

Assessment of Target Organ Damage in Patients with Hypertension: A Hospital-Based Study

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Abstract:

Background: Hypertension is a major modifiable risk factor for cardiovascular, cerebrovascular, renal, and ocular complications. Early identification of hypertension-mediated target organ damage (TOD) is essential for reducing disease-related morbidity and mortality. This study aimed to assess the prevalence and determinants of target organ damage among patients with hypertension attending a tertiary care hospital.

Material and Methods: A hospital-based, observational, cross-sectional study was conducted among 220 adult patients with essential hypertension. Demographic and clinical characteristics were recorded, and all participants underwent evaluation for cardiac, renal, ocular, cerebrovascular, and peripheral vascular involvement using standard clinical and diagnostic investigations. Continuous variables were compared using the Student's *t*-test or Mann-Whitney *U* test, while categorical variables were analysed using the Chi-square or Fisher's exact test. Multivariable logistic regression was performed to identify independent predictors of target organ damage.

Results: The mean age of the participants was 56.8 ± 11.4 years, and 60.0% were male. Target organ damage was present in 114 (51.8%) patients, with left ventricular hypertrophy (37.3%), hypertensive retinopathy (29.5%), and chronic kidney disease (22.3%) being the most frequent manifestations. Patients with target organ damage had significantly higher age, longer duration of hypertension, higher blood pressure, greater body mass index, higher prevalence of diabetes mellitus, smoking, and poor medication adherence (all $P < 0.05$). Multivariable logistic regression identified hypertension duration >10 years (adjusted OR: 3.26, 95% CI: 1.72–6.19), diabetes mellitus (adjusted OR: 2.18, 95% CI: 1.18–4.04), poor medication adherence (adjusted OR: 2.41, 95% CI: 1.24–4.68), increasing age, higher systolic blood pressure, and elevated body mass index as independent predictors of target organ damage.

Conclusion: Target organ damage affected more than half of hypertensive patients and was independently associated with older age, prolonged hypertension, uncontrolled blood pressure, diabetes mellitus, higher body mass index, and poor medication adherence. Comprehensive evaluation and timely management may help reduce hypertension-related complications.

Keywords: Hypertension; Target Organ Damage; Left Ventricular Hypertrophy; Hypertensive Retinopathy; Chronic Kidney Disease; Risk Factors.

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Introduction

Hypertension remains one of the leading contributors to premature morbidity and mortality worldwide and is a major risk factor for cardiovascular, cerebrovascular, and renal diseases. Persistent elevation of blood pressure induces structural and functional alterations in multiple organs, collectively referred to as hypertension-mediated target organ damage (HMOD). These changes may initially be subclinical but substantially increase the risk of adverse cardiovascular events, heart failure, stroke, chronic kidney disease, and

death. Early recognition of HMOD is therefore considered an essential component of comprehensive cardiovascular risk assessment in patients with hypertension [1,2].

The heart, kidneys, brain, retina, and peripheral vasculature are the principal organs affected by sustained hypertension. Cardiac manifestations commonly include left ventricular hypertrophy and diastolic dysfunction, whereas renal involvement is characterised by declining glomerular filtration rate

and albuminuria. Hypertensive retinopathy provides a readily accessible indicator of systemic vascular injury, while cerebrovascular disease and peripheral arterial disease reflect advanced vascular involvement. The presence of target organ damage identifies patients at substantially higher cardiovascular risk and often necessitates more intensive therapeutic intervention [2,3].

The development of hypertension-mediated organ damage is influenced by multiple factors, including advancing age, prolonged duration of hypertension, inadequate blood pressure control, obesity, diabetes mellitus, smoking, and poor adherence to antihypertensive therapy. Recent evidence has further demonstrated that persistent vascular inflammation, oxidative stress, endothelial dysfunction, and mitochondrial abnormalities contribute to progressive organ injury despite the absence of overt clinical symptoms during the early stages of disease [4,5].

Despite advances in antihypertensive therapy, a considerable proportion of patients continue to develop target organ damage because of delayed diagnosis, inadequate blood pressure control, or coexistence of additional cardiovascular risk factors. Hospital-based assessment of HMOD provides valuable information regarding disease burden and facilitates identification of patients requiring intensified management strategies. However, the pattern and determinants of target organ damage may vary across different populations owing to differences in demographic characteristics, comorbidities, healthcare access, and treatment practices [2,6].

