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**MINIREVIEWS**

- 86**    Reno protective role of amlodipine in patients with hypertensive chronic kidney disease  
*Abraham G, Almeida A, Gaurav K, Khan MY, Patted UR, Kumaresan M*
- 96**    Liposoluble vitamins A and E in kidney disease  
*Rojo-Trejo MH, Robles-Osorio ML, Sabath E*
- 105**    Multidisciplinary basic and clinical research of acute kidney injury with COVID-19: Pathophysiology, mechanisms, incidence, management and kidney transplantation  
*Wishahi M, Kamal NM*

**ABOUT COVER**

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## Reno protective role of amlodipine in patients with hypertensive chronic kidney disease

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### Abstract

Chronic kidney disease (CKD) and hypertension (HTN) are closely associated with an overlapping and intermingled cause and effect relationship. Decline in renal functions are usually associated with a rise in blood pressure (BP), and prolonged elevations in BP hasten the progression of kidney function decline. Regulation of HTN by normalizing the BP in an individual, thereby slowing the progression of kidney disease and reducing the risk of cardiovascular disease, can be effectively achieved by the anti-hypertensive use of calcium channel blockers (CCBs). Use of dihydropyridine CCBs such as amlodipine (ALM) in patients with CKD is an attractive option not only for controlling BP but also for safely improving patient outcomes. Vast clinical experiences with its use as monotherapy and/or in combination with other anti-hypertensives in varied conditions have demonstrated its superior qualities in effectively managing HTN in patients with CKD with minimal adverse effects. In comparison to other counterparts, ALM displays robust reduction in risk of cardiovascular endpoints, particularly stroke, and in patients with renal impairment. ALM with its longer half-life displays effective BP control over 24-h, thereby reducing the progression of end-stage-renal disease. In conclusion, compared to other classes of CCBs, ALM is an attractive choice for effectively managing HTN in CKD patients and improving the overall quality of life.

**Key Words:** Amlodipine; Chronic kidney disease; Hypertension; End-stage-renal disease; Monotherapy; Combination therapy

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**Core Tip:** Amlodipine (ALM) is a powerful, well-tolerated, and safe anti-hypertensive agent widely used alone or as a key component of combination therapy for hypertension in chronic kidney disease (CKD). Its effectiveness in reducing blood pressure has proven benefits in cardiovascular event reduction and progression of renal disease. Overall, ALM emerges as the drug of choice in comparison to the newer calcium channel blockers in terms of its effectiveness and potency in BP lowering in CKD patients.

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## INTRODUCTION

Hypertension (HTN) – also known as high blood pressure (BP) – is a significant medical illness in which the arterial BP remains consistently high, with a systolic BP (SBP) of 140 mmHg or higher or a diastolic BP (DBP) of 90 mmHg or higher[1]. The World Health Organization has identified HTN as one of the most important risk factors for morbidity and mortality worldwide, with roughly 9 million people dying each year[2]. Even though other risk factors play a role, poor diets, such as excessive salt consumption, a diet high in saturated fat and trans-fats, low intake of fruits and vegetables, physical inactivity, tobacco/alcohol use, and being overweight/obese, appear to be the most common contributing factor to HTN. Non-modifiable risk factors include a family history of HTN, elderly age, and comorbidities such as diabetes or kidney disease[3]. According to recent analysis and observational research, people in Western countries have a higher prevalence of HTN and higher BP levels than those in other parts of the world, and this disparity is narrowing as non-Westerners adapt to Western culture and lifestyle[4].

HTN continues to be the greatest cause of premature mortality, affecting roughly 1.13 billion people globally and accounting for nearly 45% of deaths due to heart disease, 51% of deaths due to stroke, and 85%-95% of patients with chronic kidney disease (CKD)[5]. The overall prevalence of HTN in India was 29.8% from 1950 to 2014, according to data, and a meta-analysis of prior Indian prevalence studies showed a considerable increase in the incidence of HTN from the 1960s to the mid-1990s[6]. HTN prevalence studies in urban and rural populations from the mid-1990s to the present show a growing trend, with a bigger increase in urban (33.8%) than rural (27.6%) populations[6]. Early detection, consistent follow-up, and HTN control methods may be a cost-effective way to lower the worldwide disease burden associated with HTN.

## HYPERTENSION AND CHRONIC KIDNEY DISEASE

CKD is characterized by persistent kidney damage, a decrease in the estimated glomerular filtration rate (eGFR), and the development of albuminuria. It is a long-term disorder that causes kidney function to deteriorate over time, eventually leading to kidney failure or end-stage renal disease (ESRD)[7]. CKD refers to all five stages of kidney damage, from very mild in stage 1 (eGFR  $\geq$  90 mL/min/1.73 m<sup>2</sup>) to complete kidney failure in stage 5 (eGFR < 15 mL/min/1.73 m<sup>2</sup>)[8] (shown in Table 1). In 2017, 12 million people died from CKD worldwide, with a global prevalence of 697.5 million. Women and girls had a greater age-standardized global prevalence of CKD (9.5%) than men and boys (7.3%), and China and India accounted for over one-third of all CKD cases (132.3 million and 115.1 million, respectively) [9]. Since the eGFR estimation equation and the Modification of Diet in Renal Disease formula have not been verified, the incidence of CKD in India is high[10]. The Indian Society of Nephrology established the Indian CKD Registry in 2005 as a comprehensive statewide data collection for examining all aspects of CKD. According to the initial research, diabetic nephropathy has emerged as the leading cause of CKD in India, according to a cross-sectional survey of 52273 adult patients[11].

