



blood pressure

TERI JUNGE CST, CFA, FAST

Editor's Note: This is part of a review series of short articles about blood. Additional related topics include blood basics, blood components, blood types and the blood clotting mechanism.

blood pressure is the force of the blood within the vascular system against the vessel wall. The pressure—or force—is caused by the contraction of the heart pushing the blood into the arteries and also by the size of the blood vessel wall (resistance).

Typically, arterial blood pressure is measured. In certain situations, however, venous blood pressure also may be measured.

Blood pressure is measured in millimeters (mm) of mercury (Hg) and is recorded as two numbers in relation to one another (the format is similar to writing a fraction). Often, when recording blood pressure the designation “mm of Hg” is not included, as it is understood that this is the only method used for blood pressure measurement.

The systolic (when the heart is contracted) portion of the blood pressure is the higher number and is written first. The diastolic (when the heart is relaxed) portion of the blood pressure is the lower number and is written second, with a slash separating the two numbers (systolic/diastolic).

When the numbers are verbalized, the slash is represented with the word “over.” For example, a blood pressure that is written as “120/80” is spoken or heard as “one twenty over eighty.”

PHYSIOLOGY OF BLOOD PRESSURE MAINTENANCE

Several negative feedback systems are in place to help regulate blood pressure and blood flow to keep the body in balance (homeostasis). The body is able to carry out some of these responses within seconds, while other responses may not be evident for several hours or days.

The resultant changes help raise or lower the blood pressure as needed. All blood pressure maintenance systems will not be discussed in this article.

Pressure sensors, called baroreceptors, are located within the walls of the arteries and the heart. The baroreceptors sense if the blood pressure is normal, too high or too low and then send signals to the regulation centers in the brain to maintain, increase or decrease several physiological functions, including:

- Heart rate;
- The intensity of the contractions of the heart;
- Contraction or dilation of blood vessels; and
- The kidneys' ability to retain or release fluid.

Hypertension... Consider the numbers⁵

"High blood pressure precedes 74% of cases of heart failure in the United States.

High blood pressure is the second leading cause of chronic kidney failure in the United States.

High blood pressure causes more visits to doctors than any other condition—just a 10% decline in the number of visits would save \$450 million each year.

High blood pressure affects circulation—creating a higher risk for mental deterioration and Alzheimer's.

High blood pressure and its complications cost the US economy more than \$100 billion each year."

In addition to controlling the amount of fluid excreted in the form of urine, the kidneys also provide negative feedback that helps regulate blood pressure. The juxtaglomerular apparatus of the kidneys produces an enzyme called renin when blood pressure is too low.

Renin, in turn, activates a blood protein called angiotensinogen, which is a product of the liver, and converts it into angiotensin I. Angiotensin I is converted to angiotensin II by an enzyme



called angiotensin-converting enzyme (ACE), which is a product of the lining of the capillaries, particularly those found in the lungs.

Angiotensin II causes four responses that individually contribute to an increase in blood pressure. The presence of angiotensin II in the blood causes:

1. Cardiac output to be increased and the blood vessels to constrict. Cardiac output is the amount of blood that is pumped from the ventricles of the heart in a specified amount of time, such as one minute or one hour. Cardiac output is calculated by multiplying the number of heart beats per minute by the stroke volume, which is the amount of blood forced from either ventricle (the right ventricle to the pulmonary artery or the left ventricle to the aorta) with each heart beat.
2. A hormone called aldosterone to be released by the adrenal cortex, which results in an increase in the amount of sodium that is reabsorbed by the distal convoluted tubules of the nephrons of the kidneys. A secondary effect of the sodium reabsorption is water reabsorption.
3. A hormone called antidiuretic hormone to be released by the posterior pituitary gland, which directly causes the distal convoluted tubules to absorb more fluid and also causes vasoconstriction.

4. The thirst center in the hypothalamus to be stimulated, and fluid intake to be increased.

Epinephrine and norepinephrine are hormones that are released from the adrenal medulla, especially in times of stress. The presence of high levels of epinephrine and norepinephrine in the blood increase blood pressure and heart rate. The response of the adrenal cortex is part of the “fight or flight” response of the sympathetic nervous system.

