Circulatory Reactions

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This presentation includes only the most important terms and facts. Its content by itself is not a sufficient source of information required to pass the Physiology exam.

Circulatory Reactions

- Regulation of circulation – a complex system of feed backs which are continually in a dynamic balance.
- Individual parameters (BP, blood flow through organs, *etc.*) regulated by neural and humoral mechanisms, both systemic and local – their quantitative ratio changes dynamically.
- Physiological stimuli (a change of the body position, exertion, *etc.*) induce rather standard reaction in a healthy person (integration of many particular reflex changes).

Circulatory Reactions

- **Orthostatic / Clinostatic Reaction**
- a change of the body position from lying to standing / from standing to lying
- orthostatic reaction – due to gravity:
  → ↑ BP in all vessels below the heart level
  → ↓ BP in all vessels above the heart level

Circulatory Reactions

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  veins – a sudden closure of valves due to ↑ BP (prevention of backward flow; persists only shortly, valves open immediately again to keep a continual blood flow) + ↑ venous pressure due to continuous blood inflow from arteries → total filling of veins considerably ↑, blood flow sustained → dilation of veins

Circulatory Reactions

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- orthostatic reaction – due to gravity:

  → ↑ BP in all vessels below the heart level

  → ↓ BP in all vessels above the heart level

  veins – ↓ volume (in chest veins by ~20%) → ↓ central venous pressure → ↓ venous return → ↓ stroke volume (from 70 to ~ 45 ml) → **↓ BP**

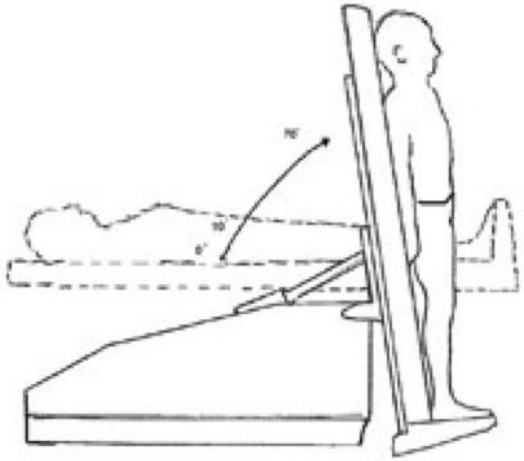
  ↓ BP + direct action of gravity – inhibition of baroreceptors → ↓ activity of vagus nerve and ↑ activity of sympathetic system → ↑ HR + ↑ SV + ↑ PR