HTN control is important in the care and well-being of CKD patients because it is both a cause and an effect of the disease, and it contributes to its progression[12]. Uncontrolled BP during the day causes a BP "load" in CKD patients, which is linked to eGFR decrease and proteinuria. Masked HTN, nocturnal

**Table 1 Classification of chronic kidney disease Stages 1-5[8]**

Stage	Description	GFR, mL/min/1.73 m <sup>2</sup>
-	At increased risk	≥ 60
1	Kidney damage with normal or increased GFR	≥ 90
2	Kidney damage with mild decreased GFR	60-89
3	Moderately decreased GFR	30-59
4	Severely decreased GFR	15-29
5	Kidney Failure	< 15 (or dialysis)

GFR: Glomerular filtration rate.

non-dipping, and 24-h day/night BP fluctuation are all seen in patients with CKD[12]. As evidenced by studies showing a higher risk of all-cause death, hemorrhagic strokes, and total cardiovascular (CV) events in people with CKD, BP fluctuation is a powerful predictor of end organ damage[13]. Furthermore, both HTN and CKD are independent risk factors for CVD, and when both are present, the risk of CVD morbidity and mortality is significantly enhanced. Furthermore, HTN has been recorded in 85%-95% of CKD (stages 3-5) patients[14]. The pathophysiology of HTN in CKD is multifaceted and complicated[15]. There is an upregulation of the renin-angiotensin-aldosterone system (RAAS) with a functional drop in eGFR, which increases salt and water retention even more, and this is compounded by an enhanced salt sensitivity of BP[16]. Proteinuria is a critical sign of renal impairment that is related with CKD progression and incident CVD in a gradual and independent manner. Reduced BP lowers proteinuria, which slows eGFR decline and lowers CV risk. When treating HTN in individuals with CKD, the influence of a medicine on proteinuria is a significant consideration in addition to its antihypertensive effects. Another emerging worry is the prevalence of treatment-resistant HTN in CKD, and including this patient population in large-scale randomized outcome trials may assist to guide future treatments[16].

## BLOOD PRESSURE CONTROL IN CKD

Accurate and effective BP readings are required for optimal HTN therapy. Due to a lack of repeat measurements, diurnal variation in BP, and white-coat HTN, BP obtained in clinic or office BP recordings may provide an erroneous assessment of the clinical condition[17,18]. Different phenotypes of HTN have been identified and linked to varying degrees of CVD risk and all-cause death (shown in Table 2). In comparison to clinic measurements, 24-h ambulatory BP monitoring is more reliable, since it allows assessment of diurnal fluctuation in BP and serves as a stronger predictor of CVD events in people with CKD, according to the 2017 American College of Cardiology guidelines[19]. Home BP monitoring is a less resource-intensive alternative technique, and individuals who acquire data from home readings have better overall BP control than those who do not. HTN and CKD have a cause-and-effect connection that is intertwined. A rise in BP is linked to a reduction in kidney function, and a continuing rise in BP is linked to a faster development of renal function decline. As people get older, the prevalence of HTN rises, making BP control more challenging[20]. As a result, HTN control is an important part of CKD patient treatment, and medicines that provide 24-h BP control and thus minimize BP variability should be the preferred therapeutic option for CKD patients.

## USE OF ANTI-HYPERTENSIVE AGENTS IN CKD

HTN management in CKD is critical for patients because HTN treatment can improve CV outcomes in patients with ESRD and CKD[20]. The treatment of HTN is crucial in the management of CKD. HTN is common in people with CKD and ESRD because it is both a cause and a consequence of the disease. In addition, HTN therapy is linked to better CV outcomes in both CKD and ESRD patients. As a result, both the patient and the practitioner must be vigilant when dealing with HTN in CKD[20]. Dietary salt restriction, maintaining an adequate dry weight, and lifestyle changes are among nonpharmacological therapies for HTN. These techniques, however, are ineffective in treating HTN and must be combined with pharmacological therapies for more efficient BP control in the CKD population[16].

Several anti-hypertensive drug types may be useful in the treatment of CKD with HTN[21]. Most patients with CKD and HTN should start with BP medications that also reduce proteinuria. Proteinuria reduction results in long-term improvements in both CV and renal outcomes, according to data[16].

**Table 2 Association of hypertension phenotype with all-cause mortality[18]**

BP phenotype	Description <sup>1</sup>	All-cause mortality hazard ratio (95%CI)
Normotension	Normal clinic BP, normal 24-h ABPM	Reference
White-coat hypertension	High clinic BP, normal 24-h ABPM	1.79 (1.38–2.32)
Sustained hypertension	High clinic BP, high 24-h ABPM	1.80 (1.41–2.31)
Masked hypertension	Normal clinic BP, high 24-h ABPM	2.83 (2.12–3.79)

<sup>1</sup>Normal clinic BP defined as < 140/90 mmHg, Normal 24-h BP defined as < 130/80 mmHg. Values represent patients on treatment and without chronic kidney disease. ABPM: Ambulatory blood pressure monitoring; BP: Blood pressure; CI: Confidence interval.

Angiotensin-converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARBs), which target the RAAS, are commonly used as first-line antihypertensive medications[22]. However, it is widely known that RAAS inhibitors cause hyperkalemia, and that when an ACE and an ARB inhibitor are coupled, renal function is worsened and hypotension occurs[22]. Hyperkalemia was found to be common in patients with CKD who were treated with RAAS inhibitors, and as a result, RAAS inhibitors should be used with caution in patients with underlying CKD and HTN[23]. A preferable first-line therapy in patients without proteinuria has not been firmly established, and drugs such as thiazides may be tried.

Patients with CKD and HTN frequently develop fluid retention/fluid overload, necessitating the use of diuretics in their treatment plan[24]. Thiazides are suggested for people with CKD stages 1 to 3 (GFR 30 mL/min) and have been shown to be beneficial in lowering BP and reducing the risk of CVD. In addition, loop diuretics are favored in patients with CKD stage 4 or 5 (GFR 30 mL/min) because they have been found to be more successful in lowering extracellular fluid volume in individuals with significantly reduced GFR[12,20]. Beta-blockers have a limited effect on CKD progression and proteinuria, thus they are only used as a second- or third-line treatment if the patient has a compelling reason to take one, such as coronary artery disease or chronic heart failure[25]. When first- and second-line therapy fails to reach BP targets, aldosterone receptor antagonists such as spironolactone and eplerenone may be used in CKD treatment[21]. When used with an ACE inhibitor or an ARB, these drugs reduce proteinuria. Aliskiren, a renin inhibitor, is the only drug approved for the treatment of HTN as a monotherapy or in combination with valsartan[26]. Because of the increased risk of renal impairment, hypotension, and hyperkalemia, the ALTITUDE trial has led to the contraindication of its usage with ACE/ARB inhibitors in patients with diabetes or renal impairment[27]. If a patient is unable to take an ACE inhibitor or an ARB, Aliskiren may be tried; however, it is not indicated for individuals with stage 4 or 5 renal failure.

