# The right heart:
# the Cinderella of heart failure

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# Disclosure

**none**

# Look into the Heart Failure ESC guidelines

European Heart Journal (2012) **33**, 1787–1847
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ESC GUIDELINES

## ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012

**The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC**

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# Right heart (RV) in the HF ESC Guidelines

1. RV & LV interaction – cause of limited cardiac reserve
2. RVF – other cause of elevated BNP / NT-proBNP (diagnosis)
3. Echocardiography – information about RV function / RA pressure
4. AVRC – imaging techniques
5. RV failure as a potential cause of renal dysfunction
6. RV infarction – cause of acute deterioration / AHF
7. Adult congenital heart disease
8. MCS – need for RV function assessment; deteriorating RV function as an indication for VAD implantation
9. Isolated RV failure

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# Right heart (RV) in the HF ESC Guidelines

### 12.7.2 Isolated right ventricular failure

New-onset isolated right ventricular failure may occur secondarily to an acute coronary syndrome (and is managed as described above) and following massive pulmonary embolism (see pulmonary embolism guidelines[239]). In both situations, diuretics and vasodilators should be used cautiously or avoided so as not to reduce right ventricular filling.

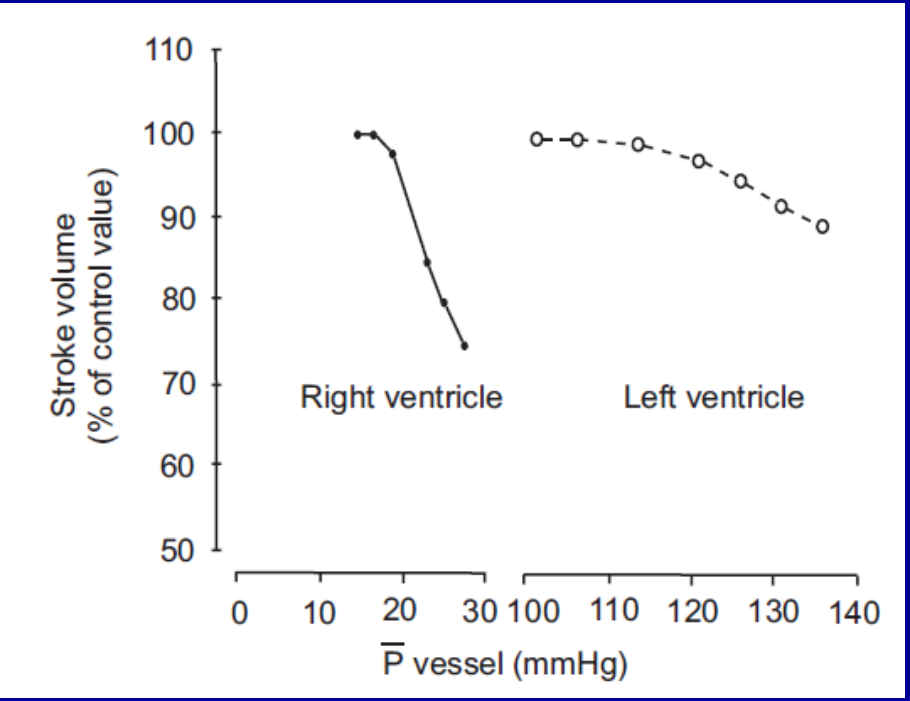
Progressive isolated right ventricular failure may occur in patients with pulmonary hypertension. Type V phosphodiesterase inhibitors, endothelin antagonists, and prostacyclin analogues may help by decreasing pulmonary arterial resistance (see guidelines[240]).

**9. Isolated RV failure**

# The normal right ventricle

| Characteristic | RV | LV |
|---|---|---|
| End Diastolic Volume (ml) | 75±13 (49-101) | 66±12 (44-89) |
| Mass ($g/m^2$) | 26±5 (17-34) | 87±12 (64-109) |
| Wall thickness (mm) | 2 – 5 | 7 – 11 |
| Ejection Fraction (%) | 61±7 (47-76) Nl: >40-45 | 67±5 (57-78) Nl>50 |
| Ventricular pressure (mmHg) | 25/4 [(15-30)/(1-7)] | 130/8 [(90-140)/(5-12)] |
| Vascular Resistance ($dyne \cdot s \cdot cm^{-5}$) | 70 (20-130) | 1100 (700-1600) |

**Comparison of normal LV and RV structure and function**




**The response of the RV and LV to experimental increase in afterload**

Haddad F et al. *Circulation* 2008;117:1436-48.

# RV: “the take home message”

the main aim of the RV is to

**keep RVEDP or RAP**

**as low as possible**

to optimize the venous return

to provide sustained low-pressure perfusion through the lungs

# Right ventricle

- generates **flow**
- pulmonary vessels:
  - low resistances, transpulmonary gradient = 5mmHg
  - great distensibility
  - no changes in compliance throughout the lungs
  - no reflection

## Special Report

# Right Ventricular Function and Failure

## Report of a National Heart, Lung, and Blood Institute Working Group on Cellular and Molecular Mechanisms of Right Heart Failure

Norbert F. Voelkel, MD; Robert A. Quaife, MD; Leslie A. Leinwand, PhD; Robyn J. Barst, MD; Michael D. McGoon, MD; Daniel R. Meldrum, MD; Jocelyn Dupuis, MD, PhD; Carlin S. Long, MD; Lewis J. Rubin, MD; Frank W. Smart, MD; Yuichiro J. Suzuki, PhD; Mark Gladwin, MD; Elizabeth M. Denholm, PhD; Dorothy B. Gail, PhD

***Circulation 2006;114:1883-91***

## Contemporary Reviews in Cardiovascular Medicine

# Right Ventricular Function in Cardiovascular Disease, Part II

## Pathophysiology, Clinical Importance, and Management of Right Ventricular Failure

François Haddad, MD; Ramona Doyle, MD; Daniel J. Murphy, MD; Sharon A. Hunt, MD

***Circulation* 2008;117:1436-48.**

# Right ventricular failure

RV failure is a complex clinical syndrome that can result from any structural or functional cardiovascular disorder that impairs the ability of the RV to fill or to eject blood.

