

SYSTEMIC HYPERTENSION

Relevant Guidelines

AHA/ACC 2025 guideline on hypertension.

AHA/ACC/AANP/AAPA/ABC/ACCP/ACPM/AGS/AMA/ASPC/NMA/PCNA/SGIM 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 Joint Committee on Clinical Practice Guidelines. *Circulation*. 2025.

ESC 2024 guideline on hypertension

2024 ESC Guidelines for the management of elevated blood pressure and hypertension

ACC/AHA 2019 Guideline on the Primary Prevention of Cardiovascular Disease

2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease. *J Am Coll Cardiol*. 2019;74:1376-1414.

ESC 2026 GL on chronic kidney disease

2026 ESC Guidelines for the management of cardiovascular disease and chronic kidney disease, in collaboration with the European Renal Association (ERA). *Eur Heart J*. 2026.

ESC 2022 Guidelines on noncardiac surgery

2022 ESC Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery. *Eur Heart J*. 2022

AHA/ACC 2024 Guideline on noncardiac surgery

2024 AHA/ACC/ACS/ASNC/HRS/SCA/SCCT/SCMR/SVM Guideline for Perioperative Cardiovascular Management for Noncardiac Surgery. *JACC* 2024

ESC 2022 Guidelines on cardio-oncology

2022 ESC Guidelines on cardio-oncology developed in collaboration with the European Hematology Association (EHA), the European Society for Therapeutic Radiology and Oncology (ESTRO) and the International Cardio-Oncology Society (IC-OS). *Eur Heart J*. 2022.

ESC 2025 guidelines on Pregnancy

2025 ESC Guidelines on the management of cardiovascular diseases and pregnancy. *Eur Heart J*.

Relevant Scientific Statements

AHA 2020 Scientific Statement on Pregnancy

Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. *Circulation*. 2020;141:e884-e903.

AHA 2020 Scientific Statement on Sleep Apnea

Obstructive Sleep Apnea and Cardiovascular Disease: A Scientific Statement From the American Heart Association. *Circulation*. 2021:CIR0000000000000988.

ESC/EAPCI 2023 Consensus Statement on Renal denervation

Renal denervation in the management of hypertension in adults. A clinical consensus statement of the ESC Council on Hypertension and the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *Eur Heart J*. 2023.

AHA 2026 Statement on Caffeine

Caffeine and Cardiovascular Disease: A Scientific Statement From the American Heart Association. *Circulation*. 2026;154:e345-e355.

DEFINITION, CLASSIFICATION AND PATHOPHYSIOLOGY OF HYPERTENSION

Definition

Hypertension in adults is defined as blood pressure $\geq 130/80$ mm Hg, based on the average of ≥ 2 seated blood pressure measurements, properly measured with well-maintained equipment, on ≥ 2 occasions.¹ Hypertension has been divided into stages as shown in Table 1 and Figure 1. Home blood pressures are consistently lower than clinic pressures in most hypertensive patients.² Threshold values for office and home measurements as well as for ambulatory blood pressure measurements are presented in Table 2. Recommendations for children and adolescents ≤ 16 years have been provided by the European Society of hypertension in 2016.³ The JNC8 guideline recommended initiation therapy for values $\geq 140/90$ mm.⁴

Epidemiology

Hypertension is an increasingly important public health issue. High systolic blood pressure remains the leading modifiable risk factor globally for attributable premature cardiovascular deaths, accounting for 10.8 million cardiovascular deaths and 11.3 million deaths overall in 2021, and has been particularly linked to ischemic heart disease and stroke-related deaths.⁵ Its prevalence increases with advancing age. In the US, the age-adjusted prevalence of hypertension among adults ≥ 20 years of age was estimated to be 46.7% in NHANES in 2017 to 2020 (50.4% for males and 43.0% for females) (Table 3).^{1,6} In subjects ≥ 60 years of age the percentage rises to 67%, and African Americans have higher mean day-time and night-time ambulatory BP than whites, and among the highest prevalence of hypertension in the world.⁷ During the past four decades, the highest worldwide blood pressure levels have shifted from high-income countries to low-income countries in south Asia and sub-Saharan Africa due to opposite trends, while blood pressure has been persistently high in central and eastern Europe.⁸ According to data from the Framingham Heart Study the lifetime risk of hypertension is approximately 90% for men and women who were not hypertensive at 55 or 65 years old and survived to age 80 to 85. Even after adjusting for competing mortality, the remaining lifetime risks of hypertension were 86 to 90% in women and 81 to 83% in men.⁹ Healthy young females have lower BP than males at similar age but experience a steeper

