Supra-aortic extracranial artery atherosclerotic lesions in patients diagnosed for coronary artery disease: prevalence and predictors

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Abstract

Background: In patients with coronary artery disease (CAD), the presence of atherosclerotic lesions in other vascular beds is associated with a markedly worse prognosis.

Aim: To determine the prevalence and predictors of extracranial supra-aortic artery atherosclerotic disease (SAD) in patients with suspected CAD.

Methods: Supra-aortic artery angiography was performed in 379 consecutive patients aged 64.2 ± 8.8 years (231 male) referred for coronary angiography. Clinical and laboratory data (total cholesterol, LDL, HDL cholesterol, hs-CRP, creatinine level) and left ventricular ejection fraction were analysed.

Results: Significant stenosis (≥ 50% by quantitative angiography) within at least one main branch of the coronary arteries was found in 314 (82.8%) patients, including 87 (27.7%), 96 (30.6%) and 131 (41.7%) with 1-vessel, 2-vessel, and 3-vessel CAD, respectively. Among all 379 patients, stenosis ≥ 50% of the carotid artery was documented in 9.5%, vertebral in 13.7%, and subclavian in 7.4% of patients. We found 130 stenoses ≥ 50% within the supra-aortic arteries in 90 patients (23.7% of the whole study group, and 28.7% of CAD patients), including 42 internal carotid artery stenoses in 36 patients, 58 vertebral artery stenoses in 52, and 30 subclavian stenoses in 28 patients. In 24 (6.3%) patients more than one SAD was present. The SAD ≥ 50% was found in 8 (12.3%) patients without significant CAD, in 22 (25.3%), 17 (17.7%) and 43 (32.8%) with 1-, 2- and 3-vessel CAD, respectively ($p = 0.001$). Independent predictors of SAD ≥ 50% identified by multivariate analysis were: previous neurological ischaemic event ($p = 0.001$), CAD ($p = 0.015$), creatinine level ($p = 0.031$), male gender ($p = 0.001$), claudication ($p < 0.001$) and low HDL cholesterol ($p = 0.033$). The following independent predictors of vertebral and/or subclavian artery stenosis ≥ 50% were identified: CAD severity ($p = 0.002$), creatinine level ($p = 0.024$), male gender ($p = 0.013$), claudication ($p < 0.001$) and low HDL cholesterol level ($p = 0.059$).

Conclusions: In a large patient sample, we have found that significant supra-aortic atherosclerosis is present in a quater of patients with suspected CAD. Importantly, SAD prevalence increases with CAD severity. Previous neurological ischaemic event, CAD, creatinine level, male gender, claudication and hyperlipidaemia were identified as independent predictors of SAD ≥ 50%.

Key words: coronary artery disease, carotid, vertebral and subclavian artery stenosis, predictors

Kardiol Pol 2009; 67: 985-991

Introduction

Cardiovascular diseases are responsible for about half of deaths in Europe and North America [1-3]. A significant number of cardiovascular deaths are caused by myocardial infarction (MI) and ischaemic stroke [1-3]. In the ageing populations, the increasing frequency of polyvascular atherosclerotic involvements, including coronary artery disease (CAD), supra-aortic artery disease (SAD) and lower extremities and renal artery disease has been observed [4, 5].

Internal carotid artery stenosis (ICAS) often coexists with CAD [5, 6]. However, there are limited data on prevalence of vertebral (VAS) and subclavian (SAS) artery stenosis in CAD patients [7]. The presence of SAD (carotid and, possibly, also vertebral) significantly increases the risk of cardiac revascularisation procedures [5, 8]. Significant subclavian stenosis may result in life-threatening coronary-subclavian steal after surgical revascularisation with internal mammary artery implantation [9]. Periprocedural stroke has also been reported as a complication of a percutaneous coronary intervention (PCI), especially in patients with acute coronary syndrome, prolonged hypotension or cardiogenic shock [10]. The Framingham

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study demonstrated that each of the following – MI, ischaemic stroke or lower extremity atherosclerosis – cuts life expectancy by 9, 12 and 7 years, respectively [11]. The expected length of life is 16 years less in those who have experienced both ischaemic stroke and MI, as compared to the average life expectancy [11].

