EVALUATION OF INTRARENAL RESISTIVE INDEX BY DUPLEX COLOR DOPPLER ULTRASONOGRAPHY IN PATIENTS WITH DIABETIC NEPHROPATHY – COMPARISON BETWEEN HEALTHY ADULT CONTROL SUBJECTS

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Abstract

Background: Renal Doppler Ultrasonography (USG) has become a useful adjunct to gray scale sonography in the evaluation of renal function in various pathophysiological conditions like diabetic nephropathy. We can diagnose diabetic nephropathy by serum creatinine level and creatinine clearance rate. But early stage diagnosis of diabetic nephropathy is not always possible. In this study we have focused on resistive index of interlobar arteries of kidney to see changes of renal parenchyma for early stage diagnosis of diabetic nephropathy.

Objectives: To observe the difference between values of intrarenal resistive index measured by duplex color Doppler USG in type 2 diabetic patients having diabetic nephropathy and in healthy adult control subjects.

Materials and methods: This cross sectional observational study was conducted in the Department of Radiology and Imaging, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh. 65 diabetic nephropathy patients were taken as study group and 65 healthy subjects were included as healthy control subjects. Duplex Color Doppler Ultrasonography of interlobar artery was carried out in both groups to measure the peak systolic velocity, the end diastolic velocity and arterial Resistive Index.

Results: The Resistive Index of interlobar artery of left kidney in control group and diabetic group was 0.58 ± 0.08 and 0.74 ± 0.53 respectively. For the right kidney the values were 0.60 ± 0.09 and 0.76 ± 0.03 respectively for the control and case group. The difference of resistive index of interlobar artery of both kidney in the two groups were statistically significant. So, resistive index of interlobar artery was increased in type 2 diabetic nephropathy patients compared to control group.

Conclusion: It can be concluded in present study that resistive index remains significantly higher in patients with diabetic nephropathy than in controls. Thus Duplex Doppler ultrasonography allows the rapid, noninvasive evaluation of the intrarenal vasculature and can be used as an easily available parameter of the evolution and a predictor in patients with clinical diabetic nephropathy.

Keywords: Doppler Ultrasonography, Intrarenal Resistive Index, Diabetic Nephropathy

Introduction:

Diabetes mellitus (DM) is the most prevalent metabolic, non communicable disorder in the world.¹ It is a chronic and evolutionary illness, complicates itself naturally as a result of vascular attacks. All arteries, from the thickest to smallest, are affected by the disease, the appearance of the vascular complication being variable during the time.² Diabetic nephropathy is one of the dreaded complications of

diabetes,¹ progress to end stage renal failure and leading cause of morbidity and mortality among diabetic patients in Bangladesh.³ The incidence of end-stage renal disease (ESRD) and type 2 DM as a co-morbid condition has increased continuously during the past decades.^{4,5} Presently, there is greater focus on early detection of nephropathy, to help in better patient outcomes.¹ In the early stage of clinical diabetic nephropathy, renal function remains normal despite the development of proteinuria, where the

advanced stage is characterized by clinical renal dysfunction including gradually increased serum creatinine concentration (SCC) and reduced creatinine clearance rate.⁶⁻¹⁰ In diabetic patients duplex Doppler sonography can be used as noninvasive tool for early diagnosis of diabetic nephropathy and for follow up of renal function in established diabetic nephropathy.¹¹ Color Doppler duplex sonography noninvasively interrogate intrarenal arteries and can access general renal perfusions.¹² Among parameters measured by Doppler US, resistance index (RI) value has been most frequently used in clinical practice.¹³ In diabetic nephropathy changes in the compliance of the vessels' valve and the resistance of the vessels' valve affects the resistivity index.¹⁴ In this study we have focused on resistive index value obtained from interlobar arteries of kidney and tried to determine whether resistive index could remain higher in type 2 diabetic patients having nephropathy in comparison with that of non-diabetic controls.

