# *ULTRAFILTRATION IN HEART FAILURE*

***ILJA ZAKKE***

Latvian Centre of Cardiology

in collaboration with group of Renal Replacement Therapy,

Dr. V. Liguts

Paul Stradins Clinical University Hospital

ESC Congress 2005, Stockholm

# Heart Failure (HF)

- is the progressive inability of the heart to pump enough blood to support the needs of the vital organs
- is classically accompanied by significant fluid retention
- is a leading cause of mortality and morbidity

# Fluid overload leads to the common symptoms of HF:

- fatigue
- edema
- shortness of breath

# Heart Failure – "disease of the millenium"

- 5 mln. patients in the US currently have the diagnosis of HF
- HF has a prevalence of ten per 1000 in the elderly population (age > 65 years)
- HF is responsible for 1 mln. hospitalization and 300. 000 deaths per year

I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artifical Organs*
*Vol. 28/ no. 5, 2005/ pp. 466 - 476*

# Heart Failure – "disease of the millenium"

- The rate of increase in new cases diagnosed each year is more than 500.000
- Patients with HF (NYHA class III–IV) are hospitalized 2 to 4 times annualy
- The total annual cost of caring for patients with HF is up to $ 40 billion

I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artifical Organs*
*Vol. 28/ no. 5, 2005/ pp. 466 - 476*

# Acute Heart Failure – Etiology I

Preexisting normal ventricular function:

- Global ishemia
- Myocardial infarction
- Acute valvular regurgitation
- Myocarditis
- Malignant hypertension

→ Cardiogenic shock



*Cardiology, 2001; 96; 144-154*

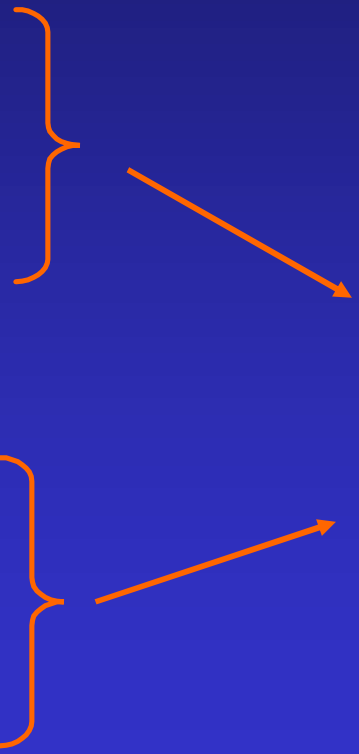
# Acute Heart Failure – Etiology II

<u>Preexisting normal systolic ventricular function:</u>

- postoperative myocardial stunning
- toxin exposure (sepsis, chemotherapy)

<u>Preexisting subclinical ventricular dysfuntion:</u>

- ishemic heart disease
- valvular heart disease
- idiopathic cardiomyopathy
- secondary cardiomyopathy



Acute presentation



*Cardiology, 2001; 96; 144-154*

# Acute Heart Failure – Etiology III

Known systolic or diastolic ventricular dysfuntion:

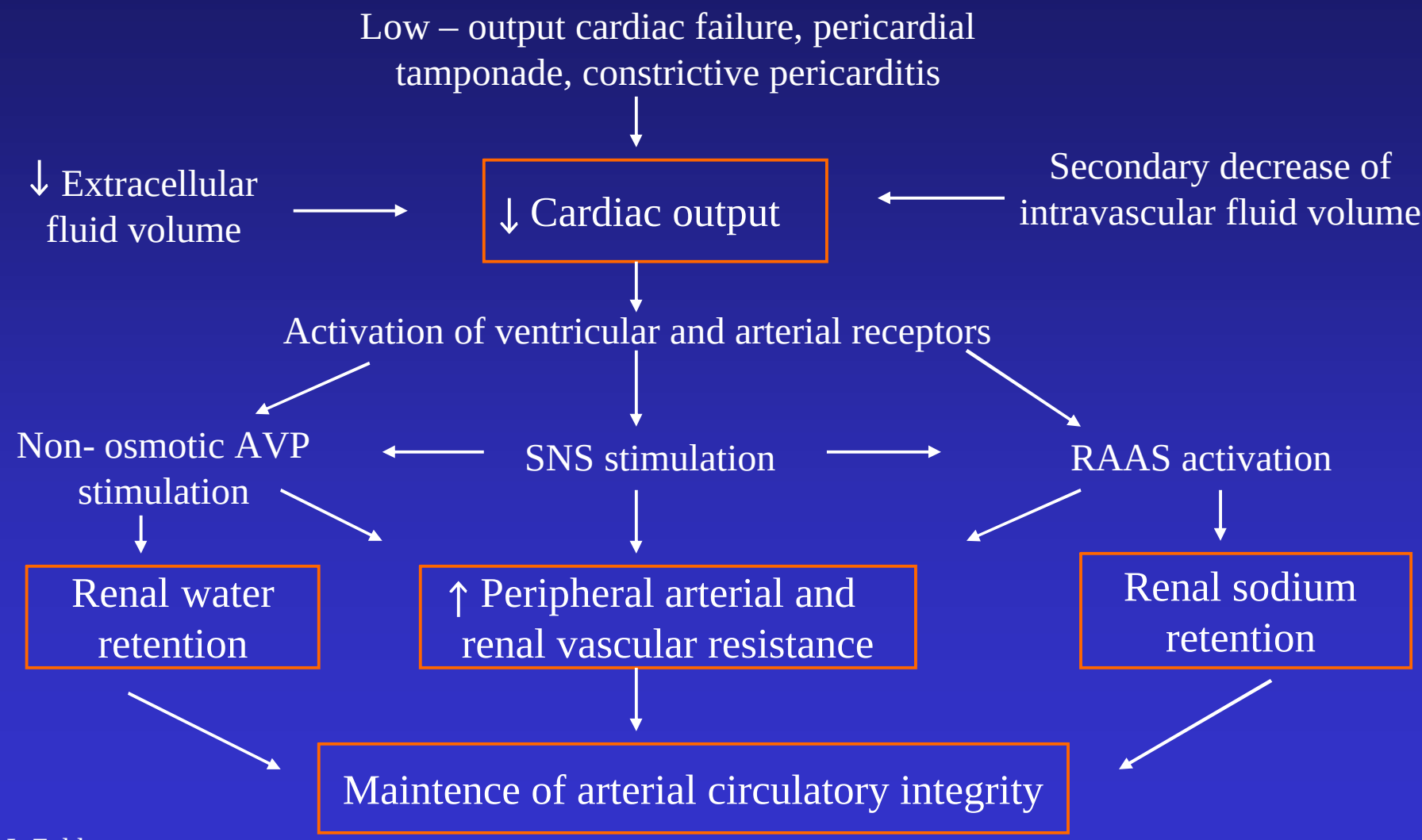
- dietary sodium excess
- medication noncompliance
- toxin exposure
- worsening renal function
- precipitating factor requires identification

