

Preoperative clinical and renal ultrasonography variables associated with improved systolic and diastolic blood pressure reduction after renal artery stenting

Type

Research paper

Keywords

prediction models, atherosclerotic renal artery stenosis, responders, blood pressure improvement

Abstract

Introduction

Response to stent-assisted angioplasty (PTA) in hypertensive patients with atherosclerotic renal artery stenosis (ARAS) is unpredictable. Therefore, the present study aimed to search for preoperative clinical and renal ultrasonography variables associated with systolic (SBP) and diastolic blood pressure (DBP) reduction.

Material and methods

Preoperative clinical assessment and renal ultrasonography were performed in 202 patients who underwent PTA for ARAS (2003–2018). Patients were categorized as responders if decrease of SBP of at least 20mmHg or DBP of 5mmHg was achieved. Logistic regression models, with percentage shares, were evaluated by basic decision characteristics for ultrasonographic and clinical variables.

Results

Logistic regression analysis showed that preoperative SBP ≥ 145 mmHg (OR, 20.0 [95%CI 8.67–46.2], $p < 0.001$), (2) baseline DBP > 82 mmHg (OR, 3.46 [95%CI 1.61–7.42], $p = 0.001$), (3) prior myocardial infarction (OR, 3.14 [95%CI 1.09–9.0], $p = 0.033$), and (4) Renal-Aortic-Ratio > 5.1 (OR, 2.67 [95%CI 1.20–6.0], $p = 0.016$) predicted the SBP response, with respective influence shares of 69.8%; 12.1%; 10.9%; and 7.2%.

The DBP response was associated with (1) baseline SBP > 145 mmHg (OR, 3.79 [95%CI 1.87–7.70], $p < 0.001$), (2) baseline DBP > 82 mmHg (OR, 6.09 [95%CI 2.88–12.9], $p < 0.001$), (3) ARAS progression (OR, 0.32 [95%CI 0.09–1.07], $p = 0.062$), (4) contralateral kidney length > 106 mm (OR, 0.43 [95%CI 0.22–0.86], $p = 0.017$), and (5) bilateral PTA (OR, 2.39 [95%CI 1.08–5.27], $p = 0.03$), with respective shares of 21.8%; 35.0%; 18.2%; 13.3% and 11.8%.

Conclusions

Current study identified clinical and ultrasonographic characteristics of patients who are likely to respond to PTA for ARAS. The RAR and contralateral kidney size may enhance prediction of response likelihood.

Preoperative clinical and renal ultrasonography variables associated with improved systolic and diastolic blood pressure reduction after renal artery stenting

Short title: response to renal artery stenting

Competition of interest: none

Type of research: the single-center retrospective cohort study

Preprint

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Conclusions: current study identified clinical and ultrasonographic characteristics of patients who are likely to respond to PTA for ARAS. **The RAR and contralateral kidney size may enhance prediction of response likelihood.**

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Preprint

Introduction

Atherosclerotic renal artery stenosis (ARAS) is a frequent finding, especially in older patients and those with cardiovascular comorbidities [1,2]. While even non-obstructive renal artery lesions, relate to higher incidence of cardiovascular death (CVD), all-cause mortality and cardiovascular ischemic events, therapy with statin, **angiotensin-II-receptor antagonists (sartans)** and angiotensin-converting enzyme inhibitors (ACEI) may decrease this risk [3,4,5]. On the other hand, ACEI may also offer renal function (RF) preservation in medically treated patients with primary hypertension, but in those with ARAS, use of ACEI and sartans suppress renal function [5,6].

Although, medical treatment is a first line management in patients with renovascular hypertension [4], recent population-based data show that blood lowering therapy is insufficient in about 30% of hypertensive patients leading to masked uncontrolled blood pressure elevations [7]. This blood pressure instability is most frequent in patients with cardiovascular comorbidities, and those who require **multiple** antihypertensive medications [7,8].