MATERIAL AND METHODS

This cross sectional observational study was conducted from 1st July 2017 to 30th June 2018 (One year) in the Department of Radiology and Imaging, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh. The study was performed according to the guideline of the Helsinki Declaration and was approved by the institutional ethical committee. 65 diabetic nephropathy patients were taken as study group and 65 healthy subjects were included as healthy control subjects. Patients with type 2 diabetes mellitus having nephropathy, diagnosed by serum creatinine and creatinine clearance test were selected for the study according to inclusion criteria as cases and non-diabetic adult subjects were also being selected in control group. However, hypertensive diabetic nephropathy patients, patients with single or transplanted kidney, patients having evidence of hydronephrosis, patients having acute or chronic inflammatory disease, known history of cardiovascular system (such as coronary artery bypass graft and cardiovascular related drug usage) and patients having drug induced nephropathy were excluded from the study.

Doppler Ultrasonography

Doppler ultrasonography was performed for all patients by Hitachi (Aloka) machine with a multifrequency curvilinear transducer of 3.5 MHz.

and measure the Peak systolic velocity, the end diastolic velocity and arterial Resistive Index (RI). Patients lied on supine position, then kidney was identified. From that position patient was turned lateral on the side of examination. First, gray scale ultrasonography confirmed proper anatomic position of kidney. Then color flow was given and flow velocity was measured. Doppler waveforms of interlobar arteries were taken by placing the Doppler sample volume cursor at 0°-35° angle by selecting midpole vessel as parallel to the beam as possible. RI were calculated as $PSV-EDV/PSV$ where PSV=peak systolic velocity and EDV=End diastolic velocity.

Statistical analysis

Result of the study was calculated and analyzed by standard statistical method and was presented in forms of tables and graphs. Data were expressed as mean $\pm$ SD. A value of $P < 0.05$ was considered statistically significant. Independent sample "t" test and paired "t" tests were used to compare the peak systolic velocity, End diastolic velocity and Resistive index between case and control and between right and left kidney of the same respondents respectively. The data were analyzed with the SPSS for Windows (IBM SPSS Statistics for Windows, version 17.0, Armonk, NY:IBM Corp.) software.

RESULTS

65 diabetic nephropathy patients were taken as study group and 65 healthy subjects were included as healthy control subjects. Duplex Colour Doppler Sonography of interlobar arteries was carried out in both groups to measure the peak systolic velocity, end diastolic velocity and resistive index (RI).

The mean age of the control subjects was 51.31 (± 7.79) years and that of the case patients was 52.88 (± 8.96) years. Figure-1,2

Figure-1

Figure-2

The mean duration of diabetes mellitus was 12.78 years with standard deviation (SD) ± 4.01 years. Maximum patients were suffering from diabetes mellitus for 10-15 years (39/65) (Table I).

Table I: Distribution of mean duration of DM (N=65)

Duration of DM	Frequency	Percent	Mean ($\pm$ SD)	Range (yrs)
5-10	15	23.1	12.78 (4.01)	5-20
10-15	39	60.0		
16-20	11	16.9		
Total	65	100.0		

The mean peak systolic velocity of interlobar artery of right kidney of normal control subjects was 23.99 ± 5.24 , ranged 16.6-32.2 and the mean peak systolic velocity of interlobar artery of left kidney was 21.52 ± 3.12 , ranged 16.9-26.1. There was no statistically significant ($p > 0.05$) difference of mean peak systolic velocity of interlobar artery in right and left kidneys of normal control subjects in paired "t" test. The result is shown in table II.

Table II: Comparison between peak systolic velocity of right and left kidneys of normal control subjects (n=65)

Peak systolic velocity	Mean $\pm$ SD	Range	t value	p value
Right kidney (n=65)	23.99 ± 5.24	16.6-32.2	3.64	0.32
Left kidney (n=65)	21.52 ± 3.12	16.9-26.1		

The mean peak systolic velocity of interlobar artery of type 2 diabetic patients with nephropathy in right kidney was 28.87 ± 17.07 , ranged 16.2-75.0 and the mean peak systolic velocity of interlobar artery of left kidney was 29.95 ± 18.28 , ranged 12.9-74.1. There was no statistically significant ($p > 0.05$) difference of mean peak systolic velocity of interlobar artery in right and

left kidneys type 2 diabetic patients with nephropathy in paired "t" test. The result is shown in table III.

