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Follow-up of Pediatric Patients With Renovascular Hypertension in Türkiye

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Abstract

Background

We aimed to evaluate the treatment and follow-up approaches used in children diagnosed with renovascular hypertension (RVHT).

Methods

Data from 91 patients diagnosed with RVHT in 20 centers were evaluated retrospectively. Age, blood pressure, and complaints at admission, imaging methods, medications, surgical intervention methods, subsequent progression of blood pressure, and complications were questioned.

Results

The mean age at admission was 9.7 ± 5.1 years, the systolic blood pressure SDS was 2.24 ± 0.32, and the diastolic blood pressure SDS was 2.03 ± 0.49. Although all patients were diagnosed with at least one angiographic examination, Doppler ultrasonography was normal in 41.7% of the patients. Of the patients, 40.7% had idiopathic renal artery stenosis, 25.3% had fibromuscular dysplasia, 13.2% had Takayasu arteritis, 8.7% had neurofibromatosis, 4.4% had mid-aortic syndrome, and 3.3% had renal artery stenosis in the transplanted kidney. 52.7% of the patients were asymptomatic at the time of diagnosis. 72.3% of the patients were using two or more antihypertensive drugs before surgery. 27.7% had left ventricular hypertrophy. 41.7% of the patients did not undergo any surgical intervention. 30.8% underwent balloon, 5.6% had stents, 1.1% had balloons and stents, 16.4% had angioplasty, 4.4% had patients underwent nephrectomy. The need for antihypertensive drugs decreased or was eliminated in 58.1% of the patients after the procedure. At the last visit, 18.6% were followed without treatment, while 19.7% were using a single antihypertensive drug.

Conclusions

Since most patients with RVHT are asymptomatic at first presentation, it was concluded that blood pressure measurement is very important. In addition, the number of antihypertensives decreased significantly after an interventional procedure.

INTRODUCTION

Renovascular hypertension (RVHT) represents a rare but clinically significant cause of secondary hypertension in the pediatric population [1]. Unlike primary (essential) hypertension, RVHT is characterized by structural or functional abnormalities of the renal vasculature. Stenosis of the renal arteries leads to renal hypoperfusion, triggering the release of renin from the juxtaglomerular apparatus. This initiates the conversion of angiotensinogen to angiotensin I, which is subsequently converted to angiotensin II by angiotensin-converting enzyme (ACE) [2]. Angiotensin II induces vasoconstriction of the renal efferent arterioles, increasing glomerular filtration pressure and systemic arterial pressure, ultimately resulting in activation of the renin-angiotensin-aldosterone system (RAAS) and the development of sustained hypertension [3].

Early and accurate diagnosis of RVHT in children remains challenging, as the condition frequently presents with nonspecific clinical signs and is often discovered incidentally in asymptomatic children with refractory hypertension [4]. Several studies have reported that between 26% and 70% of pediatric RVHT cases are identified during evaluations for resistant hypertension, highlighting the risk of delayed diagnosis and subsequent treatment failure [5].

If left untreated or insufficiently managed, pediatric RVHT significantly elevates the risk of serious long-term cardiovascular complications, including myocardial infarction, stroke, and chronic kidney disease in adulthood. Therefore, prompt diagnosis and appropriate intervention are critical to minimize irreversible target organ damage and improve long-term clinical outcomes.

The optimal management strategy for pediatric RVHT remains a matter of ongoing clinical debate. Medical therapy alone is often inadequate in cases of significant vascular obstruction, necessitating interventional approaches such as percutaneous transluminal renal angioplasty (PTRA) or surgical revascularization. Although surgical interventions were historically regarded as the primary treatment modality, PTRA has gained increasing acceptance in recent years due to its minimally invasive nature and favorable outcomes in selected pediatric populations [6].

In response to these challenges, a national multicenter study was initiated to systematically investigate the clinical characteristics, diagnostic pathways, treatment approaches, and treatment outcomes of children diagnosed with RVHT in our country. Our primary goal is to establish comprehensive, evidence-based clinical follow-up protocols for pediatric RVHT, facilitate the development of management algorithms, and provide valuable data to guide future research and improve long-term prognostic outcomes in this patient population.

MATERIALS AND METHODS

Study Design and Ethical Approval

The study protocol was approved by the Izmir City Hospital Ethics Committee on April 15, 2022 (approval no: 2022/04–43). The study was conducted in accordance with the Declaration of Helsinki and relevant local regulations. Informed consent was not obtained from the patients due to its retrospective design.