Lack of sufficient blood pressure control and progression of renal failure in the presence of ARAS promotes patients' referral to endovascular intervention with stent-assisted angioplasty (PTA) [9,10,11]. Although, systolic (SBP) and diastolic blood pressure (DBP) lowering following PTA for ARAS is associated with better **outcomes**, the effect of PTA on blood pressure response is difficult to predict [9,10]. **For example** randomized trials demonstrate mild or no advantage of PTA plus best medical therapy (BMT) over BMT alone in regard to blood pressure or renal function improvement in all-comers with ARAS [6,7,8,12]. On the other hand, **observational studies** reported potential advantage of PTA of ARAS in terms of cardiovascular death (CVD) and all-cause mortality risk decrease, blood pressure lowering or even hypertension cure [13,14,15].

In summary, the picture of the individual patient with ARAS who may have advantage from PTA of ARAS is blurred. The ongoing clinical issue is how to predict responders of PTA in terms of BP improvement, preferably also associated with reduction of cardiovascular risk [9,16].

Renal color-coded dopler ultrasonography (DUS) **is used to** identify patients with ARAS, and it is recommended in class I according to guidelines [17]. However, whether DUS can enhance patients selection to PTA of ARAS, and whether it has any predictive value in assessment the probability of favorable post-PTA response in terms of SBP and DBP lowering remains undetermined.

Data regarding role of the preoperative renal ultrasonography and clinical variables assessment as potential predictors of PTA response are **scarce** [18,19]. Whilst the data on kidney size, renal resistive index or stenosis parameters may indicate degree of renovascular system damage, kidneys and renal vasculature may be also indicative of reversibility of the process. ARAS-induced neurohormonal activation of the sympathetic nervous system and the renin-angiotensin-aldosterone system is a key factor associated with accelerated hypertension, progressive renal impairment and cardiovascular instability [20].

Therefore, **the aim of the present study was** to investigate what ultrasonographic and clinical features distinguish subjects, who are responders vs. non-responders of PTA of ARAS **in terms of reducing SBP and DBP**.

Material and methods

Study population. From January 2003 to December 2018, 202 patients with anatomically and / or functionally significant ARAS (**50% to 99%** lumen diameter stenosis on quantitative angiography), concomitant accelerated or refractory hypertension on at least 3

antihypertensive medications, and /or RF impairment underwent PTA for ARAS. Exclusion criteria **included**: non-atherosclerotic renal artery stenosis (9 patients with fibromuscular dysplasia) and non-diagnostic renal ultrasonography (1 patient).

The institutional review board approved the protocol and all patients gave written informed consent.

Assessment of renal flow parameters and kidneys on renal color-coded Doppler ultrasonography (DUS)

The DUS was performed with the patient in a supine and/or left or right lateral position, depending on which renal artery was assessed. Assessments were performed by 2 operators, using a high-resolution ultrasonograph (TOSHIBA APLIO with a 3.5–5MHz probe). The DUS assessment included following parameters: systolic velocity in aorta, peak-systolic (PSV) and the end-diastolic velocity (EDV) in the index renal artery, renal-aortic-ratio (RAR), resistive index in the renal artery (RI) and intra-renal resistive index (IRI). The pole-to-pole kidneys length of the index and contralateral kidney were measured.

Renal artery stenting

The detailed PTA procedure was described previously [16]. **In brief, PTA was performed either for angiographically significant ARAS exceeding at least 70% diameter stenosis on quantitative angiography, or in cases with angiographic 50-69% diameter stenosis (9 patients) after hemodynamic confirmation of the stenosis severity by means of a fractional flow reserve (<0.8) performed with papaverine.**

All patients received dual antiplatelet therapy before the procedure, which was continued for 3 months after PTA, **then** single antiplatelet therapy was continued indefinitely. The choice of stent type and route of vascular access was left to the individual operator's discretion. Distal embolic protection device was used in one procedure.

Preoperative and **follow-up** blood pressure assessment

SBP and DBP data were collected on patient admission to the Department, prior to any intervention, immediately after the signed informed consent was obtained from the patients.

