



Prescription Pattern Analysis of Antihypertensive Medication Use and Blood Pressure Control in Patients with Treatment-Resistant Hypertension in a Tertiary Care Hospital in North India

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ABSTRACT

Background: Treatment-resistant hypertension (TRH) is associated with increased cardiovascular morbidity and mortality and often requires multidrug antihypertensive therapy. Limited data are available regarding prescription patterns and blood pressure control among TRH patients in India.

Objectives: To analyse the prescription pattern of antihypertensive medications and evaluate blood pressure control among patients with treatment-resistant hypertension attending a tertiary care hospital in North India.

Materials and Methods: This prospective observational study was conducted in the Department of Cardiology and Department of Pharmacology at Dr Ram Manohar Lohia Institute of Medical Sciences over 18 months. A total of 94 patients with treatment-resistant hypertension were enrolled. Demographic details, comorbidities, antihypertensive drug use, and blood pressure values were recorded using a structured Case Record Form. Patients were followed up at 2 weeks, 4 weeks, and 12 weeks using Home Blood Pressure Monitoring (HBPM). Statistical analysis was performed using Jamovi software.

Results: The mean age of the study population was 54.96 ± 12.50 years, with male patients constituting 63.8% of participants. Diabetes mellitus (41.5%) and dyslipidaemia (40.4%) were the most common comorbidities observed. Calcium channel blockers (88.3%), diuretics (85.1%), and angiotensin receptor blockers (78.7%) were the most frequently prescribed antihypertensive drug classes. Four-drug antihypertensive regimens were the most commonly prescribed treatment combinations (48.3%). Mean systolic blood pressure decreased from 168.6 ± 12.6 mmHg at baseline to 142.6 ± 13.2 mmHg at 12 weeks, while mean diastolic blood pressure decreased from 100.3 ± 8.6 mmHg to 84.9 ± 10.0 mmHg. The reductions in both systolic and diastolic blood pressure during follow-up were statistically significant ($p < 0.001$). At 12 weeks, blood pressure control (HBPM $\leq 135/85$ mmHg) was achieved in 42.6% of patients.

Conclusion: Treatment-resistant hypertension commonly required multidrug antihypertensive therapy and was associated with multiple comorbidities. Although a significant reduction in blood pressure was observed during follow-up, optimal BP control remained inadequate in many patients, highlighting the need for individualised therapy, regular monitoring, and lifestyle modification.

INTRODUCTION

Hypertension is one of the most common non-communicable diseases worldwide and remains a major risk factor for cardiovascular morbidity and mortality. Persistent elevation of blood pressure significantly increases the risk of coronary artery disease, stroke, chronic kidney disease, heart failure, and premature death. Despite the availability of several effective antihypertensive medications, adequate blood pressure control remains suboptimal in a considerable proportion of patients, particularly those with treatment-resistant hypertension (TRH) [1].

Treatment-resistant hypertension is generally defined as blood pressure that remains above the target level despite adherence to treatment with three antihypertensive drugs of different classes, including a diuretic, prescribed at optimal doses, or controlled blood pressure requiring four or more antihypertensive medications [2]. The prevalence of TRH has increased globally due to ageing populations, sedentary lifestyles, obesity, diabetes mellitus, chronic kidney disease, and poor medication adherence [3].

Patients with TRH are at substantially greater risk of adverse cardiovascular and renal outcomes compared to patients with controlled hypertension. Studies have shown that resistant hypertension is associated with increased incidence of myocardial infarction, stroke, heart failure, and all-cause mortality [4]. The coexistence of metabolic disorders such as diabetes mellitus, dyslipidaemia, obesity, and chronic kidney disease further complicates management and contributes to poor blood pressure control [5].

Pharmacological management of TRH usually requires multidrug therapy using combinations of angiotensin-converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), calcium channel blockers (CCBs), beta-blockers, diuretics, mineralocorticoid receptor antagonists (MRAs), alpha-blockers, and centrally acting agents [6]. Recent guidelines recommend optimising diuretic therapy and inclusion of MRAs as important components of resistant hypertension management [7]. However, prescription patterns may vary depending on physician preference, patient characteristics, comorbidities, availability of drugs, and institutional practices.

Home Blood Pressure Monitoring (HBPM) has emerged as a valuable tool in the assessment and follow-up of hypertension. HBPM helps identify white-coat hypertension, improves patient adherence, and provides better prediction of cardiovascular outcomes compared to office blood pressure measurements alone [8]. Monitoring BP trends using HBPM can therefore assist in evaluating the effectiveness of antihypertensive regimens in TRH patients.