→ Acute exacerbation

I. Zakke
ESC Congress 2005, Stockholm

*Cardiology, 2001; 96; 144-154*

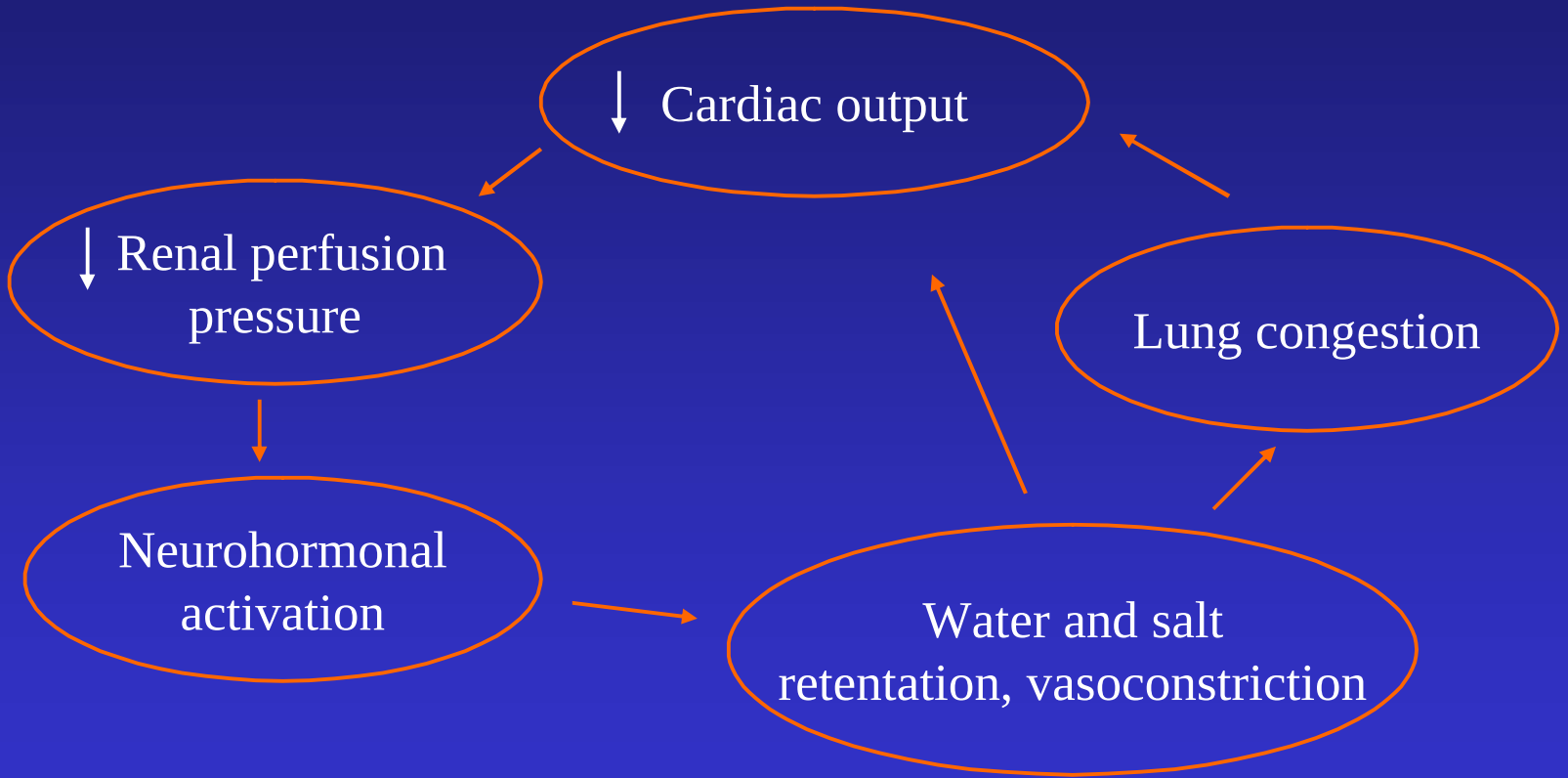
# Pathophysiology of sodium and water retention in Heart Failure