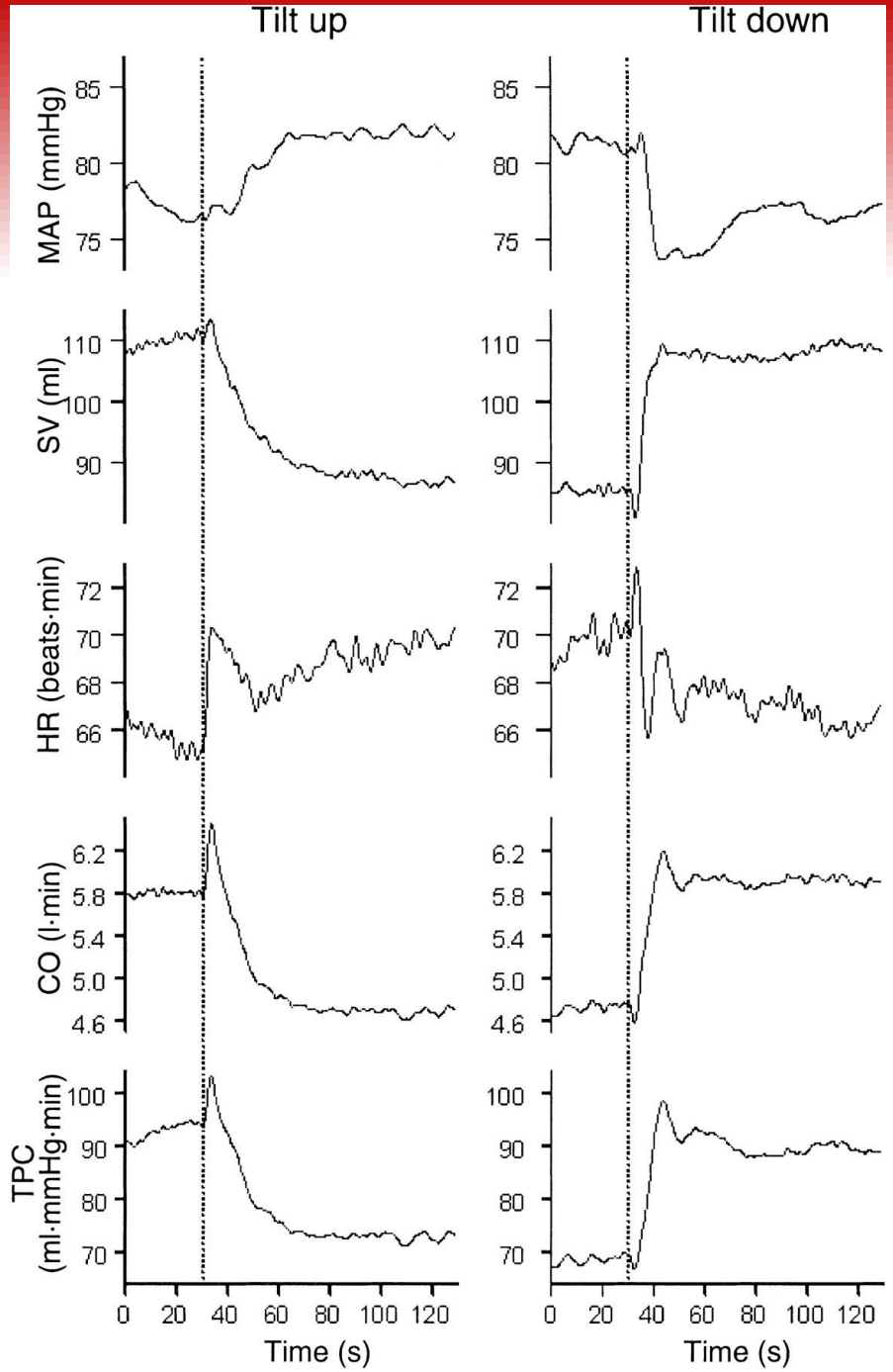
Circulatory Reactions

- **Orthostatic / Clinostatic Reaction**
- a change of the body position from lying to standing / from standing to lying
- orthostatic reaction – due to gravity:

  a) acute reaction – passes within 1 min

Tilt-up test




Tilt up
Tilt down
MAP (mmHg)
85
80
75
SV (ml)
110
100
90
HR (beats·min)
72
70
68
66
CO (l·min)
6.2
5.8
5.4
5.0
4.6
TPC (ml·mmHg·min)
100
90
80
70
0 20 40 60 80 100 120
Time (s)

Circulatory Reactions

- **Orthostatic / Clinostatic Reaction**
- a change of the body position from lying to standing / from standing to lying
- orthostatic reaction – due to gravity:

  a) acute reaction – passes within 1 min

  b) subsequently:

  ↑ capillary filtration → ↓ plasma volume (within ~40 min; by ~10 %)

  ↑ level of ADH + ↑ activity of RAS + reflex vasoconstriction in kidneys → ↓ excretion of salt and water in kidneys

Circulatory Reactions

- **Orthostatic / Clinostatic Reaction**
- a change of the body position from lying to standing / from standing to lying
- orthostatic reaction – due to gravity:

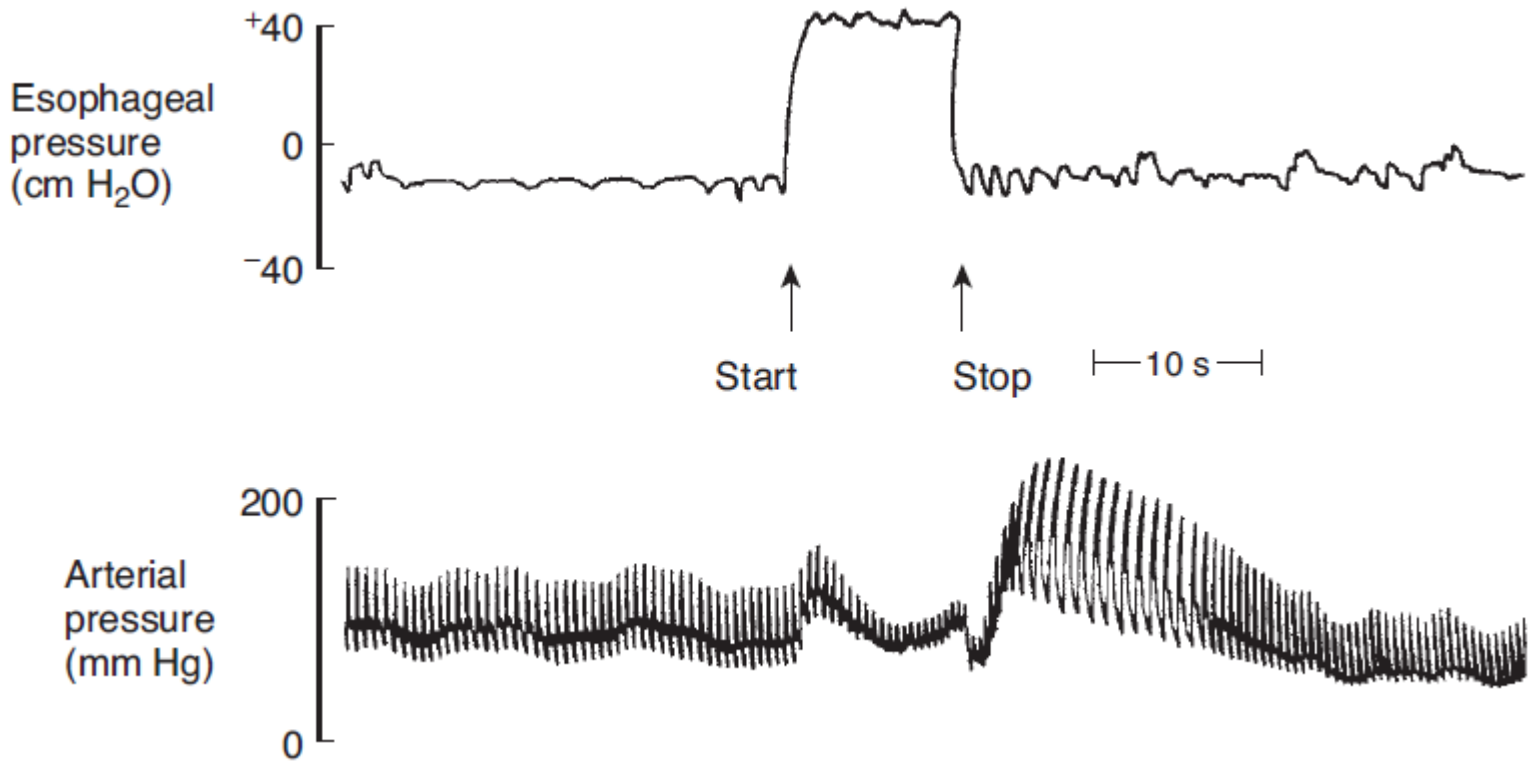
  The above described complex reaction provides maintenance of BP and, thus, sufficient perfusion of brain. Despite, the brain blood flow ↓ even by 20%.

  The brain blood flow is ↓ due to a reflex vasoconstriction induced by ↓ pCO_2 (↑ ventilation during the orthostatic reaction) and sympathetic vasoconstrictive activity.

