An evaluation of the incidence of haemodynamic depression during carotid angioplasty and stenting and its relationship with specific risk factors

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Abstract

Introduction: *Haemodynamic depression is a drop in systolic pressure below 90 mmHg and/or heart rate to less than 60 beats per minute. Its incidence during the carotid angioplasty and stenting (CAS) perioperative period is as high as 68%. It is suggested that haemodynamic depression may result in serious perioperative incidents (major adverse cardiac events – MACE) and strokes.*

Aim: *To evaluate the incidence of haemodynamic depression and to attempt to find a relationship with specific risk factors in patients undergoing carotid angioplasty and stenting.*

Material and methods: *The study involved a group of 23 patients aged 40 to 79 (13 men and 10 women) who underwent CAS between August 2009 and July 2010. Initial values of arterial pressure and heart rate, values at moments critical for successful CAS and values at the end of the procedure were recorded. Haemodynamic depression was defined as hypotension below 90 mmHg and/or bradycardia below 60 beats per minute.*

Results: *The incidence of haemodynamic depression was 30.4%. There is a positive and statistically significant correlation between initial systolic pressure and systolic and diastolic pressure and heart rate measured during stent implantation. Gender, artery operated on, previous stroke/TIA or carotid endarterectomy, type 2 diabetes, ischaemic heart disease and smoking did not significantly affect the incidence of haemodynamic depression. A statistically significant correlation with the length of the implanted stent was observed.*

Conclusions: *The probability of haemodynamic depression is markedly higher in patients with low initial systolic pressure and longer stenosis of the carotid artery.*

Key words: *haemodynamic depression, carotid angioplasty and stenting, perioperative bradycardia.*

Introduction

Operative management of carotid artery disease is performed in patients with the most advanced, substantial haemodynamic changes, which narrow the lumen of arteries by more then 70%, even if the stenosis itself is asymptomatic. 60% narrowing is considered to be treated if it is accompanied by symptoms of insufficient blood supply to an area of the brain.

The common methods of operative management of carotid artery stenosis include classic carotid endarterectomy (CEA) and newer, percutaneous techniques based on carotid catheterization (CAS).

Currently however, neither of these methods has a distinct advantage over the other.

Supporters of both classic surgery and less invasive techniques are still searching for new factors which would allow them to predict the risk of periop-

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erative complications in order to improve methods they use and select patients more safely in the future.

Apart from CAS, complications such as stroke, temporary ischaemic attack (TIA) and those connected with femoral artery puncture, researchers are particularly interested in haemodynamic depression in the perioperative period.

Haemodynamic depression is commonly diagnosed if there is a drop in systolic pressure below 90 mmHg and/or heart rate to less than 60 beats per minute [2-4]. Its occurrence rate in the CAS perioperative period can be as high as 68% [2, 5-6]. Since it is sometimes suggested that haemodynamic depression may lead to major adverse cardiac events (MACE) and strokes [2, 4], it is crucial to take preventive action.

Lack of previous arterial angioplasty (CEA), chronic nicotinism, diabetes, ischaemic heart disease, age, value of ejection fraction (EF) and location of atheromatous plaque together with its morphology are among relatively well-known factors influencing the incidence of haemodynamic depression in the peri- and postoperative period. The type of stent placed, its length, material which it was made of and the performance of postdilatation in order to recreate the arterial lumen after the stent was released are also not without significance.

Aim

The aim of this study was to determine the incidence of haemodynamic depression and attempt to associate it with selected risk factors in patients undergoing percutaneous angioplasty of carotid arteries combined with stent placement.

Material and methods

Patients

There were 23 patients aged between 40 and 79 involved in the study. The series consisted of 13 men and 10 women who underwent carotid angioplasty and stent placement (CAS) in the Department of Cardiology of the Pomeranian Medical University (PMU). The study covered the period from August 2009 to July 2010.

In 15 cases the procedure was performed within the right internal carotid artery (RICA), and in the remaining 8 in the left internal carotid artery (LICA). Four patients were treated by predilatation antecedent to stent placement.

