

## Kim Carlberg, ARNP

Mercy Medical Center  
Heart Failure Services

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## Incidence of Heart Failure

- ♥ > 5 million people in the U.S.
- ♥ 550,000 new patients are diagnosed each year.
- ♥ ~ 80% of hospitalized pts. are > 65 years old.
- ♥ Mortality within eight years of diagnosis.
- ♥ The most common Medicare diagnosis
- ♥ In 2005, spent \$28 billion on this diagnosis with \$3 billion spent on drugs.

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## ACC/AHA 2001 Guideline: Classification of HF

Stage	Patient Description	
A	High risk for developing HF <ul style="list-style-type: none"><li>• HTN</li><li>• CAD</li><li>• Diabetes mellitus</li><li>• Family history of CM</li></ul>	62 million
B	Asymptomatic HF <ul style="list-style-type: none"><li>• Previous MI</li><li>• LV systolic dysfunction</li><li>• Asymptomatic valvular disease</li></ul>	10 million
C	Symptomatic HF <ul style="list-style-type: none"><li>• Known structural heart disease</li><li>• Shortness of breath and fatigue</li><li>• Reduced exercise tolerance</li></ul>	5 million
D	Refractory end-stage HF <ul style="list-style-type: none"><li>• Marked symptoms at rest despite maximal medical therapy (eg, those who are recurrently hospitalized or cannot be safely discharged from the hospital without specialized interventions)</li></ul>	0.2 million

Hunt SA et al. *J Am Coll Cardiol*. 2001;38:2101-2113.

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### New York Heart Association (NYHA) Functional Classification



Class I	Class II	Class III	Class IV
<p><b>No symptoms</b></p> <p>Can perform ordinary activities without any limitations</p>	<p><b>Mild symptoms</b></p> <p>Occasional swelling</p> <p>Somewhat limited in ability to exercise or do other strenuous activities</p> <p>No symptoms at rest</p>	<p><b>Noticeable limitations</b> in ability to exercise or participate in mildly strenuous activities</p> <p>Comfortable only at rest</p>	<p><b>Unable to do any physical activity</b> without discomfort</p> <p>Symptoms at rest</p>

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### Risk Factors for Heart Failure

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- Coronary artery disease
- Chronic hypertension
- Cardiomyopathies (ischemic, idiopathic, post partum, alcoholic, etc)
- Valvular heart disease
- Obstructive sleep apnea
- Arrhythmia (e.g., atrial fibrillation)
- Anemia
- Fluid volume overload with non-cardiac causes
- Thyroid disease (hypo- or hyperthyroidism)
- Drugs: chemotherapy, illicit

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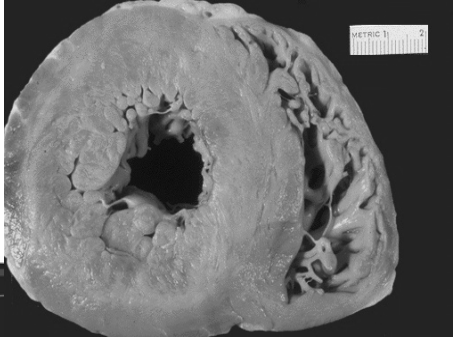
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### “Right ventricular remodeling” Diastolic or Right Heart Failure



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**“Cardiomyopathy”  
(Systolic or Left Heart Failure )**




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**Rapid Assessment of Hemodynamic Status**

		Congestion at Rest	
		NO	YES
Low Perfusion at Rest	NO	Warm & Dry	Warm & Wet 67%
	YES	Cold & Dry 5%	Cold & Wet 28%

*Nohria, J Cardiac Failure 2000;6:64*

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**Rapid Assessment  
of Hemodynamic Status**

