

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

- **Orthostatic / Clinostatic Reaction**

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→ ↑ BP in all vessels below the heart level

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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→ ↑ BP in all vessels below the heart level

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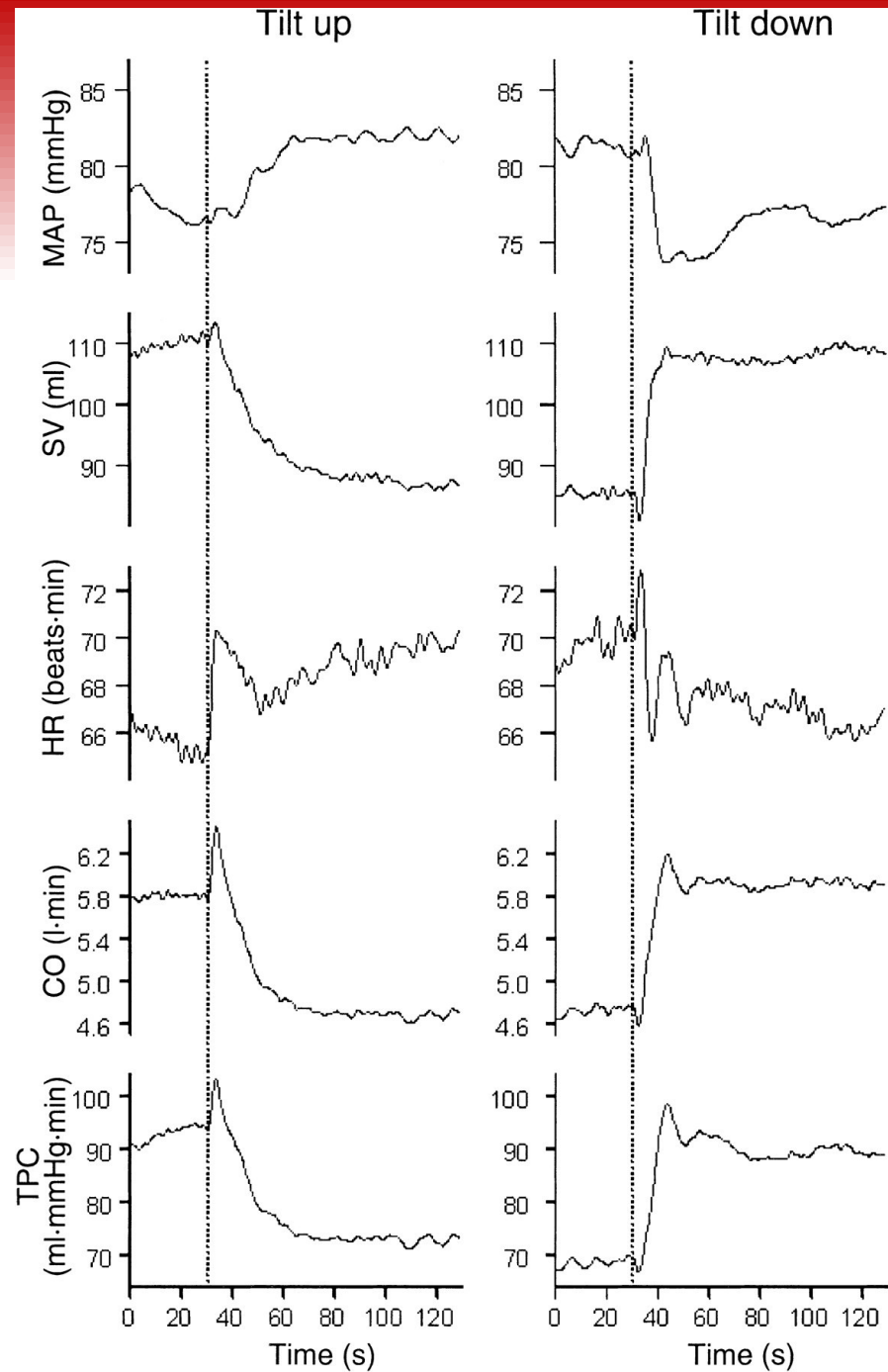
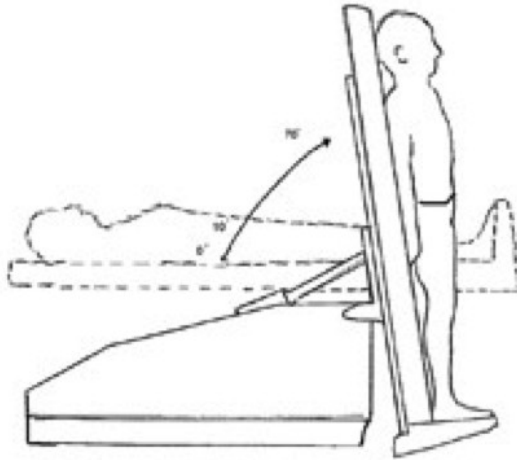
veins – ↓ **volume** (in chest veins by ~20%) → ↓ central venous pressure → ↓ **venous return** → ↓ **stroke volume** (from 70 to ~ 45 ml) → ↓ **BP**

