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Assessment of renal artery diameter for diabetic patients using computed tomography among Sudanese population

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Abstract

This analytical (case and control) study was conducted to evaluate renal changes in Sudanese patients with diabetes using Computed Tomography (CT), to assess and measure the diameter of the renal artery in both kidneys, as correlated with age, duration of disease, control status, and hypertension. The study was conducted in different hospitals and medical centers in Khartoum state using a CT machine. A sample of 522 subjects was collected (138 in the control group and 384 in the diabetic group). The findings showed that the Mean age of case group was 58.5 The study found the mean of Left Kidney Renal Artery diameter (Lt K RA)is bigger in un control diabetic group than in controlled diabetes group p-value (.036), but there were no difference in Right Kidney Renal Artery(Rt K RA) p-value (0.561) between all duration of Diabetes mellitus (DM). However, there was no difference in the Lt K RA p-value (0.452) for all DM durations. The study found that the duration of DM did not affect Rt K RA and Lt K RA, there were no significant difference in rest of the mean measurements between two groups (Rt K RA), The study found the mean of Lt K RA diameter is bigger in un control diabetic group than in controlled diabetes group, whereas there was no deference's in means in the measurements of both kidney between control and un control groups. Diabetes affects the renal artery diameter. So, the early identification of kidney abnormalities can significantly enhance patient outcomes by enabling timely interventions that slow the progression of diabetic nephropathy.

Keywords: Computed tomography, Diabetic patients, Diameter, Duration of DM, Renal artery.

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1. Introduction

The kidneys are important body organs, Anatomically they are two organs of characteristic shape (reddish brown are retroperitoneal bean-shaped organs that lie against the posterior abdominal wall on either side of the vertebral column, a lateral convex border and medial border which is convex above and below, but has a central indentation, the renal hilum, through which renal vessels and ureter pass and consist of cortex and medulla, sinuses and Pelvis,) [1, 2].

Physiologically, the kidneys excrete waste (end products of metabolism) from blood, urine, and body fluids; they also have other functions [3, 4].

The kidney is affected by many diseases, which lead to changes in its function and morphology; diabetes is one of them [5]. Diabetes is common lifelong health, it is a condition where the amount of glucose in blood is too high because the body cannot use it properly, diabetes affected most body organs like eye (blurred vision) blood vessels (atherosclerosis), With diabetes small blood vessels of the kidney injured so kidney cannot clean the blood properly, Morphologic changes in diabetic nephropathy affect all 4 renal compartments: glomeruli, tubules, interstitium, and vessels [6-8].

Diabetes affects several organs. In particular, the kidney causes changes in size. As kidney size is affected, many modalities are used to assess these renal changes, and CT plays an important role in renal measurement because of its high image contrast [9]. The main objectives of our study were to measure the renal artery diameter for both kidneys and correlate the above measurements with the age of patients and duration of disease, to compare this measurement between controlled diabetic patients and uncontrolled diabetic patients, and to compare this measurement between diabetic patients (case) and control groups.

2. Materials and Methods

This case-control analytical non-investigational study was performed to evaluate renal morphology in Sudanese patients with diabetes.

2.1. Study Sample

This analytical study evaluated the renal changes in patients with diabetes using CT. Total sample of (522) were included in this study (138) control group (normal group), and (384) case group (diabetic group) this case group include (40.4%) males' (155) and (59.6 %) were females'(229) aged from 24-85 years, who underwent CT examination for the abdomen or urinary system (CTU), at the Radiology and Imaging Department.

2.1.1. Exclusion Criteria

Patients with other renal diseases (except diabetes and hypertension) that affect renal morphology were excluded.

2.1.2 Inclusion Criteria.

Were adult diabetic patients or diabetic and hypertensive patients with an average age ranging from 24-85 years old, both genders.

2.2 Area and Duration of the Study.

The study was conducted from November 2019 to November 2024 in the Khartoum state.

2.3. Machine used (CT machine)

Asia hospital: Optima 16 slice computed tomography machine, Alzytoona hospital: Lightning Aquilion 16 slice computed tomography machine, Aliaa 1 hospital: Toshiba 64 slice computed tomography machine, Aliaa 2 hospital: 32 slices of semen with 64 soft tissue computed tomography machine, Ibn Sina hospital: GE 16 slice computed tomography machine. Alnelien Medical center: optima 16 slice computed tomography machine; Emergency Military Hospital: Toshiba 64 slice computed tomography; Alkwity hospital: optima 16 slice computed tomography machine; and Albogaa hospital: optima 16 slice computed tomography machine.

