , it plateaued at 85% probability. Furthermore, compare to cortical thickness alone the average fat-to-CRT was statistically significant ($P\text{-value} = .02$) in predicting the progression to renal failure. However, only the left kidney demonstrated statistical significance when comparing the average fat-to-cortical thickness ratio between the two kidneys. Particularly for the left kidney, there is a substantial inverse relationship between GFR and the renal sinus fat-to-cortical thickness ratio. Higher ratios increase the likelihood of having renal failure [34].

Ryumshina Nlet al., (2022) performed a study in which they included individuals with diabetes; resistant hypertension (RHT) is frequently linked to chronic renal illness and kidney damage. Although the imaging features of renal impairment in RHT are still unknown, early diagnosis of renal abnormalities can prevent serious cardiovascular consequences. The current study set out to ascertain the correlations between renal parenchyma volumes and kidney function biomarkers in a group of RHT patients. Thirty-four RHT patients who meet the enclosure criteria were incorporated in the study. Serum values of creatinine and cystatin C, as well as eGFR, were used to assess renal function. When compared to reference characteristics, patients with RHT showed altered cortical surface, attenuated cortical thickness, reduced renal volumes, and round kidneys based on primary MRI-based changes in renal parenchyma. Every parameter used to describe the renal parenchyma showed a reasonably strong positive relationship with eGFR. eGFR and bsa-TKV had the strongest direct correlation ($r = 0.6166$, $p = 0.000$); ht-TKV correlated with both eGFR ($r = 0.4751$, $p = 0.007$) and creatinine ($r = -0.4302$, $p = 0.016$). In individuals with $eGFR < 60 \text{ mL/min/1.73 m}^2$, $ht\text{-T-Cortex-V} < 32.4$ is a critical component of MRI-presentation of renal impairment. An MRI investigation revealed early renal parenchymal changes in RHT patients that showed a link between renal

function and renal parenchymal volume. The study discovered an MRI pattern of renal failure in RHT for the first time [35].

Musa MJ. (2022) conducted study in the Aseer region in the southwest of Saudi Arabia with the goal of examining the impact of hypertension on renal cortical size and comparing it with normotensives. Three hundred twenty-five participants (control group) and 155 hypertension subjects were recruited for the study. The individuals were divided into five age-based groups, three body mass index (BMI)-based groups, and three additional groups based on the length of time they had hypertension. One radiologist used a General Electric logic 3 LSD ultrasound equipment to perform ultrasound imaging. A low frequency curvilinear transducer was used to obtain acceptable image quality; for thin individuals, the frequency was occasionally adjusted to 5MHZ. The patient was positioned laterally and in a supine position during the scan. According to the findings there is a positive association between BMI and cortical dimensions, there is a strong and negative correlation between age and cortical size. For almost five years, patients with hypertension had decreased cortical thickness. Age and the length of hypertension had a greater impact on cortical size. Ultrasound measurements of cortical thickness can be a useful tool for assessing renal function and tracking the development of hypertension. Hypertensive patients may occasionally have their cortical size measured with ultrasound [36].

Sah Det al., (2022) conducted a study in which they showed that for many renal diseases, renal cortical thickness is a crucial metric. An effective method for measuring several kidney parameters is ultrasonography. Finding the renal cortical thickness in well persons without any renal impairments and comparing it to age, sex, height, weight, BMI, and side of the body were the goals of this study. This study comprised 150 adults in good health with normal renal function. Every patient had a thorough clinical history obtained. Ultrasonography, clinical, and basic studies were conducted. Ethical approval and informed written permission were obtained. There were 150 patients in the study, with a mean age of 33.0 ± 9.5 years (67 men and 83 women). 8.3 ± 0.69 mm was the mean renal cortical thickness. Gender and RCT were significantly correlated ($p=0.013$). Nevertheless, no such association was found between the participants' age, height, weight, and BMI and the RCT. A key factor in the diagnosis of numerous renal disorders is the ultrasonographic evaluation of renal cortical thickness. Therefore, the study's findings can be applied to assess renal cortical thickness and identify aberrant renal diseases [37].

function and renal parenchymal volume. The study discovered an MRI pattern of renal failure in RHT for the first time [35].

Musa MJ. (2022) conducted study in the Aseer region in the southwest of Saudi Arabia with the goal of examining the impact of hypertension on renal cortical size and comparing it with normotensives. Three hundred twenty-five participants (control group) and 155 hypertension subjects were recruited for the study. The individuals were divided into five age-based groups, three body mass index (BMI)-based groups, and three additional groups based on the length of time they had hypertension. One radiologist used a General Electric logic 3 LSD ultrasound equipment to perform ultrasound imaging. A low frequency curvilinear transducer was used to obtain acceptable image quality; for thin individuals, the frequency was occasionally adjusted to 5MHZ. The patient was positioned laterally and in a supine position during the scan. According to the findings there is a positive association between BMI and cortical dimensions, there is a strong and negative correlation between age and cortical size. For almost five years, patients with hypertension had decreased cortical thickness. Age and the length of hypertension had a greater impact on cortical size. Ultrasound measurements of cortical thickness can be a useful tool for assessing renal function and tracking the development of hypertension. Hypertensive patients may occasionally have their cortical size measured with ultrasound [36].

Sah Det al., (2022) conducted a study in which they showed that for many renal diseases, renal cortical thickness is a crucial metric. An effective method for measuring several kidney parameters is ultrasonography. Finding the renal cortical thickness in well persons without any renal impairments and comparing it to age, sex, height, weight, BMI, and side of the body were the goals of this study. This study comprised 150 adults in good health with normal renal function. Every patient had a thorough clinical history obtained. Ultrasonography, clinical, and basic studies were conducted. Ethical approval and informed written permission were obtained. There were 150 patients in the study, with a mean age of 33.0 ± 9.5 years (67 men and 83 women). 8.3 ± 0.69 mm was the mean renal cortical thickness. Gender and RCT were significantly correlated ($p=0.013$). Nevertheless, no such association was found between the participants' age, height, weight, and BMI and the RCT. A key factor in the diagnosis of numerous renal disorders is the ultrasonographic evaluation of renal cortical thickness. Therefore, the study's findings can be applied to assess renal cortical thickness and identify aberrant renal diseases [37].