Calcium channel blockers (CCBs) are drugs that relax blood arteries and enhance blood and oxygen supply to the heart while lowering the strain of the heart[28]. Based on electrophysiological and pharmacological features, CCBs are classified as L-, N-, P-, Q-, R-, and T-type[29]. L-type voltage-gated CCBs are potent vasodilators that are commonly utilized as first- or second-line treatments for HTN. In the treatment of HTN in patients with CKD, they are considered second- or third-line therapy[30]. Dihydropyridines (DP) and non-NDP are two types of CCBs that have been demonstrated to be effective in the treatment of HTN in patients with CKD[31]. In non-proteinuric CKD, DP CCBs [such as amlodipine (ALM), cilnidipine, felodipine, nifedipine, and others] can be utilized as first-line therapy alone or in combination, but their impact in proteinuric CKD is inferior to RAAS inhibition[32]. Adding DP CCB to proteinuric patients with RAAS inhibition improves BP control without worsening proteinuria, according to European Society of Hypertension/European Society of Cardiology guidelines, which recommend combination therapy with an ACE inhibitor and CCB as first-line therapy in proteinuric circumstances[33]. In conclusion, the decision to use one medication over another is based on patient-specific considerations such as probable adverse effects, cost, and other underlying comorbidities.

## EMERGENT ROLE OF CCBs IN PATIENTS WITH HTN AND CKD

The most potent and common situation presently is the use of CCBs and RAAS inhibitors (ACE/ARB) as anti-hypertensive medicines for mild to moderate HTN. Although there is no consensus on which antihypertensive drugs should be given as first-line therapy in patients with CKD, a systematic review and meta-analysis of 21 randomized controlled trials (RCTs) involving 9492 patients found that CCBs and RAAS inhibitors had similar BP-lowering effects in HTN patients with CKD and ESRD[34]. In the test population, there were no significant changes in long-term BP maintenance, mortality, heart failure, stroke, cerebrovascular episodes, or renal function. Overall, this study demonstrated that CCBs are comparable to RAAS inhibitors and can protect the kidneys in CKD patients with HTN. This was in line

with a prior study (ALLHAT) that found CCBs to be particularly beneficial for long-term GFR maintenance when compared to diuretics and ACE inhibitors[35]. Furthermore, the INSIGHT study randomized 6321 HTN patients with one or more related risk factors to the DP CCB, nifedipine gastrointestinal therapeutic system, or the diuretic combination hydrochloro-thiazide amiloride for the treatment of HTN. The major composite end point of CV mortality, non-fatal myocardial infarction, stroke, and heart failure had no statistically significant difference in both groups throughout the trial [36]. The ACCOMPLISH (Avoiding CV Events *via* Combination Therapy in Patients Living with Systolic Hypertension) trial compared the effectiveness of ALM/ACE inhibitor against hydrochloro-thiazide/ACE inhibitor combination therapy in adults with HTN and CKD in lowering CVD mortality [37]. The superior efficacy of ALM plus ACE inhibitor on CVD mortality was revealed in this multicenter, double-blind, randomized experiment. Notably, the ALM group had a considerably decreased probability of CKD progression, which was independent of BP values obtained. In the HTN/CKD group, the addition of ALM to ACE inhibitor therapy appears to provide an additional Reno protective benefit compared to the addition of a thiazide diuretic. In summary, the anti-hypertensive use of CCBs in patients with CKD is an attractive option for reducing BP variability with minimal side effects.

In certain countries, DP CCBs are a common class of antihypertensive medicines. ALM and barnidipine, for example, are third generation DPs that are more lipophilic and have stable pharmacokinetics with long-term effects. They are well tolerated in people with heart failure and advantageous for those with CKD since they are less cardio-selective[31].

## AMLODIPINE-THE UNIQUE CCB

DP CCBs are a class of potent, well-tolerated, and safe medicines that are widely used to treat high BP as a monotherapy or as a crucial component of HTN treatment[38]. ALM was first released in the early 1990s and has a number of distinguishing characteristics that set it distinct from other agents in this category. ALM is a longer-acting DP CCB that has been proven in trials to block all channels as well as the N-type channel more effectively than cilnidipine[39]. The elimination half-life of 40-60 h confers various pharmacokinetic properties not found with other calcium-antagonist medications due to its low clearance. It has a high oral bioavailability (60%-80%) and a steady-state accumulation with once-daily dosage over a period of 1-1.5 wk. Furthermore, the pharmacodynamic profile is consistent with the drug's disposition, with BP steadily decreasing over 4-8 h following a single dose and returning to baseline over 24-72 h. Furthermore, stopping ALM therapy causes a delayed restoration of BP to baseline over 7-10 d, with no indication of a 'rebound' impact.

It has great selectivity for vascular smooth muscle, limited impact on heart rate, no negative inotropic effects/electrophysiological disturbances, and milder side events[40]. It is a well-studied classic medication with a wide range of capabilities, including BP regulation and anti-anginal and anti-atherosclerotic effects[41]. Studies documenting ALM's gradual and protracted drop in BP due to a long elimination half-life and delayed receptor dissociation kinetics[42,43] demonstrate its function in delaying the onset of CKD. ALM also has a long duration of action of at least 24 h and good anti-hypertensive effects with high safety in clinical trials with HTN patients at doses of 2.5-5 mg once a day [44]. Furthermore, 35 HTN patients with renal dysfunction were given ALM at 2.5-5.0 mg/d for 8 wk to examine its clinical efficacy and safety in HTN patients with renal dysfunction. With moderate side effects, target BP reduction was reached in 28 of the 35 patients (80%), and ALM was deemed clinically helpful in 27 of the 35 patients (77.1%)[45]. In a clinical trial, individuals treated with telmisartan and ALM combined therapy had a 70% lower urine albumin-to-creatinine ratio (UACR) than those treated with ALM alone[46]. In a similar vein, compared to high dose monotherapy of either medication alone, a low dose telmisartan-ALM combination showed considerably higher BP reductions for both SBP and DBP[47]. ALM safely lowers SBP in hypertensive hemodialysis patients and has a favorable influence on CV outcomes[48]. The link between ALM and contrast-induced acute kidney injury is uncertain, although a retrospective, matched cohort investigation in a large Chinese hypertension population found that ALM medication prior to contrast exposure protected hypertensive patients from contrast-induced acute kidney injury and increased survival[49]. Results from several trials proving the superiority of ALM in decreasing hypertensive CKD are shown below and summarized in [Table 3](#).

