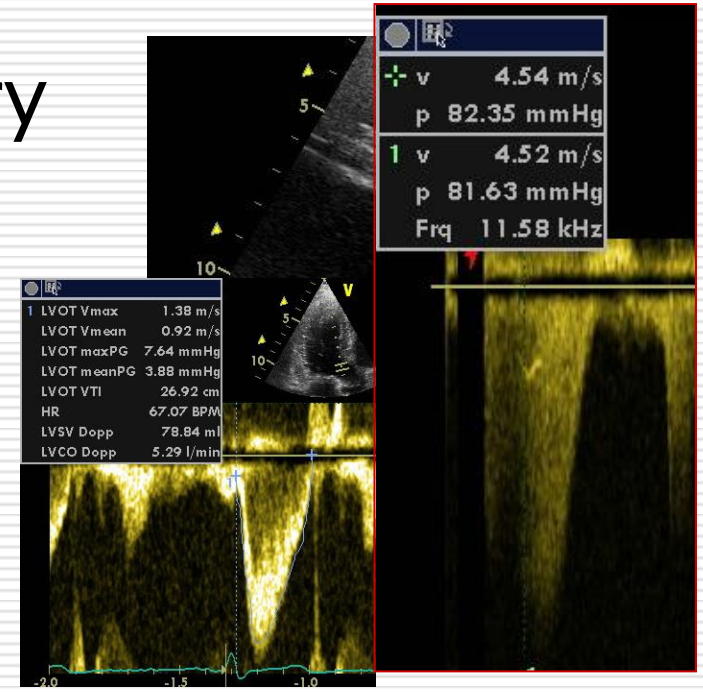
Echokardiografie a anémie

Dan Marek

- Interní odd. nemocnice Přerov, SMN a.s.
- I.interní klinika – kardiologická, FN a LFUP Olomouc

Co lze najít na ECHO u anémie

- Remodelaci levé komory
- vysoký srdeční výdej
- plicní hypertensi
- srdeční selhání



- případně další:
  - perikardiální výpotek (malignity, systémové ch., sepse …)
  - infiltrace myokardu a perikardu (lymfomy, infiltrativní ch.,…)
  - poškození chlopní (systémové choroby, endokarditida…)

Co lze najít na E u anémie

O čem bude přednáška:

o patofyziologii anémie

o hemodynamice

- remodelace levé komory
- vysoký srdeční výdej
- plicní hypertense
- srdeční selhání

Jak těžká anemie způsobí změny v hemodynamice?

- Autoři se v experimentech a pozorováních shodují, že pro rozpoznání hemodynamických změn jsou kritické hodnoty Hb kolem 60-70 g/l, s dalším poklesem již výrazná alterace oběhu
- Důležitá je také rychlost vzniku anemie (náhle = větší reakce oběhu)
- Roli hraje i typ anemie

Není anémie jako anémie

- otázka viskozity:

náhrada Ery LM dextranem: ↑ zv. CO o 93%

náhrada Ery HM dextranem: ↑ zv. CO o 43%

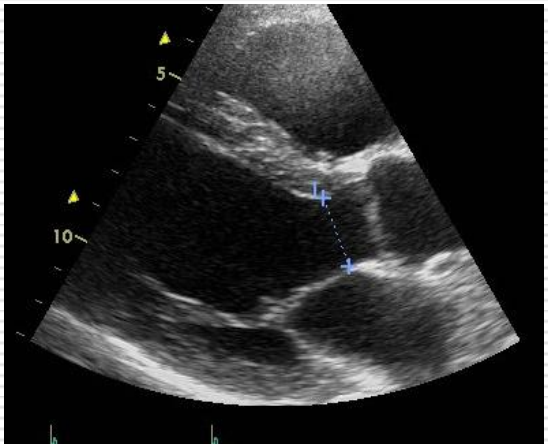
transfuse Ery + LM dex: ⟷ CO

transfuse Ery + HM dex : ↓ CO

Studie na zvířatech

Fowler, J - Appl Physiol 1975: **Blood viscosity and cardiac output in acute experimental anemia**

Remodelace levé komory



- Dilatace
- Hypertrofie
- EF zůstává zachována – proporcionální změna EDV i ESV, ale
- Ale jiné decentní známky systolické dysfunkce: strain
  - nižší GLS, GCS, GRS

Remodelace LK

- Anémie (čínská populace)
  - kontroly norma - A
  - nad 90 - B
  - 60-90g - C
- Trvání anémie min. 6M
- Symptomatičtí většinou i v klidu

Anatol J Cardiol. 2017 Sep; 18(3): 194–199.
Assessment of left ventricular systolic function in patients with iron deficiency anemia by three-dimensional speckle-tracking echocardiography
Qiao Zhou, Jiaqi Shen, Yue Liu, Runlan Luo, Bijun Tan, and Guangsen Li

Table 3

RT3D and 3DSTE parameters of the study population

Variables	Group A (n=40)	Group B (n=44)	Group C (n=39)
3DRT			
LVMI, g/m^2	72.5±8.2	73.8±7.9	77.4±6.8†§
LVEF, %	64.9±4.3	65.4±4.2	63.7±4.8
LVEDV, mL	94.9±31.7	97.2±29.4	115.0±27.4†§
LVESV, mL	35.7±12.3	36.9±10.1	40.2±9.9†§
3DSTE			
GLS, %	-21.4±2.7	-20.8±2.6	-18.3±1.8$^{\ddagger\|\|}$
GRS, %	53.4±11.0	53.1±10.6	50.0±9.1†§
GCS, %	-19.8±4.2	-19.6±4.6	-18.1±3.7†§
GAS, %	-34.2±4.3	-33.8±4.1	-31.1±2.9$^{\ddagger\|\|}$

(Mass)

EDV

ESV

GLS

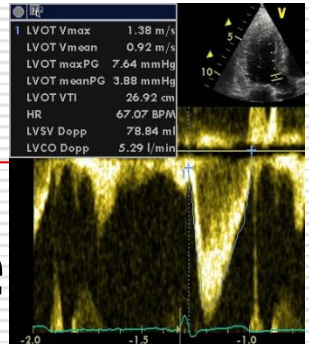
GRS

GCS

GAS

normální populace 60-90 pod 60 g Hb/l

Vysoký CO/CI



- Je přítomen u všech typů anemie
- Je nepravidelně distribuován
  - Zachována oxygenace mozku bez zvýšení průtoku
  - Zachována perfuse koronárními tepnami a oxygenace myokardu za cenu vyššího průtoku
  - Zvýšené prokrvení orgánů při vasodilataci
  - Snížené? Prokrvení ledvin