Blood pressure values were measured according to guidelines published by the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure VII [21]. Hypertension was defined as SBP \geq 140mmHg and/or DBP \geq 90mmHg.

The **follow-up** evaluation of SBP and DBP was conducted before discharge and at 6 and 12 months following PTA. BP evaluation was based on at least 2 BP measurements in a patient in a sitting position with a 5 minute intervals during outpatient office visits.

Subjects were categorised as responders or non-responders. The SBP responders were defined as patients demonstrating decrease of SBP of at least 20 mmHg or higher, and DBP of at least 5 mmHg or higher at 12 months **follow-up**. The above cut-offs were adopted from previously published study, as associated with reduced risk of cardiovascular events after PTA for ARAS [16].

Statistical analysis

Predictors of SBP and DBP improvement after PTA

In the initial univariate regression analyses, we specified potential independent prognostic markers of blood pressure response, including clinical, DUS, and angiographic variables. Variables with p-level <0.01 from univariate analysis were included in the logistic multivariate regression model to calculate adjusted ORs for improvement in each of 2 categories (SBP or DBP responder).

We next specified our predicting models of SBP and DBP response by step-wise elimination procedure. Decision characteristics, such as sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) have been evaluated on the basis of classification of the learning set. The percentage shares of each independent variable in each of built models were calculated.

A receiver-operating characteristic (ROC) analysis was performed to determine the optimal cut-off values of continuous variables of DUS, preoperative SBP, DBP, as well as angiographic parameters (lumen diameter stenosis, reference diameter) in predicting SBP and DBP response (as a dichotomous variable responder vs non-responder) after PTA.

Angiographic and procedural parameters of index renal artery (PTA of single-functional, unilateral or bilateral PTA) were also analyzed.

Statistical analyses were performed with Statistica 13.0 software. Statistical significance was assumed at $p < 0.05$.

Results

The detailed patients characteristics is shown in Table I. Study participants were characterised with high prevalence of atherosclerotic risk factors and comorbidities, a substantial number of patients had concomitant atherosclerotic lesions in the other major arterial beds.

Blood pressure response

Following PTA, the median SBP and DBP decrease was -14 mmHg (IQR, -26; 2.3) and -5 mmHg (IQR, -12; 2.0), respectively. The overall mean values of SBP and DBP after PTA in comparison to baseline values were 134.3 ± 17.8 vs 150 ± 25 mmHg ($p < 0.001$) and 75.5 ± 10.8 vs 83 ± 13 mmHg ($p < 0.001$), respectively. Out of 202 patients, SBP decrease of at least 20 mmHg and DBP decrease of at least 5 mmHg or higher were observed in 104 (51.5%), and 135 (66.8%) patients respectively, resulting in hypertension cure (blood lowering therapy withdrawal) in 4 (2.0%) patients, blood lowering regiments reduction in 31 (15.3%) patients. The overall number of blood lowering medications was 3.61 ± 1.3 before PTA vs 3.33 ± 1.3 after the procedure ($p = 0.025$).

Univariate logistic regression analysis, indicated several parameters that may have impact on response likelihood (Table II).

For SBP decrease of at least 20mmHg or higher at 12-months, the following cut-offs from ROC analyses were established: baseline SBP >145mmHg (sensitivity: 89%, specificity: 78%) and DBP >82 mmHg (sensitivity: 68.9%, specificity: 85.9%), ARAS diameter stenosis >67% (sensitivity: 76.5%, specificity: 46.1%), use of 5 and more blood pressure lowering medications before PTA (sensitivity: 24%, specificity: 84%), as well as the following DUS parameters: IRI <0.7 (sensitivity: 36.6%, specificity: 80.6%), RAR >5.12 (sensitivity: 48.4%, specificity: 69.4%), and contralateral kidney length \geq 120 mm (sensitivity: 16.4%, specificity: 86%), (Figure 1A).