FACTORS INFLUENCING BLOOD PRESSURE

An individual’s blood pressure normally varies throughout the day and over time. These variations are attributed to age, dietary intake (including, but not limited to, fluids—for example, sodium intake may be a factor), activity levels, cigarette smoking, alcohol intake, hormone levels, and periods of high stress, among other influencing factors.

Blood pressure is also affected by a number of medications and medical conditions.

Additionally, the strength of the contraction of the heart muscle, the volume of blood within the vascular system, the viscosity (thickness) of the blood, and vasomotor changes (constriction or dilation) that increase or decrease the resistance (tension) of the blood vessel walls also affect blood pressure.

Normally, the arterial wall is soft and elastic in nature. Over time, and due to dietary influences, the walls of the blood vessels may harden—causing increased resistance to blood flow, thus raising blood pressure. This condition of hardening is referred to as arteriosclerosis or—if there is a buildup of plaque (atheroma) within the vessel—it is called atherosclerosis.

Normal/optimal blood pressure

In the year 2000, the American Heart Association redefined what is considered normal blood pressure. Blood pressure is considered normal when it is less than 120/80 mmHg.

Blood pressure within the optimal range is necessary for good cardiovascular health and to reduce an individual’s risk of stroke. A consistently abnormal (repeated over time) blood pressure measurement (high or low) is an indication of a problem that may require medical intervention.



©iStockphoto/Lisa Fletcher

Prehypertension

Blood pressure is considered prehypertensive when the systolic reading is between 120–139 mmHg, and the diastolic reading is 80–89 mmHg. A diagnosis of prehypertension is a warning signal that an individual may be headed toward hypertension. An individual with prehypertension needs careful monitoring, and lifestyle changes may be recommended.

Hypertension

Hypertension, or high blood pressure, indicates increased pressure within the walls of the blood vessels. Blood pressure is considered hypertensive when the systolic reading is above 140 mmHg, and the diastolic reading is above 90 mmHg. Typically, both the systolic and diastolic pressures are elevated, although in some cases, only diastolic pressure may be affected.

“The strong association of high blood pressure with obesity and the marked increase in the prevalence of childhood obesity indicate that both hypertension and prehypertension are becoming a significant health issue in the young.”

Hold the salt!

According to the American Heart Association,⁸ Americans eat an average of 6-18g of salt every day ... far more than the 200 mg that our bodies actually need.

Where's all that extra salt coming from?

About 75% of it is coming from processed foods, like premade spaghetti sauce, canned foods and prepared mixes.

Read those food labels!

During your next trip to the grocery store, slow down and read the nutritional information printed on the back of what you're buying.

Ingredient words to avoid:

- Salt (sodium chloride)
- Monosodium glutamate (may be abbreviated as MSG)
- Baking soda (sodium bicarbonate)
- Baking powder
- Disodium phosphate
- Sodium compounds (anything with the word sodium in it, eg sodium alginate, sodium benzoate and sodium nitrite)

Typically, hypertension does not cause any symptoms, which is why it is referred to as the "silent killer." Some individuals, though, do experience symptoms, such as headache, dizziness, and vision problems.

Hypertension is considered a major contributing factor to heart disease and stroke and can result in kidney damage, nervous system disorders and vision difficulties.

In approximately 90–95% of individuals with hypertension, the cause cannot be determined,

and the condition is referred to as essential hypertension. It is suspected that essential hypertension is caused by genetics, caffeine intake, tobacco smoking, obesity, sodium intake, lack of exercise, strong heart contractions, rapid heart rate or vasoconstriction.

Lifestyle changes and the use of medications that reduce resistance to blood flow in the arteries, such as diuretics, vasodilators, renin inhibitors, ACE inhibitors and calcium blockers can lower blood pressure. Beta adrenergic blockers are useful in controlling the heartbeat.

When hypertension is the result of another problem, it is referred to as secondary hypertension. Hypertension may be secondary to diabetes, kidney disease, toxemia of pregnancy, vascular disease and endocrine imbalances. Treatment of the causative condition usually causes the blood pressure to return to the normal range.