Asif HSet al., (2019) The term CRF refers to a variety of situation that impact the kidney's architecture and physiology. The source, pathophysiology, severity, and pace of development of Chronic Renal Failure (CRF), which is recognized as a life-threatening condition, are some of the factors that contribute to the variance in disease expression. The reason of this study was to use ultrasound to estimate the affiliation between cortical thickness and echogenicity in individuals with chronic renal failure. 138 participants participated in the cross-sectional prospective trial. All of the patients were gathered from the Mayo Hospital's emergency room, outdoor area, and indoor area in Lahore. Data was gathered using the Toshiba Nimo 7 ultrasonography equipment following informed permission. The results showed that there were 138 CRF patients, of whom 82 were men and 56 were women. The P value of 0.131, which is higher than the significance level of 0.05. Shows that there was no significant relationship between the two variables. It has been established that there is no correlation between cortical thickness and echogenicity on ultrasonography in patients with chronic renal failure [38].

Nwafor N et al., (2018) done a study in which they projected that renal USG data can be used to indirectly evaluate renal function or status because hypertension can indirectly affect the kidneys. USG evaluation of renal parameters in patients with essential hypertension was the purpose of this study in order to identify the indicators that would suggest a higher risk of renal damage. The University of Benin Teaching Hospital's consultant outpatient clinic evaluated 150 patients with essential hypertension, 96 of whom were female and 54 of whom were male. As controls, an equal number of non-hypertensive volunteers—70 men and 80 women—were examined. Renal length, width, AP diameters, renal parenchymal volume, cortical thickness, and echogenicity were measured for both subjects and controls. Additionally, serum creatinine was measured. Data analysis was conducted using the SPSS version 17.0. There was a statistically significant difference in cortical thickness between the two groups. The renal parenchymal volume of the right and left kidneys in the subjects and controls did not differ significantly. The difference in cortical echogenicity between the hypertensives and the controls was statistically significant; the right kidney's cortical echogenicity was higher in 74.0% and 75.3% of hypertensives while the left kidney's cortical echogenicity was higher in 28.0% and 26.0% of normotensives. The hypertensive group's serum creatinine level was noticeably greater. Males had greater renal parenchymal volume, cortical thickness, and renal length than females, and the left kidney had greater renal

length than the right kidney in hypertensives and normotensives. The renal cortex appears to be more affected by hypertension than the medulla [39].

Korkmaz M et al., (2018) showed a study to assess the relationships among laboratory results and USG measurements of renal length and RCT in patients undergoing follow-up for CKD. This prospective study included 41 CKD patients with low glomerular filtration rate who did not need renal replacement therapy. USG was done twice a year and laboratory tests were conducted every two months to monitor the patients. The paired-samples T test was used to compare the estimated eGFR, renal length, and renal cortical thickness. In order to evaluate kidney function, a Pearson correlation analysis was also performed between measurements of renal length and cortical thickness and eGFR values. At the start of the trial, the mean renal length was 91.29 mm, and at the end, it was 90.24 mm. Both eGFR and mean renal length ($r=0.66$, $P<0.01$) and mean cortical thickness ($r=0.85$, $P<0.01$) showed statistically significant positive associations, with the latter being more pronounced. According to our research, ultrasonographic assessments of cortical thickness could be a crucial imaging method for CKD patients' follow-up therapy [40].

Quaia E et al., (2018) conducted a study in which they showed that in renal parenchymal disorders, ultrasound (US), which can be either color and power Doppler US, grayscale and spectral Doppler US, or with or without microbubble contrast agents, is typically the initial imaging modality used. Increased renal cortical echogenicity and increased or decreased corticomedullary differentiation are the most common grayscale US appearances of diffuse renal parenchymal disorders. The intrarenal resistive index value may rise by more than 0.70 in native kidneys and more than 0.8 in renal transplants, according to spectral Doppler examination of intrarenal flows. Grayscale Spectral and US Because distinct renal parenchymal disease frequently present with the same US look, while the same renal parenchymal ailment may present with varied appearances on the US depending on the disease stage, Doppler US does not demonstrate great specificity and sensitivity. Therefore, for an accurate characterisation, the US pattern must be correlated with the patient's history and clinical background [41].

Boddi M. (2017) conducted a study for non-invasive assessment of renal morphological alterations and arrangements of renal and extrarenal vascularization is made possible by ultrasound US. In recent years, there has been more evidence regarding the therapeutic importance of renal RRI for the study of vascular and renal parenchymal abnormalities.

However, morphological changes are frequently predictable late and non-specifically. RRI is calculated by dividing the difference between the PSV and EDV by the PSV in an intrarenal artery using Doppler sonography. RRI was initially confirmed to be a marker of the development and progression of renal disease; however, later research revealed that systemic vascular characteristics had an impact on RRI, and the authors asserted that it may be used as an independent predictor of cardiovascular risk as opposed to renal damage. It is still up for debate whether RRI measurement is clinically relevant as a surrogate endpoint of particular renal damage or as a surrogate endpoint of atherosclerotic diffuse vascular damage. To summarize, from the literature: (a) RRI is an early display of renal impairment in hypertensives with normal renal function and no albuminuria, particularly in younger individuals. It is particularly helpful when diabetes and hypertension coexist in the same subjects. RRI may help these individuals' current clinical scores, which are used to categorize early renal damage. Because of this strong correlation, RRI is also a measure of systemic atherosclerotic burden in older individuals, and the influence of renal factors may diminish. RRI rises in tandem with an increase in systemic vascular stiffness. No particular research was done on the clinical relevance. (b) Renal failure can be independently predicted by high RRI values (>0.80) in chronic renal disease and transplant kidney. (c) In both atherosclerotic and fibromuscular dysplastic disorders, renal stenosis can be diagnosed and graded using Doppler ultrasound. Furthermore, due to the stenosis-induced drop in pulse pressure, Doppler ultrasound can be used to indirectly quantify the hemodynamic effects of renal artery stenosis on the homolateral kidney using the RRI assay [42].

Takata Tet al., (2016) conducted a study on advanced chronic kidney disease causes the kidney to atrophicate, and renal function is correlated with renal size and parenchymal volume. However, the renal cortex and medulla have not been well explored in relation to changes in renal parenchymal volume. We looked into the connection between renal function and alterations in the renal cortex and medulla. A total of 176 subjects were evaluated for renal US parameters such as renal length, parenchymal thickness, RCT, and medullary thickness. The four groups' renal US parameters in both kidneys were compared. Step wise correlations between reduced renal function and renal length, cortical thickness, and parenchymal thickness were discovered. There were no differences in medullary thickness between groups 1-3. Only renal length was an independent predictor of renal function, according to multiple linear regression analysis that included

sex, age, and renal US characteristics. Cortical thickness was the most strongly linked measure when examined in groups 1-3. A decline in renal function was progressively linked to a lower cortical left/right ratio. Renal function was linked with US measurements of cortical thickness and renal length. Specifically, left cortical thickness may be useful in identifying early alterations in renal function [43].