2.4. Technique Used

The data collected from patients referred to an abdominal computed tomography exam with contrast or CTU. Measurement of renal artery diameter for each kidney was taken from a contrast-enhanced coronal section scan from the arterial phase at the level of the renal hilum, and the renal artery diameter was measured just before bifurcation when entering the hilum, as explained in images (1) and (2).

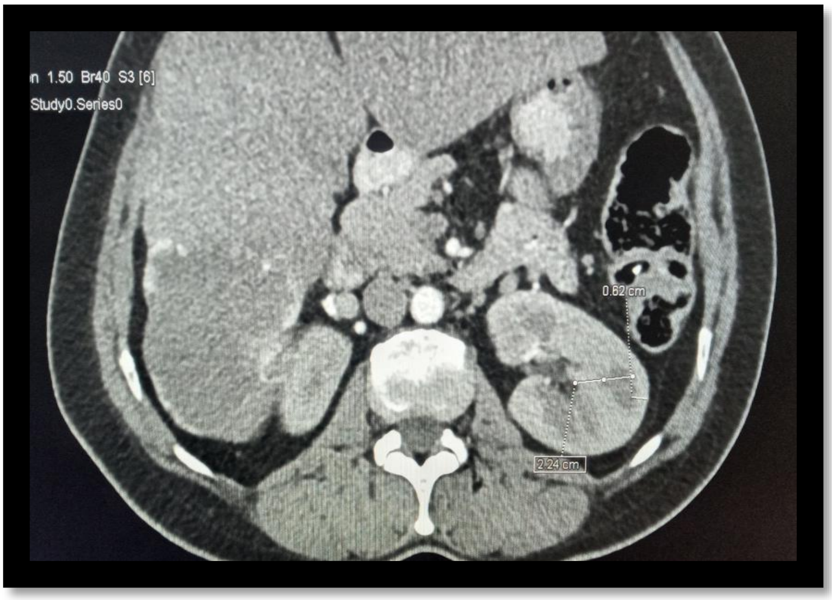

Figure 1.
Explained the way of measuring the left renal arterial diameter.
Source: Aliaa Hospital [10].

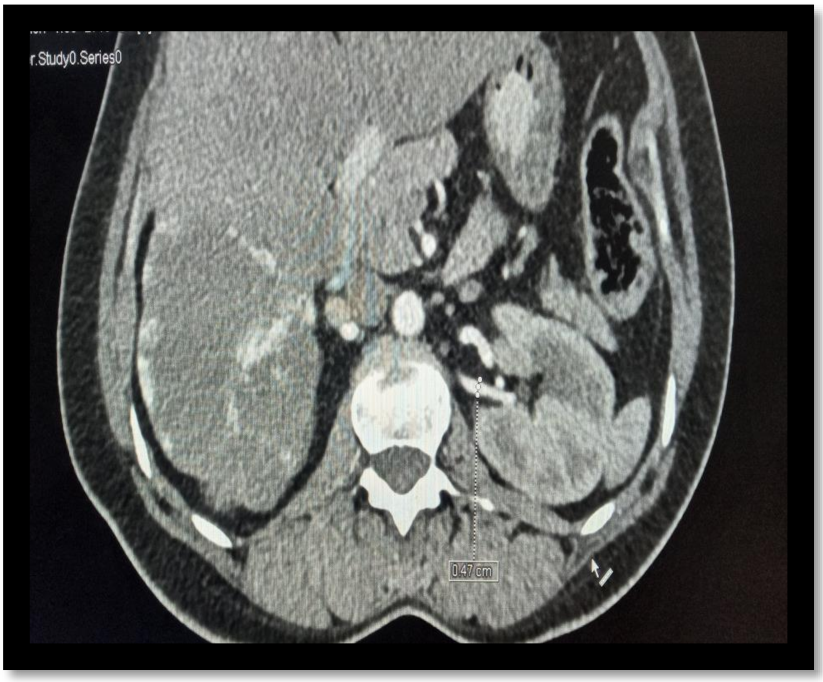

Figure 2.
Explained the way of measuring the left renal arterial diameter.
Source: Aliaa Hospital [10].

2.4.1. CT Abdomen

Most abdominal protocols are performed while the patient lies in a supine position on the scan table with the arms elevated above the head, and the feet first enter the CT gantry [11].

The Start location: Just above the diaphragm.

End location: Just below the symphysis pubis.