Despite advances in antihypertensive therapy, data on real-world prescribing patterns and blood pressure control in treatment-resistant hypertension in India remain limited, particularly in tertiary care settings. Understanding current prescribing practices and patterns of BP control may help identify gaps in management and improve therapeutic strategies. Therefore, the present study was undertaken to analyse the prescription pattern of antihypertensive medications and evaluate blood pressure control among patients with treatment-resistant hypertension attending a tertiary care hospital in North India.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted jointly by the Department of Pharmacology and the Department of Cardiology at Dr. Ram Manohar Lohia Institute of Medical Sciences, a tertiary care teaching hospital in North India. The study was carried out in the Cardiology Outpatient Department (OPD). The Department of Cardiology was responsible for patient recruitment, clinical evaluation, diagnosis, and prescription of antihypertensive medications, whereas the Department of Pharmacology coordinated data collection, monitoring of blood pressure control, analysis of prescription patterns, and statistical evaluation.

Study Duration

The study was conducted over a period of 18 months, which included patient recruitment, baseline clinical assessment, follow-up evaluations, data compilation, and statistical analysis.

Ethical Approval and Informed Consent

Prior to commencement, the study protocol was reviewed and approved by the Institutional Ethics Committee (IEC) of Dr. Ram Manohar Lohia Institute of Medical Sciences. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment after

explaining the purpose and procedures of the study in a language understandable to them. Participation was entirely voluntary, and confidentiality of patient information was strictly maintained throughout the study period.

Study Population

Patients attending the Cardiology OPD with a diagnosis of treatment-resistant hypertension were screened for eligibility. Consecutive patients fulfilling the inclusion criteria and willing to participate were enrolled in the study.

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- Age ≥ 18 years
- Diagnosed with treatment-resistant hypertension, defined as blood pressure remaining above 140/90 mmHg despite the use of three or more antihypertensive drugs of different classes including a diuretic, or controlled blood pressure requiring four or more antihypertensive agents
- Patients receiving antihypertensive therapy and willing to comply with scheduled follow-up visits
- Patients providing written informed consent

Exclusion Criteria

Patients with any of the following conditions were excluded:

- Pregnancy or lactation
- End-stage renal disease
- End-stage liver disease
- Diagnosed malignancy
- Incomplete medical records regarding drug dose, frequency, or duration
- Patients lost to follow-up

Sample Size

A total of 94 patients were enrolled in the study.

Sample Size Determination

Sample size estimation was performed using data from previous literature evaluating antihypertensive prescription patterns in resistant hypertension. Based on a reported prevalence of 33% for prescription of angiotensin-converting enzyme inhibitors or angiotensin receptor blockers in resistant hypertension, the sample size was calculated using the formula:

$$n = \frac{Z^2 \times P \times Q}{d^2}$$

Where:

- $Z = 1.96$ at 95% confidence interval
- $P = 0.33$
- $Q = 1 - P$
- $d = 0.10$

The calculated sample size was 85. After accounting for approximately 10% non-response and loss to follow-up, the final sample size was increased to 94 patients.

Data Collection Procedure

After obtaining written informed consent, demographic details including age and sex were recorded. Clinical information such as duration of hypertension, associated comorbidities, and details of current antihypertensive treatment were documented using a structured Case Record Form (CRF).

Details regarding antihypertensive medications, including drug class, dose, frequency, and drug combinations, were recorded from outpatient prescriptions and patient case records. Since this was an observational study, no intervention or modification in treatment was made by the investigators.

Follow-Up and Blood Pressure Assessment

Patients were followed up at 2 weeks, 4 weeks, and 12 weeks after enrolment. Blood pressure control was assessed using Home Blood Pressure Monitoring (HBPM). Participants were educated regarding the standard technique for BP measurement and instructed to record readings according to recommended guidelines. Blood pressure readings obtained during follow-up visits were documented and analysed to evaluate trends in BP control over time.

