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ANKLE BRACHIAL PRESSURE INDEX AS AN INDICATOR OF RENAL FUNCTION IN CHRONIC KIDNEY DISEASE PATIENTS

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ABSTRACT

Background: Ankle brachial pressure index (ABI) is a simple and effective way to diagnose peripheral artery disease (PAD) in chronic kidney disease (CKD) patients to predict the cardiovascular morbidity and outcomes in them. **Objective:** ABI of CKD patients were recorded to find out if it could independently be used as an indicator of renal function and assess its relationship across increasing CKD stage severity. **Study design:** An observational cross sectional study based on a sample population of 100 CKD patients of stages 3-5 was performed. The demographic details were obtained using proforma and ABI calculated with the help of Doppler ultrasound and results were analysed using SPSS software. Chi-square test was used for categorical variables while independent t-test for continuous variables and multivariate forward logistic regression analysis to identify the independent determinant factors of low ABI. **Results:** ABI was <= 0.9 in 69% of the patients and 31 % had normal ABI > 0.9. A low ABI and low GFR correlated significantly (p value < 0.001) with increasing CKD stage severity along with other renal function parameters like urea, creatinine, uric acid, urine PC ratio, calcium, phosphorus and cholesterol. Unlike many studies ABI did not correlate well with diabetic status of the patients in my study while hypertension did. **Conclusion:** ABI being a marker of systemic atherosclerosis and vascular calcification can predict cardiovascular outcomes, and feasibility of vascular access and or failure of them in CKD patients while identifying those at high risk of progression to ESRD.

KEYWORDS: Ankle brachial pressure index (ABI), chronic kidney disease (CKD), Peripheral artery disease (PAD).

INTRODUCTION

Chronic kidney disease (CKD) is a major worldwide public health problem, with adverse outcomes of kidney failure, cardiovascular disease, and premature death. CKD patients are at increased risk for cardiovascular diseases, independent of conventional cardiovascular risk factors like systemic hypertension, diabetes mellitus, dyslipidaemia and metabolic syndrome. As a marker for systemic atherosclerosis, Ankle Brachial Pressure Index (ABI) has been of significant importance in giving prognostic information regarding cardiovascular and cerebrovascular events. Symptomatic peripheral artery disease (PAD) is more prevalent among individuals with CKD than in the general population. Furthermore, PAD and CKD synergistically affect mortality and morbidity.

An ABI <=0.9 defines PAD and an ABI >1.3 means the arteries are nearly incompressible which occurs with vessel calcification. In such cases ABI may not be a reliable tool for screening PAD. Patients with CKD are at higher risk for critical limb ischemia and higher rates of limb loss after revascularization, and to have higher mortality and morbidity. Dialysis patients have more diffuse and distal disease compared to those with normal GFR. Hence, simple and effective methods are required to identify high-risk patients among CKD patients to prevent them from developing cardiovascular events. ABI may be one such tool - a simple test with good reproducibility and hence maybe employed to identify high risk patients among those with chronic kidney disease to assess the renal function and its progression, compared to other indicators of renal function such as serum levels of urea, creatinine, uric acid, or proteinuria and creatinine clearance

Numerous studies have assessed the relationship of ABI in CKD patients across the globe but significant such studies are still wanted from Indian literature and also to assess its relation with other renal function parameters. This study is set on this background and attempts to find a meaningful relationship of spectrum of renal parameters of CKD patients with ABI in them and predict cardiovascular outcomes, and feasibility of vascular access and or failure of them in CKD patients while identifying those at high risk of progression to ESRD

OBJECTIVES OF THE STUDY

Primary Objective

To record the ABI of CKD patients and analyse its relationship with CKD severity.

Secondary Objective

To study the relationship of ABI with renal function tests in CKD patients.

MATERIALS AND METHODS

Sample size

Minimum sample size was calculated using the formula,

$$n = (z\alpha)^2 \times p \times q/d\ 2$$

Where, p is percentage of agreement between two variables, P = 19.2 (selected from similar study in which proportion of low ABI in CKD patients was 19.2), q = 100 – p = 80.8, d = Absolute precision-10%, Confidence Interval – 95% and n=100.

GFR was calculated using the Cockroft-Gault equation

Study Design

Descriptive, cross sectional study.

Study population

Patients admitted to medical wards in MCH

Inclusion criteria

CKD patients of GFR<60 ml/min/1.73m2 to be included in the study.

