EDITED BY

Hiram C. Polk, Jr., M.D.
Ben A. Reid, Sr. Professor and Chairman, Department of Surgery
University of Louisville
Louisville, Kentucky

Bernard Gardner, M.D.
Professor of Surgery and Director, Division of Surgical Education
University of Medicine and Dentistry of New Jersey
Newark, New Jersey

H. Harlan Stone, M.D.
Program Director, Phoenix Integrated Surgical Residency
Good Samaritan Regional Medical Center
Phoenix, Arizona

with 648 illustrations and 12 color plates

QUALITY MEDICAL PUBLISHING, INC
ST. LOUIS, MISSOURI 1993
Hypertension

G. RAINEY WILLIAMS

KEY FEATURES

After reading this chapter you will understand:
- The pathogenesis of hypertension.
- How to determine which hypertensive patients are amenable to surgical correction.

One of six Americans is hypertensive, but approximately half of those affected are unaware they have the disease. Hypertension is significantly more common among African-Americans, in whom hypertension begins at an earlier age, tends to be more severe, and more often progresses to end-organ disease than in other groups. This high incidence in African-Americans is of particular interest, because hypertension is relatively uncommon among Africans living in Africa. Surgeons are interested in hypertension because it is a significant risk factor when considering surgical treatment of diseases unrelated to hypertension and because it can be caused by surgically treatable lesions. Identifying patients whose conditions fall into the latter group is obviously important; unfortunately, this continues to be difficult to do.

HOW DO HYPERTENSIVE PATIENTS PRESENT?

Hypertension does not produce a characteristic complex of symptoms, and many hypertensive patients are totally asymptomatic. A dull occipital headache is commonly described and, because it is often relieved by control of the hypertension, cause and effect are assumed. When the hypertensive process results in functional and structural changes in other organ systems, a variety of symptom complexes develop. The most common end-organ systems affected by hypertension are the cardiovascular system, kidneys, and brain. Hypertension is a leading cause of stroke, as well as the catastrophe of massive intracranial bleeding.

PATHOPHYSIOLOGY OF HYPERTENSION

Arterial blood pressure is determined by the interrelationship among blood volume, cardiac output, peripheral vascular resistance, and blood viscosity. Blood pressure is controlled by a highly complex system (which has neural, chemical, and hormonal components), the mechanism of which is not completely understood. The four principal control systems are:

1. The arterial baroreflex. Impulses from pressure sensors in the carotid sinus, aorta, and left ventricle are relayed through neural pathways to the brainstem. The efferent arc also involves the sympathetic adrenergic nerves and vagal cholinergic nerves.

2. Regulation of fluid volume. This is a slowly responding system that results in loss of fluid with elevated blood pressure and retention of fluid when blood pressure falls.
3. Renin and angiotensin. The initiating enzyme renin, released from the kidney, splits angiotensin I from plasma globulin, which is then converted to angiotensin II. Angiotensin II also stimulates aldosterone secretion (Fig. 21-1).

4. Vascular autoregulation. In several organ systems, changes in perfusion pressure result in local changes in vascular resistance to keep perfusion volume constant.

A schematic of the various feedback loops is shown in Fig. 21-2.

**DIAGNOSIS**

The diagnosis of hypertension is established simply by measuring blood pressure. The clinical significance of hypertension increases with increased levels of blood pressure, but even moderate elevations are associated with decreased life expectancy. For this reason, determining the cause of the hypertension is important in all patients whose diastolic pressure consistently exceeds 90 mm Hg. Causes of hypertension are listed and illustrated in the box on p. 372 and Fig. 21-3, respectively. An algorithm for the investiga-

---


**FIGURE 21-2** Major feedback loops regulating blood pressure. (From Haber E, Slater EE. High blood pressure. In Rubenstein E, Federman DD [eds]. Scientific American Medicine, Section I, Subsection VII. © 1988 Scientific American, Inc. All rights reserved.)
tion of hypertensive patients devised by Fry is reproduced in Fig. 21-4. As with all schemata, this should not be followed slavishly, and, because of cost, tests should rarely be ordered in batteries.

**WHAT IS ESSENTIAL HYPTERTENSION?**

In approximately 95% of hypertensive patients, no specific cause for hypertension can be determined; these patients are considered to have essential hypertension. Patients with mild, untreated hypertension are probably not at increased risk at operation, but patients with diastolic pressures exceeding 100 mm Hg should be treated prior to undergoing elective operations. The treatment of essential hypertension is a combination of restriction of dietary salt and administration of a variety of drugs. These are listed by type of action and drug name on pp. 376-377. The side effects of common drugs are also listed. Adequate control of hypertension by a single drug is frequently difficult; therefore combinations of agents are commonly employed. The out-of-pocket cost for a lifetime is considerable. There is, however, good evidence that control of hypertension significantly lessens the incidence of end-organ damage. Because many drugs used in the treatment of hypertension significantly alter the patient's response to various anesthetic agents, this becomes an important factor in the surgical management of hypertensive patients.