- orthostatic hypotension

Circulatory Reactions

- **Valsalva Maneuver**
- forced expiration over closed or narrowed glottis (cough, defecation, lifting of heavy objects, *etc.*)

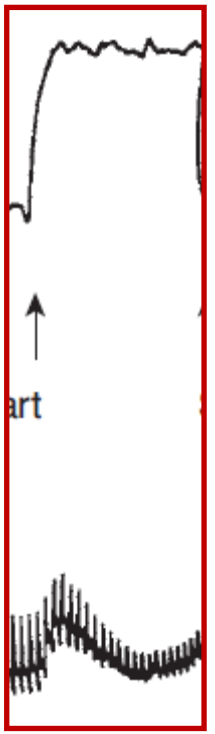


Circulatory Reactions

- **Valsalva Maneuver**
- forced expiration over closed or narrowed glottis (cough, defecation, lifting of heavy objects, *etc.*)
- **start of maneuver→ ↑ intrathoracic pressure:**

  → ↑ BP (the intrathoracic pressure contributes to the aortal pressure)

  → compression of chest vessels → ↓ venous return → ↓ stroke volume (Frank-Starling) → ↓ pulse and mean BP → inhibition of baroreceptors → reflex tachycardia and vasoconstriction → mean BP at the level before maneuver

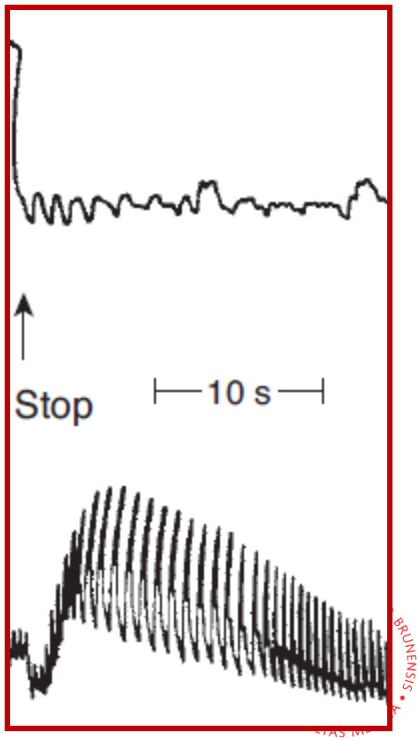


Circulatory Reactions

- **Valsalva Maneuver**
- forced expiration over closed or narrowed glottis (cough, defecation, lifting of heavy objects, *etc.*)
- **end of maneuver → ↓ intrathoracic pressure:**

  → ↓ BP

  → compression of chest vessels released → ↑ venous return → ↑ stroke volume (Frank-Starling) → ↑ pulse and mean BP → stimulation of baroreceptors → fast reflex bradycardia and gradual vasodilation (~ ↓ peripheral resistance) → normalizing of BP



