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The correlation between interarm blood pressure differences and postoperative complications after peripheral vascular surgery: a prospective observational study

Ocena zależności pomiędzy różnicą ciśnienia tętniczego między ramionami i powikłaniami pooperacyjnymi w chirurgii naczyń obwodowych: badanie obserwacyjne prospektywne

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Abstract

Background: A large difference in blood pressure between both arms is common in patients with disseminated atherosclerosis undergoing vascular surgery. In patients with high cardiovascular risk, inter-arm blood pressure difference > 10 mm Hg can occur in more than 38% of the population, but the impact on short-term postoperative complications is still unclear.

Material and methods: The aim of this study was to evaluate the effect of inter-arm blood pressure asymmetry on the overall postoperative complications in the Revised Cardiac Risk Index class I–II patients undergoing peripheral vascular surgery. Secondly, other possible risk factors for postoperative complications and duration of hospital stay were established.

Design: Prospective observational study.

Setting: Single-centre study.

Patients: Ninety-five RCRI class I-II patients undergoing peripheral vascular surgery.

Interventions: The authors measured blood pressure in brachial arteries on both arms in the operating room prior to administering anaesthesia for every patient enrolled in the study. After the surgery, all participants were followed up from the time of hospitalization for any postoperative complications.

Main outcome measures: Blood pressure values

Results: There was no correlation found between overall postoperative complications and blood pressure differences (neither systolic, diastolic nor mean) between the arms. Patients who underwent emergent surgery had highly increased risk of postoperative complications (OR 13.0; 95% CI 1.4 to 69.3; $p < 0.01$) and prolonged hospital stay time (HR 2.5; 95% CI 1.7 to 3.7; $p < 0.01$).

Conclusion: Although the authors did not find any relevant correlation between inter-arm blood pressure differences and postoperative complications, the measurement in both arms is crucial to determine adequate baseline values prior to surgery.

Key words: blood pressure, vascular surgery, complications

Introduction

An elevated and unstable blood pressure is common in patients with disseminated atherosclerosis undergoing vascular surgery due to ischaemia of the lower limb. Among them, there is a large group of patients with an increased difference in blood pressure between the arms, both systolic and diastolic. Since November 2017, when new American Heart Association guidelines on hypertension were published, all patients with SBP equal to 130 mm Hg or DBP 80 mm Hg were classified into the first category of hypertension. In particular, every patient with SBP greater than or equal to 180 mm Hg or DBP ≥ 120 mm Hg is classified as having a hypertensive crisis and must obtain proper treatment prior to surgery [1]. Despite this recommendation, clinical experience shows that intensification of pharmacotherapy in a short period of time may be ineffective in the vast majority of patients and scheduled surgery is not postponed. Although high arm-to-arm blood pressure difference is associated with increased cardiovascular mortality, commonly used risk scores, such as Revised Cardiac Risk Index (RCRI), it is not considered as an independent risk factor for postoperative complications; thus, the problem might be neglected [2]. The incidence of overall cardiovascular complications in RCRI class I and II are under 0.6%, while in classes above II, they exceed 6%. These major differences in postoperative outcome between patients should prompt more attention to other risk factors, which are not included in the RCRI scale [3]. The aim of this study was to evaluate the impact of inter-arm blood pressure asymmetry on the overall postoperative complications in RCRI class I–II patients undergoing peripheral vascular surgery. Secondly, the authors established the impact of other possible risk factors on overall complications and duration of hospital stay.

