NEUROGENIC AND HORMONAL HYPOTENSION * † ‡

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By contrast to arterial hypertension, the chronic forms of which are of greatest practical importance, in hypotension it is chiefly the rapid and temporary fall of the blood pressure to critically low levels which deserves the watchful interest and therapeutic judiciousness of the clinician.

The pathogenic mechanisms leading to hypotensive states are manifold, and rational corrective action requires a broad understanding of the causal factors involved.

Abnormal lowerings of the arterial blood pressure are produced either by one or by a combination of three principal derangements: (a) diminution of peripheral vascular tone, (b) diminution of cardiac output, and (c) diminution of the effective circulatory volume.

In this study, an attempt will be made, first, to analyze fundamental neural and hormonal factors which are responsible for the maintenance of a normal vascular tone, cardiac output, and circulatory blood volume, and second, to outline those related clinical conditions that are believed to cause an abnormal lowering of the blood pressure, either transitory or sustained.

I. Neural and Hormonal Factors in Blood Pressure Regulation

(1) The *state of constriction of the individual vascular muscle cell* is determined, apart from its own structural and metabolic integrity, by certain additional factors:

(a) The presence of physiological pressor catecholamines in the vascular wall. These catecholamines are discharged from the supplying terminals of the sympathetic nerves into the vascular walls, and have been demonstrated there in comparatively large quantities (1, 2, 3). The bulk of these catecholamines consists of norepinephrine while smaller amounts of epinephrine from the adrenal medulla reach the vessel walls through the blood stream. Angiotonin, pherentasin® and other more or less problematic pressor substances are of minor significance as regulators of the normal vascular tone.

(b) The intracellular-extracellular electrolyte equilibrium seems to

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be of particular importance for the contractile responsiveness of the vascular muscle cells to the above-named pressor agents. This responsiveness is markedly decreased or even abolished when either sodium (4) or potassium (5) is withdrawn from the food, and restored when these electrolytes are again administered in sufficient quantity. Conversely, the pressor effect of epinephrine and norepinephrine is augmented after pretreatment with desoxycorticosterone acetate (6, 7) but only under condition that adequate amounts of sodium (4) and potassium (5) are present in the body. Since it is known that desoxycorticosterone increases intracellular sodium (8, 9), and since adrenalectomy is followed by the opposite situation (9) and a fall of the blood pressure, the assumption seems permissible that the adrenal mineralocorticoids contribute to the maintenance of normal vascular tone by guaranteeing a normal intracellular-extracellular electrolyte equilibrium. According to Fleckenstein (10) and Lenzi and Caniggia (24), the intracellular-extracellular electrolyte gradient determines the electrical membrane potential and through it influences the contractile amplitude of muscular elements. Epinephrine and norepinephrine act as depolarizing agents (11, 12), and a distortion of the transmembranous electrolyte gradient, for example, in adrenal insufficiency (lack of mineralocorticoids), will lower the blood pressure by diminishing their pressor effectiveness. The glucocorticoids (11-oxysteroids), on the other hand, seem to be instrumental in upholding the vascular tone and its response to the intrinsic pressor catecholamines by safeguarding the integrity of vascular cell carbohydrate metabolism (13, 14).

(c) VEM. This chemically unidentified substance maintains the vasoconstrictor effectiveness of epinephrine at the precapillary level of the mesenterial vascular system. It is believed to be dependent on the availability of adrenal corticoids, both regarding its production by the kidney and its functional effectiveness (15).

(d) The interplay of adrenergic and cholinergic neurohormonal discharges at the respective vascular nerve endings. It has recently been stated by Lindgren and Uvnäs (16) that, in addition to the nor-epinephrine-secreting sympathetic and the acetylcholine-liberating parasympathetic fibers, there exist also cholinergic vasodilator sympathetic pathways which connect the medulla oblongata with the vascular tree. Enzymatic influences (aminoxidase, cholinesterase) regulate the action of the neurohormones on the vascular cells and thus are able to alter their effects on the blood pressure. Aminoxidase activity appears to be reduced by the thyroid hormone which is believed to interfere in the state of vascular tone in this indirect fashion (17, 18). Hypothyroidism diminishes the vasoconstrictor effect of epinephrine and norepinephrine (19, 20).