increase in BP from the third decade of life, and the risk for cardiovascular disease increases at a lower BP level in females than in males.¹⁰

The risk of hypertension has increased substantially in the recent decades, rendering it the leading cause of death and disability-adjusted life years worldwide.^{11,12} In the USA, it accounted for more CVD deaths than any other modifiable cardiovascular disease risk factor and was second only to cigarette smoking as a preventable cause of death for any reason.¹³ According to NHANES data, >50% of deaths from coronary heart disease and stroke occurred among individuals with hypertension.¹⁴ Estimated prevalence of hypertension is presented in Table 3.

Aetiology

In most cases (>90%) no underlying pathology can be identified (primary or essential hypertension). Established causes of hypertension are discussed in the Chapter on secondary hypertension. In primary hypertension no specific cause can be identified, but certain conditions contribute to the elevated BP (Figure 2 and Table 4). Excessive consumption of **calories, salt and alcohol** are among the most important behavioral determinants of hypertension. Men who average 1-2 drinks daily have increased risk for hypertension relative to non-drinkers (relative risk, 1.2), with risk increasing as alcohol intake increased. Among women, hypertension risk begins to increase at 3 or more drinks per day.¹⁵ **High sodium intake** (sodium excretion ≥ 7 g/day) has been associated with an increased risk of cardiovascular events and death in hypertensive populations, while an association of low sodium intake (excretion < 3 g) with increased risk of cardiovascular events and death is observed in those with or without hypertension.^{16,17} **Sugar-sweetened beverages** and high **fruit juice** consumption (≥ 1.5 servings/d) and hypertension risk. are associated with a higher risk of hypertension.¹⁸ The dose-response analysis in this study suggested a possible J-shaped pattern, indicating a trend in which low fruit juice consumption was not associated with hypertension risk and may even confer potential benefits, whereas higher intake levels may be linked to harm.¹⁸ **Visceral adiposity**, a feature of metabolic syndrome is related to hypertension (see next Chapter for the “obesity paradox”). An inverse J-shaped association of habitual **coffee** consumption with the risk of hypertension, demonstrating an increased risk with intake of 1 to 3 cups/d but a trend toward a decreased risk with higher consumption has been shown.¹⁹ The long-term effects of habitual caffeine consumption on blood pressure remain unclear and are likely minimal, although the risk may increase with high intake, particularly among individuals with severe hypertension or heightened sensitivity, because regular use can lead to tolerance.¹⁹ There is, also, no strong evidence for causal associations between **uric acid** and blood pressure or ischaemic heart disease.²⁰ There is a causal association of **smoking** heaviness with higher level of resting heart rate, but not with blood