The study aimed to report the prevalence of significant ICAS, VAS and SAS in patients undergoing coronary angiography for suspected CAD. The present study also aimed to identify independent predictors of aortic arch artery disease concomitant with CAD.

Methods

Patients

The study enrolled 379 consecutive patients (231 men) aged 64.2 ± 8.8 years (range 35-87), admitted to our Department for coronary angiography and PCI between May 2007 and December 2007. The indication for coronary angiography was CAD suspicion (on the basis of exertional angina, atypical chest pain with positive result of treadmill test) or known CAD in patients with a previous MI or recurrent angina in patients previously treated with coronary bypass or PCI. Patients with acute coronary syndrome were not included in this study.

In all patients ultrasonographic assessment of extracranial arteries was performed. Supra-aortic arteries were also visualised with aortography performed in all patients. Supra-aortic artery stenosis detected with ultrasonography and/or aortography was verified and graded by selective contrast injection to the diseased artery.

The study was supported by the national grant 2PO5B09330, and the protocol was reviewed and approved by the local ethical committee and all patients signed informed consent.

Ultrasonography

A high resolution B mode, colour Doppler, and pulse Doppler ultrasonography of carotid, vertebral and subclavian arteries bilaterally was performed with an ultrasound machine Toshiba Aplio PowerVision (Toshiba Medical Systems Co, Ltd, Tokyo, Japan) equipped with a 4--11 MHz linear array transducer. Patients were examined in the supine position with the head tilted backwards. The grade of stenosis in the carotid, vertebral and subclavian arteries was assessed through the increase in the peak systolic and the end-diastolic velocities [12]. The carotid, vertebral and subclavian atherosclerosis was considered significant when the grade of stenosis was > 50%.

Angiography

Angiographic procedures were performed by means of a Coroscop system (Siemens AG, Munich, Germany) equipped with Quantcor version 2.0 quantitative coronary analysis software. All examinations were performed by the Seldinger technique through femoral or radial artery access. Coronary angiography was performed in several views that best displayed the lesion and enabled stenosis grade evaluation. Coronary artery stenosis was defined as significant when lumen reduction was ≥ 50%.

Angiography of supra-aortic arteries was performed following coronary angiography with a 6 French pigtail catheter placed in the aortic arch in the antero-posterior projection with left oblique 20-30° and cranial angulation 10-15°. In case of supra-aortic artery stenosis, a selective contrast injection was performed in several projections that enabled stenosis grade evaluation. Stenosis degree was determined with software for quantitative angiography (QA) and expressed as the percentage of lumen reduction.

Clinical characteristics, atherosclerotic risk factors prevalence and left ventricular ejection fraction (LVEF) were analysed. Left ventricular EF was assessed with Simpson method with a sector-array transducer (Toshiba Aplio PowerVision machine) and measurements were taken in compliance with the guidelines of the American Society of Echocardiography [13].

Fasting blood samples were obtained for total cholesterol, LDL and HDL cholesterol, hs-CRP and creatinine level evaluation. Data regarding hypertension, hyperlipidaemia, diabetes, smoking habit, lower limb claudication, renal insufficiency, body mass index (BMI), a previous neurological ischaemic event (ischaemic stroke or transient ischaemic attack; TIA), or a previous MI were collected. Definitions of hypertension, diabetes, hyperlipidaemia, smoking status, stroke and MI were adopted from the scientific statements of the European Society of Cardiology (http://www.escardio.org) and the American Heart Association (http://www.americanheart.org). Hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg measured in the sitting position twice at least 2 days apart after at least 5 min rest; or current administration of hypotensive agents. Hyperlipidaemia was defined as total cholesterol level ≥ 5.2 mmol/l or LDL cholesterol ≥ 2.6 mmol/l. Patients who currently or any time in the past actively smoked cigarettes for at least 5 years were assumed to be smokers. Diabetes was defined as fasting serum glucose level > 7.1 mmol/l twice or glucose level ≥ 11.2 mmol/l at 2 h after oral administration of 75 g of glucose solution for newly recognised disease, or the patient was on anti-diabetic agents. Renal insufficiency was defined as glomerular filtration rate below 60 ml/min/1.73 m^2. Lower limb intermittent claudication was defined as present in patients with typical lower limb pain on exertion or at rest (we did not grade severity of claudication). The BMI was calculated from the following equation:

$$BMI = \frac{\text{body mass [kg]}}{(\text{height [m]})^2}$$

Statistical analysis

Continuous variables are presented as mean ± one standard deviation (SD), while categorical variables are expressed as frequencies and percentages. Means of analysed parameters across groups were tested with analysis of variance (ANOVA) test, and frequencies were compared with the Chi-squared test for independence.

The coexistence and prevalence of significant ICAS, VAS and SAS were determined in patients with suspected and documented CAD.

Searching for independent predictors of concomitant SAD, 19 clinical variables were assessed by univariate analysis (ANOVA). Factors indicating SAD probability with p-value below 0.2 were included in the multivariable step-wise regression model. The following clinical variables were included initially in the ANOVA analysis: age, gender, number of involved coronary arteries (CAD severity), hypertension, BMI, hyperlipidaemia, diabetes, smoking habit, history of MI and neurological ischaemic event, total LDL and HDL cholesterol, hs-CRP and serum creatinine level.

A backward binary multivariable logistic regression analysis (non-linear quasi-Newton estimation method) was performed in order to identify the independent predictors of SAD.

Statistical analyses were performed with statistical software (Statistica 5.5, Stat Soft Inc, Tulsa, Oklahoma, USA). Differences were considered significant when p value was < 0.05 (95% confidence interval).

Table I. Clinical characteristics of 379 consecutive patients with suspected CAD referred for coronary angiography

	All study group n = 379
Age [years ± SD]	64.2 ± 8.8
Male, n (%)	271 (71.5)
Hypertension, n (%)	315 (83.1)
Diabetes, n (%)	127 (33.5)
Hyperlipidaemia, n (%)	319 (84.2)
Smoking, n (%)	251 (66.2)
Previous myocardial infarction, n (%)	151 (39.8)
Neurological ischaemic event, n (%)	32 (8.4)
LVEF [% ± SD]	56.4 ± 11.4
Lower limb claudication, n (%)	27 (7.1)
BMI [kg/m^2 ± SD]	27.4 ± 3.4
Laboratory results	
Renal insufficiency, n (%)	42 (11.1)
Serum creatinine [µmol/l ± SD]	90.8 ± 32.0
LDL cholesterol [mmol/l ± SD]	2.8 ± 0.9
HDL cholesterol [mmol/l ± SD]	1.2 ± 0.3
Triglycerides [mmol/l ± SD]	1.7 ± 1.2
hs-CRP [mg/dl ± SD]	4.1 ± 4.0

Results

The study group involved patients with typical clinical characteristics for atherosclerosis. The majority had multiple risk factors and many had a history of atherothrombotic events. Baseline data regarding risk factors prevalence, laboratory data, and LVEF are given in Table I.

Significant CAD was found in 314 (82.8%) patients, including 87 (27.7%) patients with 1-vessel CAD, 96 (30.6%) 2-vessel CAD, and 131 (41.7%) with 3-vessel CAD.

Of the 314 patients with documented CAD, significant SAD was found in 82 (26.1%) patients (Table II). The SAD was identified in 22 (25.3%), 17 (17.7%) and 43 (32.8%) patients with 1-, 2- and 3-vessel CAD, respectively (p = 0.001). In 22 (9.2%) patients more than 1 supra-aortic artery involvement was present. Thus, we identified 120 stenoses ≥ 50% within supra-aortic arteries in patients with significant CAD, including 36 ICAS ≥ 50% in 30 (9.6%) patients, 56 VAS ≥ 50% in 50 (15.9%), and 28 SAS ≥ 50% in 26 (8.3%) patients (Table II). Left and right side stenosis ≥ 50% of ICAS was found in 6 subjects, of VAS in 6, and SAS in 2 patients with CAD, respectively. Thus, among CAD patients, 9.6% had ICAS ≥ 50%, 15.9% had VAS, and 8.3% of patients had SAS.