I. Zakke
ESC Congress 2005, Stockholm

*Cardiology: 2001: 96: 122 - 131*

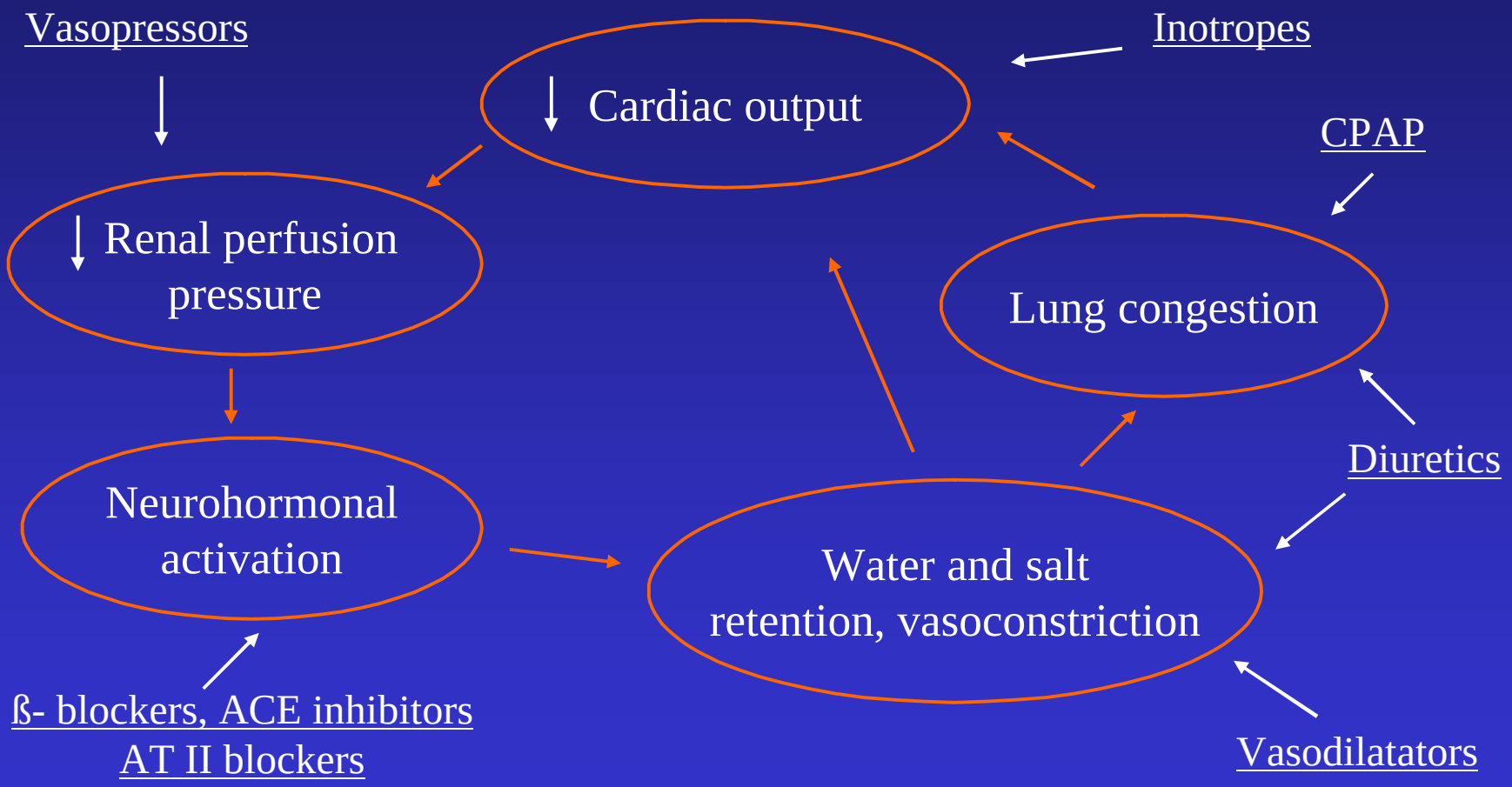
# Heart Failure – vicious circle
## (clinical aspects)




