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TOPOGRAPHY OF AORTIC BIFURCATION IN A BLACK KENYAN POPULATION

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ABSTRACT

Topography of aortic bifurcation is important for gynaecologists, surgeons and radiologists operating in the retroperitoneal area, in order for them to minimize vascular injury. It also influences the occurrence of aortic-iliac atherosclerosis. It shows ethnic variations, but data from African populations are scarce. This study therefore investigated the topography of aortic bifurcation in a black Kenyan population by dissection of 106 cadavers. After removal of abdominal viscera, peritoneum, fibrofatty connective tissue, inferior vena cava was removed to expose the termination of abdominal aorta. Vertebral level, angle and asymmetry of bifurcation were recorded. Data were analysed by SPSS version 17.0 for windows and are presented in tables and bar charts. All aortae terminated by bifurcating into 2 common iliac arteries. The most common level of bifurcation was L4 (73.6%). It bifurcated below L4 in 22.7% of the cases. Mean angle of bifurcation was 55.2^0 (range $23 – 78^0$); 55.6^0 in males and 54.3^0 in females. Mean bifurcation asymmetry was 4.4 (range 0 – 23). Topography of aortic bifurcation in the black Kenyan population varies from conventional descriptions on over 20% of the individuals studied. Surgeons and radiologists must be aware of this to avoid inadvertent vascular injury. Higher bifurcation angles and asymmetry than those reported for Caucasian and Indo Asian populations suggest higher vulnerability to abdominal aortic atherosclerosis. Preoperative evaluation of terminal aorta, and follow up for atherosclerosis are recommended.

INTRODUCTION

Topography of aortic bifurcation is important for interventional radiologists, gynaecologists, vascular, orthopaedic and general surgeons operating in the retroperitoneal area in order to avoid inadvertent vascular injury (Kornreich et al., 1998; Piro et al., 2005; Lakchayapakorn and Siriprakarn, 2008; Khamanarony et al., 2009). It also influences occurrence of atherosclerosis (Friedman et al., 1983; Smebdy 1996; Shakeri et al., 2007). These parameters display age (Voboril et al., 1993, 2001) gender and ethnic variations (Sun et al., 1994; Kornreich et al., 1998; Klepacki et al., 2011) and are important in explaining differences in occurrence of atherosclerosis. The disease is rapidly increasing in African countries. Data on geometric risk factors for the conditions are, however scarce from black African populations. This study, therefore, aimed at describing selected geometric features of the aortic bifurcation in a black Kenyan population.

MATERIALS AND METHODS

This was a cadaveric dissection study on 106 aortae of adult black African Kenyans age range 27 – 81 years; 67 male, 39 females. The abdomen was opened by midline incision. The abdominal viscera were removed and peritoneum, fibrofatty tissue, inferior vena cava and its tributaries dissected away to expose the terminal part of aorta. Vertebrae were counted from the sacral promontory. Cases of lumbarization and sacralization, as well as grossly visible aneurysms and aortosclerosis were excluded from the study. Level of aortic bifurcation was determined by counting vertebrae and recorded to the nearest whole vertebra. Angle of aortic bifurcation as well as asymmetry were measured using a pair of dividers. Data were analysed using statistical programme for social scientists (SPSS) version 17.0 for windows to determine frequencies, means and standard deviations. The data are presented in tables and bar charts.

RESULTS

The aorta terminated by bifurcating into two common iliac arteries in all the cases. There were variations, however, in level, angle, and asymmetry of bifurcations, which showed subtle gender differences.

Level of bifurcation

Most (73.6%) of the cases terminated at L4, 38.7% at the lower and 34.9% at the upper part. In 22.7% cases, bifurcation was below L4. It was above L4 in only 3.8% of cases (Table 1).

Angle of bifurcation

The mean bifurcation angle was (55.2^0) higher in males (55.6^0) than in females (54.3^0) [range $23\text{-}78^0$]. Majority (59.4%) were above 50^0; while 17% were 40^0 and below (Table 2).

Bifurcation asymmetry

The overall mean asymmetry was 4.4^0 (range 0 – 23). Males had a slightly higher value (4.5^0) compared to females (4.2^0). Half (50%) had asymmetry below 5.0. Only 6.6% had asymmetry above 20^0 (Table 3)

Table1: Vertebral level of aortic bifurcation in a Kenyan population

Level of bifurcation	Frequency			Percentage
	Male	Female	Total	
L3/4	02	02	04	3.8
Upper L4	23	14	37	34.9
Lower L4	29	12	41	38.7
L4/5	09	06	15	14.2
L5	04	05	09	08.5
Total	67	39	106	100