Patients and methods

in this single-centre, prospective, observational study, data was collected from patients undergoing vascular surgery between October 2017 and March 2018 in Independent Public research hospital No. 7 of Silesian Medical University in Katowice. Informed consent was obtained from all participants. The flow chart of participant selection can be found in Figure 1. Participants were recruited during pre-assessment visits either from the elective operating schedules or prior to urgent surgery. Two hundred fifteen patients were evaluated by an anaesthesiologist and information such as demographic indicators (age, gender), biometrical (height, weight, BMI), detailed medical history, smoking habits, ASA-PS, RCRI score and type of surgery were obtained. Ninety-nine patients who underwent vascular elective or urgent surgery were eligible and fulfilled the inclusion criteria. These inclusion criteria were: RCRI 0–1pts and peripheral vascular surgery beneath inguinal ligament. Among 99 of the preliminarily analysed patients, two were excluded from the study because of upper limb

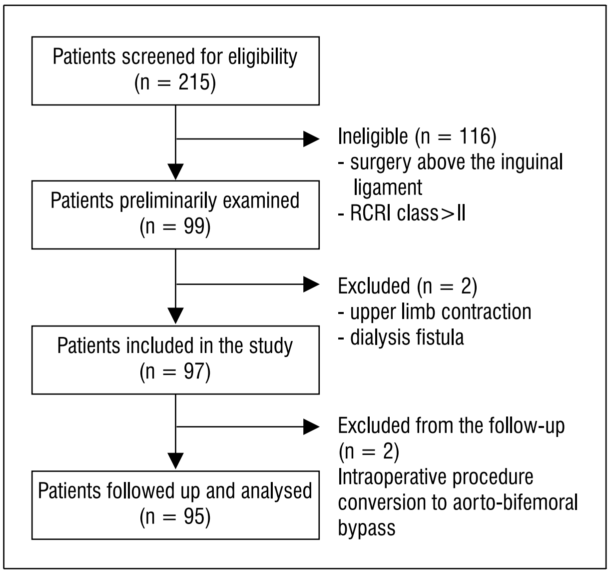

Figure 1. STROBE Flow chart of participants

contraction (n = 1) and dialysis fistula (n = 1). Patients who were receiving antihypertensive therapy before the surgery, such as beta-blockers, calcium channel blockers or RAAS inhibitors, had them administered in the morning of the date of surgery. Midazolam dose for premedication differed between the patients and depended on the anaesthesiologist's individual assessment. By using Infinity C500 (Drager, Germany) or Datex-Ohmeda S5 Anaesthesia Monitor (Datex-Ohmeda, USA) in the operating room, NIBP was measured in the brachial artery on both arms in every enrolled patient prior to vein cannulation and before the anaesthesia procedures were conducted. Measurements in single patients were not performed simultaneously, but by maintaining the shortest possible period between measurements. After the surgery, two patients were excluded from the study because of intraoperative conversion of the surgery type to a high-risk procedure. 95 patients were analysed. All participants were followed-up for the time of hospitalization for any postoperative complications such as major morbidity, surgical complications, reoperations and mortality. Expected major morbidity included delirium, hypertensive crisis, pneumonia, pulmonary oedema, stroke, myocardial infarction, cardiac arrest, or ICU admission. Surgical complications included, among others, thrombosis, active bleeding, or haematoma or infection of the operated area. Reoperations were classified as any surgical procedure performed after the primary operation before discharge.

Statistics

All calculations were made with StatsDirect (StatsDirect Ltd, Cambridge, UK). For logistic regression, the sample size was estimated to be 91 participants (two tails p = 0.05, test power 80%, OR 2.0). The authors chose to analyse the following variables collected from the patients: arm-to-arm differences in blood pressure (SBP, DBP, MAP), higher value of systolic, diastolic, and mean arterial pressure between the arms, heart rate, urgency of surgery (classified as elective or emergent), ASA score, RCRI score, patient age, gender, and BMI. All data were analysed in terms of the type of variable distribution using the Shapiro-Wilk test and visualization of the quantile-quantile plot. For the normally distributed variables the results are presented as mean, standard deviation (SD) and 95% CI of the mean [95% CI] while for non-normal variables, these were presented as median with interquartile range (IQR) and quartiles [lower quartile — upper quartile]. Categorical variables were presented as proportion and percentage, any differences were investigated with contingency tables and the chi-square test or Fisher's exact test. The authors used the univariate logistic regression to estimate the correlation between tested factors and outcome defined as any postoperative complication. Variables with "relaxed" correlation $p < 0.1$ and those not correlated to each other were considered in stepwise multivariate logistic regression to identify the factors of postoperative risk, with a cut-off of $p < 0.05$. For assessing the differences in hospitalization time between the group of patients with postoperative complications and a group of patients without postoperative complications, Kaplan Meier estimator curves and log-rank test were used. The results are presented as hazard ratios (HR) with 95% CI.