Circulatory Reactions

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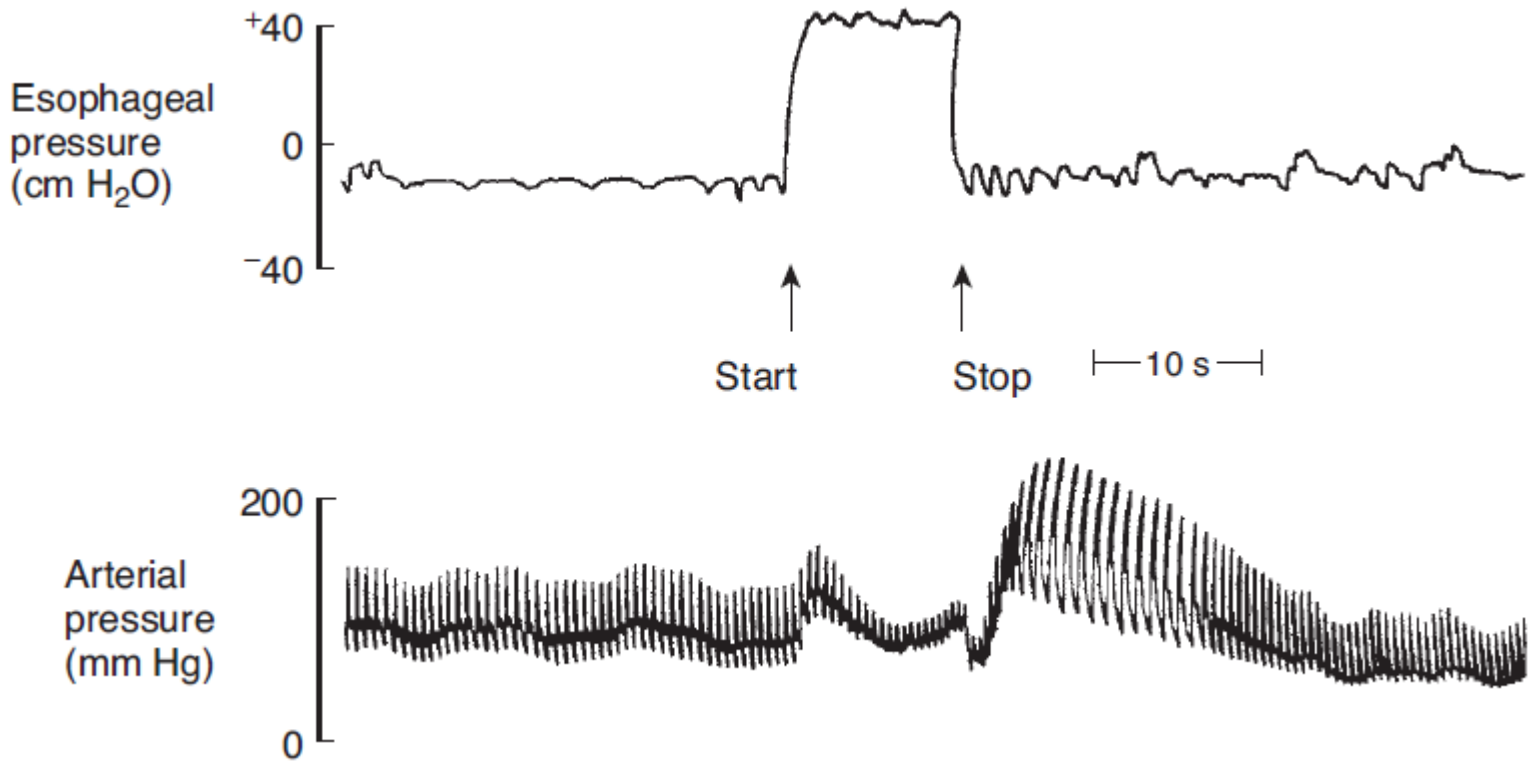

Circulatory Reactions

- **Diving Reflex**
- well developed in diving animals (duck, whale, …)
- diving – excitation of receptors of *n. trigeminus* (namely around eyes and nose) by cold water:

  → apnoe

  → bradycardia

  → peripheral vasoconstriction

  ~ conservation of limited O_2 reserves for function of brain and heart → prolongation of diving period (whale 2 hours, seal 70 min; they have also higher O_2 reserves in haemoglobin and myoglobin, higher tolerance to hypoxia)

Circulatory Reactions

- **Reaction on loss of blood**
- bleeding → hypovolemia → ↓ venous return → ↓ SV → ↓ CO → ↓ BP (even shock)
- The resulting state is dependent on the amount of lost blood and on the velocity of loss of blood!

Circulatory Reactions

- **Reaction on loss of blood – sudden**
- bleeding → hypovolemia → ↓ venous return → ↓ SV → ↓ CO → ↓ BP (even shock)
- loss of 10 % of the blood volume (~ in a blood donor):
- → slightly and transiently ↓ BP
- loss of 20-30 % of the blood volume :
- → ↓ mean BP to about 60-80 mmHg
- loss of 30-40 % of the blood volume :
- → ↓ mean BP to about 50-67.5 mmHg → shock with brain and heart ischemia and with anuria, may shift into an irreversible state