CI

CARDIAC OUTPUT IN PATIENTS WITH CHRONIC ANEMIA 335

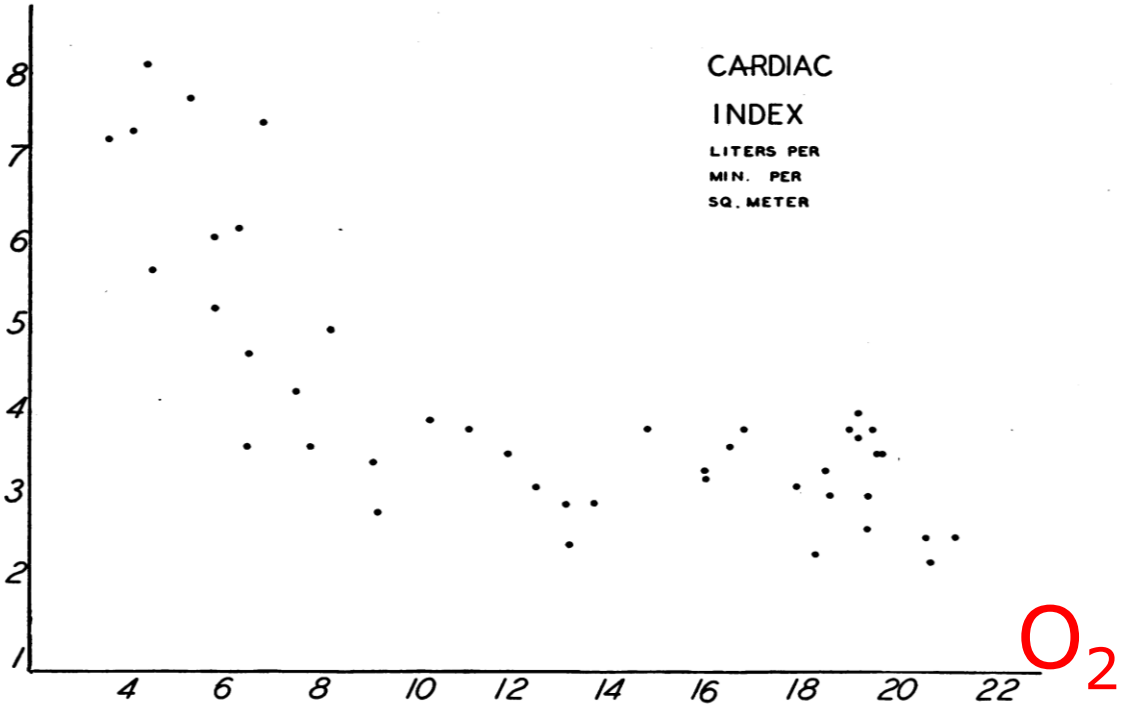
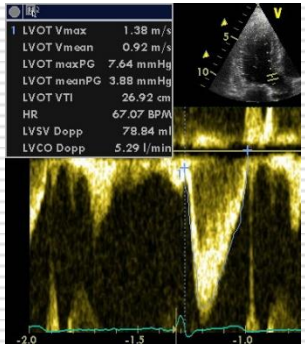


FIG. 1. RELATIONSHIP BETWEEN THE CARDIAC INDEX AND THE OXYGEN CONTENT OF THE ARTERIAL BLOOD



J Clin Invest. 1945 May;24(3):332-6.

THE CARDIAC OUTPUT IN PATIENTS WITH CHRONIC ANEMIA AS MEASURED BY THE TECHNIQUE OF RIGHT ATRIAL CATHETERIZATION.

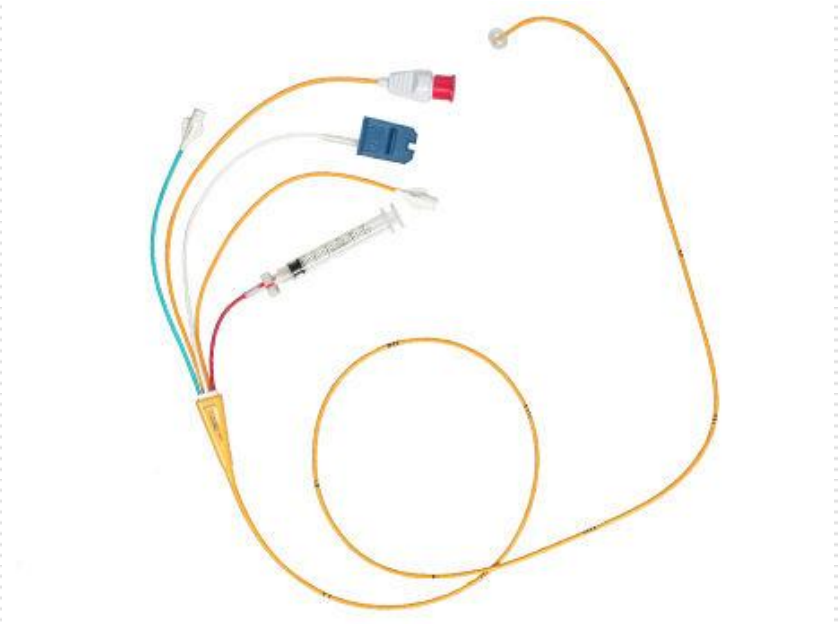
Brannon ES[1], Merrill AJ, Warren JV, Stead EA.

