AN OVERVIEW OF ANTIHYPERTENSIVE MEDICATIONS AND ASSESSING BLOOD PRESSURE USING THE LATEST GUIDELINES

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INTRODUCTION

One of the most important vital signs for a chiropractic physician to measure is blood pressure, 1 of several useful indicators that help a physician evaluate the health of a patient.

Blood pressure is defined as the force of the blood against the walls of the arteries. Maximum blood pressure is reached when the left ventricle of the heart pushes blood into the aorta. The point of highest blood pressure is the systolic pressure. The lowest point of blood pressure, when the heart is resting between beats, is the diastolic pressure. The difference between the 2 pressures is the pulse pressure.

Blood pressure is most frequently measured in millimeters of mercury (Hg), and is measured as a fraction with the systolic pressure as the numerator and diastolic pressure as the denominator, eg, 120/80.

Five factors are responsible for maintaining blood pressure.

1. Peripheral blood vessel resistance. The circulatory system is a closed loop, consisting of a high-pressure side (the arteries) and a low-pressure side (the veins). Connecting the 2 sides are the very fine arterioles. When the arterioles contract (vasoconstrict), less blood flows through the capillaries, and blood pressure rises. Conversely, when the arterioles expand (vasodilate), more blood can flow through the capillaries, and blood pressure falls. Normally, the arterioles are in a state of partial contraction, which results in a range of normal blood pressures. Generally speaking, the degree of vasoconstriction primarily affects the diastolic pressure.
2. Heart output. When cardiac output is increased, more blood is pumped into the arteries, causing

greater arterial distension and an increase in blood pressure. Conversely, decreased cardiac output results in lower blood pressure. Blood pressure, therefore, is directly related to the strength of cardiac pumping and cardiac output.

3. Blood volume. Blood pressure varies directly with blood volume because the pressure on the arteries is also a direct result of the blood volume.
4. Blood viscosity. Viscosity may be thought of as the thickness of blood—not unlike the different grades of motor oil in an automobile engine. Viscosity depends on the proportion of blood cells to plasma and since more force is required to pump more viscous blood, blood pressure will rise in a direct relation to viscosity.
5. Elasticity of blood vessel walls. The elasticity of arteries and the resistance at the arterioles help maintain normal blood pressure. Vessels with less elasticity or those with arteriosclerosis or atherosclerosis present greater resistance to the flow of blood, which contribute to higher blood pressure.

DISCUSSION

Normal Blood Pressure

Only a short time ago, the American Heart Association guidelines considered normal adult blood pressure to range from 100/70 mm Hg to 140/90 mm Hg, with 120/80 mm Hg being the “gold standard” taught to most physicians.

The U.S. Government has recently issued new guidelines under its National High Blood Pressure Education Program by which they hope to motivate physicians and patients to detect potential hypertensive risks, such as heart attacks or strokes.

The National Institutes of Health (NIH) now says that 120/80 is prehypertensive and 140/90, the previous upper limit of normal, is Stage 1 hypertension (see Table 1).

TABLE 1
BLOOD PRESSURE DEFINITIONS AND ACTIONS RECOMMENDED BY THE NIH

NEW DEFINITION	SYSTOLIC	DIASTOLIC	REMEDY
NORMAL	<120	<80	N/A
PREHYPERTENSION	120–139	80–89	LOSE WEIGHT, REDUCE SALT INTAKE, LOW-FAT DIET HIGH IN FRUITS AND VEGETABLES, INCREASE EXERCISE, MODERATE ALCOHOL CONSUMPTION.
STAGE 1 HYPERTENSION	140–159	90–99	DRUG TREATMENT CANDIDATE, WITH A DIURETIC THE FIRST CHOICE.
STAGE 2 HYPERTENSION	≥160	≥100	START WITH TWO DRUGS, INCLUDING A DIURETIC.

ADAPTED FROM THE SEVENTH REPORT OF THE JOINT NATIONAL COMMITTEE ON PREVENTION, DETECTION, EVALUATION, AND TREATMENT OF HIGH BLOOD PRESSURE.