Patients were asked to hold their breath during scan acquisition to reduce movement and decrease motion artifacts.

Scouts: AP and lateral

Scan type: Helical

IV contrast: 125 mL at 3.0 mL/s; 50 mL saline flush. Scan delay = 65 seconds

Oral contrast: 675 mL barium sulfate suspension (1.5 bottles Readi-Cat 2). An additional 225 mL (the remainder of the second bottle) was administered immediately before scanning.

DFOV: ~38 cm (optimize for individual)

A routine soft-tissue window setting (window width approximately 450 mm; window level approximately 50 mm) adequately displays most abdominal anatomy [12].

Table 1.
Shows the detector protocols for 16 and 64 detectors for abdominal CT examinations.

Parameter	16-Detector Protocol	64-Detector Protocol
Gantry rotation time	0.8 s	0.8 s
Acquisition (Detector width × number of detector rows = detector coverage)	16 × 1.25 = 20 mm	64 × 0.625 = 40 mm
Reconstruction (Slice thickness/interval)	5 mm / 5 mm	5 mm / 5 mm
Pitch	1.375	1.375
kVp	120	120
mA	≥ 230	≥ 230

Source: Williams [12].

2.4.2. CTU

CT urography (CTU) is a relatively new imaging examination designed to provide a comprehensive evaluation of the upper and lower urinary tract and is defined as a diagnostic examination optimized for imaging the kidneys, ureters, and bladder. The examination involves the use of MDCT with thin-slice imaging, intravenous administration of contrast medium, and imaging in the excretory phase. Protocols may include only the excretory phase or as many as four phases (unenhanced, corticomedullary, nephrographic, and excretory). Excretory phase imaging for CTU studies can range from 3 to 16 minutes after injection. Longer delays are beneficial for the opacification of distal ureters. Contrast administration is accomplished using one of two different approaches: single-bolus injection or split-bolus injection. A single bolus injection of 100 to 150 mL of low-osmolality contrast media (LOCM) is administered at a rate of 2–3 mL/s; scans are typically obtained in the nephrographic phase to assess the renal parenchyma and in the excretory phase to assess the urinary tract mucosa. Begin running a 250 mL bag of 0.9% saline intravenously (IV) when the patient first gets on the CT table.

Scouts: AP and lateral
Scan type: Helical
Scan sequences: Noncontract Scan, IV contrast, Excretory Scan
Start location: 2 cm above the kidneys
End location: Just below the symphysis pubis
Breath-hold: Inspiration
IV contrast (split bolus): 75 mL at 3 mL/s; 20 mL saline at 3 mL/s
Injection delay: 600 seconds, then 100 mL at 3 mL/s; 20 mL saline at 3 mL/s
Scan delay: Scan begins 100 seconds after the second contrast injection
Oral contrast: None
DFOV: ~38 cm (optimize for individual)
SFOV: Large body
Window settings: 350 ww/50 wl (soft tissue) [12].

Table 2.
Shows the detector protocols for the 16 and 64 detectors for the CTU exam.

Parameter	16-Detector Protocol	64-Detector Protocol
Gantry rotation time	0.8 s	0.8 s
Acquisition (detector width × number of detector rows = detector coverage)	16 × 1.25 = 20 mm	64 × 0.625 = 40 mm
Reconstruction (slice thickness/interval)	5 mm / 5 mm	5 mm / 5 mm
Pitch	1.375	1.375
kVp	120	120
mA (200 lbs or less)	80	80
mA (More than 200 lbs)	200	200

Source: Williams [12].

2.5. Sample Size

The sample size required to be representative of the study population was calculated using a sample size calculation formula based on a known population. With a margin of error of 5%, the population was entered into the formula to determine the sample size after calculation, giving a total sample size of 384.

2.6. Data Analysis

The collected data were analyzed using SPSS version 23. Frequency and percentage were used to describe the qualitative data. Descriptive statistics were used to estimate the mean values of the quantitative data. *Statistical significance was set at* $p < 0.05$.

2.7. Ethical Considerations

Informed consent was obtained from all participants before data collection. This study was approved by the Ethics Committee of the College of Graduate Studies and Scientific Research, Karary University. Ethical considerations were adhered to ensure confidentiality and privacy of the collected data. Participants were informed of their right to withdraw from the study at any time without any consequences.

3. Results

This analytical (case and control) study was conducted to evaluate renal changes in patients with diabetes using Computed Tomography. The results are tabulated in the form of figures and tables as follows.