The cardinal clinical manifestations of RV failure are:

(1) fluid retention, which may lead to peripheral edema, ascites, and anasarca;

(2) decreased systolic reserve or low cardiac output, which may lead to exercise intolerance and fatigue;

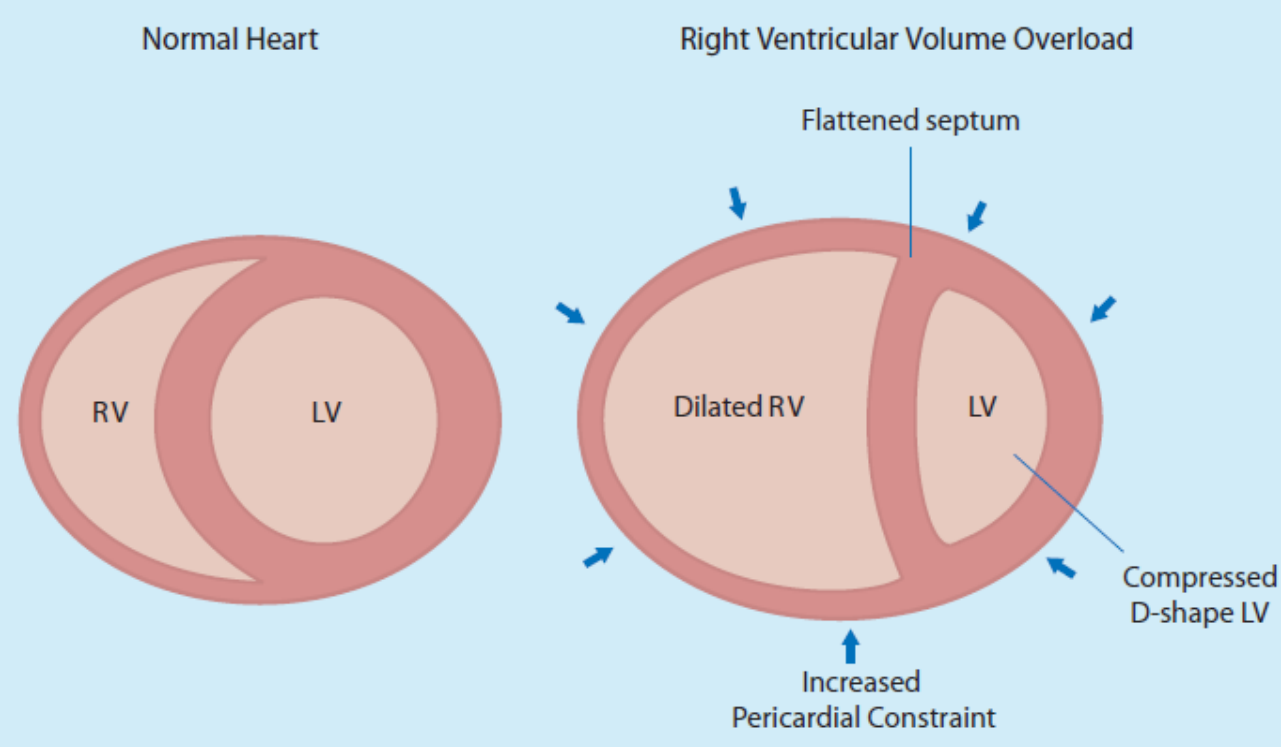
(3) atrial or ventricular arrhythmias

**Haddad F et al. *Circulation* 2008;117:1436-48.**

# RV and LV are interlinked:

- by a shared wall (the septum)
- by mutually encircling epicardial fibers
- by attachment of the RV free wall to the anterior and posterior septum
- by sharing the pericardial space

*Voelkel NF et al. Circulation 2006;114:1883-91*




**Haddad F et al. *Circulation* 2008;117:1436-48.**

# Right ventricular failure

## Mechanisms & Specific Causes

1. **Pressure overload**
   - left-sided HF (most common cause)
   - other causes of pulmonary hypertension
   - …
2. Volume overload
3. Ischaemia and infarction
4. **Intrinsic myocardial process**
   - cardiomyopathy and heart failure
5. Inflow limitation
6. Complex congenital defects
7. Pericardial disease

Haddad F et al. *Circulation* 2008;117:1436-48.

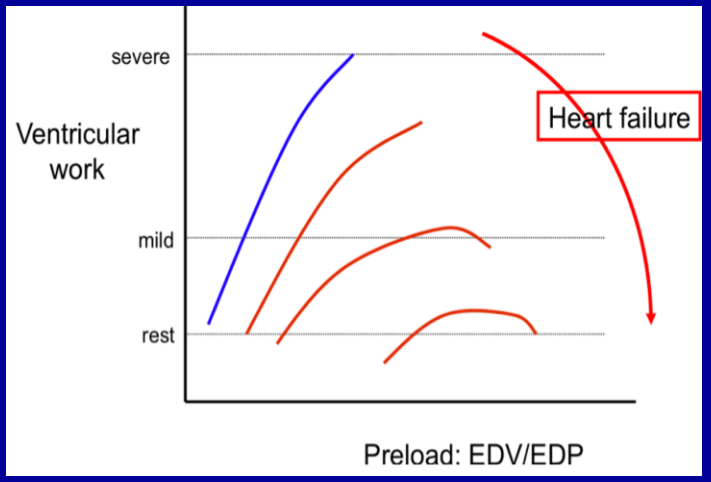
# STARLINGS LAW

- **RV is subject to the same haemodynamic mechanisms as the left: as the right heart fails, so a higher filling pressure is required to maintain right heart output. In health, the CVP is around zero.**

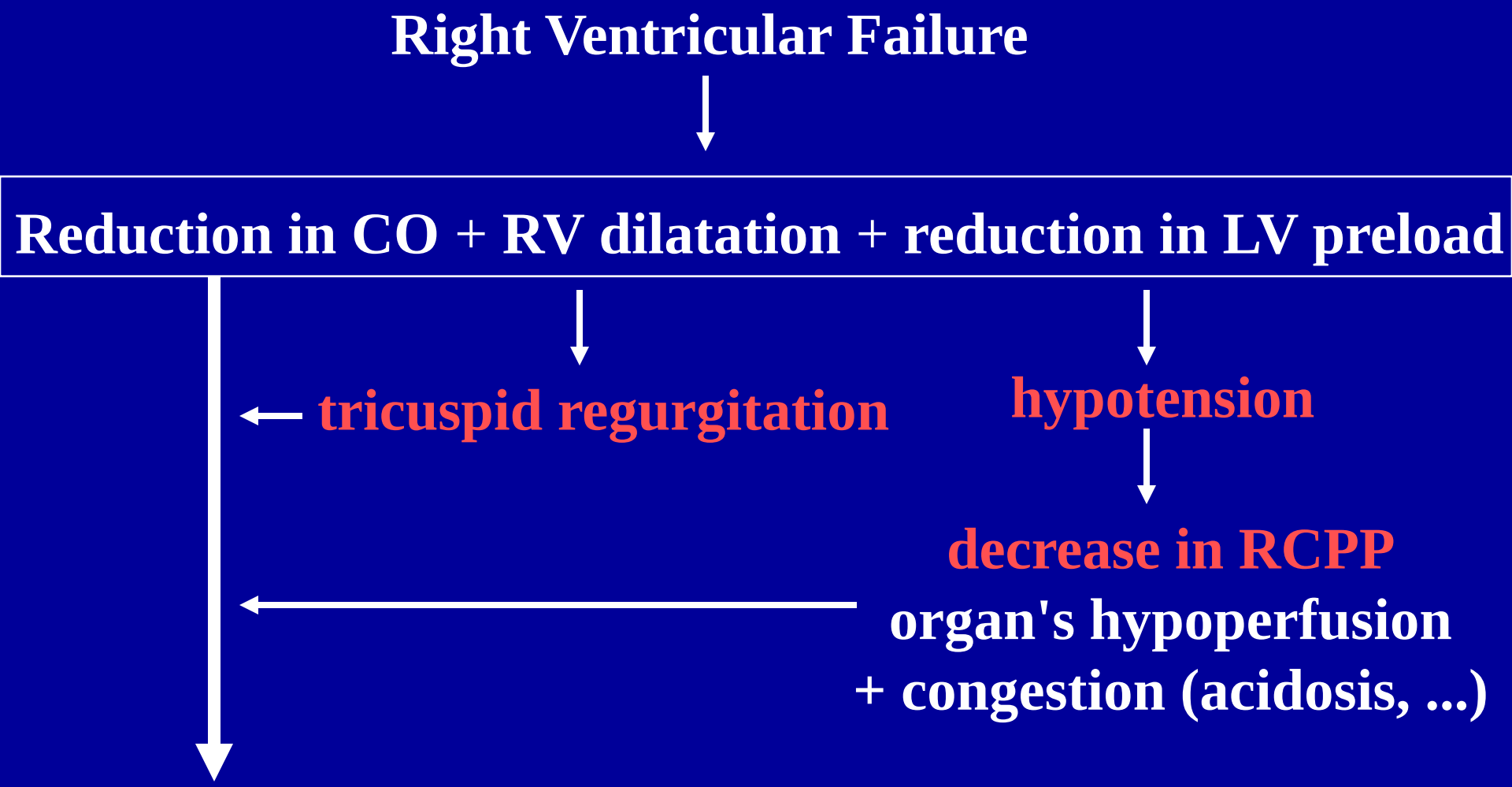
- **RV -very sensitive to changes in afterload, more compliant than the LV.**