Twenty symptomatic patients, after stroke or TIA, were selected for the procedure, 4 patients with restenosis after classical carotid endarterectomy in the same artery CAS was later performed on. Four patients had type 2 diabetes. Ischaemic heart disease was confirmed by means of coronarography in 18 cases. Seventeen patients reported chronic nicotinism. All patients received lengthy (minimum 5 days before the procedure) double antiplatelet therapy with clopidogrel and acetylsalicylic acid. On the day of the procedure heparin was administered intravenously according to body mass. Hypotensive drugs were discontinued on the day of the procedure.

Methods

The procedure was performed in the Laboratory of Haemodynamics in the Department of Cardiology of PMU with antecedent coronarography and carotid arterial angiography combined with the assessment of cerebral circulation.

Nitinol stents were implanted through a transfemoral approach using distal neuroprotection systems. Depending on the size of the narrowing, 30 or 40 mm, tapered or straight stents were used. Next the stents were expanded by a balloon catheter until the best patency results were achieved.

In some cases of extreme stenosis predilatation was performed before neuroprotection placement and stent implantation.

In all cases the arterial blood pressure and EKG recordings were continuously monitored during the procedure and postoperative period (non-invasive method, within the Cardiac Intensive Care Unit) as long as full stability of the circulatory system was achieved. During the procedure atropine was administered prophylactically and pressor amines were infused. Their dose depended on bradycardia and hypotension increase.

In all patients arterial blood pressure and heart rate were recorded before the procedure (initial data), in crucial moments for CAS success, meaning during the stent release and its postdilatation, and finally after the procedure (final data). Haemodynamic depression was considered, according to a commonly accepted definition, as hypotension below 90 mmHg and/or bradycardia below 60 beats per minute [1-3]. Statistical analysis was carried out with Statistica software (StatSoft, Inc. USA). Normality of distribution was tested by the Shapiro-Wilk

test. Features with non-normal distribution were tested by nonparametric tests, usually by the Kolmogorov-Smirnov test. Dependant variables with normal distribution were tested by the t test for dependent samples, while dependant variables with abnormal distribution were tested by the signed-rank test or Wilcoxon test. The analysis of categorical data was carried out by Pearson's χ^2 test and Fisher's exact test for small sample sizes (non-parametric tests). Spearman's rank correlation test was used to assess the correlation between separate parameters. Values of $p < 0.05$ were accepted as statistically significant.

Results

Haemodynamic depression (HD) was registered in 7 cases (4M and 3F). In 2 patients only a drop in arterial pressure was observed, in the next 2 bradycardia, while in the last 3 cases hypotension together with bradycardia occurred (Figure 1).

In Table I clinical and biochemical parameters in the series of patients with HD and without haemodynamic depression (no HD) connected with CAS were compared.

The patients studied were not statistically different from each other regarding age, height, weight, BMI, and EF. There were no differences observed for parameters describing lipid metabolism (concentration of each: total cholesterol, LDL, HDL and triglycerides in serum), carbohydrate metabolism (blood glucose level on an empty stomach) or parameters of inflammation, meaning the concentration of c-reactive protein in serum (CRP).

In Table II haemodynamic parameters in both patients with haemodynamic and without haemodynamic depression during CAS are presented.

Statistically significant, lower values of systolic pressure were observed during stent release (stent SBP) in patients with haemodynamic depression. This was one of the criteria for patients' division into analysed groups. The series also differed with respect to initial systolic pressure values (initial SBP) and heart rate (initial HR), but they were not statistically significant differences.

In the entire group, as Table III shows, a positive, statistically significant correlation was found between initial SBP and systolic pressure, diastolic pressure (stent SBP, stent DBP) and heart rate (stent HR) measured during stent implantation. After dilatation the initial systolic pressure was also positively correlated with systolic and diastolic pressure (postdil SBP, postdil DBP), while at the end of the procedure only diastolic pressure (final DBP) was positively correlated with the initial SBP. Similar correlations were observed in relation to initial diastolic pressure (initial DBP), except between initial DBP and postdil DBP. Initial HR was statistically correlated only with stent DBP and stent HR.