(2) The second principal element of blood pressure homeostasis, namely *cardiac output*, is likewise subject to neural and hormonal interferences. Locally discharged sympathogenic and, to a lesser

extent, blood-borne adrenergic catecholamines (norepinephrine and epinephrine, respectively), contribute to the preserevation of a normal heart rate and stroke volume. But, if present in excess, they may reduce cardiac output by helping to provoke ventricular tachycardia or fibrillation, and by metabolically injuring the myocardium (21). Cholinergic discharges, elicited by reflectory vagal stimulation, on the other hand, serve as potent cardiac inhibitors. Vagal reflexes which diminish the cardiac output originate either in the peripheral vascular and other pressor receptor areas (eyeballs, pleura), in the central nervous system or in the heart muscle itself. The vagotropic depressor Bezold-Jarisch reflex mechanism is elicited by distention as well as presumably by metabolic injury of the myocardial tissue (22, 23).

The corticoid-regulated electrolyte (sodium, potassium) balance of the cardiac muscle cells participates significantly in the maintenance of myocardial dynamics. It is believed by Lenzi and Caniggia (24) that the intracellular-extracellular electrolyte gradient is largely responsible for the magnitude of cardiac muscular contraction. Specific abnormalities of the sodium and potassium concentration of the heart muscle cells in relation to the distribution of these electrolytes in the extracellular space occur in adrenal cortical insufficiency and under the influence of experimentally or clinically exaggerated corticoid action. Although different in character, both types of electrolyte imbalance result ultimately in a diminution of cardiac contractile power and output. It has also been suggested that an abnormal accumulation of intracellular sodium may interfere with the synethesis of energy-yielding phosphocreatine (25), which constitutes a vital factor in the cardiac contraction mechanism.

(3) Reductions of the *effective circulatory volume* which contribute to a lowering of the blood pressure level can be ascribed in part to neurogenic mechanisms, such as blood pooling in the musculature of the limbs and splanchnic areas under hypothalamic influence, attributable to either inhibition of sympathetic vasoconstrictor tone or to active cholinergic vasodilatation (16, 26, 27).

Circulating epinephrine also produces vasodilatation in certain segments of the vascular tree (28, 29, 30), especially in the musculature, possibly by way of a reflex mechanism which is believed by Gruhzit (31) to be mediated by periaortic "tension receptors." The resulting decrease of peripheral resistance accounts for the fall of diastolic pressure which is often elicited by epinephrine injection, while the systolic pressure rises, owing to an augmentation of cardiac output.

The hemodynamic role of the release of histamine by autonomic nerve fibers (32) remains to be elucidated. In allergic conditions it seems to produce marked decreases of the effective circulatory volume through vasodilatation (64).

An actual shrinkage of the total plasma volume on a primarily

hormonal basis occurs in experimental or clinical adrenal insufficiency because of the lack of sodium and water-retaining corticoids (33).

II. Pathogenic Patterns of Clinical Hypotension

With the above enumerated neural and hormonal factors in mind, it is possible to classify different types of arterial hypotension according to their established or suspected pathogenic mechanisms, with the understanding, however, that there is considerable overlapping

TABLE 1

NEURAL-HORMONAL FACTORS REGULATING BLOOD PRESSURE

I. *Vascular Muscular Tone Affected by:*
   (1) Sympathogenic catechols (norepinephrine constricting, epinephrine prevailingly dilating)
   (2) Mineralocorticoids, potentiating contractile vascular cell responsiveness to catechols (probably via influence on intracellular-extracellular cation gradient and electrical cell membrane potential)
   (3) Glucocorticoids, potentiating vascular reactivity to catechols (probably via influence on carbohydrate metabolism of vascular cells)
   (4) Thyroid hormone, potentiating vascular reaction to catechols (probably via inactivation of catechol-destroying aminoxidase)
   (5) VEM, potentiating epinephrine sensitivity of mesenterial metarterioles
   (6) Acetylcholine, liberated at parasympathetic and certain sympathetic postganglionic nerve endings (generally dilating)
   (7) Histamine, liberated by sympathetic fibers (generally dilating)