  **accomodates volume overload well, with only small increases in systemic venous pressure**

  **tolerates pressure overload poorly (hence R heart failure in L heart failure or pulmonary vascular pathology)**

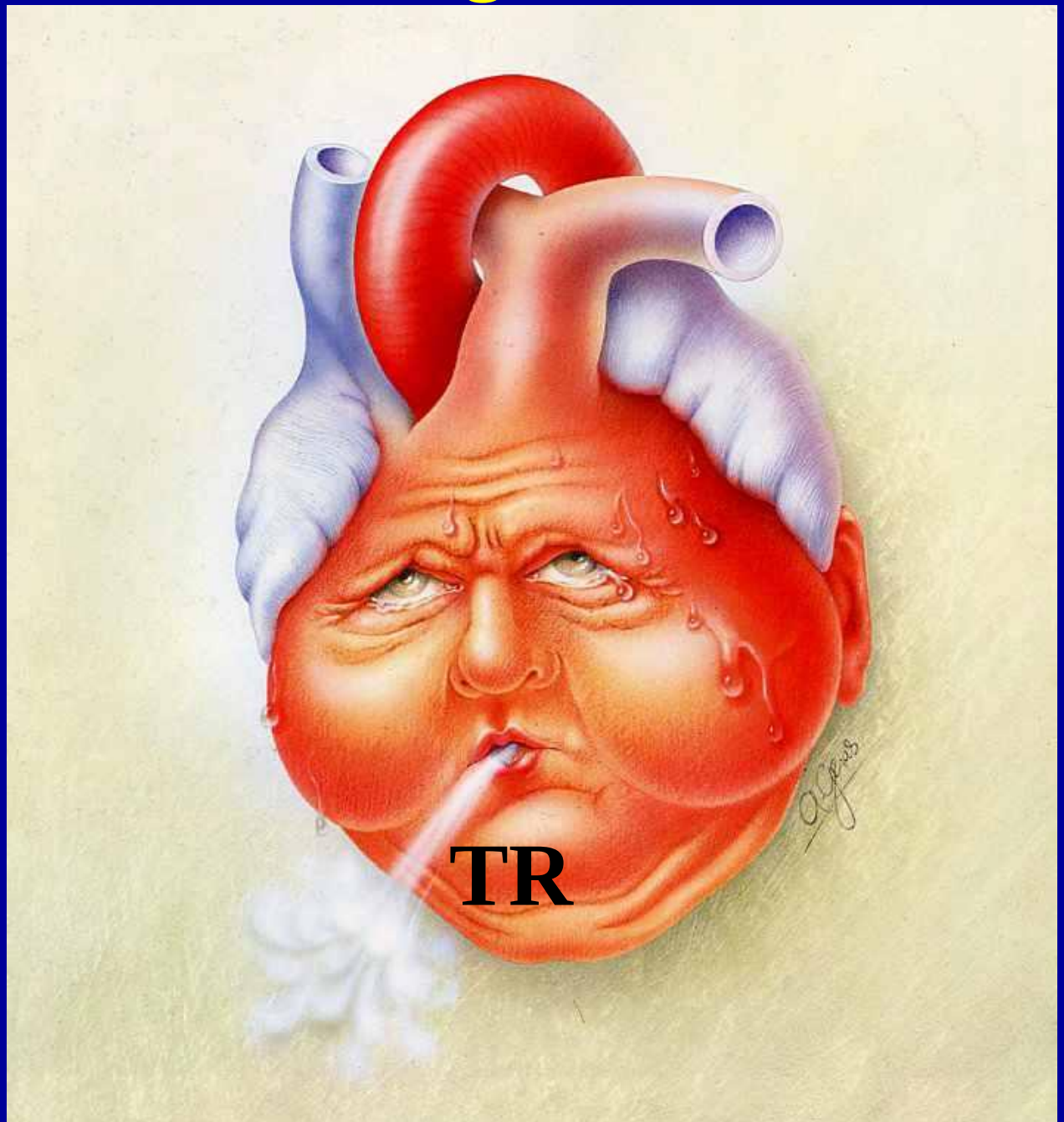


# Auto-aggravation of CO decrease in ARVF



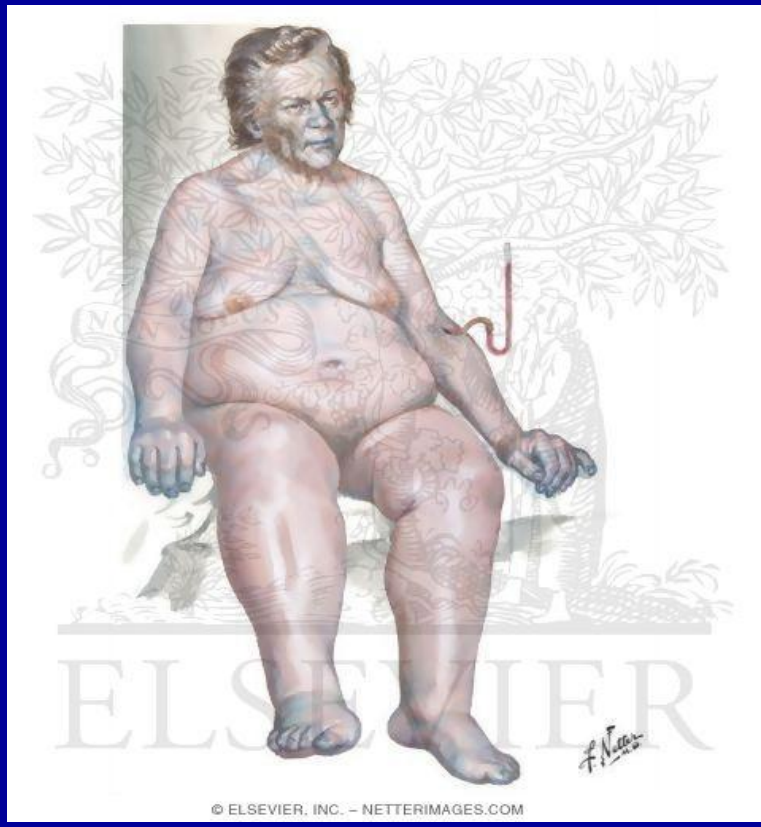

*Mebazaa et al. Intensive Care Med, 2004;30:185-96*

# Dilated Right Ventricle !



# The Syndrome of "Right Heart Failure"

- Characterised by Peripheral Oedema
  - Ankle, sacral oedema
  - Ascites
- Anasarca-ανασαρα
- Genuine Fluid overload