Circulatory Reactions

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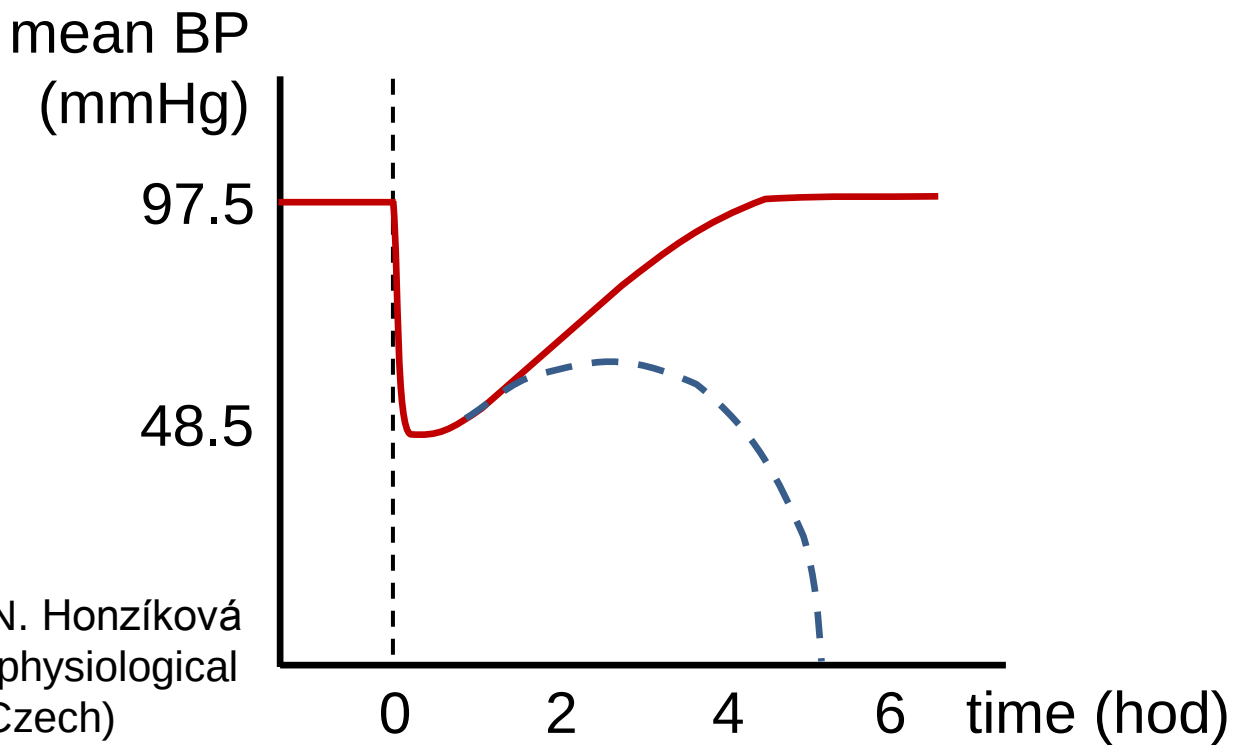


according to prof. N. Honzíková (Comments to the physiological lectures, 1992; in Czech)

Circulatory Reactions

- **Reaction on loss of blood – sudden**
- bleeding → hypovolemia → ↓ venous return → ↓ SV → ↓ CO → ↓ BP (even shock)
- Instantaneous reaction (seconds till minutes)
- Reaction within 5 - 60 min
- Reaction within hours till days

Circulatory Reactions

- **Reaction on loss of blood – sudden**
- Instantaneous reaction on ↓ BP (seconds till minutes)
- ↓ stimulation of baroreceptors → ↓ activity of parasympathicus and ↑ activity of sympathicus → ↑ HR + ↑ CO + ↑ PR → ↑ BP
- limited tissue perfusion due to ↑ PR → metabolic acidosis
- limited renal perfusion due to ↑ PR (*v. eff.* > *v. aff.*) → ↑ FF but, anyway, ↓ urine formation → retention of Na^+ in body (prospectively also of waste nitrogen products – uremia – a risk of renal tubule damage)
- RAS activation (angiotensine II, aldosteron) + ↑ secretion of ADH, thirst → vasoconstriction + retention of salt and water in body → ↑ PR + ↑ volume of body fluids → ↑ BP