As a result of univariate logistic regression analysis, multivariate analysis confirmed four independent predictors of SBP response: (1) baseline SBP >145mmHg (OR,20.0 [95%CI 8.67–46.2], $p<0.001$), (2) baseline DBP >82 mmHg (OR,3.46 [95%CI 1.61–7.42], $p=0.001$), (3) prior myocardial infarction (OR,3.14 [95%CI 1.09–9.0], $p=0.033$), and (4) Renal-Aortic-Ratio (OR,2.67 [95%CI 1.20-6.0], $p=0.016$), with the sensitivity, specificity, PPV and NPV of the model of 82%, 86.3%, 82% and 86.3%, respectively. The calculated influence of these variables on SBP response probability were as follows: 69.8%; 12.1%; 10.9%; and 7.2%, respectively (Figure 2A).

For DBP decrease of at least 5mmHg or more, ROC cut-offs were as follows: baseline SBP >145mmHg (sensitivity: 75.6%, specificity: 73.7%) and DBP >82mmHg (sensitivity: 72%, specificity: 84.8%), preoperative use of 5 or more blood pressure lowering medications (sensitivity: 21.2%, specificity: 82.8%), and contralateral kidney length >106 mm (sensitivity: 64%, specificity: 54.6%) (Figure 1B).

The final prediction model for DBP decrease \geq 5mmHg included: (1) baseline SBP >145 mmHg (OR,3.79 [95%CI 1.87–7.70], $p<0.001$), (2) baseline DBP >82 mmHg (OR,6.09 [95%CI 2.88–12.9], $p<0.001$), (3) ARAS progression (OR,0.32 [95%CI 0.09–1.07], $p=0.062$), (4) contralateral kidney length>106mm (OR,0.43 [95%CI 0.22–0.86], $p=0.017$), and (5)

bilateral PTA (OR,2.39 [95%CI 1.08–5.27], $p=0.03$), with respective influence shares of 21.8%; 35.0%; 18.2%; 13.3% and 11.8% (Figure 2B). The sensitivity, specificity, PPV and NPV of the predictive model were 76%, 77.8%, 80.7% and 72.6%, respectively.

Discussion

Arterial stiffness, endothelial dysfunction, atherosclerosis, and oxidative stress all contribute to the development of systemic hypertension [22]. Also, ARAS can result in various cardiopulmonary complications mostly through activation of neurohormonal pathways that result in fluid overload and systemic hypertension [20]. Unfortunately, correction of ARAS with PTA does not mean automatic lowering of SBP and DBP [6,9,10,11,23]. In fact, PTA for ARAS doesn't lead to subsequent reduction in SBB and/or DBP in about 30 to 60% of subjects [5,9,10,11,16].

In the present study, hypertension cure (blood lowering treatment withdrawal) was achieved in 2.0% of subjects, while blood pressure reduction above the predefined thresholds with subsequent treatment reduction was possible in 15% of subjects. In remaining patients, SBP decrease of at least 20 mmHg and DBP decrease of at least 5 mmHg or higher was observed in 34%, and 49.5% of patients, respectively (which did not result in the reduction of numbers or doses of antihypertensive treatment), whereas no SBP and DBP reduction (or even increase) was found in 48.5% and 33.2% of subjects, respectively. In line with our results, also in patients with primary systolic hypertension the higher proportion of responders is observed in DBP than in SBP [24].

We analyzed parameters associated with SBP and DBP reduction separately, as the clinical significance of SBP and DBP on cardiovascular risk differs, moreover, elevations in SBP frequently occur without elevations in DBP [22,25]. The meta-analysis performed by Lewington et al. revealed that a 20 mmHg reduction in usual SBP was associated with

significantly lower risk of death from stroke (hazard ratios, 0.36–0.67) and ischemic heart disease (HR, 0.49–0.67) [25].

SBP seems also superior to DBP as a predictor of adverse renal outcomes in patients with diabetic nephropathy. Pohl et al found that patients who lowered SBP by 20 mmHg had decreased relative risks of doubling of serum creatinine (HR, 0.79) and progression to end-stage renal disease (HR, 0.52) [26]. This SBP lowering effect was maintained continuously down to a level of 120 mmHg, whereas SBP lower than 120 mmHg was associated with huge increase in the all-cause mortality [26].

