VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 66, No. 3, pp. 181–184
ISSN 0015–5659
www.fm.viamedica.pl

Aortic bifurcation angle as an independent risk factor for aortoiliac occlusive disease

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[Received 2 January 2007; Revised 25 April 2007; Accepted 25 April 2007]

Recently, there has been interest in potential geometric risk factors that might result in or exaggerate atherosclerosis. The aortic bifurcation is a complex anatomical area dividing the high pressure blood of the descending abdominal aorta into the lower limbs and pelvis. The distribution of the bifurcation angle and any asymmetry, its relation with age and its possible contribution to the risk of aortoiliac atherosclerosis are presented here. Statistical analysis was performed by SPSS version 11.0 using, Fisher's exact test, the Pearson and Spearman correlation tests and logistic regression analysis. The p value was set at 0.05. No correlations were found between age, bifurcation angle and angle asymmetry in the Pearson test ($p > 0.05$). Logistic regression analysis revealed that the bifurcation angle, but not its asymmetry, gender or age, was a significant and independent risk factor for aortoiliac atherosclerosis (model $r^2 = 0.662$, $p = 0.027$). With additional study these results may have implications regarding risk factors for aortoiliac atherosclerosis. To our knowledge, this study is the first of its kind to indicate the potential of such an important geometric risk factor for atherosclerosis at the aortic bifurcation.

Key words: aorta, iliac, artery, atherosclerosis

INTRODUCTION

Aortoiliac occlusive disease is one of the most disabling causes of peripheral arterial insufficiency. Atherosclerosis of the abdominal aorta and distal arteries are anatomically divided into three types. Type I involves the infrarenal aorta and common iliac arteries (5–10%), type II extends into the external iliac and occasionally into the common femoral arteries, (35%) and type III, which is also the most common form, involves the femoral, popliteal and tibial arteries as well. It appears that aortoiliac atherosclerosis may be seen more often in individuals with a history of such diseases as diabetes mellitus, hyperlipidaemia or a history of smoking [2, 6]. Varying risk factor profiles have been suggested for atherosclerosis at different sites. In a study patients with aortoiliac disease were more likely to be young, female and smokers compared to those with femoropopliteal atherosclerosis [11]. However, it is said that systemic risk factors for atherosclerosis only explain approximately one half of these cases [3]. The concept of local vascular geometric risk factors for atherosclerosis has been proposed [4]. For example, a larger carotid sinus [5], a larger common carotid artery bifurcation angle [7], left lateral orientation of the abdominal aorta [8, 9], femoral artery curvature [9] and coronary artery planarity have all been suggested as possible local geometric risk factors for atherosclerosis.

The objective of this study was to assess how geometric features at the aortoiliac bifurcation (bifurcation angle and asymmetry) may affect the

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predisposition for aortoiliac occlusive disease. The recognition of risk factors for atherosclerosis at different vascular beds may aid the clinician in taking prophylactic measures in these patients in order to prevent arterial compromise.

MATERIAL AND METHODS

A total of 59 patients aged over 40 years who had undergone angiography were evaluated. All patients were catheterised via the femoral arteries to visualise the abdominal aorta, iliac arteries and their branches in an anteroposterior view. The causes of angiography were either lower limb ischaemia or pre-transplantation assessment of the renal vasculature, presumed intra-abdominal vascular pathologies such as renal artery stenosis, gastrointestinal bleeding, and hepatic and coeliac artery diseases. Some patients in the control group suffered from lower limb ischaemia due to atherosclerosis and arterial occlusion distal to the aortic bifurcation.

Age, abdominal aortic bifurcation angle and asymmetry, as well as the presence or absence of aortoiliac occlusive disease, were recorded for all patients. The axis of the terminal aorta and proximal common iliac arteries were drawn and the angles between the two iliac arteries and one iliac artery and aorta were defined as α and β (β_1 for the right side and β_2 for the left side) respectively (Fig. 1). The bifurcation angle was defined as angle α. Asymmetry of the bifurcation angle was determined by the following formula: Bifurcation asymmetry = $[\beta_1 - \beta_2]/\beta_1 + \beta_2$.

