British Journal of Hospital Medicine

Br. J. Hosp. Med. (Lond) **2026**; 87(6): 55374
https://doi.org/10.31083/BJHM55374

Review

Updates in the Diagnosis and Management of Hypertension: A Review of Recent Guidelines

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Academic Editor: Dimitrios Patoulias
Submitted: 13 December 2025 Revised: 30 April 2026 Accepted: 22 May 2026 Published: 28 June 2026

Abstract

Hypertension is one of the leading contributors to global cardiovascular morbidity and mortality. Recent updates to major international guidelines have introduced changes in diagnostic thresholds, risk stratification, and treatment recommendations aimed at earlier detection and improved outcomes. This review summarises recent developments in the diagnosis and management of hypertension, comparing key recommendations from the American Heart Association (AHA)/American College of Cardiology (ACC), the European Society of Cardiology (ESC) and European Society of Hypertension (ESH), and the UK National Institute for Health and Care Excellence (NICE). Particular emphasis is placed on differences in diagnostic criteria, blood pressure targets, and evolving pharmacological and non-pharmacological management strategies. Updated guidelines increasingly promote out-of-office blood pressure monitoring and individualised treatment based on overall cardiovascular risk, comorbidities, and target-organ damage. Despite greater consensus on risk-based management, important regional differences remain, including the lower diagnostic threshold adopted in the United States and variation in treatment targets. Implementation in clinical practice continues to present challenges, as access to ambulatory blood pressure monitoring, healthcare resources, and patient adherence may limit uptake of guideline recommendations.

Keywords: hypertension; clinical guidelines; blood pressure; diagnosis; antihypertensive therapy; cardiovascular risk

1. Introduction

Systemic arterial hypertension is the most common and preventable risk factor for cardiovascular disease (CVD) and all-cause mortality worldwide [1]. It affects an estimated 1.28 billion adults globally, yet fewer than half achieve optimal blood pressure control [2]. The burden of hypertension continues to rise, driven by increasing life expectancy, sedentary lifestyles, and widespread unhealthy dietary patterns [3].

Hypertension contributes to the development of coronary artery disease, stroke, heart failure, and chronic kidney disease (CKD), and it plays an important role in cognitive decline and dementia [4]. The relationship between blood pressure and cardiovascular risk is continuous and linear, with increased risk observed at systolic levels above 115 mmHg [5]. Even modest reductions in blood pressure can therefore produce substantial reductions in cardiovascular morbidity and mortality.

Despite the availability of effective pharmacological and lifestyle interventions, hypertension remains underdiagnosed and undertreated worldwide. Barriers include a lack of awareness, limited access to diagnostic tools such as ambulatory blood pressure monitoring (ABPM), poor adherence to treatment, and systemic healthcare constraints.

Over the past decade, several major international societies have updated their hypertension guidelines. These include the American Heart Association (AHA)/American College of Cardiology (ACC), the European Society of Cardiology (ESC), the European Society of Hypertension (ESH), and the UK's National Institute for Health and Care Excellence (NICE). While these guidelines share common principles, they differ in diagnostic thresholds, risk stratification, and treatment targets, reflecting variations in healthcare systems, available evidence, and cultural contexts.

This review provides an overview of the most recent updates in the diagnosis and management of hypertension, comparing recommendations across major international guidelines and examining their implications for clinical practice, particularly in the UK hospital setting. These updates have been informed by emerging evidence from major trials, including the Systolic Blood Pressure Intervention Trial (SPRINT), which have shaped contemporary treatment targets. To support this, a targeted literature search was conducted using PubMed and key guideline publications from the AHA/ACC, ESC/ESH, and NICE, with emphasis on recent clinical guidelines, randomised controlled trials, and high-quality systematic reviews relevant to adult populations.

2. Updates in Hypertension Diagnosis

Recent guideline updates have introduced significant changes in the thresholds and classification of hypertension, reflecting a large body of evidence linking lower blood pr-

Table 1. Diagnostic thresholds and classification of hypertension across major guidelines.

Category	AHA/ACC 2025 (mmHg)	ESH 2023 (mmHg)	ESC 2024 (mmHg)	NICE 2023 (mmHg)
Normal/Optimal	<120/<80	<120/<80	<120/<80	<120/<80
Elevated/High-normal	120–129/<80	120–139/80–84 = normal-high 135–139/85–89 = high-normal	120–139/70–89 = elevated BP (new category)	120–139/80–89 (not formally classified as hypertension)
Stage 1 hypertension	130–139/80–89	140–159/90–99 = Grade 1	≥140/≥90 (no Grade subdivisions)	≥140/≥90 = Stage 1
Stage 2 hypertension	≥140/≥90	160–179/100–109 = Grade 2	—	≥160/≥100 = Stage 2
Stage 3/Severe hypertension	No separate Stage 3 category; BP ≥140/90 mmHg is classified as Stage 2 hypertension	≥180/≥110 = Grade 3	—	≥180/≥110 = Severe hypertension
Hypertensive crisis/Severe hypertension	>180/>120	>180/>120 (urgent or emergency)	>180/>120 (urgent or emergency)	≥180/≥120 (same-day specialist assessment if symptomatic or with evidence of acute target-organ damage)
Notes	Lower threshold; emphasises early lifestyle and risk-based treatment.	Retains traditional Grade 1–3 classification; defines high-normal 130–139/85–89 as warning range.	No grade subdivisions; introduces elevated BP category (120–139/70–89); emphasizes ABPM/HBPM confirmation and CV risk stratification.	ABPM/HBPM confirmation required for diagnosis; treatment guided by BP level and overall cardiovascular risk.

Colour gradient guide: The colours flow from green (healthy) through lime, yellow-green, yellow, orange, to red (crisis). This creates a "visual heat map" showing increasing blood pressure severity.

AHA/ACC, American Heart Association/American College of Cardiology; ESC, European Society of Cardiology; ESH, European Society of Hypertension; NICE, National Institute for Health and Care Excellence; BP, blood pressure; ABPM, ambulatory blood pressure monitoring; HBPM, home blood pressure monitoring.

The data used in Table 1 are derived from references [6,7,8,9].

essure (BP) levels to adverse cardiovascular outcomes. All major organisations agree on the importance of early diagnosis; however, the specific thresholds and criteria differ across the NICE, ESC/ESH, and AHA/ACC guidelines.

2.1 New Blood Pressure Thresholds

The AHA/ACC 2025 guidelines take a slightly more aggressive approach in their guidelines, lowering the diagnostic threshold for hypertension to ≥130/80 mmHg (see Table 1, Ref. [6,7,8,9]). These guidelines classify blood pressure into three key categories: elevated blood pressure (120–129/<80 mmHg), Stage 1 hypertension (130–139/80–89 mmHg), and Stage 2 hypertension (≥140/≥90 mmHg) [6]. The shift from previous guidelines aims to promote early diagnosis and intervention to reduce long-term cardiovascular risk, particularly in high-risk populations. By eliminating the previous "high-normal" or "pre-hypertension" terms used in earlier frameworks [6], the AHA/ACC now establishes that even modest elevations in blood pressure are clinically significant. However, this new addition has sparked debate because of the potential of over-diagnosis and overtreatment in individuals at lower risk.

The European Society of Hypertension (ESH) 2023 guidelines maintain the conventional hypertension threshold of ≥140/90 mmHg but adopt a more granular severity-based classification: Grade 1 (140–159/90–99 mmHg), Grade 2 (160–179/100–109 mmHg), and Grade 3 (≥180/≥110 mmHg), allowing clinicians to tailor treatment intensity by severity [7]. They additionally define a high-normal blood pressure category (130–139 systolic and/or 85–89 diastolic mmHg) as a warning range in which intensified lifestyle modification and, in selected high-risk individuals or those with hypertension-mediated organ damage [7], earlier pharmacotherapy may be considered. This approach emphasises cardiovascular risk stratification and target-organ assessment rather than relying solely on blood pressure thresholds. The 2024 ESC (in collaboration with ESH) [8] retains the definition of hypertension as ≥140/90 mmHg, without subdividing into grades, but introduces a new "elevated BP" category (120–139/70–89 mmHg) to flag individuals at higher risk before frank hypertension. The ESC places greater emphasis on overall cardiovascular risk stratification and evaluation of hypertension-mediated organ damage, rather than relying solely on absolute BP cutoffs.

