

Heart failure

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Definition

Heart failure (HF) is an abnormality of cardiac structure or function leading to failure of the heart to deliver oxygen at *a rate* commensurate with the requirements of the metabolizing tissues, despite *normal filling pressures* (or only at the expense of *increased filling pressures*)



Risk Factors for HF

- Coronary artery disease
- Hypertension (LVH)
- Valvular heart disease
- Alcoholism
- Infection (viral)
- Diabetes
- Congenital heart defects
- Other:
 - Obesity
 - Age
 - Smoking
 - High or low hematocrit level
 - Obstructive Sleep Apnea

Epidemiology of Heart Failure

- Approximately 1–2% of the adult population in developed countries has HF, with the prevalence rising to $\geq 10\%$ among persons 70 years of age or older ¹
- “...one-year mortality of approximately 45 percent.” ²
- “Survival ranges from 80% at 2 years for patients rendered free of congestion to less than 50% at 6 months for patients with refractory symptoms.” ³

¹ ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012

² Jessup M, Brozena S, Medical Progress: Heart Failure, NEJM, 348(20): 2007-18, 2003.

³ Nohria A, et al, Medical Management of Advanced Heart Failure, JAMA, 287(5): 628-40, 2002.

Poor ventricular function/myocardial damage
(eg post myocardial infarction, dilated cardiomyopathy)

Heart failure

Decreased stroke volume and cardiac output

Neurohormonal response

Activation of sympathetic system

Renin angiotensin aldosterone system

- Vasoconstriction: increased sympathetic tone, angiotensin II, endothelins, impaired nitric oxide release
- Sodium and fluid retention: increased vasopressin and aldosterone

Further stress on ventricular wall and dilatation (remodelling)
leading to worsening of ventricular function

Further heart failure

Types of Heart Failure

- **Systolic** (or squeezing) heart failure
 - Decreased pumping function of the heart,
- **Diastolic** (or relaxation) heart failure
 - The heart does not fill with blood properly

Systolic dysfunction

- The heart no longer works well in **systole**: it does not **contract** well.
- Most common cause is CAD and infarctions, with remodeling of the ventricular wall.
- Cardiomyopathies can also cause systolic dysfunction CHF.

Diastolic dysfunction

- Stiff, fibrotic LV muscle **does not relax** in **diastole**, does not **fill** enough.
- The ventricle “fights” against **hypertension** and against increased **afterload** by becoming “stronger” and the heart muscle **hypertrophies**.
- Concentric hypertrophy, directed inwardly, encroaches on the LV cavity.
- Thus, reduced end diastolic volume, reduced stroke volume, reduced cardiac output.

Diastolic dysfunction over time:

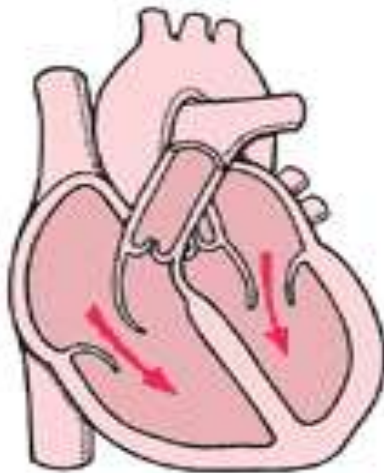
- As it progresses, CAD will often develop and the pathology will overlap with systolic dysfunction.

Normal

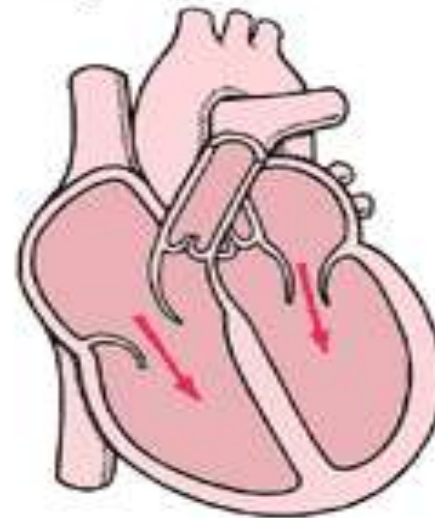
Systolic Dysfunction

Diastolic Dysfunction

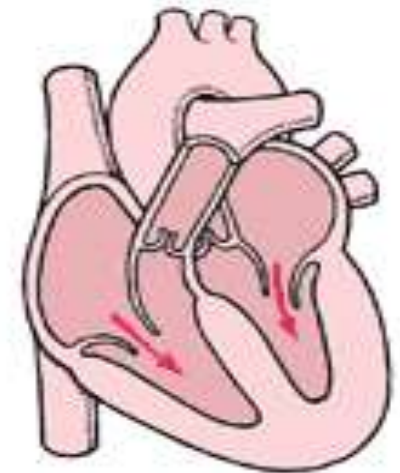
Diastole
(filling)



The ventricles fill normally with blood.

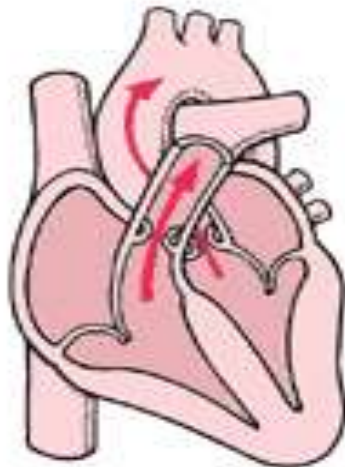


The enlarged ventricles fill with blood.

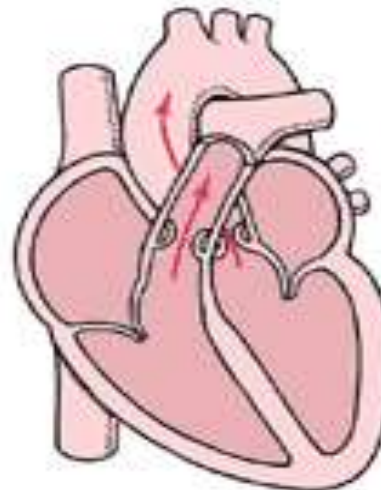


The stiff ventricles fill with less blood than normal.