Normal or non-significant lesions (< 50%) in coronary arteries were observed in 65 (17.2%) patients. The SAD stenosis ≥ 50% was found in 8 (12.3%) out of 65 patients without significant CAD, including one-sided ICAS ≥ 50% in 6 (9.2%) patients, and concomitant VAS ≥ 50% and SAS ≥ 50% in 2 (3.1%) patients (Table II). The SAD was statistically less frequent in patients without significant CAD as compared to those with significant CAD (12.3 vs. 26.1%; p = 0.017).

In summary, among all 379 patients, ICAS ≥ 50% was documented in 9.5%, VAS in 13.7%, and SAS in 7.4% of patients.

Accuracy of Doppler duplex ultrasonography, as compared to angiography, in detection of significant stenoses ≥ 50% was 97.6% (41 out of 42) for ICAS, 87.9% (51/58) for VAS and 96.7% (29/30) for SAS.

Independent predictors of SAD ≥ 50% were: previous neurological ischaemic event (p = 0.001), CAD (p = 0.015), creatinine level (p = 0.031), male gender (p = 0.001), claudication (p < 0.001) and low HDL cholesterol level (p = 0.033) (Table III). Similarly, the following independent predictors of VAS and/or SAS ≥ 50% were identified: CAD severity (p = 0.002), creatinine level (p = 0.024), male gender (p = 0.013), claudication (p < 0.001) and low HDL cholesterol level (p = 0.059). The only difference between SAD and VAS/SAS predictors was a previous neurological ischaemic event, which was an independent predictor for SAD ≥ 50%, but not for VAS/SAS.

Table II. Prevalence of SAD, including ICAS ≥ 50%, VAS ≥ 50% and SAS ≥ 50% in 306 patients with significant CAD documented on coronary angiography and in 64 patients with normal coronary arteries or no significant CAD

Patients with documented significant CAD (n = 314)	Supra-aortic arterial disease ≥ 50%
1-vessel CAD (coronary artery stenosis ≥ 50%), n = 87	**26 stenoses in 22 (25.3%) patients**
ICAS	6 (6.9%)
VAS	10 (11.5%)
SAS	2 (2.3%)
ICAS + SAS	2 (2.3%)
VAS + SAS	2 (2.3%)
2-vessel CAD, n = 96	**21 stenoses in 17 (17.7%) patients**
ICAS	4 (4.2%)
VAS	7 (7.3%)
SAS	2 (2.1%)
ICAS + VAS	4 (4.2%)
3-vessel CAD, n = 131	**59 stenoses in 43 (32.8%) patients**
ICAS	8 (6.1%)
VAS	15 (11.5%)
SAS	6 (4.6%)
ICAS + SAS	2 (1.5%)
VAS + SAS	8 (6.1%)
ICAS + VAS + SAS	8 (6.1%)
Patients with non-significant CAD (n = 65)	**Supra-aortic arterial disease ≥ 50%**
ICAS	6 (9.2%)
VAS + SAS	2 (3%)

Abbreviations: CAD – coronary artery disease, ICAS – internal carotid artery stenosis, SAS – subclavian artery stenosis, VAS – vertebral artery stenosis, SAD – supra-aortic arterial disease

Table III. Independent predictors of SAD ≥ 50% and VAS/SAS ≥ 50% in 379 patients with suspected CAD

	Beta	St. error of beta	t	p
SAD ≥ 50% predictors				0.002
Male gender	0.18	0.05	3.21	0.001
Claudication	0.25	0.05	4.71	< 0.001
Coronary artery disease	0.13	0.05	2.45	0.015
Neurological ischaemic event	0.18	0.05	3.36	0.001
Serum creatinine	–0.12	0.06	2.17	0.031
HDL cholesterol level	–0.12	0.05	2.15	0.033
VAS/SAS ≥ 50% predictors				0.013
Male gender	0.14	0.06	2.50	0.013
Claudication	0.21	0.06	3.79	< 0.001
Coronary artery disease severity	0.18	0.06	3.17	0.002
Serum creatinine	0.13	0.06	2.27	0.024
HDL cholesterol level	–0.11	0.06	–1.90	0.059

Abbreviations: as in Table II

Discussion

Our study showed that significant SAD is frequent in patients with confirmed or suspected CAD. In general, more than one in four (26.1%) patients with confirmed CAD had SAD ≥ 50%. This finding is consistent with some smaller studies where the SAD frequency was similar (21--24% in CAD patients) [14-16]. Significant ICAS was found in 9.6% of CAD patients, which is in concordance with our previous findings [6] and those of others [from 7.2% (Tunio et al.) to 18% (Rigatelli et al.)] [5, 14-18].