The National Institute for Health and Care Excellence (NICE) guidelines define hypertension as a clinic blood pressure of ≥140/90 mmHg [9], aligning with the thresholds used by the other European organisations. A distinct feature of the NICE guidelines is its requirement to use ambulatory blood pressure monitoring (ABPM) or home blood pressure monitoring (HBPM) [9]. Once confirmed, hypertension is classified into three categories: Stage 1 hypertension is defined as clinic BP ≥140/90 mmHg with ABPM/HBPM readings of ≥135/85 mmHg; Stage 2 hypertension is defined as clinic BP ≥160/100 mmHg with ABPM/HBPM readings of ≥150/95 mmHg, while severe (Grade 3) hypertension is defined by clinic blood pressure ≥180/110 mmHg. Hypertensive urgency or emergency is identified when clinic systolic BP is ≥180 mmHg or diastolic BP is ≥120 mmHg, with classification depending on the presence of acute target-organ damage [9]. Treatment decisions are guided by a combination of blood pressure severity, cardiovascular risk profile, and comorbid conditions such as diabetes or CKD. The NICE framework emphasises diagnostic accuracy and risk-based treatment to avoid unnecessary treatment in low-risk individuals [9].

These differences in classification reflect varying philosophies across regions. The AHA/ACC's lower diagnostic threshold aims to promote early lifestyle interventions and risk-based therapy, whereas the ESC/ESH and NICE guidelines remain more conservative, aiming to reduce overtreatment and emphasise diagnostic precision. Overall, although the AHA/ACC adopts a lower diagnostic threshold (≥130/80 mmHg) than the ESC/ESH and NICE guidelines (≥140/90 mmHg), the definition and staging of hypertension remain guideline-dependent, influencing treatment eligibility and estimates of disease burden. Nevertheless, all major recommendations emphasise that hypertension diagnosis and management should be guided not only by blood pressure values but also by overall cardiovascular risk and evidence of hypertension-mediated organ damage. A distinctive feature of the NICE recommendations is the requirement to use ABPM or HBPM to confirm the diagnosis.

2.2 Changes in Diagnostic Approaches

In conjunction with the evolving thresholds of hypertension, new guidelines have placed increased emphasis on out-of-office blood pressure measuring, including ambulatory blood pressure monitoring (ABPM) and home blood pressure monitoring (HBPM). These methods have gained increased usage due to their aid in capturing an individual's true blood pressure profile throughout the day, minimising the influence of situational factors such as white coat or masked hypertension.

The 2025 AHA/ACC guidelines expand the role of out-of-office blood pressure monitoring as central to diagnosis and management. While standardised in-office measurements remain essential for screening, ABPM and HBPM are strongly recommended to confirm hypertension, detect white-coat or masked hypertension, and guide therapy [6]. ABPM is considered the gold standard, providing 24-hour readings for risk assessment, while HBPM offers a practical patient-driven alternative for ongoing monitoring. The guidelines emphasise using validated oscillometric devices, averaging ≥2 readings on ≥2 occasions, and incorporating out-of-office data for treatment titration and adherence tracking, reflecting a broader shift toward data-driven, patient-centred hypertension care [6].

The ESC/ESH and NICE guidelines elevate the importance of out-of-office blood pressure monitoring by in-

tegrating ABPM and HBPM into diagnostic and management pathways. While office BP $\geq$140/90 mmHg remains the diagnostic threshold, the guidelines emphasise that repeated or out-of-office confirmation is essential before labelling a patient hypertensive. The ESC 2024 specifically recommends using ABPM/HBPM to verify "elevated BP" (120–139/70–89 mmHg) when accompanied by increased cardiovascular risk and highlights their role in confirming that target BP (typically 120–129 mmHg systolic) is safely achieved [8]. Similarly, the ESH 2023 guidelines identify ABPM as the gold standard for diagnosis and cardiovascular risk stratification, in cases of white-coat or masked hypertension, and endorse HBPM as a practical alternative when ABPM is unavailable [7]. Both guidelines advocate a hybrid, risk-based approach, combining office BP for initial screening with out-of-office monitoring for confirmation, therapy adjustment, and tracking of BP variability, nighttime readings, and patient adherence [7,8].

NICE remains one of the strongest advocates for out-of-office BP measurement, recommending ABPM to confirm a diagnosis of hypertension whenever feasible, with HBPM as an alternative when ABPM is unavailable [9]. Clinic blood pressure measurements are used as an initial screening tool but are considered insufficient for diagnosis on their own. This approach improves diagnostic accuracy, reduces misclassification, particularly white coat hypertension, and helps avoid unnecessary treatment, reflecting NICE's emphasis on precision, cost-effectiveness, and minimising over-treatment.

These updated recommendations reflect a broad shift from reliance on solely office-based measurements. While clinic BP readings remain an essential part of cardiovascular risk assessment, current evidence highlights the superior prognostic value of ABPM and HBPM, particularly in detecting abnormalities in BP regulation that are missed in the clinic setting. The integration of these tools into routine practice is reshaping the diagnostic landscape and enabling more individualised, accurate, and risk-informed decision-making in hypertension management, as agreed upon across the US, UK, and European organisations.

2.3 Risk Stratification and Cardiovascular Risk Assessment

The updated hypertension guidelines increasingly emphasise the importance of cardiovascular risk stratification in diagnostic and therapeutic decisions. Rather than relying solely on absolute blood pressure values to determine treatment, recent updates further encourage clinicians to include estimates of a patient's overall cardiovascular risk, including both short-term and lifetime risk projections.

The 2025 AHA/ACC guidelines expand cardiovascular risk assessment beyond blood pressure thresholds by incorporating the Predicting Risk of Cardiovascular Disease Events (PREVENT™) calculator [6], which estimates both 10-year and 30-year risk of atherosclerotic cardiovascular disease (ASCVD), heart failure, and other cardiovascular outcomes to inform treatment decisions and guide the intensity of preventive interventions. Pharmacologic therapy is advised for all adults with BP $\geq$140/90 mmHg, and for those with BP $\geq$130/80 mmHg who have ASCVD, diabetes, CKD, prior stroke, or a 10-year risk $\geq$7.5%. For lower-risk or younger adults, the emphasis shifts toward lifestyle modification informed by lifetime risk. The guidelines also recommend targeted screening for secondary causes like primary aldosteronism, renovascular disease, CKD, or obstructive sleep apnea (OSA) in patients with resistant, early-onset, or severe hypertension [6]. Overall, the 2025 update promotes a prevention-focused approach, aligning treatment with total cardiovascular risk and long-term disease burden.

The ESC 2024 and ESH 2023 guidelines integrate long-term cardiovascular risk into hypertension management, emphasising assessment beyond BP thresholds by incorporating overall risk, hypertension-mediated organ damage (HMOD), and comorbidities [7,8]. Both advocate a multidimensional approach that includes ischemic burden, imaging, and clinical factors, supported by risk tools such as Systematic Coronary Risk Evaluation 2 (SCORE2) for individuals aged 40–69 years, Systematic Coronary Risk Evaluation 2–Older Persons (SCORE2-OP) for those aged $\geq$70 years, and coronary artery calcium scoring (CACS) to refine risk prediction and personalise therapy [7,8]. The ESH 2023 guidelines particularly emphasise treatment decisions for patients with high-normal BP (130–139/85–89 mmHg), recommending pharmacotherapy only when cardiovascular (CV) risk or organ damage is elevated, while promoting lifestyle intervention for others [7]. Both guidelines stress long-term prevention, especially in younger adults with low short-term but high lifetime risk, and reinforce screening for secondary hypertension, including primary aldosteronism, renal disease, and OSA in cases of early-onset, resistant, or rapidly progressive hypertension [7,8]. Renal denervation is discussed but not recommended due to insufficient outcome data [8].