Study Population

A total of 20 Pediatric Nephrology Clinics were included in the study. Pediatric patients (0–18 years old) diagnosed with RVHT and followed up in the participating centers were included in the study. Inclusion criteria were (1) confirmed RVHT diagnosis based on clinical, laboratory, and radiological findings; and (2) availability of complete medical records for retrospective data collection. Patients with insufficient clinical data or incomplete medical records were excluded from the analysis.

Data Collection

Demographic data including patient age, gender, body weight, and height at the time of diagnosis were collected. Symptoms at presentation, physical examination findings, blood pressure (BP) measurements, serum electrolytes, and renal function tests were evaluated. Radiologic imaging modalities used for diagnostic confirmation of RVHT such as Doppler ultrasonography, computed tomography angiography (CTA), magnetic resonance angiography

(MRA), and conventional digital subtraction angiography (DSA) were also included. The location of renal artery stenosis (RAS) was documented based on imaging findings.

Clinical Management and Follow-up

Data on antihypertensive treatments used before diagnosis and subsequent interventional procedures (e.g., PTRA, surgical revascularization) were recorded. Information on the type and timing of surgical or interventional procedures was collected. Follow-up duration, BP monitoring results, medication dose adjustments, and clinical outcomes were also documented.

Data Sources

All data were abstracted retrospectively from institutional medical records, electronic health databases, radiology reports, and follow-up notes.

Statistical Analysis

Normality of continuous variables was assessed using the Shapiro–Wilk test. Data are presented as mean ± standard deviation (SD) for normally distributed variables and as median (minimum–maximum) for non-normally distributed variables. Between-group comparisons were performed with the independent-samples t-test or Mann–Whitney U test, as appropriate. Within-group comparisons were analyzed using the paired-samples t-test. Categorical variables were expressed as counts and percentages, and compared using Pearson's chi-square, Fisher's exact, or Fisher–Freeman–Halton tests. Statistical significance was set at $p < 0.05$. Analyses were conducted using IBM SPSS Statistics, Version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Data of 105 patients followed up for RVHT were obtained. However, patients with insufficient data and very short follow-up periods were not included in the evaluation. As a result, 91 patients were included in the study. Patients' demographic data are given in Table 1.

Although all patients were diagnosed with at least one angiographic examination, 38 patients had normal renal Doppler ultrasonographic evaluation. It was learned that 24 patients were diagnosed with magnetic resonance angiography (MRA), 59 patients with computerized tomographic angiography (CTA), and 11 patients with digital subtraction angiography (DSA). Some patients underwent more than one imaging method.

Before treatment, 72.3% of patients were using two or more antihypertensive drugs. The most commonly used antihypertensive agent was calcium channel blockers (35.3%). Beta blockers were second in the list (20.9%), and ACEi/ARBs were third (20%).

Left ventricular hypertrophy was present in 23 (27.7%) of 83 patients evaluated with echocardiography before treatment, retinopathy was present in 26 (28.9%) of 90 patients with fundus examination, and microalbuminuria was present in 8 (8.8%) of 91patients with spot urine examination.

While 38 (41.7%) patients did not undergo any surgical intervention, 28 (30.8%) patients underwent balloon, 5 (5.6%) underwent stent, 1 (1.1%) underwent balloon and stent, and 15 (16.4%) underwent angioplastic surgery. 4

(4.4%) patients underwent nephrectomy.

We classified the patients into three groups: Group 1 (no procedure), Group 2 (balloon ± stent applied), and Group 3 (surgery applied). We did not observe any differences in laboratory values between the groups (Table 2). Since renin, plasma renin activity and aldosterone values were studied in different centers and different numbes of patients, comparison between groups could not be made.

In Table 3, we evaluated the antihypertensive medications used by the patients and their responses. At the beginning, only 7.6% of the patients were not using any medication, while 19.7% were using one medication, 26.3% were using two medications, 25.2% were using three medications, and 20.8% were using four medications. In the final evaluation, the rate of individuals not using medication increased to 18.6%; 19.7% were using one medication, 29.6% were using two medications, 20% were using three medications and 10.9% were using four medications. There was no statistically significant difference between the groups in terms of the distribution of the final number of medications (p=0.334). In addition, as seen in the table, BP decreased or returned to normal by 44.6% in the no-procedure group, 58.8% in the balloon + stent group, and 84.1% in the surgical group The rate at which blood pressure returned to normal was significantly higher in the group that underwent surgery compared to the other two groups (p:0.014).