  - At least 5 litres for ankle oedema
  - Often , 20 litres or more
- Gradual
  - Key stage, neurohormonal response to poor renal perfusion
  - Increase venous hydrostatic pressure
  - Starling forces
  - Fluid loss from vessels into tissues

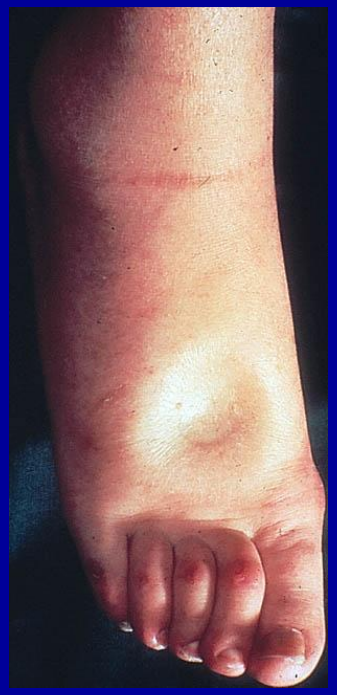


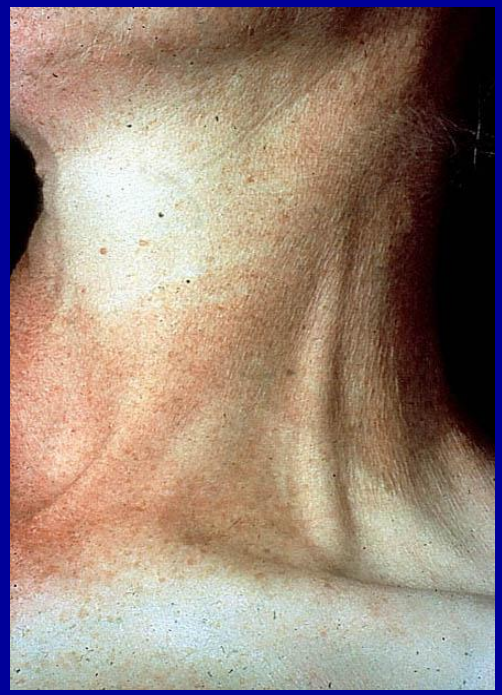
# The Syndrome of "Right Heart Failure"

## Clinical signs

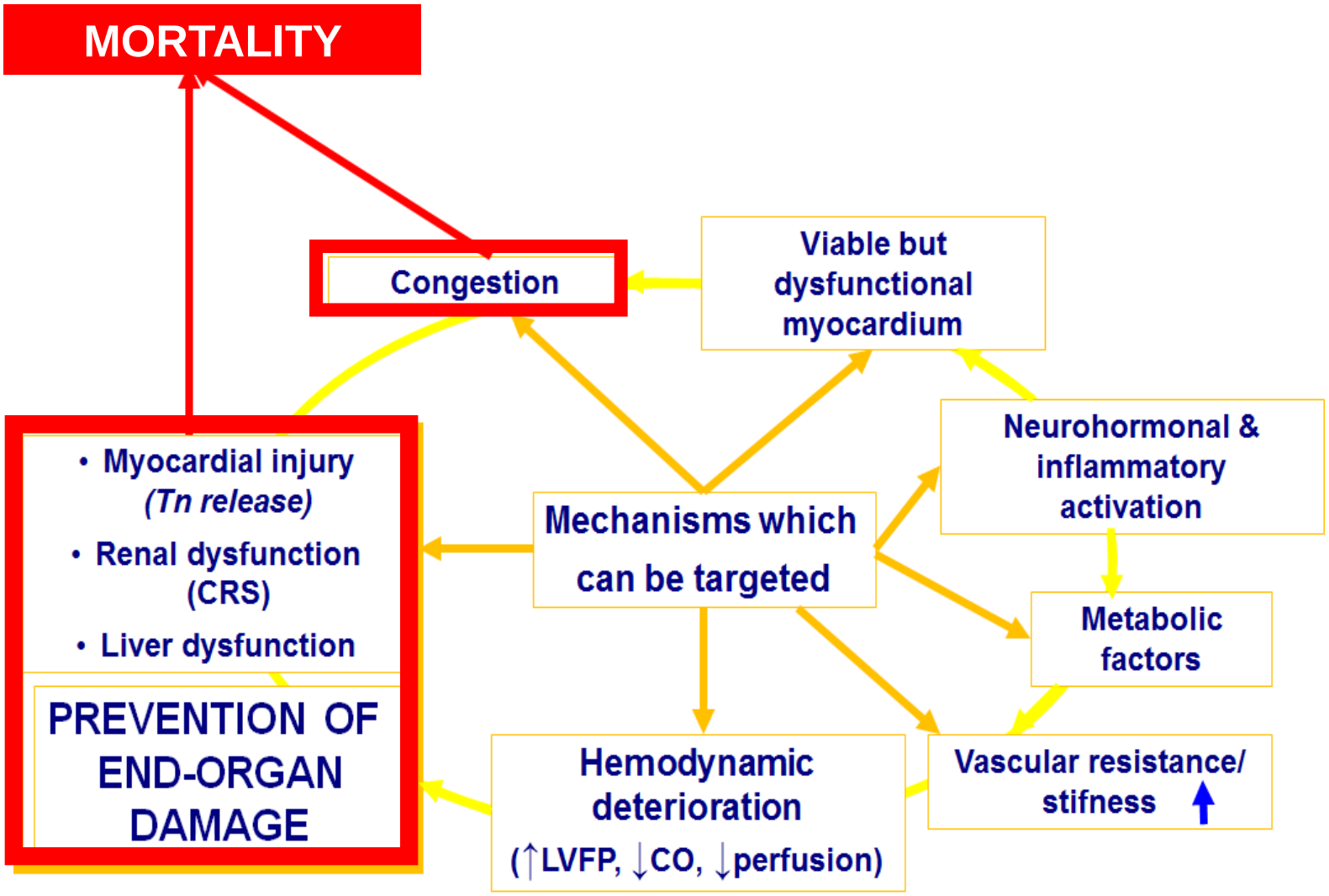
- Ankle oedema
  - Legs
  - Abdominal wall
- Pleural effusions
- Ascites
- Pericardial effusions
- Sinus tachycardia or AF,
- low SBP, ↑JVP,TR, cardiomegaly, S3