Hypotension

Hypotension, or low blood pressure, indicates decreased pressure within the walls of the blood vessels. In most cases, low blood pressure is desired. However, if the blood pressure is too low, organs and body tissues may not receive enough oxygenated blood and nutrients.

If an area of the body does not receive the substances necessary to sustain the life of the cells, permanent damage or tissue death may result. Hypotension is only considered problematic if the patient is experiencing symptoms.



Symptoms of low blood pressure include dizziness and fainting—especially when moving from a lying or sitting position to a standing position (postural or orthostatic hypotension).

Causes of hypotension that produce problematic symptoms include the administration of various medications, dehydration, hemorrhage (hypovolemic shock), toxic shock, psychogenic shock, vasodilation, slow or inadequate heart contractions and excessive urine production.

Treatment of hypotension includes administration of blood or other intravascular fluids and use of vasoconstrictors and medications to increase the force and/or frequency of the contractions of the heart.

“More women than men have died of cardiovascular diseases every year since 1984. Cardiovascular disease kills as many women each year as the next 16 causes of death combined, including breast cancer.”

BLOOD PRESSURE MEASUREMENT

Blood pressure is measured with a sphygmomanometer. The sphygmomanometer may be an automatic electronically controlled device capable of recording the measurements at specific time intervals, or it may be a manual device that typically requires the additional use of a stethoscope.

A manual sphygmomanometer consists of four main components. All of the components are connected with flexible tubing.

- Inflatable cuff—Available in a variety of sizes
- Pump—Inflates the cuff
- Valve—Controls the pressure in the cuff
- Column of mercury or a dial—Displays the pressure

A series of sounds, called Korotkoff’s sounds, are heard when listening (auscultation) to the blood pressure. Korotkoff’s sounds occur in five distinct phases that must be identified during blood pressure measurement.

Phase I Two initial tapping sounds are heard. The listener notes the pressure on the gauge and interprets that number as the systolic blood pressure.

Phase II A soft, swishing sound is heard as the cuff is further deflated, and more blood passes through the artery.

Phase III Rhythmic tapping sounds are heard as the cuff is deflated further. This phase is often misinterpreted as the systolic blood pressure.

Phase IV The tapping sounds become muffled and faded, as the cuff is further deflated.

Phase V Sounds disappear completely. The listener notes the pressure on the gauge and interprets that number as the diastolic blood pressure.

The following technique is used to measure blood pressure manually. Remember—standard precautions require that the caregiver’s hands are washed before and after providing patient care.

1. Secure the necessary equipment (sphygmomanometer and stethoscope or an automated blood pressure machine). Use of a sphygmomanometer and stethoscope will be described.
2. The patient is typically in the sitting or supine position. (When attempting to diagnose orthostatic hypotension, the blood pressure may also be measured with the patient standing up.)

Women are at particularly high risk³

“Despite the efforts of many health care professionals, voluntary health organizations and policy makers, many women—as well as many healthcare professionals—are still unaware that cardiovascular disease is the leading cause of death among women.”

To commemorate the fifth anniversary of the launch of its “Go Red for Women” campaign, the American Heart Association (AHA) devoted the entire April 1, 2008, issue of its clinical journal, *Hypertension*, to the unique issues and challenges surrounding women, hypertension and the resulting cardiovascular risks.

According to research data published in AHA’s *Heart Disease and Stroke Statistics—2008 Update*, “high blood pressure kills significantly more women than men.”

For free access to the online version of this special issue of *Hypertension*, visit: http://hyper.ahajournals.org/current.dtl#GO_RED_PREFACE

3. Apply the appropriate size blood pressure cuff to the left (preferably) upper arm. (Note: Alternate sites, such as the wrist, ankle or thigh, may be used, but in most situations the upper arm is preferred.)
4. Locate the brachial artery at the antecubital portion of the elbow, and place the stethoscope over the artery.
5. Secure the stethoscope with the fingers (not the thumb).
6. Inflate the blood pressure cuff to the appropriate pressure.
7. Deflate the blood pressure cuff slowly while listening for Korotkoff's sounds.
8. Note systolic (Korotkoff Phase I) and diastolic (Korotkoff Phase V) blood pressure measurements.
9. Continue to deflate the blood pressure cuff, and note the auscultatory gap, if present.