Study Variables

The following variables were assessed during the study:

- Demographic characteristics
- Duration of hypertension
- Associated comorbidities
- Pattern of antihypertensive drug use
- Drug combinations used in treatment-resistant hypertension
- Blood pressure control during follow-up

Tools for Data Collection

The following tools were used:

- Structured Case Record Form (CRF) for recording demographic, clinical, and treatment-related information
- Microsoft Excel for data entry and management
- Jamovi Statistical Software (Version 2.6.44) for statistical analysis

Statistical Analysis

Data collected were entered into Microsoft Excel and analysed using Jamovi statistical software. Quantitative variables were expressed as mean \pm standard deviation (SD), whereas categorical variables were represented as frequencies and percentages.

Normality of continuous variables was assessed using the Shapiro–Wilk test. Changes in blood pressure readings over time were analysed using repeated-measures analysis of variance (ANOVA). A p-value of <0.05 was considered statistically significant.

RESULT AND OBSERVATIONS;

Table 1. Baseline Demographic and Clinical Characteristics of Patients with Treatment-Resistant Hypertension

Variable	Value
Age (years), mean \pm SD	54.96 \pm 12.50
Sex, n (%)	
Male	60 (63.8%)
Female	34 (36.2%)
Duration of hypertension, n (%)	
≤ 5 years	19 (20.2%)
6–10 years	29 (30.9%)
>10 years	40 (42.6%)
Duration not available	6 (6.4%)
Comorbidities, n (%)	
Diabetes mellitus	39 (41.5%)
Coronary artery disease	36 (38.3%)
Chronic kidney disease	16 (17.0%)
Dyslipidaemia	38 (40.4%)
Cerebrovascular accident (Stroke)	13 (13.8%)
Addiction history, n (%)	
Smoking	17 (18.1%)

Alcohol use	10 (10.6%)
Tobacco use	22 (23.4%)

The study included 94 patients with treatment-resistant hypertension. The mean age of the study population was 54.96 ± 12.50 years, with male patients constituting 63.8% of the participants. Most patients had hypertension for more than 10 years (42.6%). Diabetes mellitus (41.5%) and dyslipidaemia (40.4%) were the most common comorbidities observed, followed by coronary artery disease (38.3%). Tobacco use was the most common addiction history noted among the study population (23.4%).