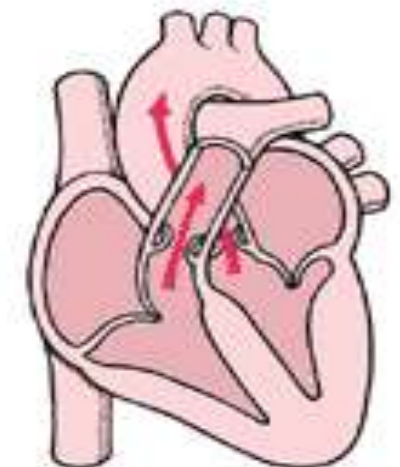
Systole
(pumping)



The ventricles pump out about 60% of the blood.



The ventricles pump out less than 40 to 50% of the blood.



The ventricles pump out about 60% of the blood, but the amount may be lower than normal.

HIGH OUTPUT FAILURE

Non-cardiac circulatory overload

- **Etiology**
 - fistula / anemia / pregnancy / hyperT4
- **Pathophysiology**
- ↑SV
- ↑CO at rest
- ↑blood volume due to xs Na/H₂O
- **Symptoms/ Signs** : congestion

Approach to HF diagnostics

- I. Symptoms and signs of HF (at rest or during exertion)
- II. Objective signs of systolic or diastolic cardiac dysfunction (preferably in echocardiography) at rest
- III. Positive changes on treatment (in questionable diagnosis of HF)

Criteria I и II are obligatory

Signs and Symptoms of Heart Failure

– Shortness of Breath (dyspnea)

- **WHY?**

- Blood “backs up” in the pulmonary veins because the heart can’t keep up with the supply and fluid leaks into the lungs

- **SYMPTOMS**

- Dyspnea on exertion or at rest
- Difficulty breathing when lying flat
- Waking up short of breath

Signs and Symptoms of Heart Failure

– Persistent Cough or Wheezing

- **WHY?**

- Fluid “backs up” in the lungs

- **SYMPTOMS**

- Coughing that produces white or pink blood-tinged sputum

Signs and Symptoms of Heart Failure

– Edema

- WHY?

- Decreased blood flow out of the weak heart
- Blood returning to the heart from the veins “backs up” causing fluid to build up in tissues

- SYMPTOMS

- Swelling in feet, ankles, legs or abdomen
- Weight gain

One of the Best Devices for Monitoring Heart Failure



Signs and Symptoms of Heart Failure

– Tiredness, fatigue

- **WHY?**

- Heart can't pump enough blood to meet needs of bodies tissues
- Body diverts blood away from less vital organs (muscles in limbs) and sends it to the heart and brain

- **SYMPTOMS**

- Constant tired feeling
- Difficulty with everyday activities

Signs and Symptoms of Heart Failure

– Lack of appetite/ Nausea

- WHY?

- The digestive system receives less blood causing problems with digestion

- SYMPTOMS

- Feeling of being full or sick to the stomach

Signs and Symptoms of Heart Failure

– Confusion/ Impaired thinking

- **WHY?**

- Changing levels of substances in the blood (sodium) can cause confusion

- **SYMPTOMS**

- Memory loss or feeling of disorientation
- Relative or caregiver may notice this first

Signs and Symptoms of Heart Failure

– Increased heart rate

- **WHY?**

- The heart beats faster to “make up for” the loss in pumping function

- **SYMPTOMS**

- Heart palpitations
- May feel like the heart is racing or throbbing

Sinus Tachycardia

Cardiac Output = Heart Rate x Stroke Volume

- If SV is reduced and fixed by heart failure, then an increase in CO will require an increase in HR.
- ***Always suspect HF in a patient with unexplained sinus tachycardia.***

LOCATION

Heart failure classified according to location of ventricular failure

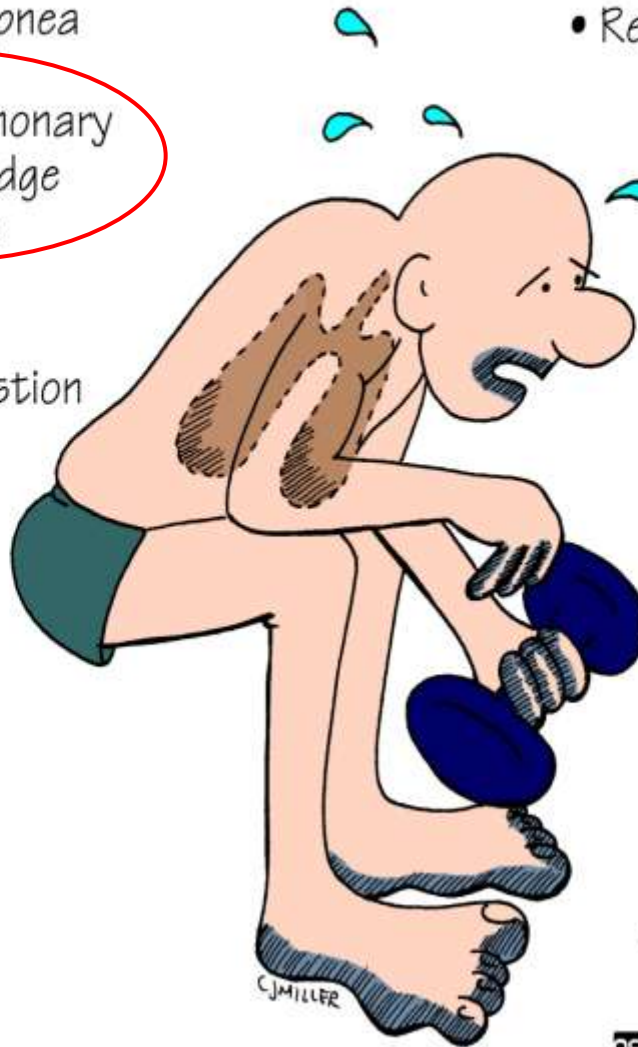
One ventricle may fail independently of another, but failure in one will impact on the other.