Exclusion criteria

1. Patients with diagnosed peripheral occlusive vascular disease.
2. Patients who had undergone renal transplantation.

The ABI was calculated with Doppler ultrasound as the ratio of the highest systolic BP (SBP) measured at the posterior tibial and dorsalis pedis arteries to the highest SBP of the brachial arteries. The mean of the two ABI measurements obtained is to be used for the study. Patients to be categorized as those with ABI <=0.9 and those above 0.9 and analyze CKD stage severity. Demographic data, including age, gender, diabetes mellitus status, hypertension status, and use of prescribed antihypertensive agents, to be obtained from the patients' medical records. A patient would be considered to have hypertension if the systemic blood pressure is more than 140mmHg or diastolic blood pressure is more than 90mmHg or if the patient is currently using antihypertensive agents. A patient is considered to have diabetes mellitus if the fasting blood sugar is more than 126mg/dl or if the patient is using oral antidiabetic agents or insulin. Systemic blood pressure and diastolic blood pressure to be recorded during the same visit when ABI is measured. Laboratory data, including levels of serum albumin, cholesterol, uric acid, calcium, phosphate, hemoglobin, urine PC ratio collected from using proforma.

Analysis

Data was analyzed using IBM SPSS 20 software. For analysis, chi-square test was used for categorical variables, and an independent *t*-test used for continuous variables. Multivariate forward logistic regression analysis was applied to identify the independent determinant factors of low ABI.

OBSERVATIONS AND RESULTS

Table 1: Study Population characteristics.

	N	Minimum	Maximum	Mean	sd
Age	100	17.0	78.0	57.3	9.5
Weight	100	50.0	82.0	66.8	7.1
SBP	100	128.0	170.0	146.0	9.6
DBP	100	68.0	100.0	85.2	6.4
ABI	100	0.6	1.1	0.9	0.1
Ca	100	6.8	8.3	7.7	0.4
P	100	4.6	9.8	6.3	1.4
Uric acid	100	3.0	11.0	6.9	1.9
Hb	100	6.0	9.9	8.2	0.8
Albumin	100	2.8	3.9	3.3	0.3
UPC Ratio	100	0.2	2.5	0.9	0.5
Urea	100	49.0	102.0	74.2	13.8
Craetinine	100	2.0	6.1	3.3	1.1
eGFR	100	9.2	45.7	25.8	8.6

Table 1 and figure 1 show the general characteristics of the study population.

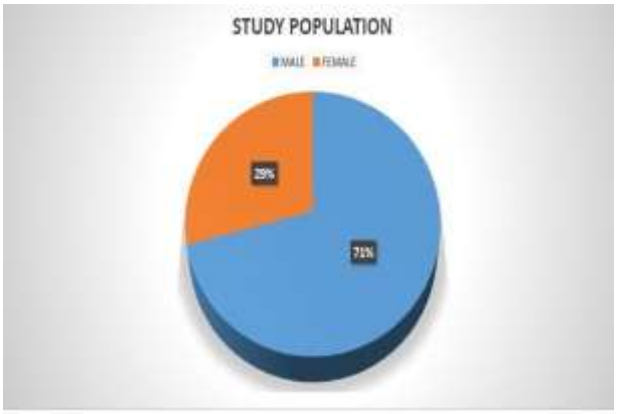

Figure 1: Gender distribution of study population.

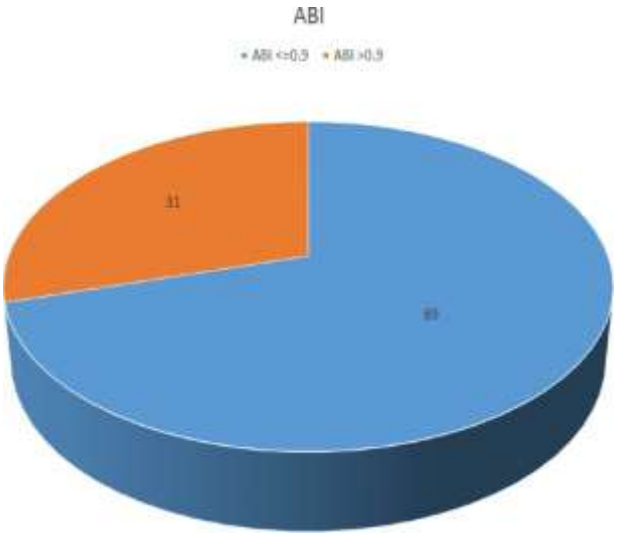

Figure 2: Characterisation of ABI in study population.

Ankle brachial pressure index was <= 0.9 in 69% of the patients 31 % had ABI > 0.9.

Table 2: Gender distribution and ABI.

Gender	ABI				Total	
	≤0.9		>0.9			
	N	%	N	%	N	%
Male	48	67.6	23	32.4	71	100.0
Female	21	72.4	8	27.6	29	100.0
Total	69	69.0	31	31.0	100	100.0

χ^2= 0.223 df=1 p=0.637

Table 2 depicts that 67.6% of male patients (48/71) and 72.4 % of female patients (21/29) in the study had an ABI of <= 0.9 but the gender difference had no significant association with ABI.