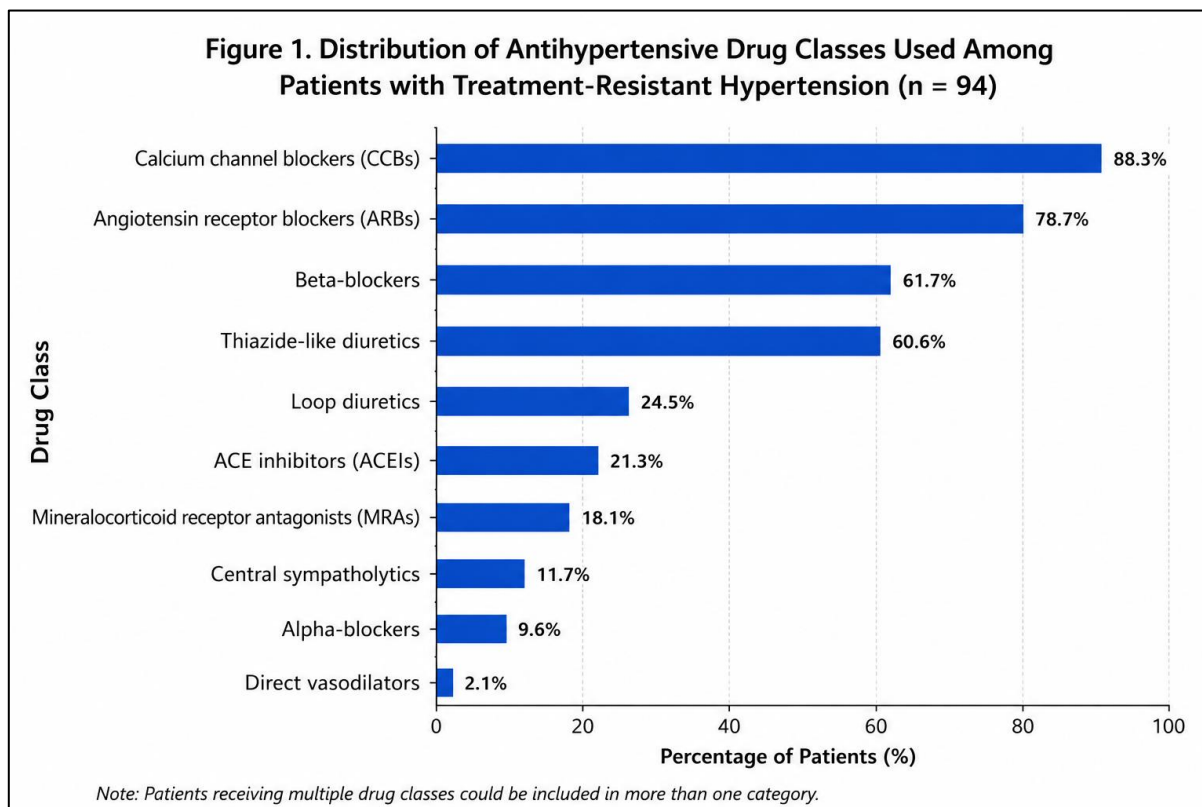


Figure 1 demonstrates distribution of antihypertensive drug classes prescribed among patients with treatment-resistant hypertension. Calcium channel blockers were the most frequently prescribed antihypertensive agents (88.3%), followed by diuretics (85.1%) and angiotensin receptor blockers (78.7%). Beta-blockers and thiazide-like diuretics were also commonly used. In contrast, mineralocorticoid receptor antagonists, alpha-blockers, and direct vasodilators were prescribed less frequently. The findings indicate that multidrug regimens based predominantly on calcium channel blockers, diuretics, and renin-angiotensin system blockers formed the cornerstone of treatment in the study population.

Table 2. Pattern of Antihypertensive Combination Regimens Among Patients with Treatment-Resistant Hypertension

Combination Regimen	n (%)
Number of antihypertensive drugs used	
3-drug regimens	30 (33.7%)
4-drug regimens	43 (48.3%)
≥5-drug regimens	16 (18.0%)
Most frequently prescribed antihypertensive combinations	
ARB + CCB + BB + Diuretic	19 (21.3%)
ARB + CCB + Diuretic	14 (15.7%)
ARB + CCB + Diuretic + Central agent	6 (6.7%)
ACEI + CCB + BB + Diuretic	5 (5.6%)
ARB + CCB + BB	5 (5.6%)
ARB + CCB + BB + Diuretic + Alpha-blocker	5 (5.6%)
ARB + CCB + Diuretic + MRA	4 (4.5%)

ARB + CCB + BB + Diuretic + MRA	4 (4.5%)
ACEI + BB + Diuretic	3 (3.4%)
ACEI + CCB + Diuretic	3 (3.4%)
ARB + BB + Diuretic + MRA	3 (3.4%)
ARB + BB + Diuretic	2 (2.2%)
ARB + CCB + BB + Diuretic + Central agent	2 (2.2%)
Others	18 (20.2%)

Four-drug antihypertensive regimens were the most commonly prescribed treatment combinations, accounting for 48.3% of patients, followed by three-drug regimens (33.7%). The most frequently prescribed combination regimen was ARB + CCB + beta-blocker + diuretic (21.3%), followed by ARB + CCB + diuretic (15.7%). Combination regimens containing mineralocorticoid receptor antagonists and centrally acting agents were used less frequently. Overall, multidrug regimens predominantly based on ARBs, calcium channel blockers, beta-blockers, and diuretics were commonly employed for the management of treatment-resistant hypertension.

Table 3. Changes in Home Blood Pressure Monitoring (HBPM) Values During Follow-Up Among Patients with Treatment-Resistant Hypertension

Follow-up Period	Systolic BP (mmHg), Mean \pm SD	p-value	Diastolic BP (mmHg), Mean \pm SD	p-value
Baseline	168.6 \pm 12.6	—	100.3 \pm 8.6	—
2 weeks	158.6 \pm 15.1	<0.001	93.5 \pm 8.8	<0.001
4 weeks	151.7 \pm 15.7	<0.001	88.9 \pm 8.9	<0.001
12 weeks	142.6 \pm 13.2	<0.001	84.9 \pm 10.0	<0.001
Mean reduction from baseline to 12 weeks	26.1 \pm 19.7	<0.001	15.4 \pm 14.6	<0.001

A progressive reduction in both systolic and diastolic blood pressure values was observed during follow-up. Mean systolic blood pressure decreased from 168.6 \pm 12.6 mmHg at baseline to 142.6 \pm 13.2 mmHg at 12 weeks, while mean diastolic blood pressure decreased from 100.3 \pm 8.6 mmHg to 84.9 \pm 10.0 mmHg. The reductions in both systolic and diastolic blood pressure at all follow-up visits were statistically significant compared to baseline values ($p < 0.001$).

