

1 **ULTRASOUND MEASUREMENT OF THE ABDOMINAL AORTIC DIAMETER IN**
2 **A NORMOTENSIVE AND HYPERTENSIVE ADULT NIGERIAN POPULATION IN**
3 **ENUGU**

4

5 **ABSTRACT**

6 **Background:** Hypertension has direct effect on abdominal aortic diameter, some of which
7 include aneurysm and aortic dissection. Ultrasound measurement of the abdominal aortic
8 diameter (AAD) in hypertensives and normotensives will help to establish the severity of this
9 effect among Nigerians.

10 **Aims-** To compare the AAD in adult normotensive and hypertensive subjects and correlate it
11 with age, sex and blood pressure.

12 **Materials and methods:** Participants will be randomly selected from hypertensives attending
13 Cardiology Clinic, in University of Nigeria teaching hospital (UNTH) Enugu, Nigeria.
14 Controls will be apparently healthy normotensive volunteers. Participant's age, gender,
15 weight, height and blood pressure will be documented. Ultrasound measurements of
16 infrarenal AAD will be taken at 2 cm below the origin of the superior mesenteric artery and
17 data analyzed. A p-value of ≤ 0.05 will be considered significant.

18 **Results:** 300 subjects: 150 normotensives and 150 hypertensives were studied. The mean
19 values for AAD in normotensive males and females were 16.66 ± 2.04 mm and 15.36 ± 1.97
20 mm respectively while for the hypertensives, they were 18.89 ± 2.64 mm and 16.57 ± 2.54
21 mm respectively. Abdominal aortic diameter was significantly larger in hypertensives than in
22 the normotensives ($p < 0.001$). The AAD showed a positive correlation with systolic blood
23 pressure ($r^2 = 0.317$, $P \leq 0.001$) but not with diastolic blood pressure.

24 **Conclusion:** Abdominal aortic diameter was significantly larger in the hypertensives than in
25 normotensives. It increased with age in both the normotensive and the hypertensive subjects.

26 **Key words:** Hypertensives, normotensives, abdominal aortic diameter, ultrasound.

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28 **INTRODUCTION**

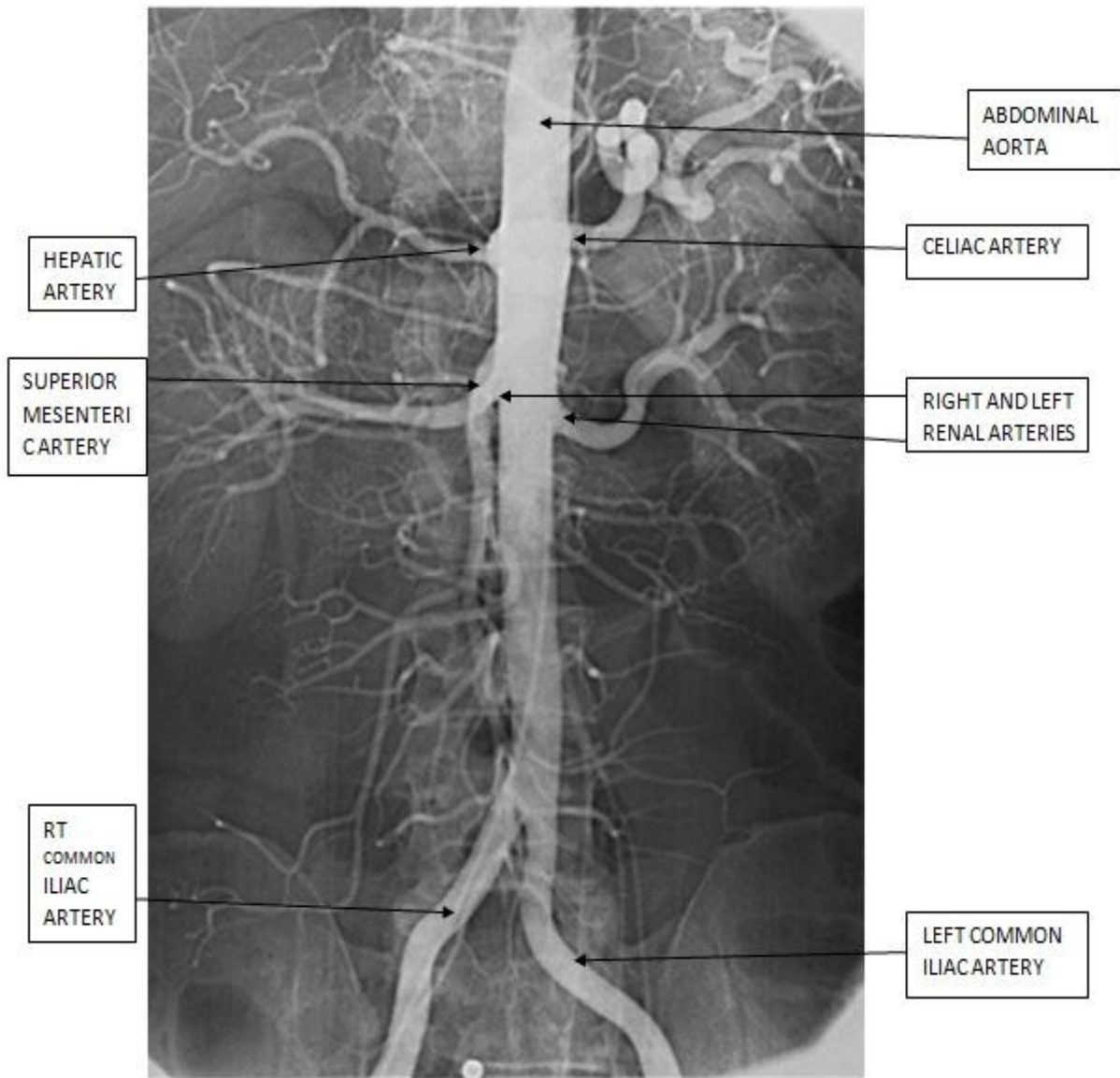
29 The normal cross-sectional luminal diameter of adult abdominal aorta varies from about 3 cm
30 proximally to about 1 cm at the bifurcation.¹ A mild increase in these values is regarded as