  - **Clear lungs or some pulmonary oedema**

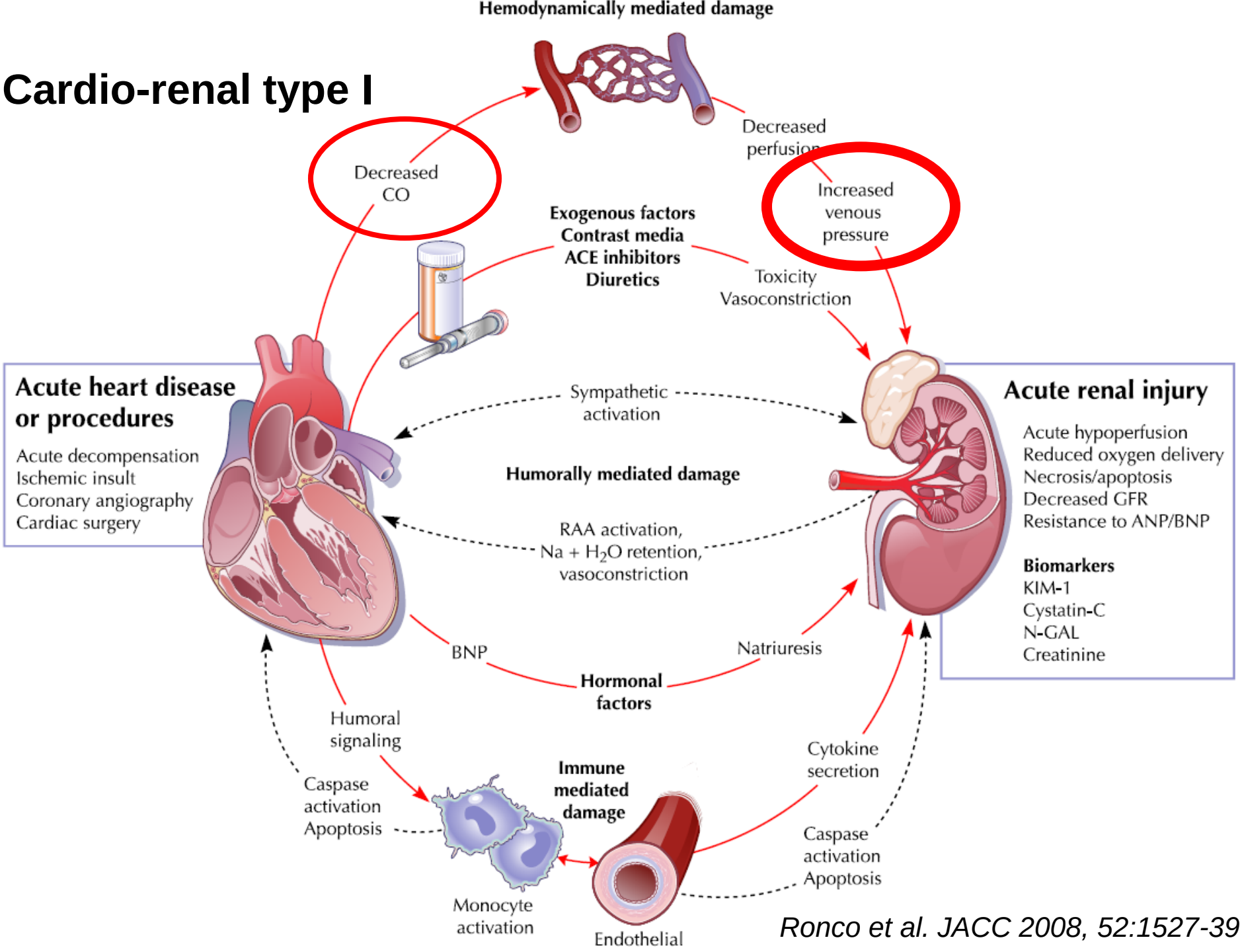




# Better understanding of Acute Heart Failure pathophysiology



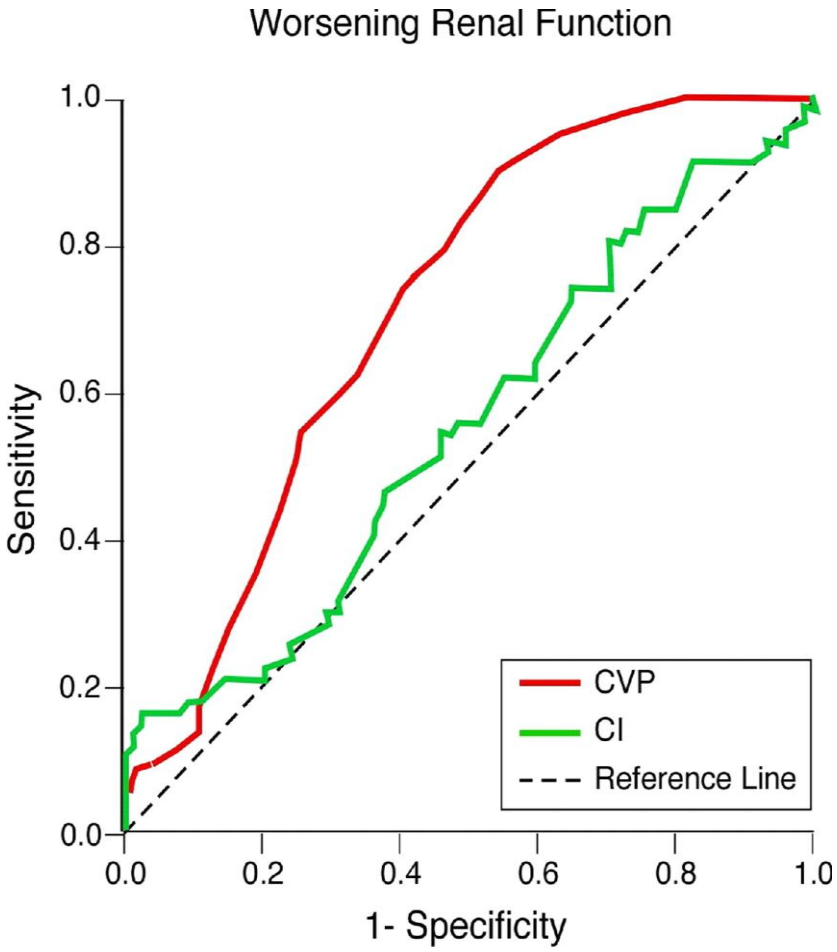
# Cardio-renal type I



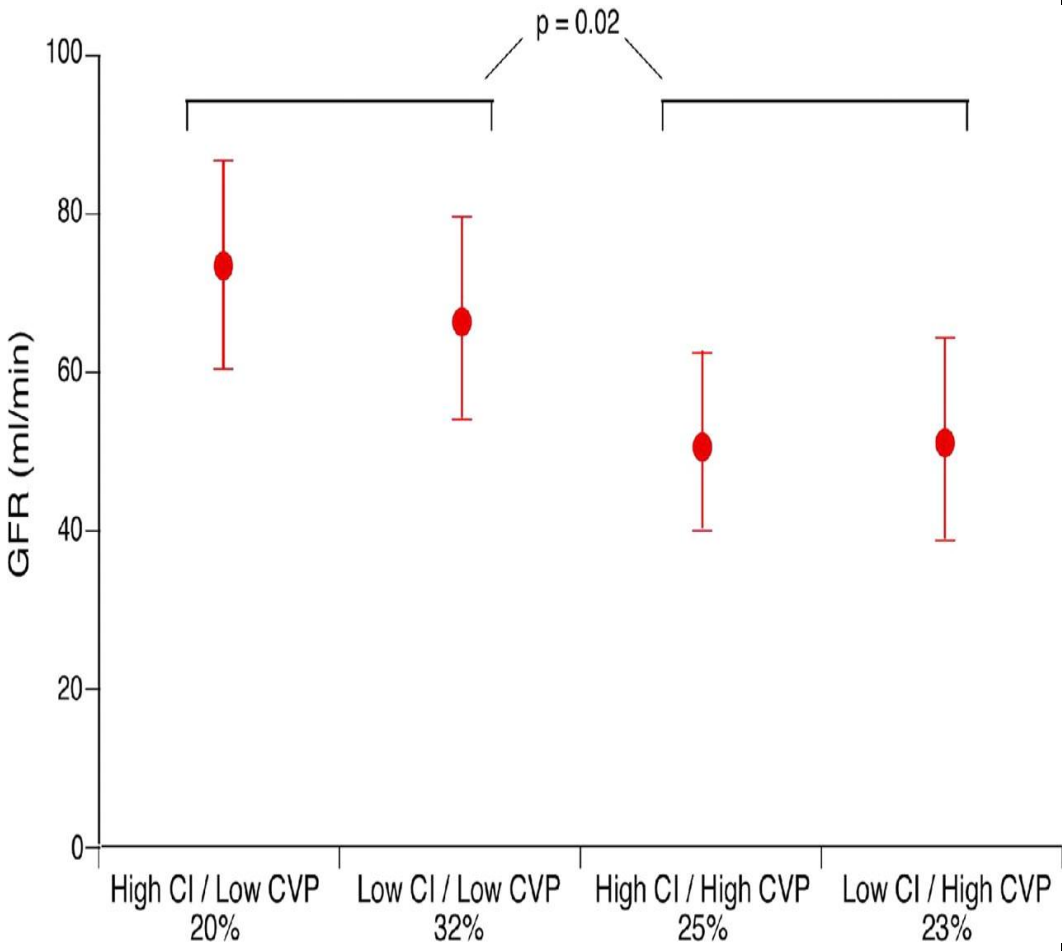

*Ronco et al. JACC 2008, 52:1527-39*

# Venous congestion as relevant hemodynamic factor underlying WRF in acute heart failure

**ROC for CVP and CI on Admission for the Development of WRF**




**Relative Contributions of CVP and CI to GFR at Time of PAC Removal**




*Mullens, W. et al. J Am Coll Cardiol 2009;53:589-596*

# Clinical characteristics of pts with liver dysfunction

| | Alk Phosphatase | | | Transaminases | | |
|---|---|---|---|---|---|---|
| | normal | abnormal | | normal | abnormal | |
| N | 944 | 261 **(22%)** | | 740 | 427 **(37%)** | |
| ***Clinical signs at baseline*** | | | | | | |
| SBP (mmHg) | 117 | 114 | 0.013 | 117 | 114 | 0.012 |
| DBP (mmHg) | 71 | 69 | 0.073 | 70 | 71 | NS |
| HR (bpm) | 83 | 83 | NS | 81 | 87 | <0.001 |
| Peripheral edema (%) | 65.8 | 79.3 | <0.001 | 70.0 | 63.7 | 0.023 |
| Ascites **(%)** | 16.9 | 31.0 | <0.001 | 22.0 | 17.1 | 0.049 |
| Cold extremities (%) | 20.8 | 26.1 | 0.076 | 19.6 | 25.5 | 0.022 |
| ***Biological parameters at baseline*** | | | | | | |
| BNP (pg/mL) | 1465.1 | 2250.9 | <0.001 | 1464 | 1918 | <0.001 |
| ***Initial hospitalization characteristics (%)*** | | | | | | |
| Acute MI | 19.0 | 10.7 | 0.002 | 11.1 | 30.1 | <0.001 |
| LVEF | 24.0 | 23.3 | 0.071 | 24.1 | 23.5 | 0.048 |
| Tricuspid regurgitation | 45.8 | 52.9 | 0.04 | 51.6 | 40.8 | <0.001 |
| ***All-cause mortality (%)*** | | | | | | |
| at 31 d | 11.1 | 14.6 | NS | 8.4 | 17.6 | <0.001 |
| at 180 d | 23.5 | 34.9 | 0.001 | 22.4 | 31.6 | <0.001 |

*Nikolaou et al, Eur Heart J (in press)*