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| <p>♥ S/S of Low Perfusion:</p> <ul style="list-style-type: none"> <li>• Narrow pulse pressure</li> <li>• Cool extremities</li> <li>• Sleepy / obtunded</li> <li>• Hypotension</li> <li>• Low serum sodium</li> <li>• Renal Dysfunction</li> <li>• Elevated LFTs</li> <li>• Pulsus alternans</li> </ul> | <p>♥ S/S of Congestion:</p> <ul style="list-style-type: none"> <li>• Orthopnea / PND</li> <li>• JV Distension</li> <li>• Hepatomegaly</li> <li>• Edema</li> <li>• Rales (rare in chronic heart failure)</li> <li>• Abdominojugular reflux</li> <li>• S3</li> </ul> |
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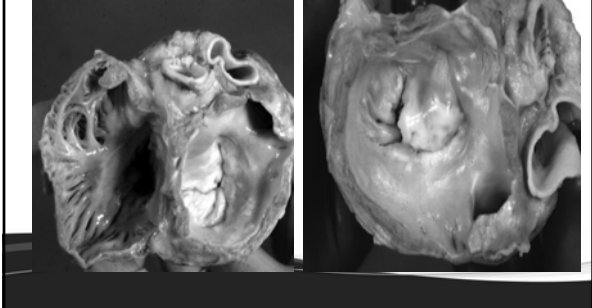
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### Bulging Mitral Valve Causing an S3 with Volume Overload



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### “Warm & Dry” Interventions

- ♥ Does not reflect evidence of elevated filling pressures or hypoperfusion
- ♥ The goal of therapy is focused on disease management and prevention of disease progression



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### “Warm & Wet” Interventions

- ♥ Has adequate perfusion but s/s of congestion
1. Enhance diuretic regimen
  2. May require enhanced vasodilation with ACEI or IV Nitroglycerin to decrease SVR
  3. May require mechanical methods of fluid removal with dialysis or ultrafiltration



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## “Wet & Cold” Interventions

- ♥ Need to warm them up before you can them dry out!
- ♥ Necessary to impact perfusion issues first and then the congestion issues
- ♥ Medications such as nitroprusside, nitroglycerin, and natrecor can be used to reduce afterload and thereby improve cardiac output, organ perfusion, and diuresis
- ♥ May need to hold beta blockers & ACEI



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## “Cold & Dry” Interventions

- ♥ Treatment strategies for this subgroup will focus on improving the low perfusion state
- ♥ Have poor LV function but no congestion



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## Rapid Assessment Case Study

- |                                   |  |
|-----------------------------------|--|
| ♥ Patient #1                      | ♥ Patient #2   |
| • Hx ischemic CM with systolic HF | • Diastolic HF, COPD, recently tx for pneumonia                  |
| • Weight gain 22 lbs              | • Weight gain 6 lbs  |
| • B/P 102/52, HR 70, R 20         | • B/P 96/74, HR 104, R 28  |
| • O2 sat 96% on RA                | • O2 sat 88% on 4L   |
| • Denies PND or orthopnea         | • Always sleeps in recliner                                      |
| • (+) JVD, 2+ edema, crackles, S3 | • (+) JVD, trace edema, lungs diminished, heart tones diminished |
| • Pink, warm, dry                 | • Pale, cool   |

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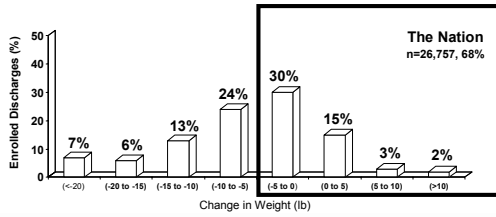
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## Inadequate Diuresis During ADHF Treatment



Change in Weight From Admission to Discharge

ADHERENT Diagnostics

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## Results of diuretic resistance



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## Diuretic Resistance

- 25-30% develop diuretic resistance
- Defined as reduced diuresis & natriuresis (urine output < 125 cc/hr or 1,500 mL in 12 hours)



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## Types of Diuretic Resistance

### “Braking” phenomenon

- A decrease in response to a diuretic after the first dose has been administered

### Long-term tolerance

- Tubular hypertrophy to compensate for salt loss

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## HFSA 2006 Practice Guideline (7.23) Loop Diuretics