Results

Among 99 cases in the final step, a total of 95 patients were analysed, comprising 26 females and 69 males aged over 52 years. All of the patients had atherosclerosis, 77 patients (81%) were also treated for hypertension, 85 patients (89.5%) were current smokers. Summary of demographic and biometric data of the patients is presented in Table 1. The most common type of surgical operation was endarterectomy with patch angioplasty, which was performed in 35 of 95 patients (36.8%). The second most common operation was a femoropopliteal bypass performed 29 times (30.5%). No surgical revascularization was possible in eight patients during the operation (11.3%). The types of surgery among patients with postoperative complications are presented in Table 2. The postoperative complications included occlusion of operated vessels (13.7%; 13/95), local haematoma (4.2%; 4/95), pseudoaneurysm (1%; 1/95), lymphorrhoea (1%; 1/95), abscess (2.1%; 2/95), delirium (1%; 1/95), stroke (1%; 1/95), myocardial infarction with ICU admission (1%; 1/95). Twenty-one patients (22.1%) required reoperation. All patients were discharged from the hospital. Among the patients with a low-risk complication status (RCRI ≤ 1 pt) undergoing peripheral vascular surgery, there was not found any correlation between overall postoperative complications and blood pressure differences (neither systolic, diastolic nor mean) between the arms ($p > 0.05$). Among the tested variables, three

Table 1. Patient characteristics

		Uncomplicated postoperative course (n = 71)	Complicated postoperative course (n = 24)	p
Age (years)		68.8 (SD 7.7) [67.0–70.6]	66.9 (SD 9.4) [62.9–70.8]	NS (0.3)
Gender	F	22 (31.0%)	4 (16.7%)	NS (0.2)
	M	49 (69%)	20 (83.3%)	NS (0.2)
BMI (kg/m^2)		24.6 (SD 4,8) [22,8–27,7]	24,8 (SD 4,7) [23,3–28,0]	NS (0.5)
IHD/CAD		29.6% (21/71)	16.7% (4/24)	NS (0.2)
MI		8.5% (6/71)	4.2% (1/24)	NS (0.7)
CABG		14.1% (10/71)	0% (0/24)	NS (0.06)
CKD		9.9% (7/71)	0% (0/24)	NS (0.2)
DM2		18.3% (13/71)	8.3% (2/24)	NS (0.3)
Stroke		5.6% (4/71)	0% (0/24)	NS (0.6)
Inter-arm difference (mm Hg)	SBP	9 (IQR 13) [4–17]	9 (IQR 10.5) [4–14.5]	NS (0.4)
	DBP	6 (IQR 8) [3–11]	4 (IQR 8) [2–10]	NS (0.3)
	MAP	7 (IQR 10) [4–14]	6.5 (IQR 8) [2.5–10.5]	NS (0.2)
Maximal value (mmHg)	SBP	161.4 (SD 24.9) [155.5–167.3]	170.5 (SD 28.1) [158.6–182.3]	NS (0.1)
	DBP	84.7 (SD 12.5) [81.7–87.6]	91.1 (SD 9.4) [87.2–95.1]	< 0.05
	MAP	115.7 (SD 15.4) [112.1–119.3]	123.2 (SD 17.20) [116.0–130.5]	NS (0.2)
Urgency		2/71 (2.8%)	7/24 (29.2%)	< 0.01
Hospitalization time (days)		4(IQR 2) [3–5]	7(IQR 3) [5–8]	< 0.01
ASA (I / II / III / IV)		0 / 13 (18.3%) / 52 (73.2%) / 6 (8.5%)	0 / 7 (29.2%) / 17 (70.8%) / 0	NS (0.1)