Vysoký CO

- Anemie (hypoxemie) způsobuje vasodilataci a pokles SVR
- Anemie způsobuje tachykardii, vyšší tepový objem a vyšší CO/CI
- Nezvyšuje se plnicí tlak komor
- zvýšení CO otevírá plicní arterioly a nezvyšuje se PAP, ale:
- hypoxie způsobuje vasokonstrikci v plicním arteriálním řečišti – zvýšení PVR

Srdeční selhání

- Může být způsobeno anémií per se
- Ale chronické SS může být také jednou z příčin i významné anémie



Aetiologies of heart failure (3)

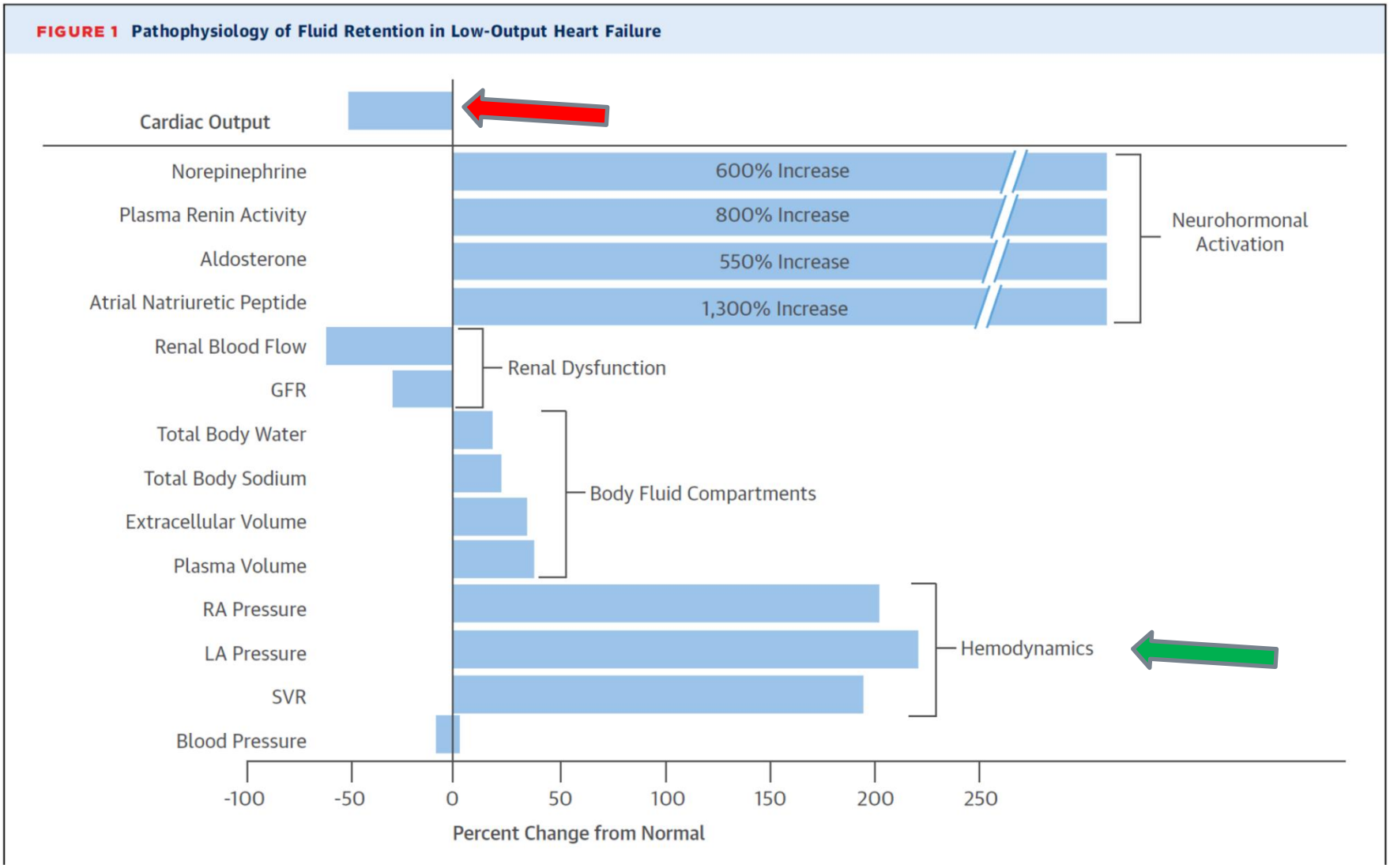
ABNORMAL LOADING CONDITIONS		
Hypertension		
Valve and myocardium structural defects	Acqu	Mitral, aortic, tricuspid ar lmonary valve diseases.
	genital	Atrial and ventricular um defects and others (for details see a respective ex document).
Pericardial and endomyocardi pathologies	Pericardial	Constrictive peric is. Pericardial effus
	Endomyocardial	HES, EMF, e rdial fibroelastosis.
High output states		Severe anaemia, sepsis, thyrotoxicosis, Paget's disease, arteriovenous fistula, pregnancy.
Volume overload		Renal failure, iatrogenic fluid overload.
ARRHYTHMIAS		
Tachyarrhythmias		Atrial, ventricular arrhythmias.
Bradyarrhythmias		Sinus node dysfunctions, conduction disorders.

European Heart Journal (2016) **37**, 2129-2200 - doi:10.1093/eurheartj/ehw 128

Aetiologies of heart failure (2)

DISEASED MYOCARDIUM *(cont'd)*		
Immune-mediated and inflammatory damage	Related to infection	Bacteria, spirochaetes, fungi, protozoa, parasites (Chagas disease), rickettsiae, viruses (HIV/AIDS).
	Not related to infection	Lymphocytic/giant cell myocarditis, autoimmune diseases (e.g. Graves' disease, rheumatoid arthritis, connective tissue disorders, mainly systemic lupus erythematosus), hyper-sensitivity and eosinophilic myocarditis (Churg–Strauss).
Infiltration	Related to malignancy	Direct infiltration and metastases.
	Not related to malignancy	Amyloidosis, sarcoidosis, haemochromatosis (rare), glycogen storage diseases (e.g. Pompe disease), lysosomal storage diseases (e.g. Fabry disease).
Metabolic derangements	Hormonal	Thyroid diseases, parathyroid diseases, acromegaly, growth hormone deficiency, hypercortisolaemia, Conn's disease, Addison disease, diabetes, metabolic syndrome, phaeochromocytoma, pathologies related to pregnancy and peripartum.
	Nutritional	Deficiencies in thiamine, L-carnitine, selenium, iron, phosphates, calcium, complex malnutrition (e.g. malignancy, AIDS, anorexia nervosa), obesity.
Genetic abnormalities	Diverse forms	HCM, DCM, LV non-compaction, ARVC, restrictive cardiomyopathy (for details see respective expert documents), muscular dystrophies and laminopathies.

European Heart Journal (2016) **37**, 2129-2200 - doi:10.1093/eurheartj/ehw 128



Anand IS, Ferrari R, Kalra GS, et al. Edema of cardiac origin. Studies of body water and sodium, renal function, hemodynamic indexes, and plasma hormones in untreated congestive cardiac failure. Circulation 1989;80:299–305.