Various factors influence blood pressure in the average healthy adult, which is why only 1 reading is not necessarily significant:

1. Increased age may raise blood pressure.
2. Normal circadian fluctuations throughout the day can vary by as much as 10 mm Hg from the lowest reading upon rising in the morning to the highest in late afternoon.
3. Women usually have lower blood pressure than men of the same age.
4. Blood pressure can rise postprandially.
5. Exercise of strenuous activity raises blood pressure.
6. Emotions and pain can raise blood pressure.
7. Lying down tends to lower blood pressure.

Hypertension is defined as blood pressure higher than normal. If the hypertension is from a known cause, it is called *secondary hypertension*; hypertension without a known cause is called *primary* or *essential hypertension*.

Under the new guidelines, about 22% of the American adult population (45 million persons) has chronic hypertension, making it the most common and serious blood pressure problem. Hypertension, with major implications in death and disability, is also about twice as prevalent in Blacks compared to Whites. Before age 50 it is more prevalent in White males than in White females, while after age 50 the roles are reversed. There is no difference in prevalence between Black males and females.

Hypotension is blood pressure below normal. A consistently low pressure, within reason, appears to have no harmful effects and is usually associated with increased lifespan.

Orthostatic or postural hypotension is a variant of hypotension. A person suddenly rising to an upright position may feel weak or faint. Peripheral vasodilatation without a compensatory rise in cardiac output leaves the brain momentarily starved of blood flow. Orthostatic hypotension can be prevented by rising slowly, allow-

ing the blood flow to recover, especially after a prolonged recumbent position. Lowering the head usually corrects the problem, if it does occur.

The sphygmomanometer and a stethoscope are used to obtain an indirect auscultatory measurement of blood pressure, accurate to within about 10% of direct blood pressure measurements. The sphygmomanometer is customarily an aneroid or mercury manometer with an inflatable cuff containing a flat, rubber bladder covered with cloth.

The bladder must be of the proper width and length, or inaccurate readings may occur. The width of the bladder should be about 40% of the circumference of the limb that it will be wrapped around. The length of the bladder should almost encircle the limb. Cuffs that are too short or narrow may give erroneously raised readings because they do not evenly transmit pressure to the artery they cover.

A loose cuff or a patient supporting his own arm may also give erroneously high readings. Using a cuff too large, eg, an adult cuff on a child, may give erroneously low readings.

Korotkoff's Sounds

When measuring blood pressure, the stethoscope is used to listen for a series of sounds caused by turbulent arterial blood flow from the pressure exerted by the inflated cuff. These sounds are called Korotkoff's sounds (see Table 2).

Technique

1. Select the correct size cuff. Have the patient comfortably seated or recumbent, with the forearm supported at the level of the heart and the palm of the hand upward.
2. The bladder is centered over the brachial artery with the lower border about 2.5 to 5 cm (1 to 2 inches) above the antecubital crease. The brachial artery

TABLE 2
KOROTKOFF'S SOUNDS

PHASE I	APPEARANCE OF CLEAR, FAINT TAPPING SOUNDS THAT GRADUALLY INCREASED IN INTENSITY. THE FIRST TAPPING SOUND IN SYSTOLE.
PHASE II	MUFFLED OR SWISHING SOUNDS, WHICH MAY TEMPORARILY DISAPPEAR (CALLED THE AUSCULTATORY GAP), ESPECIALLY IN HYPERTENSIVE PERSONS. THE GAP MAY COVER A RANGE AS MUCH AS 40 MM HG. IF THE GAP IS NOT RECOGNIZED, IT MAY LEAD TO SERIOUS UNDERESTIMATION OF SYSTOLIC PRESSURE OR OVERESTIMATION OF DIASTOLIC PRESSURE.
PHASE III	DISTINCT, LOUD SOUNDS.
PHASE IV	MUFFLED SOUND WITH A SOFT, BLOWING QUALITY. THE FIRST MUFFLED SOUND IS THE DIASTOLIC PRESSURE FOR CHILDREN.
PHASE V	SOUNDS DISAPPEAR. THIS IS THE DIASTOLIC PRESSURE FOR ADULTS.

should be approximately at heart level. If it is much below heart level a false high reading will occur; if it is much above heart level a false low reading will occur.