I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artificial Organs/ Vol 27/ no. 12,2004/ pp. 1070 - 1076*

# Heart Failure – vicious circle
## (clinical aspects)




I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artificial Organs/ Vol 27/ no. 12,2004/ pp. 1070 - 1076*

# Heart Failure – managment and treatment
# Selected pharmacological therapy

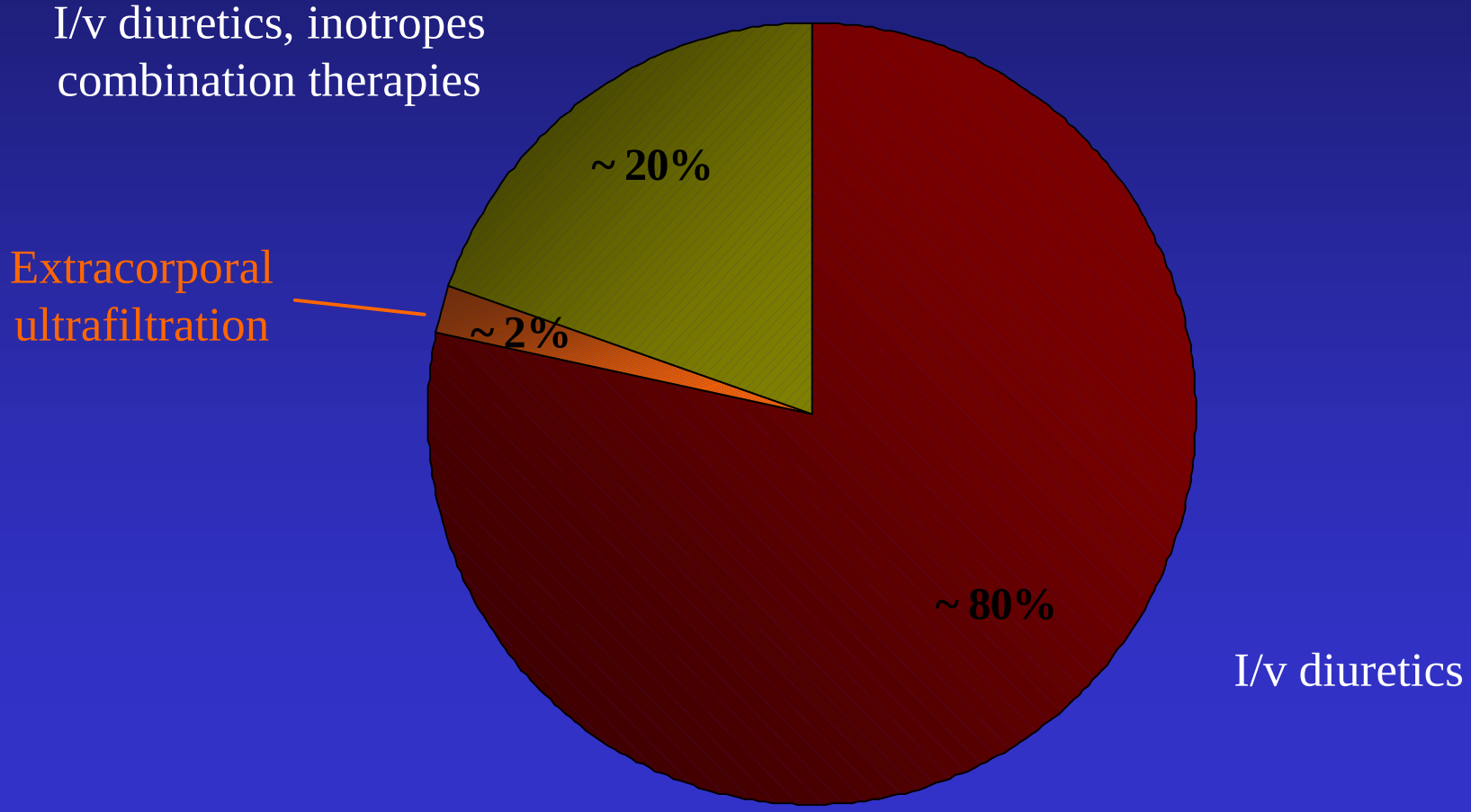
| | Loop diuretics | Inotropes | Systemic vasodilatator |
|---|---|---|---|
| Symptoms | improve | may improve | may improve |
| Mortality | may increase | increase | increase |
| Side effects | - electrolyte abnormalities<br>- renal disfuntion<br>- neurohormonal activation | - arrhytmias<br>- hypotension<br>- potential myocardial damage | - increased tolerance<br>- hypotension<br>- renal dysfunction |