As concerns DBP lowering therapy, the target DBP values to which DBP lowering therapy is recommended, should range between 70 and 80 mmHg [27]. This target DBP values are associated with the lowest risk of major vascular events as well as stroke [27].

In the ARAS context, in our former study, reduction of SBP by least 20 mmHg and DBP by 5 mmHg following ARAS-PTA was associated with improved cardiovascular prognosis [16].

However, it is difficult to predict the probability of SBP or DBP response following PTA for ARAS in patients with renovascular disease [9,10,11,18]. As a consequence of flawed randomized trial, in which results were based on intention-to-treat, physician selection of patients uncertain (subsequently excluding patients most likely to benefit from revascularization), overestimation of ARAS degree or creating a selection bias against severe ARAS, guidelines largely restricted patient' selection to PTA [12,13,14]. PTA is currently recommended to patients presented with resistive to pharmacotherapy arterial hypertension on 3 maximally tolerated medications, 1 of which is diuretic [23], episodes of sudden-onset pulmonary flash edema [17,23], and/or accelerating decline in renal function [23].

Some authors point out patients who are likely to have a favorable blood pressure response following PTA against recommendations [28].

In the present study, we calculated a percentage shares (individual impact) of identified independent parameters on blood pressure reduction likelihood, such as preoperative SBP and DBP values, bilateral PTA, DUS criteria of ARAS severity and kidney viability.

Our main finding, in accordance to the guidelines, is that we cannot expect improvement in patients with well-controlled SBP and DBP, unless SBP and DBP values exceed 145 and 82 mmHg respectively, despite best medical treatment. The preoperative SBP >145 mmHg and DBP >82 mmHg had a share of around 70% in predicting SBP lowering after PTA, whereas preoperative DBP >82 mmHg had a 35% share for DBP decrease likelihood. The RAR>5.12 had an impact of 7% on SBP reduction, whereas bilateral PTA of 12% and contralateral kidney length >106 mm of 13% on DBP reduction.

Role of preoperative SBP and DBP in the post-interventional blood pressure lowering probability was also observed by the others [11,20,23,28,29,30]. Modrall et al. identified that preoperative DBP > 90mmHg (OR,13.9; p<0.001) was an independent predictor of a positive blood pressure response [29]. In Kim et al study, 77.8% of patients with preoperative mean SBP of 152 mmHg improved SBP (mean post-intervention SBP 134 mmHg), while there was no difference between preoperative (77 mmHg) and postoperative mean DBP values [30].

Many authors pay attention to the ARAS degree [11,28,30,31,32].

In our present study, SBP decrease of at least 20 mmHg or higher was associated with ARAS diameter stenosis >67% according to ROC analysis (sensitivity of 76.5%, specificity of 46.1%), **nonetheless ARAS severity not proved to be an independent indicator of SBP improvement following PTA.** This is in line with findings that ARAS greater than 70-80% is necessary to activate intra-renal neurohormonal system, thus renovascular hypertension is less probable in patients with lesser degree of ARAS [33].

However, the visual estimate of ARAS severity may be inaccurate [31,34], and this limitation can be overcome through the assessment of the renal fractional flow reserve, or

translesional pressure gradient and renal frame count [31,32,33]. Clinical studies showed improved blood pressure response when treating lesions with resting or hyperemic pressure gradients $>20\text{mmHg}$ [31,32]. In our present study, papaverine-induced hyperemic pressure gradients $>20\text{mmHg}$ were identified as potentially important predictors of SBP response in univariate analysis, but failed to show their role in the multivariate logistic regression analysis.