Quantitative variables are provided as mean or median, (SD or IQR), [95% CI or quartiles]; qualitative variables are provided as relative frequency and proportions. Gender — F —female / M —male; BMI — body mass index; IHD — ischemic heart disease; CHD — coronary artery disease; MI — previous myocardial infarction; CABG — coronary artery bypass grafting; CKD — chronic kidney disease; DM2 — diabetes mellitus type 2 and insulin therapy, STROKE — both ischaemic and haemorrhagic stroke; SBP — systolic blood pressure; DBP — diastolic blood pressure; MAP — mean arterial pressure); ASA — American Society of Anaesthesiologists Physical Status Classification System; SD — standard deviation; 95% CI — 95% confidence interval; IQR — interquartile range; NS — not significant

Table 2. Type of surgery

	Uncomplicated postoperative course (n = 71)	Complicated postoperative course (n = 24)	p
Endarterectomy with patch angioplasty	38.0% (27/71)	33.3% (8/24)	NS (0.8)
Femoro-popliteal bypass	33.8% (24/71)	20.8% (5/24)	NS (0.3)
Femoro-popliteal bypass (silver)	1.4% (1/71)	4.2% (1/24)	NS (0.4)
Endovascular surgery	12.7 (9/71)	41.7% (10/24)	< 0.05
Arteriography / no possibility of revascularization	11.3% (8/71)	0% (0/24)	NS (0.2)
Femoro-femoral crossover bypass	2.8% (2/71)	0% (0/24)	NS (0.9)

The frequency of procedure is expressed as a percentage and proportion; NS — not significant