31 aortic ectasia, whereas it is aneurismal when the diameter is above 3 cm below the renal
32 arteries.²

33 The primary structural elements of the aortic tunica media are elastin and collagen.³ These
34 are the major components affecting the hemodynamic events.³ The phenomenon of injuries
35 and repairs in the media of a normal abdominal aorta seen on histology is a consequence of
36 these hemodynamic events.⁴ These changes are more pronounced in the abdominal aorta than
37 in other arteries.³ Hypertension increases this haemodynamic load on the aorta by increasing
38 the mechanical stress of billions of cyclic contractions and expansions of the heart cycle. The
39 result is increased fragmentation of elastin and consequent aortic ectasia. Hence, in
40 hypertension the aorta tend to dilate to accommodate the increased fluid volume.^{3,5}
41 Consequently, increased blood pressure is commonly cited as a risk factor for abdominal
42 aortic aneurysms.^{3,6-9} The definition of hypertension is systolic blood pressure of 140 mmHg
43 and above or diastolic blood pressure of 90 mmHg and above or both.

44 The choice of ultrasonography in this study is favored by its low cost, high accuracy, non-
45 invasive nature and Doppler potentials, as well as its good correlation with computed
46 tomography (CT).² Ninety to ninety five percent of abdominal aortic aneurysms are known
47 to occur at infrarenal aorta; therefore this study is restricted to infrarenal AAD in adult
48 normotensive and hypertensive subjects.²

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51 **Fig. 1 Conventional aortic arteriogram showing the abdominal aorta, the superior**
 52 **mesenteric artery (SMA), and its major branches.¹⁰**

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59 **Aims and objectives**

- 60
- To compare the infrarenal AAD in normotensives and hypertensives.

- 61 • To correlate AAD in normotensives and hypertensives with diastolic and systolic
62 blood pressures.

63 **Materials And Methods**

64 Hypertensive participants in this study will be selected from the patients attending
65 Cardiololgy Clinic at UNTH Enugu, while the controls (normotensives) will be selected from
66 patients' relations and hospital staff. Male and female hypertensive and normotensive
67 participants of various ages will be selected by simple random sampling. The data will be
68 collected over a period of six months.. A total of about three hundred (300) participants will
69 be expected to participate in this study. Their weights and heights will be measured on
70 ELGIL Height/Weight scale in light clothing and without shoes.

71 The blood pressure of each subject will be measured thrice in a sitting position using
72 Accusson's mercury sphygmomanometer after five minutes interval of rest. The mean of the
73 three sitting blood pressure measurements will be recorded. The duration of hypertension
74 and how long the patient had been on antihypertensive medications will be recorded. No
75 laboratory investigation will be conducted.