Agent	Initial Daily Dose	Max Total Daily Dose	Elimination: Renal – Met.	Duration of Action
Furosemide	20-40mg qd or bid	600 mg	65%R-35%M	4-6 hrs
Bumetanide	0.5-1.0 mg qd or bid	10 mg	62%R/38%M	6-8 hrs
Torsemide	10-20 mg qd	200 mg	20%R-80%M	12-16 hrs
Ethacrynic acid	25-50 mg qd or bid	200 mg	67%R-33%M	6 hrs

Adams KF, Lindenfeld J, et al. HFSA 2006 Comprehensive Heart Failure Guideline. J Card Fail 2006;12:e1-e122

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## HF Decompensation

- ♥ Double the dose for a couple days
- ♥ Once a diuretic effect is achieved with short-acting loop diuretics, increase frequency to 2-3 times a day if necessary, rather than increasing a single dose.
- ♥ Add agents from different class (Zaroxolyn)
- ♥ Give IV bolus
- ♥ Change agent (develop tolerance)
- ♥ Try diuretic infusion over 4 hours (Bumex 4 mg)



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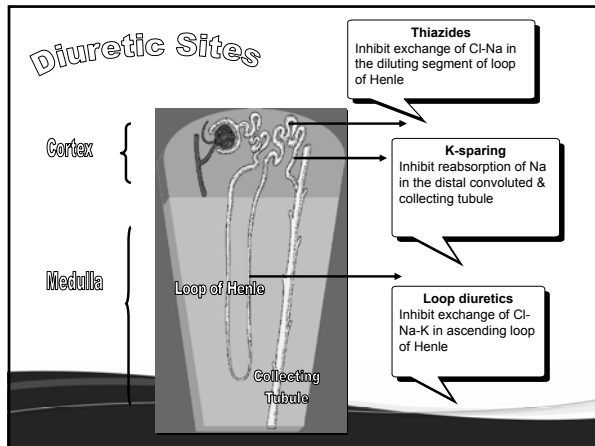
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### Diuretic Resistance Calculation Using UNa

- UNa < 50 generally means diuretic resistance → go to AQ
- UNa > 100 = just needs bigger dose of diuretic
- UNa 50-100 try giving higher dose diuretic. If trial is unsuccessful → go to AQ

John Wigneswaran, MD, PC, 2008

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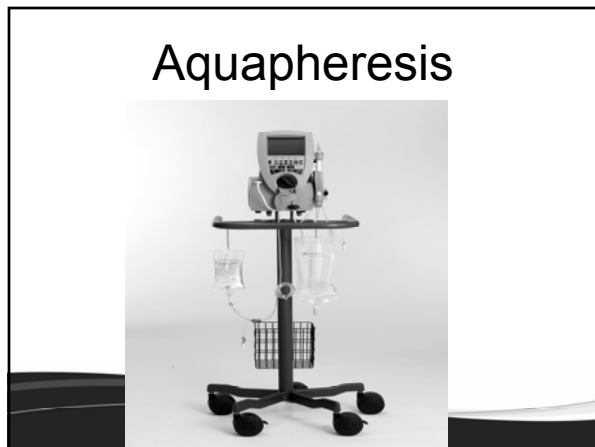
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## What is Aquapheresis?

- Advanced form of ultrafiltration
- Removes excess salt & water from the body **safely, predictably, and effectively**
- Has no clinical impact on blood pressure, heart rate or balance of electrolytes
- No adverse impact on renal function

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## Selected Guideline Updates



Ultrafiltration is reasonable for patients with refractory congestion not responding to medical therapy

(Class IIa, Level of Evidence B)

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## Unload Trial

(Ultrafiltration vs. IV diuretics for hospitalized acute decompensated heart failure patients)

Results at 90 days after discharge:

- ▼ **43%** reduction in patients requiring re-hospitalizations for heart failure (p=0.037)
- ▼ **50%** reduction in the total number of re-hospitalizations for heart failure (p=0.022)
- ▼ **52%** reduction in emergency department or clinic visits (p=0.009)
- ▼ **63%** reduction in total days re-hospitalized for heart failure (p=0.022)