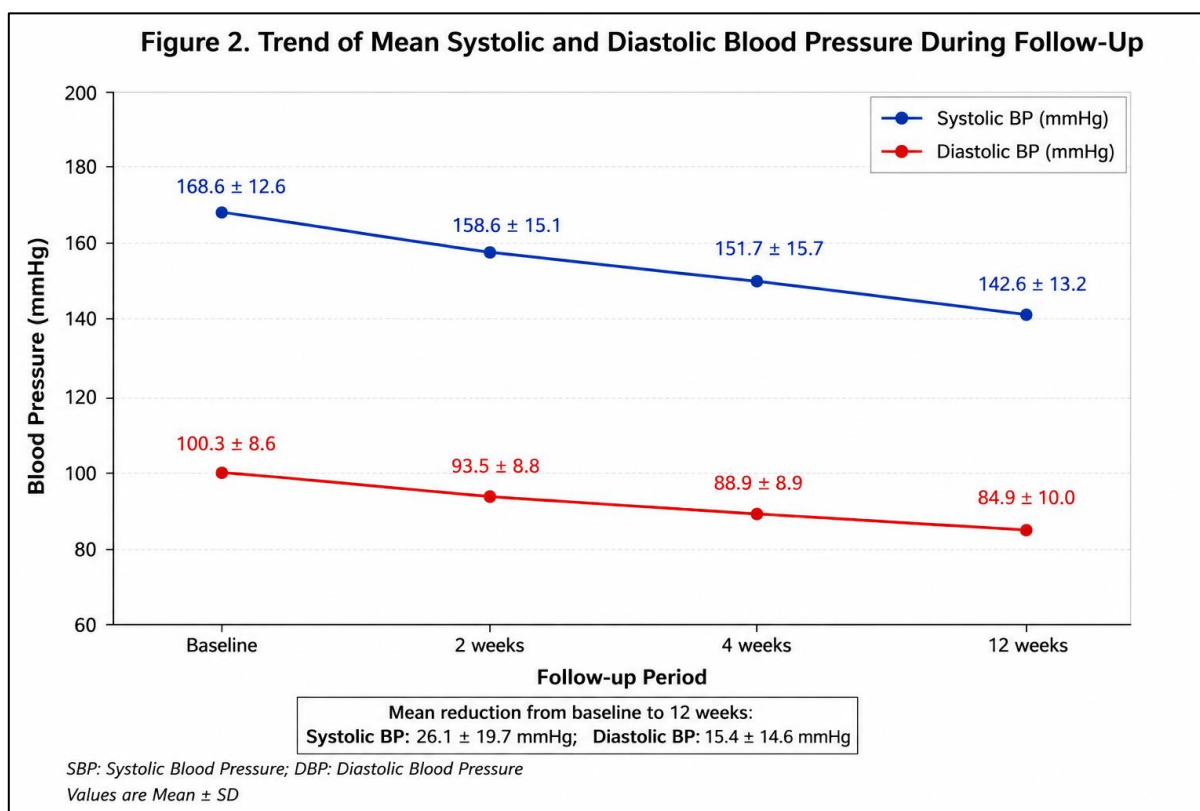


Figure 2 demonstrates the trend in mean systolic and diastolic blood pressure values during follow-up among patients with treatment-resistant hypertension. A progressive reduction in both systolic and diastolic blood pressure was observed from baseline to 12 weeks. Mean systolic blood pressure decreased from 168.6 \pm 12.6 mmHg at baseline to 142.6 \pm 13.2

mmHg at 12 weeks, while mean diastolic blood pressure decreased from 100.3 ± 8.6 mmHg to 84.9 ± 10.0 mmHg. The findings indicate significant improvement in blood pressure control during follow-up with multidrug antihypertensive therapy and regular monitoring.

