

Title: Association of Ankle Brachial Index (ABI) with Hemodynamic parameters among patients undergoing various Cardiovascular Surgeries in South India

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Introduction

Peripheral artery disease (PAD) is a common clinical manifestation associated with patients having cardiovascular diseases. A significant correlation of PAD with altered coronary anatomy has already been established. The risk of PAD development increases in patients undergoing cardiovascular surgeries owing to altered vasculature and systemic perfusion. Ankle Brachial Index (ABI) is a non-invasive inexpensive clinical tool for screening PAD in the extremities. However its association with hemodynamic parameters among Asian Indians undergoing cardiovascular surgeries is understudied. Our study explores around ABI interpretation & its hemodynamic correlation.

Methods/Materials

It is a **cross-sectional analytical study**. We recruited **375** adult patients with cardiovascular complaints requiring surgical correction. The resting Blood pressure was measured on all the four limbs using a clinically authenticated digital BP monitor (OMRON™ Blood Pressure Monitor HEM-7121J) and handheld Doppler device (EMCO D580 Handheld Vascular Doppler) to calculate ABI (normal ranging between **0.9** to **1.4**).

Inclusion Criteria:

Adults (age ≥ 18 years) presented with Cardiovascular complications to CTVS Out-Patient Department (OPD) or admitted to In-Patient department (IPD)

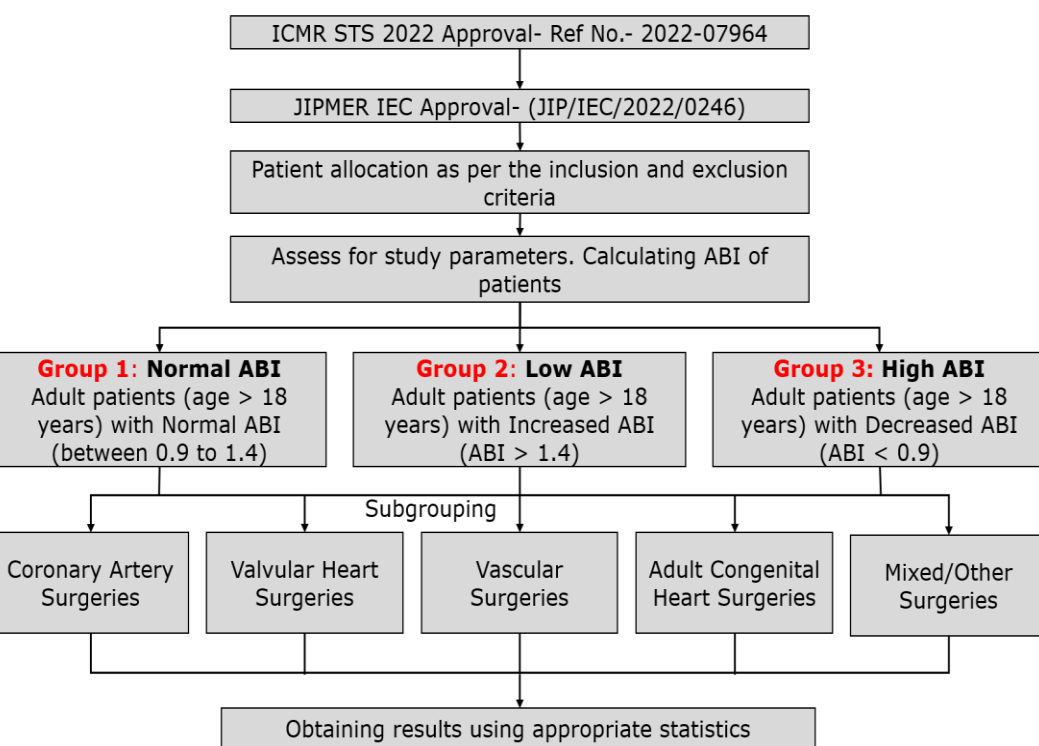
Exclusion Criteria:

Paediatric patients (age < 18 years)
Acutely symptomatic patients

ABI Calculation

Systolic BP of ankle on either sides (seperately)
Highest among the systolic BP in the arms

Statistical Analysis using **IBM SPSS 22.0**



Demonstration of recording ABI in patients



Results

Table 1: Comparison of hemodynamic parameters among patients with normal and abnormal ABI