I. Zakke
ESC Congress 2005, Stockholm

*Klein et al, 2003; Jain et al, 2003*

# What do the doctors do?

# Current inpatient treatment strategies for Heart Failure




I. Zakke
ESC Congress 2005, Stockholm

*Estimate based on: HCAP net 1999 data HCF coding books, physician interviews*

# Heart Failure – managment and treatment

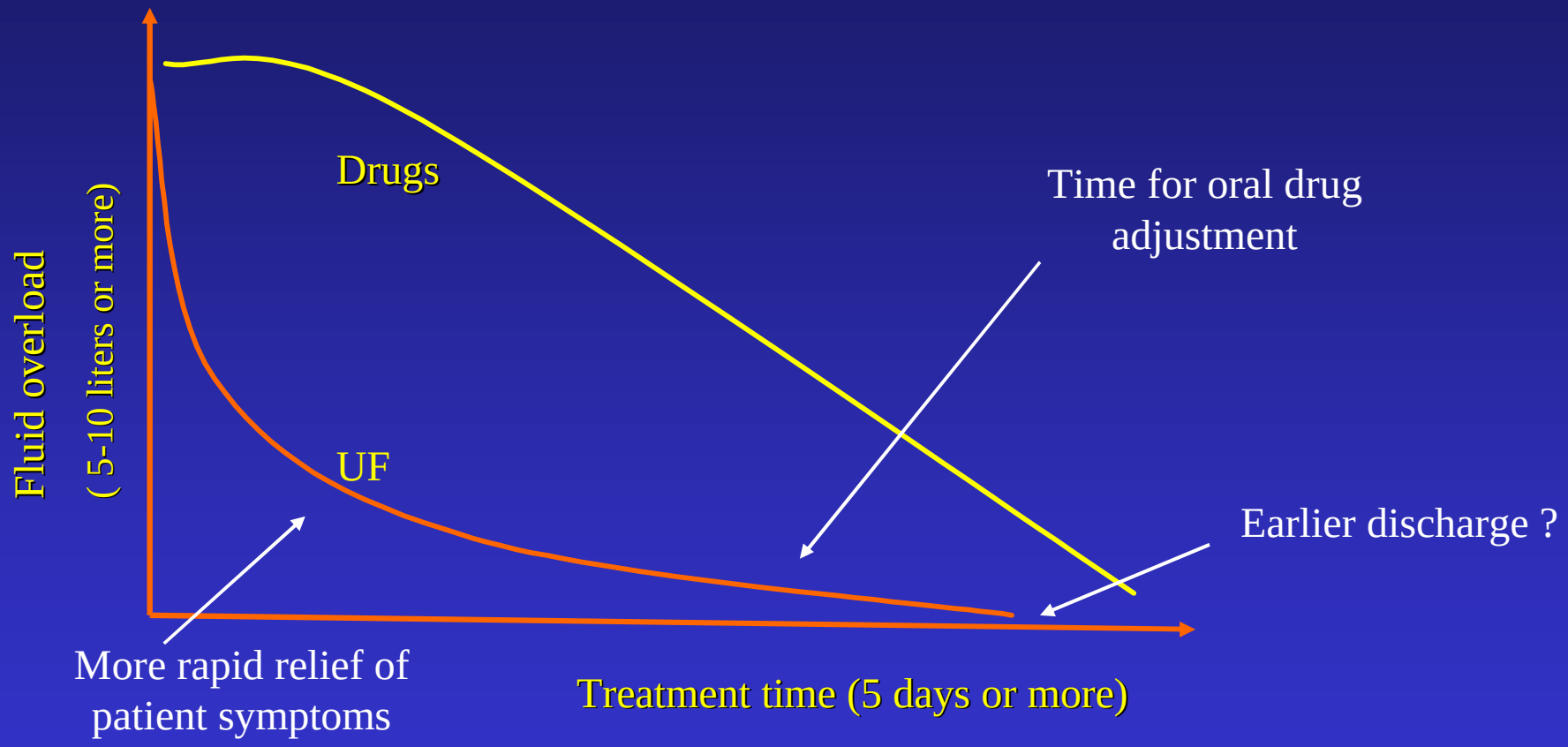
## Treatment effects in acute Heart Failure

| | Diuretics | Dobutamin | Ultrafiltration |
|---|---|---|---|
| Plasma norepinehrine | ↑ | unchanged | ↓ |
| Plasma atrial natriuretic peptid | unchanged or ↑ | possibly ↓ | ↑ |
| Urinary output | ↑ | ↑ | ↑ |
| Right atrial pressure | ↓ | ↓ | ↓ |
| Left atrial pressure | ↓ | ↓ | ↓ |
| Cardiac output | variable | ↑ | ↑ or unchange |
| Arterial blood pressure | ↓ | no change | no change |
| Heart rate | unchanged or ↑ | unchanged or ↑ | unchanged or ↑ |

I. Zakke
ESC Congress 2005, Stockholm

*Cardiology 2001: 96: 144 0 159*

# Medical managment vs medical managment + ultafiltration




Reduced drug related complications – electrolyte imbalances, arrhytmias

I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artifical Organs / Vol. 28 / no.5, 2005 / pp. 466 - 478*

# Ultrafiltration technique

First suggested extracorporal ultrafiltration as a technique to treat uremia

1947. year

Authors : Manilow and Korzon

# Why ultrafiltration?

# Rationale for the use of ultrafiltration therapies

- Fluid regulation
- Solute regulation
- Establish homeostasis



*Cardiology 2001, 96, 144 - 154*

# Rationale for the use of ultrafiltration therapies

- *Fluid regulation*
- Solute regulation
- Establish homeostasis

# Rationale for the use of ultrafiltration therapies

- Fluid regulation

Therapeutic goal:

- Has been successful in patients when urine output is less than 1000 ml/day
- Relieve pulmonary edema
- Reduce ascites
- Reduce peripheral edema
- Hemodynamic stabilization
- Improve oxygenation
- Facilitate blood product replacement without excess volume
- Enable parenteral support without excess volume



*Cardiology 2001; 96, 144 - 154*

# Rationale for the use of ultrafiltration therapies

- Fluid regulation
- *Solute regulation*
- Establish homeostasis

# Rationale for the use of ultrafiltration therapies

- Solute regulation

Therapeutic goal:

- Correct acid – base balance
- Correct serum sodium content
- Eliminate “myocardial depressant factor” or known toxin
- Correct uremia
- Correct hyperkaliemia
- Correct other electrolyte disturbances



*Cardiology 2001; 96, 144 - 154*

# Rationale for the use of ultrafiltration therapies

- Fluid regulation
- Solute regulation
- *Establish homeostasis*

# Rationale for the use of ultrafiltration therapies

- Establish homeostasis

Therapeutic goal:

- Rest water osmostat
- Restore diuretic responsivences
- Reduce neurohormonal stimulation



*Cardiology 2001; 96, 144 - 154*

# Ultrafiltration strategy in acute Heart Failure

| | Outcome goal |
|---|---|
| Post – cardiac surgery | - recovery of myocardial function<br>- support renal function<br>- support ventricular assist devices<br>- support intra-aortic ballon pump |
| Acute cardiogenic shock | - fluid regulation<br>- minimize effect on mean arterial pressure |



*Cardiology 2001; 96, 144 - 154*

# Ultrafiltration strategy in decompensated congestive Heart Failure

- ***Candidate for heart transplant***

  - bridge to transplant that maintains renal function and fluid balance

- ***Not a candidate for heart transplant***

  - optimize fluid status and establish new baseline, relieve symptoms

I. Zakke
ESC Congress 2005, Stockholm

*Cardiology 2001; 96, 144 - 154*

# Isolated ultrafiltration

- First line for treatment of heart failure
- Therapy concept – removal of isotonic fluid through an extracorporal filter
- Therapy - controlled and predictable, even when urinary ouput is low
- For treatment of renal failure patients

I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artifical Organs / Vol. 28 / no.5, 2005 / pp. 466 - 478*

# Isolated ultrafiltration

Clinical benefits:

- Decrease
  - cardiac filling pressure
  - plasma norepinephrine
  - aldosterone
  - renin activity
- Improve
  - diuretic resposiveness
  - hyponatriemia
  - edema
  - renal function
  - dyspnea

I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artifical Organs / Vol. 28 / no.5, 2005 / pp. 466 - 478*

# Ultrafiltration vs hemofiltration

Ultrafiltration:

- is not effective as a blood cleaning modality
- the concentrations of small solutes not rejected
- the fraction of the total body solute mass removal is the same as the fractional removal of plasma water
- fractional mass removal in the ultrafiltrate is proportionaly less than plasma volume reduction – increase in the blood concentration of larger sized molecules