↓ 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



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**:

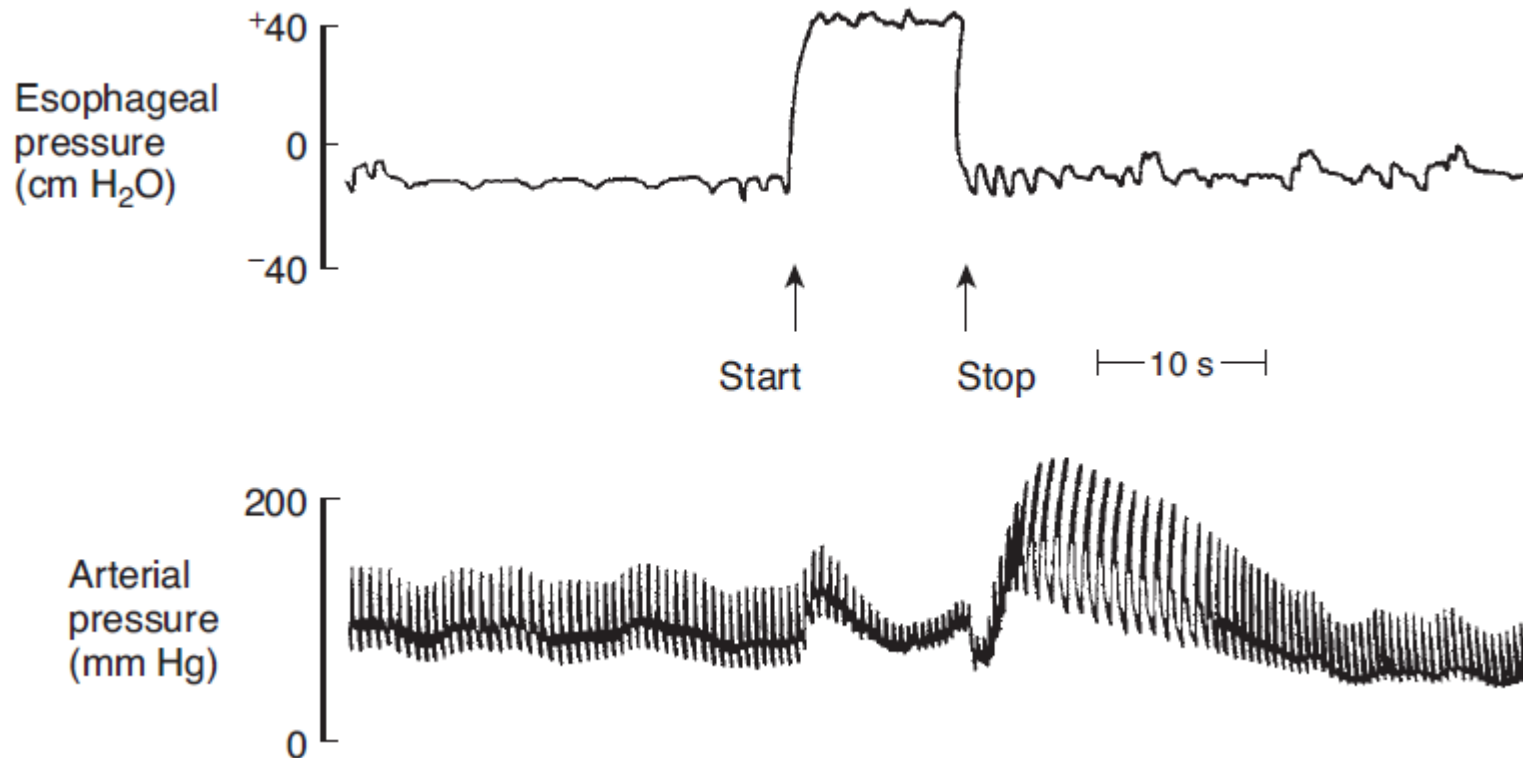
The above described complex reaction provides maintenance of BP and, thus, sufficient perfusion of brain. **Despite, the brain blood flow** ↓ even by 20%.