### ACCOMPLISH trial

This is a double-blinded, randomized trial with 11506 patients randomized benazepril (20 mg) and ALM (5 mg;  $n = 5744$ ) or benazepril (20 mg) plus hydrochlorothiazide (12.5 mg;  $n = 5762$ ), orally once a day, as previously stated in Section 4. In comparison to the hydrochlorothiazide plus benazepril, ALM plus benazepril group demonstrated a 48% reduction in the progression of CKD and 49% reduction in doubling of serum creatinine. Initiating antihypertensive treatment in CKD with benazepril plus ALM preference to benazepril plus hydrochlorothiazide should be preferred as it slows progression of nephropathy to a greater extent[37].

Table 3 Summarized data from various trials demonstrating the role of amlodipine in reducing hypertension

Trial	Objective	Design/primary endpoints	Drug/procedures used	Main outcomes	Benefits on renal parameters
ALLHAT	To determine whether treatment with a CCB or an ACE inhibitor lowers the incidence of CHD or other CVD events vs treatment with a diuretic	A total of 33357 participants aged 55 yr or older with HTN and at least 1 other CHD risk factor from 623 North American centers were enrolled. Primary Endpoints: Combined fatal CHD or nonfatal MI analyzed by intent-to-treat	Participants were randomly assigned to receive chlorthalidone, 12.5 to 25 mg/d ( $n = 15\,255$ ); ALM, 2.5 to 10 mg/d ( $n = 9048$ ); or lisinopril, 10 to 40 mg/d ( $n = 9054$ ) for planned follow-up of approximately 4 to 8 yr	In patients with HTN, chlorthalidone, ALM, and lisinopril performed similarly in regard to fatal CAD and nonfatal MI	Post hoc analysis of the trial revealed that in hypertensive patients with reduced GFR, both ALM and lisinopril performed similarly in reducing the rate of development of ESRD
ACCOMPLISH	To evaluate the effect of ALM vs hydrochlorothiazide in patients with HTN who are at high risk CVD	Multi-centered, double-blind, randomized, controlled trial with 548 centers in the US and Europe. 11506 subjects were enrolled who received Benazepril/ALM ( $n = 5744$ ) or Benazepril/HCTZ ( $n = 5762$ ). Primary Endpoint: CV mortality, nonfatal MI, nonfatal CVA, UA, resuscitation after cardiac arrest, or coronary revascularization	Subjects received benazepril/ALM 20 mg/5 mg or benazepril/HCTZ 20 mg/12.5 mg daily. Benazepril component was increased to 40 mg after 1 mo. Increase of ALM to 10 mg or HCTZ to 25 mg to reach target BP < 140/90 or < 130/80	Among patients with HTN at high risk for CV complications, benazepril/ALM decreases the rate of CV events as compared to benazepril/HCTZ	Initial antihypertensive treatment with benazepril and ALM demonstrates a superior ability in reducing the progression of nephropathy
SAKURA	To clarify whether the L-/N-type CCB cilnidipine is more renoprotective than the L-type CCB ALM in patients with early-stage diabetic nephropathy	Prospective, multicenter, open-labeled, randomized trial in 77 clinics and hospitals in Japan, to probe the anti-albuminuric effects of cilnidipine and ALM in 367 RAAS inhibitor-treated patients with HTN (BP: 130-180/80-110 mmHg), type 2 diabetes, and microalbuminuria (UACR: 30-300 mg/g). Primary Endpoint: Change in the urinary albumin/Cr ratio after a 1-yr treatment	Study subjects were randomly allocated in two groups and treated with cilnidipine (started at 10 mg/d, then adjusted to 5-20 mg/d) or ALM (started at 5 mg/d, then adjusted to 2.5-10 mg/d). The target BP was < 130/80 mm Hg	Cilnidipine did not offer greater renoprotection than ALM in RAS inhibitor treated HTN patients with type 2 diabetes and microalbuminuria	In hypertensive patients with proteinuria, L-/N- and L/T-type CCBs as add-on therapy to an ACEI or an ARB reduce albuminuria and proteinuria and improve kidney function compared with the use of an ACEI or ARB alone or in combination with other antihypertensive agents
ASCOT-BPLA	To evaluate whether treatment with a newer anti-hypertensive regimen of CCB with or without an ACE inhibitor is more effective than an older regimen of $\beta$ -blocker with or without a diuretic, and whether it reduces CHD events in hypertensive patients with relatively low cholesterol levels	A total of 19257 patients with SBP $\geq$ 160 mm Hg and/or DBP $\geq$ 100 mm Hg (untreated) or SBP $\geq$ 140 mm Hg and/or DBP $\geq$ 90 mm Hg (treated); total cholesterol $\leq$ 6.5 mmol/L (250 mg/dL) and triglycerides $\leq$ 4.5 mmol/L (400 mg/dL); age 40-79 yr; $\geq$ 3 CVD risk factors; and no history of CHD were enrolled Primary Endpoints: Nonfatal MI and fatal CHD	Patients were randomized open-label to one of the two anti-hypertensive treatments: ALM 5 mg ( $n = 9639$ ) or atenolol 50 mg ( $n = 9618$ ). In order to achieve target BP goals of < 140/90 mm Hg, study drug doses were increased, and second-line drugs were added (perindopril 4 mg for the ALM group and bendroflumethiazide 1.25 mg for the atenolol group)	ALM-based regimen is superior to an atenolol-based regimen in regard to demonstrating a greater reduction in BP variability and prevention of major CV events in patients with HTN	ALM based arm demonstrated a significant reduction in new onset diabetes mellitus, development of peripheral arterial disease and renal impairment

ACEI: Ace inhibitor; ALM: Amlodipine; ARB: Angiotensin receptor blockers; BP: Blood pressure; CAD: Coronary artery disease; CCB: Calcium channel blocker; CHD: Chronic heart disease; CVD: Cardiovascular disease; DBP: Diastolic blood pressure; GFR: Glomerular filtration rate; HCTZ: Hydrochlorothiazide; HTN: Hypertension; MI: Myocardial infarction; SBP: Systolic blood pressure; RAAS: Renin-angiotensin-aldosterone system; UACR: Urine albumin-to-creatinine ratio.