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## When to use AQ

- ♥ Diuretic Resistance
- ♥ Extensive volume overload



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## Patient Selection Criteria

- At least > 10 lbs over dry weight
- Requires high daily diuretic doses
- Inadequate diuretic/natriuretic response (urine output < 125 cc/hr or 1,500 mL in 12 hours)



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## Exclusion of Patients

### **Impaired renal function**

- Serum Cr > 3.0 mg/dL or
- GFR < 30 mL/min
  
- Must be able to receive anticoagulation therapy



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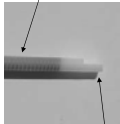
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## Line Selection

- Midline “coiled catheter”

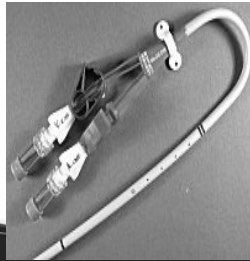
Steel coil



offset tip



- Internal jugular dialysis catheter



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## Anticoagulation Therapy

Needed to prolong the life of the filter

1. Heparin
  - a. Regular dose (best)
  - b. Low dose
  - c. If on Coumadin – may continue just hold heparin bolus & use low protocol
2. Argatroban
3. Refludan

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## Strategies for Success

- **Choose Appropriate Rate**
- **Choose Appropriate Goal**
- **Create a favorable environment**
  - Consider holding blood pressure medications
  - Hold diuretics during AQ therapy
  - Consider holding K+ therapy



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## Average UF Rates

- UF rate from 0 – 500 mL/hour
- Systolic HF – generally 200-250 mL/hour
- Diastolic HF (or other volume sensitive states such as hepatic disease, pulmonary distress, shock etc) – generally 100-150 mL/hour
- Then titrate according to vitals, labs, clinical assessment

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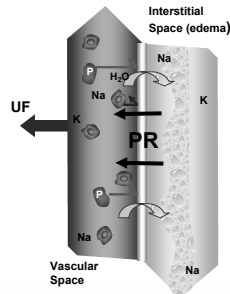
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## How Much... How Fast?

Ultrafiltration can remove fluid from the blood at the same rate that fluid can be naturally recruited from the tissue



1. Lauer et al. Arch Intern Med 1999;159:455-460.  
2. Hernandez et al. J Am Coll Cardiol 2001;38:4

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## New Hct Sensor

- Detects rise in Hct (sign of early volume depletion)
- Prevents drops in B/P, ↑in Cr
- Automatically stops pulling fluid off until reaches baseline Hct again



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### Expected UOP During AQ Therapy

- May be diminished since UF during the work
- May see sudden diuresis (seeing an artificial natriuresis from the AQ)



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### Average fluid removal at Mercy



- ♥ Current in-patient average fluid removal is 9 Liters in 36 continuous hours
- (High of 26.8 L in 7 days)
- ♥ Out-patient average is 6 liters in 3 separate 8 hour treatments

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### Aquapheresis vs Diuretic Salt removal in 9 L water loss 29.1 grams vs 12.8 grams of salt removal



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Fluid Removal Regimen	Total Dose of Diuretic	Complications	Weight Loss	LOS	Cost
AQ	None	None (Cr 1.2 → 1.4)	44 lbs	5 days after AQ started	\$30,764
Diuretic Drip w/ Thiazide	• 108 mg Bumex • 25 mg Zaroxoyln	• ↓ B/P requiring vasopressor support • Cr ↑ 3.8 requiring fluid boluses	12 lbs	13 day	\$58,586
Diuretic drip & bolus w/ Thiazide	• 90 mg Bumex • 60 mg Zaroxolyn • Diamox x9 doses	• Cr 1.2 → 2.0 Dopamine gtt	19 lbs	8 day	\$26,832

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**Long term, high dose diuretic damage**

Kidney perfused at 80 mm Hg

Kidney perfused at 180 mm Hg

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**Renal Function Post AQ Therapy**