The frequency of SAS ≥ 50% was 8.3% of CAD patients in our study, while others reported SAS frequency between 7% and 11.5% in patients with CAD or peripheral arterial disease [15, 17, 18]. This is much higher than SAS frequency in population studies (1.2-1.9%) [19-21]. The data on VAS frequency are limited, and its prevalence was estimated between 6% and 12.8% (14-16). Our study indicates higher VAS prevalence (15.9% of CAD patients).

The present study allowed comparisons to be made between patients with angiographically significant and without significant CAD. We found that in patients without significant CAD, SAD was 2 times less frequent as compared to the CAD patients, and VAS/SAS stenosis was 5 times less frequent. Interestingly, the frequency of significant ICA lesions was similar in both groups. This finding indicates that the association between CAD and significant atherosclerosis in other arterial beds is not 'uniform', and it warrants further investigation – particularly as the association between ICAS and CAD as well as ICAS impact on clinical outcome in CAD patients has been well recognised [14-18].

Our search for independent predictors of SAD in CAD patients revealed the following independent predictors of SAD ≥ 50%: previous ischaemic stroke, CAD, creatinine level, male gender, claudication and low HDL cholesterol level. The only difference between SAD and VAS/SAS predictors was previous stroke, which was an independent predictor of SAD ≥ 50%, but not of VAS/SAS. Rigatelli et al. found the following independent predictors of SAD: 3-vessel CAD, age > 60 years, and accumulation ≥ 3 atherosclerotic risk factors. Shadman et al. reported CAD and lower extremity peripheral arterial disease to be independent factors [19, 20]. In the Blue Cross & Blu eShield of Michigan Cardiovascular Consortium study, the patients with extracoronary lesions were older, more frequently were diabetic or hypertensive, had lower LFEF and more often renal insufficiency, compared to patients with atherosclerotic lesions limited to coronary arteries [22].

Coronary revascularisation (percutaneous or surgical) is the common treatment modality in patients with CAD refractory to medical therapy [23, 24]. The findings of our group and those of others show that SAD is frequent in CAD patients [6]. This is important, since the concomitant SAD can have a significant impact on the outcome of (primarily surgical) coronary revascularisation [5, 8, 16-18]. Moreover, SAD is associated with cerebrovascular events that have a negative impact on the prognosis after coronary revascularisation. This is particularly relevant for patients with CAD and significant ICAS [5, 8, 16-18]. The data on the clinical impact of 'silent' VAS in CAD patients are limited. However, it has been suggested that the risk of VAS-associated stroke may be similar to that in patients with ICAS while the mortality may be higher [25-27]. Thus it is likely that at least a proportion CAD patients with concomitant SAD might require (and benefit from) revascularisation of VAS. For these reasons, it seems important to identify potential SAS lesions in patients with CAD, and particularly in those referred for coronary revascularisation.

We believe that all patients with significant CAD should undergo non-invasive evaluation of supra-aortic and renal arteries. We do agree that routine invasive 'fly-by' supra--aortic or renal angiography is not recommended in patients evaluated invasively for CAD. Similarly to other authors, we have also demonstrated that careful non-invasive inspection, including physical examination and duplex-Doppler evaluation, is sufficient to reveal significant supra-aortic pathology [6, 28, 29]. Currently, however, not all centres would have an experienced ultrasonographer as part of the staff, and a proportion of CAD patients are diagnosed and treated on an urgent basis. In such patients, particularly when there are several SAD risk factors (or, e.g., a carotid bruit is audible on physical examination), in the absence of reliable non-invasive evaluation, one can consider performing one-stage coronary and supra-aortic angiography.