**FIGURE 21-3** Causes of some forms of hypertension. Note that many of the causes can be treated by operation.
Early consultation with an anesthesiologist is advisable before operating on patients who are hypertensive.

**SURGICALLY CORRECTABLE FORMS OF HYPERTENSION**

From 1% to 10% of hypotensive patients have a surgically correctable cause for their condition. This is a highly significant group of patients, and the importance of making a correct diagnosis is obvious. The algorithm outlined in Fig. 21-4 includes surgical options for such patients.

**Coarctation of the Aorta**

Congenital aortic coarctation is one of the most common causes of hypertension in children but may be encountered at any age. Patients with significant coarctation have diminished or absent femoral pulses: a combination of hypertension and diminished femoral pulses should instantly suggest the diagnosis. Additional findings that suggest increased collateral flow, such as interscapular pulsations or rib notching as seen on chest x-ray evaluation, corroborate the diagnosis.

The mechanism by which coarctation of the aorta produces hypertension has been debated for years. Evidence suggests that both a mechanical factor (increased vascular resistance) and the renin-angiotensin mechanism are involved.

Patients suspected of having coarctation of the aorta should have the diagnosis confirmed by angiography and, when significant coarctation is present, it should be corrected surgically. It is clear that the earlier coarctation is surgically treated, the better the chance for blood pressure reduction. The likelihood of significant control of hypertension becomes so small over time that coarctation probably should not be routinely repaired in patients older than 50 years of age.

**Renal Artery Stenosis**

Several disease processes may produce extrarenal narrowing of the renal arteries of a sufficient degree to activate the renin-angiotensin pressor system. These lesions include arteriosclerosis, fibromuscular dysplasia, dissecting aneurysm of the aorta, and trauma. The clinical picture produced by all of these entities is hypertension, with or without its cardiac, pulmonary, cerebral, or renal manifestations. The stimulus for increased renin production in renal artery stenosis is probably damping of the pulse pressure in the renal artery distal to the stenotic lesion. Details of the renin-angiotensin I and angiotensin II systems will not be reviewed here.

Hypertension produced by renal artery stenosis has no clinically distinguishing features but, because it is highly amenable to surgical treatment, the diagnosis is very important. It is estimated to occur in up to 5% of the hypertensive population. Any patient with moderate to severe diastolic hypertension who would be considered a candidate for surgical correction if a renovascular lesion were present should have an intravenous pyelogram (IVP). The rapid-sequence excretory urogram is a relatively simple variation that gives additional information. Digital subtraction angiography of the renal vessels has been suggested as a method of screening for renovascular hypertension, but it is probably no more accurate than IVP and is certainly more expensive. If renovascular hypertension is suggested by the preliminary screening, renal vein renin levels should be measured. In unilateral renal artery obstruction, the involved kidney produces excessive amounts of renin, which is detected in the renal vein assay. When the level of renin is 1.5 times or greater than that of the uninvolved side, a significant lesion is almost certainly present.

renal systemic renin indices (RSRI) may be of additional help. This is calculated as follows:

\[
\text{RSRI} = \frac{\text{Individual renal renin activity}}{-\text{Systemic renin activity}}
\]

Arteriography is the most accurate method of demonstrating renal artery stenosis. While complications of arteriography have been reduced, it is an invasive procedure and may be replaced by digital subtraction angiography when techniques for that examination are refined.

Surgical revascularization of a kidney with significant arterial lesions results in significant reduction of blood pressure in 90% of patients. Aortorenal bypass grafting is employed in most instances. Endarterectomy, with or without patch angioplasty, and reconstruction using the splenic artery may be preferable in some situations. Transplantation of renal artery lesions is of great interest, but in our experience it has been disappointing so far.

**Unilateral Renal Parenchymal Disease**

Occasionally a patient is seen who has hypertension, a contracted kidney, and arteriographic findings indicate historically, renal hypertension resulted in most patients. When the atrophic kidney is not functioning like an ischial pelvic renar function then the kidney function is in question.

**Cushing's Syndrome**

The principal feature of Cushing's syndrome is the "moon face" with increased fat in the face, back, and upper arms, and decreased muscle mass. The adrenal gland produces excessive amounts of glucocorticoids, and the symptoms are caused by the increased levels of cortisol in the blood. However, the diagnosis of Cushing's syndrome is often difficult, as the symptoms can be mimicked by a variety of other conditions.