Parameters	Patients with Normal ABI (0.9 ≤ ABI ≤ 1.4) (n=277)	Patients with Abnormal ABI (ABI < 0.9 and ABI > 1.4) (n=98)	p-Value
Normally Distributed Data			
MAP Ankle (Right)	91.58 ± 11.89	83.54 ± 17.92	<0.001***
MAP Ankle (Left)	93.00 ± 12.35	86.29 ± 15.81	<0.001***
Mean Heart Rate	73.71 ± 13.65	75.32 ± 13.77	0.316
Non-normally Distributed Data			
AGE (Years)	49 (40, 59)	50 (42.75, 55)	0.966
MAP Arm (Right)	91 (84, 98.33)	92.83 (87.42, 105.33)	0.023*
MAP Arm (Left)	92 (86.5, 100)	95.83 (88.58, 104.67)	0.020*
PP Arm (Right)	46 (38, 57)	47.5 (38, 61)	0.374
PP Arm (Left)	45 (37, 56)	47.5 (38, 59.25)	0.165
PP Ankle (Right)	58 (46.5, 68.5)	40 (26.75, 49.75)	<0.001***
PP Ankle (Left)	55 (45, 67)	37 (26.75, 50.5)	<0.001***
RPP	9.10 (7.62, 10.75)	9.46 (8.17, 12.04)	0.053
ABI-Right	1.02 (0.96, 1.09)	0.81 (0.75, 0.88)	<0.001***
ABI-Left	1.02 (0.97, 1.09)	0.82 (0.78, 0.86)	<0.001***

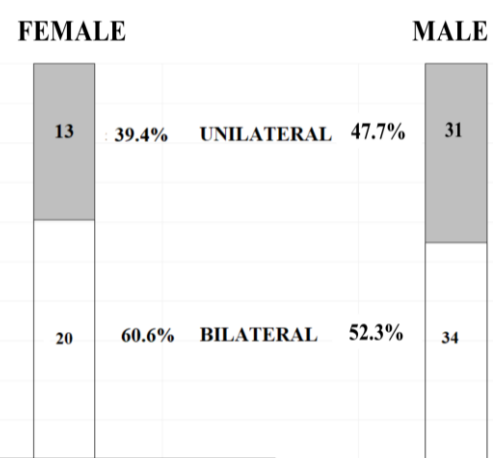


Fig 2 a & b: Distribution and laterality of ABI

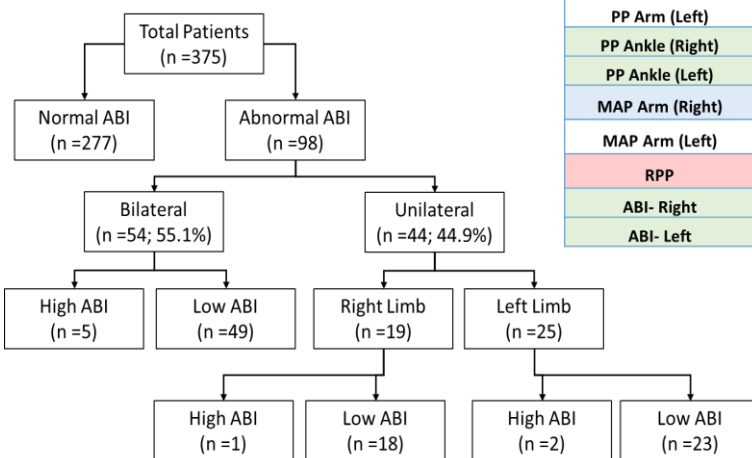


Table 3: Correlation of hemodynamic parameters with ABI

Parameters	Correlation Coefficient	Significance	95% Confidence Intervals	
			Lower	Upper
AGE (Years)	0.091	0.077	-0.013	0.194
MAP Arm (Right)	-0.241	<0.001***	-0.337	-0.141
MAP Arm (Left)	-0.246	<0.001***	-0.342	-0.146
MAP Ankle (Right)	0.415	<0.001***	0.325	0.498
MAP Ankle (Left)	0.384	<0.001***	0.291	0.469
PP Arm (Right)	-0.170	0.001**	-0.269	-0.067
PP Arm (Left)	-0.156	0.002**	-0.256	-0.052
PP Ankle (Right)	0.553	<0.001***	0.476	0.621
PP Ankle (Left)	0.554	<0.001***	0.477	0.622
Mean Heart Rate	-0.066	0.199	-0.170	0.038
RPP	-0.203	<0.001***	-0.301	-0.101