The present study was undertaken to assess the prevalence and pattern of hypertension-mediated target organ damage among adult patients with hypertension attending a tertiary care hospital and to identify the clinical factors independently associated with its occurrence.

Materials and Methods

Study Design and Setting: A hospital-based, observational, cross-sectional study was conducted in a tertiary care teaching hospital. The study was designed to assess the prevalence and pattern of target organ damage among adult patients diagnosed with hypertension.

Study Population: The study included adult patients (≥ 18 years) with previously diagnosed or newly detected hypertension who attended the outpatient department or were admitted to the hospital during the study period. Hypertension was defined according to contemporary international guidelines as a systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg on two separate occasions, or current use of antihypertensive medication.

Sample Size: The sample size was calculated using the single population proportion formula: $n = Z^2 \times p \times (1 - p) / d^2$; where $Z = 1.96$ for a 95% confidence interval, $p = 0.50$ (assuming a 50% prevalence of target organ damage among hypertensive patients to obtain the maximum sample size), and $d = 0.07$ (absolute precision of 7%). The calculated minimum sample size was 196 participants. Considering possible incomplete clinical records and missing investigations, a total of 220 consecutive eligible patients were enrolled using a consecutive sampling technique.

Inclusion Criteria:

- Patients aged 18 years or older.
- Patients with previously diagnosed essential hypertension or newly diagnosed hypertension.
- Patients willing to participate and providing written informed consent.

Exclusion Criteria:

- Secondary hypertension.
- Pregnancy-induced hypertension or pre-eclampsia.
- Patients with congenital heart disease or known inherited renal disorders.
- Patients with acute severe illness requiring emergency intervention.
- Patients with incomplete clinical evaluation or missing investigations necessary for assessment of target organ damage.

Data Collection: After obtaining informed consent, demographic and clinical information was recorded using a predesigned case record form. Data collected included age, sex, duration of hypertension, history of diabetes mellitus, smoking status, alcohol consumption, body mass index (BMI), family history of hypertension, current antihypertensive treatment, and medication adherence.

Blood pressure was measured using a calibrated mercury sphygmomanometer or validated automated blood pressure monitor after the participant had rested for at least five minutes in a seated position. Two readings were obtained five minutes apart, and the average value was considered for analysis.

Assessment of Target Organ Damage: All participants underwent comprehensive clinical examination and relevant laboratory and imaging investigations to identify hypertension-mediated target organ damage.

Cardiac Assessment: Cardiac involvement was evaluated using a standard 12-lead electrocardiogram (ECG) and two-dimensional transthoracic echocardiography. Left ventricular hypertrophy (LVH) was diagnosed based on echocardiographic measurements using indexed left

ventricular mass according to standard recommendations.

Renal Assessment: Renal involvement was assessed by serum creatinine, estimated glomerular filtration rate (eGFR), routine urine examination, and urine albumin estimation. Chronic kidney disease was defined according to Kidney Disease: Improving Global Outcomes (KDIGO) criteria [7].

Ocular Assessment: Fundus examination was performed by an ophthalmologist using direct or indirect ophthalmoscopy after pupillary dilatation. Hypertensive retinopathy was graded according to the Keith–Wagener–Barker classification.

Cerebrovascular Assessment: A history of transient ischaemic attack or stroke was documented from clinical records. Neuroimaging findings (computed tomography or magnetic resonance imaging), when available, were reviewed to confirm cerebrovascular involvement.

Peripheral Vascular Assessment: Peripheral arterial disease was evaluated clinically based on diminished peripheral pulses, symptoms of intermittent claudication, and Doppler ultrasonography whenever clinically indicated.