Lowering Blood Pressure with Diet and Exercise

LOWERING BLOOD PRESSURE WITH DIET

There are two kinds of high blood pressure or hypertension. Primary or essential blood pressure has no known specific cause and is the most common type occurring in the population. The other or second type does have an organic causal factor, such as kidney disease or pregnancy. Secondary blood pressure must be evaluated and monitored by a physician who will address the specific cause(s).

Although there is not one specific underlying factor that results in primary hypertension, it is often being successfully addressed by an individual's alterations in lifestyle, such as weight loss, dietary changes, exercises and stress reduction, as well as medications.

Many treatment options are easily accomplished at a very low cost and accessible to everyone. What you eat has a major influence on whether or not you may develop high blood pressure. Certain foods can increase blood pressure. Weight gain increases blood pressure. Healthy eating not only reduces the risk of developing high blood pressure but also contributes to overall health.

- The general rule of thumb for recommended foods that control high blood pressure include:
 - Eat foods lower in fat, salt and calories
 - Use spices and herbs, instead of salt to flavor foods
 - Reduce oil, butter, margarine, shortening and salad dressings

One of the hidden contributors to salt in most diets is prepared foods. Read labels carefully and remember, even such items as parmesan cheese contain high levels of sodium.

Recommended foods include:

- Low fat or 1% milk
- Lean meat

- Skinless turkey or chicken
- Low-salt, ready-to-eat cereals
- Cooked hot cereal (not instant)
- Low-fat and low-salt cheeses
- Fruits, (fresh, frozen or canned without added salt)
- Vegetables (fresh, frozen or canned, no added salt)
- Plain rice, pasta and potatoes
- Breads (English muffins, bagels, rolls and tortillas)
- Lower salt "prepared" convenience food

Foods to avoid include:

- Butter and margarine
- Regular salad dressings
- Fatty meats, lunch meats, sausage, bacon, ham
- Whole milk dairy products
- Fried foods
- Salted snacks, such as chips, pretzels—etc
- Regular canned soups, bouillions, dried soup mixes
- Fast food
- Deli meats
- Weight control prepared foods (often high in sodium)
- Condiments, such as ketchup, soy sauce)
- Pickled or marinated food

What about sodium

The American Heart Association recommends limited daily sodium intake to no more than 2,300 milligrams. Considering that a teaspoon of salt has about 2,400 milligrams of sodium means that most people exceed the recommended amount several times over.

Common table salt is a compound of mostly sodium and chloride (NaCl); a mineral that occurs in many foods naturally. It is the sodium that causes

blood pressure to rise. There are other types of sodium that are also present in food, such as monosodium glutamate (MSG) that is a common ingredient in many Asian recipes.

But there are now other forms of salt available that are not sodium based and are becoming more and more popular. Gray salt, pink salt and others are now available at many food stores and can be used to season cooked foods rather than the common table salt.

Besides salt, it's a good idea to remember that some of these foods, while low in sodium, are also high in fat, which is another factor to consider in lowering blood pressure. Dairy items are often available in low fat varieties and should be given preference when adopting a diet to reduce blood pressure.

Comparison of sodium in food²

Meat, poultry, fish and shellfish (3 oz)

Fresh meat, cooked, 90 mg or less
 Shellfish, 100-325 mg
 Tuna, canned, 300mg
 Lean ham, 1,025

Dairy

Whole milk, 1 cup, 120 mg
 Skim or 1% milk, 1 cup, 125 mg
 Buttermilk (with salt), 1 cup, 260 mg
 Swiss cheese, 1 oz, 75 mg
 Cheddar cheese, 1 oz, 175 mg
 Low-fat cheese, 1 oz, 150 mg
 Cottage cheese, regular, ½ cup, 455 mg

Vegetables

Fresh or frozen, (canned, no salt added), ½ cup, 70 mg or less
 Vegetables, canned or frozen (no sauce), ½ cup, 55-470 mg

10. Remove the blood pressure cuff when fully deflated.
11. Record or report findings.
12. Care for the equipment as needed, and return it to its storage location.