II. *Cardiac Output Affected by:*
   (1) Sympathogenic catechols as stimulating (depolarizing) and, if present in excess, as hypoxia-producing, efficiency-impairing agents
   (2) Vagal acetylcholine as inhibitory agent
   (3) Adrenal corticoids (probably via influence on cellular cation gradient and carbohydrate metabolism)
   (4) Thyroid hormone as potentiator of catechol effects

III. *Effective Circulatory Volume Affected by:*
   (1) Vascular muscular tone (see above), responsible for absence or presence of blood pooling
   (2) Total plasma volume, regulated by adrenocortical influence on water retention and distribution

of the respective pathogenic entities, and that some of the interpretations must still be regarded as speculative in nature.

A. Primarily Vascular Forms of Hypotension

Primarily vascular forms of hypotension are those in which the blood pressure level is lowered by a decrease of sympathetic tone and of neurosecretion into the vascular effector cells; by a decreased responsiveness of the vascular walls to these neurohormones; by pharmacodynamic counteraction against the sympathogenic pressor catecholamines, or by an increase of cholinergic or histamine-induced vasodilator activity.

(a) A *rather clear-cut diminution of sympathetic tone* exists in the case of postural or sustained hypotension following sympathectomy (34, 35) or after the administration of ganglionic blocking agents

(tetraethylammonium chloride, hexamethonium and so forth) (36, 37) and sympatholytic drugs (dibenamine, regitine®, priscoline, and so forth) (38). Similar hemodynamic conditions, owing to a reduction of primary sympathetic tone or of reflectory responsiveness, originate in the central vasomotor apparatus of the spinal cord or of the cerebral stem ganglia, for example, in individuals suffering from tabes dorsalis, combined sclerosis, syringomyelia, postencephalitic states, brain tumors or some obscure hypothalamic derangements. All of these abnormalities are likely to give rise to the clinical syndrome of "asympathicotonic" postural hypotension, owing to failure of the vascular bed of the dependent parts of the body to maintain its caliber in the presence of a gravitational downward shift of a large portion of the blood volume. Both the diastolic and systolic pressures decline in the erect position, usually without acceleration of the heart rate (39, 40, 41, 42).

Bacteriotoxic influences upon the vasomotor centers in infectious diseases, certain specific, centrally acting depressor agents, such as dihydrogenated ergot alkaloids (43) and apresoline® (44), as well as narcotic drugs (morphine, barbiturates, and so forth), are capable of lowering the blood pressure level and of diminishing central vasomotor reactivity to stimulation (45).

Most of the above-mentioned types of hypotension can be assumed to have one decisive feature in common, namely a diminished sympathogenic discharge of pressor catecholamines, notably norepinephrine, into the respective effector cells, even though direct evidence of this has been presented so far only in the heart muscle after sympathectomy (46, 47). A diminished urinary excretion of catecholamines was observed by Luft and v. Euler (48) in patients with orthostatic hypotension and by Raab and Gigee (49) in patients with hypopituitarism. This latter finding suggests a participation of a deficient adrenosympathetic neurosecretory activity also in the origin of the characteristic hypotension in this endocrine syndrome. Diminution of vascular responsiveness to norepinephrine, however, may likewise be responsible, as will be discussed.