The diagnosis of Cushing's syndrome is usually made using clinical and laboratory findings, such as an increased level of cortisol in the blood and a decreased response to the drug dexamethasone. However, the diagnosis can be confirmed by a CT scan of the abdomen, which shows an enlarged adrenal gland. A biopsy of the adrenal gland may also be performed to confirm the diagnosis.

**Hyperaldosteronism**

Hyperaldosteronism is less commonly caused by hyperse
findings indicating no extrarenal stenotic lesions. Historically, removal of the involved kidney has not resulted in reduction of blood pressure in most patients. Recently it has been observed that when the atrophic kidney behaves physiologically like an ischemic kidney, as determined by split renal function or renin vein assays, nephrectomy will result in blood pressure reduction.

Cushing's Syndrome

The principal features of Cushing’s syndrome are the “moon” face, central obesity, cutaneous striae, and hypertension. The syndrome is produced by excess circulating glucocorticoids. Excessive glucocorticoid levels may result from iatrogenic administration, pituitary or adrenal lesions, or nonadrenal sources of ACTH production, principally malignant neoplasms.

The diagnosis of Cushing’s syndrome usually begins with clinical observation of the distinctive physical changes. The most widely used screening test is measurement of the urinary excretion of 17-hydroxycorticosteroids. The plasma cortisol level can be determined, and, like the urinary 17-hydroxycorticosteroids, it is usually elevated in Cushing’s syndrome. Measurement of ACTH levels and its response to dexamethasone suppression may be helpful in differentiating pituitary disease from adrenal disease. Cranial and abdominal CT scans and/or magnetic resonance imaging are currently the most accurate methods of demonstrating the lesions anatomically.

The most satisfactory treatment of Cushing’s syndrome is surgical removal of the lesion responsible for the syndrome. This is more completely discussed in Chapter 10.

Hyperaldosteronism

Hyperaldosteronism is a condition that occurs less commonly than was once thought. It is caused by hypersecretion of aldosterone, a mineralocorticoid, by an adrenal adenoma or adrenal hyperplasia. Hypertension is present but is usually not severe in adults. The diagnosis is suspected when persistent hypokalemia and metabolic alkalosis are detected in hypertensive patients who are not receiving diuretic therapy. Plasma renin activity is usually low and urinary aldosterone levels are elevated.

Treatment of this condition is discussed in Chapter 10.

Pheochromocytoma

Pheochromocytoma is a rare neoplasm arising in the adrenal medulla and producing norepinephrine and/or epinephrine. The tumor may be unilateral or bilateral, benign or malignant. Patients with pheochromocytomas have episodic or sustained hypertension. Determination of urinary catecholamine and vanillylmandelic acid (VMA) secretions are probably the best screening tests for pheochromocytoma. Confirming tests include measurement of plasma epinephrine and norepinephrine levels. When biochemical evidence for pheochromocytoma exists, it becomes important to localize the responsible neoplasm. Intravenous pyelography may show downward displacement of the kidneys. A CT scan of the abdomen appears to be the most valuable diagnostic tool for locating adrenal lesions as well as other retroperitoneal mass lesions, superseding conventional tomography, arteriography, and retroperitoneal gas insufflation.

Operations on patients with unsuspected pheochromocytoma can be disastrous because anesthesia and operative manipulation of the tumor may result in uncontrollable hypertension or hypotension. Preoperative preparation of patients with pheochromocytoma with alpha-adrenergic and beta-adrenergic blocking agents has decreased surgical risk. Conduct of anesthesia is extremely important.

The surgical treatment of pheochromocytoma is discussed in Chapter 10.
# Surgical Pharmacopeia

## For Treatment of Chronic Hypertension

### Diuretics
1. Benzothiadiazine diuretics
   - Chlorothiazide (Diluril)
   - Hydrochlorothiazide
     - (Hydrodiuril, Esiatrix, Oretic)
   
   May require potassium supplementation
   - Same
   
   Dosage: 25-1000 mg/day
   
   Dosage: 25-50 mg/day

2. Loop diuretics
   - Furosemide (Lasix)
     
   Dehydration and electrolyte depletion possible
   - Same
   
   Dosage: 20-1000 mg/day
   
   Dosage: 50-400 mg/day

3. Potassium-sparing diuretics
   - Spironolactone (Aldactone)
   
   Relatively contraindicated in the setting of renal insufficiency; watch for hypervolemia
   