I. Zakke
ESC Congress 2005, Stockholm

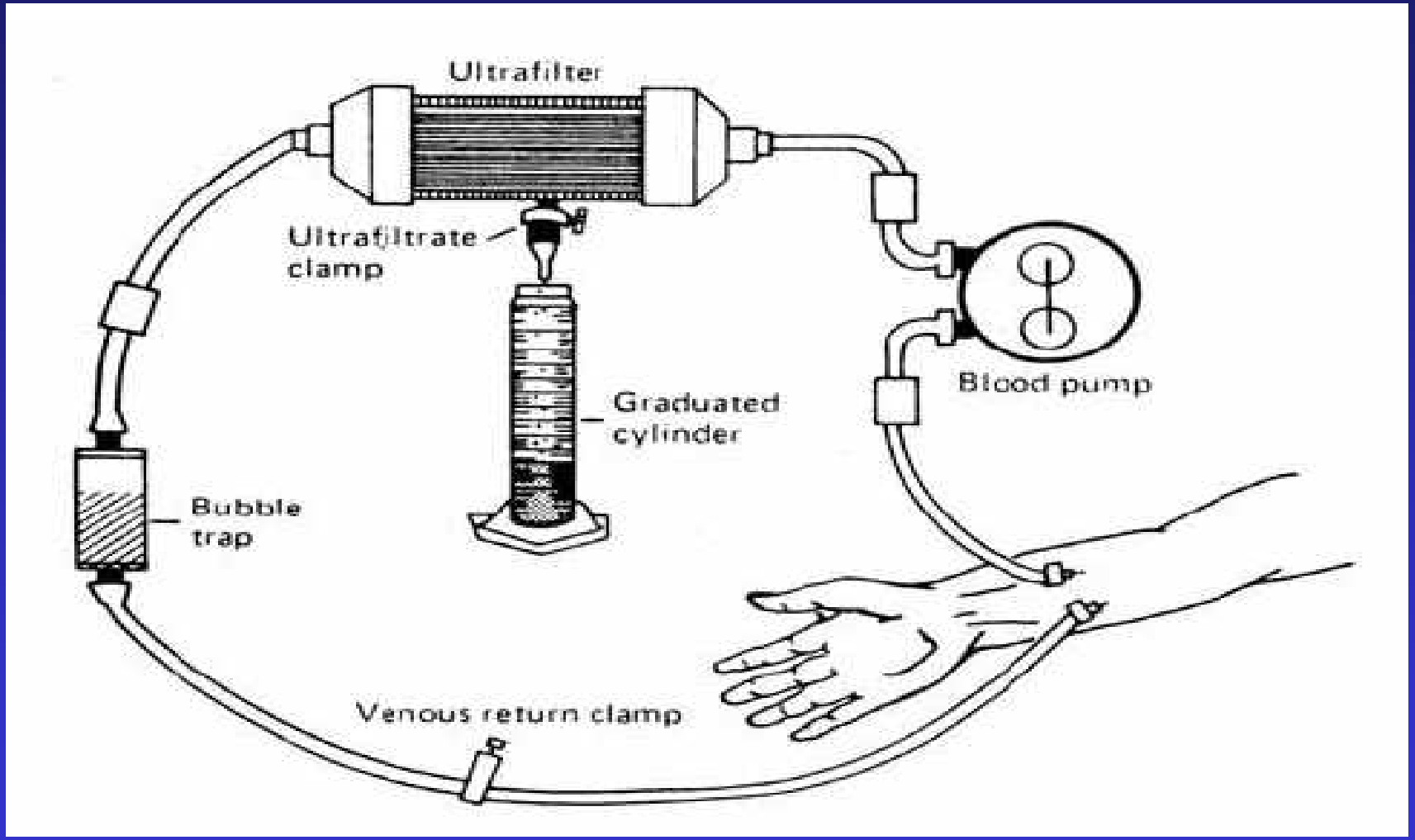
*The International Journal of Artifical Organs / Vol. 28 / no.5, 2005 / pp. 466 - 47*

# Ultrafiltration vs hemofiltration

Hemofiltration:

- involves the simultaneous removal of plasma water and replacement with electrolyte solution