The mean resistive index (RI) of interlobar artery in right kidney of control subjects was 0.60 ± 0.09 , ranged 0.37-0.72 and the mean resistive index (RI) of interlobar artery in left kidney was 0.58 ± 0.08 , ranged 0.35-0.69. There was no statistically significant ($p > 0.05$) difference of mean resistive index (RI) of interlobar artery was found in right and left kidneys of normal control subjects in paired "t" test. The result is shown in (table IV)

Table III: Comparison between peak systolic velocity of right and left kidneys of diabetic nephropathy patients (n=65)

Peak systolic velocity	Mean $\pm$ SD	Range	t value	p value
Right kidney (n=65)	28.87 ± 17.07	16.2-75.0	-1.001	0.321
Left kidney (n=65)	29.95 ± 18.28	12.9-74.1		

Table IV: Comparison between resistive index (RI) of interlobar artery of right and left kidneys of normal control subjects (n=65)

Resistive index	Mean $\pm$ SD	Range	t value	p value
Right kidney (n=65)	0.60 ± 0.09	0.37-0.72	-3.39	0.17
Left kidney (n=65)	0.58 ± 0.08	0.35-0.69		

The mean resistive index (RI) of interlobar artery in right kidney was 0.76 ± 0.031 , ranged 0.72-0.84 and the mean resistive index (RI) of interlobar artery in left kidney was 0.74 ± 0.53 , ranged 0.62-0.84. There was no statistically significant ($p > 0.05$) difference of mean resistive index (RI) of interlobar artery was found in right and left kidneys of diabetic nephropathy patients in paired "t" test. The result is shown in table V.

Table V: Comparison between resistive index (RI) of interlobar artery of right and left kidneys of diabetic nephropathy patients (n=65)

Resistive index	Mean $\pm$ SD	Range	t value	p value
Right kidney (n=65)	0.76 ± 0.03	0.72-0.84	1.48	0.16
Left kidney (n=65)	0.74 ± 0.53	0.62-0.84		

The mean resistive index (RI) of interlobar artery of right kidney in control group was 0.60 ± 0.09 , ranged 0.37-0.72 and the mean resistive index (RI) of interlobar artery of right kidney in diabetic nephropathy patients was 0.76 ± 0.031 , ranged 0.72-0.84. The mean difference of resistive index (RI) of interlobar artery of right kidney in the two groups was statistically highly significant ($p < 0.001$) in Independent sample "t" test. The result is shown in table VI.

Table VI: Comparison of resistive index (RI) of interlobar artery of right kidney between case and control groups (n=130)

Resistive index of right kidney	Mean $\pm$ SD	Range	t value	p value
Control group (n=65)	0.60 ± 0.09	0.37-0.72	13.74	<0.001
Case group (n=65)	0.76 ± 0.03	0.72-0.84		

The mean resistive index (RI) of interlobar artery of left kidney in control group was 0.58 ± 0.08 , ranged 0.35-0.69 and the mean resistive index (RI) of interlobar artery of left kidney in diabetic nephropathy patients was 0.74 ± 0.53 , ranged 0.62-0.84. The mean difference of resistive index (RI) of interlobar artery of left kidney in the two groups was statistically significant ($p < 0.05$) in Independent sample "t" test. The result is shown in table VII.

Table VII: Comparison of resistive index (RI) of interlobar artery of left kidney between case and control groups (n=130)

Resistive index of left kidney	Mean $\pm$ SD	Range	t value	p value
Control group (n=65)	0.58 ± 0.08	0.35-0.69	11.50	0.003
Case group (n=65)	0.74 ± 0.53	0.62-0.84		

DISCUSSION

Diabetic nephropathy is a frequent microvascular complication of Diabetes mellitus.¹⁵ The aim of this study was to observe the difference between values of intrarenal resistive index measured by duplex color Doppler USG in type 2 diabetic patients having diabetic nephropathy and in healthy adult control subjects.