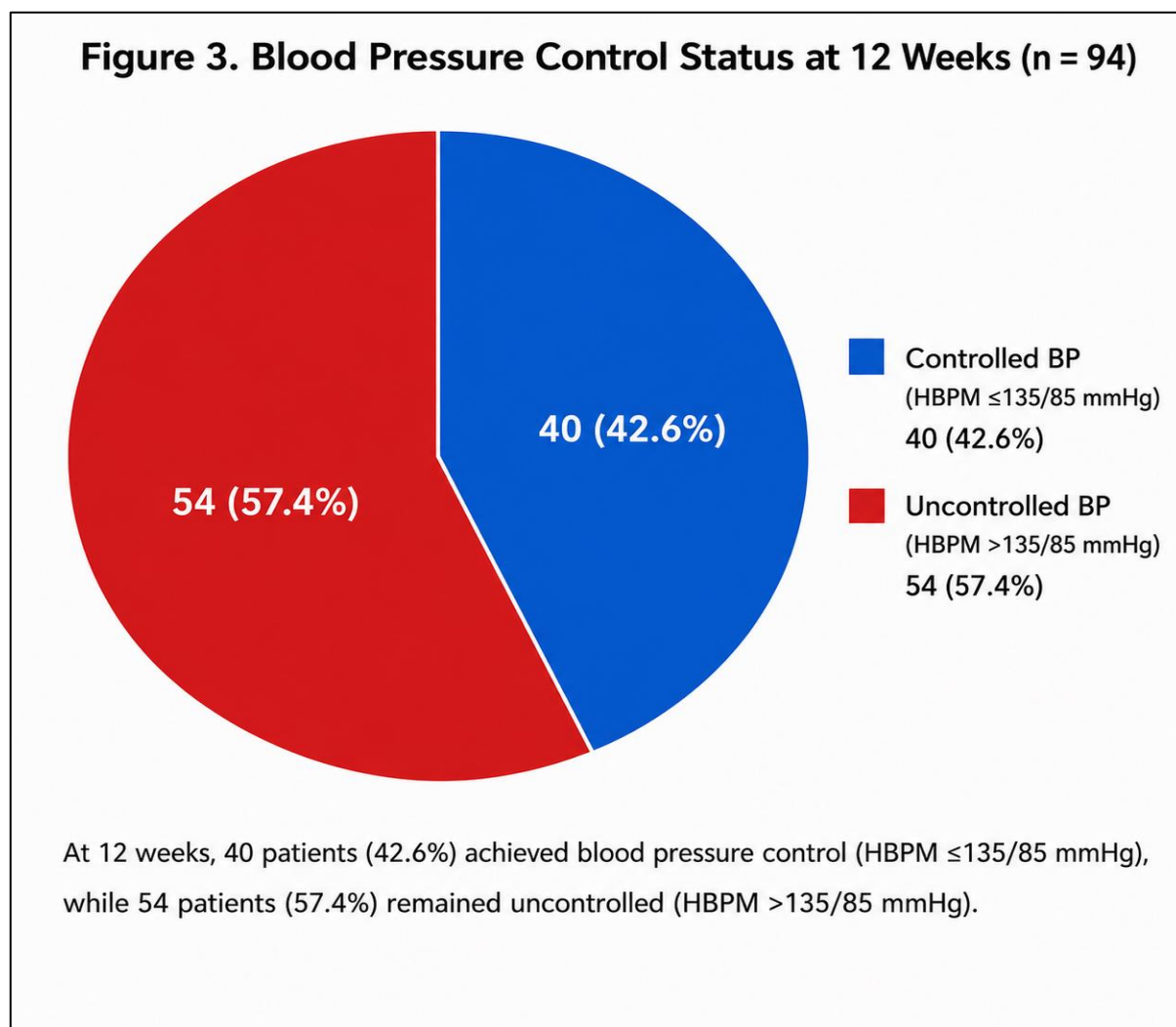


Table 4. Association Between Addiction History and Blood Pressure Control at 12 Weeks

Addiction Status	Uncontrolled BP (n)	Controlled BP (n)
Smoking		
No smoking	41	32
Smoking present	13	8
Alcohol use		
No alcohol use	42	34
Alcohol present	12	6
Tobacco use		
No tobacco use	40	27
Tobacco present	14	13

Table 5. Drug Combinations Used Among Patients Achieving BP Control at 12 Weeks

Drug Combination	Number of Patients
ARB + CCB + Beta-blocker + Diuretic + MRA	9
ARB + CCB + Beta-blocker + Diuretic	6
ARB + CCB + Diuretic + MRA	4
ACEI + CCB + Beta-blocker + Diuretic + MRA	3
ARB + CCB + Beta-blocker + Diuretic + Alpha-blocker	2