L sided failure- **pulmonary congestion**

R sided failure- **peripheral congestion**

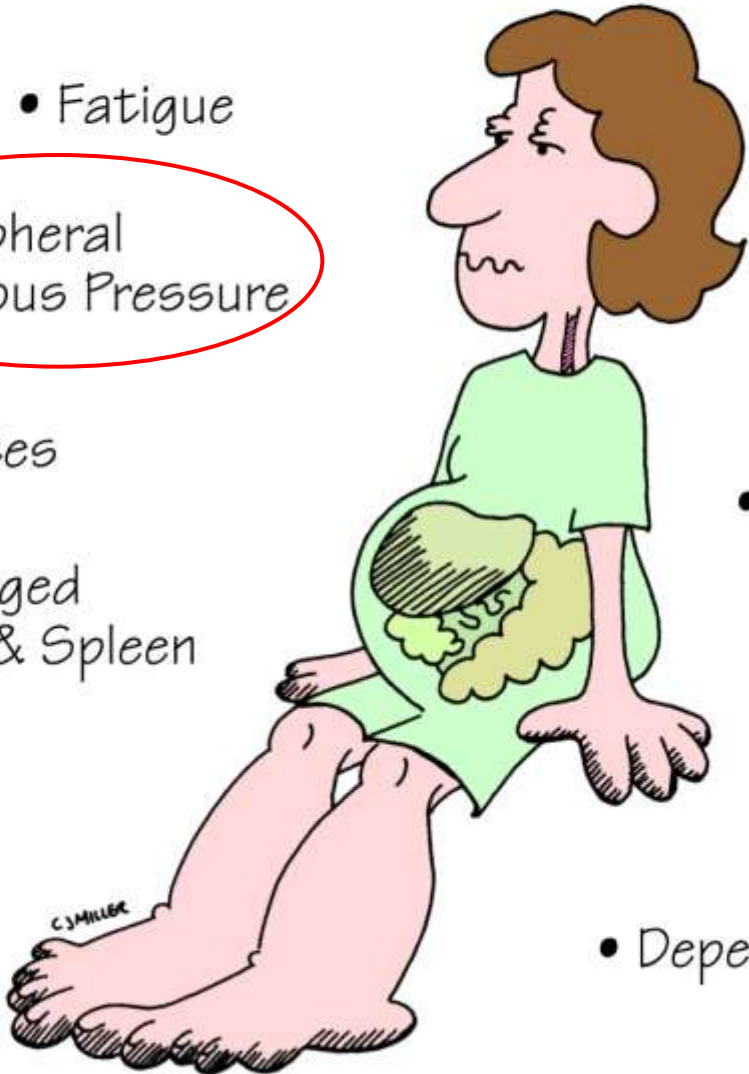
LEFT SIDED ♥ FAILURE

- Paroxysmal Nocturnal Dyspnea
 - Elevated Pulmonary Capillary Wedge Pressure
 - Restlessness
 - Confusion
 - Orthopnea
 - Tachycardia
 - Exertional Dyspnea
 - Fatigue
 - Cyanosis
- Pulmonary Congestion
 - Cough
 - Crackles
 - Wheezes
 - Blood-Tinged Sputum
 - Tachypnea



RIGHT SIDED ♥ FAILURE

(Cor Pulmonale)

- Fatigue
 - ↑ Peripheral Venous Pressure
 - Ascites
 - Enlarged Liver & Spleen
 - May be secondary to chronic pulmonary problems
 - Distended Jugular Veins
 - Anorexia & Complaints of GI Distress
 - Swelling in Hands & Fingers
 - Dependent Edema
- 

Differential diagnosis of HF

- **Dyspnoe** (respiratory system diseases, anemia, obesity, poor physical status (detraining), central nervous system diseases)
- **Cough** (respiratory system diseases, side effects of drugs)
- **Tachycardia** (thyrotoxicosis, anemia, caffeine)
- **Fatigue** (cancer, diabetes, anemia, poor physical status)
- **Oedema** (renal diseases, malabsorption, vein insufficiency, lymphostasis, myxedema)
- **Hepatomegaly** (liver diseases, myelogenous leukemia, Budd-Chiari syndrome)
- **Pleural effusion** (pleurisy inf- / meta-, connective tissue diseases, myxedema, kidney diseases)
- **Ascites** (meta - Meigs syndrome, portal hypertension, kidney diseases, myxedema).

Clinical features of HF

- **The difficulties of interpretation - older age, obesity, female**
- **Evaluation of symptoms in a variety of situations (at rest, during exertion, in at night)**