Yamashita SR et al., (2015) conducted a study to evaluate the reproducibility of these dimensions using USG and to ascertain whether renal cortical thickness, bipolar length, and parenchymal cortical thickness have a linear relationship in patients with chronic kidney disease who present with varying eGFRs. 54 patients with chronic renal failure underwent ultrasonography. Two separate radiologists who were blinded conducted the scans. The Cockcroft-Gault equation was used to determine the eGFR. Measurements of RCT, bipolar length, and parenchymal thickness showed moderate correlations with GFR, respectively. For measurements of cortical thickness and bipolar length (0.833), the interobserver agreement was rated as outstanding (0.754), whereas for parenchymal thickness (0.523), it was deemed satisfactory. The renal measures had high interobserver consistency. Cortical thickness and eGFR showed a moderate correlation, although bipolar length and parenchymal thickness showed a weak correlation [44].

A study by Gareeballah A et al. (2015) sought to categorize renal parenchymal disorders by evaluating sonographic findings using gray-scale ultrasound. The study was conducted using a cross-sectional methodology. A total of 204 people were thought to have kidney problems. To evaluate the kidneys, they had undergone an ultrasound scan. Echogenicity, renal cortex and parenchyma, and cortico-medullary differentiation had all been evaluated. The study found that the renal parenchyma and cortex were more echogenic in all types of renal parenchymal disorders. The cortico-medullary distinction showed a significant difference ($p\text{-value} = 0.0001$) and was lost in chronic end-stage parenchymal disease (85%) and mainly disrupted in acute parenchymal illness (69.04%). Ultrasound could provide a useful and accurate diagnosis of renal parenchymal disorders. Acute, chronic, and end-stage renal parenchymal illnesses were the three categories into which this study separated them [6].

El-Reshaid W, Abdul-Fattah H. (2014) estimated the typical USG values of renal length and cortical thickness in healthy individuals and identified orientation arrays in our population for association when analyzing renal illness. Sonographic evaluations of renal length and cortical thickness were performed on 252 healthy individuals who self-referred

to the El-Reshaid Renal Clinic in Kuwait between January 2006 and December 2011. To ensure there were no kidney issues, they were screened. Measurements were made of height, weight, body surface area, and BMI. To create reference graphs for renal length and cortical thickness, five patient age groups were created: 18–30, 31–40, 41–50, 51–60, and 61–80 years. RCT was 0.6 cm or more. The renal length was correlated with the patients' weight ($p < 0.01$) and BMI ($p < 0.01$) but not with their height. Cortical thickness and renal length were not significantly changed by age. Renal length was strongly correlated with weight and BMI but not with height [45].

Viazzi Fet al., (2015) conducted a study in many clinical settings, including the estimation of chronic renal allograft rejection, the identification and treatment of renal artery stenosis, the assessment of development risk in CKD. More recently, there has been mounting facts that an elevated RRI may offer valuable prognostic information for patients with primary hypertension since it not only indicates changes in intrarenal perfusion but also has a correlation with systemic hemodynamics and the existence of subclinical atherosclerosis. Based on these findings, it has been suggested that the RRI be evaluated in order to supplement other indicators of renal abnormalities in patients with primary hypertension during assessment and treatment [46].

Adibi A (2008) conducted a study for many renal disorders; RCT is a crucial indicator. An efficient technique for determining various kidney parameters is USG. This study sought to ascertain the RCT sonographic measurement in persons with normal renal function in Isfahan and its correlation with height, weight, gender, age, BMI, and side of the body. A prospective study was conducted on 142 healthy individuals. Urine analysis and BUN/Cr assays were normal for these patients. Their kidney sonography was likewise normal. Sonography was performed on 80 males and 62 women, whose mean $\pm$ SD age was 38.8 $\pm$ 7.7 years. RCT was 9.09 $\pm$ 0.99 mm on average. RCT was linked to gender ($P=0.02$), although the left and right RCTs did not differ significantly ($P=0.15$). Significant positive associations were found between RCT and the patients' height and renal length, but not between RCT and the patients' age, BMI, or weight. Gender, height, and kidney length are only a few of the many characteristics that affect RCT. The findings of this investigation can be utilized to assess RCTs in order to identify aberrant clinical situations [47].

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US frequently the first imaging modality used in patients with renal failure, haematuria, or proteinuria. DUS and RI studies provide renal functional evaluation following standard US evaluation. In any case, conventional US and DUS still have limited sensitivity and specificity when evaluating renal parenchymal disease. While various renal parenchymal disorders may exhibit comparable appearance on US and DUS examination, kidneys may exhibit normal US morphological appearance and normal RIs values in the early or mild clinical stages of these diseases. Furthermore, even though percutaneous renal biopsy is frequently required to make a definitive diagnosis, many renal parenchymal disorders may exhibit some unique signs on conventional US and DUS with CD and PD examination. Since a steady reduction in RIs is associated with a progressive recovery of renal function [48].

Buchholz NP et al., (2000) performed a study in which they measured the ultrasonographic kidney diameters in people without known renal illness in order to establish some early statistics about our group. We evaluated the effects of age, sex, side, BMI, and the presence or absence of hypertension and diabetes mellitus on renal size. 194 adults without known renal abnormalities had their kidneys measured using ultrasonography. Length, breadth, and cortical thickness were measured, and the renal size was estimated by multiplying the first three variables. The average kidney length was 10.4 ± 0.8 cm, the average cortical thickness was 1.6 ± 0.2 cm, and the average kidney breadth was 4.5 ± 0.6 cm. 76 ± 22 cm³ was the calculated mean renal size. There was no significant difference in kidney length between the left and right kidneys, however there was a difference in kidney width, cortical thickness, and size ($p < 0.05$). Compared to the left kidney, the right kidney was smaller. However, sex and BMI were the only significant factors influencing kidney size in a multivariate analysis. We come to the conclusion that an individual's height, weight, sex, age, and side all affect renal size. The typical ideals for the people of Pakistan Population-based research are required to determine [49].