The NICE 2023 guideline integrates 10-year cardiovascular disease (CVD) risk estimation into treatment decisions using the QResearch Cardiovascular Risk Algorithm (QRISK) calculator, including the QRISK2 and QRISK3 versions [9]. For Stage 1 hypertension, treatment is typically offered if the 10-year risk is $\geq$10%, or if the patient has diabetes, kidney disease, or organ damage [9]. While NICE focuses on 10-year risk, they also recognise the importance of lifetime risk in younger adults, suggesting early lifestyle interventions even when short-term risk appears low. NICE is more conservative in initiating treatment than ACC/AHA, but it still encourages early action in those with cumulative risk over time [9]. Routine screening for secondary hypertension is not advised universally; however, NICE recommends investigation in cases of early-onset, severe, or resistant hypertension, highlighting renal disease, endocrine disorders, and OSA as common causes [9]. Referral to specialists is encouraged when initial workup is

abnormal, while ABPM or HBPM should be used to exclude white-coat hypertension before diagnosing secondary causes [9].

In conclusion, the AHA 2025, ESC 2024, ESH 2023, and NICE 2023 guidelines collectively mark a shift toward integrating lifetime cardiovascular risk into hypertension management, moving beyond short-term risk estimation. The AHA 2025 emphasises the new PREVENT™ calculator to guide both 10-year and 30-year risk-based treatment [6], while the ESC 2024 and ESH 2023 advocate for a multidimensional, long-term strategy that includes imaging, advanced risk scores like SCORE2 and SCORE2-OP, and individualised factors [7,8]. NICE 2023 maintains a more conservative stance but similarly prioritises early lifestyle interventions in younger, low-risk adults [9]. Across the organisations, there is a growing emphasis on proactive prevention, personalised therapy, and targeted screening for secondary hypertension. Together, these updates reflect a unified focus on lifelong cardiovascular risk reduction and tailored, evidence-based care.

3. Updates in Hypertension Management

Recent updates in hypertension management emphasise earlier treatment, greater use of home and ambulatory BP monitoring, and more personalised therapy based on overall cardiovascular risk. Evidence linking even mild BP elevations to adverse outcomes has prompted tighter control targets and broader adoption of combination therapy. Although major guidelines differ in specific thresholds and preferred regimens, they all underscore proactive, individualised BP management to reduce long-term cardiovascular risk.

3.1 Revised Blood Pressure Targets

The AHA/ACC 2025 guidelines reaffirm the diagnostic threshold for hypertension as ≥130/80 mmHg and maintain a general treatment goal of <130/80 mmHg, while introducing a risk-adaptive approach through the new PREVENT™ calculator [6], which estimates both 10-year and 30-year ASCVD risk to guide therapy intensity. Pharmacologic treatment is recommended for adults with BP ≥140/90 mmHg and for those with BP ≥130/80 mmHg who have clinical ASCVD, diabetes, CKD, prior stroke, or a 10-year CVD risk ≥7.5% [6]. The guidelines emphasise individualised management based on overall cardiovascular risk, with evidence from the Systolic Blood Pressure Intervention Trial (SPRINT) continuing to support intensive control (<120 mmHg systolic) in high-risk populations. For older or frail adults, targets may be adjusted to balance benefits with tolerability. Overall, the 2025 update reflects a shift toward personalised, prevention-focused hypertension management, combining validated out-of-office monitoring, lifetime risk assessment, and selective secondary hypertension screening to reduce long-term cardiovascular burden [6], as shown in Table 2 (Ref. [6,7,8,9,10,11,12]).

The ESC 2024 and ESH 2023 guidelines both retain a diagnostic threshold of ≥140/90 mmHg but differ slightly in classification and treatment focus. The ESC introduces an "Elevated BP" (120–139/70–89 mmHg) category to identify higher-risk individuals and recommends confirming hypertension with ABPM/HBPM before initiating therapy [8]. It promotes systolic targets of 120–129 mmHg when tolerated and more lenient goals (<140/90 mmHg) in frail or orthostatic patients under the As Low As Reasonably Achievable (ALARA) principle [8]. Similarly, the ESH 2023 guidelines advocate a stepwise reduction strategy, initiating treatment at ≥140/90 mmHg and progressively aiming for <130/80 mmHg if safely achievable [7]. Informed by earlier landmark trials such as SPRINT and Strategy of blood pressure intervention in the Elderly hypertensive Patients (STEP), the ESH emphasises flexibility and individualised targets in elderly or comorbid patients to balance benefit and tolerability [7]. Together, both societies endorse a personalised, risk-based approach that prioritises out-of-office confirmation, comorbidity assessment, and safe, sustained BP control [7,8].

NICE 2023 remains the most conservative among the major guidelines. It defines hypertension as ≥140/90 mmHg (or ABPM daytime average/HBPM average ≥135/85 mmHg) [9], and generally recommends initiating treatment if BP is ≥140/90 mmHg with a 10-year CVD risk ≥10%, or if the patient has diabetes, CKD, or end-organ damage. The treatment target for most adults is <140/90 mmHg, and <150/90 mmHg for those aged ≥80 years, unless other risk factors are present [9]. Unlike AHA and ESC/ESH, NICE has not adopted a universal <130/80 mmHg target, stating concerns about overtreatment and patient tolerability, particularly in the older population [9]. While NICE acknowledges trials like SPRINT, it takes a more cautious approach, focusing on avoiding harm from aggressive treatment in lower-risk individuals or the elderly.

Published in 2015, SPRINT enrolled over 9300 adults aged 50 and older with systolic blood pressure (SBP) ≥130 mmHg and increased cardiovascular risk (excluding those with diabetes, prior stroke, or polycystic kidney disease) [10]. It compared a standard SBP target of <140 mmHg with an intensive SBP target of <120 mmHg [10]. The trial was stopped early due to a significantly lower rate of the primary composite cardiovascular outcome (myocardial infarction, stroke, heart failure, or cardiovascular death) in the intensive treatment group (hazard ratio (HR) 0.75) [10]. All-cause mortality was also significantly reduced (HR 0.73) [10]. SPRINT provided strong evidence supporting lower SBP targets in high-risk individuals without diabetes, directly influencing the AHA 2017 guidelines' more aggressive recommendations.

The Blood Pressure Control Target in Diabetes (BPROAD) trial was a large Chinese randomised controlled trial, published in 2025 (and thus influential for very recent and future guidelines), that investigated intensive BP con-

Table 2. Revised blood pressure targets.

Guideline	General target (mmHg)	Elderly target (mmHg)	Diabetes/CKD (mmHg)	Notes
AHA/ACC 2025	<130/80	Same, individualised if frail	<130/80	Risk-based via PREVENT™; supported by SPRINT; integrates 10- & 30-year ASCVD risk.
ESC 2024	120–129 systolic (if tolerated)	ALARA, <140/90 in frail elderly	<130/80	Risk-adapted approach using CACS, SCORE2; emphasises ABPM/HBPM confirmation.
ESH 2023	<130/80 if tolerated; <140/90	<140/90; stepwise lowering	<130/80	Flexible but intensive; influenced by SPRINT, BPROAD, STEP.
NICE 2023	<140/90 (<135/85 HBPM)	<150/90 in ≥80 yrs	<140/90 (individualised targets in selected patients with diabetes, CKD or organ damage)	More conservative; prioritises tolerability and safety in elderly.

Colour legend: Orange tone—Aggressive, evidence-based approaches. Blue tone—Balanced, individualised approach. Purple tone—Conservative, safety-first approach.

AHA/ACC, American Heart Association/American College of Cardiology; ESC, European Society of Cardiology; ESH, European Society of Hypertension; NICE, National Institute for Health and Care Excellence; ASCVD, atherosclerotic cardiovascular disease; PREVENT™, Predicting Risk of Cardiovascular Disease Events; ALARA, As Low As Reasonably Achievable; CACS, coronary artery calcium scoring; SCORE2, Systematic Coronary Risk Evaluation 2; ABPM, ambulatory blood pressure monitoring; HBPM, home blood pressure monitoring; CKD, chronic kidney disease; SPRINT, Systolic Blood Pressure Intervention Trial; STEP, Strategy of Blood Pressure Intervention in the Elderly Hypertensive Patients; BPROAD, Blood Pressure Control Target in Diabetes; yrs, years.