# Cardio-hepatic syndromes

- *Abnormal transaminases*:
  - systemic and peripheral **hypoperfusion**
  - « Forward » HF
- *Abnormal Alkaline Phosphatase*:
  - clinical and biological signs of marked systemic - mostly right-sided- **congestion**
  - Varies with BNP changes
  - « backward » HF, marker of « congested liver ».

***Nikolaou et al, Eur Heart J (in press)***

# Markers of RV Dysfunction Associated With Clinical Status and Prognosis

Right ventricular ejection fraction (echocardiography, radionuclide angiography or thermodilution) [28,29,31,33,35-38,77]

Right ventricular ejection fraction response to pulmonary vasodilation[65]

Right ventricular dilation[78]

Degree of right ventricular dilation compared with left ventricular dilation[32]

Tricuspid annular velocity (systolic and/or diastolic) or excursion, or echo right ventricular descent (shortening)[30,34,79-81]

Right ventricular index of myocardial performance[80,82,83]

Doppler-estimated dP/dt[84]

Tricuspid regurgitation[85-87]

Doppler echo-derived right ventricular tissue displacement and strain[88]

Right atrial size[85,89]

Radionuclide angiographic, invasive angiographic, or echo/catheterization pressure-volume or pressure-area loops[90-92]

Brain natriuretic peptide level[15-19]

Heart rate variability[93]

*Circulation 2006;114:1883-91*

# How can I detect a RVF in acute settings: *Biology*?

- Plasma lactate seems much higher than expected by systemic hemodynamic
- Elevated liver enzymes
- Decrease in PT
- Oliguria

*Courtesy A. Mebazaa*

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- Plasma lactate seems much higher than expected by systemic hemodynamic
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## How to diagnose RVF in the context of advanced LVF?