(b) *Diminution of vascular contractile responsiveness to the intrinsic pressor catecholamines,* especially to norepinephrine (14, 50, 51), appears to be the dominant factor in those forms of postural and sustained hypotension that develop as a result of experimental or clinical adrenal cortical insufficiency (52, 53). Apart from the lack of VEM which may contribute to hypoadrenal hypotension (15), it has been suggested by the writer (54) that the loss of sodium and the ensuing distortion of the intracellular-extracellular electrolyte gradient of the vascular muscle cells lower the blood pressure through interference with the normal vasoconstrictor efficiency of intrinsic norepinephrine. A concomitant disturbance of energy metabolism in the vascular cells, owing to a lack of 11-oxysteroids, must also be con-

sidered. Analogous derangements may be assumed to exist in cases of temporary, stress-induced exhaustion of the adrenal cortex which may account, for example, for the postural hypotensive episodes during convalescence from severe infections and other illnesses.

Hypopituitarism is usually accompanied by low blood pressure levels (55, 56), a paradoxical fall of the blood pressure after muscular exercise, and postural hypotension (57, 58) in which a state of secondary adrenal cortical insufficiency is likely to be involved. Since it was found that the experimental sustained "post-desoxycorticosterone hypertension" can be abolished by hypophysectomy but not by adrenalectomy (59), however, the conclusion appears justified that the pituitary also participates in regulation of the blood pressure in some as yet undefined, specific fashion.

Although the thyroid does not play a prominent role in blood pressure regulation, its underfunction may occasionally give rise to the syndrome of postural hypotension (60), possibly likewise by reducing the vasoconstrictor activity of the catecholes (18, 19, 20, 61).

(c) An *increase of cholinergic vasodilator activity* is being suspected as the main cause of those acute hypotensive episodes which have been termed "vasovagal syncope" by Sir Thomas Lewis (62). They occur under a variety of emotional and traumatic circumstances such as intense grief, joy or fear, the sight of an accident and of blood, physical pain, arterial puncture, spinal anesthesia, distention of hollow organs, blood withdrawal, starvation, pregnancy, acute infections, standing up after prolonged recumbency, and so forth. These attacks of hypotension are more likely to develop when the patient is in the upright than in the supine position. The attacks are ascribed to vascular dilatation in the muscles under central nervous influence (27, 63) with simultaneous constriction of the cutaneous vessels, and usually bradycardia (64). The existence of cholinergic vasodilator fibers of the sympathetic system which connect certain hypothalamic areas with the vascular musculature (16, 26, 65) suggests a prominent involvement of these dilator pathways in the mechanism of noncardiac syncope. It seems tempting to attribute to them also an important part in the early "neurogenic" stage of shock which occurs after injury to the central nervous system or to peripheral tissues. It should be mentioned, however, that the neurogenic shock phase presents also certain indications of an exaggerated discharge of epinephrine from the adrenal glands, such as epinephrine depletion of the adrenal medulla and eosinopenia (66, 67, 68), so that both cholinergic and adrenergic mechanisms may be considered as participating.

The precipitous fall of the blood pressure during attacks of the vagal carotid sinus syndrome (see below) is the result chiefly of a sudden diminution of cardiac output, but a simultaneous cholinergic vasodilatation is suggested by the occasionally dissociated behavior of heart rate and blood pressure, for example, under the influence of

atropine, which was seen to prevent the bradycardia but not the fall of blood pressure (69).

B. Primarily Cardiogenic Forms of Hypotension

A fall of blood pressure attributable to *drastic reduction of the cardiac output* occurs under inhibitory vagal influence upon the heart, especially in the *carotid sinus syndrome,* which is due to an exaggerated sensitivity of the underlying reflex mechanism (69, 70). The latter may be overactivated either by local pressure on the carotid sinus (lymph nodes, aneurysms, tumors, stiff collar and so forth) or by an abnormal reactivity of the central synapses or perhaps even by an excessive responsiveness of the cardiac effector cells themselves (71). The vagal response evokes bradycardia, atrioventricular block and, in extreme cases, complete cardiac standstill.

Hypotensive reactions develop also in connection with attacks of the *Stokes-Adams syndrome,* that is, sudden diminutions of the cardiac output, caused either by paroxysmal bradycardia, owing to transitory atrioventricular block under vagal influence, or by paroxysmal tachycardia (over 180 beats per minute), or by ventricular fibrillation under adrenosympathetic influence.