The data used in Table 2 are derived from references [6,7,8,9,10,11,12].

trol in adults with type 2 diabetes and hypertension at elevated CVD risk. It randomised over 12,800 participants to an intensive SBP target of <120 mmHg or a standard target of <140 mmHg [11]. BPROAD found that the intensive treatment group had a 21% lower risk of the composite CVD endpoint (nonfatal stroke, nonfatal myocardial infarction, heart failure events, or cardiovascular disease mortality) compared to the standard group [11]. This trial provides crucial evidence supporting aggressive BP control in diabetic patients, a population that has previously had less definitive evidence from trials like Action to Control Cardiovascular Risk in Diabetes Blood Pressure (ACCORD BP), which was underpowered.

STEP was conducted in China and published in 2021. The trial focused on older hypertensive patients (60–80 years). It compared an intensive SBP target of 110 to <130 mmHg with a standard target of 130 to <150 mmHg [12]. STEP demonstrated that intensive BP treatment significantly reduced the risk of major cardiovascular events (by 26%) in this older population [12]. This trial challenged the idea that less aggressive BP control is always appropriate for the elderly, providing evidence for careful but more intensive management in non-frail older adults.

Building on these landmark trials, two recent pooled analyses provide a more comprehensive assessment of intensive blood pressure reduction. A contemporary aggregate-data meta-analysis demonstrated that intensive systolic blood pressure lowering reduced major cardiovascular events (HR 0.82, 95% CI 0.76–0.88), with consistent benefits in patients with and without diabetes, but increased the risks of syncope and hypotension [13].

Similarly, a large individual participant data meta-analysis of over 80,000 participants across six trials confirmed reductions in major cardiovascular events (HR 0.76) and all-cause mortality (HR 0.87), alongside higher rates of adverse and renal events, with an overall favourable benefit–harm profile [14].

Collectively, these findings support risk-stratified intensive blood pressure control while emphasising the need to balance cardiovascular benefit against treatment-related harm. Overall, there is increasing convergence among contemporary hypertension guidelines towards lower blood pressure targets, particularly <130/80 mmHg when tolerated, while emphasising individualised, risk-based treatment decisions. All major guidelines support the use of out-of-office blood pressure monitoring to improve diagnostic accuracy and guide management. Evidence from landmark randomised controlled trials and recent pooled analyses consistently demonstrates cardiovascular benefit from intensive blood pressure lowering, although this must be balanced against an increased risk of treatment-related adverse events. Despite some differences in treatment thresholds and targets, particularly within the more conservative NICE recommendations, the overall direction of practice is towards personalised, prevention-focused hypertension management.

3.2 Changes in Pharmacological Management

While foundational principles remain, recent edits to guidelines reflect advancements in pharmacotherapy, strategies for improving treatment adherence, and tailored approaches for diverse patient populations. This section

delves into the nuanced recommendations across these influential guidelines concerning antihypertensive agents, the increasing emphasis on early combination therapy, specialised management for the elderly, individuals with diabetes or chronic kidney disease, and those with resistant hypertension, while also highlighting the growing role of agents like sodium–glucose cotransporter-2 (SGLT2) inhibitors that are shaping the future of care.

First-Line Therapy: ACE Inhibitors, ARBs, Calcium Channel Blockers, Diuretics-New Recommendations

The AHA/ACC 2025 guidelines reaffirm angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), calcium channel blockers (CCBs) and diuretics as first-line therapies for most adults with hypertension. Among diuretic options, chlorthalidone is preferred due to its longer half-life and stronger evidence in reducing cardiovascular risk (see Table 3, Ref. [6,7,8,9]). The update strengthens recommendations for initial combination therapy, particularly for those with Stage 2 hypertension ($\geq$140/90 mmHg) or elevated cardiovascular risk, emphasising fixed-dose single-pill combinations to improve adherence and BP control. Beta-blockers are reserved for patients with compelling indications such as heart failure with reduced ejection fraction (HFrEF), post-myocardial infarction (MI), or arrhythmias. The guidelines also stress personalised treatment based on comorbidities, age, sex, and race, endorsing CCBs or thiazide diuretics as initial choices in Black adults without CKD, and recommending SGLT2 inhibitors or glucagon-like peptide-1 (GLP-1) receptor agonists in patients with diabetes or CKD to enhance cardiovascular and renal outcomes [6]. Overall, the 2025 update reflects a shift toward risk-based, combination-centred, and comorbidity-guided therapy designed to optimise long-term BP control and organ protection.

The ESC 2024 and ESH 2023 guidelines both endorse ACE inhibitors, ARBs, calcium channel blockers (CCBs), and thiazide diuretics as first-line antihypertensive therapies, emphasising individualised treatment based on comorbidities, patient characteristics, and tolerability [7,8]. Both strongly recommend initiating therapy with a single-pill combination of two low-dose antihypertensives, representing a major shift toward combination therapy from the outset to improve adherence and blood pressure control [7,8]. Beta-blockers are not recommended as first-line agents unless specific indications exist, such as ischemic heart disease or arrhythmias [8]. The ESH 2023 guidelines emphasise combination therapy as the preferred initial approach for most patients with hypertension, typically prioritising angiotensin-converting enzyme inhibitors (ACE inhibitors) or angiotensin receptor blockers (ARBs) in combination with CCBs or diuretics. When diuretics are included, long-acting agents such as chlorthalidone are favoured, particularly in older patients or those with volume-depleted hypertension. The guidelines further highlight that single-pill combinations improve adherence, persistence, and long-term blood pressure control [7]. Both ESC and ESH emphasise tailoring therapy according to sex, organ protection needs, and overall cardiovascular risk, while also looking toward future triple single-pill combinations to simplify regimens and optimise outcomes [7,8].

NICE adopts an age and ethnicity-based approach. For people $<$55 years or those with diabetes, ACE inhibitors or ARBs are first-line therapy. For those $\geq$55 years or Black patients of African or Caribbean descent, a CCB is first line [9]. A thiazide-like diuretic is added as a second agent if a CCB is not suitable or tolerated [9]. NICE remains relatively traditional in its stepwise escalation, although it does endorse combining agents when needed.

There is a growing consensus across major hypertension guidelines supporting the early use of combination therapy, preferably as fixed-dose combinations (FDCs) or single-pill combinations (SPCs), to enhance blood pressure control, improve adherence, and accelerate attainment of target levels.

The AHA/ACC 2025 guidelines formally recommend initial dual therapy with agents from different classes for adults with Stage 2 hypertension ($\geq$140/90 mmHg) or when BP is $>$20/10 mmHg above target, unless contraindicated (see Table 4, Ref. [6,7,8,9]). Preferred combinations include a renin-angiotensin-aldosterone system (RAAS) blocker (ACE inhibitor or ARB) with either a CCB or thiazide diuretic, ideally as a single-pill formulation to improve adherence and simplify dosing. The AHA emphasises once-daily regimens and early use of combination therapy to improve long-term compliance, particularly in high-risk and older adults [6].

Similarly, the ESC 2024 and ESH 2023 guidelines strongly endorse initial dual therapy, with the ESC assigning a Class I recommendation for single-pill combination treatment in most patients, except those with low-risk or borderline hypertension [7,8]. Both favour combinations such as ACE inhibitors or ARBs combined with a CCB or diuretic, citing faster BP control, improved adherence, and better persistence than stepwise monotherapy. The ESH 2023 additionally supports expanding access to single-pill combinations, highlighting benefits in adherence and long-term BP maintenance, and anticipates the introduction of triple-agent SPCs for resistant hypertension [7].

By contrast, the NICE 2023 guidelines remain more conservative, following a stepwise escalation from monotherapy and reserving combination treatment for cases where BP remains above goal after initial titration (see Fig. 1, Ref. [6,7,8,9]). Although NICE acknowledges the adherence benefits of combination therapy, it continues to prioritise safety and tolerability, especially in elderly or frail patients [9]. Overall, contemporary hypertension guidelines increasingly favour risk-based and combination-centred pharmacological management. The AHA/ACC 2025 guidelines support earlier use of dual therapy and preferential use of chlorthalidone, whereas the ESC 2024 and ESH 2023 guidelines strongly endorse single-pill com-

Table 3. Pharmacology of hypertension.