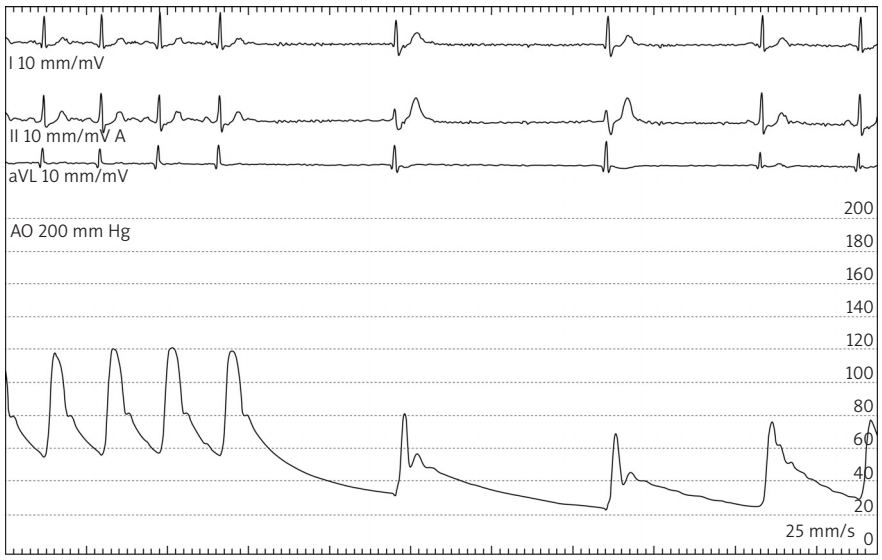

Figure 1. Example of hemodynamic depression in continous cardiac monitoring

Table I. Clinical and biochemical characteristics of patients with haemodynamic depression (HD) and without haemodynamic depression (no HD) associated with CAS

Feature	HD associated with CAS $n = 7$	No HD associated with CAS $n = 16$	Level of statistical significance
	Average ± SD	Average ± SD	
Age [years]	62.71 ±5.70	64.31 ±10.36	NS
Body mass [kg]	80.00 ±12.05	74.18 ±8.09	NS
H [m]	1.68 ±0.06	1.65 ±0.12	NS
BMI [kg/m^2]	28.27 ±3.46	27.41 ±3.98	NS
EF [%]	59.57 ±6.42	56.87 ±9.46	NS
GLU [mmol/l]	5.31 ±0.16	5.62 ±0.52	NS
T-CH [mmol/l]	4.02 ±1.46	4.10 ±1.11	NS
HDL [mmol/l]	1.17 ±0.46	1.08 ±0.22	NS
LDL [mmol/l]	2.39 ±1.12	2.49 ±0.91	NS
TG [mmol/l]	1.14 ±0.31	1.63 ±0.63	NS
CRP [mg/l]	5.05 ±2.43	3.77 ±3.82	NS

H – height, BMI – body mass index, Glu – fasting glucose, T-CH – total cholsterol, HDL – HDL cholsterol, LDL – LDL cholestrol, TG – triglycerides

Table II. Haemodynamic parameters during CAS in patients with haemodynamic depression and (HD) without haemodynamic depression (no HD)