76 **Scanning Technique**

77 Each subject will be examined using 3.5MHz curvilinear probe on a Hitachi EUB-525
78 Doppler Ultrasound machine by the researchers. The transducer will be placed on the
79 epigastrium and moved longitudinally to visualize the full length of abdominal aorta.

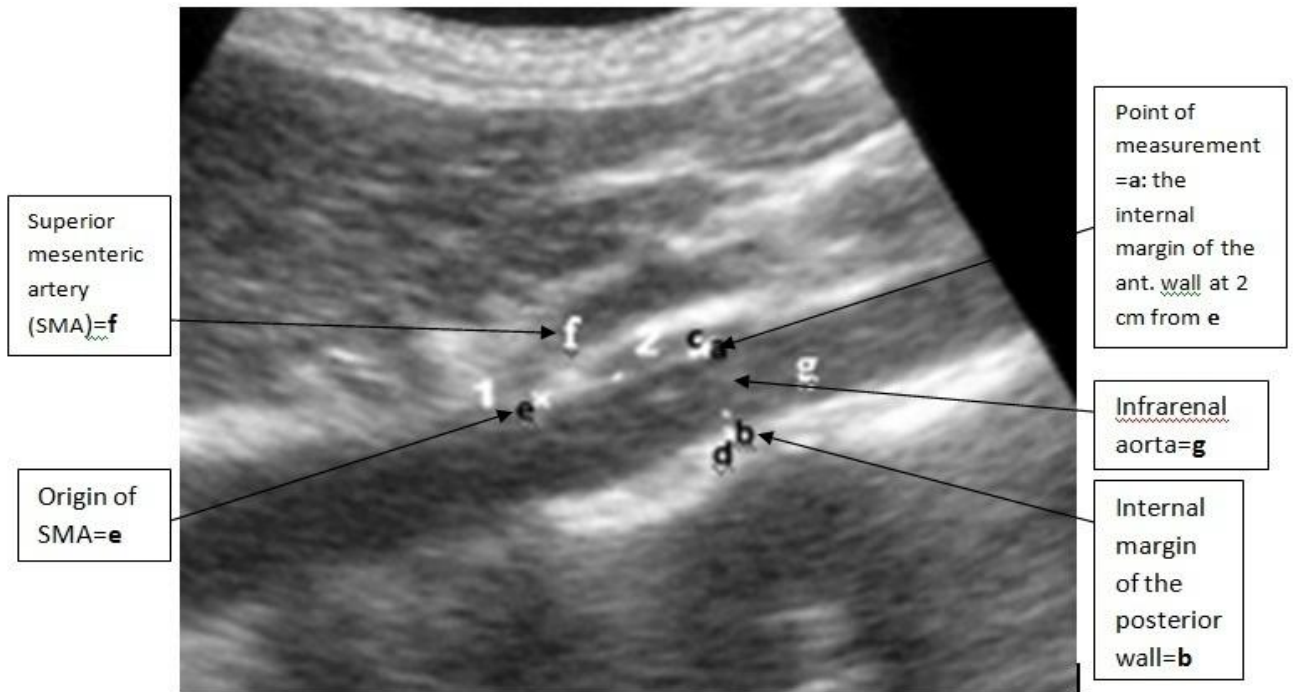
80 The superior mesenteric artery will be identified and traced to its origin from the aorta on the
81 longitudinal view, Figure 2. The image with the widest diameter in the longitudinal plane will
82 be frozen in systole and the play back function will be used to identify the best view.

83 The inner to inner technique of measurement used by Huseyin et al.¹³ will be adopted for this
84 study. The anteroposterior (AP) diameter will be measured from the inner margin of the
85 anterior aortic wall to the inner margin of the posterior aortic wall (ITI).