Guideline	First-line	Combination therapy	Special populations
AHA/ACC 2025	Thiazide (chlorthalidone preferred), ACEi, ARB, CCB	Early dual therapy if Stage 2 HTN ($\geq$140/90) or >20/10 mmHg above target; prefer single-pill (FDC) combos	Diabetes/CKD: ACEi/ARB $\pm$ SGLT2i/GLP-1 RA; Black patients: CCB or thiazide; Elderly: individualised
ESC 2024	ACEi/ARB + CCB or diuretic	Start with single-pill dual therapy for most patients	Tailored by comorbidities, sex differences, and tolerability
ESH 2023	ACEi/ARB + CCB or diuretic	Strong single-pill combination (SPC) recommendation	Diuretics commonly used in older adults; SPCs improve adherence and persistence
NICE 2023	<55 yrs: ACEi/ARB; $\geq$55 yrs or Black African/Caribbean ethnicity: CCB	Stepwise escalation after monotherapy	Diabetes/CKD: ACEi/ARB recommended; age- and ethnicity-guided selection

ACEi/ARB: renin-angiotensin system blockers (first-line for diabetes/CKD).

CCB: calcium channel blockers (especially for elderly/Black patients).

Thiazide/Diuretic: diuretics (chlorthalidone preferred in AHA).

SGLT2i: SGLT2 inhibitors (cardiovascular/renal protection in diabetes).

GLP-1 RA: receptor agonists (weight loss + cardiovascular benefits).

AHA/ACC, American Heart Association/American College of Cardiology; ESC, European Society of Cardiology; ESH, European Society of Hypertension; NICE, National Institute for Health and Care Excellence; ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; CCB, calcium channel blocker; HTN, hypertension; FDC, fixed-dose combination; SPC, single-pill combination; CKD, chronic kidney disease; SGLT2i, sodium–glucose cotransporter-2 inhibitor; GLP-1 RA, glucagon-like peptide-1 receptor agonist.

The data used in Table 3 are derived from references [6,7,8,9].

bination therapy as the preferred initial treatment strategy while reserving beta-blockers for specific clinical indications. In contrast, NICE maintains a more traditional age- and ethnicity-based stepwise approach to treatment escalation. Despite these differences, there is a broad consensus that combination therapy improves blood pressure control and treatment adherence, with growing recognition of the role of sodium–glucose cotransporter-2 (SGLT2) inhibitors in patients with diabetes or chronic kidney disease.

3.3 Management in Special Populations

3.3.1 Elderly

The AHA/ACC 2025 guidelines recommend a BP target of <130/80 mmHg for adults $\geq$65 years with hypertension and comorbidities such as diabetes, CKD, CVD, or a 10-year ASCVD risk $\geq$7.5%, while emphasising individual metrics using the PREVENT™ calculator to balance benefit and tolerability in frail adults [6]. The ESC 2024 guidelines raise the "very elderly" threshold to $\geq$80 years and incorporate a frailty assessment, applying the ALARA principle for those with limited life expectancy, also maintaining similar targets to younger adults if well tolerated [8]. The ESH 2023 guidelines advise aiming for <140/90 mmHg in older patients, with a gradual decrease toward <130/80 mmHg when feasible, with <140/90 mmHg as the initial goal for those $\geq$80 years [7]. The NICE 2023 guidelines remain the most conservative, recommending <150/90 mmHg (or HBPM <145/85 mmHg) for adults $\geq$80 years, prioritising safety and tolerability over intensive control [9].

3.3.2 Diabetes

For adults with diabetes and hypertension, the AHA guidelines [6] recommend a target blood pressure of <130/80 mmHg, emphasising renin-angiotensin system (RAS) blockers (ACE inhibitors or ARBs) for their renoprotective benefits and supporting SGLT2 inhibitors in patients with diabetes and CKD or heart failure regardless of glycemic control. The ESC/ESH guidelines advise a target of 120–129 mmHg if tolerated, also prioritising ACEi/ARB as first-line therapy and highlighting the cardiovascular and renal advantages of SGLT2 inhibitors and GLP-1 receptor agonists [7,8]. Similarly, the NICE guidelines [9] start with ACEi/ARB in diabetics, generally aiming for <140/90 mmHg, or <130/80 mmHg when kidney, eye, or cerebrovascular disease is present, and suggest a target of $\leq$130/80 mmHg in younger adults with type 1 diabetes and albuminuria.

3.3.3 Chronic Kidney Disease (CKD)

For patients with chronic kidney disease (CKD), the AHA [6] recommends a target BP of <130/80 mmHg, emphasising RAS blockers (ACE inhibitors or ARBs) as first-line agents for renoprotection, particularly in those with albuminuria, and endorsing the addition of SGLT2 inhibitors in patients with CKD or heart failure regardless of diabetic

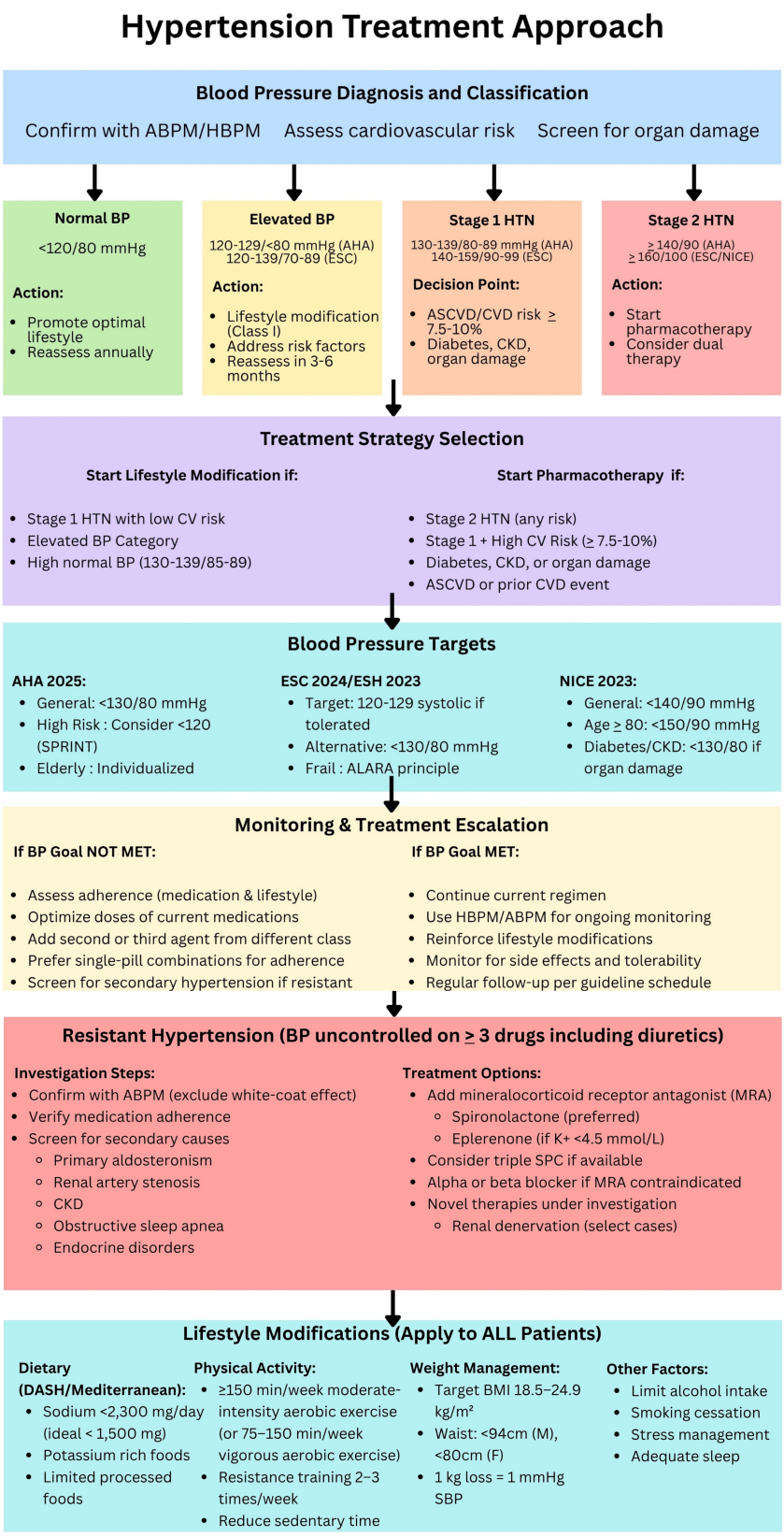

Fig. 1. Hypertension treatment approach. Fig. 1 uses data from [6,7,8,9]. Created using Canva Software (Version: Web-based platform (no discrete version number—Canva is continuously updated and does not use traditional version numbering), Canva Pty Ltd., Sydney, NSW, Australia). 2–3x/wk: 2–3 times a week. BMI, body mass index; SBP, systolic blood pressure.