Clinical features of HF

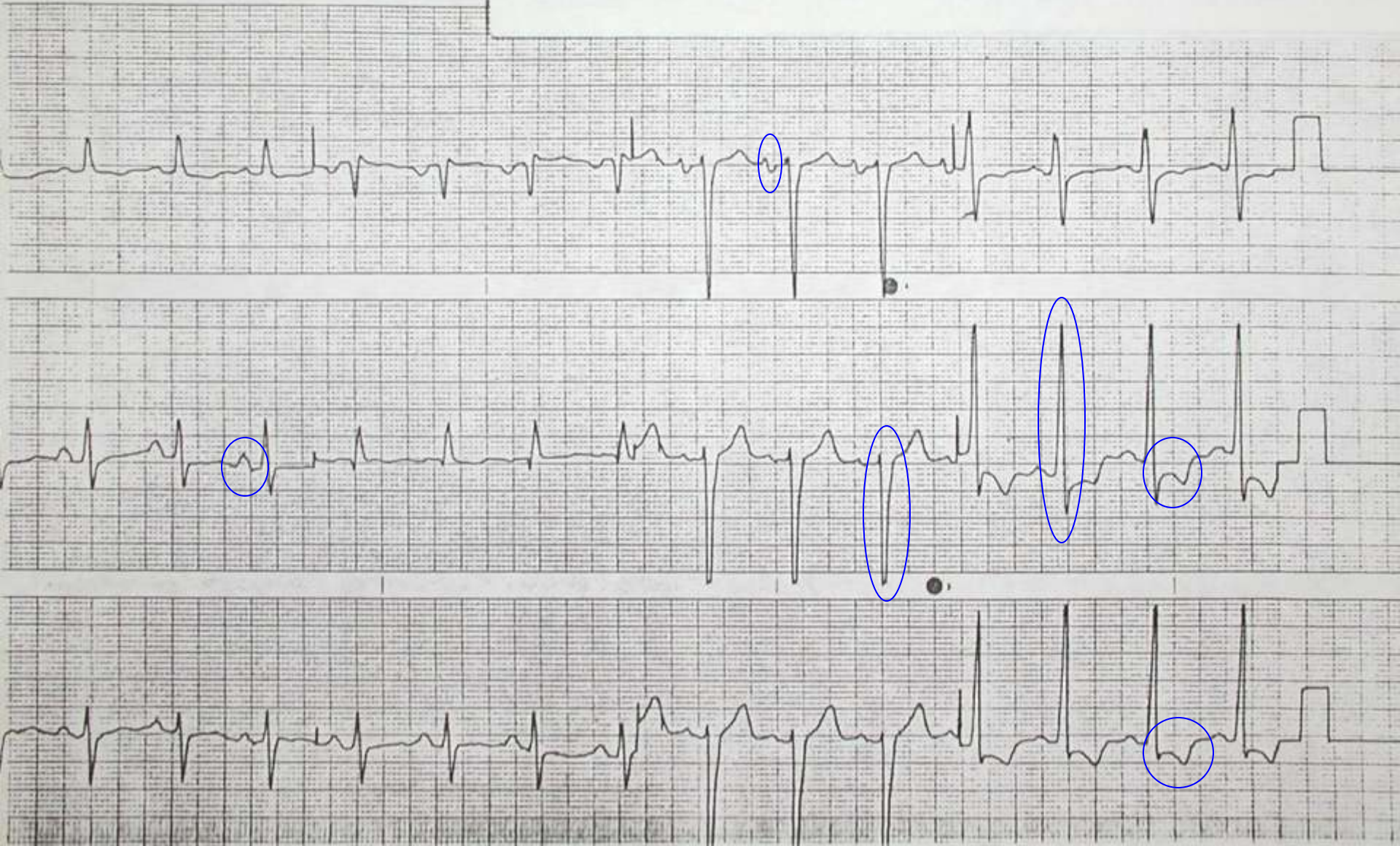
- After confirming the **diagnosis** of HF clinical symptoms/signs can be used to determine the **severity** of heart failure and to evaluate the **effectiveness** of treatment.
- But clinical symptoms should NOT be used for **dose titration** of neurohormonal systems blockers.

ECG in HF

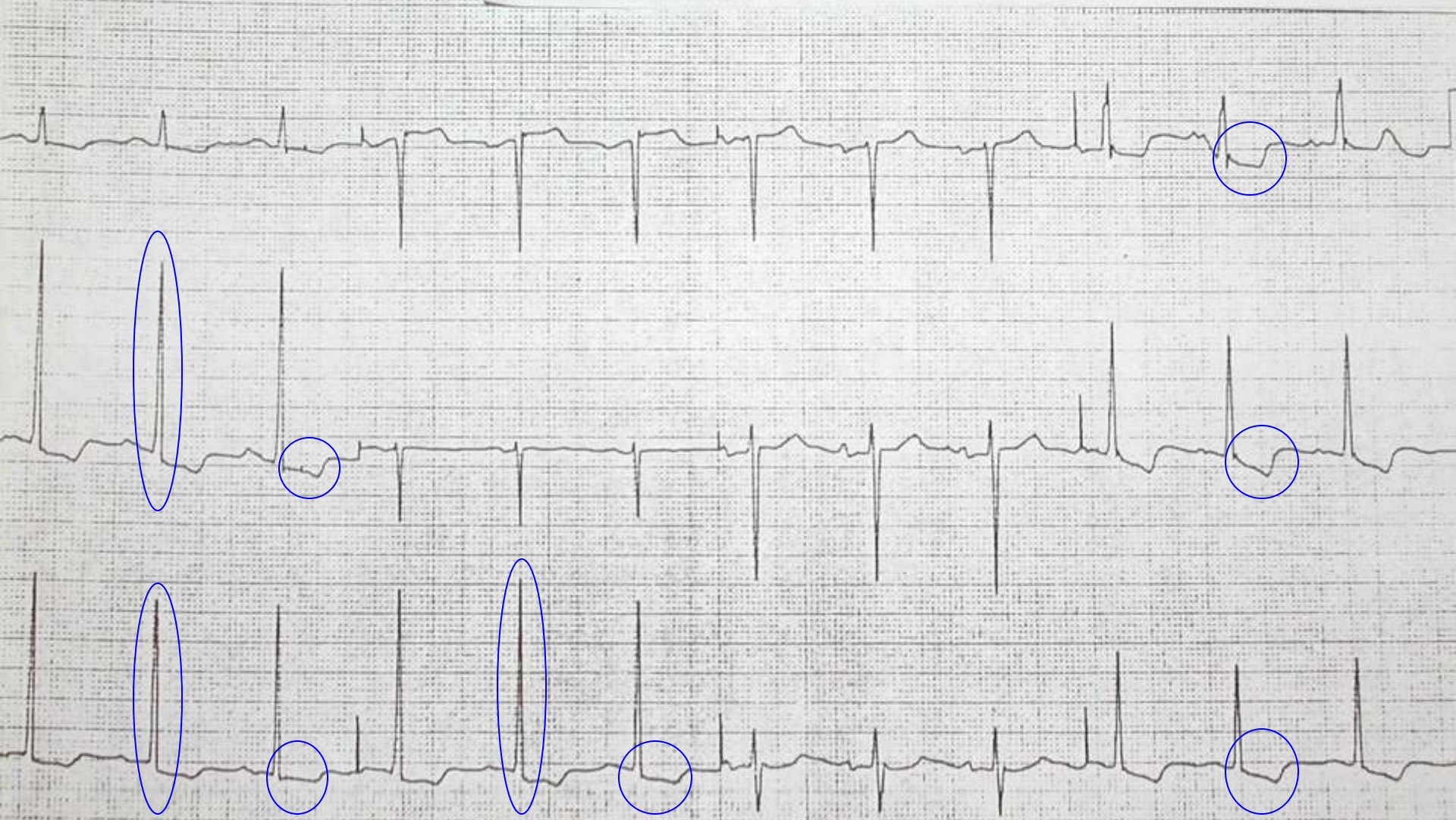
- **Normal ECG requires a re-evaluation of the diagnosis, especially due to LV systolic dysfunction**
- **Q wave – previous AMI as the cause of HF CH**
- **Signs of cardiac chambers hypertrophy**
- **Rhythm abnormalities**