86 The site of measurement will be at 2 cm below the origin of the SMA, on the static
87 longitudinal image using electronic calipers, Figures 2 and 3. This allows correct
88 measurement and placement of the calipers perpendicular to the long axis of the vessel.¹⁷

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92 **Fig. 2: 2D grayscale ultrasound longitudinal image of the abdominal aorta showing the**
 93 **pattern of measurement. a = point of measurement of AAD (inner margin of the**
 94 **anterior wall), b = Inner margin of the posterior wall, c = outer margin of anterior wall,**
 95 **d = outer margin of posterior wall, e = origin of superior mesenteric artery, f = superior**
 96 **mesenteric artery, g = infrarenal aorta.**

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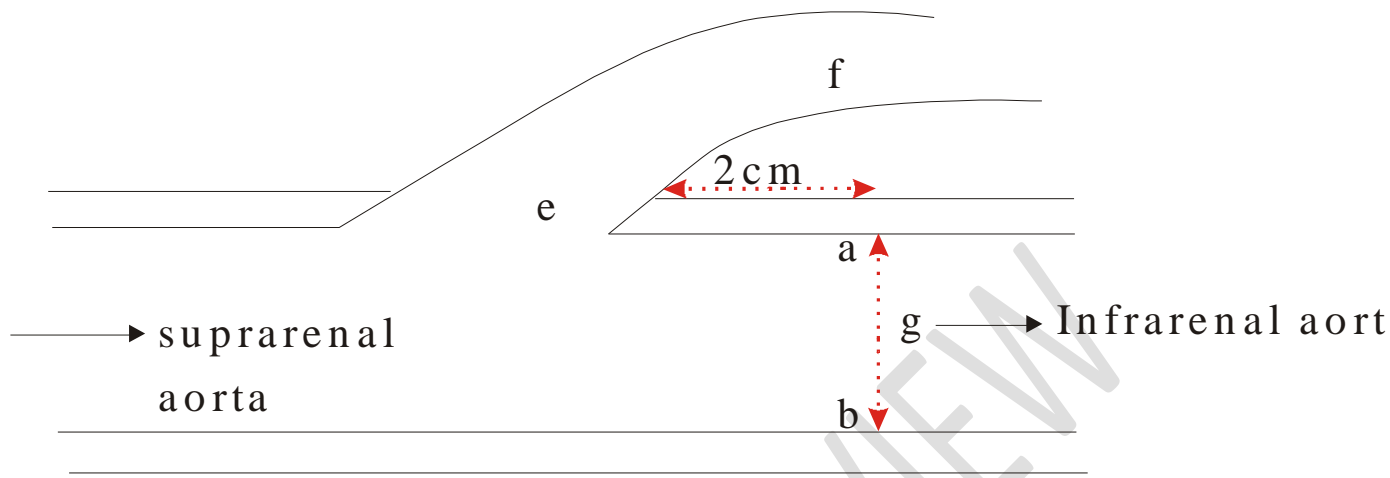


Fig. 3: Line diagram to demonstrate the pattern of measurement of the infrarenal aorta, longitudinal section. a = point of measurement of AAD (inner margin of the anterior wall), b = inner margin of the posterior wall, e = origin of superior mesenteric artery, f = superior mesenteric artery, g = infrarenal aorta

138 **RESULTS**

139 **Demographic Data**

140 **A total of 300 participants were studied. There were 136 (45.3%) males and 164 (54.7%)**
141 **females giving a male to female ratio of 1:1.4.**

142 **Their ages ranged from 20 – 99 years, see Table 1. Figures 4 and 5 demonstrate the**
143 **frequency distribution of diastolic and systolic blood pressures of the participants.**

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Table 1: Demographic Data

Variable		Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
		Normotensive		Hypertensive	
Age(yr)	20-29	12	8.00	8	5.33
	30-39	21	14.00	11	7.33
	40-49	27	18.00	32	21.33
	50-59	38	25.33	38	25.33
	60-69	23	15.33	24	16.00
	70-79	17	11.33	21	14.00
	80-89	10	6.67	12	8.00
	90-99	2	1.33	2	1.33
Sex	Male	66	44.00	70	46.67
	Female	84	56.00	80	53.33