Table 3: Association of ABI and Diabetes mellitus.

DM	ABI				Total	
	≤0.9		>0.9			
	N	%	N	%	N	%
Present	49	65.3	26	34.7	75	100.0
Absent	20	80.0	5	20.0	25	100.0
Total	69	69.0	31	31.0	100	100.0

χ^2= 1.886 df=1 p=0.170

Table 3 depicts 65.3% of diabetic patients (49/75) and 80% of non-diabetic patients (20/25) had an ABI of <= 0.9 and the association was not statistically significant indicating that low ABI in patients poorly correlated with the diabetic status in my study population.

Table 4: Association of ABI and Hypertension.

HTN	ABI				Total	
	≤0.9		>0.9			
	N	%	N	%	N	%
Present	65	79.3	17	20.7	82	100.0
Absent	4	22.2	14	77.8	18	100.0
Total	69	69.0	31	31.0	100	100.0

χ^2= 22.456 df=1 p<0.001

Presence of hypertension was significantly associated with a low ABI of <= 0.9 with significant p value (<0.001).82 % of the study group had hypertension. ABI was low in a significant 79.3 % of all the hypertensives.

Table 5- ABI and stages of CKD severity

Stage of CKD	ABI				Total	
	≤0.9		>0.9			
	N	%	N	%	N	%
Grade 3	8	23.5	26	76.5	34	100.0
Grade 4	51	91.1	5	8.9	56	100.0
Grade 5	10	100.0	0	0.0	10	100.0
Total	69	69.0	31	31.0	100	100.0

χ^2= 50.111 df=2 p<0.001

When ABI is assessed across CKD stage severity it is seen that 69 % of the whole study group had an ABI of <= 0.9 with all those who were in Stage 5 CKD (100%) and 91.1% of people in Stage 4 CKD and only 23.5% of people in stage 3 CKD. ABI was significantly associated with CKD stage severity and a low ABI highly correlated with advanced CKD stages. (p value <0.001)

Table 6: Association of ABI with other parameters.

S. No	Variable	Value	ABI		t	p value
			≤0.9	>0.9		
1	Hemoglobin	N	69	31	-1.884	.063
		Mean	8.1	8.5		
		SD	0.9	0.3		
2	Serum Calcium	N	69	31	4.031	<0.001
		Mean	7.6	7.9		
		SD	0.4	0.3		
3	Serum Phosphorous	N	69	31	3.427	.001
		Mean	6.5	5.6		
		SD	1.5	0.7		
4	Serum Uric acid	N	69	31	5.629	<0.001
		Mean	7.5	5.5		
		SD	1.8	.12		
5	Serum Albumin	N	69	31	-3.797	<0.001
		Mean	3.2	3.4		
		SD	0.3	0.3		
6	Urine PC ratio	N	69	31	2.424	.017
		Mean	1	0.7		
		SD	0.6	0.5		
7	Serum urea	N	69	31	7.175	<0.001
		Mean	79.6	62.1		
		SD	11.4	10.8		
8	Serum creatinine	N	69	31	6.891	<0.001
		Mean	3.7	2.4		
		SD	1	0.3		
9	GFR	N	69	31	-9.146	<0.001
		Mean	21.9	34.4		
		SD	6.6	5.6		
10	Serum Cholesterol	N	69	31	2.331	.022
		Mean	196.12	175.77		
		SD	45.216	26.24		

Mean calcium was 7.6mg /dl in patients of ABI <= 0.9 and 7.9 mg/dl in those with ABI>0.9 and calcium levels had significant correlation with low ABI. Hyperphosphatemia was present in almost all of the patients with a mean of 6.6 mg/dl in patients with ABI <= 0.9 an 5.6 mg/dl on the other group. Significant p value of 0.001 was obtained in patients of ABI <= 0.9 with a mean uric acid level of 7.5 mg/dl and 5.5 mg /dl in the patients with no PAD. (ABI > 0.9). PAD patients with ABI of <= 0.9 had a mean Hemoglobin of 8.1 gm/dl while 8.5gm/dl in normal subjects. Anemia and ABI poorly correlated in my study. Hypoalbuminemia with a mean of 3.2 gm /dl was observed in patients of ABI<= 0.9. Mean Urine PC ratio was 1.0 in patients of ABI <= 0.9 and 0.7 in those with ABI > 0.9 which had statistically significant association with a p value of 0.017. ABI and Urea levels statistically correlated significantly with a p value of < 0.001 when 79.6mg% was the mean urea levels in patients with ABI <=0.9 and 62.1mg% in those with ABI >0.9. Mean creatinine was 3.7mg /dl in patients of ABI <= 0.9 and 2.4 mg/dl in those with ABI>0.9 and high creatinine levels had significant correlation with low ABI. ABI and GFR (Creatinine clearance) levels statistically correlated significantly with a p value of < 0.001 when 21.9 ml/min per $1.73m^2$ was the mean GFR levels in patients with ABI <=0.9 and 34.4 ml/min per $1.73m^2$ in those with ABI >0.9. Mean total cholesterol was 196.12mg /dl in patients of ABI <= 0.9 and 175.77mg/dl in those with ABI > 0.9 which had statistically significant association with a p value of 0.022