Table 3.
Frequency distribution of age in patients with DM.

Age	Frequency	Percent	Valid Percent	Cumulative Percent
24-40	40	10.4	10.4	10.4
41-60	187	48.7	48.7	59.1
61-80	145	37.8	37.8	96.9
More than 80	12	3.1	3.1	100.0
Total	384	100.0	100.0	
Mean age 58.46±11.9				

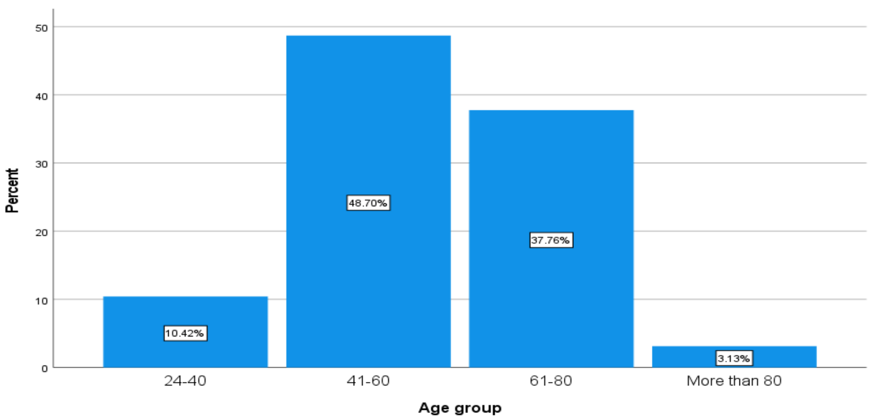

Figure 1.
A bar graph shows the frequency distribution of age in DM.

Table 4.
Frequency distribution of sex in DM.

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	155	40.4	40.4	40.4
Female	229	59.6	59.6	100.0
Total	384	100.0	100.0	

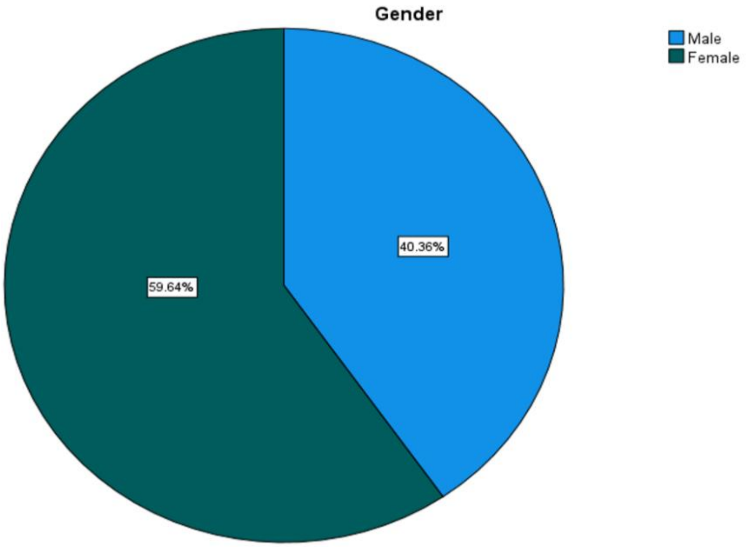

Figure 2.
A pie chart shows the frequency distribution of gender in DM.

Table 5.
Shows the frequency distribution of the duration of diabetes**.**

Duration of DM	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 5 years	126	32.8	32.8	32.8
5 - 10 years	136	35.4	35.4	68.2
More than 5 years	122	31.8	31.8	100.0
Total	384	100.0	100.0	