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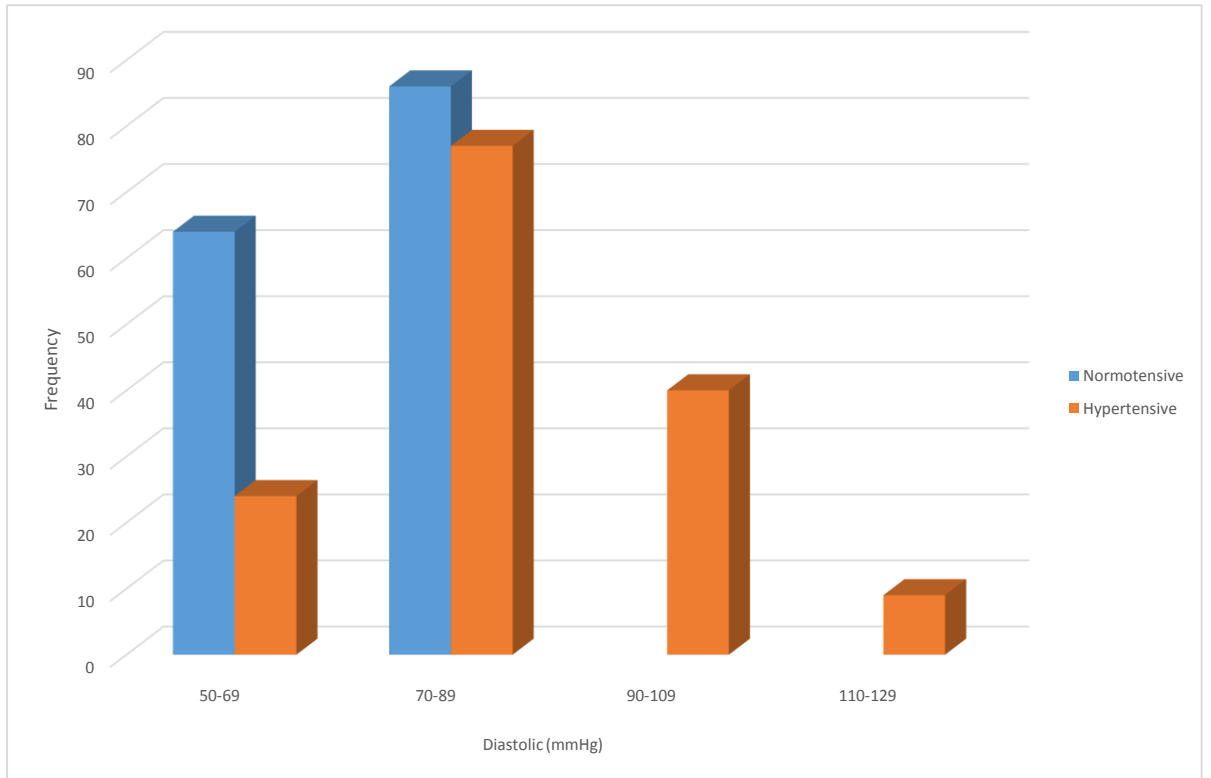


Fig. 4: Frequency distribution of participants by diastolic blood pressure

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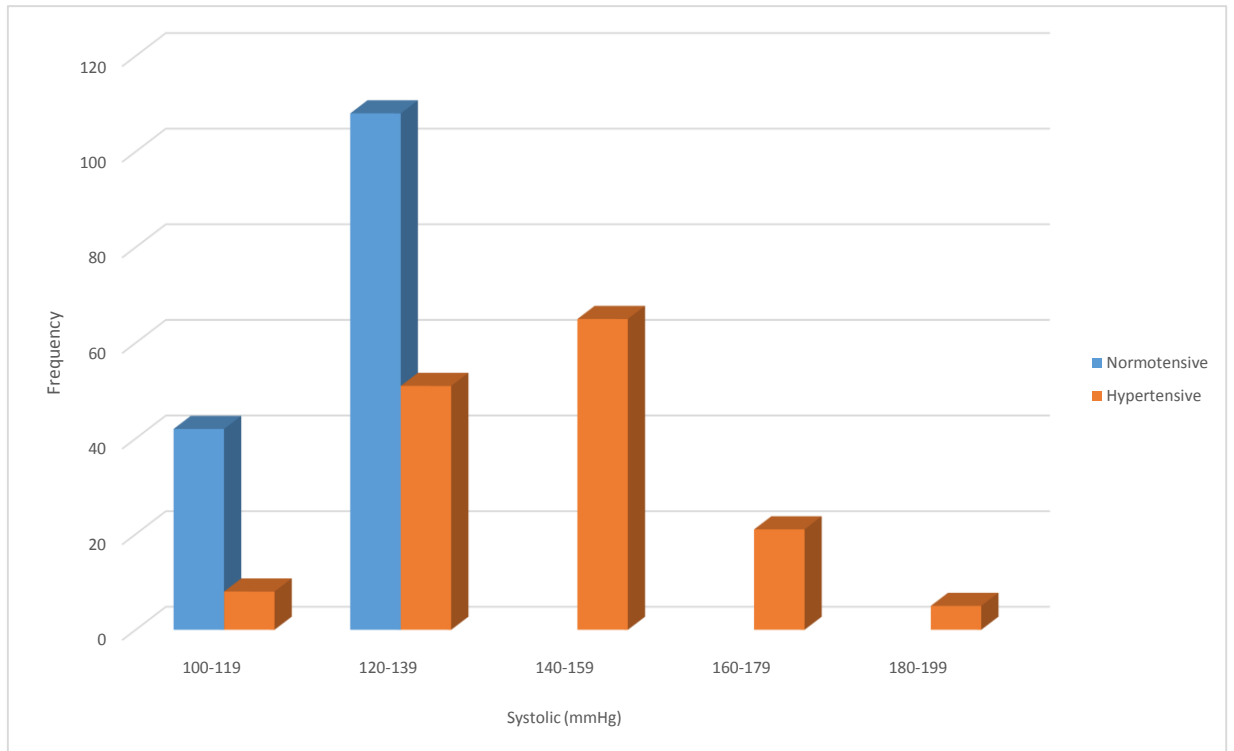