Outcome Measures: The primary outcome was the prevalence of hypertension-mediated target organ damage. Secondary outcomes included the distribution of individual organ involvement and the association between target organ damage and clinical characteristics such as age, sex, duration of hypertension, blood pressure level, diabetes mellitus, and body mass index.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro–Wilk test. Normally distributed variables were expressed as mean $\pm$ standard deviation, while non-normally distributed variables were summarised as median with interquartile range. Categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the independent Student's *t*-test or Mann–Whitney *U* test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables, as appropriate. Variables demonstrating statistical significance in univariate analysis were entered into multivariable logistic regression to identify independent predictors of target organ damage. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. A two-tailed *P* value of <0.05 was considered statistically significant.

Results

A total of 220 patients with hypertension were included in the final analysis. The mean age of the

participants was 56.8 ± 11.4 years, with males accounting for 60.0% of the study population. The median duration of hypertension was 7 years (IQR: 3–12 years). The mean systolic and diastolic blood pressures were 151.6 ± 16.8 mmHg and 92.4 ± 9.8 mmHg, respectively. Diabetes mellitus was present in 39.1% of patients, while 21.8% were current smokers and 19.1% reported alcohol consumption. The majority of participants (83.2%) were receiving antihypertensive therapy, whereas 27.7% had poor medication adherence (Table 1).

Hypertension-mediated target organ damage was identified in 114 (51.8%) patients. Left ventricular hypertrophy was the most frequently observed manifestation (37.3%), followed by hypertensive retinopathy (29.5%) and chronic kidney disease (22.3%). Previous stroke or transient ischaemic attack was documented in 10.9% of participants, while 8.2% had evidence of peripheral arterial disease. Multiple target organ involvement (two or more affected organs) was observed in 17.7% of the study population (Table 2).

Patients with target organ damage were significantly older than those without target organ involvement (60.9 ± 10.2 vs. 52.4 ± 10.8 years; $P < 0.001$). They also had a significantly longer duration of hypertension (median 10 vs. 4 years; $P < 0.001$), higher systolic and diastolic blood pressures, and greater body mass index values. Diabetes mellitus, current smoking, and poor medication adherence were significantly more prevalent among patients with target organ damage (all $P < 0.05$). Although male patients exhibited a higher frequency of target organ damage than females, the association was modest on univariate analysis (Table 3).

The prevalence of target organ damage increased progressively with increasing duration of hypertension. Among patients with hypertension for less than five years, only 28.4% had evidence of organ damage, compared with 51.3% among those with a disease duration of 5–10 years and 77.1% among those with hypertension for more than ten years. This trend was statistically significant ($P < 0.001$) (Table 4).

Multivariable logistic regression analysis demonstrated that longer duration of hypertension, increasing age, higher systolic blood pressure, diabetes mellitus, elevated body mass index, and poor medication adherence were independent predictors of target organ damage. Patients with hypertension lasting more than ten years had over three times higher odds of developing target organ damage than those with a shorter disease duration (adjusted OR = 3.26, 95% CI: 1.72–6.19, $P < 0.001$). Similarly, diabetes mellitus (adjusted OR = 2.18, 95% CI: 1.18–4.04, $P = 0.013$) and poor medication adherence (adjusted OR = 2.41, 95% CI: 1.24–4.68, $P = 0.010$) remained significant independent

determinants. In contrast, sex and smoking status were not independently associated with target organ damage after adjustment for potential confounding factors (Table 5).

Analysis of individual target organ involvement according to the duration of hypertension revealed a significant increase in all forms of organ damage with longer disease duration. The prevalence of left ventricular hypertrophy increased from 16.2%

among patients with hypertension of less than five years to 61.4% among those with hypertension exceeding ten years. Similar increasing trends were observed for hypertensive retinopathy (13.5% to 47.1%), chronic kidney disease (6.8% to 40.0%), previous stroke or transient ischaemic attack (2.7% to 20.0%), and peripheral arterial disease (2.7% to 15.7%), with all associations reaching statistical significance (Table 6).