Finally, ARAS severity can be estimated from DUS parameters, such as velocities in aorta and renal artery. Identified in the present study preoperative RAR >5.12 as marker of SBP lowering, is in fact parameter of truly severe ARAS. Some authors postulate important role of pre-operative renal and intra-renal RIs and kidney size assessment, as markers of arterial stiffness and renal function decline reversibility [18]. RI higher than >0.8 was associated with a lower probability of BP or renal function improvement after renal intervention [18]. Also, in our present study, resistive indexes and kidneys size occurred important in predicting either the SBP/DBP response in at least univariate logistic analysis. **In conclusion**, renovascular hypertension that is controlled medically should not undergo ARAS-PTA, as there is no added benefit of blood lowering. Patients with SBP of 145 mmHg or higher and DBP of at least 83 mmHg or higher, despite medical treatment on at least 3 antihypertensive medications failed are likely to benefit from renal artery stenting. Adding renal ultrasonography parameters offers little add, however, information on the RAR and contralateral kidney size may enhance probability of favorable SBP and DBP response to PTA for ARAS.

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Table I. Baseline characteristics of 202 study participants with atherosclerotic renal artery stenosis according to clinical, renal Doppler ultrasonography and angiographic status

Men, n (%)	111 (54.9)
Age (years), mean \pm SD	66 \pm 10
Number of blood lowering medications, mean \pm SD	3.61 \pm 1.30
Hypertension, n (%)	202 (100)
Hypercholesterolemia, n (%)	194 (96)
Diabetes mellitus, n (%)	68 (33.7)
Current smoking, n (%)	96 (47.5)
Prior ischemic stroke, n (%)	22 (10.9)
Prior myocardial infarction, n (%)	33 (16.3)
Prior pulmonary flash oedema, n (%)	11 (5.4)
Prior hypertension crisis, n (%)	95 (47)
Co-existing atherosclerotic lesions >50%:	
Coronary artery disease (>50%), n (%)	139 (68.8)
Internal carotid artery disease (>50%), n (%)	77 (38.1)
Peripheral athero-occlusive disease (>50%), n (%)	69 (34.1)
Baseline blood pressure and renal function parameters:	
Systolic blood pressure (mmHg), mean \pm SD	150 \pm 25
Diastolic blood pressure (mmHg), mean \pm SD	83 \pm 13
Serum creatinine (μ mol/L), mean \pm SD	129.5 \pm 58
eGFR (ml/min/1.73 m ²), mean \pm SD	55.2 \pm 23
Angiographic and procedural parameters:	
Degree of renal artery lumen stenosis (%), mean \pm SD	74 \pm 14
PTA of unilateral renal artery stenosis, n (%)	137 (67.8)

PTA of bilateral renal artery stenosis, n (%)	35 (17.3)
PTA of single functional kidney, n (%)	30 (14.9)
Stent implantation, n (%)	202 (100)
Stent diameter (mm), mean \pm SD	5.74 \pm 0.95
Stent length (mm), mean \pm SD	16.3 \pm 4.2
Ultrasonographic parameters:	
Aortic systolic velocity (m/s), mean \pm SD	0.86 \pm 0.19
Peak-systolic velocity in index renal artery (m/s), mean \pm SD	3.9 \pm 1.23
End-diastolic velocity in index renal artery (m/s), mean \pm SD	1 \pm 0.46
Renal-aortic-ratio for index renal artery, mean \pm SD	4.73 \pm 1.75
Resistive index in the index renal artery, mean \pm SD	0.74 \pm 0.06
Intrarenal resistive index in the index kidney, mean \pm SD	0.64 \pm 0.09
Index kidney length (mm), mean \pm SD	99.4 \pm 11.7
Contralateral kidney length (mm), mean \pm SD	102.4 \pm 16.9

Table II. Table II. Univariate logistic regression analysis for responders vs non-responders in systolic and diastolic blood pressure at 12-months following stent-assisted angioplasty for atherosclerotic renal artery stenosis