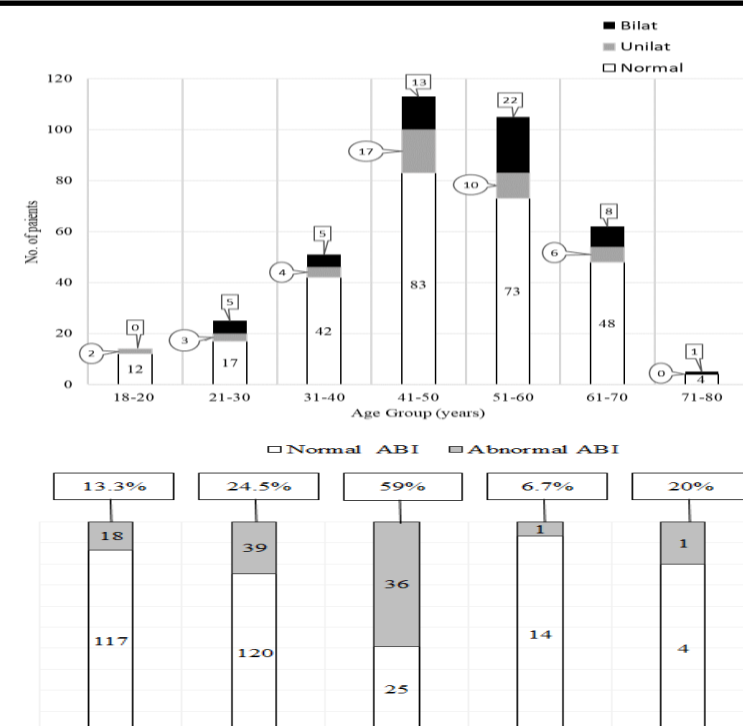


Fig 1 a & b: Pattern of abnormal ABI trends over the different age groups and among different patient surgical groups

Table 2: Comparison of hemodynamic parameters among different surgical groups

Parameters	CAD Cases	VHD Cases	Vascular Cases	Others	p-value
Normally Distributed Data					
Age (Years)	57.21 ± 8.38	42.07 ± 12.68	49.48 ± 11.82	41.15 ± 11.01	<0.001
SBP- Ankle (Right)	133.96 ± 20.51	121.89 ± 21.85	117.57 ± 29.12	122.00 ± 18.34	<0.001
SBP- Ankle (Left)	134.70 ± 21.63	120.97 ± 22.45	120.36 ± 24.82	122.45 ± 15.96	<0.001
MAP Ankle (Right)	92.73 ± 13.19	87.73 ± 12.67	87.72 ± 18.83	86.83 ± 11.85	0.01
MAP Ankle (Left)	94.60 ± 13.33	88.55 ± 13.19	91.02 ± 15.28	90.78 ± 9.13	0.002
Mean Heart Rate	72.86 ± 12.92	74.23 ± 13.48	75.95 ± 15.35	76.34 ± 15.05	0.429
Non-normally Distributed Data					
SBP- Arm (Right)	125 (116, 140)	122 (107, 132)	126 (117.5, 138.5)	118 (110.5, 133.25)	0.02
SBP- Arm (Left)	127 (117, 139)	120 (110, 131)	129 (119.5, 143.5)	117 (112.25, 132)	<0.001
PP Arm (Right)	50 (41, 60)	44 (36, 56)	48 (39, 58)	39 (34, 53.25)	0.006
PP Arm (Left)	48 (40, 58)	42 (34, 54)	48 (39.5, 59)	41 (37, 54)	0.002
PP Ankle (Right)	63 (50, 74)	49 (36, 60)	46 (27, 56)	54 (38.25, 67)	<0.001
PP Ankle (Left)	61 (49, 72)	46 (34, 58)	46 (29.5, 58.5)	49 (33, 61.75)	<0.001
MAP Arm (Right)	92 (84.67, 101.67)	89.67 (82.67, 96.33)	96 (88.5, 103.83)	90.5 (84.08, 98.33)	0.009
MAP Arm (Left)	94 (87.67, 104.67)	90.67 (84.67, 99)	97.3 (90.67, 104.33)	90.67 (85.42, 98.42)	<0.001
RPP	9.06 (8.06, 10.85)	9.08 (7.38, 10.74)	9.72 (8.50, 11.64)	8.79 (8.03, 11.18)	0.106
ABI-Right	1.03 (0.95, 1.11)	0.98 (0.90, 1.06)	0.89 (0.74, 1.04)	1.01 (0.94, 1.09)	<0.001
ABI-Left	1.04 (0.95, 1.11)	0.97 (0.88, 1.05)	0.92 (0.79, 1.03)	0.99 (0.94, 1.07)	<0.001