pressure, suggesting that part of the cardiovascular risk of smoking may operate through increasing resting heart rate.²¹ **Non-steroidal anti-inflammatory agents** are the main cause of drug-induced hypertension, but paracetamol (4 g daily) use also increases blood pressure in patients with coronary artery disease, perhaps through COX2 (cyclooxygenase-2) inhibition.²² Low-dose celecoxib (200 mg od) is safer than ibuprofen in this respect.²³ Acute exposure to **high altitude** initially results in a reduction in BP, probably related to hypoxia-induced compensatory vasodilation from metabolites released from skeletal muscle and red blood cells which causes a ‘functional sympatholysis’ similar to that observed during exercise. Sympathetic nervous system activity increases immediately, and continues to rise throughout the period of exposure to high altitude. As oxygen content is restored by acclimatization, hypoxic vasodilation is abolished, leaving unopposed sympathetic vasoconstrictor tone and contributing to increasing BP.²⁴ The previously reported association with **vitamin D deficiency** does not appear to be causal.²⁵ Recreational drugs such as **amphetamines, LSD, cocaine or ecstasy** may cause resistant hypertension or hypertensive crisis.²⁶ Evidence of a causal relationship between **periodontitis** and hypertension has also been reported.²⁷ Mean systolic BP is higher in **winter** than in summer, and this may be related to an observed substantial increase in cardiovascular mortality.²⁸ Long-term residential exposures to **air pollution** and **traffic noise** are also associated with increased incidence of self-reported hypertension.²⁹ **Aging** seems to be associated with a subclinical form of aldosterone excess.³⁰ **Preterm birth** is associated with increased risks of hypertension from childhood into early adulthood.³¹

Sleep apnoea is one of the most causes of secondary hypertension.³² Other causes are discussed in the Chapter on Secondary Hypertension.

Blood pressure is a complex **genetic trait** with heritability estimates of 30-50%, but the intrinsic origin of essential hypertension remains obscure.³³ Certain genes can cause Mendelian forms of hypertension,³⁴ and single nucleotide polymorphisms have also been identified as risk factors for hypertension and coronary artery disease.³⁵ Genetic disorders affecting blood pressure regulation are Liddle syndrome, glucocorticoid remediable aldosteronism, Bartter syndrome, Gitelman syndrome, and pseudohypoaldosteronism.³⁶

Pathophysiology

Systolic pressure within the aorta is a composite of two items: 1) the outgoing pressure wave, generated by ventricular contraction; and 2) pressure wave reflection from periphery. Since the pulse wave is amplified in transit from the heart to the brachial artery, central aortic systolic pressure is usually lower than brachial pressure. The magnitude of amplification is greatest in people with healthy compliant arteries and diminishes with age.

Established hypertension exposes the arterial tree to increased pulsatile stress but major complications are thrombotic rather than hemorrhagic, referred to as the so-called thrombotic paradox of hypertension.³⁷ Blood flow abnormalities, endothelial damage or dysfunction and a hypercoagulable state are consequences of long-standing hypertension.³⁸ The prothrombotic state could be the result of chronic low-grade inflammation and damage and remodeling of the vascular endothelium due to elevated shear stress. The mechanisms leading to endothelial dysfunction are multifactorial and include decreased activity of vasodilator agents and increased activity (or sensitivity) to vasoconstrictor agents. Enhanced activity of the renin-angiotensin system and kallikrein-kinin system has opposite effects, resulting in vasoconstriction and vasodilation, respectively, but with respect to coagulation, they both cause a hypercoagulable state.³⁷ Thus, hypertension not only confers a hypercoagulable state (vulnerable blood) but also gives rise to left-ventricular hypertrophy, ventricular and atrial arrhythmias, increased aortic stiffness, and impaired coronary reserve (vulnerable myocardium), thereby fulfilling all criteria for a vulnerable patient. In enhancing the coagulation-fibrinolysis balance, antihypertensive treatment can decrease the frequency of thrombotic events independent of blood pressure.

Target organ disease due to essential hypertension comprises damage of the heart, brain and kidneys (Figure 3). Left ventricular hypertrophy, coronary artery disease, atrial fibrillation and ventricular arrhythmias are consequences of long-standing hypertension. Hypertension is the most common cause of atrial fibrillation and congestive heart failure. Typically, hypertension leads to LV hypertrophy (Figure 4) that progresses to dilated cardiac failure. However, patients with hypertension may progress directly to dilated cardiac failure in the absence of myocardial infarction or antecedent concentric hypertrophy.³⁹ Microalbuminuria, proteinuria, and elevated creatinine levels and reduced glomerular filtration rate are signs of progressive renal impairment. Retinopathy, Binswanger lesions (subcortical vascular dementia), transient ischemic attacks and eventually stroke and dementia are manifestations of brain damage.