Feature	HD associated with CAS $n = 7$	No HD associated with CAS $n = 16$	Level of statistical significance
	Average ± SD	Average ± SD	
Initial SBP [mmHg]	127.85 ±31.73	150.31 ±30.7	NS
Initial DBP [mmHg]	67.28 ±8.93	68.31 ±16.26	NS
Initial HR [min^{-1}]	66.00 ±11.76	73.63 ±10.78	NS
Stent SBP [mmHg]	122.00 ±18.87	149.31 ±26.32	< 0.05
Stent DBP [mmHg]	57.57 ±10.78	69.37 ±17.59	NS
Stent HR [min^{-1}]	76.50 ±17.22	75.45 ±7.18	NS
Postdil SBP [mmHg]	96.14 ±30.45	147.00 ±37.51	NS
Postdil DBP [mmHg]	49.00 ±15.17	69.75 ±16.78	NS
Postdil HR [min^{-1}]	71.66 ±25.27	84.75 ±16.45	NS
Final SBP [mmHg]	132.50 ±17.24	137.45 ±20.86	NS
Final DBP [mmHg]	62.5 ±11.72	67.18 ±11.80	NS
Final HR [min^{-1}]	91.66 ±20.98	83.00 ±18.19	NS

SBP – systolic blood pressure, DBP – diastolic blood pressure, HR – heart rate

Table III. Correlations between haemodynamic parameters registered during CAS

Group	Initial SBP [mmHg]		Initial DBP [mmHg]		Initial HR [min^{-1}]	
	r	*p*	*r*	*p*	*r*	*p*
Stent SBP [mmHg]	0.71	< 0.001	0.30	< 0.03	0.46	0.05
Stent DBP [mmHg]	0.58	< 0.004	0.45	< 0.001	0.53	< 0.03
Stent HR [min^{-1}]	0.55	< 0.02	0.67	< 0.04	0.70	< 0.002
Postdil SBP [mmHg]	0.47	< 0.04	0.51	< 0.04	0.27	NS
Postdil DBP [mmHg]	0.58	< 0.01	–0.01	NS	0.36	NS
Postdil HR [min^{-1}]	0.38	NS	0.42	NS	0.04	NS
Final SBP [mmHg]	0.17	NS	0.22	NS	0.06	NS
Final DBP [mmHg]	0.52	< 0.04	0.61	< 0.01	0.35	NS
Final HR [min^{-1}]	–0.31	NS	–0.30	NS	–0.33	NS

r – Spearman rank correlation value, p – level of statistical significance, SBP – systolic blood pressure, DBP – diastolic blood pressure, HR – heart rate

As presented in Table IV, sex, artery operated on (RICA vs. LICA), previous stroke/TIA or carotid endarterectomy, diabetes, ischaemic heart disease and chronic nicotinism did not have any significant influence on haemodynamic depression occurrence. A statistically significant correlation with the length of the stent implanted ($p < 0.002$) was found. Longer stents were implanted in 3 patients (13%) without haemodynamic depression and in 6 patients (26.1%) in the series with haemodynamic depression occurrence.

Discussion

The incidence of haemodynamic depression defined as hypotension with systolic arterial pressure < 90 mmHg and/or bradycardia < 60/ min is estimated from just a few per cent up to several dozen per cent [2, 5-7]. Such wide variation in its occurrence may be connected with the lack of a uniform definition, accepted by all researchers. Different centres accept different criteria, taking into consideration not only absolute pressure or heart rate values, but also the percentage of their change in relation to initial values [8].

In the researched series haemodynamic depression was registered in 7 out of 23 patients, which constituted 30.4% of the entire group. Despite many risk factors described in the literature, in our research material we discovered that initial haemodynamic parameters, systolic pressure and heart rate, were statistically significant. From a pathophysiological point of view it seems understandable since the procedure itself is conductive to the decrease of arterial pressure, and with low initial values even the smallest drop can qualify a patient to a group with haemodynamic depression.

A characteristic, positive relationship between the length of the implanted stent with haemodepression was also observed, which means the longer the stent the higher the possibility of depression. This can be explained by the fact that a larger area of the carotid artery (and a higher number of baroreceptors) is subject to a mechanical, centrifugal force, which triggers the reflex cascade [9].