NO-00
17-00
396
114

(H)



50YR AVR-OVR OTHR MA
MED UNKNOWN
PC 01 IND 00 OUT/NO-QC
ECG TAKEN 10-FEB-89 09:
VENT. RATE 72 BPM
PR INTERVAL 180 MS
QRS DURATION 96 MS
QT/QTc 368/398 MS
P-R-T AXES 39 82 248



Chest X-ray investigation in HF

- **Detection of cardiomegaly (cardiac enlargement, pericardial effusion)**
- **Detection of pulmonary congestion**

Chest X-ray: cardiomegaly and pulmonary congestion

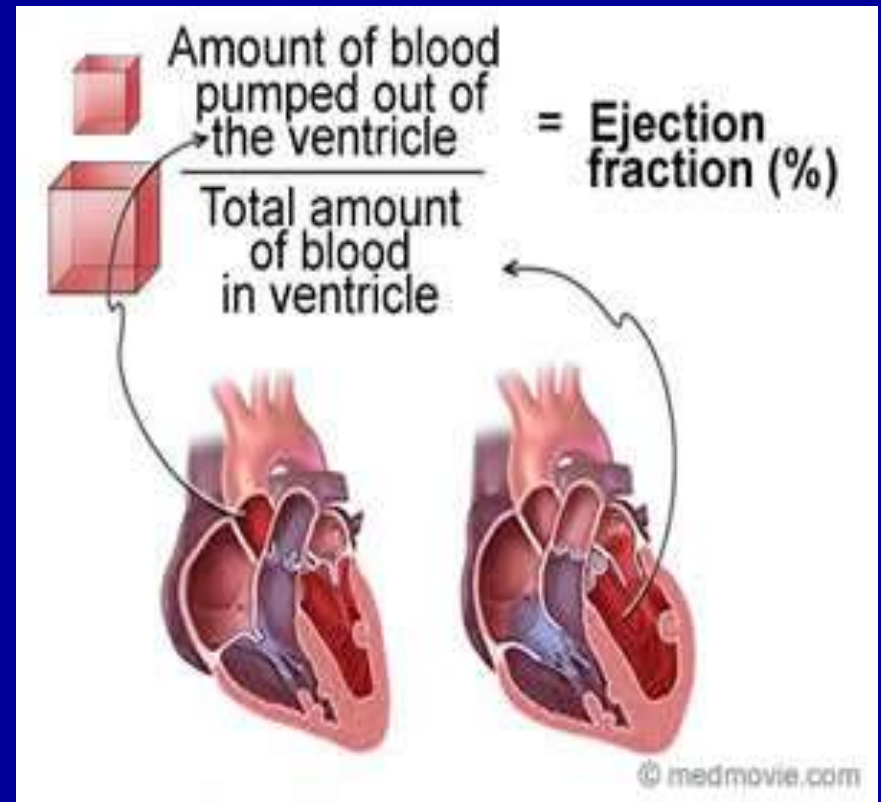


Echocardiography

- **The method of choice** for confirmation of cardiac dysfunction at rest
- The main indicator of left ventricular systolic function - **left ventricular ejection fraction** (LVEF): distinguishing HF with reduced (LVEF < 40%) and preserved LV systolic function
- **Cause of HF** – postMI scars, valvular abnormalities, hypertrophy, pericardial effusion and so on...

Ejection Fraction (EF) : a Key Indicator for Diagnosing Heart Failure

Ejection Fraction (EF) is the percentage of blood that is pumped out of the ventricle during each beat



Evaluation of diastolic LV function

Indications:

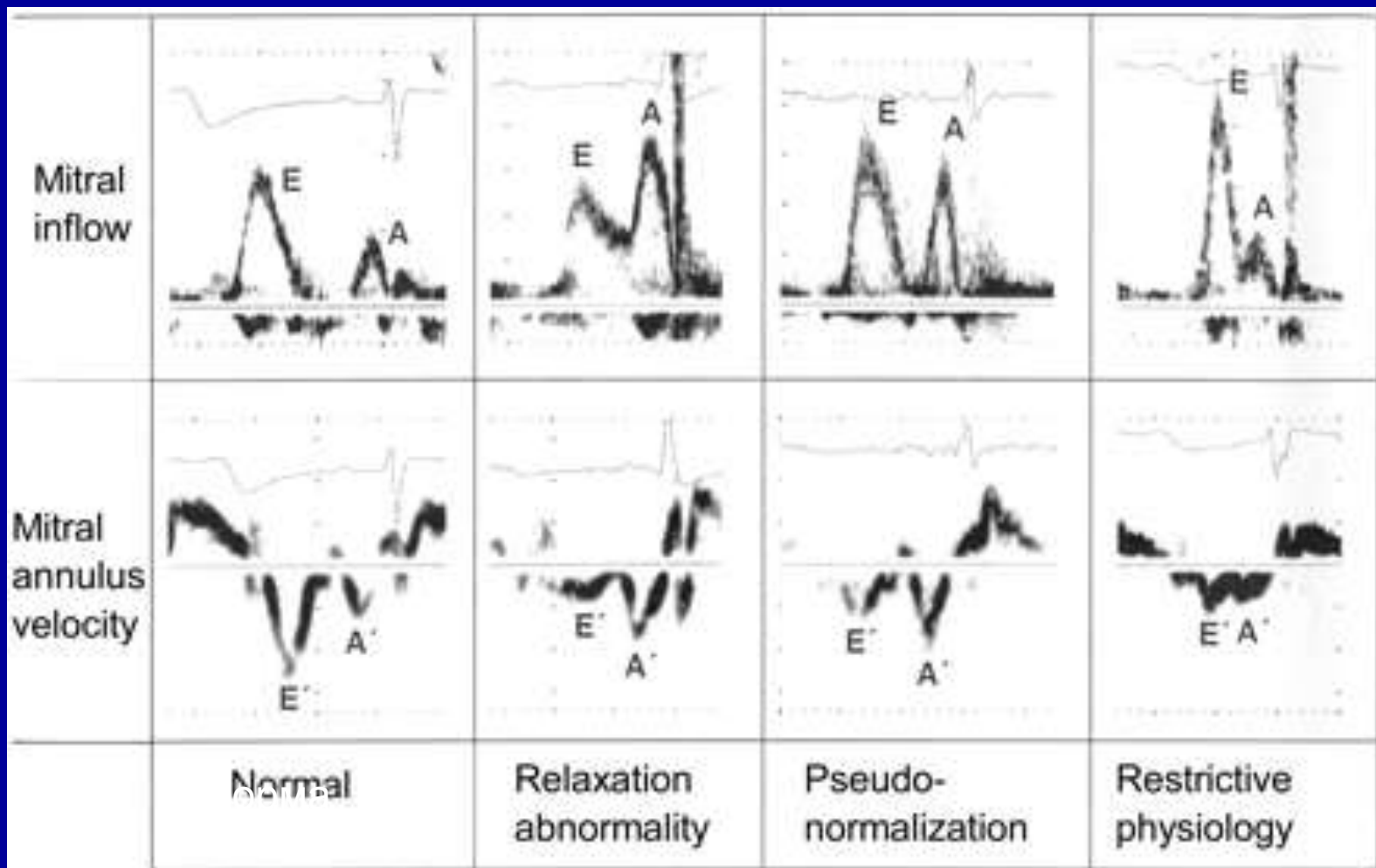
- clinical symptoms of heart failure with normal ejection fraction
- determination of prognosis in heart failure
- non-invasive measurement of diastolic pressure in the left ventricle
- diagnostics of constrictive pericarditis
- diagnosis of restrictive cardiomyopathy

Diagnostic criteria for diastolic dysfunction

Diagnosis is confirmed by the presence of all three components:

- 1. Clinical symptoms/signs of heart failure**
- 2. Normal or slightly reduced (45-50%) left ventricular ejection fraction**
- 3. Signs of abnormal relaxation, flexibility and rigidity of the LV**

Three types of LV diastolic dysfunction



Additional non-invasive methods of investigation in HF

- **Indications:**

- Noninformative resting echocardiography
- Severe / refractory heart failure in ischemic heart disease

- **Methods:**

- Stress echocardiography
- radionuclide investigation
- Magnetic resonance imaging

Measurements of lung function

- **Performed to rule out pulmonary disease as a cause of dyspnea**
- **Spirometry for the assessment of severity of COPD which often co-exists with HF**

Stress testing in heart failure

Normal results of stress tests rule out heart failure!

Aims of stress tests:

- Prognostic evaluation
- Evaluation of the functional class of HF
- Evaluating the effectiveness of therapy

Holter ECG monitoring

Indications:

- identification of arrhythmias (atrial and ventricular)
- evaluation of their characteristics (frequency, duration)

Invasive methods of investigation in HF

The purpose of invasive methods of investigation:

- clarification of the cause of HF
- prognosis evaluation

HF: lab tests

- **Complete blood test (Hb, leucocytes, platelets)**
- **Serum electrolytes (Na, K)**
- **Renal function tests**
- **Glucose**
- **Urine analysis**
- **Liver function tests**
- **Additional tests:**
 - **Thyroid gland function evaluation**

Biomarkers in HF

Natriuretic peptides (B-type natriuretic peptide (BNP) and N-terminal pro B-type natriuretic peptide (NT-proBNP))

- Diagnosis or exclusion of HF
- Prognosis of HF

Biomarkers of myocardial injury

- Acute HF

Natriuretic peptides Brain Natriuretic peptide

- For patients presenting with acute onset or worsening of symptoms, the optimal exclusion cut-off point is < 300 pg/mL for NT-proBNP and < 100 pg/mL for BNP
- For patients presenting in a non-acute way, the optimum exclusion cut-off point is < 125 pg/mL for NT-proBNP and < 35 pg/mL for BNP.

Classification of HF

- **Stage** (after Vasilenko-Strazhesko):
I; II-A; II-B; III
- **Variant of HF:**
 - With preserved LV systolic function
 - With reduced LV systolic function (EF <50%)
- **Functional class** according to NYHA (New York Heart Association) I-IV

HF Stages

(after Vasilenko- Strazhesko)

Stage I - the initial stage the latent heart failure, marked only with exertion (dyspnea, palpitations, fatigue). Hemodynamics is normal.

Stage II - a long standing, severe form of heart failure. Overt hemodynamic abnormalities are present at rest

Substage A – hemodynamic abnormalities are moderate and are present only in one (large or small) circulation circle, i.e. **one ventricular** (left or right) **failure**

Substage B – hemodynamic abnormalities are severe and are present throughout the cardiovascular system (manifested in the large AND small circulation circles), i.e. **biventricular** failure

Stage III - the final, dystrophic stage with severe hemodynamics impairment, significant disorders of metabolism and irreversible changes in the structure of tissues and organs.