The brain blood flow is ↓ due to a reflex vasoconstriction induced by ↓ pCO₂ (↑ ventilation during the orthostatic reaction) and sympathetic vasoconstrictive activity.

- **orthostatic hypotension**

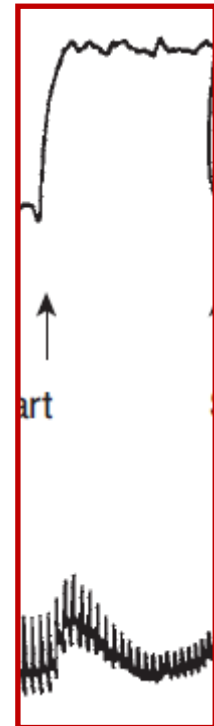
Circulatory Reactions

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



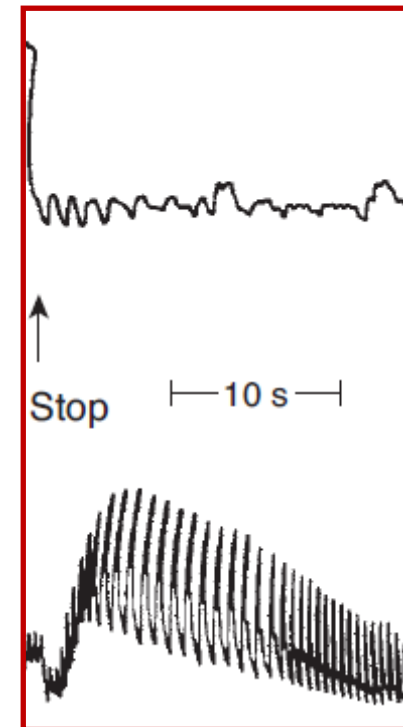
Circulatory Reactions

- **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



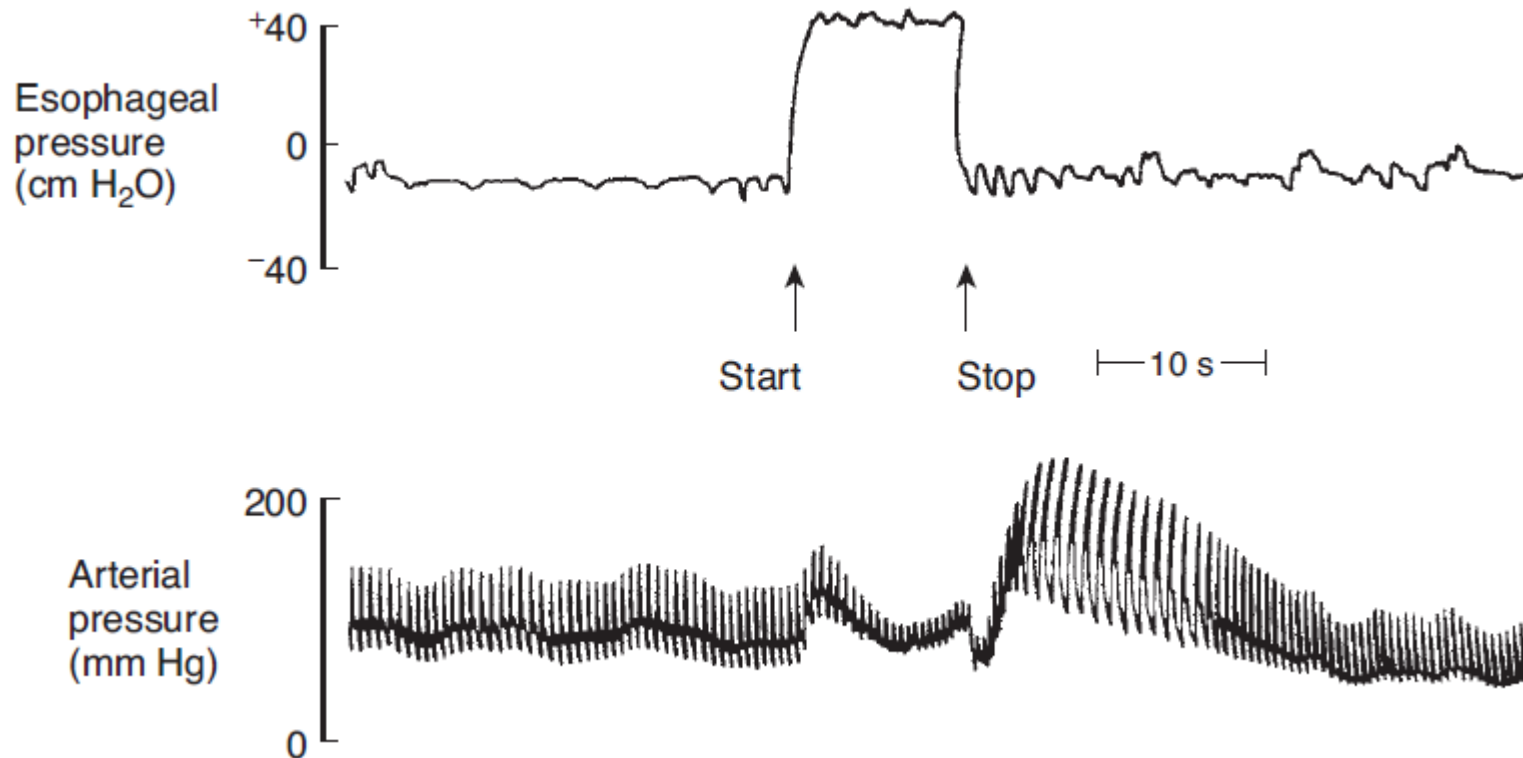
Circulatory Reactions

- **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