The characteristic decline of the blood pressure shortly after *myocardial infarction* appears to result, as a rule, from a reduction of cardiac output (72, 73, 74) in the presence of a relatively high peripheral resistance (23). This phenomenon has been ascribed to an activation of the vagotropic Bezold-Jarisch reflex by the injured portion of the heart muscle (22, 23, 75). In more severe cases, however, with a fall of the blood pressure to levels below 90 mm. or so, a concomitant peripheral vasodilation, similar to that occurring after other tissue injuries (see above), seems to participate in this ominous cardiogenic shock syndrome.

Sympathogenic neurohormonal metabolic influences can be assumed to play a significant role in the origin of certain myocardial lesions themselves and in the resulting hypotensive reactions, in so far as an excessive influx of the specific hypoxiating catecholamines is capable of producing disseminated, chiefly subendocardial necroses even in the absence of coronary vascular lesions (76, 77, 78, 79).

Neurogenic syncopes, for example, in the carotid sinus syndrome or in drug-induced hypotensive states (80), may diminish the coronary flow below the critical level and thus provoke acute hypoxic structural myocardial damage which, in turn, is likely to elicit detrimental cardiogenic hypotension and to lead to death by a vicious circle of events.

The decreased pulse pressure which is often observed in *hypoadrenocortical and hypopituitary hypotension* (52, 55, 56) indicates a reduction of cardiac output, which not only is a result of vascular relaxation (see above), diminished circulatory volume and venous re-

turn, but also is a sign of myocardial weakness, caused by the derangement of electrolyte balance (81) and disturbed carbohydrate metabolism (82, 83) of the myocardium, especially in the stage of crisis.

A *constitutionally low blood pressure level,* sometimes referred to as "essential hypotension," exists in numerous healthy individuals (84). It cannot be designated as a pathological condition in the ordinary sense, and little is known concerning its neural and hormonal background. A low sympathetic tone and a prevalence of vagal influences, possibly under primarily hypothalamic control, are suggested

TABLE 2

PRESUMABLE PATTERNS OF CLINICAL NEUROGENIC AND/OR HORMONAL HYPOTENSION

I. *Vascular Factors in Hypotension* (diminished vascular tone):
  (1) Primary decrease of sympathetic tone:
    a. Sympathectomy (mainly postural hypotension)
    b. Ganglionic blocking and sympatholytic drugs (mainly postural hypotension)
    c. Central nervous pathology (mainly postural hypotension)
    d. Central depressant drugs (morphine, barbiturates, etc.) and toxins
    e. Decreased catechol production (hypopituitarism?)
  (2) Diminished vascular reactivity to intrinsic catechols:
    a. Lack of corticoids (adrenal insufficiency)
    b. Lack of VEM (secondary to adrenal insufficiency)
    c. Lack of thyroid hormone
  (3) Increased cholinergic effects on vascular walls:
    a. Overstimulation of cholinergic pathways (neurogenic shock; Bezold-Jarisch reflex; Veratrum alkaloids)
    b. Overexcitability of cholinergic reflex mechanisms (carotid sinus syndrome; vasovagal syncope)
  (4) Increased local dilating effect of epinephrine in certain vascular areas (neurogenic shock?)

II. *Cardiogenic Factors in Hypotension* (diminished cardiac output):
  a. Overexcitability of cholinergic cardio-inhibitory reflex mechanism (carotid sinus syndrome)
  b. Overstimulation of cholinergic pathways (Adams-Stokes syndrome; Bezold-Jarisch reflex elicited by myocardial injury?)
  c. Paroxysmal tachycardia, ventricular fibrillation under catechol influence
  d. Catechol-induced myocardial injury (metabolic hypoxia)
  e. Myocardial weakness due to hypoadrenocortical electrolyte and metabolism derangement

III. *Hypovolemic Factors in Hypotension* (diminished effective circulatory volume):
  a. Peripheral blood pooling caused by vascular dilatation (see above)
  b. Dehydration owing to adrenal cortical insufficiency, diabetic acidosis

by the generally low cardiac output (85). Nothing definite is known regarding the role played by the endocrine glands, especially the adrenal cortex, in this clinically insignificant condition.