The mean time for BP to return to normal after the first invasive procedure was 51.0 days.

A second invasive procedure was performed in 11 patients. 5 cases were initially bilateral, and invasive procedures were also performed on the other kidney. Three patients who initially underwent balloon angioplasty had the same procedure repeated. One patient who initially underwent balloon angioplasty had surgical correction performed on the other kidney during follow-up. Another patient who initially underwent surgery had surgical correction performed on the other kidney during follow-up. Two patients underwent grafting in the same vessel (one month and six months after the first procedure), and one patient underwent a second procedure one month later. Another patient with unilateral stenosis who initially underwent balloon angioplasty had nephrectomy performed during follow-up.

During follow-up, two patients who had previously undergone a second balloon angioplasty in the same vessel underwent a third balloon angioplasty; one of these underwent a fourth procedure involving graft implantation.

No procedure was performed in 5 of the 24 bilateral RAS cases. 13 patients underwent initial balloon + stent placement, and only 4 of them underwent the contralateral procedure (3 balloon and 1 surgery). Of the 6 patients who underwent initial surgery, only 1 patient underwent contralateral surgery (Figure 1).

At the end of the average follow-up period of 62.58±51.26 months, 18.6% were followed up without treatment, while 19.7% were using a single antihypertensive drug at the end of the follow-up.

The presence of unilateral or bilateral stenosis did not significantly differ in baseline systolic and diastolic BP SDSs. Similarly, the presence of unilateral or bilateral stenosis did not cause a significant change in patients' eGFRs during follow-up (Table 4).

Whether the stenosis was on the right or left did not create a significant difference in initial systolic and diastolic BP SDS or surgical requirement. However, the need for surgery was significantly higher in cases with bilateral stenosis compared to cases with unilateral stenosis (p: 0.044) (Table 5).

When we divided the patients into 3 groups (Group 1: no procedure; Group 2: balloon ± stent intervention; Group 3: surgical procedure) or 2 main groups (those who did not undergo the procedure (Group 1), those who underwent the procedure (Group 2 + 3), the change in eGFR between the groups was not statistically significant (Table 6).

DISCUSSION

In our study, where patients who were followed up with the diagnosis of RVHT in our country were examined retrospectively and we found that there was a significant decrease in the number of antihypertensive drugs used by patients who underwent surgery after the procedure. In addition, since most of the patients were asymptomatic at presentation, the importance of BP measurement as part of the physical examination in routine pediatric practice has been highlighted once again. The fact that renal Doppler USG was normal in most of the patients diagnosed suggests that angiographic examination should be considered when clinical suspicion arises.

The most common manifestation of RVHT is resistant hypertension detected in asymptomatic patients [7]. Newborns are also often asymptomatic at first, and hypertension is often diagnosed incidentally during routine BP examinations. Rarely, heart failure, feeding intolerance, or failure to thrive may also be the first symptoms [8, 9]. In the study by Yang et al., 32.4% of patients were asymptomatic and RAS was detected upon high BP measurements, and 27.0% had mild symptoms such as mild dizziness, headache, nausea or vomiting [10]. In the study by Green et al., most children reported non-specific symptoms such as headache and abdominal pain, and unlike adults, they had difficulty in characterizing common symptoms associated with hypertension such as tinnitus or blurred vision [11]. A retrospective study conducted in Israel noted behavioral changes in children, including hyperactivity, restlessness, and attention deficits, in the 3–12 months before the diagnosis of RVHT [12]. In our study, approximately 51.6% of the patients were asymptomatic at the time of diagnosis.

The diagnosis of RVHT in children is delayed due to both the neglect of BP measurement in routine practice and the difficulties in measuring and interpreting BP [1]. In the study by Yang et al., the mean age of 37 patients was 11.51 ± 4.57 years [10]. The fact that the average age of diagnosis in our study was 9.7 ± 5.1 supports this situation.

Although the discovery of new genes continues to increase, data suggest that approximately 11–60% of RAS cases are familial [1]. In our study, 10.6% of the 47 patients for whom family data was available had a history of hypertension in their mother and/or father.