Females with hypertension more often develop atrial fibrillation and HFpEF, while males more often develop AMI and HFrEF.¹⁰

Risk Stratification

Although systolic blood-pressure elevation had a greater effect on outcomes, both systolic and diastolic hypertension independently influence the risk of adverse cardiovascular events, regardless of the definition of hypertension ($\geq 140/90$ mm Hg or $\geq 130/80$ mm Hg).⁴⁰ Investigations in hypertensive patients are aimed at establishing risk factors, subclinical or overt organ damage, and, when suspected, diagnosis of causes of secondary hypertension.

Screening for and management of other modifiable cardiovascular risk factors is essential in adults with hypertension. For risk stratification the Framingham and SCORE models are mainly used.⁴¹⁻⁴³

Factors influencing prognosis are presented in Table 5 and Figures 5-7.

Impaired glucose tolerance (prediabetes) is defined by WHO and the American Diabetes Association (ADA) as:

fasting blood glucose 6.1-6.9 mmol/L (110-125 mg/dL) (WHO), or 5.6-6.9 mmol/L (100-125 mg/dL) (ADA), or

≥ 7.8 - < 11.1 mmol/L (≥ 140 - < 200 mg/dL) (WHO) or 7.8 - 11.0 mmol/L (140 - 198 mg/dL) (ADA), 2-h after 75 gm glucose solution (glucose tolerance test)

Diabetes is defined as (WHO and ADA):

HbA1c $\geq 6.5\%$ (48 mmol/mol), or

fasting blood glucose ≥ 7 mmol/L (126 mg/dL), or

≥ 11.1 mmol/L (200 mg/dL) 2-h after 75 gm glucose solution (glucose tolerance test)

Metabolic syndrome is defined as the occurrence of at least three out of the following 5 risk factors: abdominal obesity, BP $> 130/85$ mmHg, borderline or abnormal fasting glucose, low HDL, and high triglycerides. Increased body mass index [body weight (kg)/height (m)²] is overweight ≥ 25 kg/m², obesity ≥ 30 kg/m².

Abdominal obesity (waist circumference > 102 cm-men, > 88 cm-women). However, in patients with hypertension and coronary artery disease, overweight and obesity are associated with a decreased mortality risk compared with normal weight (obesity paradox).⁴⁴

Family history of premature cardiovascular disease (men < 55 years, women < 65 years).

Absence of a family history of hypertension suggests secondary hypertension.

Age (Men > 55 years, women > 65 years).

Blood Pressure Measurement

Screening and diagnosis of hypertension are presented in Table 6 and Figure 8.

Medical Office Blood Pressure Measurement

Measured with the patient seated with the back supported or supine and the arm at heart level. The patient should have refrained from smoking or drinking coffee for at least 30 min, and allowed to sit for 3-5 min (Table 7 and Figures 9 and 10).

Patient position

Diastolic pressure measured while sitting is higher than when measured supine (by 5 mm Hg), although there is less agreement about systolic pressure. When the arm position is adjusted so that the cuff is at the level of the right atrium in both positions, the systolic pressure has been reported to be 8 mm Hg higher in the supine than the upright

position. If the back is not supported (as when the patient is seated on an examination table as opposed to a chair), the diastolic pressure may be increased by 6 mm Hg. Crossing the legs may raise systolic pressure by 2 to 8 mm Hg. In the supine position, the arm should be supported with a pillow. In the sitting position, the right atrium level is the midpoint of the sternum or the fourth intercostal space; it is preferred in diabetics due to increased possibility of postural hypotension. Systolic blood pressure measured in the ankles (eg in patients with bilateral arm fistulae), is higher by approximately 20 mmHg than in the arm, whereas diastolic blood pressure measurements are not significantly different.⁴⁵