Retence tekutin u anémie

Br Heart J 1993;70:357–362

Pathogenesis of oedema in chronic severe anaemia: studies of body water and sodium, renal function, haemodynamic variables, and plasma hormones

Inder S Anand, Y Chandrashekhar, Roberto Ferrari, Philip A Poole-Wilson, Peter C Harris

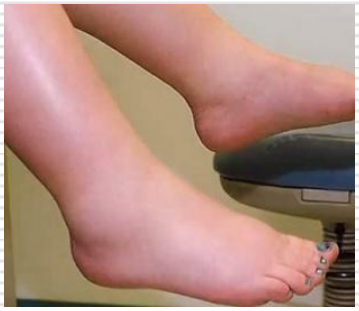
Abstract

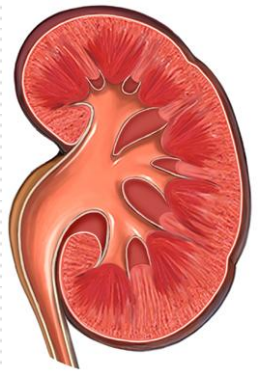
***Background*—Patients with chronic severe anaemia often retain salt and water. Fluid retention in these patients is not caused by heart failure and the exact mechanisms remain unclear. This study was designed to examine some of the possible mechanisms.**

***Methods and results*—Haemodynamic variables, body fluid compartments, renal function, and plasma hormones were measured in four patients with oedema caused by chronic severe anaemia (mean (SE) haematocrit 13 (1·7)) who had never received any treatment. Cardiac output was increased (6·1 (0·6) l/min/m²) and right atrial (7·8 (1) mm Hg), mean pulmonary arterial (20·5 (2·0) mm Hg), and mean pulmonary arterial wedge (13 (2·7) mm Hg) pressures were slightly increased. The mean hormonal activation and salt and water retention.**

(*Br Heart J* 1993;70:357–362)

Chronic severe anaemia is often associated with various degrees of salt and water retention.[1–3] When fluid retention is severe the condition is often referred to as "congestive heart failure".[2 3] Though the pathogenesis of salt and water retention in congestive heart failure caused by low output states has been well studied,[4 5] the mechanisms of fluid retention in patients with chronic severe anaemia remain unclear. Patients with anaemia and "congestive heart failure" have a high cardiac output which increases with exercise even more than in healthy subjects.[1 2] The intracardiac filling pressures of these patients are usually normal or only slightly raised[2 3 6 7] and myocardial contractility is normal or





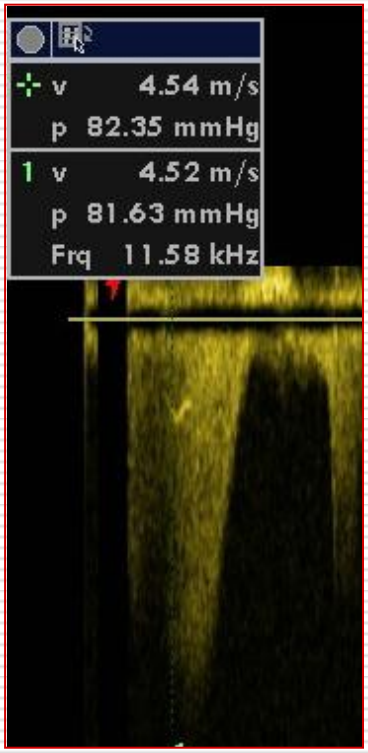
CI	↑	+150%
mPAP	↓	
SVR	↓	- 50%
mBP	↓	
Tělesná voda	↑	+15%
Plasma volum	↑	+70%
Renální průtok	↓	-20%
Noradrenalin	↑	+100%
Renin	↑	+1500%
Aldosteron	↑	
ANP	↑	+1200%

Hypoxická plicní vasokonstrikce

- O_2 senzitivní voltážově dependentní K^+ kanál
- hypoxie … inhibice K^+ kanálu … depolarizace membrány … influx Ca^{++}
- … vasokonstrikce bb hladkého svalstva medie arteriol

Na jaký O_2 vlastně arterioly reagují?

- alveolární nízké pO_2 – 80% podíl na vasokonstrikci – CHOPN!
- <u>hypoxemie žilní krve – 20%</u>

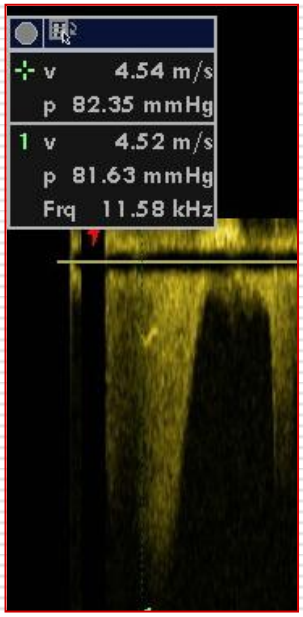


Rovnováha relaxace plicní cévy

- L-arginin je substrátem pro NO syntézu v endotelových bb
- … difuse NO z EB do hladké svaloviny cévy
- … aktivace cGMP
- … relaxace hladké svaloviny

HPV -

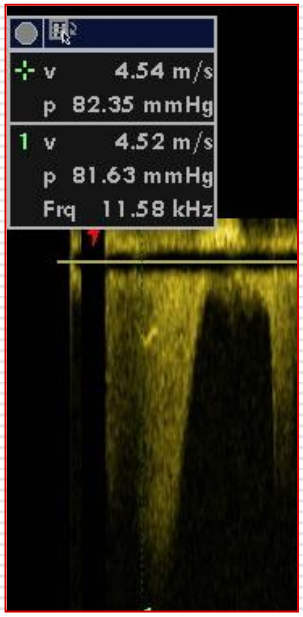
- O2
- substance P
- ANP
- PGI_2
- NO
- alkalóza



- zv. LAP
- zv. alveolární tlak

HPV +

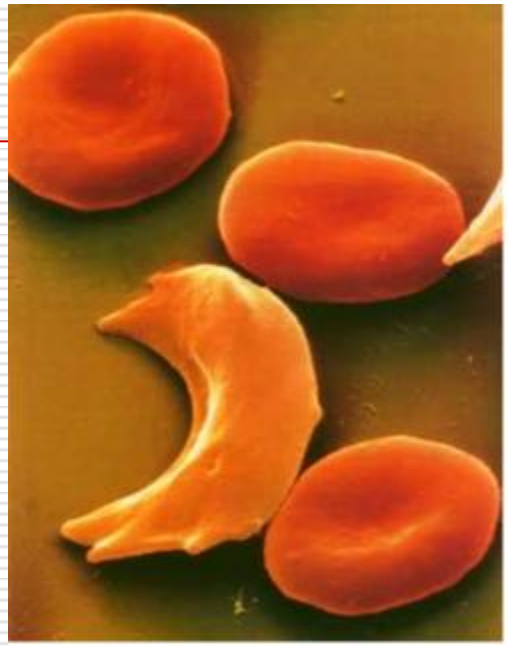
- hypoxie
- acidóza
- inhibice cyklooxygenázy
- inhibice syntézy NO