Less frequent occurrence of haemodynamic depression in patients with diabetes and habitual smokers is reported in the available literature [2, 7, 10-16]. These are states in which either the number or sensitivity of baroreceptors in the wall of carotid arteries is decreased. In our research, unlike these findings, we did not obtain such results. A possible explanation for the discrepancies is too small size of the series. In the case of diabetes it could also have been due to too short duration and the lack of autonomic neuropathy, which in the literature is an explanation for its paradoxically protective influence [2, 17-19]. Some researchers describe less frequent occurrence of haemodynamic depression in patients after antecedent endarterectomy [2, 7]. In the re-

Table IV. Comparison of incidence of selected features in group with haemodynamic depression (HD) and without haemodynamic depression (no HD)

Feature	Group	HD [%] (*n*)	No HD [%] (*n*)	χ^2	*p*
Sex	Women	13.0 (3)	30.4 (7)	0.01	NS
	Men	17.4 (4)	39.1 (9)		
ICA artery	RICA	21.7 (5)	47.8 (11)	0.02	NS
	LICA	8.7 (2)	21.7 (5)		
CEA	No	30.4 (7)	52.2 (12)	3.25	0.07
	Yes	0.0 (0)	17.4 (4)		
Stroke/TIA	No	8.7 (2)	4.4 (1)	1.95	NS
	Yes	21.7 (5)	65.2 (15)		
IHD	No	4.4 (1)	17.4 (4)	0.35	NS
	Yes	26.1 (6)	52.2 (12)		
DM	No	27.3 (6)	54.6 (12)	0.108	0.741
	Yes	4.6 (1)	13.7 (3)		
Nicotinism	No	8.7 (2)	17.4 (4)	0.031	0.858
	Yes	21.7 (5)	52.2 (12)		
Predilatation	No	27.3 (6)	54.6 (12)	2.86	0.090
	Yes	0.0 (0)	18.2 (4)		
Length of stent	Longer stents (40 mm)	26.1 (6)	13.0 (3)	9.60	< 0.002
	Shorter stents (30 mm)	4.4 (1)	56.5 (13)		

ICA – internal carotid artery, CEA – carotid endarterektomy, TIA – transient ischemic attack, IHD – ischemic heart disease, DM – diabetes mellitus

search material a similar, but statistically insignificant tendency was observed. None of the patients with diagnosed haemodynamic depression had undergone endarterectomy, which was why the "protection" against circulatory instability did not occur (χ^2 – 3.25, p = 0.07). With a larger series this difference might have been statistically significant.

In the research material proven, positive, statistically significant correlations confirm that initial systolic and diastolic pressure plays the most crucial role in predicting the occurrence of haemodynamic depression during CAS. In the available literature no similar reports were found.

The role of diastolic arterial pressure should be analysed more carefully and its inclusion in the definition of haemodynamic depression might be taken into consideration. It plays a crucial part in coronary perfusion, and its too aggressive decrease is associated with occurrence of cardiovascular incidents, especially in patients with ischaemic heart disease (J-curve relationship). This was confirmed by the INVEST study, whose authors demonstrated that excessive decrease of diastolic arterial pressure, even though it did not correlate with stroke frequency, had a substantial influence on mortality and cardiac arrest incidence [20]. What is more, in the case of ischaemic heart disease, atrioventricular node receptors may be stimulated, which can increase vagus nerve tension [21]. In the research material almost 80% of patients suffered from ischaemic heart disease.

In the literature a relationship between haemodynamic incidence and heart insufficiency with

decreased ejection fraction (below 25%) is reported [7, 14]. In the research material no such relationship was found, which can be explained by the fact that the patients did not have decreased ejection fraction.

This study is limited by the lack of initial USG with the assessment of atheromatous plaque morphology. In the available literature it is emphasized that calcified plaque, unlike ulcerated and soft ones, more frequently predisposes patients to hypotension and bradycardia in the postoperative period [13-15].

Conclusions

The estimated incidence of haemodynamic depression in the research material, according to commonly accepted criteria, was 30.4%. The probability of haemodynamic depression is significantly higher in patients with low initial systolic pressure.

Increasing length of the lesion, and implantation of longer stents connected with it, increases the risk of haemodynamic depression.

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