### SAKURA trial

The Study of Assessment for Kidney Function by Urinary Microalbumin in Randomized (SAKURA) experiment was conducted to examine the anti-albuminuric effects of L-/N-type and L-type CCBs in HTN patients with diabetes and microalbuminuria. The anti-albuminuric effects of cilnidipine and ALM were investigated in RAAS inhibitor-treated patients with HTN (BP: 130-180/80-110 mmHg), type 2 diabetes, and microalbuminuria (UACR: 30-300 mg/g) in this prospective, multicenter, open-labeled, randomized investigation. Despite the fact that cilnidipine and ALM both reduced BP and showed

similar effects on UACR, ALM provided greater renoprotection in RAS inhibitor-treated hypertensive patients with type 2 diabetes and microalbuminuria. Clonidine provided no more renoprotection than ALM in RAS inhibitor-treated hypertensive patients with type 2 diabetes and microalbuminuria.

### **ASCOT-BPLA trial**

The Anglo-Scandinavian Cardiac Outcomes Trial: Blood Pressure-Lowering Arm (ASCOT-BPLA) trial found that an ALM-based regimen outperformed an atenolol-based regimen in terms of lowering BP variability and preventing major CV events in patients with HTN[51].

Treatment-resistant HTN is emerging as an increasingly recognized problem and is markedly over-represented in patients with CKD[52]. It is defined as uncontrolled BP despite maximally effective dosing of three drugs from different classes, one of which should be a diuretic. Recent evidence has highlighted the heightened risk for both adverse renal and CV outcomes associated with resistant HTN, even when BP control is attained[52]. In a study involving 157 resistant HTN patients (over 60-years-old) who were randomized to 8 wk of treatment and received double-blinded treatment with placebo, ALM (10 mg/d), olmesartan medoxomil (40 mg/d), and ALM (10 mg/d) + olmesartan medoxomil (40 mg/d), the research findings suggested that ALM and OM combination therapy had superior efficacy to ALM or OM monotherapy. Furthermore, patients who received combination therapy met their BP goals more often than those who received placebo, ALM, or OM monotherapies. The long-term CV effects of ALM were compared to other classes of anti-hypertensive medicines in high-risk HTN patient subgroups with diabetes and/or renal failure in another investigation[53]. Thirty-eight RCTs comparing ALM/CCBs to diuretics, -blockers, ACE/ARB inhibitors, and -blockers with a 6-mo follow-up were enrolled, with BP and CV events examined. ALM was found to be successful in lowering SBP and DBP, making it a promising treatment alternative for the long-term management of HTN in diabetic and renal failure patients. In terms of preventing major CV events and causing less diabetes, an ALM-based regimen was found to be superior than an atenolol-based regimen[54].

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## **CONCLUSION**

CCBs are a good choice of anti-hypertensive medications in HTN patients with CKD. ALM is a well-known medication having a wide range of effects, including BP regulation and anti-anginal and anti-atherosclerotic characteristics. ALM is a longer-acting DP CCB that controls BP for up to 24 h and minimizes BP variability. Several pharmacokinetic properties can be linked to it, including limited clearance and a longer rate of elimination (elimination half-life of 40-60 h). It also has a high oral bioavailability and a steady-state accumulation with once-daily treatment. In the absence of albuminuria and with a preserved GFR (> 60 mL/min), it can be used as a first-step therapy since it can block all calcium channels and the N-type channel more effectively than clonidine. It is a strong, well-tolerated, and safe antihypertensive drug that is commonly used for HTN in CKD, either alone or as part of a combination therapy. Its effectiveness in lowering BP has been linked to a reduction in CV events, as evidenced by large RCTs. ALM in combination with other medicines that elicit RAAS blockage (ACE/ARB) has been demonstrated to be an effective BP-lowering strategy in reducing CV risk and slowing the progression of renal impairment. ALM substantially lowers BP in patients with HTN and renal impairment while causing minimal or little worsening of renal dysfunction. In terms of effectiveness and potency in decreasing BP in CKD patients, ALM emerges as the medicine of choice when compared to the newer CCBs.

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## **FOOTNOTES**

**Author contributions:** Khan MY, Patted UR, and Gaurav K developed the concept and drafted the manuscript; All authors reviewed the manuscript and gave final approval.

**Conflict-of-interest statement:** Khan MY, Patted UR and Gaurav K are employees of Dr. Reddy's Laboratories and may own stock. Abraham G, Almeida A, Kumaresan M are members of the advisory board for Dr. Reddy's Laboratories.