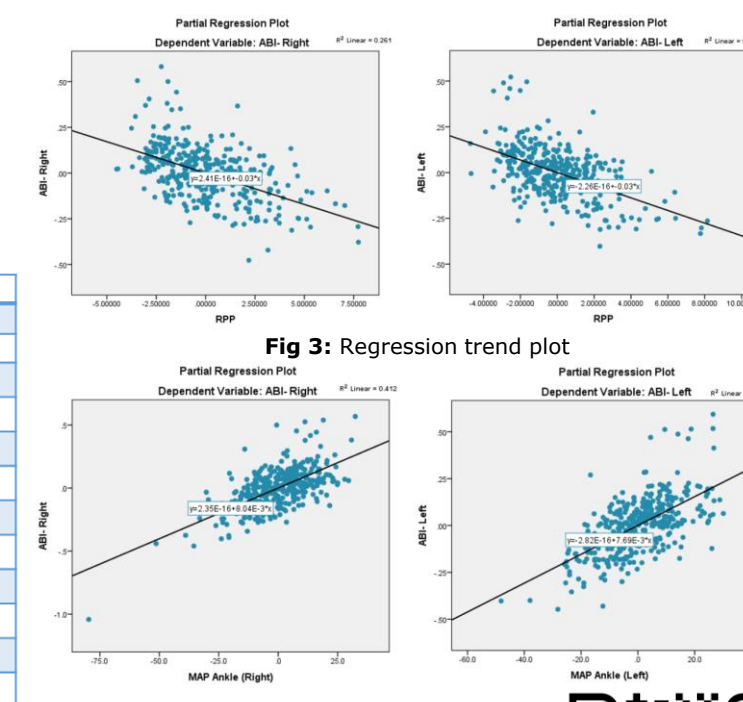


Fig 3: Regression trend plot

$$\text{ABI}_{\text{Right}} = 0.593 + 0.008 (\text{MAP})_{\text{Right}} - 0.034 (\text{RPP})$$

$$\text{ABI}_{\text{Left}} = 0.614 + 0.008 (\text{MAP})_{\text{Left}} - 0.035 (\text{RPP})$$

Accuracy: **81.9%**



Discussion

The risk of cardiovascular disease increases with the progression of age, maximum between the age of **40-60 years**. Asymptomatic PAD has been found more commonly associated with established **major arterial disease, valvular heart diseases, and coronary artery diseases**.

An interesting finding is that in the patients with unilateral abnormal ABI recordings, the **left limb (56.1%)** was found to be **more affected** than the **right limb (43.9%)**. Abnormal **unilateral** ABI presentation is more common in males (**47.7%**) and **bilateral** ABI presentation more common in females (**60.6%**). (**Overall: Bilateral > Unilateral**)

A **positive correlation** of ABI with **ankle Mean Arterial Pressure (MAP)** and **Pulse Pressure (PP)**, and a **negative correlation** with **arm MAP, PP, and Rate Pressure Product (RPP)**. ABI was significantly affected by gender and comorbidities like diabetes, hypertension etc. among the various surgical groups. **Multivariate linear regression analysis** of ABI with the hemodynamic parameters proved that **MAP, PP and RPP** were significantly associated with ABI.

Conclusion

Asymptomatic peripheral vascular changes are common in CVD patients. We observed **ABI** to be associated with **indicators of organ perfusion and myocardial oxygen consumption (MAP and RPP)**. **Perioperative ABI can be deduced from the equation derived utilizing MAP and RPP, in a cardiovascular surgical setting.** ABI monitoring should be considered in all patients undergoing cardiovascular operations to ensure better perioperative outcomes.