C. Hypovolemic Forms of Hypotension

In this review, which is limited to neurogenic and hormonal hypotension, the hemodynamically most important forms of hypovolemia, namely those caused by outward or inward hemorrhage and by certain types of dehydration, will not be discussed.

A reduction of the effective circulatory volume through blood-pooling in the arteries and veins of the musculature and the splanchnic

regions constitutes an element of hypovolemia in postural hypotension, vasovagal syncope, neurogenic and allergic shock, but cannot be regarded as a primary mechanism, divorced from the underlying vascular relaxation.

In adrenal cortical insufficiency, on the other hand, we are dealing with a combination of hypotension-producing weakness of cardiovascular muscle, with an actual reduction of total blood volume which is especially marked in addisonian crises (52). Diabetic acidosis is often associated likewise with a considerable reduction of the circulatory volume and systolic blood pressure levels below 90 mm. of mercury (86).

III. THERAPEUTIC CONSIDERATIONS

An excellent review of specific therapeutic procedures in the various types of hypotension was recently presented by Judson (64). Only some guiding principles will briefly be reviewed here as they emerge from the recognition of the neural and hormonal factors involved in the pathogenesis of hypotensive states.

The parenteral administration of l-norepinephrine or of similarly acting pressor amines (vasoxyl®, wyamine®, and so forth) is indicated in acute conditions of deficiency of sympathetic tone, such as overdosage of ganglionic blocking or sympatholytic drugs, severe infections, hypoadrenocortical crises, allergic shock and cardiogenic shock following myocardial infarction. It is not advisable in states of overexcitability of the cardiac vagal pathways, for example, in the carotid sinus syndrome, and also in the bradycardic Stokes-Adams syndrome, because norepinephrine elicits a secondary reflectory stimulation of the cardiac vagus by means of the vascular pressoreceptors. In cases of hypotension due to paroxysmal supraventricular tachycardia, on the other hand, this latter phenomenon is useful and makes l-norepinephrine the remedy of choice.

Epinephrine may be used, together with *thyroid* hormone preparations, in cases of bradycardic Stokes-Adams syndrome caused by atrioventricular block. It is contraindicated, however, whenever direct stimulation and metabolic exhaustion of the heart appear hazardous, thus particularly in cardiogenic shock after infarction, and also during the action of dibenamine and other sympatholytic drugs which convert the pressor effect of epinephrine into a depressor one. During the action of ganglionic blocking agents (TEA, hexamethonium), on the other hand, epinephrine is likely to elicit excessive pressor reactions.

The postural "asympathicotonic" hypotensive episodes of central nervous origin, the carotid sinus syndrome, the bradycardic Stokes-Adams syndrome, and the various types of presumably cholinergic vasovagal syncope can be influenced favorably by the use of *sympathomimetic amines* with partly central action, such as amphetamine, paredrine, and ephedrine. Cardiac standstill has been successfully overcome by Zoll's electric pacemaker (87).

Atropine helps to control exaggerated vagal cardio-inhibitory impulses in the carotid sinus syndrome, in the bradycardic Stokes-Adams syndrome, and in recurrent vasovagal syncopes.

