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Review Article

THE PHYSIOLOGY OF BLOOD PRESSURE REGULATION

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Abstract

In day today's era, Hypertension is becoming a very common disorder affecting large no of people. The human body is an incredibly complex machine, maintains important physiological parameters such as temperature, blood pressure, PH, Blood sugar levels in narrow ranges. An important parameter that must be kept within the normal range for biological health is blood pressure. In response to certain situations, a series of actions take place in the body that can either raise or lower blood pressure. It is vital to understand these actions and why they take place. In case of treatment of hypertension it becomes crucial to know normal physiology of blood pressure regulation. This article highlight the summery based on the physiology of blood pressure regulation.

Keywords: Hypertension; pH; Blood pressure; Physiology.

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INTRODUCTION

In day today era, Hypertension is becoming a very common disorder affecting large numbers of people. The human body is an incredibly complex machine, maintains important physiological parameters such as temperature, blood pressure, PH, Blood sugar levels in narrow ranges. An important parameter that must be kept within the normal range for biological health is blood pressure.

Every cell in our body requires a constant supply of nutrients, such as glucose oxygen etc as well as removal of waste products such as CO_2 to prevent a toxic build up.

To maintain this constant exchange of material, we rely on blood to circulate in the transport network of blood vessels and interact with cells in organs and tissues. If this does not occur at a sufficient rate cells suffer hypoxia, lack of energy substrates and toxic effects of metabolic waste build up. Therefore, it is obviously crucial to maintain blood flow at a sufficient rate through the systemic tissues and lungs. This is achieved by maintaining blood pressure.[1]

The arterial blood pressure is the force or pressure that the blood exerts on the walls of the blood vessels.[2] The line of demarcation between normal blood pressure and hypertension is obscure and depends on individual circumstances. The arterial blood pressure varies even under physiological conditions. However, immediately it is brought back to normal level because of the presence of well organized regulatory mechanisms in the body.[3]

When the systolic pressure remains elevated above 150 mm Hg and diastolic pressure remains elevated above 90 mm Hg .It is considered as hypertension.[4]

Hypertension is a major risk factor for cardiovascular disease, stroke and kidney diseases. About 2.3 million details in India were attributed to cardiovascular diseases in the year 1990 and are projected to double by the year 2020.[5]

AIMS AND OBJECTIVES

To study the concept of Blood pressure in detail.

To study physiology of blood pressure regulation.

MATERIALS AND METHODS

Since the present study is a literary research, different opinions available in Modern Physiology texts on blood pressure with special reference to physiology of its regulation are compiled here.

Conceptual study

The arterial blood pressure is the lateral pressure exerted by the blood on the vessel wall while flowing through it.[6]

Function

To maintain a sufficient pressure head to keep the blood flowing through the blood vessels.

To provide the motive force of filtration at the capillary bed, thus assuring nutrition to the tissue, cells, formation of urine, lymph etc.[7]

Components of systemic arterial BP

Systolic blood pressure “SBP”

It is the maximum pressure exerted during systole.

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Features

It undergoes considerable fluctuations.

a) Increased by excitement, exercise meals.
b) Decreased by sleep, rest

The height of SBP indicates

c) The force with which the heart is working.
d) The degree of pressure with which the arterial walls have to withstand.

Normal value

Range : 100-130 mm Hg.
Average : 120 mm Hg.

Diastolic blood Pressure "DBP"

It is the minimum pressure exerted during diastole.

Features

It undergoes much less fluctuations.
It is the measure of total peripheral resistance.
It indicates the constant load against which heart has to work.

Normal value

Range : 60-90 mm Hg.
Average : 80 mm Hg.

Pulse pressure

It is the difference of SBP and DBP
PP = SBP – DBP.

Features

It determines the pulse volume.

Normal value: Average 40 mm Hg.

Mean blood pressure

It is the average pressure throughout the cardiac cycle. It can be computed as.
MBP = DBP + 1/3 PP.

Features

It is same for each organ and determines the pressure head ie regional blood flow through an organ depends on it.

All cardiovascular reflexes are sensitive to change in MBP.

Normal Value

Range : 95 – 100 mm Hg.
Average : 96 Hg[8]

Regulation of Arterial blood Pressure

The various mechanisms exist within the body to regulate the systemic arterial B.P These mechanisms are well inter connected and their main aim is to maintain the normal MBP within a narrow range, between 95 to 100 mm Hg. The different mechanisms available are,

a. Short term regulatory mechanism.
b. Long term regulatory mechanism.
c. Intermediate acting regulatory mechanism.
d. Miscellaneous mechanism.

Short term regulatory mechanism or rapidly acting regulatory mechanism or nervous regulatory mechanism

Nervous regulatory mechanism begins to act within seconds to minutes after the arterial BP becomes abnormal. Most of these mechanisms lose their capability for pressure control after a few hours or a few days.

These are primarily the circulatory reflexes which begin to act within seconds and help to

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control BP from rising extremely high or falling extremely low.

The Circulatory reflexes of these mechanisms include.

i. Baroreceptor reflexes.
ii. Chemo receptor reflexes.
iii. CNS ischaemic responses.

Baroreceptor reflexes

Fall in arterial BP decreases inhibitory discharge from baroreceptors to cause

i. Less inhibition of vasomotor centre.
ii. Less stimulation of cardiac vagal center.

This results in increased sympathetic and decreased parasympathetic discharge to restore blood pressure back to normal and vice versa in case of high arterial BP.