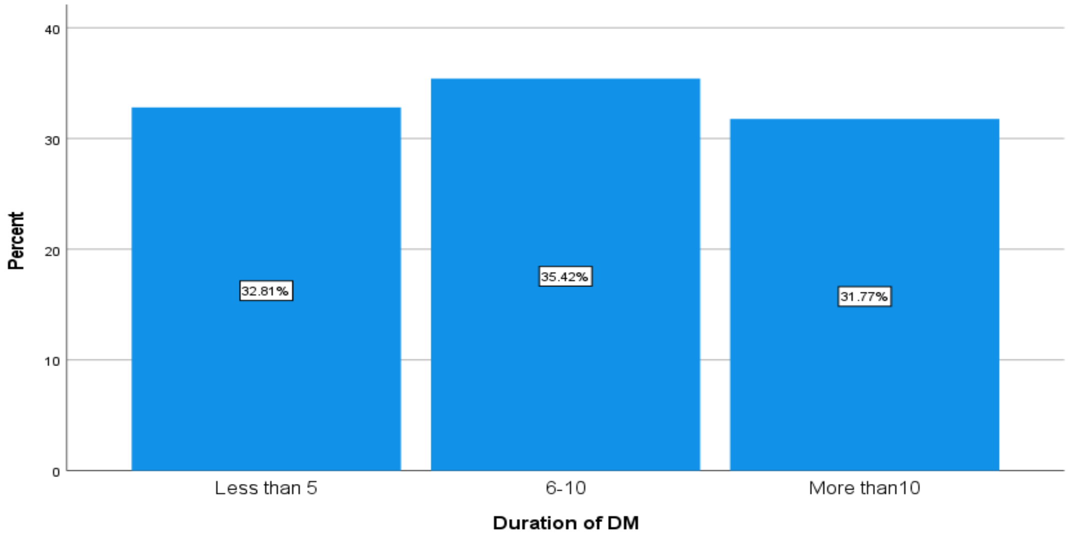

Figure 3.
A bar graph shows the frequency distribution of the duration of DM.

Table 6.
Shows frequency distribution of control state of diabetic.

DM control status	Frequency	Percent	Valid Percent	Cumulative Percent
Control	296	77.1	77.1	77.1
Uncontrolled	88	22.9	22.9	100.0
Total	384	100.0	100.0	

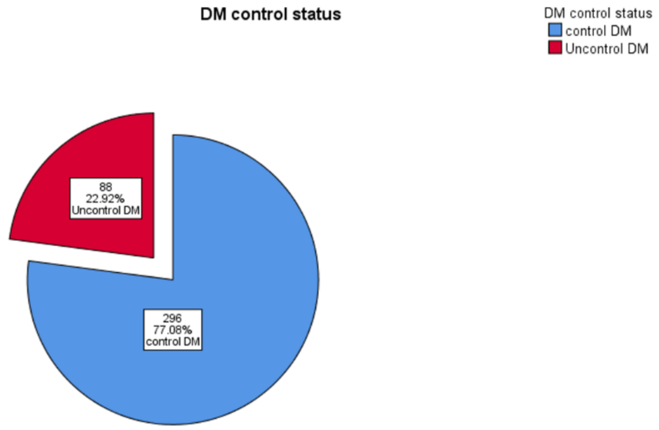

Figure 4.
A Pie chart shows the frequency distribution of the control state of diabetes.

Table 7.
Shows the frequency distribution of hypertension prevalence in the case group.

Prevalence of HTN	Frequency	Percent	Valid Percent	Cumulative Percent
HTN	110	28.6	28.6	28.6
Non-HTN	274	71.4	71.4	100.0
Total	384	100.0	100.0	

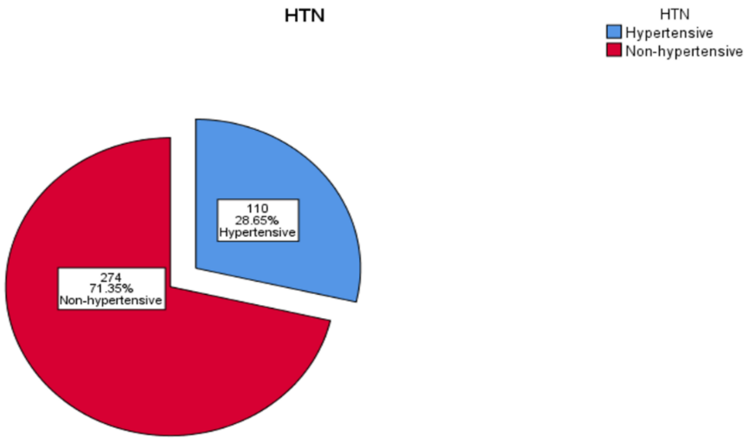

Figure 5.
A pie chart shows the frequency distribution of hypertension in diabetics.

Table 8.
Shows descriptive statistics measurements for the means of Rt and LT Kidneys of the case group.

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Age	384	24	85	58.46	11.977
RtK RA	384	3	6.8	4.911	0.7179
LtK RA	384	3	6.8	4.895	0.7176
Duration of DM	384	1	3	1.99	0.805
Valid N (Listwise)	384				

Table 9.
Correlation of kidney measurements with age and duration in the case group.