Fig. 5: Frequency distribution of participants by systolic blood pressure

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Infrarenal Aortic Diameter

161 The normotensive group, had a mean AAD of $15.70 \pm 2.0\text{mm}$ while the hypertensive group
 162 had mean AAD of $17.72 \pm 2.8\text{mm}$.

163 The hypertensives had significantly higher AAD than the normotensives, $p < 0.001$, Table 3.

164 In both sexes, hypertensives had higher AAD than the normotensives, $p < 0.001$.

Table 3: The mean AAD in normotensive and hypertensive males and females

Category	Total	Males		Females		Total	
	No	No.	AAD	No.	AAD	P	
Normotensives	150	66	16.66 ± 2.04	84	15.36 ± 1.97	0.001	15.70 ± 2.03
Hypertensives	150	70	18.89 ± 2.64	80	16.57 ± 2.54	0.001	17.72 ± 2.83

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Table 4: Correlation of AAD with SBP and DBP

Normotensives			
	r	r ² (%)	P
SBP	0.317	10	0.000
DBP	0.121	1	0.192
Hypertensives			
SBP	0.195	4	0.032
DBP	0.097	1	0.290

r = 'Pearson's correlation coefficient'. r²(%) = 'coefficient of determination'

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168 The mean values of AAD in both normotensives and hypertensives, at different diastolic and
169 systolic blood pressures, are shown in Figures 6 and 7, while Table 4 shows the correlation.