In the study by Yang et al., fibromuscular dysplasia was diagnosed in 56.8% of patients, and Takayasu arteritis in 35.1. In this study, unilateral RAS was present in 78.4% of the patients, 16.2% of which were detected in a solitary kidney. The remaining 21.6% had bilateral lesions [10]. In our study, 40.7% of patients were diagnosed with idiopathic RAS. Right-sided involvement was observed in 29 (31.9%) patients, left-sided involvement in 25 (27.4%) patients, and bilateral involvement in 24 (26.4%) cases.

Although electrolyte disturbances are not sensitive markers for the diagnosis of RVHT, they are important to exclude other causes of hypertension [13]. There was no patient with electrolyte abnormalities at baseline in our study. Increased creatinine levels depend on the degree of RAS. In unilateral disease, serum creatinine concentration usually remains normal due to compensation by the healthy kidney, which may mask dysfunction in that kidney. However, bilateral disease may lead to decreased renal function due to hypoperfusion [14]. In our study, only 8 patients had an initial eGFR < 60 ml/min/1.73 m^2. Three of them had bilateral RAS.

In the study evaluating pediatric patients with RVHT, target organ damage was diagnosed in 40.5% of the patients. Hypertensive encephalopathy, hypertensive fundus lesion and LVH were found in 10.8%, 2.7% and 29.7% of the patients, respectively [10]. In our study, 27.7% of 83 patients evaluated with echocardiography had left ventricular hypertrophy, 28.9% of 90 patients with fundus examination had retinopathy, and 8.8% of 91 patients with spot urine examination had microalbuminuria.

Imaging tests such as Renal Doppler USG, CTA, and MRA are increasingly used in diagnosis. The sensitivity and specificity of Doppler USG in children range from 63–90% to 68–95%, respectively [15]. CTA has better resolution than MRA, but requires radiation exposure. On the contrary, young children also require sedation for MRA. For CTA, 88% sensitivity and 81% specificity were reported, while for MRA, sensitivity was reported as 80% and specificity as 63% [16]. Two studies in pediatric patients reported that renal scintigraphy with 99mTc dimercaptosuccinic acid (DMSA) or 99mTc mercaptoacetyltriglycine (MAG3) showed sensitivity and specificity ranging from 48–73% to 68–88%, respectively, in detecting RAS [17]. DSA is the gold standard investigation method as it provides the best resolution, offers additional visualization of intrarenal vessels, and confirms the diagnosis of RAS while also allowing a therapeutic intervention [18]. On the other hand, it is an invasive procedure and the radiation dose is significantly higher than CTA [19]. In their study on children aged 0–18 years, Orman et al. showed that CTA identified all RAS cases and found a higher sensitivity and specificity (90.0% and 89.7%) of CTA for the diagnosis of RAS [20]. Saida et al also found that renal USG showed a high sensitivity (89%) for diagnosing RVHT. The sensitivity and specificity of CTA were 100% for each. Therefore, they recommended CTA as a diagnostic test for RVHT in children [21]. In our study, although all patients were diagnosed with at least one angiographic examination, renal Doppler USG evaluation was normal in 38 (41.7%) patients. This stated that Doppler ultrasonography is not an appropriate method to exclude RAS, and an angiographic evaluation should be considered when clinical suspicion arises.

The most commonly used antihypertensives in treatment are calcium channel blockers and beta blockers. RAAS blockers can be used with caution, as these drugs are contraindicated due to the risk of causing renal failure if bilateral or solitary kidney RAS has not yet been excluded [22]. In addition to in-office BP monitoring, 24-hour ambulatory BP monitoring (ABPM) can provide valuable information about control [23]. Additionally, patients may need two or more antihypertensive medications to control BP elevation [16]. In our study, 72.3% of them were using two or more antihypertensive drugs.

Children with RAS often have lesions amenable to therapeutic intervention [9]. Revascularization with percutaneous transluminal renal angioplasty (PTRA) or surgery is an important treatment option, with the ultimate goal of preserving renal function by restoring renal perfusion. Balloon angioplasty is generally preferred over other procedures because it is less invasive and has a lower risk of complications. Surgery is usually indicated if endovascular procedures fail, but may be the first treatment option in selected cases [24]. It is important to note that local expertise should be taken into account when determining the appropriate procedure. The literature on PTRA in young children is limited and is mostly in the form of case reports. In older children, the success rate of PTRA ranges from 50% to 100% [25]. It is not uncommon for percutaneous transluminal renal angioplasty to be repeated because of restenosis or significant residual stenosis from the previous procedure. Therefore, if high BP persists or medication requirements increase and imaging findings suggest arterial narrowing, repeat angioplasty should be performed or surgical revascularization should be considered if the patient fails to respond to a repeat endovascular approach [22]. In the literature, the recurrence of stenosis after the first PTRA varies between 17% and 40% [26]. In our study, the second invasive procedure was performed in 11 patients. 5 cases were initially bilateral and underwent invasive procedures on the other kidney. The same procedure was repeated on 3 patients who