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## REFERENCES

- 1 **Carretero OA**, Oparil S. Essential hypertension. Part I: definition and etiology. *Circulation* 2000; **101**: 329-335 [PMID: 10645931 DOI: 10.1161/01.CIR.101.3.329]
- 2 **Prasad V**, Schwerdtfeger U, El-Awa F, Bettcher D, da Costa E Silva V. Closing the door on illicit tobacco trade, opens the way to better tobacco control. *East Mediterr Health J* 2015; **21**: 379-380 [PMID: 26369995 DOI: 10.26719/2015.21.6.379]
- 3 **Ibikwe R**. Modifiable Risk factors of Hypertension and Socio-demographic Profile in Oghara, Delta State; Prevalence and Correlates. *Ann Med Health Sci Res* 2015; **5**: 71-77 [PMID: 25745581 DOI: 10.4103/2141-9248.149793]
- 4 **Angeli F**, Reboldi G, Verdecchia P. Modernization and hypertension: is the link changing? *Hypertens Res* 2013; **36**: 676-678 [PMID: 23552517 DOI: 10.1038/hr.2013.28]
- 5 **Bromfield S**, Muntner P. High blood pressure: the leading global burden of disease risk factor and the need for worldwide prevention programs. *Curr Hypertens Rep* 2013; **15**: 134-136 [PMID: 23536128 DOI: 10.1007/s11906-013-0340-9]
- 6 **Saju MD**, Allagh KP, Scaria L, Joseph S, Thiyagarajan JA. Prevalence, Awareness, Treatment, and Control of Hypertension and Its Associated Risk Factors: Results from Baseline Survey of SWADES Family Cohort Study. *Int J Hypertens* 2020; **2020**: 4964835 [PMID: 32351729 DOI: 10.1155/2020/4964835]
- 7 Chapter 1: Definition and classification of CKD. *Kidney Int Suppl (2011)* 2013; **3**: 19-62 [PMID: 25018975 DOI: 10.1038/kisup.2012.64]
- 8 **Slee AD**. Exploring metabolic dysfunction in chronic kidney disease. *Nutr Metab (Lond)* 2012; **9**: 36 [PMID: 22537670 DOI: 10.1186/1743-7075-9-36]
- 9 **Hill NR**, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS, Hobbs FD. Global Prevalence of Chronic Kidney Disease - A Systematic Review and Meta-Analysis. *PLoS One* 2016; **11**: e0158765 [PMID: 27383068 DOI: 10.1371/journal.pone.0158765]
- 10 **Anupama YJ**, Uma G. Prevalence of chronic kidney disease among adults in a rural community in South India: Results from the kidney disease screening (KIDS) project. *Indian J Nephrol* 2014; **24**: 214-221 [PMID: 25097333 DOI: 10.4103/0971-4065.132990]
- 11 **Rajapurkar MM**, John GT, Kirpalani AL, Abraham G, Agarwal SK, Almeida AF, Gang S, Gupta A, Modi G, Pahari D, Pisharody R, Prakash J, Raman A, Rana DS, Sharma RK, Sahoo RN, Sakhuja V, Tatapudi RR, Jha V. What do we know about chronic kidney disease in India: first report of the Indian CKD registry. *BMC Nephrol* 2012; **13**: 10 [PMID: 22390203 DOI: 10.1186/1471-2369-13-10]
- 12 **Pugh D**, Gallacher PJ, Dhaun N. Management of Hypertension in Chronic Kidney Disease. *Drugs* 2019; **79**: 365-379 [PMID: 30758803 DOI: 10.1007/s40265-019-1064-1]
- 13 **Di Iorio B**, Pota A, Sirico ML, Torraca S, Di Micco L, Rubino R, Guastaferrero P, Bellasi A. Blood pressure variability and outcomes in chronic kidney disease. *Nephrol Dial Transplant* 2012; **27**: 4404-4410 [PMID: 22962409 DOI: 10.1093/ndt/gfs328]
- 14 **Pálsson R**, Patel UD. Cardiovascular complications of diabetic kidney disease. *Adv Chronic Kidney Dis* 2014; **21**: 273-280 [PMID: 24780455 DOI: 10.1053/j.ackd.2014.03.003]
- 15 **Ku E**, Lee BJ, Wei J, Weir MR. Hypertension in CKD: Core Curriculum 2019. *Am J Kidney Dis* 2019; **74**: 120-131 [PMID: 30898362 DOI: 10.1053/j.ajkd.2018.12.044]
- 16 **Carey RM**, Muntner P, Bosworth HB, Whelton PK. Prevention and Control of Hypertension: JACC Health Promotion Series. *J Am Coll Cardiol* 2018; **72**: 1278-1293 [PMID: 30190007 DOI: 10.1016/j.jacc.2018.07.008]
- 17 **Grossman E**. Ambulatory blood pressure monitoring in the diagnosis and management of hypertension. *Diabetes Care* 2013; **36** Suppl 2: S307-S311 [PMID: 23882064 DOI: 10.2337/dcS13-2039]
- 18 **Banegas JR**, Ruilope LM, de la Sierra A, Vinyoles E, Gorostidi M, de la Cruz JJ, Ruiz-Hurtado G, Segura J, Rodríguez-Artalejo F, Williams B. Retraction: Banegas JR. Relationship between Clinic and Ambulatory Blood-Pressure Measurements and Mortality. *N Engl J Med* 2018; **382**: 786 [PMID: 31995856 DOI: 10.1056/NEJMc2001445]
- 19 **Whelton PK**, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APHA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Amer Coll Cardiol* 2018; **71**: e127-248 [DOI: 10.22141/2307-1257.7.1.2018.122220]
- 20 **Judd E**, Calhoun DA. Management of hypertension in CKD: beyond the guidelines. *Adv Chronic Kidney Dis* 2015; **22**: 116-122 [PMID: 25704348 DOI: 10.1053/j.ackd.2014.12.001]
- 21 **Sinha AD**, Agarwal R. Clinical Pharmacology of Antihypertensive Therapy for the Treatment of Hypertension in CKD. *Clin J Am Soc Nephrol* 2019; **14**: 757-764 [PMID: 30425103 DOI: 10.2215/CJN.04330418]
- 22 **Ma TK**, Kam KK, Yan BP, Lam YY. Renin-angiotensin-aldosterone system blockade for cardiovascular diseases: current status. *Br J Pharmacol* 2010; **160**: 1273-1292 [PMID: 20590619 DOI: 10.1111/j.1476-5381.2010.00750.x]
- 23 **Weir MR**, Rolfe M. Potassium homeostasis and renin-angiotensin-aldosterone system inhibitors. *Clin J Am Soc Nephrol* 2010; **5**: 531-548 [PMID: 20150448 DOI: 10.2215/CJN.07821109]
- 24 **Khan YH**, Sarrieff A, Adnan AS, Khan AH, Mallhi TH. Chronic Kidney Disease, Fluid Overload and Diuretics: A