170 Abdominal aortic diameter increased with SBP but not with DBP.

171 The SBP, unlike DBP had significant positive correlation with AAD as shown in Table 4.

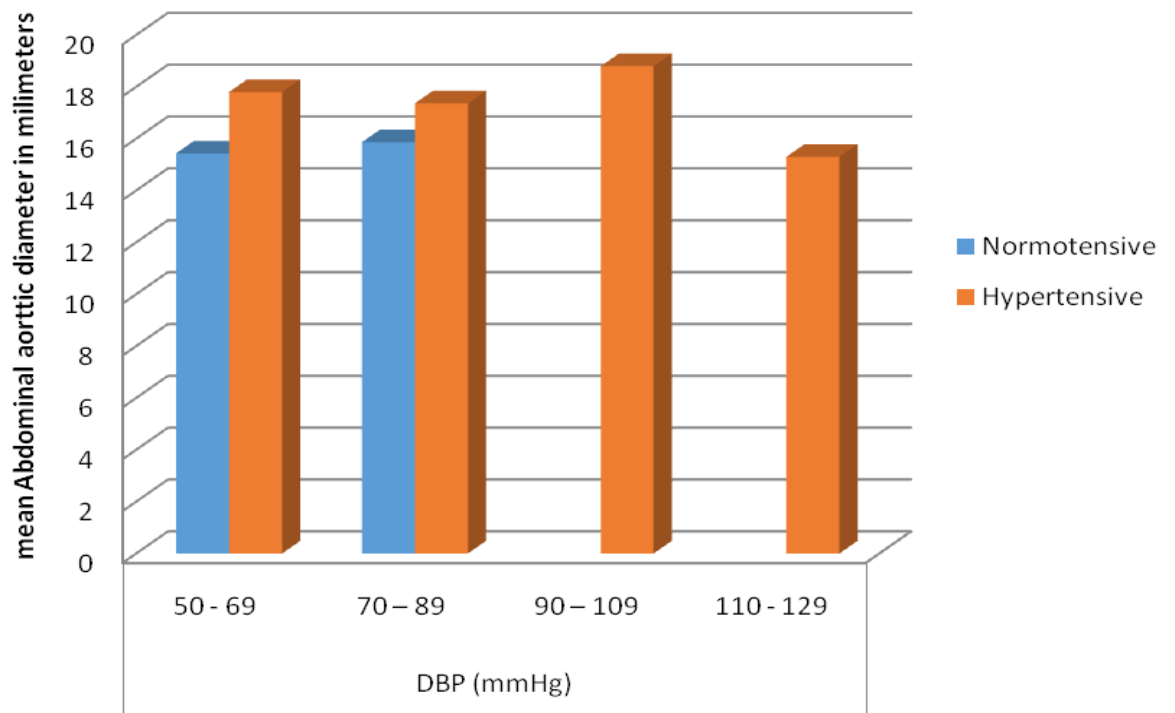


Fig. 6: Abdominal aortic diameter of normotensives and hypertensives by diastolic blood pressure

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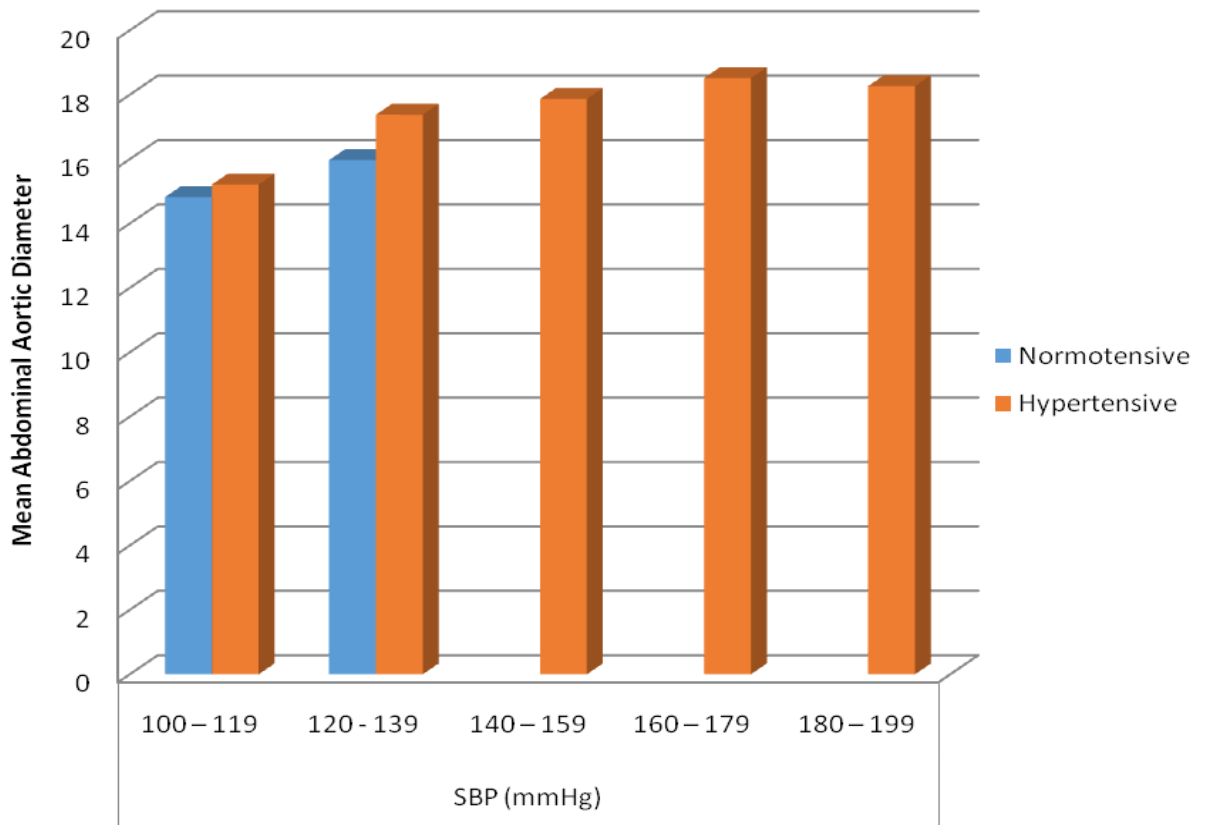


Fig. 7: Abdominal aortic diameter of normotensives and hypertensives by systolic blood pressure

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184 **Discussion**

185 In this study, there is higher female population in both normotensives and hypertensives
186 (See tables 1& 3). This may be because more females were available and willing to

187 participate while their male counterparts required more explanations to be convinced. Most of
188 the uncooperative subjects were males.