Cuff size

In adults, the use of cuffless BP devices is not recommended for the diagnosis or management of high BP (AHA/ACC GL on hypertension, 3 C-LD).¹

The cuff should be held at the heart level, whatever the position of the patient. The length and width of the cuff should be 80%/40% of the arm circumference, 1–2 cm above the antecubital fossa. Too small cuffs overestimate BP, whereas too large ones underestimate it. Cuff should be deflated at 2–3 mm Hg/sec with neither the patient or the doctor talking. Traditionally, the Korotkoff sounds have been classified as 5 phases: phase I, appearance of clear tapping sounds corresponding to the appearance of a palpable pulse; phase II, sounds become softer and longer; phase III, sounds become crisper and louder; phase IV, sounds become muffled and softer; and phase V, sounds disappear completely. The fifth phase is thus recorded as the last audible sound. The onset of phase I corresponds to systolic pressure but tends to underestimate the systolic pressure recorded by direct intra-arterial measurement, whereas the disappearance of sounds (phase V) corresponds to diastolic pressure but tends to occur before diastolic pressure determined by direct intra-arterial measurement.^{2,46} Early disappearance and recurrence of sounds (*auscultatory gap*) may occur in the elderly. The auscultatory gap often can be eliminated by elevating the arm overhead for 30 seconds before inflating the cuff and then bringing the arm to the usual position to continue in the measurement. This manoeuvre reduces vascular volume in the limb and improves inflow to enhance the Korotkoff sounds. In severe AR or large AV fistulas and rarely in pregnancy Korotkoff sounds may be heard until complete deflation of the cuff. In these cases the phase IV pressure should be noted.² At least three measurements should be taken.⁴⁷ As discussed, the Korotkoff sound method tends to give values for systolic pressure that are lower than the true intra-arterial pressure, and diastolic values that are higher.

Sphygmomanometers

All devices may be inaccurate due to technical problems and need frequent calibration.

Mercury sphygmomanometers are perhaps the most reliable despite concerns about mercury toxicity. Mercury sphygmomanometers should be examined by checking that the upper curve

of the meniscus of the mercury column is at 0 mm Hg, that the column is free of dirt, and that it rises and falls freely during cuff inflation and deflation. **Aneroid devices** or other nonmercury devices should be checked by connecting the manometer to a mercury column or an electronic testing device with a Y-tube. The needle should rest at the zero point before the cuff is inflated and should register a reading that is within 4 mm Hg of the mercury column when the cuff is inflated to pressures of 100 and 200 mm Hg. The needle should return to zero after deflation.² **Oscillometric automated monitors** that provide read-outs of systolic and diastolic pressure should be subjected by independent investigators to formal validation protocols such as those developed by the Association for the Advancement of Medical Instrumentation and the British Hypertension Society.²

Central Blood Pressure

Central aortic pressure can be estimated by non-invasive devices. However its additional value over brachial cuff BP is controversial.⁴⁸

Pulse pressure amplification

This refers to the lower systolic and higher diastolic central aortic BP compared to sites in the periphery (Figure 11).⁴⁹ Cuff-brachial measurements, however, underestimate the systolic BP and overestimate the diastolic one, in a way that might, to an extent, negate the amplification phenomenon.⁴⁶

Blood Pressure Differential

At the first visit BP should be checked in both arms. Differences between the two arms >15 mm Hg may be seen in up to 12-15% of patients with hypertension, and is an independent predictor of cardiovascular disease and death.⁵⁰ These patients may deserve further investigations for peripheral and coronary artery disease. Differences > 20 mmHg may be seen in subclavian artery stenosis, severe supraaortic AS, coarctation, Ao dissection or as a normal variant.