Remodelace P vaskulatury

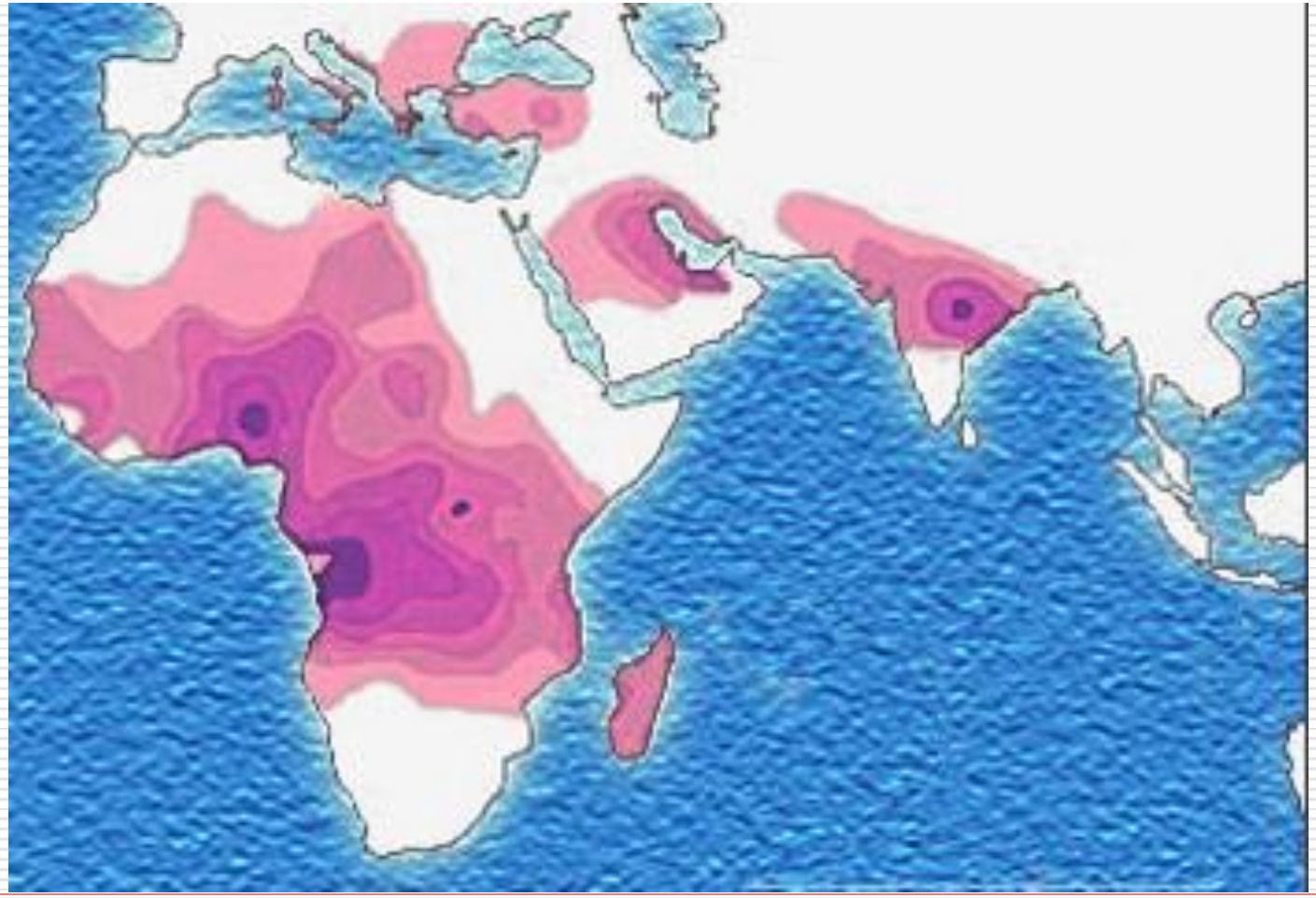
- proliferace a diferenciace pericytů a intermediárních buněk do bb. hladkého svalstva cév ...
- snížená odpověď na relaxační podněty

Plicní hypertense u HA



- Hemolytické anemie
  - srpkovitá anemie
  - thalassemie
  - dědičná sférocytosa
  - stomatocytosa
  - mikroangiopatická hemolytická anemie
  - AIHA

Srpkovitá anémie



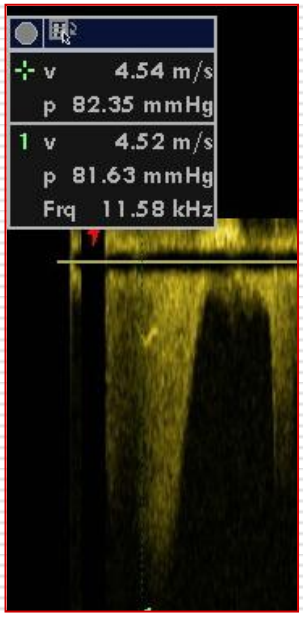
Srpkovitá anemie

- anemie + PH + zv. CVP
- renální insuficience
- pulmonální fibrosa (opakované epizody akutní vaso-oklusivní krize)
- diastolická dysfunkce (Fe, anemie)
- sukcesivní tromboembolizace

Arytmie, náhlá smrt, akutní RHF

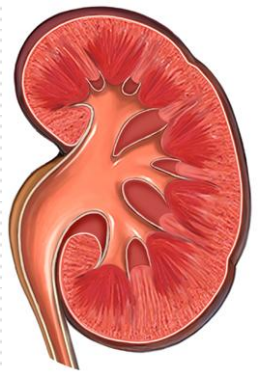
PH asociovaná s hemolýzou

- hemolýza:
  - NO požírán volným Hb … vasodilatační cGMP není aktivován
  - Sickle CD: zvýšená aktivita arginázy...snížení L-argininu (substrát pro syntézu NO)
  - endoteliální dysfunkce … Zvýšení PVR