189 The hypertensives had higher blood pressures than the normotensives (See figure 5),
190 however; more than 39% of the hypertensives in the index study had normal blood pressure
191 at the time of measurement. The high frequency of normal blood pressure among the
192 hypertensives in this study may be due to good blood pressure control at the cardiology
193 clinic.

194 The median age is higher in normotensives. This may be related to a higher life expectancy in
195 normotensives that have smaller aortic diameter than their hypertensive counterparts. It has
196 been documented that increased AAD in hypertensives is also a marker for death from other
197 cardiovascular causes.¹³

198 The mean values of AAD among the normotensive adult participants in this study, $16.66 \pm$
199 2.04 mm for males and 15.36 ± 1.97 mm for females (See table 3), are consistent with the
200 findings of Udemezue et al.⁶ in Enugu, Nigeria. They reported a mean AAD of 15.7 mm for
201 adult males and 14.9 mm for females. Since Udemezue et al.² conducted their study on the
202 same population, this similarity in values of AAD is expected.

203 In this study, higher AAD in the hypertensives in both sexes (See table 4) is in agreement
204 with many other studies.^{10,14-16} In line with this observation, Strachan¹⁷ showed that increase
205 in diastolic blood pressure was associated with increased risk of abdominal aortic aneurysm.

206 The difference in the mean AAD between the normotensives and hypertensives in this study
207 varies between the sexes: 2.23 mm for males and 1.21mm for females. It is higher in males.
208 This shows that the effect of hypertension on AAD in this study is more pronounced in males
209 than in females which corroborates the findings of Markku et al.¹⁷ The greater effect of
210 hypertension on aortic diameter and the higher prevalence of hypertension in males, indicate
211 greater risk of abdominal aortic aneurysms in males. This may be why abdominal aortic
212 aneurysm is commoner in males than in females.³

213 The inner to inner (ITI) technique was used to measure the infrarenal AAD in this study and
214 the values reported are lower than those reported by Markku et al.¹⁷ and Singh et al.¹⁸ who
215 used the outer to outer (OTO) technique of measurement. This is because the internal and
216 external wall diameter would give discrepancies of up to 5-6mm.¹⁹ The difference in values
217 of AAD between the studies may be due to technique.

218 The Whitehall study by Strachan²⁰ reported a positive correlation of AAD with the diastolic
219 blood pressure (DBP) rather than with the systolic blood pressure in hypertensives. In
220 contrast, this study showed a positive correlation with systolic blood pressure (SBP) and not
221 with diastolic blood pressure (DBP) [See figure 6 & 7]. This corroborates the report of a
222 multivariate analysis by Ryo et al.²¹⁻²³. Correlation of AAD with the SBP and not the DBP is
223 associated with increased shear stress.^{23,24} Although these changes occur with aging, they
224 are accelerated in hypertension.^{23,24,25} A number of other authors had shown that AAD

225 increases with blood pressure, even in non hypertensives.^{6,8,16,20,26,-29} These factors are
226 hypothesis for further studies in our population.

227 The significance of the study includes the establishment that AAD increases with blood
228 pressure especially systolic blood pressure, thus warranting the need of better blood pressure
229 control. Besides, we have established a local normogram of AAD among normotensive and
230 hypertensives as this information appears scanty in our locality.

231 Most of the limitations of this study were based on techniques. For example, failure to
232 acquire high resolution images were due to bowel gas. This was reduced when the
233 participants sips water slowly with a straw, while more pressure was applied to the probe.

234 Another limitation is intra-observer errors which were minimized by recording only the mean
235 of three AAD measurements of the infrarenal aorta, while inter-observer error was eliminated
236 by ensuring that all measurements were taken by the researchers only.

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238 **Conclusion**

239 Abdominal aortic diameter (AAD) is larger in the hypertensives than in the normotensives.
240 The effect of hypertension on AAD is more pronounced in males than in females. There is a
241 positive correlation of AAD with systolic blood pressure in our environment.

242 **Recommendations**

243 It is recommended that all hypertensives above the age of 60 should be screened for occult
244 abdominal aortic aneurysm and the AAD obtained should be compared with age-matched
245 local reference values. Early detection will reduce mortality from ruptured abdominal aortic
246 aneurysm.

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UNDER PEER REVIEW