3. Snugly wrap the cuff around the arm. With the left finger, palpate the brachial artery on the medial aspect of the antecubital fossa. Place the stethoscope over the artery where a beat was felt.
4. With the left fingers resting on the radial artery, pump the cuff to about 30 mm Hg above the point at which the radial pulse disappears. When the radial arterial pulse can no longer be felt, the arteries of the arm have been clamped down by the cuff.
5. Release air from the cuff at the rate of 2 to 3 mm Hg per heartbeat. Note the reading at which the first of 2 consecutive beats are heard, and record it as the systolic pressure. If the cuff is deflated too slowly, there will be congestion in the arm, leading to a false low systolic and false high diastolic reading. Conversely, if the cuff is deflated too rapidly, there will be a false low systolic reading and a false high diastolic reading.
6. Continue to release air from the cuff and note when sounds become muffled. Record this second figure as the diastolic pressure in children. Also note the point when all sounds disappear, which may occur either at the same time the muffling sounds appear or somewhat later. Record this third figure as the diastolic pressure in adults. Finally, rapidly deflate the cuff to 0.
7. Ideally, blood pressure should be taken in both arms at least once. There is normally a pressure difference, but if the difference is more than 10–15 mm Hg suspect an arterial compression or obstruction on the lower-pressure side. Subsequent readings should be taken on the higher-pressure side.
3. Korotkoff's sounds can be made more prominent by lowering the venous pressure. Elevate the arm before inflating the cuff and have the person open and close his fist several times after inflating the cuff.
4. Because Korotkoff's sounds are relatively low in pitch, the bell side of the stethoscope allows for better hearing. A useful mnemonic is "BELLOW" for remembering whether high- or low-pitched sounds are better heard with the stethoscope's bell or diaphragm.
5. If a mercury manometer is used, read the figures with the meniscus of the mercury at eye level and at no more than 3 feet away. Otherwise, parallax can introduce errors.
6. Patient anxiety (the so-called "white coat syndrome") may introduce higher blood pressure. Repeat measurements during the first and subsequent visits before determining the patient has persistent hypertension. At least 3 readings are more indicative than only 1.
7. The obesity of a patient may preclude having blood pressure checked on the arm. If necessary, apply the cuff to the forearm and listen to the radial artery sounds.
8. The blood pressure equipment should be periodically checked for air leaks. The mercury meniscus and the aneroid gauge should read exactly 0 when the cuff is deflated. The mercury manometer should be checked at least once every year to make sure the mercury is free of foreign material and air. The aneroid manometer often becomes inaccurate with repeated usage and should be calibrated at least every 6 months.

Various Helpful Techniques

1. Perform the blood pressure test as fast as possible to prevent venous congestion.
2. If repeating a blood pressure test, wait for at least 30 seconds before performing the measurement again. Make sure the cuff is completely deflated.

Classes of Antihypertensive Medications

It's a fact of life that some patients of a chiropractic physician will be taking antihypertensive medications prescribed by allopathic or osteopathic physicians. Several classes of drugs are used, sometimes in combination, to lower their blood pressure in different ways. Combinations of drugs may allow lower dosages of each medication to be as effective as a full dose of a single medication, and there may be fewer side effects.

The different classes of drugs and their side effects are described below to aid the chiropractic physician in understanding their mechanisms of action in lowering blood pressure—useful for taking a history, implementing a regimen, or discussing hypertension or side effects with a patient (see Table 3). Generic names are listed first, with trade names in parentheses.

Diuretics

Based on a recent NIH-sponsored study, diuretics are now recommended first, instead of either a diuretic or beta blocker. Another recommendation of the study is to immediately attack stage 2 hypertension with 2 drugs, including a diuretic, instead of the current advice to start with 1 drug and adding additional ones as necessary.

Diuretics are the least expensive of the antihypertensive drugs. Sometimes called water pills, they cause kidneys to excrete more sodium than usual, removing additional water from blood and reducing its volume. As mentioned earlier, reduced blood volume reduces blood pressure. Patients on diuretics should limit their sodium intake for maximum effectiveness and get enough potassium in their diet to minimize side effects.

The 3 types of diuretics listed below work by affecting different parts of the kidneys.

•Thiazide Diuretics

Thiazide diuretics reduce the amount of calcium excreted in urine (lessening chances for kidney stone formation) and increase the amount of blood calcium (lessening chances of developing osteoporosis).