Table 4. Drug classes used in hypertension.

Drug class	AHA/ACC 2025	ESC 2024	ESH 2023	NICE 2023
ACE inhibitors/ARBs	First-line for most adults; RAAS blocker required in diabetes/CKD; used in early dual therapy (ACEi/ARB + CCB/thiazide). Avoid in pregnancy.	First-line and part of preferred initial dual therapy (ACEi/ARB + CCB or diuretic); individualised to comorbidities.	First-line and central to combination therapy; emphasised for organ protection and tolerability.	First-line if <55 yrs or diabetes; second line if ≥55 yrs/Black patients.
Calcium channel blockers (CCBs)	First-line; preferred in Black adults without CKD; part of dual therapy with ACEi/ARB.	First-line and part of universal dual-therapy recommendation (CCB + ACEi/ARB).	Strong first-line option; widely used within SPCs; favoured if edema manageable.	First-line in ≥55 yrs or Black adults; used before diuretics in most cases.
Thiazide/Thiazide-like diuretics	First-line; chlorthalidone preferred for potency/long half-life. Used in early dual therapy.	Included as first-line; used in SPCs (ACEi/ARB + diuretic).	First-line; long-acting agents (chlorthalidone, indapamide) preferred, especially in elderly or volume-dependent pts.	Used if CCB not tolerated or as step 2 therapy; thiazide-like agents preferred (indapamide, chlorthalidone).
Beta-blockers	Not first-line unless compelling indication: HFrEF, post-MI, angina, arrhythmia.	Not first-line; reserved for ischemic heart disease or arrhythmias.	Not first-line; use only for specific cardiac indications.	Not first-line; used only in special indications (ischemic disease or intolerance to other drugs).
SGLT2 inhibitors/GLP-1 RAs	Recommended in diabetes/CKD to improve renal & CV outcomes; adjunct to RAAS blockade.	Recognised for CV protection but not formal first-line HTN agents; used when comorbid diabetes/CKD present.	Increasingly endorsed for renal/CV protection; considered adjunctive in high-risk patients.	Not standard antihypertensive therapy; used primarily for diabetes with CV/renal benefit.
Combination therapy (across drug classes)	Strong recommendation for initial dual therapy in Stage 2 HTN or BP >20/10 above goal; single-pill FDC preferred.	Universal recommendation for single-pill dual therapy in nearly all patients.	Strong SPC preference; anticipating triple-drug SPCs for resistant HTN.	More conservative; stepwise escalation; combination therapy added only if BP is uncontrolled after titration.
Special populations	Black adults: CCB or thiazide first-line; Diabetes/CKD: ACEi/ARB ± SGLT2i/GLP-1 RA; older adults: individualised dosing.	Tailor to comorbidities, sex, tolerability.	Diuretics commonly used in older adults are favoured in elderly; SPCs improve adherence.	Ethnicity and age drive first-line choice; ACEi/ARB recommended in diabetes/CKD.

Colour legend:

Light green—First-line/Strongly recommended: Primary recommended agents for hypertension treatment.

Yellow—Second-line/Conditional: Used as step 2 or in specific circumstances.

Orange—Adjunctive/Special purpose: Added for comorbidity benefits, not primary BP control.

Light red—Not first-line/Reserved: Only for compelling indications (e.g., heart disease).

Light blue—Informational/Context: Special populations guidance and considerations.

AHA/ACC, American Heart Association/American College of Cardiology; ESC, European Society of Cardiology; ESH, European Society of Hypertension; NICE, National Institute for Health and Care Excellence; ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; CCB, calcium channel blocker; CKD, chronic kidney disease; HFrEF, heart failure with reduced ejection fraction; MI, myocardial infarction; SGLT2i, sodium–glucose cotransporter-2 inhibitor; GLP-1 RA, glucagon-like peptide-1 receptor agonist; CV, cardiovascular; HTN, hypertension; FDC, fixed-dose combination; RAAS, renin-angiotensin-aldosterone system; SPC, single-pill combination; BP, blood pressure.

The data used in Table 4 are derived from references [6,7,8,9].

Table 5. Landmark RCTs influencing guidelines.

Trial	Year	Population	Target (mmHg)	Key findings
SPRINT	2015	9361 adults ≥50 yrs, high cardiovascular (CV) risk (without diabetes or prior stroke)	<120 vs <140	Reduced cardiovascular events and reduced mortality
STEP	2021	Elderly (60–80 yrs, China)	110–<130 vs 130–<150	26% reduction in cardiovascular events
BPROAD	2025	12,800 with T2DM + HTN	<120 vs <140	21% reduction in major cardiovascular events
ACCORD BP	2010	T2DM	<120 vs <140	Neutral overall, with reduced stroke risk

Colour legend:

Dark green—Strong positive results: Significant reduction in CV events and/or mortality (e.g., SPRINT).

Medium green—Moderate positive results: Notable CV benefit in specific populations (e.g., STEP).

Light green—Positive results: Beneficial outcomes with important clinical implications (e.g., BPROAD).

Yellow—Neutral/Mixed results: No significant overall benefit or mixed results (e.g., ACCORD BP).

RCT, randomised controlled trial; CV, cardiovascular; T2DM, type 2 diabetes mellitus; HTN, hypertension.

The data used in Table 5 are derived from references [10,11,12,15].

status. The ESC/ESH similarly advise a target SBP of 120–129 mmHg if tolerated, with ACEi/ARB as cornerstone therapy and strong evidence supporting SGLT2 inhibitors for both diabetic and non-diabetic CKD due to their reno and cardioprotective effects [7,8]. The ESH guidelines [7] specifically recommend SGLT2i when eGFR ≥20 mL/min/1.73 m^2, while the NICE guidelines [9] set tailored targets such as <130/80 mmHg for CKD with albumin-to-creatinine ratio ≥70 mg/mmol, reaffirming RAAS-based therapy with close renal monitoring as the foundation of management.

3.3.4 Resistant Hypertension

For resistant hypertension, the AHA guidelines [6] define it as blood pressure remaining above target despite the concurrent use of three antihypertensive agents of different classes (including a diuretic) or controlled with four appropriate medications after confirming adherence and excluding secondary causes. Mineralocorticoid receptor antagonists (MRAs) such as spironolactone or eplerenone are recommended as preferred fourth-line agents, with growing interest in novel interventions such as renal denervation for persistently uncontrolled cases.

The ESC/ESH similarly define resistant hypertension, emphasising verification of adherence, exclusion of white-coat hypertension, and screening for secondary causes [7,8]. They recommend MRAs as the next step if BP remains uncontrolled and highlight triple-combination single-pill therapy (ACEi/ARB + CCB + thiazide diuretic) to enhance adherence and BP control [7,8].

The NICE guidelines follow a stepped-care model, adding spironolactone if serum potassium is <4.5 mmol/L or an alpha or beta blocker if potassium is ≥4.5 mmol/L, maintaining a similar algorithmic approach to AHA and ESC guidance [9].

3.3.5 Emerging Role of SGLT2 Inhibitors

The AHA 2025 guidelines now formally recognise sodium–glucose cotransporter-2 (SGLT2) inhibitors as key adjunctive agents in hypertension management, marking a major evolution from the 2017 guidelines [6]. They are recommended for patients with hypertension and comorbid chronic kidney disease (CKD) or heart failure (heart failure with reduced ejection fraction [HFrEF] or heart failure with preserved ejection fraction [HFpEF]), regardless of diabetic status, due to consistent evidence of cardiorenal protection and modest BP reduction. The ESC/ESH 2024–2023 guidelines likewise integrate SGLT2 inhibitors prominently, citing robust outcomes from trials such as EMPA-REG OUTCOME, DAPA-HF, EMPEROR-Reduced, DAPA-CKD, and EMPA-KIDNEY, and advocate their use as add-on therapy in patients with cardiorenal disease independent of glycemic control [7,8]. This reflects a paradigm shift toward a “treat-the-comorbidity” approach, where these agents are valued for multifaceted benefits beyond BP lowering. The NICE guidelines, while earlier focused on diabetes and CKD, are increasingly aligned in acknowledging SGLT2 inhibitors for their broad cardiovascular and renal advantages, reinforcing their inclusion across modern hypertension algorithms [9].