It operates between 60-200 mm Hg ranges of MBP.

It corrects 2/3rd fall in BP.

Chemoreceptor reflex

It operates between 40-100 mm Hg ranges of MBP.

It can correct approx 2/3rd of the further fall in BP.

Especially when BP <80 mm Hg, Decrease blood flow to tissues, as a result PO_2 decreases& PCo_2increases to carotid & aortic bodies & causes stimulation of VMC, CVC and respiratory centre & The final effect is increase in BP.

CNS Ischaemic Response

It operates between 15-50 mm Hg range of MBP.

It can correct 11/12th of a further fall in BP.

Especially when BP <50mm Hg, As a result CNS ischaemia which lead to CO_2 acumulation in VMC, which directly stimulate VMC → tremendous powerful sympathetic discharge throughout the body and final effect is increase in BP.[9]

Long term Regulatory mechanism Or Auto regulation of BP By kidneys

Kidneys play an important role in the long term regulation of arterial blood pressure. When blood pressure alters slowly in several days/months/ years, nervous mechanism adapts to the altered pressure and looses the sensitivity for changes. It cannot regulate the pressure any more. In such conditions, the renal mechanism operates efficiently to regulate the blood pressure. Therefore, it is called long term regulation. Kidneys regulate arterial blood pressure by two ways.

1. By regulation of ECF volume.
2. Through rennin angiotensin mechanism.

By regulation of ECF Volume

When blood pressure increases, kidneys excrete.

1. Large amount of water by means of pressure diuresis.
2. Large amount of sodium by means of pressure natriuresis.

As a result ECF volume and blood volume decrease which in turn brings the arterial blood pressure back to normal level and viceversa when blood pressure increase

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Through rennin angiotensin mechanism

When blood pressure and ECF volume decreases, rennin secretion from kidneys is increased. It converts angiotensinogen into angiotensin I.

This is converted into angiotensin II by ACE (angiotensin converting enzyme).

Angiotensin II acts in 2 ways to restore the blood pressure.

i. Causes constriction of arterioles.
↓
Peripheral resistance Increases
↓
BP Increases

ii. Causes constriction of afferent arterioles in kidneys.
↓
Glomerular filteration reduces.
↓
Retention of water & salts.
↓
Increase in ECF volume
↓
BP Increases.

iii. Stimulate adrenal cortex to secrete aldosterone.

Aldosterone
↓
Increase reabsorption of sodium.
↓
Water reabsorption increases
↓
Increases in ECF volume & blood volume
↓
Blood Pressure increases [10]

Intermediate acting arterial blood pressure regulatory Mechanism or intrinsic physical regulatory mechanism

They begin to act within a few minutes and reaches full function within a few hours. These mechanisms remain functional from few days to a month only.

They primarily correct any alteration in BP by altering the blood volume.

The mechanism includes.

1. Capillary fluid shift mechanism and.
2. Stress relaxation and reserve stress relaxation mechanism.

Capillary fluid shift mechanism

Since mean capillary pressure is directly proportional to arterial BP, therefore rise in arterial BP, increases hydrostatic pressure at arterial end and fluid shift out of capillaries to the interstitial fluid compartments. Thus blood volume decrease to restore BP.

Stress relaxation and reverse stress relaxation mechanisms

Rise in arterial BP e.g. following massive slow intravenous transfusion increases perfusion pressure in blood storage organs such as veins, liver, spleen, lungs etc. This causea relaxation of blood vessels is simply by local vascular tone adjustment.

Therefore venous return & cardiac output decrease and BP returns to normal & vice versa in case of fall in arterial BP.

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Miscellaneous Mechanism

Role of sympathetic nerves

The kidneys are strongly supplied by sympathetic nerves & degree of sympathetic stimulation can alter renal functions tremendously.

Example**:** When sympathetic nerves to kidneys are stimulated for several weeks continuously, renal retention of fluid occurs to cause chronically elevated BP, as long as the sympathetic stimulation continues.

Role of ADH

ADH system plays an important role in acute as well as long term regulation of arterial BP viz., by its.

i. Direct**:** Vasoconstrictor action on blood vessels.
ii. Indirect**:** via effect on the kidneys in causing decrease excretion of water.[11]

Other then this orthostatic hypotension occurs when there is a sudden drop in BP due to a change in a person's position.

Here gravity acts on the vascular system to reduce the volume of blood returning to the heart and blood pools in the leg.

Valsalva reflex or manoeuvre is a sudden rise then drop in BP occurring when a person stains to open their bowels.[12]

RESULTS AND DISCUSSION

Regulation of the circulatory system to maintain a constant arterial pressure is critical in ensuring adequate perfusion to meet metabolic requirement of tissues. This is the essence of homeostasis i.e. maintain blood pressure is crucial to ensure that all tissues are adequately perfused. There is various interconnected mechanism of blood pressure regulation.

But when these mechanisms fail or are overwhelmed, that delicate balance of homeostasis is lost and disease and pathological changes occur in association with hypo or hypertension.[13]

CONCLUSION

Blood pressure is a vital bodily function and one needs to understand its anatomy and physiology to assess the risks of blood pressure becoming too high or too low. Blood pressure must be regulated. Health problems occur if it is too high or too low.

Blood pressure can adapt to changing needs such as increasing when people are in fight or flight mode or decreasing at rest. Orthostatic hypotension can occur if BP does not adjust quickly enough after a sudden change in posture.

So here an attempt is made to study basic physiology of regulation of blood pressure.

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