initially underwent balloon angioplasty. One patient who underwent balloon angioplasty initially had surgical correction performed during follow-up, while the other patient underwent surgical correction on the opposite side as well.2 patients underwent grafting in the same vein (one month and six months after the first procedure), One patient underwent surgery a month later as a second procedure. Nephrectomy was performed in the follow-up of another patient who received a balloon as the first procedure. During follow-up, in one of the two patients who had previously undergone balloon angioplasty in the same vessel for a second time, a third balloon angioplasty was performed, while the other underwent graft implantation as the fourth procedure.

Improvement in BP control was demonstrated in 32% of pediatric patients treated with PTRA and followed for at least 1 year by Alexander et al. [27]. In a retrospective study conducted by Kurt-Sukur et al. on children under 2 years of age with RVHT, twenty patients underwent PTRA procedure and seven children underwent surgery. Of the 16 patients who underwent PTRA alone, 44% had normal BP, 38% showed improvement with the same or reduced treatment, and 19% showed no improvement. Four (57%) of the patients who underwent surgery had normal BP, two (29%) had improved BP, and one (14%) had no change in BP. In conclusion, they advocated that PTRA should be performed first in young children under 2 years of age with RVHT, since it has a low complication profile and causes significant improvement in BP, and surgery may be recommended in case of failure [25]. Another study in patients with FMD also reported a better response to PTRA [28].

In the studies, indications for PTRA were patients with greater than 60% stenosis on digital subtraction angiography (DSA), patients with poor BP control despite antihypertensive medications, and patients with a condition tolerant to PTRA. Patients with extensive RAS and Takayasu arteritis (TA) were considered off-label. Patients with active stage Takayasu arteritis (TA) with diffuse stenosis of the renal artery and elevated erythrocyte sedimentation rate and C-reactive protein levels were exempt from PTRA [10]. In our study, no intervention was performed on patients with Takayasu Arteritis. Surgical revascularization is considered by some authors to be a more definitive treatment for children with RAS because of its high success rate. In a published series of children and adolescents, surgical intervention was found to improve arterial hypertension by 70% to 82% and BP measurements by 12% to 27% [29]. In selected cases with weak or dysfunctional kidneys and unilateral disease, nephrectomy may also be performed, which can lead to long-term normotension [16, 30]. In the study by Stadermann et al., normotension was achieved in 74% of children at one-year follow-up after surgery and in 85% at the last follow-up one to ten years later; in addition, significant reduction in the need for antihypertensive medications was observed; the median number of medications decreased from four before surgery to one at the last follow-up [31].

In our study, only 7.6% of the patients were not using any medication at the time of admission, while 19.7% were using one medication, 26.3% were using two medications, 25.2% were using three medications, and 20.8% were using four medications. In the final evaluation, the rate of individuals not using medication increased to 18.6% were using one medication, 29.6% were using two medications, 20% were using three medications, and 10.9% were using four medications. There was no statistical difference between the groups in terms of the distribution of the final medication count. Additionally, blood pressure decreased or returned to normal statistically significantly in the surgical group compared to the non-surgical group and the balloon + stent group.

The right renal artery originates from the anterolateral aspect of the abdominal aorta and follows a longer, inferior, and posterior course. In contrast, the left renal artery arises at a higher level and follows a shorter, more horizontal course to the left kidney. This may predispose the right renal artery to increased mechanical stress or external compression. However, the presence of right and left localization in our study did not differ between the two groups in terms of age at diagnosis, systolic and diastolic blood pressure (BP) at diagnosis, and GFR values at follow-up. While unilateral involvement may be better tolerated, bilateral involvement is generally expected to cause more