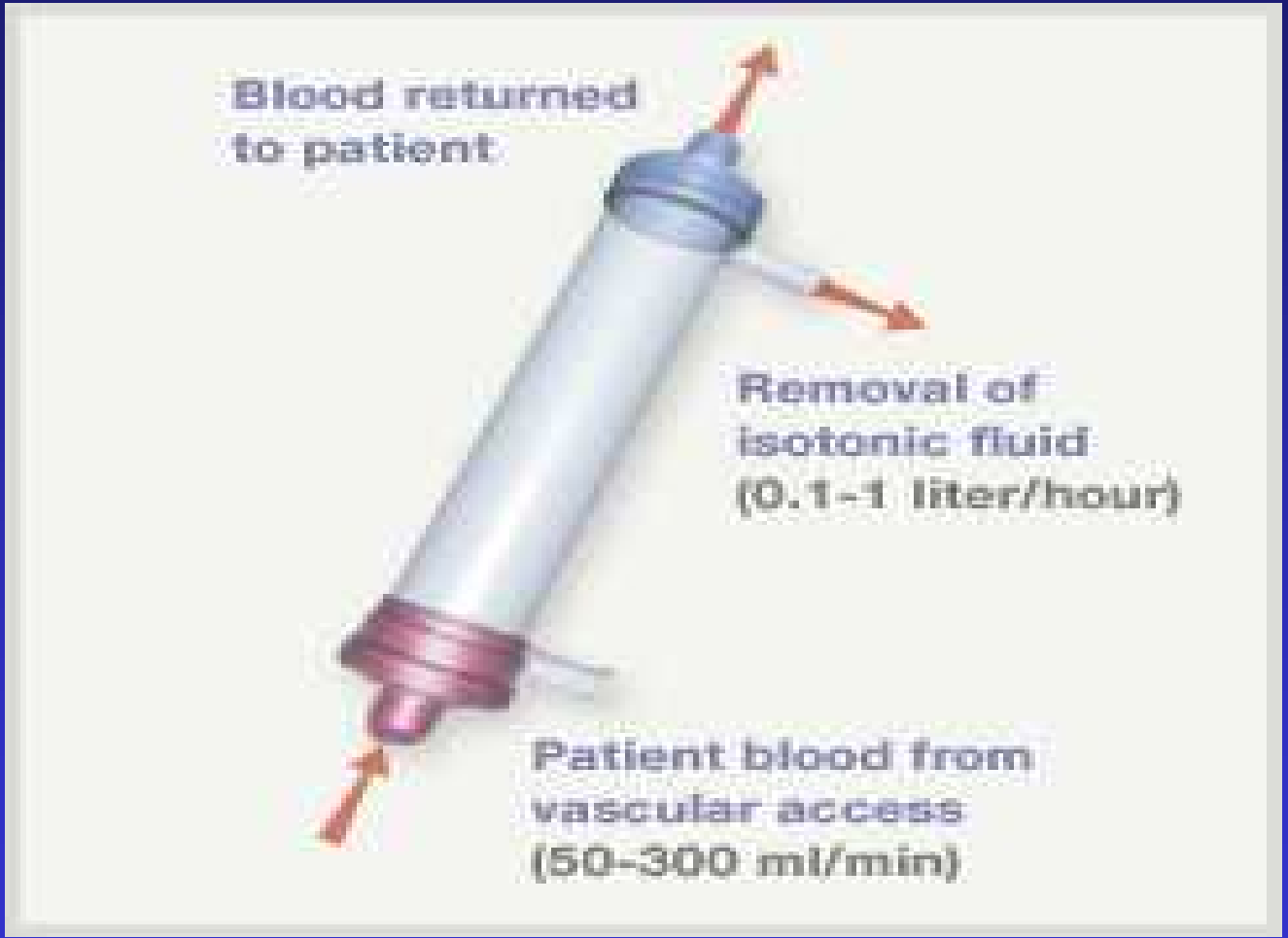
# Scheme of ultrafiltration




I. Zakke
ESC Congress 2005, Stockholm

*The International Journal of Artifical Organs*
*Vol. 28/ no. 5, 2005/ pp. 466 - 476*

# Ultrafilter construction




I. Zakke
ESC Congress 2005, Stockholm

# *ULTRAFILTRATION in HEART FAILURE*

# Benefits of ultrafiltration

- Improvement in clinical signs/symptoms of volume overload
- Improvement in the hemodynamic and functional status of the patient
- Decrease in the levels of various hormones that participate in worsening status of these patients
- Promote absorption of excessive extravascular fluid
- Improvement in renal funtion
- Restoration of diuretic resposiveness

# Selected ultrafiltration study summaris

| Investigator | Population | UF Rate | Conclusions |
|---|---|---|---|
| Abraham et al., *CHF Solutions Web Site* | 21 patients with moderate to severe fluid overload | 400 ml/hr (2.6 liters total) | • Safe and effective<br>• Symptoms relief, with no change in electrolytes, hematocrit |
| Marenzi et al., (2001). *J Am Coll Cardiol.* | 24 NYHA Class IV patients in ICU | 542 ml/hr (4.9 liters total) | • UF performed safely without side effects<br>• Urinary output increase, diuretic decrease<br>• NYHA class improvement in all |
| Ronco et al., (2001). *Cardiology.* | 22 patients treated with either 4 or 24 hour therapy | 625 ml/hr vs. 100 ml/hr (2.5 liters total) | • Blood volume more stable at lower UF rates<br>• Hematocrit monitoring useful |
| Canaud et al., (1998). *Nephrol Dial Transplant.* | 52 NYHA Class IV patients observed over 10 years | Up to 500 ml/hr | • 75% improved NYHA functional class<br>• 46% improved cardiac and/or renal function (lasting >3 months for most) |
| Agostoni et al., (1994). *Am J Med.* | 16 moderate CHF, randomized to UF or furosemide | 500 ml/hr (1.7 liters total) | • Ultrafiltration: improved neurohormonal profile, lasting functional improvement (at 3 months)<br>• Furosemide: continued neurohormona activation, no change in functional class, recurring symptoms |
| Sakurai et al., (1993). *Nippon Rinsho.* | NYHA Class IV patients | 500 ml/hr | • Up to 500 ml/hr can be removed without impacting systemic circulatio<br>• Reversal of renal dysfunction |
| Agostoni et al., (1993). *J Am Coll Cardiol.* | 36 patients randomized to UF or furosemide | 500 ml/hr (1.9 liters total) | • Ultrafiltration: improvement in hemodynamic status, neurohormonal profile, and exercise capacity<br>• Furosemide: changes not observed |
| Rimondini et al., (1987). *Am J Med.* | 11 NYHA class IV patients | 500 ml/hr (2-3 liters total) | • Evidence of congestion relief<br>• Maintenance of CV stability<br>• Urine output increased substantially |



*Ultrafiltration in Congestive Heart failure.Cardiology 2002*

# Ultrafiltration – future issues

- Device portability and case of use
- Central venous access
- Continious vs intermittent daily ultrafiltration
- Close collaboration between nephrologist and cardiologist
- Clinical date requirements for therapy adoption



*The International Journal of Artifical Organs / Vol. 28 / no.5, 2005 / pp. 466 - 478*

# Conclusion

- *" Of the various therapies that have been attempted for diuretic – resistant congestive heart failure, ultrafiltration strategies bold particular promise"*

Ultrafiltration in Congestive Heart failure.Cardiology 2002

- *" Broader adoption of this therapy would benefit from well – conducted clinical studies to further charaterize the extent of ultrafiltrations benefits"*

*The International Journal of Artifical Organs*
*Vol. 28 / no.5, 2005 / pp. 466 - 478*

I. Zakke
ESC Congress 2005, Stockholm