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



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 O₂ reserves for function of brain and heart → prolongation of diving period (whale 2 hours, seal 70 min; they have also higher O₂ reserves in haemoglobin and myoglobin, higher tolerance to hypoxia)

Circulatory Reactions

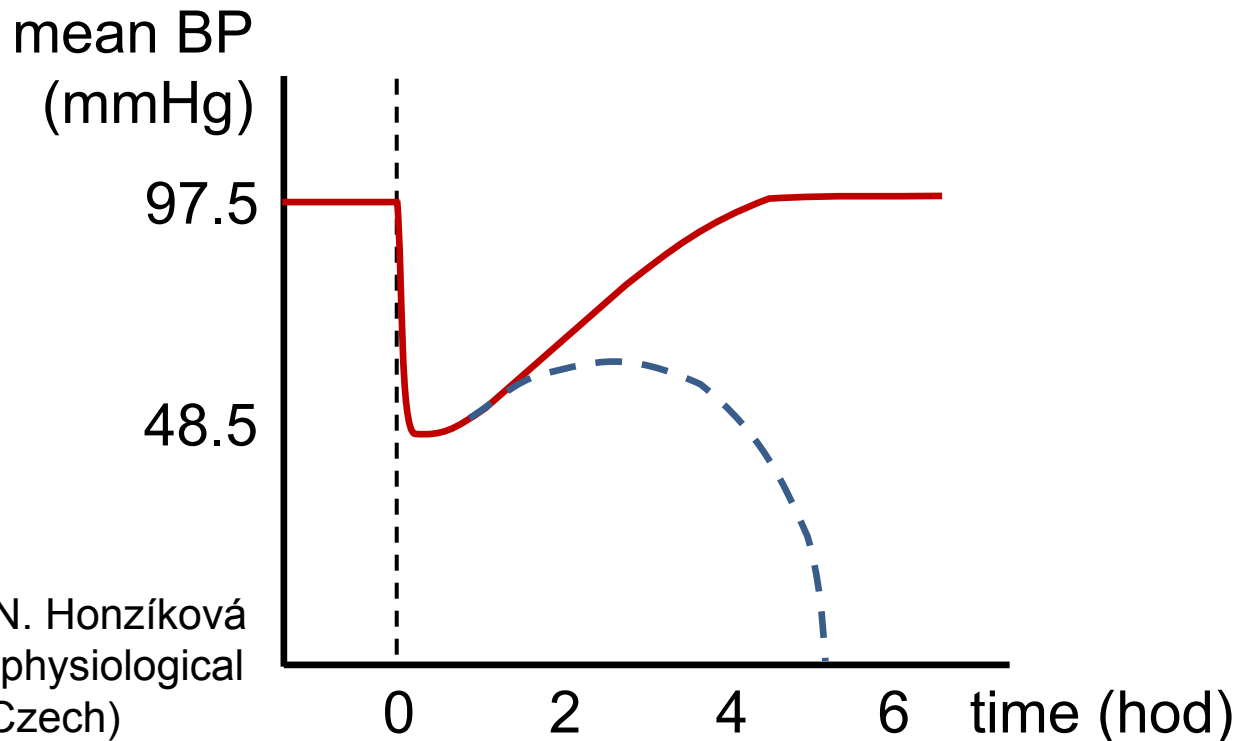
- **Reaction on loss of blood**
- bleeding → hypovolemia → ↓ venous return → ↓ SV
→ ↓ CO → ↓ **BP** (even shock)
- The resulting state is dependent on the amount of lost blood and on the velocity of loss of blood!