severe hypertension because the existing hypoperfusion in both kidneys leads to stronger activation of the renin-angiotensin system. Occasionally, if the affected kidney is nonfunctional, nephrectomy may be amenable. In bilateral RAS, nephrectomy is not an option, and BP control is more difficult and carries greater risks. In our study, there was no significant difference between unilateral and bilateral cases in terms of systolic and diastolic BP SDS at the time of diagnosis and changes in GFR during follow-up. Additionally, when we compared eGFR values between 3 groups (Group 1: no procedure; Group 2: balloon ± stent intervention; Group 3: surgical procedure) and 2 main groups (Group 1 and Group 2 + 3), we found an improvement in the final eGFR values, but the difference was not statistically significant. There is no clear indication for anticoagulant therapy in the pediatric population with RVHT. In a study conducted on children with RVHT, they stated that they used 50 U/kg low molecular weight Heparin daily for 3 days after angioplasty or stenting. They stated that aspirin was used for 6 months after angioplasty, and if a stent was placed, dual antiplatelet therapy consisting of aspirin and clopidogrel was given for 6 months, followed by lifelong aspirin [10]. In our study, although low molecular weight heparin and aspirin were used in both the balloon and/or stent groups and the surgery group, no comparison could be made because there was no standard dose and duration.

Limitations of our study are its retrospective design and relatively short follow-up period. Prospective studies with longer follow-up periods, preferably until adulthood, are needed to define the actual BP monitoring in pediatric patients. In addition, due to its multicenter nature, indications for interventions etc., could not be detailed.

In conclusion, RVHT should be suspected in any child with severe refractory hypertension that cannot be controlled with two or more antihypertensive drugs, especially if other suggestive findings such as an abdominal murmur are present and clinical symptoms suggestive of vascular damage in organs critical for hypertension (central nervous system, kidneys, and heart) are present.

Declarations

Conflicts of interest/Competing interests: The authors declare that they have no conflicts of interest.

Authors' contributions: B KASAP DEMIR and C BASARAN conceptualized and designed the study, performed data analysis, drafted the initial manuscript, and reviewed and revised the manuscript., A KARA, E KARABAĞ-YILMAZ, S YEL, ÖN TÜRKKAN, P ABDAL-YILDIRIM, E YILDIRIM, B ATMIŞ, B AKSU, S TANER, S BAKKALOĞLU, Y ÖZDEMİR, S ÇETİNCE-ŞENSES, S YAVUZ, NM SAV, Ş ZIRHLI-SELÇUK, B GÜLHAN, H DURSUN, H NALÇACIOĞLU, RY ÇİÇEK, N CENGİZ, E BAHAT-ÖZDOĞAN, E SOYALTIN, A KARABAY-BAYAZIT, M BAYRAM, İ GÖKÇE, N GÜNAY, N CANPOLAT, MK GÜRGÖZE, helped collect the data for the study.

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Tables

Table 1. Baseline characteristics of the study cohort.

Variable	Total (n = 91)
Age, years	9.7 ± 5.1
Height SDS	−0.12 ± 1.69
Weight SDS	0.13 ± 1.68
Systolic BP SDS	2.24 ± 0.32
Diastolic BP SDS	2.03 ± 0.49
Gender, n (%)	Female: 38 (41.8) Male: 53 (58.2)
Family history, n (%)	Yes: 11 (12.1)
Presenting complaint, n (%)	Asymptomatic: 48 (52.7) Headache: 30 (33.3) Palpitations/Chest pain: 3 (3.3) Nosebleed: 3 (3.3) Convulsion: 1 (1.1) Urinary incontinence: 2 (2.2) Encephalopathy: 3 (3.3) Visual impairment: 1 (1.1)
Diagnosis, n (%)	Idiopathic: 37 (40.7) FMD: 23 (25.3) Takayasu arteritis: 12 (13.2) Neurofibromatosis: 8 (8.7) Midaortic syndrome: 4 (4.4) Renal arterial dysplasia/hypoplasia:3 (3.3) Transplant RAS: 3 (3.3) Neuroblastome: 1 (1.1)
Localization of stenosis, n (%)	Right: 29 (31.9) Left: 25 (27.4) Aorta: 10 (11.0) Bilateral: 24 (26.4) Kidney transplant: 3 (3.3)

Values are expressed as mean ± standard deviation (SD) or number (%). SDS, standard deviation score; BP, blood pressure; FMD, fibromuscular dysplasia; RAS, renal artery stenosis

Table 2. Comparison of laboratory values between patients.