- Bendroflumethiazide (Naturetin)
- Chlorothiazide (Diuril)
- Chlorthalidone (Hygroton, Thalitone)
- Hydrochlorothiazide (HydroDiuril, Microzide)
- Indapamide (Lozol)
- Methyclothiazide (Aquatensen, Enduron)

- Metolazone (Mykrox, Zaroxolyn)
- Polythiazide (Renese)

•Loop Diuretics

Loop diuretics remove more sodium from kidneys than the thiazides and may be prescribed if thiazides are ineffective.

- Bumetanide (Bumex)
- Ethacrynic acid (Edecrin)
- Furosemide (Lasix)
- Torsemide (Demadex)

•Potassium-Sparing Diuretics

Diuretics not only remove sodium, they also remove potassium, but the potassium-sparing versions help retain the body's needed potassium and are usually used in combination with thiazide or loop diuretics because their action is less powerful.

- Amiloride (Midamor)
- Eplerenone (Inspra)
- Spironolactone (Aldactone)
- Triamterene (Dyrenium)

Side Effects of Diuretics

All diuretics, by their nature, increase urination. Thiazide and loop diuretics can also cause potassium loss.

Thiazides may cause weakness or dizziness upon standing and, rarely, impotence in some men. High doses of thiazides can slightly increase blood sugar and total cholesterol levels. They can also increase the level of uric acid, which may, rarely, lead to gout. Another rare condition is low blood sodium concentration (hyponatremia)—found in older adults taking thiazides and drinking too much water—leading to headaches, confusion, and even coma. The more effective loop diuretics can lead to dehydration, and potassium-sparing diuretics can raise potassium levels excessively (hyperkalemia), leading to cardiac arrhythmias.

Beta Blockers

Beta blockers block many of the effects associated with adrenaline (epinephrine), a hormone that stimulates a more rapid heartbeat and vasoconstriction. They lower blood pressure by making the heart beat slower and less forcefully, and by slowing the release of renin by the kidneys. Renin is a factor in the production of angiotension II, which is a vasoconstrictor.

TABLE 3
CLASSIFICATIONS OF
ANTIHYPERTENSIVE MEDICATIONS

ALPHA BLOCKERS
ANGIOTENSION-CONVERTING ENZYME (ACE) INHIBITORS
ANGIOTENSION II RECEPTOR BLOCKERS
BETA BLOCKERS
CALCIUM CHANNEL BLOCKERS (AKA CALCIUM ANTAGONISTS)
CENTRAL-ACTING AGENTS
DIRECT VASODILATORS
DIURETICS

Beta blockers work well in about half the people who try them, especially in older adults who have cardiovascular disease, but they don't work as well with Blacks. Beta blockers are also used to treat a variety of other ailments, such as glaucoma, tremors, migraines, hyperthyroidism, anxiety, and even stage fright.

Beta blockers are more frequently associated with side effects than other antihypertensives, especially with fatigue and lessened energy for strenuous activities. They may also cause impotence, loss of libido, insomnia, cold hands, hypoglycemia, slight elevation in blood triglycerides, and a slight reduction in HDLs.

- Acebutolol (Sectral)
- Atenolol (Tenormin)
- Betaxolol (Kerlone)
- Bisoprolol (Zebata)
- Carteolol (Cartrol)
- Carvedilol (Coreg)
- Labetalol (Normodyne, Trandate)
- Metoprolol (Lopressor, Toprol XL)
- Nadolol (Corgard)
- Penbutolol (Levitol)
- Pindolol
- Propranolol (Inderal)
- Timolol (Blocadren)

ACE Inhibitors

Angiotensin-converting enzyme (ACE) inhibitors work well and have few side effects. They prevent the production of angiotension II. Angiotension II, a vasoconstrictor, constricts blood vessels and stimulates the release of aldosterone from the adrenal gland, which then induces the kidneys to retain more sodium and water. By limiting angiotension II, the kidneys excrete more sodium and water, thereby lowering blood pressure. ACE inhibitors also allow bradykinin, a vasodilator, to remain in the blood.

Side effects may include a dry cough, hyperkalemia, rash, reduced appetite, altered sense of taste and, rarely, angioedema.