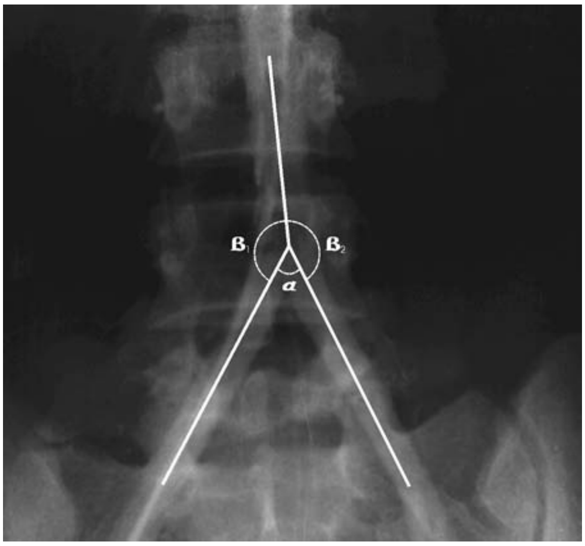

Figure 1. Angiography of the aortic bifurcation in a normal individual (from the control group). The axis of the terminal abdominal aorta and the proximal part of the iliac arteries are drawn to show the angles described (see Material and Methods).

This formula indicates that with an angle asymmetry of 0, the right and left aortoiliac angles are equal. The presence or absence of aortoiliac atherosclerosis was determined by an expert in angiography. Data were presented as the mean ± SD. All statistical analysis was performed by SPSS version 10.0. The χ^2 (Fisher's exact) test was performed to compare the gender ratio between groups. A Pearson correlation test was made between the bifurcation angle, angle asymmetry, and age. The Spearman correlation test also was used to assess the potential correlations between the status of aortoiliac atherosclerosis and the above-mentioned variables (bivariate analysis). Logistic regression analysis was performed in enter, backward and forward selections to identify the independent predictors of aortoiliac occlusive disease (atherosclerosis). A p value of less than 0.05 was considered statistically significant.

RESULTS

The study identified 33 normal individuals and 26 patients with aortoiliac occlusive disease (age 56.67 ± 12.41 and 63.92 ± 11.06 years respectively). The mean age of all the individuals studied was 59.86 ± ± 12.28. There were 48 males and 11 females. No significant difference was found between groups with regard to gender ($p > 0.05$). The aortic bifurcation angle varied from 19 to 83 degrees (mean 44.30 ± ± 14.77). Aortic bifurcation asymmetry ranged between 0 and 14.4 (mean 3.78 ± 3.51). The mean bifurcation angle was 34.6 ± 7.3 in normal individuals and 58.2 ± 11.2 in patients with aortoiliac atherosclerosis. The angle asymmetries were 3.8 ± ± 3.5 and 4.0 ± 3.2 in the normal and atherosclerotic groups, respectively.

No correlations were found between age, bifurcation angle, and angle asymmetry in the Pearson test (Table 1, $p > 0.05$). The presence of aortoiliac atherosclerosis positively correlated with aortic bifurcation angle and age in a bivariate analysis (Spearman test, r = 0.82 and 0.31, respectively) (Fig. 2, Table 1). The binary logistic regression analysis with atherosclerosis as the dependent variable revealed a model (Table 2) in which the only significant and independent predictor of atherosclerosis at the aortic bifurcation was the bifurcation angle ($\beta = 0.51$ and $p = 0.014$). The contributions of age and angle asymmetry were not significant (Table 2). A multinominal logistic regression analysis with gender as a factor also revealed that the bifurcation angle, but not angle asymmetry, age or gender, was an independent and significant predictor of aortoiliac atherosclerosis (model $r^2 = 0.662$, $p = 0.027$).