For this purpose, 65 diabetic nephropathy patients were taken as study group and 65 healthy subjects

were included as healthy control subjects. Duplex Color Doppler sonography of interlobar artery was carried out in both groups to measure the Peak systolic velocity and End diastolic velocity and Resistive Index (RI).

The mean age of the control subjects was $51.31 (\pm 7.79)$ years and that of the case was $52.8 (\pm 8.96)$ years. In control group 44 (68%) were male and 21 (32%) were female where as in case group 38 (58%) were male and rest 27 (42%) were female patients. In case group the mean duration of DM was $12.78 (SD \pm 4.01)$ years. Maximum patients were suffering from diabetes mellitus for 10-15 years.

In the current study, it was found that mean peak systolic velocity and mean end diastolic velocity right kidney of 65 healthy adult control subjects were 23.99 ± 5.24 , ranged 16.2-32.2 and 9.38 ± 2.24 , ranged 5.7-13.7 respectively and that of 65 diabetic patients with nephropathy were 28.87 ± 17.06 , ranging from 16.6-75.0 and 7.43 ± 4.55 , ranged 3.8-19. Therefore it reveals that in between case and control mean peak systolic velocity and mean end diastolic velocity of right kidneys were statistically highly significant ($p < 0.001$) in unpaired 't' test. This findings is consistent with the other study findings of Akeel 2010; Spomenka et al 2006.^{11,14}

In the present study, it was also found that the mean peak systolic velocity and mean end diastolic velocity of left kidney of 65 healthy subjects were 21.52 ± 3.12 , ranged 16.9-26.1 and 8.89 ± 1.38 , ranged 7.2-11.5 respectively. And the mean peak systolic velocity and end diastolic velocity of left kidney of 65 diabetic patients with nephropathy were 29.95 ± 18.2 , ranged 12.9-74.0 and 7.67 ± 4.02 , ranged 4.1-19.0. Therefore it was proved that mean peak systolic velocity of left kidney in between case and control groups were statistically highly significant ($p < 0.001$) and mean end diastolic velocity of left kidneys in between two groups were statistically significant ($p < 0.05$) in unpaired 't' test. Other studies (Akeel et al 2010; Spomenka et al 2006) were reported similar findings as well.^{11,14}

In this study the mean resistive index of right kidneys of control was 0.60 ± 0.09 , ranged 0.37-0.72 and that of 0.76 ± 0.03 , ranged 0.72-0.84 in case groups of right kidneys were statistically highly significant ($p < 0.001$) in unpaired 't' test. The study revealed that mean resistive index of left kidneys of control and that of left kidneys of case were 0.58 ± 0.08 , ranged 0.35-0.69 and 0.74 ± 0.53 , ranged 0.62-0.84 respectively and in

between two groups mean difference of resistive index of left kidneys were statistically significant ($p < 0.05$) in unpaired 't' test. These findings were consistent with the study findings of Kim et al 1992; Ishimura et al 1997; Sari et al 1999; Nejad et al 2009.¹⁶⁻¹⁹

So, the resistive index of interlobar artery was increased in type 2 diabetic patients with nephropathy group compared to control group.

CONCLUSION

Doppler ultrasonography adds extra dimension in the sonographic assessment of renal dysfunction. It can be concluded in present study that resistive index remains significantly higher in patients with diabetic nephropathy than in controls. Thus Duplex Doppler ultrasonography allows the rapid, noninvasive evaluation of the intrarenal vasculature and can be used as an easily available parameter of the evolution and a predictor in patients with clinical diabetic nephropathy

LIMITATIONS OF THE STUDY

The study was conducted in a single tertiary hospital. So the study population might not represent the whole community.

RECOMMENDATIONS

Duplex color Doppler sonography is a relatively cheap, available, painless and nonhazardous imaging tool. However, further study can be undertaken by including large number of study subjects, comparing haemodynamic changes in different stages of diabetic nephropathy, finding out the correlation of haemodynamic changes and levels of glycaemic control.

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