Blood pressure also can be monitored internally. A specialized catheter is inserted into a vein or artery and attached to a transducer with the pressure readings displayed on a monitor.

CONCLUSION

Millions of Americans are affected by high blood pressure. Maintenance of optimal blood pressure is essential to living a long healthy life.

In many cases, normal blood pressure can be achieved by eating sensibly and following a moderate exercise program. If a person's blood pressure cannot be brought into normal range with lifestyle changes, various medications are available to help the individual manage blood pres-

Tomato juice, canned, $\frac{3}{4}$ cup, 660 mg

Breads, cereals, rice and pasta

Bread, 1 slice, 110–175 mg

English muffin, half, 130 mg

Shredded wheat, ready-to-eat, $\frac{3}{4}$ cup, 5 mg or less

Cereal, cooked and unsalted, $\frac{1}{2}$ cup, 5 mg or less

Cereal, cooked, instant, 1 packet, 180 mg

Canned soup, 1 cup, 600–1,300 mg

Prepared convenience food

Main dishes, canned and frozen, 8 oz,

500–1,570 mg

Successful Strategies to Lower Sodium

Read food labels. Most of our food displays nutrition information, and order of ingredients is printed from the highest to lowest. Ideally, sodium should be one of the last ingredients shown. A food is considered low sodium if it has less than five percent of your daily value of sodium per serving.

- Buy fresh when possible. Processed foods often contain sodium, and fresh foods naturally have less sodium. If buying prepared food, find the low fat, reduced sodium choices.
- Fresh fruit such as apples, oranges and bananas, berries, dates and apricots are always welcome additions to a low sodium diet. Choose fruit canned in its own juice or water rather than heavy syrup.
- When baking, use low-fat egg substitutes, unsweetened cocoa powder, fat-free cooking spray or even try applesauce or mashed bananas to sweeten your desserts.
- Rinse canned foods, such as tuna and vegetables, to wash away excess sodium.
- Avoid frying foods and grill, broil, poach, or stir-fry.

■ Sauté onions, mushrooms, or other vegetables in a small amount of low-sodium broth or water.

■ Use unsoftened water for drinking and cooking since water softeners may add sodium.

■ Be your own chef of low-sodium cuisine and modify recipes that call for a high use of sodium. Experiment with herbs and spices, cinnamon for desserts or fruit. A low-sodium diet does not mean you have to eliminate all the foods you enjoy. Moderation is the key.

■ Brisk walking

■ Bicycling

■ Rowing or canoeing

■ Swimming

■ High- or low-impact aerobics

■ Jumping rope

■ Dancing

Almost any activity that accelerates your heart rate and breathing can be considered aerobic—even mowing the lawn, washing windows, etc.

LOWERING BLOOD PRESSURE WITH EXERCISE

Another resource that can help individuals lower their blood pressure is physical activity. Regular exercise can assist in the prevention of high blood pressure and for patients with high blood pressure, doctors often recommend a regular exercise routine.

Simply, exercise strengthens the heart muscles and stronger hearts don't have to work as hard to pump blood. When the heart works less, less force (pressure) on the arteries is the result.

For people with high blood pressure, exercise can lower blood pressure by an average of 10 mm Hg, and that's the result that is achieved by some medications. If individuals have a healthy blood pressure, then exercise can keep it from rising and is also effective in maintaining a healthy weight. And obesity is another factor that contributes to high blood pressure. However, to be effective, exercise must be regular and continual.

Aerobic exercise, the type that gets your heart pumping and your breathing accelerated is the most beneficial. A minimum of 30 and up to 60 minutes at least three times per week is suggested.

There are many, many types of exercises that offer physical benefits. Review the following choices and choose several to vary your plan.