Blood Pressure Variability

Despite initial evidence about the adverse prognostic significance of visit to visit blood pressure variability in the ASCOT and MRC trials,⁵¹ only the average BP levels were found important in ELSA trial.⁵²

Home BP measurement

Self-measurement of BP at home is of clinical value and its prognostic significance is now demonstrated (Tables 8 and 9, and Figures 12 and 13).⁵³ In all patients who have an elevated office blood pressure, diagnosis should be confirmed by use of out-of-office blood pressure measurements (ie, home or ambulatory blood pressure monitoring).⁵⁴ One week morning and evening home BP measurements have been shown to be superior to clinic or ambulatory measurements in predicting LV mass index, coronary events and stroke.^{53,55,56} These

measurements should be encouraged in order to provide more information on the BP lowering effect of treatment at trough, and thus on therapeutic coverage throughout the dose-to-dose time interval. Normal values are different for office, ambulatory and home BP.

Ambulatory BP monitoring

The mean awake ambulatory BP is typically higher than clinic BP in cardiovascular disease-free, employed people not being treated for hypertension (Tables 9 and 10, and Figure 14).⁵⁷ Ambulatory BP may improve prediction of cardiovascular risk in untreated and treated patients.^{58,59} In the recent Spanish ABPM Registry, ambulatory blood-pressure measurements were a stronger predictor of all-cause and cardiovascular mortality than clinic blood-pressure measurements,^{60,61} and 24-hour systolic BP is associated with the progression of cerebrovascular disease and cognitive decline in the elderly much better than office measurements.⁵⁸ Ambulatory BP monitoring should also be considered when there is a marked discrepancy between BP values measured in the office and at home, resistance to drug treatment or hypotensive episodes are suspected, particularly in elderly and diabetic patients, and office BP is elevated in pregnant women and preeclampsia is suspected. A mean 24-h ambulatory systolic blood pressure monitoring ≥ 130 mmHg and/or a diastolic average ≥ 80 mmHg (daytime average $\geq 135/85$ mm Hg and nighttime average $\geq 120/70$ mm Hg) are considered as denoting masked hypertension.⁶²

Subtypes of Hypertension

High normal blood pressure and prehypertension

The terms high normal blood pressure (systolic BP 130–139 mm Hg and/or diastolic BP 85–89 mm Hg), and prehypertension (systolic BP 120–139 mm Hg, diastolic BP 80–89 mm Hg), reflect the fact that health risks attributable to increasing blood pressure in adults are continuous, beginning at 115/75 mm Hg.⁶³ These patients may develop established hypertension later and blockade of the renin-angiotensin axis has been found to decrease this risk.^{64,65} However, drug therapy for this population is not established.⁶⁶ Life style modification by means of low salt diet, weight loss, exercise and alcohol restriction are the best way for treating these patients.⁶⁷⁻⁶⁹

Isolated Systolic Hypertension

With increasing age, systolic blood pressure tends to rise in response to increasing arterial stiffness and losses in arterial compliance particularly after the age of 40. Isolated systolic hypertension is a common condition in individuals aged older than 60 years,³ and represents a predominant risk factor for coronary events in this group.⁷⁰ In the young, isolated systolic hypertension has been thought to result from an amplification of the pressure wave between the aorta and the brachial artery due to very elastic arteries in the context of normal aortic

systolic pressure. Isolated systolic hypertension in the young is a heterogeneous condition, and may result from an increased stroke volume and/or aortic stiffness, whereas the major hemodynamic abnormality underlying essential hypertension is an increased peripheral vascular resistance.⁷¹ The prevalence of isolated systolic hypertension has nearly doubled among young adults during the last decade, and is associated with obesity, smoking, and low socioeconomic status.⁶⁸ In adults aged 18 to 49 years, isolated systolic hypertension is associated with higher risk for cardiovascular mortality compared with normal blood pressure.⁷²

Isolated Diastolic Hypertension

Higher systemic vascular resistance is a major contributor to high diastolic BP. Isolated diastolic hypertension appears to be a predictor of cardiovascular risk in patients younger than 50 years.^{70,73} Therapy should be offered regardless of the systolic values.⁷³