Variables		Age	Duration of DM
Rt K Cortical T	Pearson Correlation	0.072	0.343**
	Sig. (2-tailed)	0.161	0.000
	N	384	384
Rt K Medulla T	Pearson Correlation	-0.030	0.421**
	Sig. (2-tailed)	0.562	0.000
	N	384	384
Rt K Cortical CT N	Pearson Correlation	-0.064	-0.174**
	Sig. (2-tailed)	0.214	0.001
	N	384	384
Rt K Medulla CT N	Pearson Correlation	-0.112*	-0.149**
	Sig. (2-tailed)	0.028	0.003
	N	384	384
Rt K RA	Pearson Correlation	0.025	0.030
	Sig. (2-tailed)	0.620	0.551
	N	384	384
Lt K Cortical T	Pearson Correlation	-0.055	0.299**
	Sig. (2-tailed)	0.279	0.000
	N	384	384
Lt K Medulla T	Pearson Correlation	-0.047	0.226**
	Sig. (2-tailed)	0.354	0.000
	N	384	384
Lt K Cortical CT N	Pearson Correlation	-0.009	-0.216**
	Sig. (2-tailed)	0.865	0.000
	N	384	384
Lt K Medulla CT N	Pearson Correlation	0.013	-0.188**
	Sig. (2-tailed)	0.806	0.000
	N	384	384
Lt K RA	Pearson Correlation	0.002	0.025
	Sig. (2-tailed)	0.974	0.628
	N	384	384

Table 10.
Compares the Mean of measurements in different DM durations (right kidney).

Duration of DM		Rt K RA
Less than 5	Mean	4.860
	N	126
	Std. Deviation	.6747
6-10	Mean	4.956
	N	136
	Std. Deviation	.7518
More than10	Mean	4.914
	N	122
	Std. Deviation	.7249
Total	Mean	4.911
	N	384
	Std. Deviation	.7179
P value		0.561

Table 11.
Compares the Mean of measurements in different DM durations (left kidney).

Duration of DM		**LtK RA**
Less than 5	Mean	4.842
	N	126
	Std. Deviation	0.7534
6-10	Mean	4.953
	N	136
	Std. Deviation	0.6749
More than10	Mean	4.885
	N	122
	Std. Deviation	0.7269
Total	Mean	4.895
	N	384
	Std. Deviation	0.7176
P value		0.452

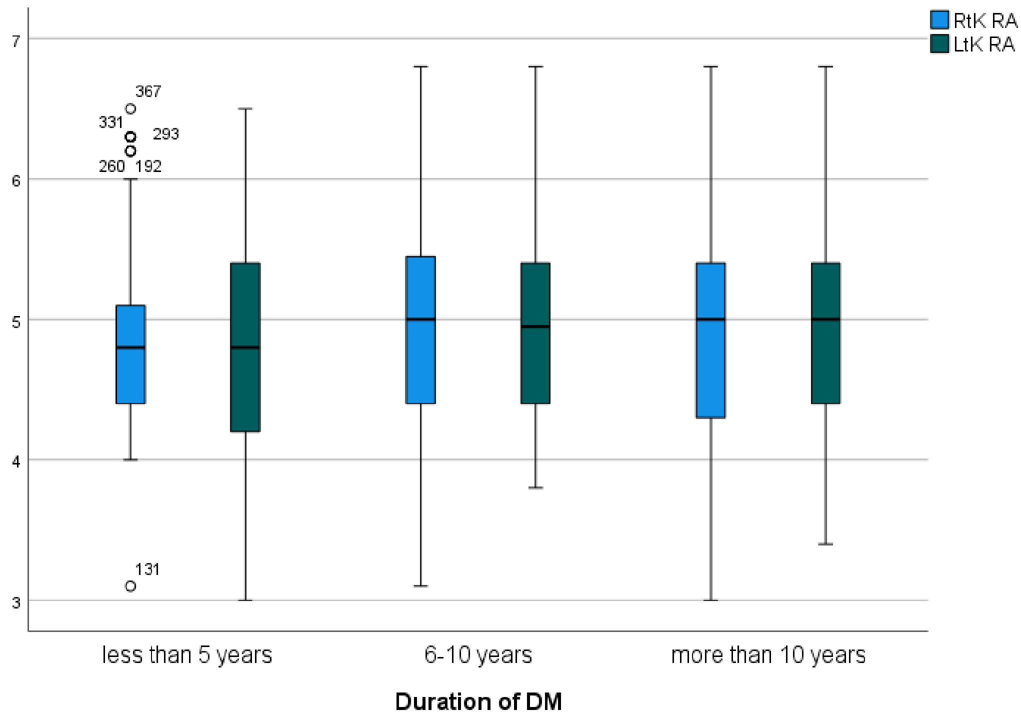

Figure 6.
A plot box shows the Mean of RA in different durations of DM.