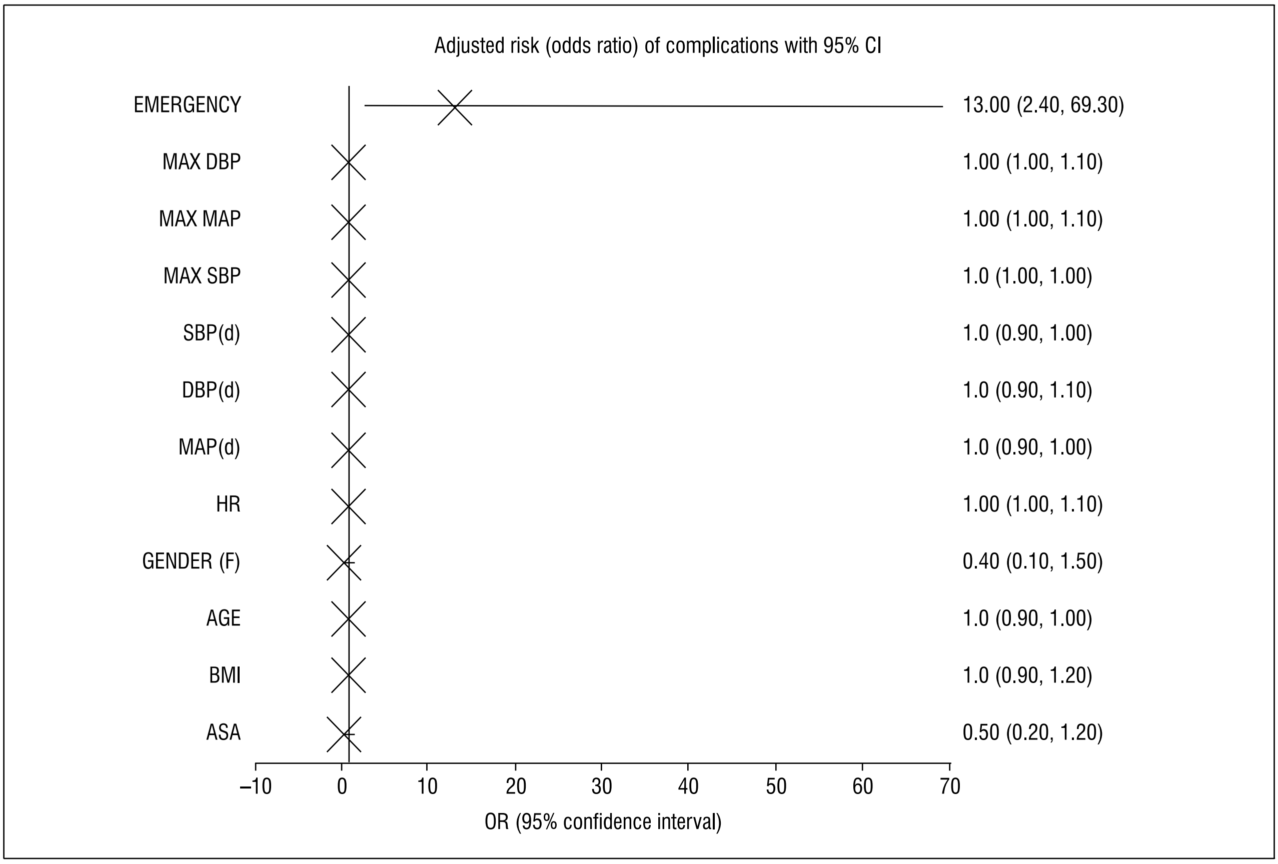

Figure 2. Risk factors of postoperative complications

correlates of surgical complications with P < 0.1 were subsequently analysed in multivariate logistic regression - the urgency of surgery, higher values of measured DBP, and MAP. calculations were performed separately for DBP and MAP. No relevant correlation was found between postoperative complications and elevated diastolic blood pressure (OR 1.04; 95%CI 1.00-1.09; p = 0.04), neither with MAP (p > 0.05). Patients who underwent emergent surgery had highly increased risk of postoperative complications [OR 13.0; 95% CI 1.4 to 69.3; p < 0.01]. The hazard ratio of hospitalization time between groups of patients with postoperative complications and without complications was estimated to be 2.5 (95% CI 1.7 to 3.7; p < 0.01). All tested risk factors are presented in Figure 2. The Kaplan Meier curve of hospital stay time can be found in Figure 3.

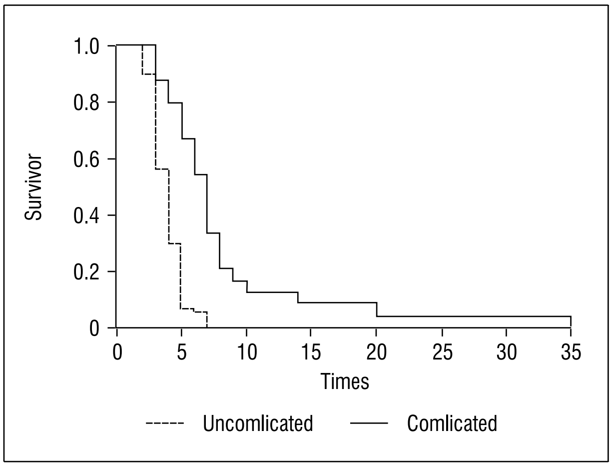

Figure 3. Kaplan Meier curve of hospital stay time. Hazard ratio 2.5 (95%CI 1.7 to 3.7; p < 0.01)