Hemodynamika u renálního S

- ESRD - dialýza
  - vysoký CO (AV shunt, anemie)
  - zv. plicní cévní resistence (hormony)
  - hypervolemie



Yigla M, Nakhoul F, Sabag A, et al. Pulmonary hypertension in patients with end-stage renal disease. Chest 2003;123:1577–82

Dialyzovaní pacienti

- pozitivní korelace mezi objemem krve a tlakem
- negativní korelace mezi HTK a objemem
- negativní korelace mezi hematokritem a tlakem

The relationship between anemia and blood pressure in chronic hemodialysis patients--studies of hemodynamics
Shitomi, Jap J Nephrol 1988, 30

Renální selhání bez srdečního S

Hemodynamics of Uremic Anemia

By MARTIN S. NEFF, M.D., KWAN E. KIM, M.D., MICHAEL PERSOFF, M.D., GADDO ONESTI, M.D., AND CHARLES SWARTZ, M.D.

SUMMARY

This study was undertaken to assess the importance of an elevated cardiac output in the generation of the hypertension associated with chronic renal failure. Forty stable uremic patients on a program of maintenance hemodialysis underwent hemodynamic studies. Cardiac index measured by dye dilution was found to be significantly elevated. Calculated peripheral vascular resistance was normal despite elevated blood pressure. Six patients underwent serial hemodynamic studies over a period of 6 to 12 weeks while being transfused with packed red blood cells to a normal hematocrit. Blood volume and body weight were constant during the study period. Cardiac index decreased during transfusion, reaching a normal level at a hematocrit of 30%. Diastolic blood pressure progressively rose, averaging an increase of 20 mm Hg at a hematocrit of 40%. Peripheral vascular resistance increased by 80% at a hematocrit of 40%.

We concluded that the elevation of cardiac index in uremic patients is secondary to anemia and is reversible when the hematocrit is raised over 30%. The high cardiac index is not responsible for hypertension because restoration of cardiac index to normal by transfusion raises blood pressure rather than lowers it.

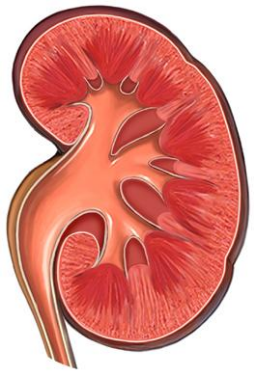
Additional Indexing Words:

Cardiac output Anemia Uremia Hemodialysis Kidney
Hypertension Hemodynamics

RENAL failure is frequently associated with an increased cardiac output and systemic hypertension.[1–6] The increased cardi- both contribute to the elevated cardiac outputs.

A high cardiac output may be important in

- Zv. CO/CI
- N/sn. SVR
- Zv. STK/DTK



Efekt transfúze/HTK na SVR

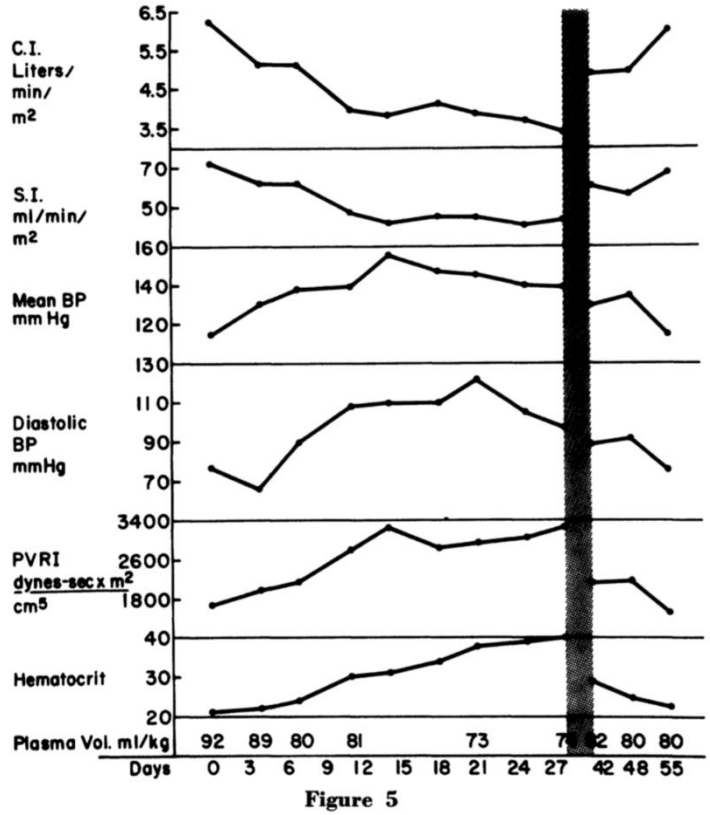


Figure 5

Serial evaluation of cardiac index, stroke index, mean blood pressure, diastolic blood pressure, peripheral vascular resistance index, and plasma volume, while the hematocrit was raised by transfusion of packed red cells. Patient V.F.