Table 1: Baseline demographic and clinical characteristics of the study participants (N = 220)

Variable	Value
Age (years), mean $\pm$ SD	56.8 $\pm$ 11.4
Male, n (%)	132 (60.0)
Female, n (%)	88 (40.0)
Duration of hypertension (years), median (IQR)	7 (3–12)
Systolic BP (mmHg), mean $\pm$ SD	151.6 $\pm$ 16.8
Diastolic BP (mmHg), mean $\pm$ SD	92.4 $\pm$ 9.8
BMI (kg/m ²), mean $\pm$ SD	27.3 $\pm$ 4.2
Diabetes mellitus, n (%)	86 (39.1)
Current smokers, n (%)	48 (21.8)
Alcohol consumption, n (%)	42 (19.1)
On antihypertensive treatment, n (%)	183 (83.2)
Poor medication adherence, n (%)	61 (27.7)

Table 2: Pattern of hypertension-mediated target organ damage among study participants (N = 220)

Target organ damage	n	%
Left ventricular hypertrophy	82	37.3
Hypertensive retinopathy	65	29.5
Chronic kidney disease	49	22.3
Previous stroke/TIA	24	10.9
Peripheral arterial disease	18	8.2
At least one target organ damage	114	51.8
Two or more target organ damages	39	17.7

Table 3. Comparison of patients with and without target organ damage

Variable	Target organ damage (n=114)	No target organ damage (n=106)	P value
Age (years), mean $\pm$ SD	60.9 $\pm$ 10.2	52.4 $\pm$ 10.8	<0.001*
Male sex, n (%)	76 (66.7)	56 (52.8)	0.036*
Duration of hypertension (years), median (IQR)	10 (6–15)	4 (2–8)	<0.001†
Systolic BP (mmHg), mean $\pm$ SD	157.3 $\pm$ 15.6	145.5 $\pm$ 15.1	<0.001*
Diastolic BP (mmHg), mean $\pm$ SD	94.5 $\pm$ 9.2	90.2 $\pm$ 9.8	0.002*
BMI (kg/m ²), mean $\pm$ SD	28.1 $\pm$ 4.3	26.4 $\pm$ 3.9	0.003*
Diabetes mellitus, n (%)	58 (50.9)	28 (26.4)	<0.001‡
Current smoker, n (%)	33 (28.9)	15 (14.2)	0.008‡
Poor medication adherence, n (%)	43 (37.7)	18 (17.0)	0.001‡

*Student's t-test; †Mann–Whitney U test; ‡Chi-square test

Table 4: Association between duration of hypertension and target organ damage

Duration of hypertension	Target organ damage present	No target organ damage	P value
<5 years (n=74)	21 (28.4%)	53 (71.6%)	<0.001
5–10 years (n=76)	39 (51.3%)	37 (48.7%)	
>10 years (n=70)	54 (77.1%)	16 (22.9%)	

Chi-square test

Table 5. Multivariable logistic regression analysis for predictors of target organ damage

Variable	Adjusted OR	95% CI	P value
Age (per year increase)	1.05	1.02–1.09	0.001
Male sex	1.38	0.77–2.49	0.278
Duration of hypertension (>10 years)	3.26	1.72–6.19	<0.001
Systolic BP (per mmHg increase)	1.03	1.01–1.05	0.004
Diabetes mellitus	2.18	1.18–4.04	0.013
BMI (per kg/m ² increase)	1.08	1.00–1.17	0.048
Current smoker	1.81	0.89–3.67	0.099
Poor medication adherence	2.41	1.24–4.68	0.010

Dependent variable: Presence of at least one target organ damage.

Table 6: Distribution of individual target organ damage according to duration of hypertension

Target organ damage	<5 years (n=74)	5–10 years (n=76)	>10 years (n=70)	P value
Left ventricular hypertrophy	12 (16.2%)	27 (35.5%)	43 (61.4%)	<0.001
Hypertensive retinopathy	10 (13.5%)	22 (28.9%)	33 (47.1%)	<0.001
Chronic kidney disease	5 (6.8%)	16 (21.1%)	28 (40.0%)	<0.001
Previous stroke/TIA	2 (2.7%)	8 (10.5%)	14 (20.0%)	0.002
Peripheral arterial disease	2 (2.7%)	5 (6.6%)	11 (15.7%)	0.014

Discussion

The present hospital-based study demonstrated that hypertension-mediated target organ damage (HMOD) was present in more than half of the hypertensive patients, with left ventricular hypertrophy being the most common manifestation, followed by hypertensive retinopathy and chronic kidney disease. Furthermore, increasing age, prolonged duration of hypertension, elevated systolic blood pressure, diabetes mellitus, higher body mass index, and poor medication adherence emerged as independent predictors of target organ damage. These findings reinforce the concept that persistent hypertension exerts cumulative adverse effects on multiple organ systems and highlight the need for routine screening for subclinical organ involvement in patients with hypertension.