Talk your doctor

Always check with your physician before beginning a new plan of exercise. If you are a male over 40, or a female over 50, consult with your physician. If you are overweight, have a chronic health condition, experienced a heart attack, smoke, have a family history of cardiac problems or felt pain in your chest, or become dizzy when exercising, be sure to talk with your doctor before starting any aerobic exercise program.

Stop exercising if you feel weakness, dizziness, chest pain or discomfort in your neck, arm, jaw or shoulder, and seek medical assistance.

Keep track of your progress with regular blood pressure checks—either at your doctor's or at home. Verify that your home blood pressure unit is accurate.

References

1. www.mayoclinic.com
2. www.clevelandclinic.org
3. www.mayoclinic.com/health/high-blood-pressure/H100024. Accessed April 8, 2008.
4. <http://hypertension.medicweb.org/lifestyle/exercise.php>. Accessed April 8, 2008.

sure that is either too high or too low—thereby avoiding secondary problems related to hypo/hypertension.

ABOUT THE AUTHOR

Teri Junge, CST, CFA, FAST, is the surgical technology program director at San Joaquin Valley College in Fresno, California. She is the medical reviewer for this journal and is the author of numerous educational publications and textbooks.



©iStockphoto/Lisa Young

EDITOR'S NOTE

May is National High Blood Pressure Education Month, sponsored by the US Department of Health and Human Services—National Heart, Lung and Blood Institute. For information, visit: <http://www.nhlbi.nih.gov/about/nhbpep/index.htm>

References

1. American Heart Association. Available at: <http://www.americanheart.org>. Accessed March 10, 2008.
2. Applegate E. *The Anatomy and Physiology Learning System*, 2nd ed. WB Saunders Co: Philadelphia, PA;2000.
3. Hall JE, Granger JP, Reckelhoff JF, Sandberg K. Hypertension and Cardiovascular Disease in Women. *Hypertension*. 2008;51:951. Available at: http://hyper.ahajournals.org/current.dtl#GO_RED_PREFACE. Accessed April 1, 2008.
4. Heart Center Online for Cardiologists and their Patients. Available at: <http://www.heartcenteronline.com>. Accessed March 10, 2008.
5. High Blood Pressure in the United States. Prevent and Control America's High Blood Pressure: Mission Possible. National High Blood Pressure Education Program. National Heart, Lung and Blood Institute. National Institutes of Health. Available at: <http://hp2010.nhlbi.nih.net/mission/about/bhp/aboutbhp.htm>. Accessed April 1, 2008.
6. Hypotension. Medicine Net. Available at: http://www.medicinenet.com/low_pressure/article.htm. Accessed March 23, 2008.
7. Memmler RL, Cohen BJ, Wood DL. *The Human Body in Health & Disease*, 10th ed. Lippincott Williams & Wilkins: Philadelphia, PA;2005.
8. National Heart, Lung and Blood Institute—National Institutes of Health. Available at: <http://www.nhlbi.nih.gov>. Accessed March 10, 2008.
9. Price P, Frey K, Junge T, eds. *Surgical Technology for the Surgical Technologist: A Positive Care Approach*, 2nd ed. Delmar Thompson Learning: Albany, NY;2004.
10. Shake Your Salt Habit. American Heart Association. Available at: <http://www.americanheart.org/presenter.jhtml?identifier=2106>. Accessed April 1, 2008.
11. Solomon EP. *Introduction to Human Anatomy & Physiology*, 2nd ed. WB Saunders Co: Fort Worth, TX;2003.
12. Strategies for Saving Lives. Prevent and Control America's High Blood Pressure: Mission Possible. National High Blood Pressure Education Program. National Heart, Lung and Blood Institute. National Institutes of Health. Available at: <http://hp2010.nhlbi.nih.net/mission/aboutbhp/save.htm>. Accessed April 1, 2008.
13. *The Fourth Report on the Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Adolescents*. NIH Publication No. 05-5267. Revised May 2005. National High Blood Pressure Education Program. National Heart, Lung and Blood Institute. National Institutes of Health. Available at: http://www.nhlbi.nih.gov/health/prof/heart/hbp/hbp_ped.htm. Accessed April 1, 2008.