N = 6	• No change on Cr
N = 15	• $\bar{x}$ improvement in Cr of 0.26 • Range of 0.1-1.0
N = 24	• $\bar{x}$ decline in Cr of 0.35 • Range of 0.1-1.5

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### Mercy Readmission Stats After AQ Therapy (N=45)

30 day HF	30 day All Cause	60 day HF	60 day All Cause	90 day HF	90 day All Cause
8.8%	6.6%	9.3%	13.9%	8.8%	14.7%
N=4	N=3	N=4	N=6	N=3	N=5

HF Readmission rates currently 5.8%  
with all cause readmission 22%

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### Bio Z Assessment

Applications:

- Differential diagnosis & therapy direction
- Assess effectiveness of treatment
- Up-titrate medications
- Pacemaker optimizations
- Qualifies patients for home infusions




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CHI CLINIC, 1111 0TH AVE., DES MOINES, IA 50314

Hemodynamic Status Report

Name: ID: Age: 67 Sex: Male Height: 5 ft 9 in Weight: 201 lb BSA: 2.07 m<sup>2</sup>

30 Beat Average Page 1 of 1

Parameter	Description	Value	Low	Normal	High
HR	Heart Rate	80	58	60	90
SBP	Systolic Blood Pressure	86	100	100	100
DBP	Diastolic Blood Pressure	44	60	60	60
MAP	Mean Arterial Pressure	55	60	100	100
CI	Cardiac Index	1.5	3.0	4.7	4.7
CO	Cardiac Output	3.2	3.0	5.7	5.7
SI	Stroke Index	19	30	60	60
SV	Stroke Volume	40	30	100	100
SVRI	Systemic Vascular Res. Index	2342	1000	1000	1000
SVR	Systemic Vascular Resistance	1136	100	1000	1000
ACI	Acceleration Index	41	70	100	100
VI	Velocity Index	16	30	60	60
TFC	Thoracic Fluid Content	45.2	30.0	30.0	30.0
LCWI	Left Cardiac Work Index	1.0	3.0	3.0	3.0
LCW	Left Cardiac Work	2.0	3.0	100	100
STR	Systolic Time Ratio	0.46	0.30	0.30	0.30
PEP	Pre-Ejection Period	118			
LVET	Left Ventricular Ejection Time	259			

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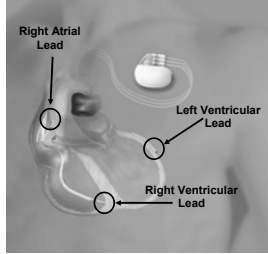
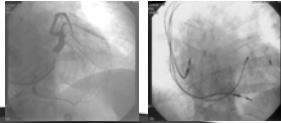
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## Achieving Cardiac Resynchronization

Goal: Atrial synchronous biventricular pacing  
 Transvenous approach for left ventricular lead via coronary sinus  
 Back-up epicardial approach




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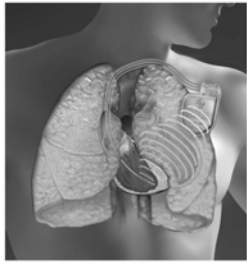
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## OptiVol to Assess Lung Fluid Status



Pulmonary Congestion:

↑ Fluid

↓ Impedance

As fluid accumulates in the thoracic space, intrathoracic impedance decreases

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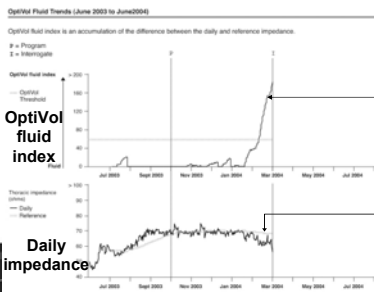
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## Assess Lung Fluid Status with Heart Failure Management Report



OptiVol fluid index tracks the accumulation of the difference between the Daily impedance and Reference impedance

Reference impedance slowly adapts to daily impedance

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## Why did the Fluid Index change?