- Benazepril (Lotensin)
- Captopril (Capoten)
- Enalapril (Vasotec)
- Fosinopril (Monopril)
- Lisinopril (Prinivil, Zestril)
- Moexipril (Univase)
- Perindopril (Aceon)
- Quinapril (Accupril)

- Ramipril (Altace)
- Trandolapril (Mavik)

Angiotensin II Receptor Blockers

ACE inhibitors block the formation of angiotension II, but angiotensin II receptor blockers (ARBs) block the action of angiotension II.

ARBs are usually as effective as ACE inhibitors, but they don't increase bradykinin. They rarely cause a dry cough, and they lower uric acid concentrations.

TABLE 4
ALPHABETIZED LIST OF
ANTIHYPERTENSIVE MEDICATIONS

CLASS	TRADE NAME	CLASS	TRADE NAME
ACE	ACEON	BB	INDERAL
ACE	ACCUPRIL	PSD	INSPIRA
CCB	ADALAT	BB	KERLONE
PSD	ALDACTONE	BB	LEVATOL
CAI	ALDOMET	DV	LONITEN
ACE	ALTACE	BB	LOPRESSOR
DV	APRESOLINE	ACE	LOTENSIN
TD	AQUATENESEN	TD	LOZOL
ARB	ATACAND	ACE	MAVIK
ARB	AVAPRO	TD	MICROZIDE
ARB	BENICAR	ARB	MICARDIS
BB	BLOCADREN	PSD	MIDAMOR
LP	BUMEX	AB	MINIPRESS
CCB	CALAN SR	ACE	MONOPRIL
ACE	CAPOTEN	TD	MYKROX
CCB	CARDENE	TD	NATURETIN
CCB	CARDIZEM	BB	NORMODYNE
AB	CARDURA	CCB	NORVASC
BB	CARTROL	BB	PINDOLOL
CAI	CATAPRES	CCB	PLENDIL
BB	COREG	ACE	PRINIVIL
BB	CORGARD	CCB	PROCARDIA
DV	CORLOPAM	TD	RENESE
CCB	COVERA-HS	CAI	RESERPINE
ARB	COZAAR	BB	SECTRAL
LP	DEMADEX	CCB	SULAR
CCB	DILACOR XR	CAI	TENEX
ARB	DIOVAN	BB	TENORMIN
TD	DIURIL	ARB	TEVETEN
CCB	DYNACIRC	TD	THALITONE
PSD	DYRENIUM	BB	TOPROL XL
LP	EDECIN	BB	TRANDATE
TD	ENDURON	ACE	UNIVASE
LP	FUROSEMIDE	ACE	VASOTEC
TD	HYDRODIURIL	CAI	WYTENSIN
TD	HYGROTON	TD	ZAROXOLYN
CAI	HYLOREL	BB	ZEBETA
AB	HYTRIN	ACE	ZESTRIL

AB = ALPHA BLOCKER

ACE = ANGIOTENSION-CONVERTING ENZYME INHIBITOR

ARB = ANGIOTENSIN II RECEPTOR BLOCKER

BB = BETA BLOCKER

CAI = CENTRAL ADRENERGIC INHIBITOR

CCB = CALCIUM CHANNEL BLOCKER

DV = DIRECT VASODILATOR

LP = LOOP DIURETIC

PSD = POTASSIUM-SPARING DIURETIC

TD = THIAZIDE DIURETIC

- Candesartan (Atacand)
- Eprosartan (Teveten)
- Irbesartan (Avapro)
- Losartan (Cozaar)
- Olmesartan (Benicar)
- Telmisartan (Micardis)
- Valsartan (Diovan)

Calcium Channel Blockers

When calcium enters the calcium channels in arterial wall muscle cells, it causes the muscles to contract and the arteries to narrow. Calcium channel blockers prevent calcium from entering the calcium channels, but have no effect on bone calcium. Some types even slow heart rate.

Side effects may include constipation, headache, tachycardia, rash, swollen lower limbs and gums. Grapefruit or grapefruit juice cannot be taken with those marked with an asterisk. The juice prevents the kidneys from eliminating the drugs and allows them to build up to a toxic level.