DISCUSSION

In our study it was found that low ABI had a significant association with increasing CKD stage severity and decreasing creatinine clearance. This is in accordance with the study of ***O'Hare et al***. who found that prevalence of PAD as defined by low ABI was significantly higher in CKD population with ABI being low as stage of CKD worsens with rising creatinine levels.[1] ***Feringa et al.*** also demonstrated that every 0.1 decrease in the ABI level was associated with a 1.43-fold increase in the risk of development of ESRD in patients with PAOD.[2] Low ABI was associated with presence of hypertension in patients but diabetes mellitus could not be associated with a low ABI in my study subjects. This is in sharp contrast to one study done by ***Ghimire et al***. where it was found that the prevalence of PAD in patients with CKD (Chronic Kidney Disease) and Type 2 DM is two to four fold greater than that of

normal population and no significant association was observed between HTN and PAD.[3] Among the hypertensive population ABI > 0.9 i.e. normal ABI was seen in 17 out 82 hypertensive only with 12 of them in stage 3 CKD, 5 patients in stage 4 CKD and none in Stage 5 CKD or otherwise 70.5 % of Stage 3 hypertensive CKD had normal ABI while it was only 29.5 % in Stage 4 CKD patients. None of Stage 5 CKD patients with hypertension had normal ABI.

In the diabetic study population 84.6% of Stage 3 CKD patients (22/28) had normal ABI of > 0.9 and only 15.4 % in Stage 4 CKD (4/37) had normal ABI. There were no diabetic patients with normal ABI in Stage 5 CKD which means that diabetes might have contributed to development of PAD in my CKD patients but was not statistically significant.(p value 0.170). CKD stage severity when assessed in the diabetic study population yielded the following results like – out of 75 total diabetics in the group, 28 had stage 3 CKD while 41 had stage 4 CKD and 6 patients in stage 5.When gender distribution is sought for it was seen that 18 males and 10 females constituted Stage 3 CKD group, 30 males and 11 females in stage 4 CKD and 4 males and 2 females in Stage 5 CKD.

CKD stage severity in the hypertensive study population was like – out of 82 total hypertensive patients in the group, 18 had stage 3 CKD while 56 had stage 4 CKD and 8 patients in stage 5.When gender distribution was analyzed, 12 males and 6 females constituted Stage 3 CKD group, 43 males and 13 females were in stage 4 CKD and 4 males and 4 females in Stage 5 CKD. In patients of ABI <= 0.9 the mean uric acid level was 7.5 mg/dl and 5.5gm /dl in the patients with no PAD. The results were statistically significant (p value <0.001). The result hold good against similar study by ***Zhan Y et al.*** where higher uric acid levels were significantly associated with higher risk of low ABI (P = .0045).[4]

Mean Urine PC ratio was 1.0 in patients of ABI <= 0.9 and 0.7 in those with ABI > 0.9 which had statistically significant association with a p value of 0.017. ***Baber U et al*** and ***Wu CK et al***. in their studies also demonstrated albuminuria independently correlated with low ABI in CKD patients.[5,6]

LIMITATIONS OF THE STUDY

- The sample population may not be a true reflection of the actual population since sample size was 100 patients only and 71 % of them were males and rest females.
- The etiology of CKD as well as duration of the diagnosis of CKD was not taken into account which could have affected the ABI and renal function test results.
- With advanced stages of CKD it is usual that vascular calcification occur which renders the arteries nearly incompressible leading to ABI values of more than 1.3.Hence ABI may not be effectively relied upon such subjects for PAD screening.
- The study did not try to differentiate the subjects into those who were on maintenance hemodialysis and those who were not. This could have affected the study parameters

CONCLUSIONS

Thus to conclude, our study found significant association between a low ABI and increasing CKD stage severity and it was independently a risk factor for progression into ESRD after multivariate analysis. Low ABI was associated with hypertension but not diabetes mellitus in my study which is in sharp contrast to many studies currently available. A low ABI could independently reflect the state of renal function in CKD patients as evidenced from significant statistical correlation among other renal function parameters like blood levels of urea, creatinine, uric acid, and calcium, phosphorous and low albumin and also with urine PC ratio.

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