Age-related changes in cardiovascular system

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Objectives

- explain the main structural and functional changes in cardiovascular system associated with normal aging

Introduction

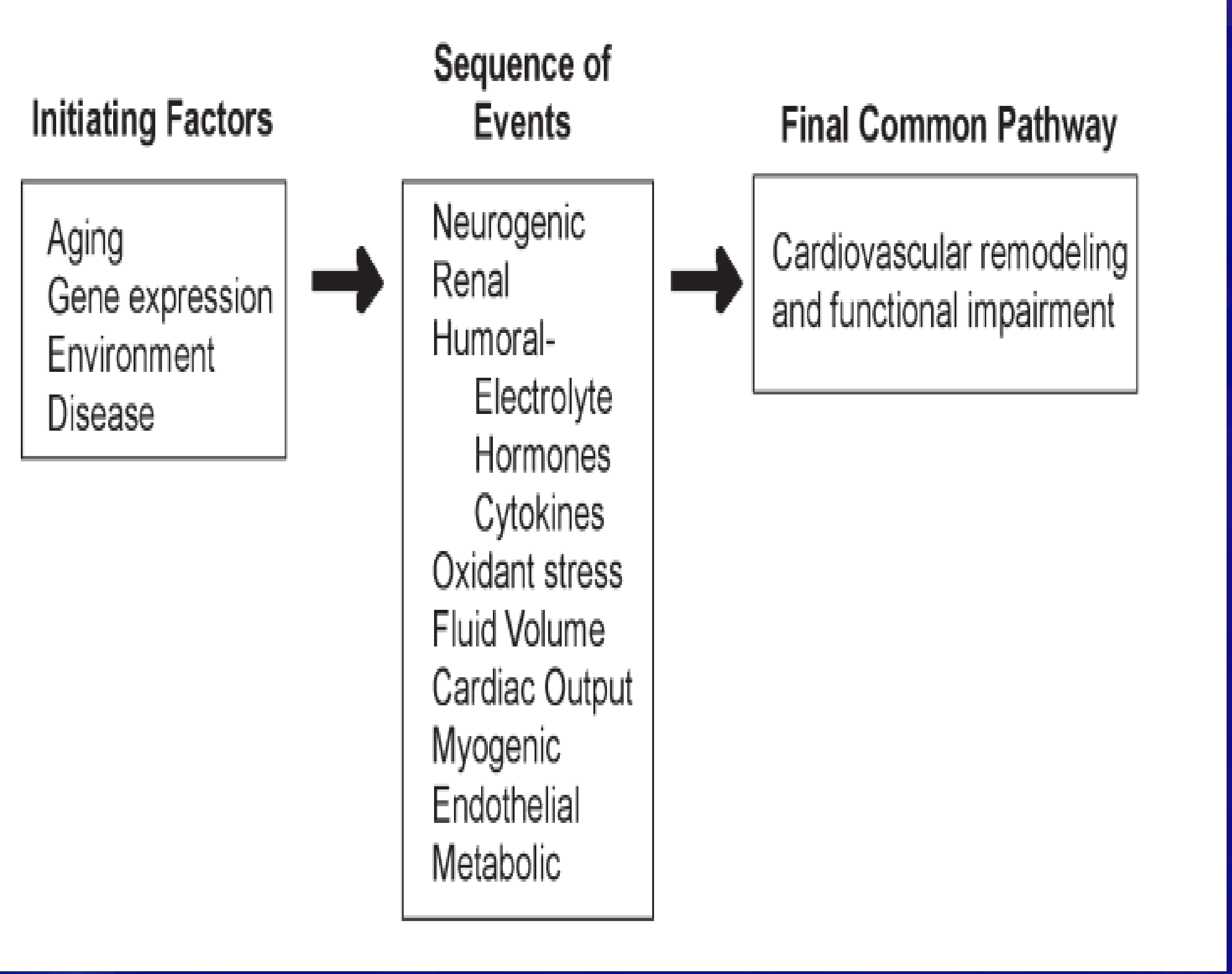
- aging results in significant anatomic and functional changes in all the major organ systems.
- Aging is marked by a decreased ability to maintain homeostasis. However, within the elderly population there is significant heterogeneity of this decline.