	Systolic blood pressure decrease ≥ 20mmHg	Diastolic blood pressure decrease ≥ 5mmHg
	OR (95%CI), P-value	OR (95%CI), P-value
Age	1.04 (0.91-1.20), .561	0.99 (0.86-1.14), .906
Female gender	1.12 (0.97-1.28), .128	0.88 (0.76-1.01), .069
Number of blood lowering agents	0.90 (0.81-0.99), .034	0.99 (0.86-1.14), .935
Diabetes	1.02 (0.89-1.18), .746	1.05 (0.91-1.21), .496
Hyperlipidaemia	1.06 (0.92-1.22), .415	0.96 (0.84-1.11), .614
Smoking	1.01 (0.88-1.16), .909	1.02 (0.89-1.17), .792
Body Mass Index	1.15 (0.97-1.36), .104	1.07 (0.90-1.26), .441
Previous myocardial infarction	1.22 (1.07-1.40), .005	0.95 (0.83-1.09), .477
Previous stroke	1.00 (0.86-1.15), .938	1.07 (0.93-1.23), .364
Prior pulmonary flash oedema	0.94 (0.82-1.08), .374	0.94 (0.82-1.08), .386
Prior hypertensive crisis	1.06 (0.92-1.22), .427	0.94 (0.81-1.08), .372
Documented ARAS progression	1.14 (1.00-1.31), .050	1.17 (1.03-1.34), .020
Internal carotid artery stenosis	1.16 (1.01-1.15), .039	0.96 (0.84-1.11), .621
Coronary artery disease	0.93(0.81-1.07), .309	0.87 (0.75-1.00), .056
Lower extremity occlusive disease	1.00 (0.87-1.15), .657	0.98 (0.85-1.12), .743
Baseline systolic blood pressure	1.97 (1.79-2.16), .000	1.41 (1.20-1.67), .000

Baseline diastolic blood pressure	1.44 (1.28-1.63), .000	1.20 (1.06-1.36), .006
Baseline creatinine	1.12 (0.94-1.33), .202	0.95 (0.84-1.08), .455
Baseline eGFR	0.92 (0.81-1.05), .235	0.99 (0.87-1.13), .862
Bilateral vs. Unilateral PTA	1.09 (0.96-1.25), .199	1.24 (1.08-1.43), .003
PTA of single functional kidney	1.25 (1.09-1.44), .002	1.22 (1.07-1.39), .002
Degree of renal artery stenosis	0.83 (0.73-0.94), .005	0.98 (0.85-1.13), .780
Papaverine-induced renal flow	2.20 (1.35-3.59), .020	0.80 (0.37-1.74), .591
Stent diameter	0.97 (0.85-1.10), .634	1.12 (0.98-1.27), .104
Stent length	0.69 (0.61-0.79), .578	1.07 (0.94-1.22), .914
Ultrasonography parameters		
Peak-systolic velocity in ARAS	0.83 (0.68-1.02), .073	1.68 (0.55-5.10), .415
End-diastolic velocity in ARAS	0.95 (0.78-1.16), .618	1.69 (0.42-6.86), .503
Renal-aortic-ratio	1.27 (1.09-1.47), .002	0.65 (1.19-2.17), .518
Resistive index in ARAS	0.89 (0.77-1.01), .068	1.05 (0.92-1.20), .481
Intrarenal resistive index in the index kidney	0.87 (0.76-0.99), .037	1.09 (0.95-1.24), .217
Index kidney length	1.07 (0.94-1.22), .316	0.94 (0.82-1.07), .344
Contralateral kidney length	1.12 (1.00-1.25), .047	1.25 (1.06-1.47), .008