NYHA Functional Classification

I: Asymptomatic - No symptoms or limitations in ordinary physical activity

II: Symptomatic with moderate exertion - Mild symptoms and slight limitation during ordinary activity

III: Symptomatic with minimal exertion - Marked limitation in activity even during minimal activity. Comfortable only at rest

IV: Symptomatic at rest (cardiac cripple) - Severe limitation. Experiences symptoms even at rest

ACC-AHA Stages of HF

- A: At high risk for HF but WITHOUT structural heart DISEASE or symptoms of HF
- B: Structural heart disease but WITHOUT SYMPTOMS of HF
- C: Structural heart disease with prior or current symptoms of HF
- D: Refractory HF requiring specialized interventions

Lifestyle Changes

What

- Eat a low-sodium, low-fat diet
- Lose weight
- Stay physically active
- Reduce or eliminate alcohol and caffeine
- Quit Smoking

Why

- Sodium is bad for high blood pressure, causes fluid retention
- Extra weight can put a strain on the heart
- Exercise can help reduce stress and blood pressure
- Alcohol and caffeine can weaken an already damaged heart
- Smoking can damage blood vessels and make the heart beat faster

Heart Failure Treatments: Medication Types

Type	What it does
•ACE inhibitor (angiotensin-converting enzyme)	•Expands blood vessels which lowers blood pressure, neurohormonal blockade
•ARB (angiotensin receptor blockers)	•Similar to ACE inhibitor—lowers blood pressure
•Beta-blocker	•Reduces the action of stress hormones and slows the heart rate
•Digoxin	•Slows the heart rate and improves the heart's pumping function (EF)
•Diuretic	•Filters sodium and excess fluid from the blood to reduce the heart's workload
•Aldosterone blockade	•Blocks neurohormal activation and controls volume