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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- bleeding → hypovolemia → ↓ venous return → ↓ SV → ↓ CO → ↓ **BP** (even shock)



according to prof. N. Honzíkova
(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

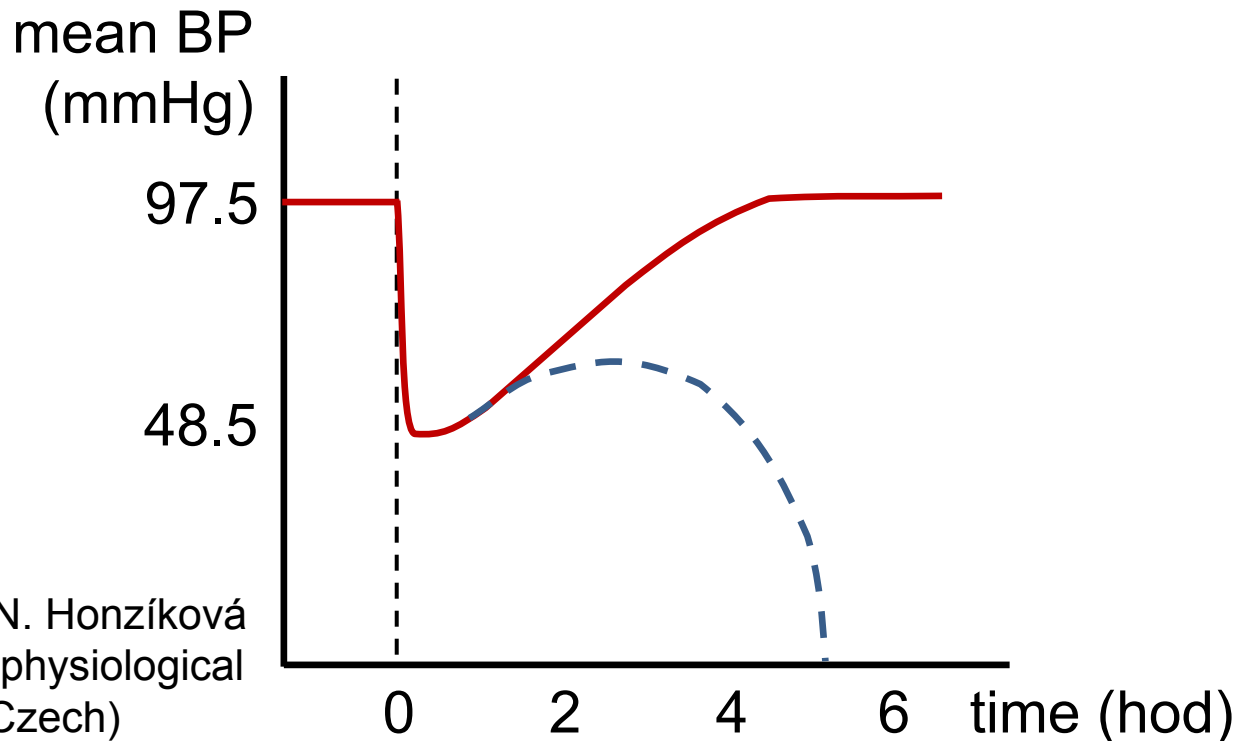
- **Reaction on loss of blood – sudden**
- **Reaction on ↓ BP within 5 - 60 min**
- ↓ capillary hydrostatic pressure → **oncotic pressure > hydrostatic pressure** → reabsorption of fluids from the interstitial tissue into capillaries → **↑ volume of intravasal fluid** even by 500 ml in adults („internal 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:** \downarrow BP \rightarrow insufficient perfusion of myocardium \rightarrow \downarrow contractility \rightarrow \downarrow CO \rightarrow \downarrow BP (positive feed back, *circulus vitiosus*)
- **serious tissue hypoxia:** accumulation of metabolites \rightarrow metabolic acidosis + \uparrow permeability of capillaries \rightarrow vasodilation \rightarrow loss of fluid into the interstitial tissue \rightarrow \downarrow BP (positive feed back)