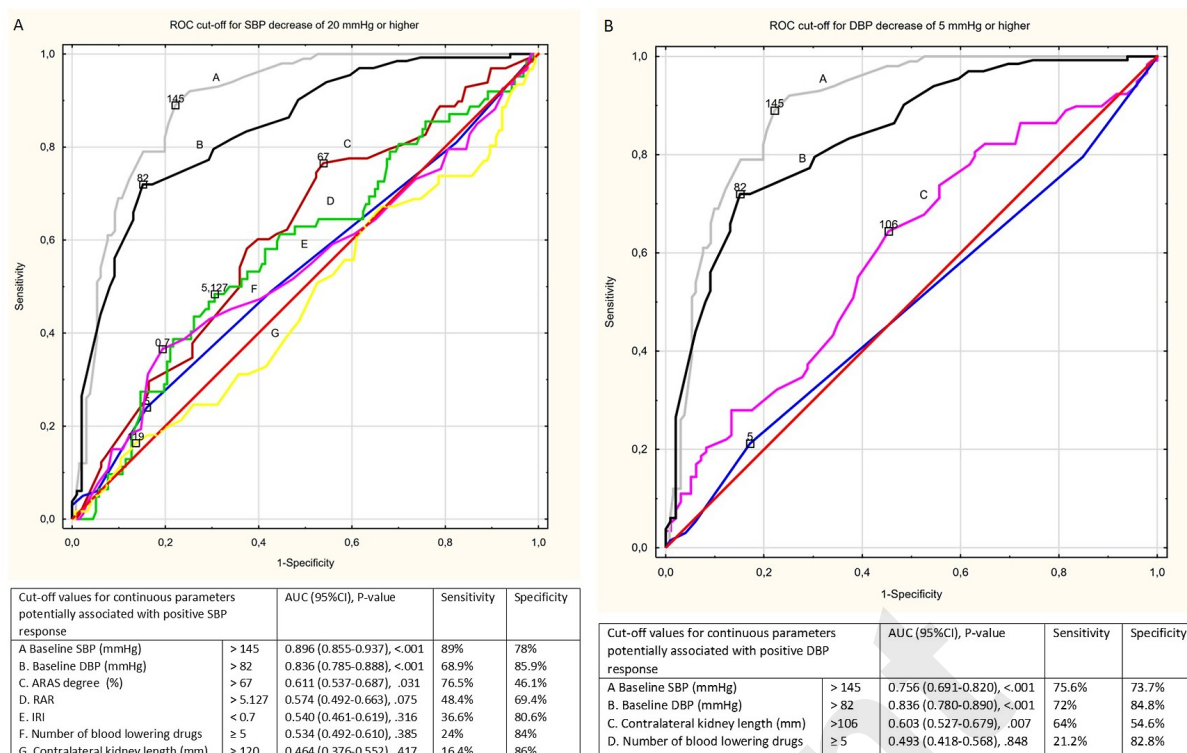
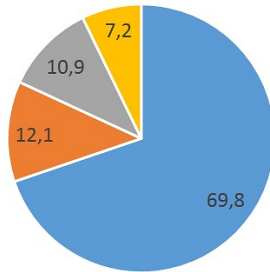


Figure 1. A receiver-operating characteristic (ROC) analysis to determine the optimal cut-off values of continuous parameters for: A – systolic blood pressure (SBP) decrease ≥ 20 mmHg, B – diastolic blood pressure (DBP) decrease ≥ 5 mmHg following PTA. Abbreviations: ARAS - atherosclerotic renal artery stenosis; AUC – area under the curve; DBP - diastolic blood pressure; IRI - intra-renal resistive index; RAR - renal-aortic-ratio; SBP - systolic blood pressure

A

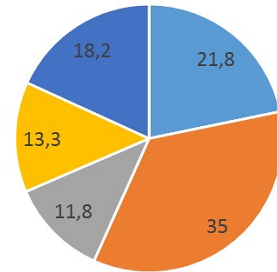
Percentage share in decision tree for
SBP responders



- Baseline SBP > 145 mmHg
- Baseline DBP > 82 mmHg
- Previous myocardial infarction
- Renal-Aortic-Ratio in the index artery on DUS > 5.1

B

Percentage share in decision tree for
DBP responders



- Baseline SBP > 145 mmHg
- Baseline DBP > 82 mmHg
- PTA for bilateral ARAS
- Contralateral kidney length > 106mm
- ARAS documented pregression

Figure 2. Contribution of the independent variables in SBP and DBP response probability: from the multivariate logistic regression variables A - for SBP; B - for DBP