- Amlodipine (Norvasc)
- Diltiazem (Cardizem, Dilacor XR)
- Felodipine (Plendil)*
- Isradipine (DynaCirc)
- Nicardipine (Cardene)
- Nifedipine (Adalat, Procardia)*
- Nisoldipine (Sular)
- Verapamil (Calan SR, Covera-HS)*

Alpha Blockers

Alpha blockers reduce the effect of noradrenaline (nor-epinephrine), which stimulates the muscles in arteries and veins, thereby lessening vasoconstriction. They also improve urine flow in men with prostate problems.

Possible side effects include orthostatic hypotension, headache, pounding heartbeat, nausea, and weakness. A recent study recommends that patients taking alpha blockers consult with the physicians to determine whether or not they should continue taking them.

- Doxazosin (Cardura) (long-acting)
- Prazosin (Minipress) (short-acting)
- Terazosin (Hytrin) (long-acting)

Central Adrenergic Inhibitors

Instead of working directly on blood vessels, central-acting agents prevent the brain from signaling receptors to increase heart rate and constrict vessels.

Central-acting agents may exhibit strong side effects, such as extreme fatigue, drowsiness, dizziness, impotence, dry mouth, weight gain, and cognitive and psychological problems. Patients with side effects who want to stop taking these drugs must stop gradually or there

TABLE 5
COMBINATION MEDICATIONS ALPHABETIZED BY TRADE NAME

TYPE	TRADE NAME	GENERIC NAMES
D/D	ALDACTAZIDE	SPIRONOLACTONE AND HCT
ACE/D	CAPOZIDE	CAPTOPRIL AND HCT
BB/D	CORZIDE	NADOLOL AND BENDROFLUMETHIAZIDE
ARB/D	DIOVAN HCT	VALSARTAN AND HCT
D/D	DYAZIDE	TRIAMTERENE AND HCT
ACE/D	ENALAPRIL/HYDROCHLOROTHIAZIDE	ENALAPRIL AND HCT
ARB/D	HYZAAR	LOSARTAN POTASSIUM AND HCT
BB/D	INDERIDE LA	PROPRANOLOL AND HCT
CCB/ACE	LEXCEL	ENALAPRIL AND FELODIPINE
BB/D	LOPRESSOR HCT	METOPROLOL AND HCT
ACE/D	LOTENSIN HCT	BENAZEPRIL AND HCT
CCB/ACE	LOTREL	AMLODIPINE AND BENAZEPRIL
D/D	MAXZIDE	TRIAMTERENE AND HCT
D/D	MODURETIC	AMILORIDE AND HCT
ACE/D	PRINZIDE	LISINAPRIL AND HCT
CCB/ACE	TARKA	TRANOLOLAPRIL AND VERAPAMIL
BB/D	TENORETIC	ATENOLOL AND CHLORTHALIDONE
ACE/D	ZESTORETIC	LISINAPRIL AND HCT
BB/D	ZIAC	BISOPROLOL AND HCT

BB/D = BETA BLOCKER AND DIURETIC; ACE/D = ACE INHIBITOR AND DIURETIC; ARB/D = ANGIOTENSION II BLOCKER AND DIURETIC; D/D = TWO DIURETICS; CCB/ACE = CALCIUM CHANNEL BLOCKER AND ACE INHIBITOR; HCT = HYDROCHLOROTHIAZIDE.

may be a rebound effect that quickly raises blood pressure to dangerous levels.

- Clonidine (Catapres)
- Guanabenz (Wytensin)
- Guanadrel (Hylorel)
- Guanfacine (Tenex)
- Methyldopa (Aldomet)
- Reserpine

Direct Vasodilators

Direct vasodilators, which prevent arterial muscles from contracting and narrowing the arteries, are mainly used to treat difficult cases of hypertension.

Side effects include tachycardia, dizziness, and water retention. For this reason, a beta blocker and diuretic are typically prescribed in combination with a direct vasodilator. Minoxidil may cause excessive hair growth; large doses of hydralazine increases risk of lupus.

- Fenoldopam (Corlopam)
- Hydralazine (Apresoline)
- Minoxidil (Loniten)

CONCLUSION

To aid the physician in identifying the class of drug a patient may be using, Table 4 offers an alphabetized list of common trade names used for antihypertensives. Some antihypertensives are also combined into 1 tablet or capsule to increase effectiveness (See Table 5).

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