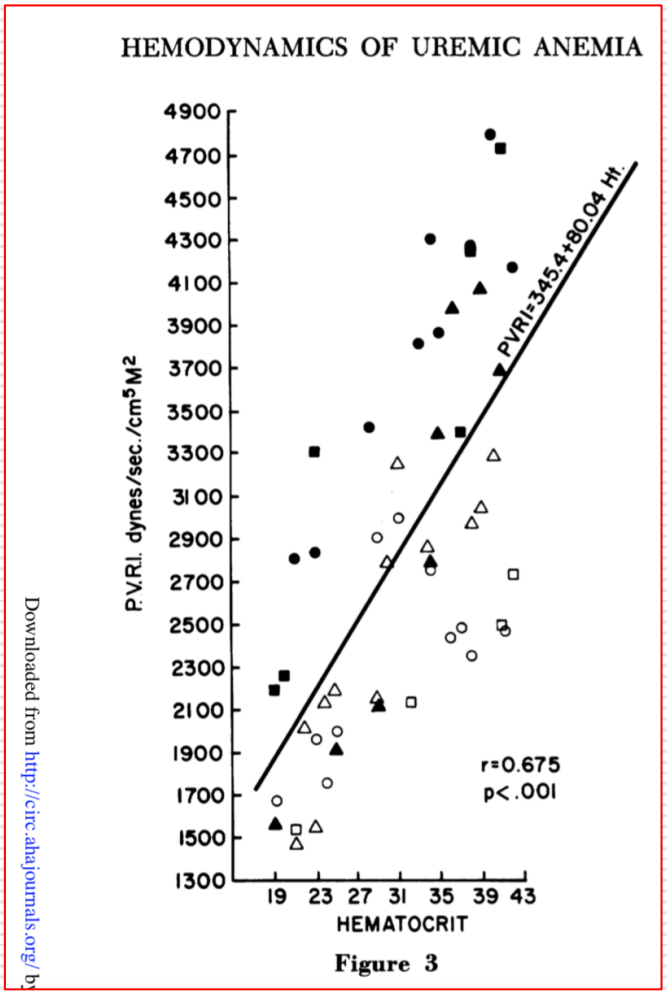


Figure 3

Renální selhání + srdeční S

Circ J 2017; **81:** 1670–1677
doi:10.1253/circj.CJ-17-0171

ORIGINAL ARTICLE
Heart Failure

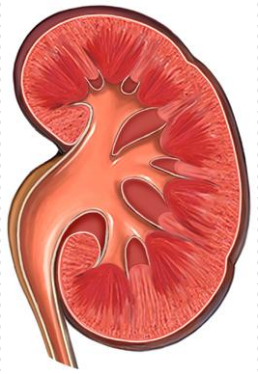
Effect of Anemia on Cardiovascular Hemodynamics, Therapeutic Strategy and Clinical Outcomes in Patients With Heart Failure and Hemodynamic Congestion

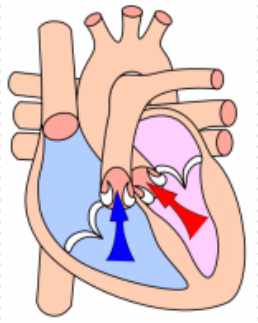
Muneyoshi Tanimura, MD; Kaoru Dohi, MD, PhD; Naoki Fujimoto, MD, PhD; Keishi Moriwaki, MD; Taku Omori, MD; Yuichi Sato, MD, PhD; Emiyo Sugiura, MD, PhD; Naoto Kumagai, MD, PhD; Shiro Nakamori, MD, PhD; Tairo Kurita, MD, PhD; Eitaro Fujii, MD, PhD; Norikazu Yamada, MD, PhD; Masaaki Ito, MD, PhD

Background: We investigated the effect of anemia on cardiovascular hemodynamics, therapeutic strategies and clinical outcomes in heart failure (HF) patients.

Methods and Results: We divided 198 consecutive HF patients who underwent right heart catheterization before in-hospital HF treatment into 2 groups according to the presence or absence of hemodynamic congestion (HC: mean pulmonary capillary wedge pressure ≥15 mmHg and/or mean right atrial pressure ≥10 mmHg). The hemoglobin level correlated with the cardiac index (CI) and systemic vascular resistance index (SVRI) ($r=-0.34$ and 0.42, $P<0.05$, respectively), and was the strongest contributor of SVRI only in the HC group. Anemic patients more frequently required intravenous inotropic support despite having higher CI and lower SVRI than non-anemic patients in the HC group. The novel hemodynamic subsets based on mean right atrial pressure and estimated left ventricular stroke work index but not Forrester subsets appropriately predicted the need for intravenous inotropic support. The probability of hospitalization for worsening HF during 2-year follow-up period was significantly higher in anemic patients than in non-anemic patients in the HC group.

Conclusions: Anemia had a direct effect on cardiovascular hemodynamics and thus can confound therapeutic planning in HF patients with HC. The novel hemodynamic subsets can be applied in daily clinical practice regardless of the presence or absence of

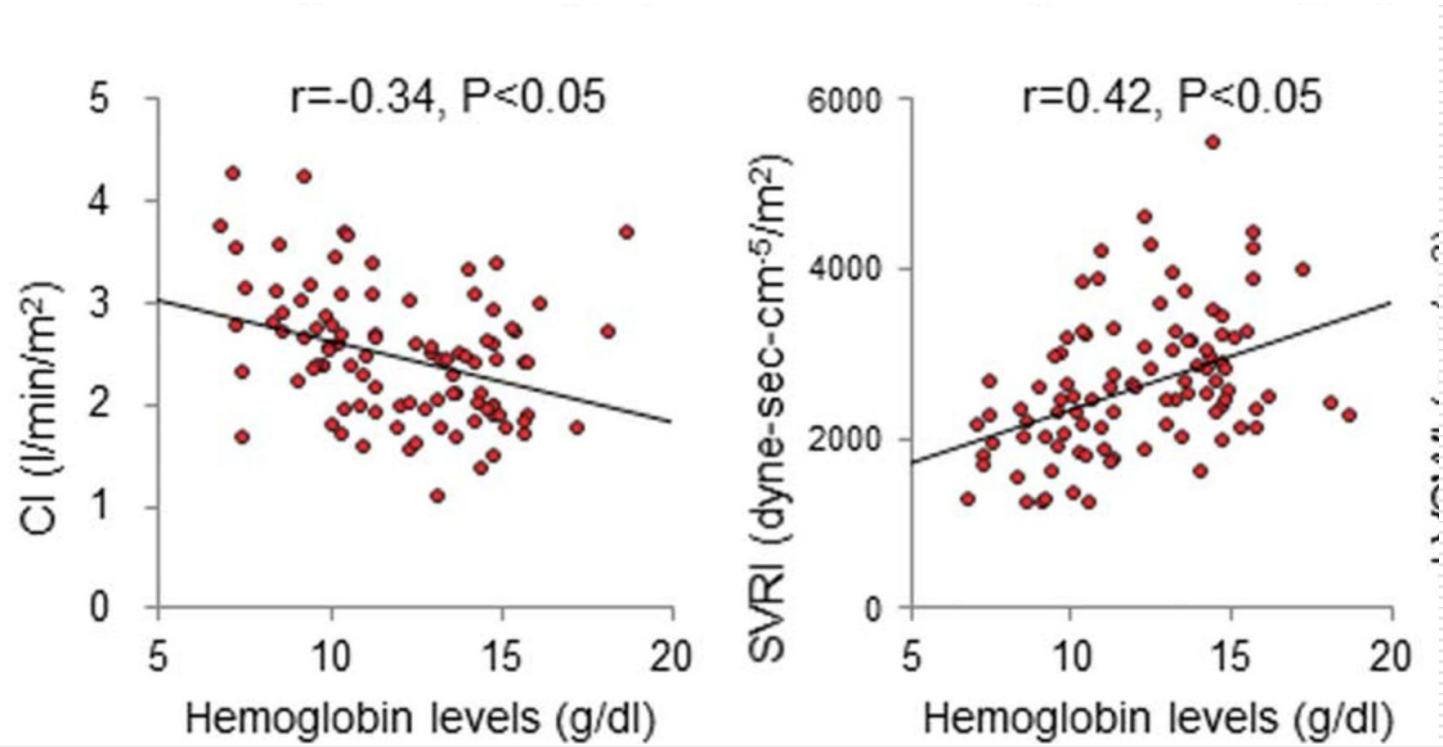




- 198 pravostranných katetrizací
- Anemie +-, SS +- (elevace R nebo L plnicích tlaků)