Mostbeck GH, conducted study prior to percutaneous renal biopsy, 68 kidneys from 34 successive patients with different types of renal parenchymal diseases were examined using duplex US in order to assess the histopathologic alterations affecting Doppler measurements of the RI in renal arteries in renal parenchymal diseases. On a scale of 0 to 100, the quantity of glomerular, interstitial, and vascular alterations was associated with the RI, renal length, and renal cortical echogenicity. Of the 34 patients, 24 had a RI of less than 0.7, which was considered to be within the normal range up to this point. The RI

also increased with the patient's age because of a higher incidence of arteriosclerosis, but there was no significant difference in the RI across the five groups of various renal parenchymal diseases. Forty-four percent of our patients had normal cerebral echogenicity at presentation. Different forms of renal medical problems cannot be consistently distinguished by quantitative duplex US utilizing the RI [50].

Kubba T, et al., (2000) conducted a study on hypertension and dyslipidemia are significant risk factors for renal disease, which is a major cause of death and morbidity in Bangladesh. This study's goal was to use ultrasonographic parameters to determine whether hypertension and non-hypertensive patients had any potential kidney impairment and how it related to their cholesterol levels. This study was a case control. Each of the two groups (hypertensive and normotensive) had a purposive sample size of 135. Information on blood pressure, smoking status, several kidney indicators, and lipid profiles, including TC, TG, LDL, and HDL, were gathered. A statistically significant relationship was discovered between TC, TAG, HLD, and LDL and several kidney characteristics, including renal bipolar length, renal AP diameter, RCT, renal cortical echogenecity, and CMD. This suggests that there was a chance of kidney injury among hypertension individuals who had elevated cholesterol levels. We must safeguard the renal problems and detect it early. This result adds to the body of research showing that those with high cholesterol and hypertension are more likely to experience kidney damage in the future. The differences between the two groups were visible in USG parameters. To identify and prevent renal illness, which is commonly linked to high cholesterol, patients with hypertension in Bangladesh should have regular BP checks as well as USG assessments of their lipid profiles and renal parameters [51].

OPERATIONAL DEFINITIONS

i. **Hypertension:**

You have hypertension, sometimes referred to as high blood pressure, if your blood vessel pressure is 140/90 mmHg or higher. Despite being common, it can become harmful if untreated [52].

ii. **Renal Cortical Thickness:**

Cortical thickness in the sagittal plane was assessed using a medullary pyramid that was perpendicular to the capsule. Cortical thickness ranged from 3.2-11.0 mm, or 5.9 mm, on average. The average length was 10 cm (7.2–12.4) [23].

iii. **Renal Parenchymal Changes:**

Any illness that damages a person's renal parenchyma is referred to as renal parenchymal disease. Chronic kidney disease is later recognized in patients who exhibit ongoing renal parenchymal damage over a few months [39].

CHAPTER 3

METHODOLOGY

3.1. Research Design:

Analytical, Cross-sectional study

3.2. Clinical Setting:

Data was collected from Rashid Hospital Shahkot, Samar diagnostic lab Lahore

3.3. Sample size:

100 participants were included in this study

3.4. Sampling Technique:

Purposive sampling technique (non-Random)

3.5. Duration of Study:

The duration of study was 12 Months.

3.6. Selection criteria

3.6.1. Inclusion Criteria:

- Patients of adult ages with hypertension
- Patient who can go for renal ultrasound examination.
- Patient who provides written informed consent to participate in research
- Patient with confirmed diagnosis of hypertension

3.6.2. Exclusion Criteria:

- Non hypertensive patient
- Polycystic kidney disease, renal artery stenosis

3.7. Equipment:

- Toshiba NEMIO 200, convex probe 3-5 MHz
- Toshiba Famio Cube SSA-520A, convex probe 3-5 MHz
- Toshiba Xario Prime 3D Color and power Doppler, convex probe 3-5 MHz

3.8. Ethical Considerations:

The rules and regulations set by the ethical committee of Superior University, Lahore was followed while conducting the research and the rights of the research participants was respected.

- Written informed consent (attached) was taken from all the participants.
- The privacy of the patient would be our first priority.
- We asked the patient permission before exposing her.
- All information and data collection was kept confidential.
- Participants were remaining anonymous throughout the study.
- The subjects were informed that there are no disadvantages or risks on the procedure of the study.
- They were also be informed that they would be free to withdraw at any time during the process of the study.
- We have done everything we can to protect your privacy. Your identity was not revealed in any publication resulting from this study.
- Your participation in this research study was voluntary. You might choose not to participate, and you might withdraw your consent to participate any time. You were not been penalized in any way should you decide not to participate or to withdraw from this study.

3.9. Data Collection Procedure:

Data was collected according to data collection sheet. Informed consent form was taken from all the participants.

Scanning Technique:

To make sure the patient was well-prepared before doing renal ultrasonography. To make it easier to reach both kidneys, patients was placed on the examination table in a comfortable supine posture with their arms either above their heads or in the right and left decubitus positions. A suitable ultrasound transducer was used (curvilinear or phased-array) with a frequency range of 3-5 MHz, taking into accounts the patient's size and anatomy. First, the probe was positioned in the lumbar area. To carefully evaluate kidney size, shape, echogenicity, and cortical thickness using systematic scanning techniques. In the upper and middle thirds of the kidney, the thickness of the renal cortical layer was measured perpendicular to the capsule in the sagittal plane, above the medullary pyramid. In the sagittal plane, the bipolar length was measured between the upper and lower poles. Depending on the level of vision, the upper or lower pole was used to estimate the parenchymal thickness [53].

3.10. Data Analysis Procedure:

The data was entered and analyzed using SPSS 25.0, and descriptive analyses were performed to examine the data distribution. Frequency and percentages was calculated for categorical variables, and the mean and standard deviation was given for quantitative variables. Linear regression was used to examine the connection between mean cortical thickness and CGeGFR.

3.11. Gantt Chart:

Activity	Year								
	April	May	June	July	August	September	October	November	December
Literature review									
Data collection									
Data analysis, writing and editing									
Thesis presentation and submission									
Thesis submission 9 after months.									