- Inability to reduce congestion
- Persistent organ dysfunction
  - Renal failure
  - Liver failure

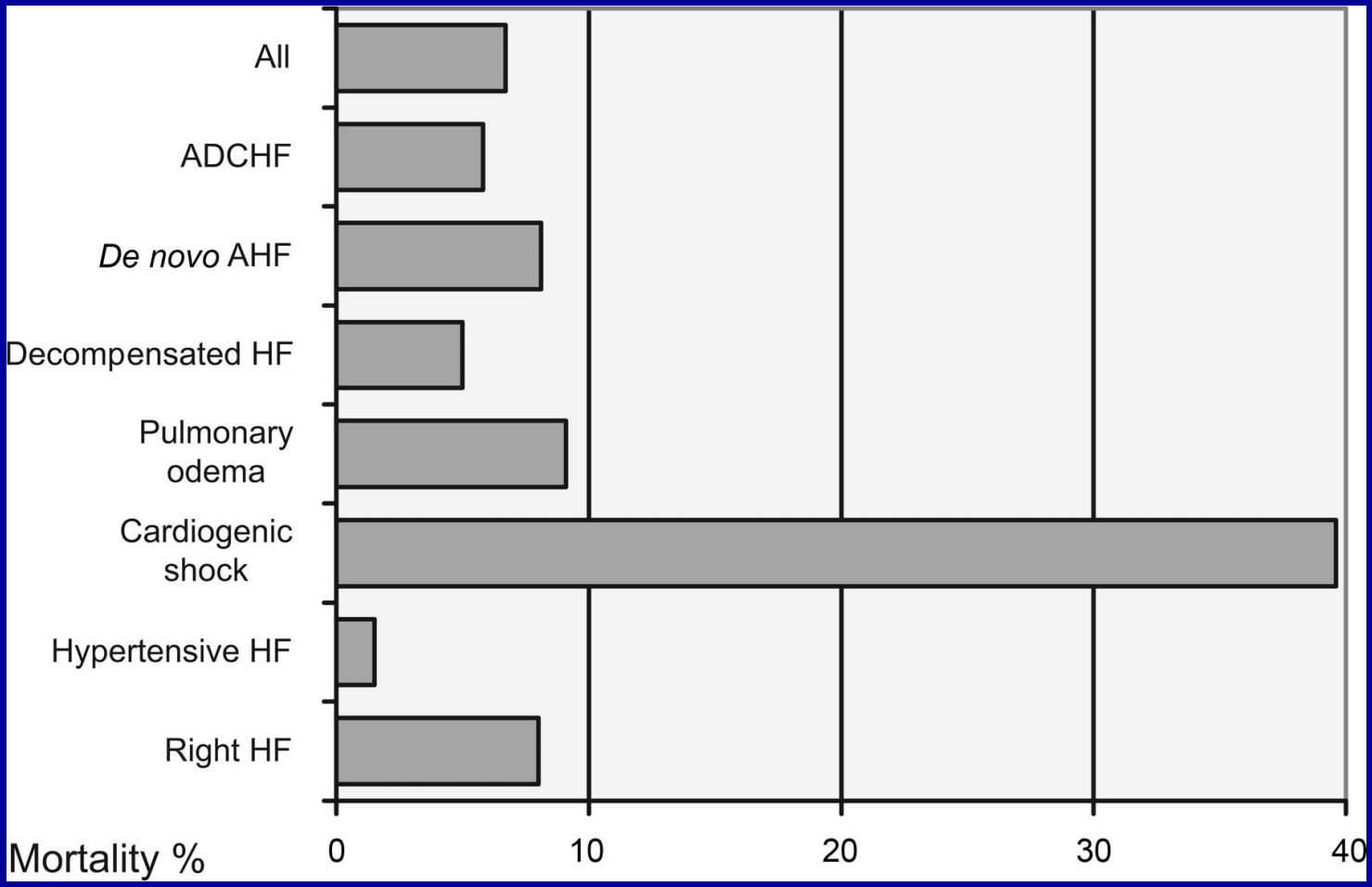
*Courtesy A. Mebazaa*

# Factors Relating to Survival in Chronic Congestive Cardiomyopathy

| Factors | Survivors | Non-Survivors | *p-value* |
|---|---|---|---|
| LVEF | 18.7±6.8 % | 18.1±10.3 % | NS |
| RVEF | 41.4±23.0 % | 23.9±10.2 % | < 0.01 |
| LV dyskinesia | 20.9±11.8 % | 29.7±15.0 % | < 0.05 |
| Ventricular arrhythmia | 50% | 44% | NS |
| Functional class (NYHA) | 3.0 ± 0.7 | 3.6 ± 0.5 | < 0.01 |
| Diabetes | 19 % | 22 % | NS |
| Hypertension | 19 % | 33 % | NS |
| Previous inferior infarction | 17 % | 42 % | NS |
| COPD | 6 % | 33 % | NS |