- U pac. se SS byly vyšší plnicí tlaky, ale bez ohledu na to, zda byla A nebo nikoliv
- SVR byla nižší a CO/CI vyšší u A

Vztah Hb / CI a SVR



Hb byla jediná proměnná v multivariantní regresní analýze která predikovala SVR (u všech i u subsetu SS)

Anémie a gravidita

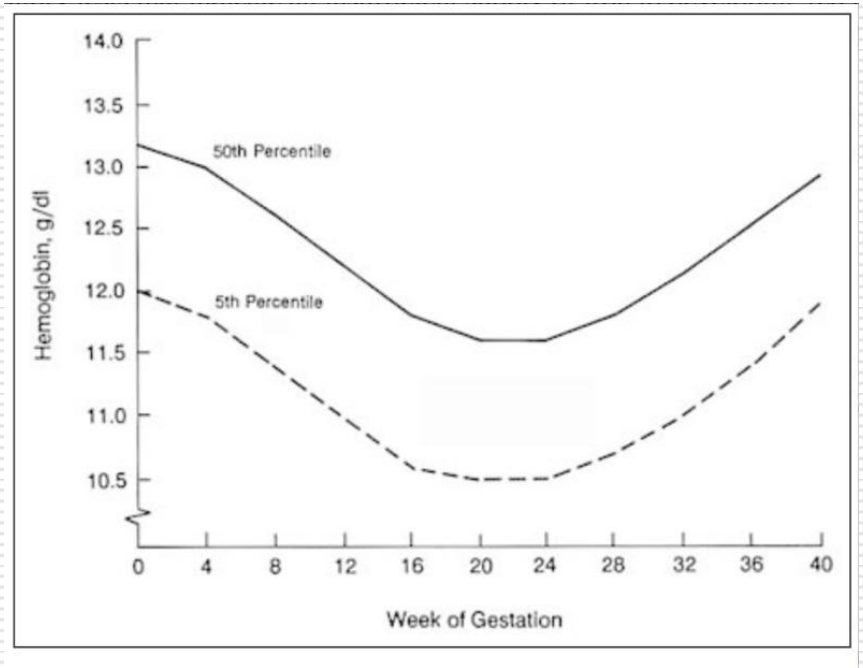


Figure 14-1

Normal hemoglobin values during pregnancy. Values from 12 to 40 weeks of gestation are based on data from Svanberg et al. (1976a), Sjöstedt et al. (1977), Puolakka et al. (1980b), and Taylor et al. (1982). The baseline values (zero weeks) are (more...)

- Fyziol. anemie v graviditě

from: Nutrition During Pregnancy. Washington (DC): National Academies Press (US); 1990.ISBN-10: 0-309-04138-4
Svanberg 1976

Příčiny patologické anemie v GR

- Nutritional – iron, folate and vitamin B12 deficiencies - 90%
- Acute or chronic blood loss (gastrointestinal bleeding/heavy periods)
- Infections – malaria, HIV
- Chronic diseases – renal, neoplasia
- Parasites
- Hemolytic anemias – drugs, congenital
- Hemoglobinopathies – sickle cell, thalassemia

Specifika těhotenství

Table 1

Summary of cardiovascular changes during pregnancy.

Variable	Change
Cardiac output	Increased by 30–50%
Stroke volume	Increases to a maximum of 85 mL at 20 weeks of gestation
Heart rate	Increased (approaches 90–100 beats/minute at rest during the third trimester)
Systemic vascular resistances	Decrease 21% (nadir at 20–24 weeks)
Pulmonary vascular resistances	Decrease by 34%
Pulmonary capillary wedge pressure	No significant change
Colloid osmotic pressure	Decreased by 14%
Hemoglobin concentration	Decreased

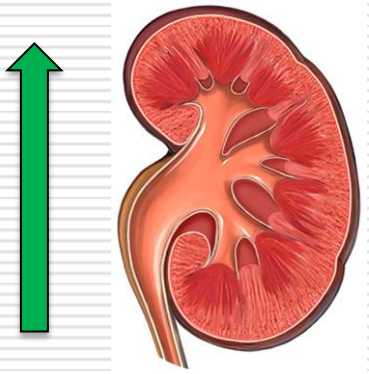
SVR ↓

PVR ! ↓

Costantine HM, Front Pharmacol. 2014; 5: 65.
Published online 2014 Apr
3. doi: 10.3389/fphar.2014.00065

Specifika těhotenství

- na rozdíl od jiných anemií:
  - klesá i PVR
  - narůstá průtok ledvinami



- jinak jsou hemodynamické změny podobné…

Závěry I:

- Anémie pod 60-70 gHb/l způsobuje významné hemodynamické změny
  - Pokles SVR, remodelace LK, zvýšení SV, CO/CI
  - Vzestup PVR, plicní hypertense
- Tyto změny jsou velmi rychle reversibilní při korekci anemie

Závěry II

- Její vyjádřený klinický obraz se může překrývat se srdečním selháním
  - Může k SS vést
  - Může být SS potencována
- Laboratorně můžeme najít podobnou aktivaci neurohumorálních systémů vedoucích k retenci soli a vody

Závěry III

- Echo
  - Dilatace komor, stejná EF, vyšší SV, CI
  - Odliší HCO a LCO
  - Může odhadnout plnicí tlaky
  - Hypertrofie?
  - Plicní hypertense při zv PVR (ne u Gr)
  - Zjistí jinou patologii, která mohla vést k anemii

Echo není specifické, vždy je třeba přemýšlet a vidět klinické souvislosti

Děkuji za pozornost