Mechanisms of cardiovascular changes in aging

- Aging is an independent risk factor for cardiovascular disease.

- The effects of aging act with other variables (initiating factors), such as gene expression, environment , and disease, to alter various organ systems.

- With respect to the cardiovascular system, it is known that the changes that occur with age are modulated by other systems in the body. For example, functional changes in the autonomic nervous system and endocrine system during aging affect the overall function of the cardiovascular system.



Mechanisms of cardiovascular changes in aging

cardiovascular changes in aging

- Recognizing normal changes of aging from pathological changes may be difficult to determine. thus may interfere with appropriate care to older adults.
- Aging affect the cardiovascular system both structurally and physiologically (function)

Structural, increased heart weight; decreased number of myocardial cells increased left ventricle wall thickness; increased arterial stiffness……

Functionally, decreased diastolic filling; decreased reaction to beta-adrenergic stimulus; increased systolic pressure; increased arterial pressure; elongation of muscle contraction phase……

Age related changes in the blood vessels

- wall thickening and dilation in the large elastic arteries
- The wall thickening involves both the tunica intima and the tunica media.
- reduction in arterial compliance
- increase in vessel stiffness

Factors that contribute to the increased wall thickening and stiffening in aging

- **increased collagen**
- **reduced elastin**
- **calcification.**

Age related changes in the blood vessels

- A portion of the stiffening of large arteries during the aging process can be attributed to a reduction in endothelial function
- As, with aging there is a reduction in the amount of nitric oxide (NO), vasoconstriction is promoted because the dilator activity of NO is removed.
- When the large arteries become stiffer, there is an increase in systolic arterial pressure, a decrease in aortic diastolic pressure, and a widening of the pulse pressure

Age related changes in the blood vessels

Veins

- Are also subject to progressive stiffening with age. The decreased compliance of the capacitance system reduces its ability to "buffer" changes in intravascular volume.

- Its electrical excitability and responsiveness to ANS tend to be less rapid.
- Little research has been done on the aging veins compare with arteries.

Age related changes in the blood vessels

The basement of the capillary thickens with aged

Exchange of O2 and nutreint more slowly

Reduced arteriovenous O2 uptake

Age related changes in the blood vessels

Because tissue perfusion occurs more slowly,, necessitating a warm-up longer than the usual requisite 3 minutes prior to more rigorous work.

Thickening of the basement wall occurs in sedentary people but not in master athletes, which suggests that this aspect of “age-related” decline is actually a lifestyle modification.

an aerobic exercise training study of older (age 60 to 70 years), previously sedentary men and women revealed that basement membrane thickening was no longer present after 3 months of training at 70% or more of Vo2max.

Age related changes in the heart

- enlargement of cardiac myocytes because of the addition of sarcomeres.
- There is a decrease in myocyte number in the aging myocardium.
- Increase in myocardial collagen , fobrosis , and lipofuscins
- increase in left ventricular mass(thickness ,hypertrophy) that may be due to:

Increased Arterial Wall Thickening and Stiffening,

increases systolic blood pressure

increase afterload

Age related changes in the heart

- The valves of the heart thicken and become stiffer
- Reduced early diastolic filling rate as result from :

Accumulation of fibrous material in the left ventricle

Slowing in Ca^{2+} activation from the preceding systole

Age related changes in the heart

decline in left ventricle compliance can be reflected into the left atrium and the pulmonary vasculature, leading to pulmonary congestion.

The prolonged action potential is caused by slower inactivation of L-type Ca2+. These age associated changes in Ca2+ movements impair myocardial relaxation

Age related changes in the heart

apoptosis of atrial pacemaker cells with a loss of 50%–75% of cells by age 50. fibrosis and cellular loss in the His bundle

Baroreceptors (stabilize BP during movement/activity) become less sensitive with aging. This may contribute to the relatively common finding of orthostatic hypotension

Reduced responsiveness to beta-adrenergic stimulation so,the elderly respond to stress with less tachycardia

Heart Rate

- Resting heart rate (HR) does not change very much with age.