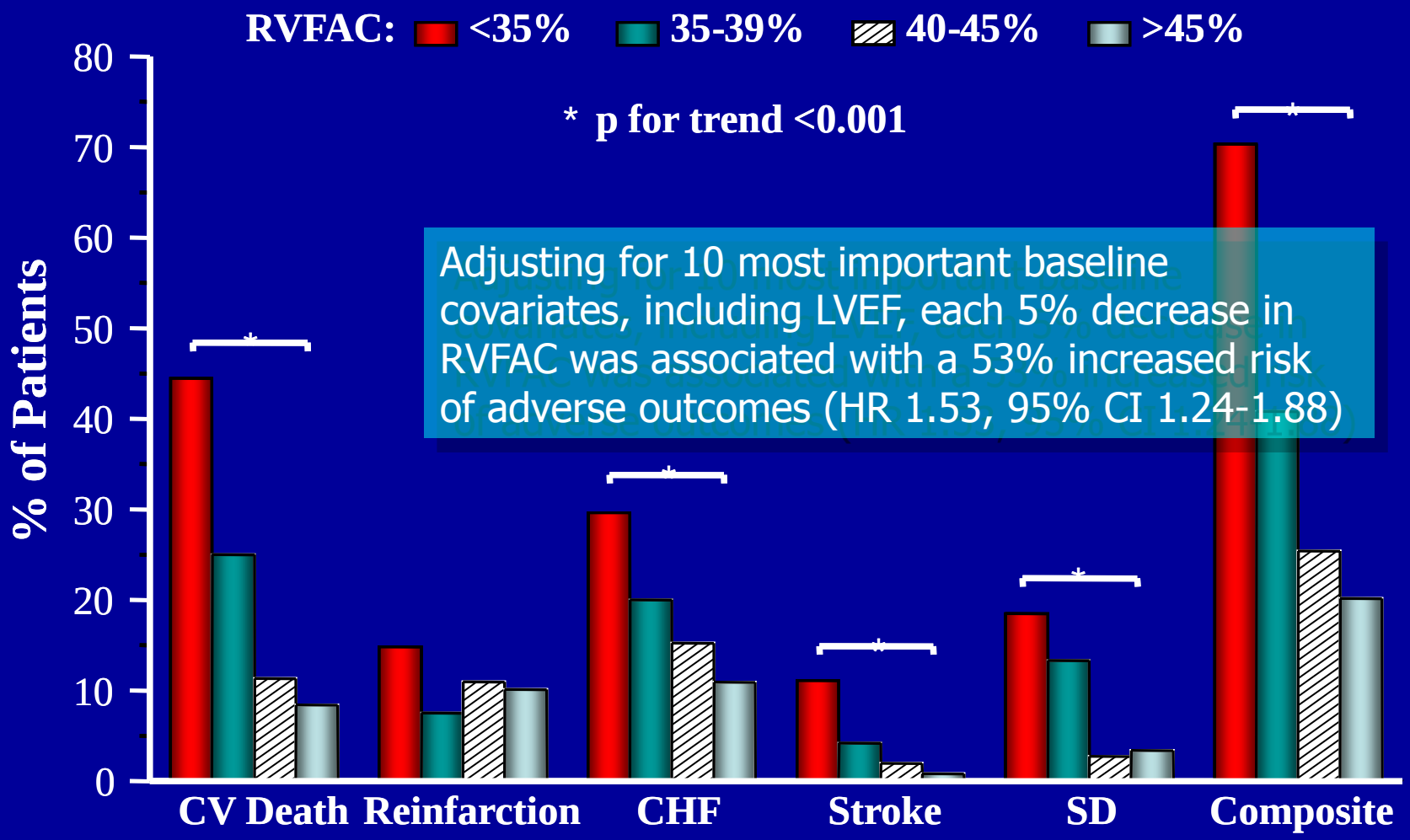
Polak JF et al. JACC 1983; 2: 217

# In-hospital mortality in EHFS II by history of HF and clinical class



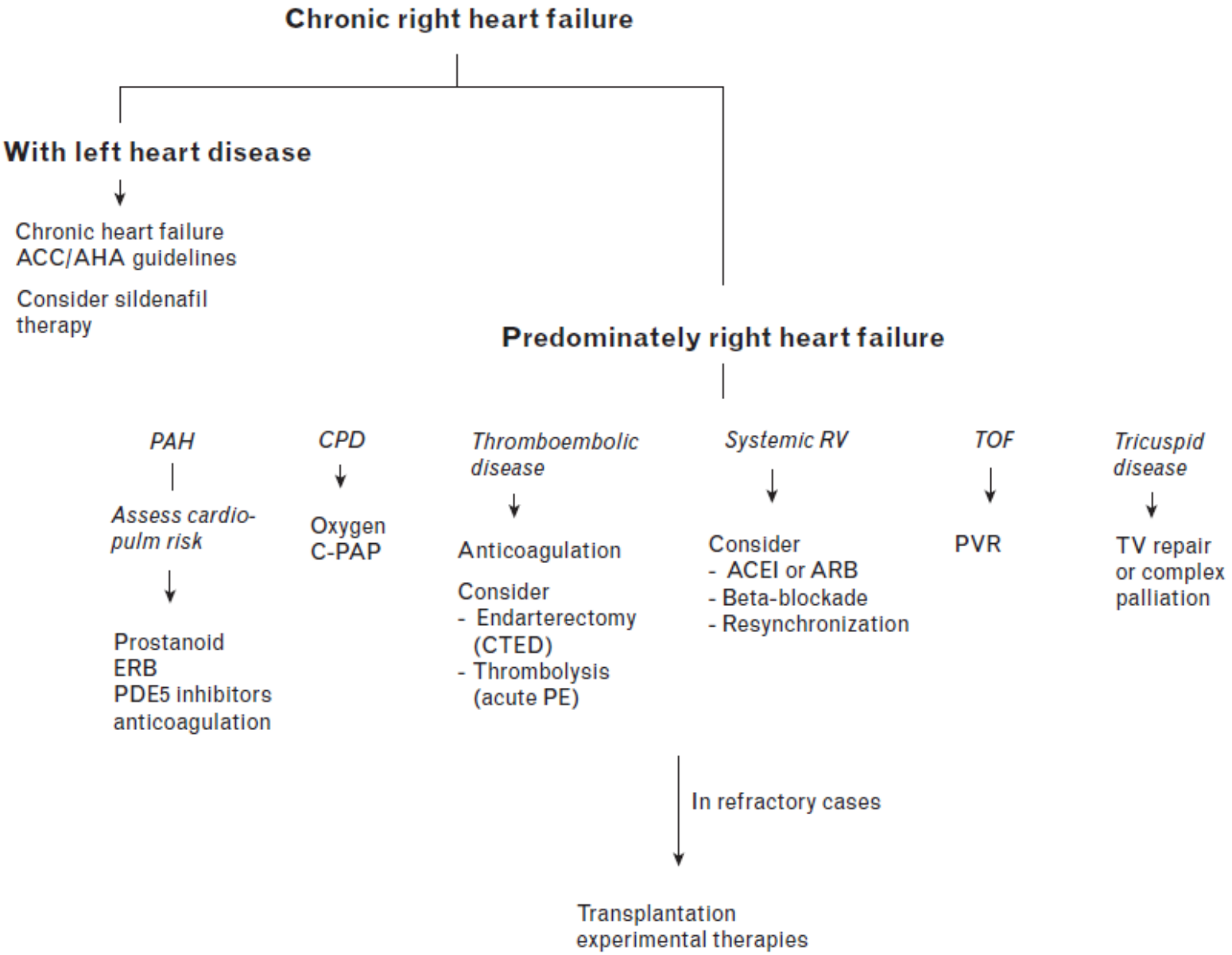

Nieminen, M. S. et al. EHJ 2006 27:2725

# RV Function and CV Events




Anavekar et al. for the VALIANT Investigators AJC 2007

# RV dysfunction/ failure: treatment




*Haddad, 2010*

# Treatment of LVF versus RVF

## LV failure

- Often decrease BP
- NIV often needed
- Volume loading might be needed

## RV failure

- Often increase Blood Pressure (Right Coronary Artery!)
- Caution if volume loading: it might aggravate RVF

*Mebazaa et al. Critical Care Medicine, 2008, Suppl 36:129-139*

# Treatment of RVF

- **What I should do**
  - Decrease RV afterload: to decrease $MVO_2$
  - Decrease volemia: to decrease RVV and TR
  - Improve contractility
  - Increase MAP: to improve RC and organ PP

- **What I should avoid**
  - Mechanical ventilation as much as possible
  - Volume loading

*Mebazaa et al. Critical Care Medicine, 2008, Suppl 36:129-139*

# Right Heart: Cinderella of HF

RV dysfunction / failure

- Syndrome of congestion
- High Morbidity and Mortality
- Heterogenous aetiology
- Not EBM therapy
- Much less studied than the Left ！