Pulse Pressure

In older hypertensive patients, increased pulse pressure (systolic-diastolic) that arises as a consequence of arterial stiffness is a major determinant of cardiovascular risk.^{74,75}

White Coat Hypertension

Differences between office and home measurements are present in the majority of hypertensive patients. The **white coat effect** is defined as the rise in BP that occurs in the medical environment, (SBP/DBP > 20/10 mmHg) regardless of the daytime ambulatory BP level or the use of antihypertensive drugs (Table 11). **White coat** or isolated office hypertension is defined as a persistently elevated average office blood pressure of >140/90 and an average awake ambulatory reading of <135/85 mm Hg.² It is reasonable to exclude white-coat hypertension using out-of-office BP monitoring for adults with high office BP (ie, SBP/DBP $\geq$ 130/80 mm Hg). One caveat is that adults with office SBP/DBP $\geq$ 160/100 mm Hg should be promptly treated and antihypertensive medication dose titrated as necessary to control BP.¹ The incidence of white coat hypertension converting to sustained hypertension (justifying the addition of antihypertensive drug therapy to lifestyle modification) is 1% to 5% per year by ambulatory or home measurements, with a higher incidence of conversion in those with elevated BP, older age, obesity, or black race.

Compared with sustained normotension, white-coat hypertension is associated with no risk to a moderately increased risk of CVD.^{76,77} The risk of CVD associated with white-coat hypertension may only be increased among older adults who have high baseline CVD risk.⁷⁸ Ambulatory blood pressure or repeat (>5) pressure measurements at home are superior to office blood pressure measurements in predicting treatment-induced regression of left ventricular hypertrophy.⁴⁷ Patients with white coat hypertension are very likely to develop sustained hypertension later in life and life style and dietary changes should be recommended.

Masked Hypertension

Masked uncontrolled hypertension is diagnosed if despite controlled clinic BP, the mean 24-h ambulatory blood pressure monitoring average remains elevated (24-h systolic BP $\geq$ 130 mmHg and/or 24-h diastolic BP $\geq$ 80 mmHg).⁶² The prevalence of masked hypertension varies from 10% to 26% (mean 13%) in population-based surveys and from 14% to 30% in normotensive clinic populations,^{79 57} but the reproducibility of its diagnosis is limited.⁸⁰ Target organ damage (as LV hypertrophy or renal impairment) is related to the more prolonged elevations in pressure and their presence can assist the diagnosis. There is now considerable evidence that such patients are at increased risk.^{60,81} Masked hypertension may also occur with severe peripheral arterial disease.

Pseudohypertension

May be seen with stiff, calcified vessels in the elderly and patients with long-standing diabetes or chronic renal failure, that are difficult to compress. The Osler manoeuvre (palpable radial pulse despite occlusive cuff pressure) is not a sensitive or specific sign of pseudohypertension. Intra-arterial radial pressure measurement and ambulatory measurements may be necessary for correct diagnosis.⁸²

Nocturnal hypertension

Nocturnal hypertension is defined as night-time BP of >120 mmHg systolic and/or >70 mmHg diastolic by 24 h ambulatory blood pressure monitoring (ABPM).⁸³ Nocturnal hypertension can occur as day–night sustained hypertension or isolated nocturnal hypertension (daytime BP $< 135/85$ mmHg on 24 h ABPM). Physiologically, BP is expected to decrease during sleep by 10%–20% relative to daytime BP.

Night-time dipping patterns are classified into four groups:

Inverse dipping (riser): nocturnal increase in BP (night-to-day ratio of >1.0).

Non-dipper: reduced night-time BP dip of $<10\%$ (or night-to-day ratio of >0.9 and ≤ 1.0).

Normal dipping: fall in night-time BP of $>10\%$ and $<20\%$ (or night-to-day ratio of 0.8 to 0.9).

Extreme dipping: marked fall in night-time BP of $>20\%$ (or night-to-day ratio of <0.8).