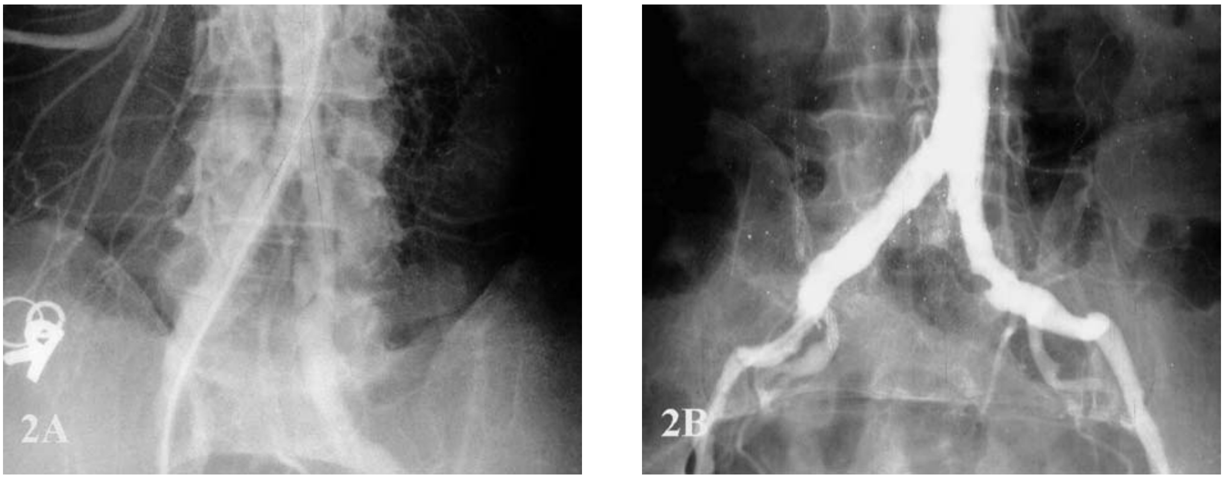

Figure 2. Angiography of the aortic bifurcation (from the atherosclerotic group) showing mild (**A**) and significant (**B**) atheroscleros around the aortoiliac angle.

Table 1. The bivariate correlations between aortic bifurcation angle and asymmetry, age and aortoiliac atherosclerosis

	Angle*	Age*	Atherosclerosis**
Angle	–	0.215/0.11	0.816/< 0.01
Asymmetry	0.212/0.11	0.113/0.40	0.07/0.60
Age	0.215/0.11	–	0.313/0.01

*Pearson correlation coefficient and the level of significance (r/p); **Spearman correlation coefficient and the level of significance (r/p)

Table 2. Binary logistic regression analysis for the independent contributions of three variables in the aortoiliac atherosclerosis (model $r^2 = 0.646$)

	B (SE)	p value
Bifurcation angle	0.51 (0.21)	0.014
Age	0.07 (0.06)	0.27
Angle asymmetry	–0.28 (0.25)	0.26

B — estimated coefficient; SE — standard error

DISCUSSION

The results of our study demonstrate that the angle of the aortic bifurcation and its asymmetry varied widely among individuals and did not change with ageing. Although the bifurcation angle was both independent and significant as a risk factor for aortoiliac atherosclerosis, age and bifurcation asymmetry were not significant. Bargeron et al. [1] reported significant variation in the bifurcation angle and angular asymmetry of the aortoiliac region in healthy subjects. Sun et al. [12] found that older individuals have a smaller bifurcation angle and greater angular asymmetry than those that are younger. The angle between the terminal aortic axis and the plane of the proximal iliac arteries, known as aortoiliac planarity, has also been shown to vary widely between individuals [9, 10].

Although we found that the aortic bifurcation angle is an independent risk factor for aortoiliac occlusive disease, the potential secondary effect of atherosclerosis on bifurcation anatomy remains a matter of debate. Some investigators have argued that atheromatous changes of, for example, the carotid bifurcation may be associated with changes in vessel anatomy [7]. Hence any association between aortoiliac bifurcation angle and atherosclerotic plaque formation is worth confirming in a cohort and longitudinal study. However, on the basis of our findings, the bifurcation angle may be an important local risk factor for aortoiliac occlusive disease. We hope that the care of patients will benefit from the results of our study in that a measurable risk factor such an aortoiliac bifurcation angle can be compensated for by addressing other factors (e.g. hypertension and hypercholesterolaemia) in high-risk individuals. These results may also have implications regarding the cardiovascular risk.

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