Variable	Group 1	Group 2	Group 3	p-value
WBC	9124.21 ± 3736.29	8309.06 ± 2486.44	7144.17 ±2980.69	0.097
Hb	12.57 ± 2.38	12.72 ± 1.71	12.92±1.86	0.838
Plt	310634	316737	296047	0.902
Glucose	92 (71–140)	91 (73–119)	91 (59-153)	0.963
BUN	28.66 (4–130)	23.75 (9 - 94)	35.29 (9-240)	0.446
Creatinine	0.74 (0.3–3.70)	0.61 (0.20–2.40)	0.81 (0.31–6.5)	0.654
Protein	6.84 (4.10–8.40)	7.27 (5.30–8.60)	6.98 (4.60-8.0)	0.204
Albumin	4.31 (2.90–5.10)	4.53 (3.20–5.00)	4.52 (2.80-5.10)	0.210
Sodium	137 (124–143)	137 (129–142)	134 (96-140)	0.197
Potassium	4.30 (2.9–5.3)	4.2 (3.2–5.8)	4.1 (2.9-5.4)	0.367
Chloride	102 (86-112)	101 (88–108)	99 (67-109)	0.411
Cholesterol	157 (112–234)	166 (116–237)	173 (127-342)	0.515
Triglyceride	116 (50–336)	109 (34–217)	99 (20-386)	0.838

Group 1: no procedure; Group 2: balloon ± stent intervention; Group 3: surgical procedure.

Table 3. Comparison of the groups without any surgical procedure, those with balloon ± stent, and those with surgical procedure according to the antihypertensives used.

Variable	Total (n)	Group 1 (n = 38, %)	Group 2 (n = 34, %)	Group 3 (n = 19, %)	p-value
Initial number of medications					0.091
0	7 (7.6)	3 (7.8)	3 (8.8)	1 (5.2)	
1	18 (19.7)	11 (28.9)	6 (19.3)	1 (5.2)	
2	24 (26.3)	9 (23.6)	6 (19.3)	9 (47.3)	
3	23 (25.2)	8 (21.0)	13 (38.2)	2 (10.5)	
4	19 (20.8)	7 (18.4)	6 (19.3)	6 (31.5)	
BP					**0.014**
Unchanged	35 (38.4)	18 (47.3)	14 (41.1)	3 (15.7)	
Decreased	39 (42.8)	15 (39.4)	15 (44.1)	9 (47.3)	
Returned to normal	14 (15.3)	2 (5.2)	5 (14.7)	7 (36.8)	
Increased	3 (3.2)	3 (7.8)	-	-	
Last number of medications					0.334
0	17 (18.6)	4 (10.5)	7 (20.5)	6 (31.5)	
1	18 (19.7)	11 (28.9)	5 (14.7)	2 (10.5)	
2	27 (29.6)	11 (28.9)	9 (26.4)	7 (36.8)	
3	19 (20)	9 (23.6)	7 (20.5)	3 (15.7)	
4	10 (10.9)	3 (7.8)	6 (17.6)	1 (5.2)	

Group 1: no procedure; Group 2: balloon ± stent intervention; Group 3: surgical procedure. BP, blood pressure.

Table 4. Characteristics of unilateral and bilateral patients.

Variable	Unilateral (n=53)	Bilateral (n=24)	p-value
Systolic BP SDS at diagnosis	2.25±0.32	2.22±0.35	0.783
Diastolic BP SDS at diagnosis	1.99±0.53	2.11±0.40	0.341
Changes in eGFR	14.65±45.28	10.36±32.16	0.696

BP, Blood pressure.

Table 5. Laterality difference.

Variable	**Right RAS (n=29)**	**Left RAS (n=25)**	**Bilateral (n=24)**	p-value
Age at diagnosis	9.75±5.38	9.48±5.38	9,04±4.67	0.881
Systolic BP SDS at diagnosis	2.26±0.37	2.20±0.35	2.24±0.33	0.876
Diastolic BP SDS at diagnosis	1.96±0.56	2.16±0.27	2.13±0.38	0.197
eGFR at diagnosis	108.20±35.64	109.94±32.93	99.50±35.74	0.536
Need for surgery	Yes: 15 No: 14	Yes: 12 No: 13	Yes: 19 No: 5	**0.044**

RAS, Renal Artery Stenosis; BP, Blood pressure.