- Complicated Triangle. *PLoS One* 2016; **11**: e0159335 [PMID: 27442587 DOI: 10.1371/journal.pone.0159335]
- 25 **Tomiyama H**, Yamashina A. Beta-Blockers in the Management of Hypertension and/or Chronic Kidney Disease. *Int J Hypertens* 2014; **2014**: 919256 [PMID: 24672712 DOI: 10.1155/2014/919256]
  - 26 **Sureshkumar KK**. Renin inhibition with aliskiren in hypertension: focus on aliskiren/hydrochlorothiazide combination therapy. *Vasc Health Risk Manag* 2008; **4**: 1205-1220 [PMID: 19337534 DOI: 10.2147/VHRM.S3364]
  - 27 **Heerspink HJ**, Persson F, Brenner BM, Chaturvedi N, Brunel P, McMurray JJ, Desai AS, Solomon SD, Pfeffer MA, Parving HH, de Zeeuw D. Renal outcomes with aliskiren in patients with type 2 diabetes: a prespecified secondary analysis of the ALTITUDE randomised controlled trial. *Lancet Diabetes Endocrinol* 2016; **4**: 309-317 [PMID: 26774608 DOI: 10.1016/S2213-8587(15)00469-6]
  - 28 **Epstein M**. Lercanidipine: a novel dihydropyridine calcium-channel blocker. *Heart Dis* 2001; **3**: 398-407 [PMID: 11975824 DOI: 10.1097/00132580-200111000-00008]
  - 29 **Tiwaskar M**, Langote A, Kashyap R, Toppo A. Amlodipine in the Era of New Generation Calcium Channel Blockers. *J Assoc Physicians India* 2018; **66**: 64-69 [PMID: 30341872]
  - 30 **Ozawa Y**, Hayashi K, Kobori H. New Generation Calcium Channel Blockers in Hypertensive Treatment. *Curr Hypertens Rev* 2006; **2**: 103-111 [PMID: 19823601 DOI: 10.2174/157340206776877370]
  - 31 **Wang AL**, Iadecola C, Wang G. New generations of dihydropyridines for treatment of hypertension. *J Geriatr Cardiol* 2017; **14**: 67-72 [PMID: 28270844 DOI: 10.11909/j.issn.1671-5411.2017.01.006]
  - 32 **Appel LJ**, Wright JT Jr, Greene T, Agodoa LY, Astor BC, Bakris GL, Cleveland WH, Charleston J, Contreras G, Faulkner ML, Gabbai FB, Gassman JJ, Hebert LA, Jamerson KA, Kopple JD, Kusek JW, Lash JP, Lea JP, Lewis JB, Lipkowitz MS, Massry SG, Miller ER, Norris K, Phillips RA, Pogue VA, Randall OS, Rostand SG, Smogorzewski MJ, Toto RD, Wang X; AASK Collaborative Research Group. Intensive blood-pressure control in hypertensive chronic kidney disease. *N Engl J Med* 2010; **363**: 918-929 [PMID: 20818902 DOI: 10.1056/NEJMoa0910975]
  - 33 **Mancia G**, De Backer G, Dominiczak A, Cifkova R, Fagard R, Germano G, Grassi G, Heagerty AM, Kjeldsen SE, Laurent S, Narkiewicz K, Ruilope L, Rynkiewicz A, Schmieder RE, Boudier HA, Zanchetti A, Vahanian A, Camm J, De Caterina R, Dean V, Dickstein K, Filippatos G, Funck-Brentano C, Hellems I, Kristensen SD, McGregor K, Sechtem U, Silber S, Tendera M, Widimsky P, Zamorano JL, Erdine S, Kiowski W, Agabiti-Rosei E, Ambrosioni E, Lindholm LH, Viigimaa M, Adamopoulos S, Bertomeu V, Clement D, Farsang C, Gaita D, Lip G, Mallion JM, Manolis AJ, Nilsson PM, O'Brien E, Ponikowski P, Redon J, Ruschitzka F, Tamargo J, van Zwieten P, Waerber B, Williams B; Management of Arterial Hypertension of the European Society of Hypertension; European Society of Cardiology. 2007 Guidelines for the Management of Arterial Hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *J Hypertens* 2007; **25**: 1105-1187 [PMID: 17563527 DOI: 10.1097/hjh.0b013e3281fc975a]
  - 34 **Lin YC**, Lin JW, Wu MS, Chen KC, Peng CC, Kang YN. Effects of calcium channel blockers comparing to angiotensin-converting enzyme inhibitors and angiotensin receptor blockers in patients with hypertension and chronic kidney disease stage 3 to 5 and dialysis: A systematic review and meta-analysis. *PLoS One* 2017; **12**: e0188975 [PMID: 29240784 DOI: 10.1371/journal.pone.0188975]
  - 35 **ALLHAT Officers and Coordinators for the ALLHAT Collaborative Research Group**. Major outcomes in moderately hypercholesterolemic, hypertensive patients randomized to pravastatin vs usual care: The Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT-LLT). *JAMA* 2002; **288**: 2998-3007 [PMID: 12479764 DOI: 10.1001/jama.288.23.2998]
  - 36 **Brown MJ**, Palmer CR, Castaigne A, de Leeuw PW, Mancia G, Rosenthal T, Ruilope LM. Morbidity and mortality in patients randomised to double-blind treatment with a long-acting calcium-channel blocker or diuretic in the International Nifedipine GITS study: Intervention as a Goal in Hypertension Treatment (INSIGHT). *Lancet* 2000; **356**: 366-372 [PMID: 10972368 DOI: 10.1016/S0140-6736(00)02527-7]
  - 37 **Jamerson K**, Weber MA, Bakris GL, Dahlöf B, Pitt B, Shi V, Hester A, Gupte J, Gatlin M, Velazquez EJ; ACCOMPLISH Trial Investigators. Benazepril plus amlodipine or hydrochlorothiazide for hypertension in high-risk patients. *N Engl J Med* 2008; **359**: 2417-2428 [PMID: 19052124 DOI: 10.1056/NEJMoa0806182]
  - 38 **Haller H**. Effective management of hypertension with dihydropyridine calcium channel blocker-based combination therapy in patients at high cardiovascular risk. *Int J Clin Pract* 2008; **62**: 781-790 [PMID: 18355239 DOI: 10.1111/j.1742-1241.2008.01713.x]
  - 39 **Furukawa T**, Nukada T, Miura R, Ooga K, Honda M, Watanabe S, Koganesawa S, Isshiki T. Differential blocking action of dihydropyridine Ca<sup>2+</sup> antagonists on a T-type Ca<sup>2+</sup> channel (alpha1G) expressed in *Xenopus* oocytes. *J Cardiovasc Pharmacol* 2005; **45**: 241-246 [PMID: 15725949 DOI: 10.1097/01.fjc.0000154374.88283.15]
  - 40 **Ciacci C**, Piazza O. Decluttering. *Transl Med UniSa* 2020; **23**: 19 [PMID: 34447706 DOI: 10.37825/2239-9747.1002]
  - 41 **Fares H**, DiNicolantonio JJ, O'Keefe JH, Lavie CJ. Amlodipine in hypertension: a first-line agent with efficacy for improving blood pressure and patient outcomes. *Open Heart* 2016; **3**: e000473 [PMID: 27752334 DOI: 10.1136/openhrt-2016-000473]
  - 42 **Abernethy DR**. Pharmacokinetics and pharmacodynamics of amlodipine. *Cardiology* 1992; **80** Suppl 1: 31-36 [PMID: 1534713 DOI: 10.1159/000175050]
  - 43 **Abernethy DR**, Schwartz JB. Calcium-antagonist drugs. *N Engl J Med* 1999; **341**: 1447-1457 [PMID: 10547409 DOI: 10.1056/NEJM199911043411907]
  - 44 **Şen S**, Demir M, Yiğit Z, Üresin AY. Efficacy and Safety of S-Amlodipine 2.5 and 5 mg/d in Hypertensive Patients Who Were Treatment-Naive or Previously Received Antihypertensive Monotherapy. *J Cardiovasc Pharmacol Ther* 2018; **23**: 318-328 [PMID: 29649885 DOI: 10.1177/1074248418769054]
  - 45 **Saruta T**, Ishii M, Abe K, Iimura I. Efficacy and safety of amlodipine in hypertensive patients with renal dysfunction. *Clin Cardiol* 1994; **17**: 317-324 [PMID: 8070149 DOI: 10.1002/clc.4960170609]
  - 46 **Sharma AM**, Bakris G, Neutel JM, Littlejohn TW, Kobe M, Ting N, Ley L. Single-pill combination of telmisartan/amlodipine versus amlodipine monotherapy in diabetic hypertensive patients: an 8-week randomized, parallel-group, double-blind trial. *Clin Ther* 2012; **34**: 537-551 [PMID: 22386829 DOI: 10.1016/j.clinthera.2012.02.004]