Orthostatic Hypotension

It is defined by a fall > 20 mmHg systolic and/or >10 mmHg diastolic in response to standing from the supine position within 3 minutes or during head-up tilt at 60 degrees. It can also be assessed more conveniently within 1 minute of standing,⁸⁴ but it should be noted that patients may occasionally present with delayed orthostatic hypotension occurring after 3 min of standing.⁸⁵ Orthostatic hypotension (OH) can be divided into 2 pathophysiological subtypes: neurogenic and non-neurogenic. Neurogenic OH is due to impairment of baroreflex-mediated vasoconstriction of the skeletal muscle and splanchnic circulation and is caused by damage or

dysfunction at central and/or peripheral sites in the baroreflex efferent pathway. This usually occurs in dysautonomic syndromes, diabetes, Parkinsons's disease, multiple myeloma or multiple system atrophy, but may also be seen in patients with vasovagal syncope. The non-neurogenic OH may be due to volume depletion (vomiting, diarrhea, blood loss, and inadequate oral intake etc), and medications such as vasodilators and diuretic agents that decrease effective circulating blood volume.⁸⁶ The major therapeutic problem is inability to control the level of blood pressure in patients with orthostatic hypotension who concomitantly have supine hypertension.

Blood Pressure During Exercise

BP increases during dynamic and static exercise, and the increase is more pronounced for systolic than for diastolic BP. However, in people with high fitness, systolic BP does not tend to increase substantially during lower level incremental exercise, and an hypertensive response to exercise is more likely to occur at higher exercise workloads (e.g. stage 3+ of a Bruce protocol). There is currently no consensus on normal BP response during dynamic exercise testing. A SBP of ≥ 210 mmHg for men and ≥ 190 mmHg for women had been previously termed 'exercise hypertension'.⁸⁷ The results on the independent relationships of the blood pressure response to physical and mental stressors, future hypertension and target organ damage are not consistent, and exercise testing to predict future hypertension is not recommended. However, an exercise test may provide some additional prognostic information at least in subjects with mild blood pressure elevation. The 21-years follow-up study of 1999 apparently healthy men disclosed independently predictive information on cardiovascular death, of both supine systolic BP and 6 min exercise systolic BP taken at an early moderate workload, but not of maximal systolic BP during exercise.⁸⁸ In a subsequent meta-analysis, each 10mm Hg increase in systolic BP during exercise at moderate intensity was accompanied by a 4% increase in CV events and mortality, independent of office BP, age, or CV risk factors.⁸⁹ Exercise systolic BP relative to fitness (>18 mmHg/MET_{Peak}) is associated with increased risk for cardiovascular events.⁹⁰

High-altitude hypertension

BP increase at high altitude appears to depend primarily on chemoreflex-induced increase in sympathetic activity. Ambulatory blood pressure increases progressively with increasing altitude, remaining elevated after 3 weeks. BP increases with high altitude exposure, especially above 3000 m and possibly above 2000 m.⁹¹ This is due to a number of factors including sympathetic activation. Patients with grade 2 hypertension and increased CV risk should check their BP values before and during high altitude (>2500 m) exposure. Patients with grade 1 hypertension may reach very high altitude (>4000 m) with adequate medical therapy; uncontrolled severe hypertensive patients (grade 3) should avoid exposure to

very high altitude.⁹¹ Angiotensin receptor blockade maintains blood pressure-lowering efficacy at 3400 m but not at 5400 m.^{24 92}

Malignant hypertension

Malignant hypertension originally was defined by the concomitant presence of severe hypertension and bilateral retinopathy. The retinal lesions associated with malignant hypertension are an important indicator of vascular damage elsewhere as can be documented by the coexistence of acute kidney injury and thrombotic microangiopathy. Because systemic microcirculatory damage is the pathological hallmark and retinal lesions can be absent in patients with acute kidney injury, the term acute hypertensive microangiopathy may be more informative.⁹³

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