Overall, contemporary hypertension guidelines, as outlined by the AHA 2025, ESC 2024, ESH 2023, and NICE 2023 recommendations, advocate increasingly personalised management strategies for high-risk populations, including older adults, patients with diabetes, chronic kidney disease, and resistant hypertension. Although blood pressure targets and treatment algorithms vary slightly between organisations, there is broad agreement on the importance of risk-based therapy, early use of combination treatment, and optimisation of adherence. Landmark trials such as SPRINT, STEP, BPROAD and ACCORD BP (see Table 5, Ref. [10,11,12,15]) have informed these recommendations, supporting tighter blood pressure control in selected populations while emphasising the need to balance efficacy with safety. In older adults, treatment targets are increasingly individualised according to frailty, comorbidity burden, and treatment tolerability. For patients with diabetes or chronic kidney disease, there is growing em-

phasis on renin–angiotensin system blockade and the use of sodium–glucose cotransporter-2 (SGLT2) inhibitors to provide cardiovascular and renal protection in addition to blood pressure reduction. Resistant hypertension continues to be managed through stepwise intensification of therapy, with mineralocorticoid receptor antagonists remaining the preferred fourth-line agents. Despite regional differences in implementation, current recommendations share a common focus on improving long-term cardiovascular outcomes through individualised, patient-centred care.

4. Non-Pharmacological Management Updates

As the global burden of hypertension continues to rise, the guidelines from the AHA, ESC, ESH, and NICE increasingly emphasise the foundational role of non-pharmacologic interventions in prevention and long-term management. Lifestyle measures like sodium restriction, structured physical activity, weight optimisation, and moderation of alcohol intake are now central to all major recommendations. The AHA 2025 further integrates digital health platforms, remote BP monitoring, and the PREVENT™ risk calculator to individualise care and improve adherence, while the ESC/ESH highlights home BP tracking and behavioural interventions for sustained control. Across societies, there is growing alignment toward evidence-based, technology-supported, and patient-centred approaches, reflecting a shift from reactive treatment to proactive, comprehensive hypertension management.

4.1 Dietary Modifications: Sodium Intake and Nutrition

The updated AHA 2025 guidelines continue to endorse the DASH diet as the cornerstone of nutritional management for hypertension, reinforcing its benefits in reducing cardiovascular and renal risk [6]. They now emphasise a daily sodium intake of $<$2300 mg, with a preferred target of $<$1500 mg/day for individuals with hypertension, Black adults, and those at high ASCVD risk [6]. Greater focus is placed on potassium-rich, plant-forward dietary patterns and reducing ultra-processed foods as practical strategies to lower sodium exposure [6]. The guidelines also highlight cultural adaptability, nutrition equity, and the use of digital tools and dietary tracking apps to improve adherence and personalise interventions, aligning with a broader, prevention-oriented approach across the 2025 recommendations.

The ESC/ESH guidelines both emphasise sodium reduction as a Class I recommendation, recommending restriction of dietary sodium intake to approximately $\leq$2 g/day (equivalent to about $\leq$5 g of salt/day), with stricter goals for high-risk groups [7,8]. Both support potassium-enriched salt substitutes (e.g., 75% NaCl/25% KCl) were safe, citing strong evidence for reduced cardiovascular events [7,8]. The ESC favours the Mediterranean diet over Dietary Approaches to Stop Hypertension (DASH) due to superior CVD outcomes in European populations and newly highlights limiting sugar-sweetened beverages [8]. Similarly, the ESH encourages higher dietary potassium through fruits and vegetables (excluding CKD patients) and endorses the Mediterranean pattern for its practicality and adherence, while advising caution with salt substitutes in specific clinical settings [7].

The NICE 2023 guidelines encourage people to keep their dietary sodium intake low, either by reducing or substituting sodium salt [9]. It provides a cautionary note regarding salt substitutes containing potassium chloride, advising against their use in older people, those with diabetes, pregnant women, people with kidney disease, and individuals taking certain antihypertensive drugs (e.g., ACE inhibitors, ARBs) due to the risk of hyperkalemia [9].

4.2 Exercise and Weight Management

The AHA 2025 guidelines reinforce regular physical activity as a cornerstone of hypertension management, recommending increased physical activity through structured exercise programmes that include aerobic and resistance training [6]. The guidelines also emphasise individualised lifestyle and weight-management strategies, noting that weight reduction is dose-responsive, with approximately a 1 mmHg reduction in systolic blood pressure for every 1 kg of weight loss. Aerobic, dynamic resistance, and isometric resistance exercises have all been shown to reduce blood pressure, with the greatest benefits observed from regular aerobic activity and combination training approaches. Exercise interventions are considered safe and effective across a wide range of patient populations, including older adults with hypertension. Maintenance of a healthy body weight remains a key lifestyle strategy for preventing and treating elevated blood pressure. Overall, the AHA highlights lifestyle modification, including physical activity, healthy dietary patterns, sodium reduction, and weight management as a fundamental component of hypertension prevention and control [6].

The ESC 2024 and ESH 2023 guidelines emphasise regular physical activity as a core intervention for blood pressure management, recommending at least 150 minutes per week of moderate-intensity aerobic exercise or 75 minutes per week of vigorous-intensity aerobic exercise, supplemented by resistance training 2–3 times weekly [7,8]. Additional benefits may be achieved with up to 300 minutes of moderate-intensity or 150 minutes of vigorous-intensity aerobic activity per week. Both guidelines strongly promote weight management and sustained lifestyle modification as essential components of cardiovascular risk reduction. The ESH recommends maintaining a normal body mass index (18.5–24.9 kg/m^2), while both organisations advocate structured, multidisciplinary approaches to support long-term weight loss and behavioural change [7,8]. The ESC further emphasises individualised exercise prescriptions, taking into account age, comorbidities, functional status, and patient preferences, particularly in older or frail individuals [8]. Together, these recommendations position

physical activity, weight management, and other lifestyle interventions as foundational strategies for long-term blood pressure control and cardiovascular risk reduction [7,8].

NICE similarly encourages regular physical activity and achievement of a healthy body weight as key non-pharmacological strategies for blood pressure management [9]. While recommendations are less prescriptive than those of the AHA or ESC/ESH, NICE supports referral to structured weight-management and physical activity programmes where appropriate, particularly within primary care settings, and recognises obesity as an important modifiable contributor to hypertension and cardiovascular risk [9].

Overall, all major guidelines emphasise lifestyle modification as a fundamental component of hypertension prevention and management. Despite differences in the level of detail provided, they consistently recognise physical activity, weight management, and other behavioural interventions as essential strategies for reducing blood pressure and long-term cardiovascular risk.

4.3 Complementary and Alternative Therapies in Hypertension Management

The AHA 2025 guidelines maintain a cautious stance on natural and herbal supplements, advising against their use as substitutes for evidence-based antihypertensive therapy because of variable product quality, limited regulatory oversight, and inconsistent evidence of efficacy [6]. The guidelines acknowledge that certain dietary and nutritional interventions may contribute modestly to blood pressure reduction when incorporated into comprehensive lifestyle modification strategies. However, these approaches are recommended only as adjuncts to established lifestyle and pharmacological treatments, and patients should discuss supplement use with healthcare professionals to minimise potential interactions and ensure safe integration into hypertension management [6].

The ESC and ESH guidelines briefly reference complementary and alternative approaches, including herbal supplements, mindfulness-based stress reduction, and yoga [7,8]. However, both emphasise that these interventions should not replace evidence-based pharmacological or lifestyle treatment and note that the supporting evidence remains limited and heterogeneous [7,8].