- 47 **Gosse P.** A review of telmisartan in the treatment of hypertension: blood pressure control in the early morning hours. *Vasc Health Risk Manag* 2006; **2**: 195-201 [PMID: [17326326](#) DOI: [10.2147/vhrm.2006.2.3.195](#)]
- 48 **Tepel M,** Hopfenmueller W, Scholze A, Maier A, Zidek W. Effect of amlodipine on cardiovascular events in hypertensive haemodialysis patients. *Nephrol Dial Transplant* 2008; **23**: 3605-3612 [PMID: [18511605](#) DOI: [10.1093/ndt/gfn304](#)]
- 49 **Yin WJ,** Zhou LY, Li DY, Xie YL, Wang JL, Zuo SR, Liu K, Hu C, Zhou G, Chen LH, Yang HQ, Zuo XC. Protective Effects of Amlodipine Pretreatment on Contrast-Induced Acute Kidney Injury And Overall Survival In Hypertensive Patients. *Front Pharmacol* 2020; **11**: 44 [PMID: [32116719](#) DOI: [10.3389/fphar.2020.00044](#)]
- 50 **Ando K,** Ueshima K, Tanaka S, Kosugi S, Sato T, Matsuo H, Nakao K, Fujita T. Comparison of the antialbuminuric effects of L-/N-type and L-type calcium channel blockers in hypertensive patients with diabetes and microalbuminuria: the study of assessment for kidney function by urinary microalbumin in randomized (SAKURA) trial. *Int J Med Sci* 2013; **10**: 1209-1216 [PMID: [23935398](#) DOI: [10.7150/ijms.5508](#)]
- 51 **Ostergren J,** Poulter NR, Sever PS, Dahlöf B, Wedel H, Beevers G, Caulfield M, Collins R, Kjeldsen SE, Kristinsson A, McInnes GT, Mehlsen J, Nieminen M, O'Brien E; ASCOT investigators. The Anglo-Scandinavian Cardiac Outcomes Trial: blood pressure-lowering limb: effects in patients with type II diabetes. *J Hypertens* 2008; **26**: 2103-2111 [PMID: [18854748](#) DOI: [10.1097/HJH.0b013e328310e0d9](#)]
- 52 **Wolley MJ,** Stowasser M. Resistant Hypertension and Chronic Kidney Disease: a Dangerous Liaison. *Curr Hypertens Rep* 2016; **18**: 36 [PMID: [27072829](#) DOI: [10.1007/s11906-016-0641-x](#)]
- 53 **Ding S,** Liu J, Fu Q, Zheng Y. Clinical effects of combined olmesartan medoxomil and amlodipine on clinic and ambulatory blood pressure in elderly patients with resistant hypertension. *Arch Gerontol Geriatr* 2013; **57**: 423-427 [PMID: [23669062](#) DOI: [10.1016/j.archger.2013.04.006](#)]
- 54 **Jeffers BW,** Robbins J, Bhambri R, Wajsbrot D. A Systematic Review on the Efficacy of Amlodipine in the Treatment of Patients With Hypertension With Concomitant Diabetes Mellitus and/or Renal Dysfunction, When Compared With Other Classes of Antihypertensive Medication. *Am J Ther* 2015; **22**: 322-341 [PMID: [25738570](#) DOI: [10.1097/MJT.0000000000000202](#)]



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