In the present study, 51.8% of patients had evidence of at least one target organ lesion. This observation is comparable with contemporary studies demonstrating that hypertension-mediated organ damage remains highly prevalent despite advances in antihypertensive therapy. Data from the Framingham Heart Study showed that the prevalence of HMOD increases progressively across blood pressure categories and confers additional cardiovascular risk beyond blood pressure values alone, emphasizing the clinical importance of systematic assessment for organ involvement in hypertensive individuals [8].

Left ventricular hypertrophy was the most frequent manifestation of organ damage in our cohort. Chronic pressure overload induces adaptive myocardial hypertrophy, which subsequently progresses to myocardial fibrosis, impaired ventricular relaxation, heart failure, and increased cardiovascular mortality. Similar findings have been reported in recent studies evaluating target organ

damage in hypertensive populations, where cardiac structural abnormalities represent one of the earliest and most common manifestations of sustained hypertension [9].

Our findings also demonstrated that the prevalence of target organ damage increased significantly with advancing age and longer duration of hypertension. Patients with hypertension for more than ten years had substantially greater odds of organ involvement than those with shorter disease duration. This is biologically plausible because prolonged exposure to elevated arterial pressure results in progressive vascular remodeling, endothelial dysfunction, arterial stiffness, and irreversible tissue injury. A recent cross-sectional study similarly identified longer hypertension duration as an important determinant of renal, retinal, cardiac, and cerebral target organ damage [10].

Higher systolic blood pressure was independently associated with target organ damage in the present study. Persistent systolic hypertension increases mechanical stress on the vascular wall, accelerating microvascular and macrovascular injury. In addition, diabetes mellitus independently doubled the likelihood of target organ damage, consistent with the synergistic adverse effects of hyperglycaemia and hypertension on vascular endothelium and renal function. Recent evidence has likewise demonstrated that metabolic abnormalities and obesity substantially increase cardiovascular and renal target organ damage among patients with essential hypertension [11].

Poor medication adherence was another independent predictor identified in our analysis. Inadequate adherence contributes to persistent blood pressure elevation and prolonged exposure of vital organs to haemodynamic stress, thereby facilitating progressive organ injury. Contemporary

interventional evidence indicates that effective blood pressure control is associated with improvement or attenuation of target organ damage, further underscoring the importance of sustained antihypertensive therapy and regular follow-up [12].

The coexistence of multiple target organ lesions observed in a proportion of our patients further highlights the systemic nature of hypertensive vascular injury. Previous longitudinal studies have shown that involvement of multiple organs is associated with a stepwise increase in major adverse cardiovascular events compared with isolated organ damage, supporting comprehensive evaluation rather than assessment of a single organ system [13,14].

The present study has certain limitations. Being a single-centre cross-sectional study, causal relationships between risk factors and target organ damage cannot be established, and the findings may not be generalisable to the wider hypertensive population. In addition, longitudinal follow-up was not performed to evaluate progression or regression of organ damage following treatment. Nevertheless, comprehensive assessment of multiple target organs using standard clinical and diagnostic methods provides valuable information regarding the burden of hypertension-mediated organ damage in routine clinical practice.

Conclusion

The present study demonstrated that hypertension-mediated target organ damage was highly prevalent among patients attending a tertiary care hospital, with more than half of the study population exhibiting involvement of at least one organ system. Left ventricular hypertrophy, hypertensive retinopathy, and chronic kidney disease were the most common manifestations. Increasing age, prolonged duration of hypertension, elevated systolic blood pressure, diabetes mellitus, higher body mass index, and poor medication adherence were identified as significant predictors of target organ damage. These findings underscore the importance of regular screening for organ involvement, optimal blood pressure control, early identification of high-risk individuals, and interventions to improve treatment adherence in order to reduce hypertension-related morbidity and long-term adverse cardiovascular and renal outcomes.

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