CHAPTER 4

RESULTS

In this cross-sectional study, 100 patients total were added in which 59 females and 41 male as shown in table below

Table 4.1: Frequency and percentage of Gender

Gender	Frequency	Percent
FEMALE	59	59.0
MALE	41	41.0
Total	100	100.0

Table 4.2: Descriptive statistics of Age

Descriptive Statistics					Std.
	N	Minimum	Maximum	Mean	Deviation
Age	100	30	85	54.16	12.869

The table 4.2 above represents the statics of age of 100 patients with minimum of 30 years and maximum of 85 years with mean 54.16 (SD=12.86).

In the figure 4.1 below the categorical distribution of parenchymal changes as Grade I, Grade II, Grade III and Normal were shown.

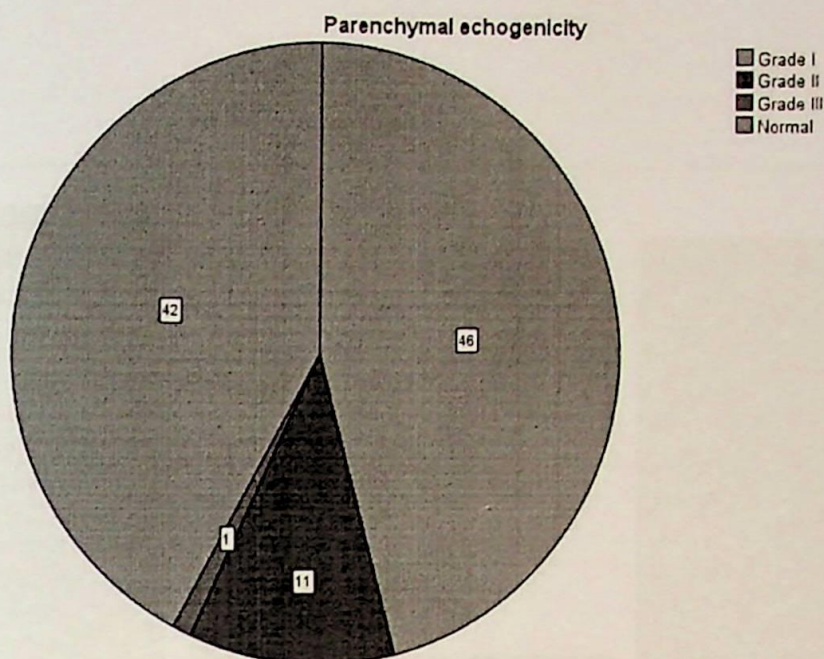


Figure 4.1: Pie chart represents the distribution of Parenchymal changes

Table 4.3: Distribution of parenchymal echogenicity in hypertensive patients

		Hx Hypertension	Total
Parenchymal echogenicity	Grade I	46	46
	Grade II	11	11
	Grade III	1	1
	Normal	42	42
Total		100	100

In table 4.3 Distribution of parenchymal echogenicity in hypertensive patients is shown with grading. In patients with Grade I there were 46 hypertensive patients, with Grade II there were 11 hypertensive patients, with Grade III there was only single patient with hypertension and there were 42 patients that has normal parenchymal echogenicity but have hypertension.

In figure 4.2 below the bar chart represents the distribution of 100 hypertensive patients with respect to grading. In patients with Grade I there were 46 patients, with Grade II there were 10 patients, with Grade III there was only single patient and there were 43 patients that has normal parenchymal echogenicity but have hypertension.

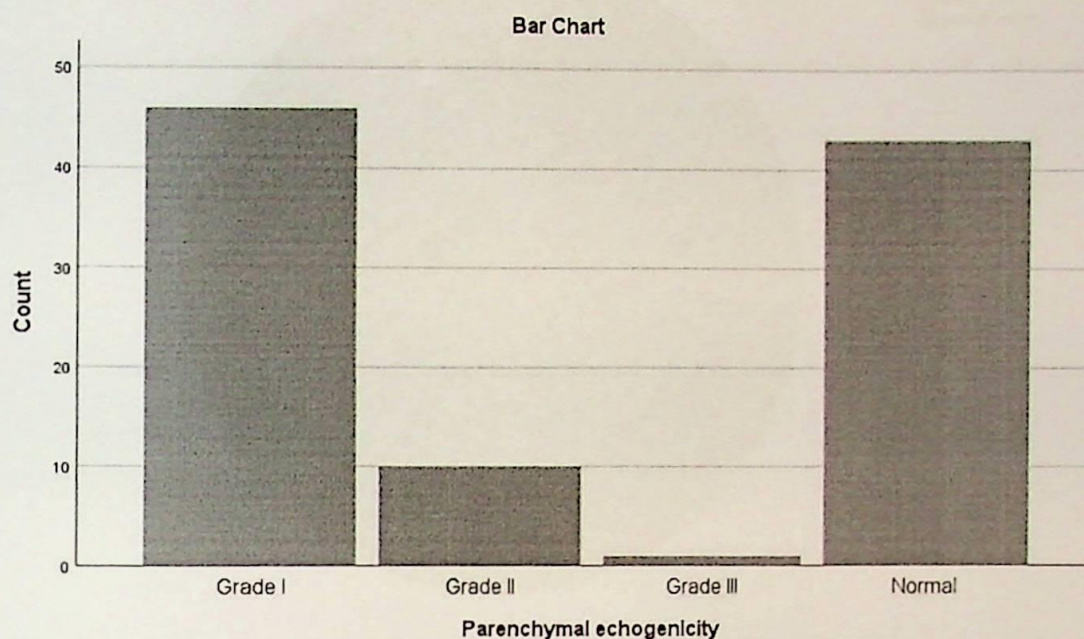


Figure 4.2: Bar chart represents the parenchymal changes with respect to its Grading

Table 4.4: Represents the frequency and percentage of renal function impairment

		CMD Ratio	
		Frequency	Percent
Valid	intact	83	83.0
	lost	3	3.0
	poorly intact	14	14.0
	Total	100	100.0

In table 4.4 above the frequency and percentage of corticomedullary distinction is intact in 83 percent, lost in 3 patients and was poorly intact in 14 percent of the total cases.

In figure 4.3 below pie chart represents the CMD Ratio with distribution as intact, lost and poorly intact.