Table 6. eGFR changes between groups.

variable	**Group 1 (n=38)**	**Group 2 (n=34)**	**Group 3 (n=19)**	p-value	**Group 1 (n=38)**	**Group 2+3 (n=53)**	p-value
İnitial eGFR	103.37±45.69	103.92±32.00	108.43±36.71	0.926	107.52±43.11	106.02±33.87	0.896
Last eGFR	118.26±33.79	115.17±33.17	121.61±25.57	0.461	114.46±33.71	117.60±28.21	0.796
eGFR	16.49±46.58	9.66±39.04	13.55±37.53	0.898	8.78±42.89	10.46±38.04	0.810

Group 1: no procedure; Group 2: balloon ± stent intervention; Group 3: surgical procedure.

Figures

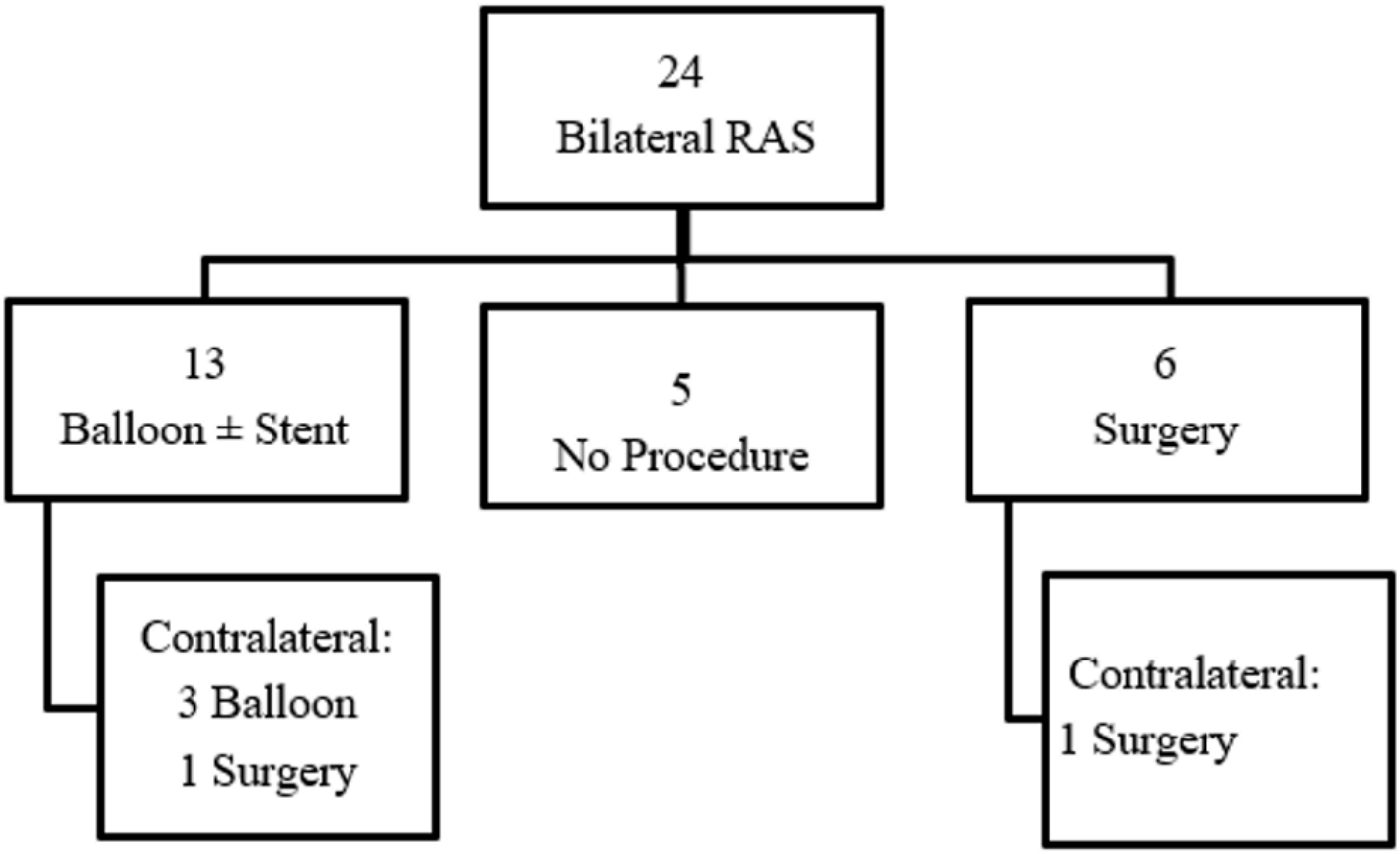


Figure 1

Cases with bilateral RAS.

RAS, Renal Artery Stenosis.