Table 12.
Compares the mean measurements in the control DM pts. Versus patients with uncontrolled DM.

Group Statistics						
	DM control status	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**p- value**
	Un control	88	25.74	4.891	0.521	
RtK RA	Control	296	4.901	0.7565	0.0440	0.55
	Un control	88	4.945	0.5717	0.0609	
	Un control	88	25.09	5.183	0.553	
LtK RA	Control	296	4.856	0.7379	0.0429	0.036
	Un control	88	5.025	0.6309	0.0673	

Table 13.
Compares the Means of measurements in cases and control groups in the Renal Artery.

Group Statistics						
	Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**P value**
Rt K RA	Case	384	4.911	0.7179	0.0366	<0.001
	Control	138	4.562	0.7886	0.0671	
Lt K RA	Case	384	4.895	0.7176	0.0366	<0.001
	Control	138	4.610	0.8981	0.0765	

Table 14.
Compares means of measurements in cases and control groups in the cortex and Medulla.

Group Statistics						
Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**		**P Value**
Rt K Cortical T	Case	384	8.511	1.7079	0.0872	<0.001
	Control	138	5.288	0.8277	0.0705	
Lt K Cortical T	Case	384	8.602	1.8668	0.0953	<0.001
	Control	138	5.313	0.8741	0.0744	
Rt K Medulla T	Case	384	22.346	5.8425	0.2982	<0.001
	Control	138	15.121	4.2584	0.3625	
Lt K Medulla T	Case	384	22.433	5.2484	0.2678	<0.001
	Control	138	14.895	4.2521	0.3620	
Rt K Cortical CT N	Case	384	36.533	5.7854	0.2952	0.852
	Control	138	36.420	6.9280	0.5898	
Lt K Medulla CT N	Case	384	25.19	5.726	0.292	0.582
	Control	138	24.86	6.518	0.555	
Rt K Medulla CT N	Case	384	25.33	5.262	0.269	0.872
	Control	138	25.41	5.468	0.465	
Lt K Cortical CT N	Case	384	36.50	6.209	0.317	0.615
	Control	138	36.57	6.162	0.525	

Table 15.
shows cross-tabulations between case and control groups according to gender.

Gender			**Gender**		**Total**
			Male	**Female**	
Groups	Case	Count	155	85	240
		Percent	40.4%	61.6%	46.0%
	Control	Count	229	53	282
		Percent	59.6%	38.4%	54.0%
Total		Count	384	138	522
		Percent	100.0%	100.0%	100.0%
P value 0.000					

4. Discussion

This study aimed to establish computed tomography (CT) as a non-invasive and reliable tool for assessing kidney health in patients with diabetes. The early identification of kidney abnormalities can significantly enhance patient outcomes by enabling timely interventions that slow the progression of diabetic nephropathy. Additionally, using CT for kidney measurements may provide a deeper understanding of the pathophysiology of diabetic kidney disease, aiding in the development of more effective treatments. This analytical case-control study was designed to evaluate the renal changes in patients with diabetes using CT imaging. Results were presented in figures and tables based on study variables, including age, sex, diabetes duration, cortex and medullary thickness, as well as cortical and medullary CT numbers for both kidneys, and diabetes control Status. The study's participants' age was 58.5 years. Among the case groups, 10.4% were aged 24–40 years, 48.7% were aged 41-60, 37.8% were aged 61-80, and 3.1% were older than 80 years, as shown in Figure 1. A total of 384 patients participated in the study, including 229 females (59.6%) and 155 males (40.4%), as shown in Table 4 and Figure 2. Regarding the duration of diabetes, 32.81% of participants had diabetes for less than five years, 35.42% had it for 6-10 years, and 31.77% had diabetes for more than ten years, as indicated in Table 5 and Figure 3, respectively. When analyzing diabetes control, 77.1% of the patients had controlled diabetes (296 individuals), while 22.9% had uncontrolled diabetes (88 individuals), as shown in Table 6 and Figure 4. Regarding the prevalence of hypertension in the case group (28.6 % HTN and Non-HTN (71.4%) as shown in Table 7 and the pie chart in Figure 5.