ARB + CCB + Diuretic	2
ACEI + CCB + Diuretic	2
ARB + CCB + Diuretic + Central agent	2
ACEI + CCB + Diuretic + MRA	2
ACEI + Beta-blocker + Diuretic	2
ACEI + CCB + Diuretic + MRA + Central agent	1
ARB + Beta-blocker + Diuretic + Alpha-blocker	1
ARB + Beta-blocker + Diuretic + MRA	1
ACEI + CCB + Beta-blocker + Diuretic + MRA + Alpha-blocker	1
ARB + Beta-blocker + Diuretic	1
ARB + CCB + Diuretic + MRA + Central agent	1

DISCUSSION

The present prospective observational study evaluated the prescription pattern of antihypertensive medications and blood pressure control among patients with treatment-resistant hypertension attending a tertiary care hospital in North India. The study demonstrated that treatment-resistant hypertension was more common among middle-aged and elderly individuals, with a predominance of male patients. Multiple cardiovascular and metabolic comorbidities were frequently observed, and most patients required multidrug antihypertensive therapy for blood pressure control.

The mean age of the study population was 54.96 ± 12.50 years, which is comparable to findings reported in previous studies on resistant hypertension [9,10]. Increasing age is a well-recognized contributor to resistant hypertension due to vascular stiffness, endothelial dysfunction, and coexistence of multiple comorbidities. Male predominance observed in the present study is also consistent with earlier Indian and international studies [11].

A significant proportion of patients had long-standing hypertension, with 42.6% reporting duration of hypertension greater than 10 years. Long duration of hypertension is associated with progressive vascular remodeling, target organ damage, and reduced responsiveness to antihypertensive therapy [12]. Diabetes mellitus and dyslipidaemia were the most common comorbidities observed in this study, followed by coronary artery disease and chronic kidney disease. Similar findings have been reported in previous studies, highlighting the close association between resistant hypertension and metabolic syndrome components [13,14].

Among antihypertensive drugs, calcium channel blockers, diuretics, and angiotensin receptor blockers were the most commonly prescribed agents. This prescription pattern is in accordance with current hypertension management guidelines recommending combination therapy involving renin-angiotensin system blockers, calcium channel blockers, and diuretics in resistant hypertension [7]. Beta-blockers were also commonly used, likely due to the high prevalence of coronary artery disease and other cardiovascular comorbidities in the study population.

The majority of patients required four or more antihypertensive drugs, indicating the complexity of managing resistant hypertension. ARB + CCB + beta-blocker + diuretic combinations were the most frequently prescribed regimens. Mineralocorticoid receptor antagonists were included in several treatment combinations, particularly among patients achieving blood pressure control at 12 weeks. Previous clinical trials have demonstrated the effectiveness of spironolactone and other MRAs in resistant hypertension management [15].

Home Blood Pressure Monitoring revealed progressive reduction in both systolic and diastolic blood pressure values during follow-up. Mean systolic blood pressure decreased from 168.6 ± 12.6 mmHg at baseline to 142.6 ± 13.2 mmHg at 12 weeks, while diastolic blood pressure decreased from 100.3 ± 8.6 mmHg to 84.9 ± 10.0 mmHg. These findings suggest that intensive multidrug therapy and regular follow-up may significantly improve blood pressure control in TRH patients. However, only 42.6% of patients achieved target HBPM control at 12 weeks, indicating that optimal BP control remains challenging in resistant hypertension.

Addiction-related factors such as smoking, alcohol consumption, and tobacco use were associated with higher proportions of uncontrolled blood pressure. Lifestyle factors are known to adversely affect vascular function, sympathetic activity, and medication adherence, thereby contributing to poor BP control [16]. These findings emphasise the importance of lifestyle modification and counselling in the comprehensive management of resistant hypertension.

The present study has certain limitations. Being a single-centre observational study, the findings may not be generalizable to the broader population. The relatively small sample size and short duration of follow-up may have limited the assessment of long-term blood pressure control and cardiovascular outcomes. Medication adherence and dietary salt intake were not objectively quantified. Nevertheless, the study provides valuable real-world data regarding

antihypertensive prescription patterns and BP control among treatment-resistant hypertension patients in a tertiary care setting in India.

CONCLUSION

Treatment-resistant hypertension was commonly associated with multiple comorbidities and required multidrug antihypertensive therapy for adequate blood pressure control. Calcium channel blockers, diuretics, ARBs, and beta-blockers were the most frequently prescribed drugs. Although a significant reduction in blood pressure was observed during follow-up, optimal BP control was achieved in less than half of the patients. Regular monitoring, individualised therapy, and lifestyle modification are essential for effective management of treatment-resistant hypertension.

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