- The maximum exercise heart rate decreases with age.
- 200 beats/min at age 20
- 140 beats/min at age 80
- to calculate estimated maximum exercise heart rate:

Max HR= 220 –age(years)

The reason:

1- **Alteration in SA node activity**

2- **Reduce beta-adrenergic sensitivity**

Cardiac Changes at Rest

- Minor ↓ in HR
- CO output maintained by ↑ SV
- ↑ ejection of blood during late systole
- ↓ early diastolic filling rate
- EDV not ↓ - enhanced atrial contribution to LV filling –

During exercise…

- ↓ in maximum HR (↓ response to β-adrenergic stimuli)
- ↓ in cardiac output - reduced by 30% between ages 20 and 80
- Maximum SV not reduced – but maintained in different manner
- Frank Starling mechanism

- The elderly respond to stress with less tachycardia, possibly due to the decline in the responsiveness of beta-receptors. Increases in CO in the elderly tend to be largely due to increases in stroke volume rather than heart rate.

Frank Starling Mechanism

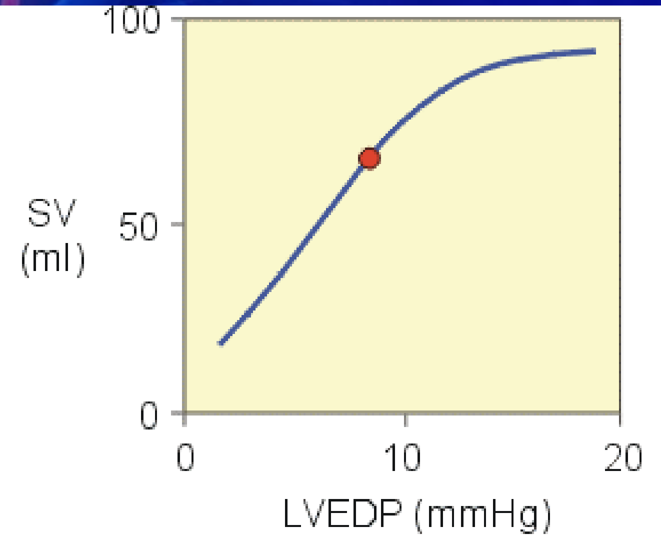


Figure 1. Frank-Starling mechanism. Increasing venous return to the left ventricle increases left ventricular end-diastolic pressure (LVEDP) and volume, thereby increasing ventricular preload. This results in an increase in stroke volume (SV). The "normal" operating point is at a LVEDP of ~8 mmHg and a SV of ~70 ml/beat.

- ↑ EDV, due to:
- Longer diastolic interval (↓ HR)
- ↓ EF - ↑ amount of blood in LV at start of diastole

Summary of changes

	HR	SV	CO	EDV	EF
At rest	↓	↑	=	=	=
Exercise	↓	=	↓	↑	↓

factors that contribute to the reduction in aerobic capacity in older individuals :

(a) an increase in body fat
(b) $\downarrow$ in cardiac output
(c) a reduction in muscle mass
(d) impaired oxygen extraction.

Major Age related cardiovascular changes

Anatomic/Physiological Change with Age	Clinical Consequences
Decline in maximum heart rate	Smaller aerobic workload possible
Decline in V o2max	Smaller aerobic workload possible
Stiffer, less compliant vascular tissues	Higher blood pressures Slower ventricle filling time with reduced cardiac output
Loss of cells from the SA node	Slower heart rate Lower HRmax

Major Age related cardiovascular changes

Anatomic/Physiological Change with Age

- Reduced contractility of the vascular walls
- Thickened basement membrane in capillary

Clinical Consequences

- Slower HR Lower Vo2max Smaller aerobic workload
- Possible Reduced arteriovenous O2 uptake

References

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