Table 2: Angle of aortic bifurcation in a black Kenyan population

Angle range	Frequency			Percentage
	Male	Female	Total	
21 – 30	02	02	04	03.8
31 – 40	09	05	14	13.2
41 – 50	13	12	25	23.6
51 – 60	25	07	32	30.2
61 – 70	14	09	23	21.7
71 - 80	04	04	08	07.5
Total	67	39	106	100

Table 3: Distribution of bifurcation asymmetry

Range	Frequency			Percentage
	Male	Female	Total	
0 – 5	32	21	53	50.0
6 – 10	17	09	26	24.5
11 – 15	08	04	12	11.3
16 – 20	04	04	08	07.5
21 - 25	04	01	05	04.7
	02	00	02	01.9
Total	67	39	106	100

Table 4: Proportion of aortae that terminate at L4 in various populations

Reference	Population	Proportion terminating at L4 (%)
Lakchayaparkorn and Siriprakarn, 2008	Chinese	63
Chithriki et al., 2002	American	67
Khamanarong et al., 2009	Thai	70.1
Lee et al., 2004	Korean	83
Current study	Kenyan	73.6

Table 5: Bifurcation angles reported in literature

Reference	Population	Bifurcation angle (^{0})
Sharp et al., 1982	-	52.0
Walburn et al., 1979	English	51.0
Lee, 1982	Korean	40.8
Bargeron et al., 1986	American	35.0
Shakeri et al., 2007	American	34.6
Lakchayapakorn and Siriprakarn, 2008	Chinese	54.0
Current Study	Kenyan	55.2

DISCUSSION

Observations of the current study reveal wide variation in geometric features of aortic bifurcation. This is concordant with previous reports (Bargeron et al., 1986; Sun et al., 1994). The most notable ones studied are level, angle and asymmetry of bifurcation. These also influence the occurrence of atherosclerosis (Friedman et al., 1983).

Vertebral level of bifurcation

The level of aortic termination is important during surgical interventions in the region. The aorta usually terminates at L4 by bifurcating into 2 common iliac arteries (Standring et al., 2008; Klepacki et al., 2011). Studies on various populations, however, reveal that in a substantial proportion of various populations, level of bifurcation is not at L4 (Table 4).

These figures reveal, wide variations in the proportion of terminations at L4. The differences may be due to age and sex variations in samples studied. Pertinent to this suggestion is the report that the bifurcation shifts caudally with age and also varies with sex (Voboril 1993, 2001). A notable observation of the current study, however, is that in 22.7% of cases, bifurcation occurred below L4. Position of bifurcation below L4 is associated with broader bifurcation angles (Bargeron et al., 1986). This implies that this proportion of the population studied would display wide bifurcation angle and hence be more vulnerable to atherosclerosis.

Bifurcation angle

Bifurcation angle varies widely and is an independent risk factor for aorto iliac atherosclerosis (Bargeron et al., 1986; Shakeri et al., 2007). Observations of the current study reveal a mean bifurcation angle of 55.2^0, which is higher than most of those reported from Caucasian and Indo Asian populations (Table 5).

This suggests that the angle shows wide variations (Bargeron et al., 1986). Since larger angles are associated with atherosclerosis (Shakeri et al., 2007), observations of higher angle suggest that this population is more vulnerable to atherosclerosis than the others. Pertinent to this suggestion are experimental findings that alteration of bifurcation angle predisposes to atherosclerosis probably due to geometry generated haemodynamic alterations that cause abnormal vascular remodeling (Ortiz-Velasquez et al., 2010). Another possible explanation may be the age of the subjects studies, as the mean bifurcation angle varies with age and gender (Shakeri et al., 2007; Klepacki et al., 2011).

Asymmetry of aortic bifurcation

The mean angular asymmetry was 4.5; without a significant gender difference. This is higher than prevailing literature reports of 2.20 and 3.80 (Bergeron et al., 1986; Shakeri et al., 2007). This geometric feature has significant effects on the flow field near the bifurcation (Friedman et al., 1983). In a branch with no concomitant angular asymmetry, the lateral aortic wall farther from the flow divider experiences an inordinately high shear stress whereas the opposing lateral wall has a low wall shear stress, the latter of which is associated with higher atherosclerosis rate (Cheng et al., 2006; Coppola and Caro, 2009). Higher asymmetry observed in the current study implies higher vulnerability to atherosclerosis in the population studied.

In conclusion, topography of aortic bifurcation in the black Kenyan population varies from conventional descriptions in over 20% of the individuals studied. Surgeons and radiologists must be aware of this to avoid inadvertent vascular injury. Higher bifurcation angle and asymmetry than those reported for Caucasian and Indo-Asian populations, suggest higher vulnerability to abdominal aortic atherosclerosis. Preoperative evaluation of terminal aorta, and follow-up for atherosclerosis are recommended.

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