   Dosage: 50-100 mg/day

### Sympatholytic Agents
1. Centrally acting alpha-adrenergic agents
   - Methylodopa (Aldomet)
   
   Rarely: anemia, liver dysfunction, and mental depression
   
   Sedative effect, drug interactions; rebound hypertension on discontinuation
   
   Mental depression (uncommon)
   
   Dosage: 250-2000 mg/day
   
   Dosage: 0.2-0.8 mg/day
   
   Dosage: 0.1-0.25 mg/day

2. Beta-adrenergic-blocking agents
   - Propranolol (Inderal)
   
   Contraindicated in setting of A-V conduction delay; may accelerate cardiac failure or cause bronchospasm
   
   Same; less risk of bronchospasm
   
   Oral and intravenous forms available, so it is useful for converting patient from a controlled hypertensive crisis to oral medication; may cause nausea and diarrhea
   
   Dosage: 40-640 mg/day
   
   Dosage: 100-450 mg/day
   
   Dosage: 200-1200 mg/day

3. Alpha-adrenergic-blocking agent
   - Prazosin (Minipress)
   
   Syncope, particularly with the initial dose; alcohol intolerance
   
   Dosage: 2-20 mg/day

4. Peripherally acting sympatholytic
   - Guanethidine (Ismelin sulfate)
   
   Used in severe hypertension; orthostatic hypotension; sexual dysfunction in men; discontinue 2 weeks before operation
   
   Dosage: 10-300 mg/day

### Direct Vasodilators
- Hydralazine (Apresoline)
  
  May precipitate angina or lead to retention of fluid; occasionally implicated concomitant rheumatoid syndrome
  
  Dosage: 20-300 mg/day
<table>
<thead>
<tr>
<th>Drug</th>
<th>Indication/Complications</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Converting Enzyme Inhibitors</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captopril (Capoten)</td>
<td>Rash; may cause hyperkalemia in renal-insufficient patients</td>
<td>75-450 mg/day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Calcium Channel-Blocking Agents</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nifedipine (Procardia, Adalat)</td>
<td>Sublingual dosage quickly lowers blood pressure; contraindicated in patients with aortic stenosis and heart failure or A-V conduction delay</td>
<td>30-120 mg/day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verapamil (Calan, Isoptin)</td>
<td>Same; no sublingual form; may cause constipation</td>
<td>240-480 mg/day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FOR CONTROL OF ACUTE HYPERTENSION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitroprusside (Nipride, Nitropress)</td>
<td>Most rapidly acting and consistently effective agent for treating hypertensive emergencies; may cause rebound tachycardia, nausea, emesis, or headache</td>
<td>0.5 to 10 µg/kg/min drip or continuous infusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitroglycerine (Nitro-bid, Nitrostat, Tridil)</td>
<td>Useful in controlling hypertension in the patient with known coronary artery disease</td>
<td>5 to 200 µg/min drip</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labetalol (Normodyne, Trandate)</td>
<td>Oral and intravenous forms available, so it is useful for converting a patient from a controlled hypertensive crisis to oral therapy; may cause nausea and diarrhea</td>
<td>20 mg IV slowly; may repeat up to 80 mg IV q10min or 2 mg/min continuous or drip infusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydralazine (Apresoline)</td>
<td>May precipitate angina or fluid retention</td>
<td>20-300 mg orally q day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BIBLIOGRAPHY**


CHAPTER REVIEW

Questions

1. Physical findings are suggestive of which types of surgically treatable hypertension?
2. Persistent hypokalemia in a patient with hypertension suggests what condition?
3. What pathologic lesions are responsible for most instances of renovascular hypertension?
4. How are patients with pheochromocytoma pharmacologically prepared for operation?
5. List the lesions responsible for development of Cushing’s syndrome.
6. What levels of hypertension should be controlled by medication before operation?
7. Why is surgical correction of coarctation of the aorta not routinely advised after the age of 50?
8. When is the measurement of plasma renin levels of clinical significance?
9. What organ systems are commonly affected by severe hypertension?

Answers

1. Coarctation
   - Cushing’s disease
2. Hyperaldosteronism
3. Atherosclerosis
   - Fibromuscular hyperplasia
4. Alpha-adrenergic and beta-adrenergic blockers
5. Excessive intake of exogenous corticosteroids
   - Pituitary adenoma
   - Adrenal adenoma
   - Adrenal hyperplasia
6. A sustained diastolic pressure of 100 or above
7. The likelihood of relief of hypertension is much diminished in patients older than 50 years of age.
8. Principally in the determination of significant renal artery stenosis
9. Cardiovascular, kidney, and central nervous system