Circulatory Reactions

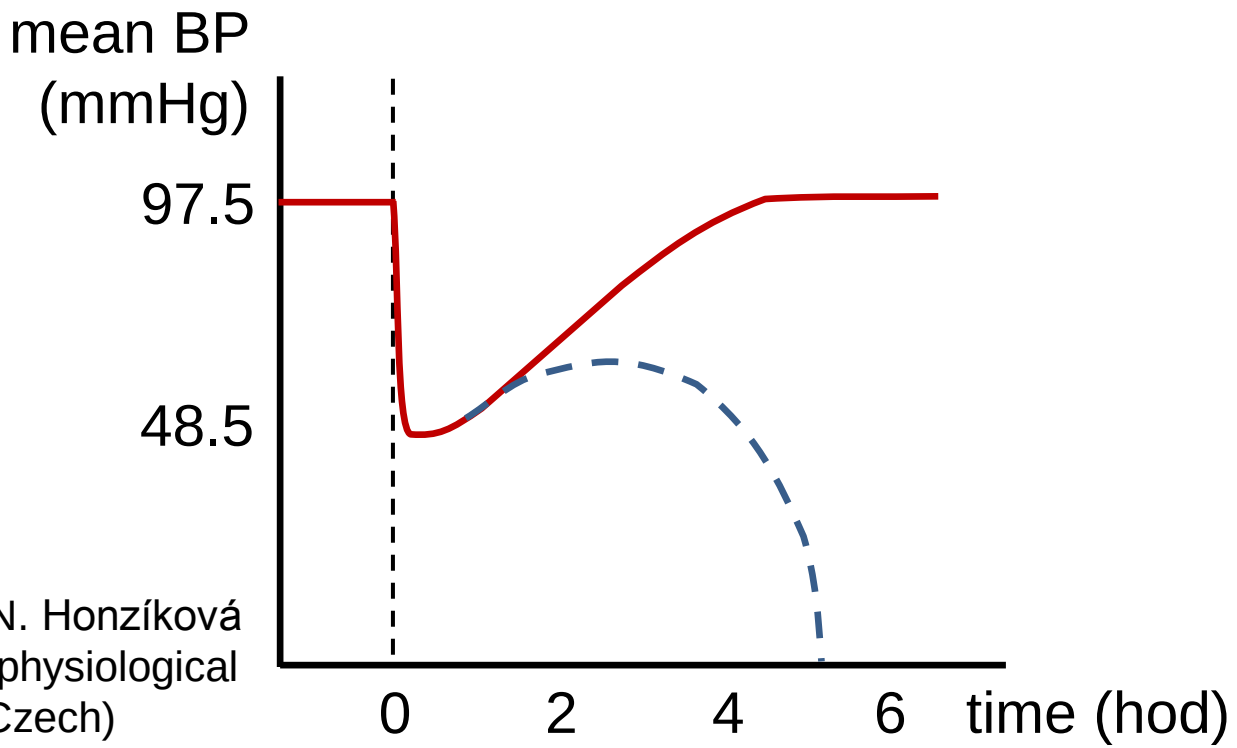
- **Reaction on loss of blood – sudden**
- Reaction on ↓ BP within 5 - 60 min
- ↓ capillary hydrostatic pressure → oncotic pressure > hydrostatic pressure → reabsorption of fluids from the interstitial tissue into cappilaries → ↑ volume of intravasal fluid even by 500 ml in adults („internal transfusion“) → ↑ BP + ↓ haematocrit + ↓ concentration of plasmatic proteins
- The so far described reactions provide the sufficient blood flow through brain and myocardium.

Circulatory Reactions

- **Reaction on loss of blood – sudden**
- Reaction on ↓ BP within hours till days (even weeks)
- restoration of content of salt and water in the organism (↓ GFR due to sympathetic constriction of *v. aff.*, RAS, ADH, thirst)
- restoration of plasmatic proteins including albumin (liver)
- stimulation of erythropoiesis in the bone marrow (erythropoietin)

Circulatory Reactions

- **Reaction on loss of blood – sudden**
- bleeding → hypovolemia → ↓ venous return → ↓ SV → ↓ CO → ↓ BP (even shock)



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Circulatory Reactions

- **Reaction on loss of blood – sudden**
- irreversible state (shock) may be caused by:
- primary heart failure: ↓ BP → insufficient perfusion of myocardium → ↓ contractility → ↓ CO → ↓ BP (positive feed back, *circulus vitiosus*)
- serious tissue hypoxia: accumulation of metabolites → metabolic acidosis + ↑ permeability of capillaries → vasodilation → loss of fluid into the interstitial tissue → ↓ BP (positive feed back)