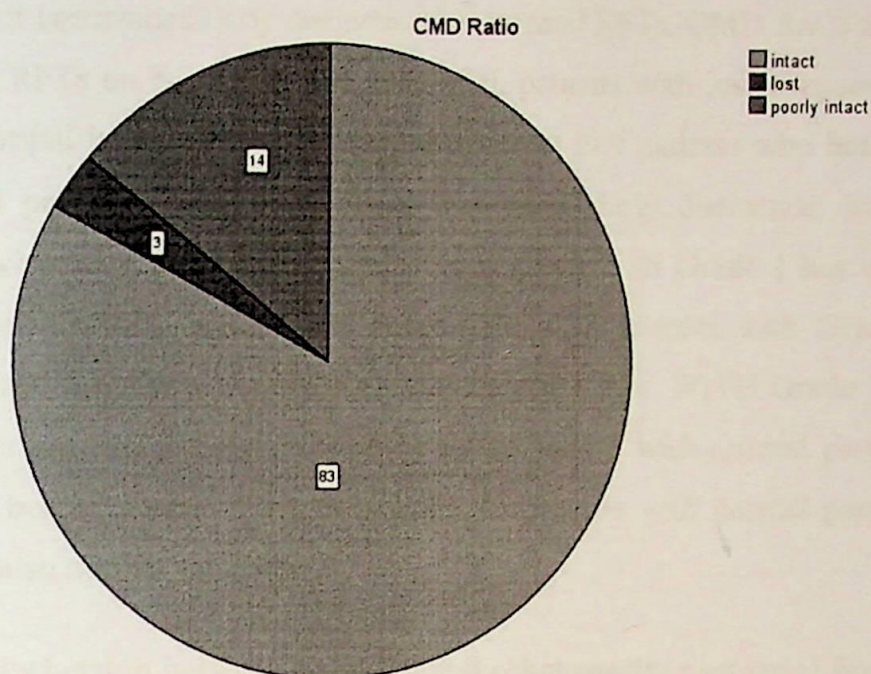


Figure 4.3: Pie chart represents the CMD Ratio

Table 4.5: Relationship of Gender,CMD Ratio and Parenchymal Echogenicity with renal function Impairment.

		Renal Function Impairment	
		Borderline Count	Normal Count
Gender	FEMALE	13	46
	MALE	12	29
CMD Ratio	intact	13	70
	lost	3	0
	poorly intact	9	5
Parenchymal echogenicity	Grade I	16	30
	Grade II	8	2
	Grade III	1	0
	Normal	0	43

In table 4.5 above relationships of Gender, CMD Ratio and Parenchymal Echogenicity with renal function Impairment is shown. For Gender it was seen that in female patients there were 13 with borderline and 46 were with normal renal function but for male patients there were 12 with borderline and 29 were with normal renal function. For CMD Ratio 13 patients with intact corticomedullary distinction has RFTs on borderline and 70

patients with intact corticomedularly distinction has normal RFTs. CMD Ratio is lost in 3 patients who has RFTs on borderline and none of th patients with lost corticomedularly distinction has normal RFTs. CMD Ratio is poorly intact in 9 patients who has RFTs on borderline and 5 patients with poorly intact corticomedularly distinction has normal RFTs. For parenchymal echogenicity changes 16 patients with Grade I has borderline RFTs and 30 patients with Grade I has normal RFTs. 8 patients with Grade II has borderline RFTs and 2 patients with Grade II has normal RFTs. WITH Grade III only 1 patient has borderline RFTs. There was not a signle patient with normal parenchymal echogenicity has borderline RFTs but there were 43 patients with normal parenchymal echogenicity has also normal values for RTFs.

Table 4.6: Relationship between parenchymal echogenecity and renal function Impairment

		Renal_function_impairm ent	
		Borderline Count	Normal Count
Parenchymal echogenicity	Grade I	16	30
	Grade II	8	2
	Grade III	1	0
	Normal	0	43

Table 4.6 shows that for parenchymal echogenicity alterations, 16 patients with Grade I had borderline RFTs and 30 patients with Grade I had normal RFTs. Eight individuals with Grade II had borderline RFTs, while three patients have normal RFTs. WITH Grade III, just one patient had questionable RFTs. There was no single patient with normal parenchymal echogenicity who had borderline RFTs, while 43 individuals with normal parenchymal echogenicity also had normal RTFs.

Table 4.7: Linear Regression between mean cortical thickness and CGeGFR

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
						F Change	df1	df2	
1	.375 ^a	.140	.132	18.84516	.140	16.012	1	98	.000

a. Predictors: (Constant), Mean_Cortical_Thickness

b. Dependent Variable: CGeGFR

In Table 4.7, the correlation coefficient (R) between the observed and predicted values of the dependent variable (CGeGFR) is 0.375, indicating a moderate positive correlation between the independent variable (Mean_Cortical_Thickness) and the dependent variable. R Square is the proportion of variance in the dependent variable (CGeGFR) that is explained by the independent variable (Mean_Cortical_Thickness). In this case, $R^2 = 0.140$, which means that approximately 14% of the variance is explained by the independent variable. Sig. F Change is the F-test's p-value, which is 0.000, indicating that the model is statistically significant. This suggests that the predictor (Mean_Cortical_Thickness) has a substantial relationship with the dependent variable (CGeGFR). Therefore, the model is statistically significant ($p < 0.001$).

In figure 4.4, the scatter plot depicts the strength and nature of the relationship between Mean_Cortical_Thickness and CGeGFR. In this case, the scatter plot shows a moderate upward trend with some dispersion around the regression line, which corresponds to the study's findings.

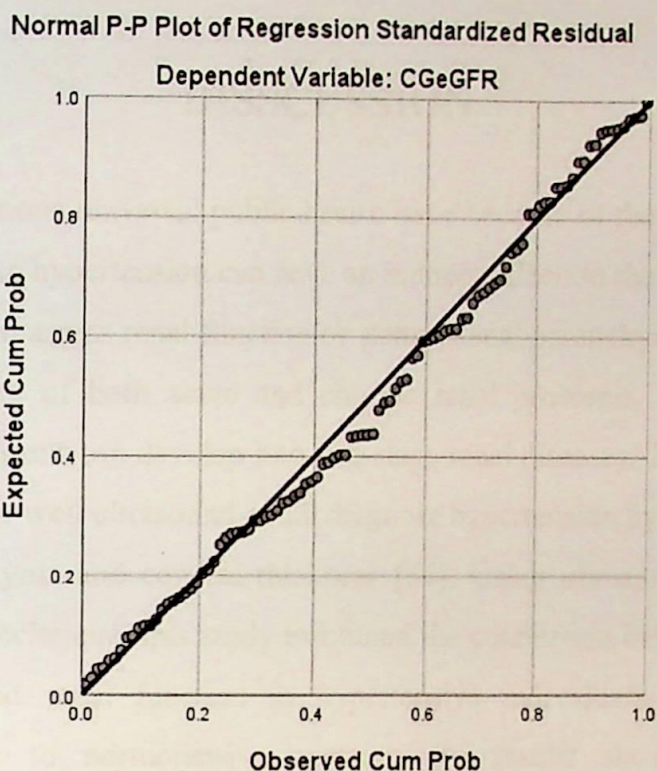


Figure 4.4: Scattered plot shows the moderate trend between Mean_Cortical_Thickness and CGeGFR