Discussion

The arterial blood pressure difference between the arms was first described by Cyriax in 1920, and it is considered to be a risk factor for cardiovascular disease and overall mortality in the long-term period, but the impact on postoperative complications is still uncertain [4–6]. Results from our study showed no correlation between arm-to-arm blood pressure difference and short-term postoperative complications. Moreover, we did not establish any relevant correlations between elevated diastolic blood pressure and postoperative complications. Other studies on patients undergoing surgery are limited and the outcomes are ambiguous. Belen et al. revealed that increased intra-arm SBP is closely related to the development of myocardial injury after noncardiac and nonvascular surgery [7]. Results from Mazzeffi's study suggest that increased arterial pulse pressure is not associated with mortality after peripheral bypass surgery [8]. Venkatesan's cohort study showed that diastolic hypertension was associated with a clinically irrelevant increased risk of postoperative mortality with an OR of 1.07 [9]. Weksler et al. revealed that elevated diastolic blood pressure in the theatre is not a risk factor for cardiovascular complications and mortality after surgery [10], but on the other hand, Wax and colleagues suggested that i ncreased preinduction SBP, as well as intraoperative DBP lower than 85 mm Hg, can be independent predictors of troponin elevation and death [11]. Monk et al. showed that only intraoperative hypotension, and not hypertension, is associated with increased perioperative mortality [12]. A long-term positive relationship between blood pressure values and cardiovascular events among the participants of the Framingham Heart Study was cited by Weinberg et al. Authors reported that interarm systolic blood pressure during 13 years follow-up was associated with an increased hazard of cardiovascular events but not mortality [13]. Meta-analysis of non-invasive studies made by Clark et al. showed that differences in SBP between the arms greater than 15 mm Hg seems to be a useful indicator of peripheral vascular disease and is highly correlated with cerebrovascular disease but not with coronary artery disease. Results from his study indicate that any correlation of arm-to-arm difference in DBP and non-fatal events or death can be considered negligible [2]. NICE clinical guideline for hypertension states that a difference in systolic blood pressure less than 10 mm Hg can be regarded as normal, while a difference greater than 10 mm Hg is found in 40.3% patients after stroke, 11.2% patients suffering from hypertension and 7.4% with diabetes [14–16]. In patients with high cardiovascular risk, inter-arm blood pressure difference > 10 mm Hg can occur in more than 38% of the population [13]. In our study, systolic blood pressure asymmetry > 20 mm Hg and diastolic blood pressure asymmetry > 10 mm Hg was observed in 17.9% (17/95) and 25.2% (24/95) respectively. Additionally, we found that only a minority of our patients (7.4%; 7/95) knew about the difference of pressure between their arms; thus, many patients with actual hypertension can be missed when blood pressure is measured only in one arm. In addition, in vascular surgery, intraoperative decisions made on inappropriate blood pressure measurements can imply serious consequences. This indicates the need for preoperative evaluation of blood pressure values on both arms and determining the side of blood pressure monitoring during the surgery.

There are several limitations to this study. First, the authors did not measure the blood pressure simultaneously on both arms. Although it is important because it eliminates bias, it is difficult to perform in the operating room [17, 18]. That is why it was decided to measure blood pressure subsequently, as it can be adapted to clinical practice. Secondly, every patient had blood pressure measured during antihypertensive therapy. the effectiveness of this therapy was not analysed, but it cannot be assumed that the influence of pharmacotherapy on the perioperative risk is negligible. Thirdly, stress is an important factor which can disturb blood pressure measurement. Less than half of the patients described their condition as "calm" or "relaxed" (44.2%; 42/95). In our study, anxiety may afflict 55.8% (53/95) of patients and could be the result of inadequate premedication. Only 18 patients (19%) were administered 7.5 mg of midazolam, while 58 patients (61%) were premedicated with 3.75 mg of midazolam and 19 patients (20%) did not receive any premedication. Finally, this study was designed to find only a strong, clinically relevant correlation, as only such correlation should cause a change in perioperative management. To minimalize covariates (and therefore bias), low risk patient population was investigated to determine the impact of a high blood pressure difference between the arms on overall postoperative complications. Thus, these observations refer to a specific population of patients with atherosclerosis and the extrapolation of the results to the general population should be considered with care.

Conclusions

There is no apparent correlation between inter-arm blood pressure differences and postoperative complications in vascular surgery patients.

Measurement of blood pressure in both arms is a crucial part of pre-assessment visits in patients scheduled for vascular surgery and is essential in adequate monitoring during and after the operation.

Emergency operations significantly increase the risk of postoperative complications and the duration of hospital stay. Further investigations are needed to assess the potential risk factors associated with this population of patients.

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