- FLUID Change
  - ✓ PULMONARY EDEMA
  - ✓ Pocket Infection
  - ✓ Pericardial Effusion
  - ✓ Pleural Effusion
- BLOOD Change
  - Blood Volume Change
    - ✓ Chamber/Vessel Dilation
    - ✓ IV Fluid
    - ✓ Transfusion
  - Blood Composition Change
    - ✓ Hematocrit
    - ✓ Electrolyte
    - ✓ Dialysis




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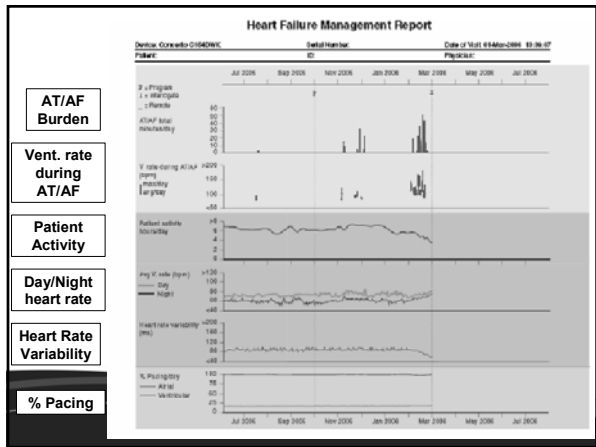
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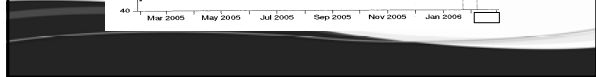
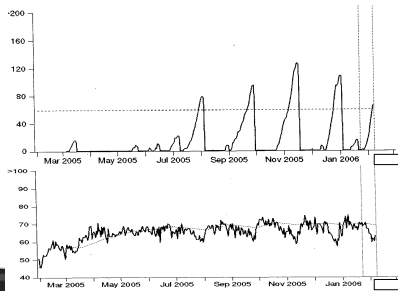
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## Medication Non-Compliance




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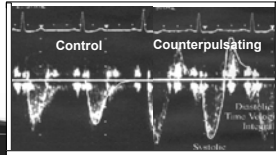






## Hemodynamic effects of EECF

- ♥ Increased diastolic perfusion pressure
- ♥ Increased coronary perfusion
- ♥ Increased collateral perfusion to ischemic areas
- ♥ Decreased left ventricular workload
- ♥ Increase cardiac output



Duplex Echocardiography of the Descending Aorta

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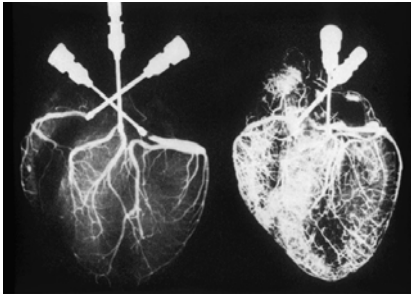
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## Collateral Development in Experimental Heart (Dog) Following Counterpulsation



Before

After

Jacobey JA, Taylor WJ, et al. *Am J Cardiol* 1993;11(2):219-27

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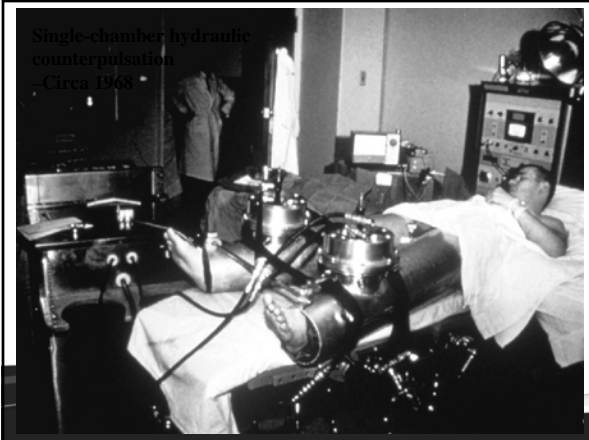
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Single-chamber hydraulic  
counterpulsation  
- Circa 1960s



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♥  
Questions

♥ *Before I came here I was confused about this subject. Having listened to your lecture I am still confused. But on a higher level.*

-Enrico Fermi



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