Quinidine, mecholyl, digitalis glycosides and, as mentioned before, *l-norepinephrine,* are being used in cases of auricular tachycardia. By restoring an adequate diastolic ventricular filling and cardiac output

TABLE 3

MEDICATION FOR NEUROGENIC AND/OR HORMONAL HYPOTENSION

Drug	*Indications*	*Contraindications*
Norepinephrine	Decreased vascular tone Neurogenic and allergic shock Acute adrenal insufficiency Severe infections Overdosage of depressor drugs Paroxysmal tachycardia (if ventricular, combined with pronestyl®)	Carotid sinus syndrome Bradycardic Adams-Stokes syndrome
Epinephrine	Bradycardic Adams-Stokes syndrome	Myocardial infarction Cardiogenic shock Paroxysmal tachycardia Overdosage of sympatholytic and ganglionic blocking drugs
Sympathomimetic drugs (amphetamine, paredrine and ephedrine)	Postural hypotension Carotid sinus syndrome; bradycardic Adams-Stokes syndrome Recurrent vasovagal syncope	
Atropine	Carotid sinus syndrome; bradycardic Adams-Stokes syndrome Recurrent vasovagal syncope	Paroxysmal tachycardia Cardiogenic shock
Digitalis glycosides	Auricular paroxysmal tachycardia	Ventricular tachycardia Atrioventricular block (unless in congestive failure)
Procaine amide (pronestyl®)	Ventricular tachycardia or fibrillation (combined with norepinehrine)	
Ardenal corticoids	Hypoadrenocorticism Hypopituitarism "Essential" hypotension (?)	
Antihistaminic drugs	Allergic shock	
Sodium chloride and glucose	Hypoadrenocorticism (with corticoid medication)	

they permit also a restoration of normal blood pressure. *Procaine amide* (pronestyl®), the most potent drug to suppress ventricular fibrillation, may offset its beneficial cardiac action by its vasodepressor side effects which can be obviated, however, by the simultaneous administration of l-norepinephrine.

Desoxycorticosterone, cortisone and *adrenal cortical extracts,* together with adequate amounts of sodium chloride and glucose, bring the blood pressure level of hypoadrenal and hypopituitary individuals back to normal, probably by restoring both the circulatory volume and

the cardiovascular contractile responsiveness to the intrinsic pressor catecholamines. Attempts to combat traumatic and other forms of shock by the administration of adrenal corticoids proved disappointing.

Antihistaminic drugs (benadryl, pyribenzamine, and so forth), epinephrine and norepinephrine are useful in allergic types of collapse.

Mechanical devices, such as abdominal corsets, elastic stockings, head-up training periods in bed, and avoidance of motionless standing, help to prevent spontaneous, drug-induced or postsympathectomy orthostatic hypotension.

Surgical denervation of the carotid sinus or removal of locally irritating structures may cure the carotid sinus syndrome. Pressure on the carotid sinus or eyeballs, provoking gag reflexes, and the Valsalva maneuver are intended to forestall or to stop attacks of paroxysmal supraventricular tachycardia; head-down position shortens the duration of vasovagal syncope.

SUMMARY

Neurogenic and hormonal factors dominate the pathogenesis of most forms of acute and sustained arterial hypotension. They concern vascular tone, cardiac output and effective circulatory volume, and overlap in many instances.

Primarily vascular hypotension is caused by a decrease of vascular tone attributable (a) to a diminution of the vasoconstrictor activity of the intrinsic adrenosympathogenic catecholamines (notably norepinephrine), (b) to a diminished contractile responsiveness of the vascular muscle cells to these catecholamines (for example, in adrenal insufficiency), or (c) to exaggerated vasodilatory cholinergic effects on the vascular musculature.

Primarily cardiogenic hypotension is caused by (a) a diminution of cardiac output owing to exaggerated cholinergic inhibitory action on the heart, (b) a marked augmentation of the heart rate under sympathetic influence with poor diastolic filling of the left ventricle, or (c) myocardial metabolic derangements (catecholamine-induced injurious hypoxia; disturbances of electrolyte and carbohydrate metabolism, for example, in adrenal insufficiency).

Hypovolemic hypotension is caused by blood pooling in hypotonic vascular areas or by dehydration, as in adrenal insufficiency.

The clinical hypotensive conditions in which the above-named mechanisms are involved, and the principles of therapeutic correction of the different pathogenic types of neurogenic and hormonal hypotension are briefly reviewed.

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