Table 4.8: Coefficients from the linear regression to represent relationship between the independent variable and the dependent variable

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	51.050	6.097		8.373	.000
	Mean Cortical Thickness	3.007	.751	.375	4.002	.000

a. Dependent Variable: CGeGFR

The baseline value of CGeGFR when Mean_Cortical_Thickness is zero is shown in Table 4.8, where the constant (intercept) of 51.050 was statistically significant. The coefficient for Mean_Cortical_Thickness is 3.007, meaning that CGeGFR should rise by 3.007 units for every unit increase in Mean_Cortical_Thickness. For Mean_Cortical_Thickness, both the intercept and the coefficient are statistically significant (p-values < 0.001). Mean_Cortical_Thickness and CGeGFR have a somewhat positive connection, as indicated by the standardized coefficient (Beta) of 0.375. According to the model, CGeGFR rises in conjunction with Mean_Cortical_Thickness, and this link is statistically significant.

CHAPTER 5

DISCUSSION

Hypertension is a serious universal public health issue because of the hazards it poses for renal disease. Because hypertension can have an indirect effect on the kidneys, renal USG data can be utilized to assess renal function or status. Renal parenchymal illnesses are the most common causes of both acute and chronic renal problems. If treatment is not received, these conditions can develop into end-stage renal diseases. The aim of the study was to determine how well ultrasound could diagnose hypertension by measuring changes in the renal parenchyma and cortical thickness [54]. Using ultrasonography as a non-invasive diagnostic technique, this study examined the connection between renal cortical thickness (RCT) and renal function in hypertensive individuals. When comparing hypertension people to normotensive controls, the results showed a statistically significant decrease in cortical thickness. These findings are in line with those of Musa MJ, who also noted that hypertension patients had a reduced mean cortical thickness. Musa MJ partially attributed this finding to variations in renal volume, namely in the left kidney [55]. The idea that persistent hypertension has a role in the gradual structural changes in the kidneys is supported by the observed cortical thinning.

According to our results, there were no discernible gender-based variations in cortical measures between the control and hypertension groups. Previous investigations like those by [56], which found that cortical thickness is unaffected by gender differences, support this. This implies that brain changes linked to hypertension might not be confounded by gender. In this investigation, cortical thickness and age were found to be significantly inversely correlated, with bilateral cortical dimensions decreasing as age increased. Given that renal perfusion and nephron density naturally decrease with age and are made worse by persistent hypertension, this pattern is consistent with physiological expectations. Similar findings in the literature, where aging has been linked to cortical thinning and decreased renal function [56], corroborate our findings.

It's interesting to note that we also found that cortical thickness changed with BMI, rising with total body mass and falling with reduction. A potential explanation for this was provided by Adibi et al., who hypothesized that bigger body sizes could necessitate a larger nephron mass in order to maintain metabolic demands, which would in turn affect cortical size [26]. This suggests that when assessing renal morphometry, body

composition should be taken into account. Regarding how long a patient had hypertension, there was no discernible difference in cortical thickness between those who had it for less than a year and those who had it for one to five years. Patients who had hypertension for more than five years, however, showed a noticeable decrease in cortical thickness. According to this research, significant cortical remodeling might not show up until after extended exposure to high blood pressure. It is consistent with hypertensive nephropathy's natural progression, in which glomerular and vascular damage worsens with time due to chronicity.

Our investigation showed greater cortical measures when compared to those published by Madubueze et al. in Nigeria [36]. The ethnic composition of the study groups, which has been demonstrated to affect renal morphology and cortical thickness norms, is most likely the cause of this disparity. Additionally, Mounier et al. assessed hypertensive individuals with unilateral renal artery stenosis (RAS) and discovered that the afflicted kidney had considerable cortical atrophy as a result of reduced renal perfusion [57]. This supports our findings of decreased cortical thickness in chronic hypertension, which may possibly be a reflection of impaired renal perfusion, and emphasizes the significance of vascular variables in cortical thinning. The asymmetry observed between left and right renal cortical thickness in our study echoes the findings of Buchholz et al. in Pakistan, who reported that the left kidney generally had greater cortical thickness than the right [49]. Anatomical and hemodynamic differences between the two kidneys could explain this consistent pattern.

Kojima et al. in Japan, using CT imaging, reported that individuals with essential hypertension had significantly reduced cortical tissue compared to normotensive counterparts [58]. Our findings, obtained through ultrasonography, align with these results and demonstrate that USG can be a reliable, cost-effective tool in evaluating hypertension-related renal changes. In contrast, Beland et al. reported lower mean cortical thickness values in patients with chronic kidney disease (CKD) [40, 59], which were lower than those observed in our hypertensive cohort. This discrepancy likely reflects the more advanced stage of renal pathology in CKD populations compared to those with primary hypertension without overt renal failure.

According to a more recent study, kidney length has a low specificity for predicting renal impairment, although kidney volume and length have a substantial correlation with the

elderly's estimated glomerular filtration rate (eGFR). It is challenging to determine the actual kidney volume with ultrasound, though. Although the ellipsoid formula can be used to estimate volume, this approach has a flaw in that the kidney is not ellipsoid in reality [60]. Alsafi Ahmed Abdella and colleagues, in their research, documented the relationship between ultrasound findings in renal failure patients and serum creatinine levels. The study indicated that as serum creatinine levels rise, kidney volume diminishes (Mohammed, 2016). Furthermore, the research found no correlation between cortical thickness and echogenicity in patients with chronic renal failure, as evidenced by a p-value of .131, which exceeds the significance threshold of .05, indicating a lack of significant association between the two variables [61]. In our research, we observed a moderate positive correlation between the independent variable (Mean_Cortical_Thickness) and the dependent variable, as indicated by a p-value of 0.000 from the test. This result demonstrates that the model is statistically significant. It implies that the predictor (Mean_Cortical_Thickness) has a meaningful association with the dependent variable (CGeGFR). Consequently, the findings of the study are statistically significant ($p < 0.001$).