NICE does not include natural medicine within its primary hypertension recommendations but supports patient autonomy and shared decision-making. The guideline advises that complementary or alternative treatments should be discussed within the clinical context, particularly when patients are using unregulated supplements or herbal remedies that may interfere with prescribed therapy [9].

Overall, contemporary guidelines remain cautious regarding natural and complementary therapies, supporting their use only as adjuncts to established lifestyle and pharmacological interventions while emphasising the importance of safety, regulation, and evidence-based care.

4.4 Digital Health Interventions and Remote Monitoring

The AHA 2025 guidelines place greater emphasis on out-of-office blood pressure monitoring, recommending home blood pressure monitoring (HBPM) and ambulatory blood pressure monitoring (ABPM) as important tools for diagnosis, treatment titration, and long-term management [6]. The guidelines support self-monitoring and telemonitoring strategies, recognising their role in improving blood pressure control and facilitating ongoing patient engagement. Telehealth interventions that incorporate remote BP data transfer, lifestyle education, and medication management have been associated with greater blood pressure reduction compared with usual care [6]. The AHA also highlights the use of electronic health records, patient registries, and clinical decision-support systems to support hypertension management and quality improvement initiatives. Collectively, these recommendations reflect an increasing shift towards patient-centred monitoring and integration of digital technologies within hypertension care.

The ESC 2024 and ESH 2023 guidelines similarly recognise the growing role of digital health technologies in supporting hypertension management and treatment adherence [7,8]. Both endorse home blood pressure monitoring, telemonitoring, and digital communication tools to facilitate ongoing assessment and guide treatment decisions. The ESC specifically recommends physician–patient web communication, including the reporting of home BP readings, and supports self-monitored BP measurement to improve BP control, patient empowerment, and adherence. The guideline also notes that enhanced self-monitoring using devices linked to smartphone applications may be considered, although current evidence does not demonstrate clear superiority over standard self-monitoring approaches [8].

NICE guidance supports the use of ambulatory and home blood pressure monitoring for diagnosis and ongoing management and recommends that patients who self-monitor receive appropriate training and support. However, unlike the ESC and ESH guidelines, NICE concluded that evidence for telemonitoring was insufficient to support a formal recommendation.

Overall, contemporary hypertension guidelines increasingly support the integration of digital health technologies and remote monitoring into routine clinical practice, recognising their potential to improve patient engagement, treatment adherence, and blood pressure control.

5. Challenges in Implementation and Future Directions

Despite the evolution of hypertension guidelines across major organisations, real-world adherence to these updated recommendations remains suboptimal. Studies consistently reveal a gap between guideline-based targets and clinical outcomes, often driven by system-level, provider-level, and patient-level barriers [16]. Even as

thresholds for diagnosis and treatment have been lowered and individualised care has been emphasised, many patients remain uncontrolled, often due to clinical inertia, limited access to appropriate tools, or challenges in maintaining long-term adherence [17].

One of the most cited implementation challenges is the limited uptake of out-of-office blood pressure monitoring, including ABPM and HBPM [18]. Although nearly all major guidelines now recommend these tools to confirm diagnosis and guide management, logistical and financial barriers persist. In many healthcare systems, ABPM is not widely available or reimbursed, and patients may lack access to validated home monitors or the training needed to use them correctly. As a result, white coat hypertension and masked hypertension remain underdiagnosed, leading to either overtreatment or missed opportunities for early intervention [19]. However, the recent development of 24-hour ABPMs may help improve access to this important tool [20].

Adherence to antihypertensive therapy is another persistent barrier. Even when diagnosis and treatment initiation occur appropriately, long-term adherence to medication and lifestyle changes is often poor. Factors such as pill burden, side effects, cost, and lack of symptoms contribute to non-adherence [21]. Additionally, interventions such as fixed-dose combinations (FDCs), digital adherence tools, behavioural counselling, and patient education are increasingly seen as essential components of comprehensive care.

An emerging area of interest is the incorporation of pulse wave analysis to assess central blood pressure and arterial stiffness as adjunctive tools for cardiovascular risk assessment. Compared with peripheral (brachial) BP readings, non-invasively derived estimates of central aortic pressure may better reflect actual cardiovascular load and target-organ risk, particularly in younger patients or those with increased arterial stiffness [22].

For patients with resistant hypertension, ongoing research is expanding therapeutic options. Renal denervation, a catheter-based procedure that targets sympathetic nerves supplying the kidneys, has shown renewed promise in recent trials such as SPYRAL HTN-ON MED (Global Clinical Study of Renal Denervation With the Symplicity Spyral™ Multi-electrode Renal Denervation Catheter in Patients With Uncontrolled Hypertension on Standard Medical Therapy) [23] and RADIANCE-HTN (Ultrasound Renal Denervation for Hypertension) [24]. While the ESC 2024 guidelines stop short of recommending its routine use, the procedure is acknowledged as a potential option for carefully selected patients with resistant hypertension when standard pharmacological therapy fails to achieve adequate blood pressure control. On the pharmaceutical front, emerging evidence suggests that certain disease-modifying cardiovascular agents- including non-steroidal mineralocorticoid receptor antagonists, angiotensin receptor neprilysin inhibitors (ARNi) [25], and sodium-glucose cotransporter 2 (SGLT2) inhibitors may confer modest blood pressure-lowering effects in select patients with complex cardiovascular comorbidities. However, current guidelines recommend ARNi primarily for patients with heart failure with reduced ejection fraction, where they reduce morbidity and mortality, with ACE inhibitors or ARBs as alternatives when ARNi cannot be used. At present, these agents are not recommended as primary antihypertensive therapies, and their role in resistant hypertension has not yet been fully established and remains an area of ongoing investigation [26].

Together, these challenges highlight the need to bridge the gap between evidence and clinical practice. Future directions in hypertension care will likely focus on precision medicine, digital health integration, improved adherence strategies, and innovative therapeutic approaches. Collectively, these developments aim to transform hypertension management from a reactive model into a proactive, personalised, and patient-centred framework.

6. Conclusion

Recent updates from the AHA (2025), ESC (2024), ESH (2023), and NICE (2023) reflect a clear shift in hypertension care toward earlier detection, risk-based treatment, and more individualised management. Although these guidelines differ in diagnostic thresholds and treatment targets, they share common priorities: integrating cardiovascular risk assessment, expanding the use of ambulatory and home blood pressure monitoring, and emphasising both pharmacological and lifestyle interventions to reduce long-term cardiovascular risk.

Growing evidence from major clinical trials has supported tighter blood pressure control and greater use of combination therapy, while newer therapeutic strategies and digital health tools are improving adherence and monitoring. At the same time, important challenges remain, including barriers to implementation, limited access to monitoring technologies, and suboptimal long-term adherence.

Overall, contemporary hypertension management is moving toward a more personalised, prevention-focused model that combines evidence-based treatment, patient engagement, and technological support. Continued efforts to translate guideline recommendations into routine practice will be essential to improving cardiovascular outcomes worldwide.

Key Points

• The AHA/ACC 2025 guideline maintains the $\geq$130/80 mmHg diagnostic threshold for hypertension, emphasising earlier detection and risk-based intervention.

• The ESH 2023 guideline retains the $\geq$140/90 mmHg threshold and Grade 1–3 classification system, with greater emphasis on cardiovascular risk assessment and hypertension-mediated organ damage.

• The ESC 2024 guideline retains the $\geq$140/90 mmHg definition of hypertension and introduces an elevated blood

pressure category to identify individuals at increased cardiovascular risk before established hypertension.

• Early combination therapy, preferably as a single-pill combination, is increasingly recommended across major international guidelines to improve blood pressure control and treatment adherence.

• Lifestyle interventions, including sodium reduction, regular physical activity, weight management, moderation of alcohol intake, and smoking cessation, remain fundamental components of hypertension prevention and management.

Availability of Data and Materials

Not applicable.

Author Contributions

RM and JMK conceived the review topic and structure. JK conducted the literature search and analysis. Different sections were initially drafted by JK and the manuscript was compiled by JK, RM and JMK. All authors contributed to the important editorial changes in the manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work and have read and approved the final manuscript.

Ethics Approval and Consent to Participate

Not applicable.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflicts of interest.

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