Study limitations

With the exception of a history of stroke, the current study has not analysed the prevalence of clinical symptoms that might suggest SAD. Also, our evaluation did not include lesions in the basilar artery or intracranial arteries.

At present we have no data on the long-term follow--up in our cohort of patients; therefore the potential clinical implications of our findings have to be based on published data.

In summary, in patients evaluated for CAD, significant supra-aortic artery atherosclerosis is frequent – it does always require consideration and careful clinical attention. The risk factors for SAD that we have identified in the current study include the following: a previous neurological ischaemic event, CAD severity, creatinine level, male gender, claudication and hyperlipidaemia.

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Występowanie zwężeń tętnic dogłowowych u osób z chorobą niedokrwienną serca

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Streszczenie

Wstęp: U osób z chorobą wieńcową (CAD) miażdżyca tętnic pozawieńcowych związana jest ze złym rokowaniem.

Cel: Ocena częstości występowania zwężeń tętnic dogłowowych (SAS) i ich czynniki predykcyjne u chorych z CAD.

Metody: Angiografię tętnic dogłowowych wykonano u 379 kolejnych chorych (231 mężczyzn) w średnim wieku 64,2 ± 8,8 roku, poddanych angiografii tętnic wieńcowych. U wszystkich chorych poddano analizie obraz kliniczny, badania laboratoryjne: stężenie cholesterolu całkowitego, frakcji LDL i HDL, hs-CRP, kreatyniny, oraz oceniono frakcję wyrzutową lewej komory.

Wyniki: Zwężenia ≥ 50% w co najmniej jednej głównej gałęzi tętnicy wieńcowej stwierdzono u 314 (82,8%) chorych, w tym u 87 (27,7%) 1-naczyniową CAD, u 96 (30,6%) chorych 2-naczyniową oraz u 131 (41,7%) – 3-naczyniową CAD. Brak zwężeń lub zwężenia < 50% w tętnicach wieńcowych odnotowano u 65 (17,2%) osób. Stwierdzono 130 zwężeń ≥ 50% w tętnicach dogłowowych u 90 chorych, co stanowi 23,7% całej grupy oraz 28,7% wśród chorych z CAD. Stwierdzono 42 zwężenia w tętnicy szyjnej wewnętrznej u 36 chorych, 58 zwężeń tętnicy kręgowej u 52 oraz 30 zwężeń tętnicy podobojczykowej u 28 chorych. Zwężenie więcej niż jednej tętnicy dogłowowej było obecne u 24 (6,3%) chorych. Zwężenia tętnic dogłowowych ≥ 50% stwierdzono u 8 (12,3%) chorych bez istotnych zwężeń w tętnicach wieńcowych oraz u odpowiednio 22 (25,3%), 17 (17,7%) i 43 (32,8%) chorych z 1-, 2- i 3-naczyniową chorobą wieńcową (p = 0,001). Metodą analizy wieloczynnikowej wykazano, że niezależnymi czynnikami prognostycznymi SAS ≥ 50% są: przebyty udar niedokrwienny mózgu (p < 0,001), CAD (p = 0,015), stężenie kreatyniny (p = 0,031), płeć męska (p = 0,001), chromanie kończyn dolnych (p < 0,001) oraz niskie stężenie frakcji HDL cholesterolu (p = 0,033).

Wnioski: Zwężenie tętnic dogłowowych jest częstym znaleziskiem u chorych kierowanych na koronarografię z podejrzeniem oraz udokumentowaną CAD i dotyczy ok. 1/4 chorych. Częstość SAS wzrasta wraz ze wzrostem zaawansowania choroby wieńcowej. Zidentyfikowano następujące niezależne czynniki prognostyczne SAS ≥ 50%: przebyty udar niedokrwienny mózgu, CAD, stężenie kreatyniny, płeć męska, chromanie kończyn dolnych oraz niskie stężenie frakcji HDL cholesterolu.

Słowa kluczowe: choroba niedokrwienna serca, tętnica podobojczykowa, zwężenie tętnicy kręgowej i dogłowowej, czynniki predykcyjne

Kardiol Pol 2009; 67: 985-991

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