The measurements for Rt and LT Kidneys of the case group were Rt K RA and Lt K RA, had means of 4.91 and 4.89, respectively, as shown in Table 8. The correlation between kidney measurements (Rt K RA, Lt K RA) and age of the case group, with corresponding significant values of Pearson Correlation Coefficients (.620,.97, respectively), is shown in Table 9. Regard to Correlation between kidneys measurements (Rt K Cortical T, Rt K Medulla T, Rt K Cortical CT NO, Rt K RA, Lt K Cortical T, Lt K Medulla T, Lt K Cortical CT NO, Lt K Medulla CT NO, Lt K RA) and age of case group with corresponding significant values of Pearson Correlation Coefficients (.161, .562, .214, .620, .279, .354, .865, .806, .97) respectively in Table 9, that implies there are no statistically significant correlation between kidneys 'measurements and age of case group unless there was weak reverse correlation between Rt K Medulla CT NO and age p-value: (028), implies that decreasing Rt K Medulla CT NO with increasing age as on Table 9. This is associated with the study of Elbashir [13] and Mohammed, et al. [14] found that there was no statistically significant correlation between cortexes, medulla thicknesses, and corresponding CT. No.'s and age in diabetes patients p value >.05. Also in Correlation between kidneys measurements and duration of disease found that there were no correlation between Rt K RA, Lt K RA and duration p value (0.56, 0.45) implies the duration of DM did not affect them as in Table (10&11) and Figure 6, this disagree with study of Elbashir [13] found that there was no statistically significant correlation between cortex and medulla thicknesses, and corresponding CT. No.'s and the duration of disease p-value >.05.

In compression between the control and un-control DM groups, there were significant differences in the mean LT K RA of both groups (.036), implying that the mean of Lt K RA diameter was larger in the control diabetic group than in the control diabetes group, whereas there was no difference in means in the rest of the measurements of both kidneys between the control and non-control groups, as shown in Table 12. In Table 13 a comparison of the mean of measurements between the case and control groups revealed that there were significant differences between the case and control groups in (Rt K RA and Lt K RA) p-value (<.001, <.001,), implying that the thickness of the cortex and medulla of both kidneys and the diameter of the renal artery of both kidneys were larger in the case group than in the control group. indicate that the diabetes affect by increasing medulla and cortex thickness and increasing diameter of renal artery, this similar results have been shown by Elbashir [13] found in his study there were statistically significant differences in the means of (Rt. Cortex, Rt. Medulla, Rt. Cortex CT. No., Lt. Cortex, Lt. Medulla, Lt. Cortex No.) between the two groups p value < .05, also similar to result shown by Noda, et al. [15] who Measured cortical thickness Choi, et al. [16] and Koo, et al. [17]. They found that the patient group had a thicker renal cortex than the normal control group (p<0.05) but disagreed with their result that there was no significant difference in renal parenchymal thickness between the two groups (p >0.05). However, there were no differences between the groups in (Rt K Cortical CT N, Lt K Medulla CT N, Rt K Medulla CT N, Lt K Cortical CT N) p-value (0.852,0.582, 0.872, 0.615), implying that diabetes did not affect the cortex and medulla CT number, as shown in Tables 14 &15. This is in line with the study of Mansour, et al. [18] and Elbashir [13] who found that there were no statistically significant differences between the two groups in the means of (Rt. Medulla CT. No, and Lt. Medulla CT. No, p-value > .05.

5. Conclusion

This analytical (case and control) study was conducted to evaluate renal changes in patients with diabetes using Computed Tomography, to measure the diameter of the renal artery in both kidneys, as correlated with age, duration of disease, and control status. The study was conducted in different hospitals and medical centers in Khartoum state using a CT machine. A sample of 522 subjects was collected (138 in the control group and 384 in the diabetic group). The findings show the mean values of the measurements for. The study found that the duration of DM did not affect Rt K RA and Lt K RA, there were no significant difference in rest of the mean measurements between two groups (Rt K RA, The study found the mean of Lt K RA diameter is bigger in un control diabetic group than in controlled diabetes group, whereas there was no deference's in means in the measurements of both kidney between control and un control groups. Diabetes affects by renal artery diameter.

Abbreviation:

CT: Computed Tomography, (Lt K RA) Left Kidney Renal Artery, (Rt K RA): Right Kidney Renal Artery, (DM): Diabetes mellitus, (CTU): Computed Tomography urography, (MDCT): multidetector computed tomography, (LOCM): low-osmolality contrast media, (IV): Intravenous, (DFOV): Diagonal Field of View, (SFOV): Scan field of view

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