CONCLUSION

Hypertension, along with its link to renal disease, represents a major global health issue. The calculation of Renal Cortical Thickness and changes in Renal Parenchyma through ultrasound may serve as indicators of renal function deterioration in individuals with hypertension. Research indicates that the predictor Mean Cortical Thickness exhibits a significant correlation with the dependent variable CGeGFR. Therefore, incorporating the evaluation of Renal Cortical Thickness and Renal Parenchymal Changes into routine examinations of hypertensive patients could provide important diagnostic and prognostic insights.

RECOMMENDATION

Research indicates a notable relationship between Mean Cortical Thickness and estimated glomerular filtration rates. Therefore, it is advisable to routinely evaluate Renal Cortical thickness in patients with hypertension. This assessment can be performed through ultrasound during regular health examinations to detect early indicators of renal decline.

LIMITATION

The accuracy of sonographic measurements of renal cortical thickness and parenchymal changes is greatly dependent on the expertise and competence of the sonographer or radiologist, and variations in technique (e.g., probe position, pressure administered) may alter consistency.

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APPENDICES

Appendix 1: Consent Form

Consent Form

Description of the Research and Your Participation

You are invited to participate in a research study conducted by **Iqra Abdul Razaq** on topic of **“Sonographic Evaluation of Renal Cortical Thickness and Renal Parenchymal Changes as a Predictor of Renal Function Impairment in Hypertensive Patients”**

Risks and Discomforts

There will be no risk and discomfort to the participants.

Protection of Confidentiality

I will do everything to protect your privacy. Your identity will not be revealed in any publication resulting from this study.

Voluntary Participation

Your participation in this research study is voluntary. You may choose not to participate, and you may withdraw your consent to participate any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

Consent

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant's Signature _____ Date: _____

A copy of this consent form should be given to the participant.

Consent form in Urdu

تحقیق اور آپ کی شرکت کی تفصیل

آپ کو اقرا عبدالرزاق کی طرف سے "رینلکوریٹیکلموٹائی کی سونوگرافک تشخیص اور ہائی بلڈ پریشر والے مریضوں میں رینل فنکشن کی خرابی کا پیش خیمہ کے طور پر رینلپیرینچیمیل تبدیلیاں" کے موضوع پر ایک تحقیقی مطالعہ میں شرکت کے لیے مدعو کیا جاتا ہے۔

خطرات اور پریشائیاں

شرکاء کو کوئی خطرہ اور تکلیف نہیں تھی۔

رازداری کا تحفظ

میں آپ کی رازداری کے تحفظ کے لیے ہر ممکن کوشش کرونگی۔ اس مطالعے کے نتیجے میں کسی بھی اشاعت میں آپ کی شناخت ظاہر نہیں کی جائے گی

رضاکارانہ شرکت

اس تحقیقی مطالعہ میں آپ کی شرکت رضاکارانہ ہے۔ آپ حصہ نہ لینے کا انتخاب کر سکتے ہیں، اور آپ کسی بھی وقت حصہ لینے کے لیے اپنی رضامندی واپس لے سکتے ہیں۔ اگر آپ اس مطالعے میں حصہ نہ لینے یا اس سے دستبردار ہونے کا فیصلہ کرتے ہیں تو آپ کو کسی بھی طرح سے سزا نہیں دی جائے گی

رضامندی

میں نے یہ رضامندی کا فارم پڑھا ہے اور مجھے سوالات پوچھنے کا موقع دیا گیا ہے۔ میں اس مطالعہ میں حصہ لینے کے لیے اپنی رضامندی دیتا ہوں۔

شریک کے دستخط _____

تاریخ _____

اس رضامندی فارم کی ایک کاپی شریک کو دی جانی چاہیے۔

Appendix 2: Questionnaire

Topic: Sonographic Evaluation of Renal Cortical Thickness and Renal Parenchymal Changes as a Predictor of Renal Function Impairment in Hypertensive Patients

Participant Information

1. Name _____
2. Age _____
3. Marital status: Single/ Married /Divorced

Medical History

1. Do you have High blood pressure?
 - Yes
 - No
2. If yes, how long have you had high blood pressure? _____
3. What grade of hypertension (high blood pressure) do you have?
 - a) Grade 1(140/90 mmHg)
 - b) Grade 2 (160/100 mmHg)
 - c) Grade 3(180/110 mmHg)
4. Have you ever had a cardiovascular event (heart attack, stroke, etc.)?
 - Yes
 - No
5. Do you have high cholesterol?
 - Yes
 - No
6. Are you currently taking any medications?
 - Yes
 - No
7. If yes, please list: _____

Lifestyle Habits

1. Do you smoke?

- Yes
- No

2. Do you exercise regularly?

Yes

No

3. If yes, how often and what type of exercise? _____

Sonographic Evaluation

1. Have you ever had a sonographic evaluation before?

- Yes
- No

2. Are you willing to undergo a sonographic evaluation as part of this study?

- Yes
- No

3. Do you have any history of kidney or liver disease?

- Yes
- No

4. Have you ever had a previous cardiovascular event or surgery?

- Yes
- No

Family history of diseases

1. Family history of hypertension?

- Yes
- No

2. Family history of cardiovascular disease?

- Yes
- No

Appendix 3: Data Collection Sheet

(Single Patient)

Topic: Sonographic Evaluation of Renal Cortical Thickness and Renal Parenchymal Changes as a Predictor of Renal Function Impairment in Hypertensive Patients

1. Sr.no.
2. Name
3. Gender
4. Age
5. Hx Hypertension
6. BP
7. CG e GFR
8. Ultrasonographic findings
 - Cortical thickness
 - Mean Renal length
 - CMD Ratio
 - Parenchymal echogenecity

Report: Sonographic Evaluation of Renal Cortical Thickness and Renal Parenchymal Changes as a Predictor of Renal Function Impairment in Hypertensive Patients (Iqra Abdul Razzaq)

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Thesis as indicated below: -

Sr. No.	Suggested Change	Change Done as	Page No
01	Strengthen research gap and rationale	Changes done as indicated	9
02	Improve discussion section by linking results to literature more effectively.	Changes done as indicated	33,34

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