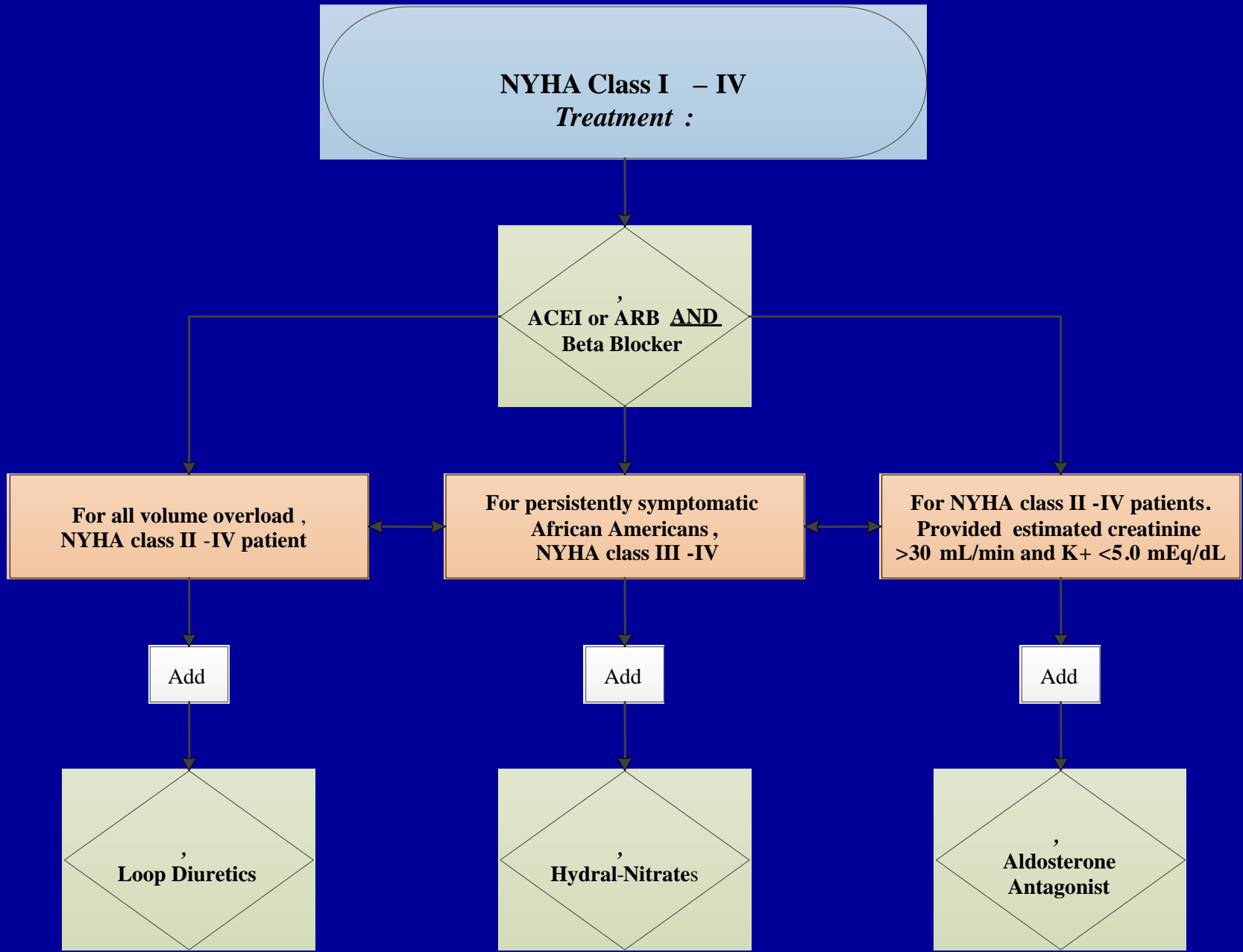
Doses of Drugs Commonly Used for HF

Drug	Initial Daily Dose(s)	Maximum Doses(s)	Mean Doses Achieved in Clinical Trials
<i>ACE Inhibitors</i>			
Captopril	6.25 mg 3 times	50 mg 3 times	122.7 mg/d (421)
Enalapril	2.5 mg twice	10 to 20 mg twice	16.6 mg/d (412)
Fosinopril	5 to 10 mg once	40 mg once	-----
Lisinopril	2.5 to 5 mg once	20 to 40 mg once	32.5 to 35.0 mg/d (444)
Perindopril	2 mg once	8 to 16 mg once	-----
Quinapril	5 mg twice	20 mg twice	-----
Ramipril	1.25 to 2.5 mg once	10 mg once	-----
Trandolapril	1 mg once	4 mg once	-----
<i>ARBs</i>			
Candesartan	4 to 8 mg once	32 mg once	24 mg/d (419)
Losartan	25 to 50 mg once	50 to 150 mg once	129 mg/d (420)
Valsartan	20 to 40 mg twice	160 mg twice	254 mg/d (109)
<i>Aldosterone Antagonists</i>			
Spirolactone	12.5 to 25 mg once	25 mg once or twice	26 mg/d (424)
Eplerenone	25 mg once	50 mg once	42.6 mg/d (445)

Doses of Drugs Commonly Used for HF (cont.)

Drug	Initial Daily Dose(s)	Maximum Doses(s)	Mean Doses Achieved in Clinical Trials
<i>Beta Blockers</i>			
Bisoprolol	1.25 mg once	10 mg once	8.6 mg/d (118)
Carvedilol	3.125 mg twice	50 mg twice	37 mg/d (446)
Carvedilol CR	10 mg once	80 mg once	-----
Metoprolol succinate extended release (metoprolol CR/XL)	12.5 to 25 mg once	200 mg once	159 mg/d (447)
<i>Hydralazine & Isosorbide Dinitrate</i>			
Fixed dose combination	37.5 mg hydralazine/ 20 mg isosorbide dinitrate 3 times daily	75 mg hydralazine/ 40 mg isosorbide dinitrate 3 times daily	~175 mg hydralazine/90 mg isosorbide dinitrate daily
Hydralazine and isosorbide dinitrate	Hydralazine: 25 to 50 mg, 3 or 4 times daily and isosorbide dinitrate: 20 to 30 mg 3 or 4 times daily	Hydralazine: 300 mg daily in divided doses and isosorbide dinitrate 120 mg daily in divided doses	-----

Pharmacologic Treatment of HF



Pharmacologic Treatment of HF

Digoxin can be beneficial in patients with HF/rEF, unless contraindicated, to decrease hospitalizations for HF. Never proven to decrease mortality

- Reduce HR in A Fib.
- Fourth line therapy, after ACE-I, beta-blockers, diuretics..
- Avoid in patients in sinus with diastolic dysfunction.

Diuretics

- Still best for acute symptoms of volume overload.
- Not to be used *alone*. Used alone, they become increasingly ineffective. Can be counter-productive, in decreasing volume, renal perfusion, activating RAA, promoting tachycardia.
- Loop diuretics most potent.
- Furosemide usually the first line, although HCTZ could be used.
- Only loop diuretics are effective in renal failure.
 - Furosemide (20 – 320 mg /day),
 - **Torsemide** (20-200mg/day)

Pharmacologic Treatment of HF

Hormonal therapies other than to correct deficiencies **are not recommended** for patients with current or prior symptoms of HF r EF.

Drugs known to adversely affect the clinical status of patients with current or prior symptoms of HF r EF **are potentially harmful** and should be avoided or withdrawn whenever possible (e.g., most antiarrhythmic drugs, most calcium channel blocking drugs (except amlodipine), NSAIDs).

Pharmacologic Treatment of HF

Long-term use of infused positive inotropic drugs is potentially harmful for patients with HF \neq EF, except as palliation for patients with end-stage disease who cannot be stabilized with standard medical treatment

Calcium channel blocking drugs are not recommended as routine treatment for patients with HF \neq EF.

Nutritional supplements as treatment for HF are not recommended in patients with current or prior symptoms of HF \neq EF.

Treatment of HFpEF

Systolic and diastolic **blood pressure** should be controlled according to published clinical practice guidelines

Diuretics should be used for relief of symptoms due to volume overload

Coronary revascularization for patients with CAD in whom angina or demonstrable myocardial ischemia is present despite GDMT (guideline- directed medical therapy)

Management of AF according to published clinical practice guidelines for HFpEF to improve symptomatic HF

Use of **beta-blocking** agents, **ACE inhibitors**, and **ARBs** for hypertension in HFpEF

Nutritional supplementation is not recommended in HFpEF

Rational for Medications

(Why does my doctor have me on so many pills??)

- Improve Symptoms

- Diuretics (water pills)
- digoxin



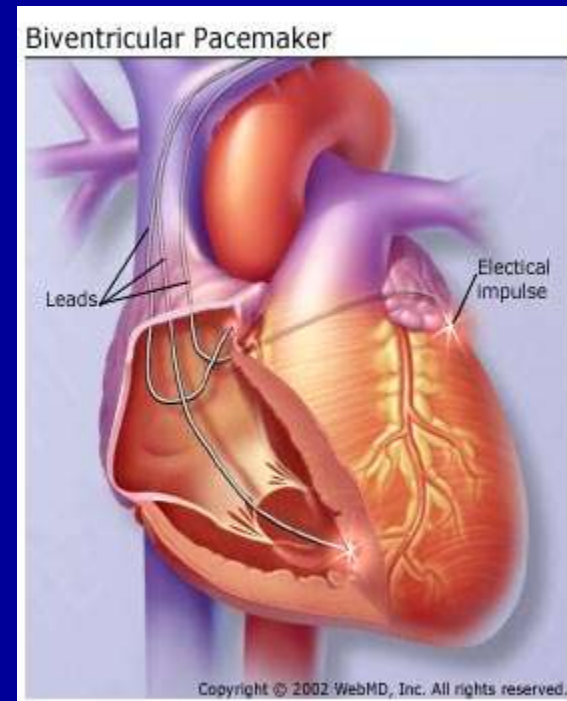
- Improve Survival

- Betablockers
- ACE-inhibitors
- Aldosterone blockers
- Angiotensin receptor blockers (ARB's)

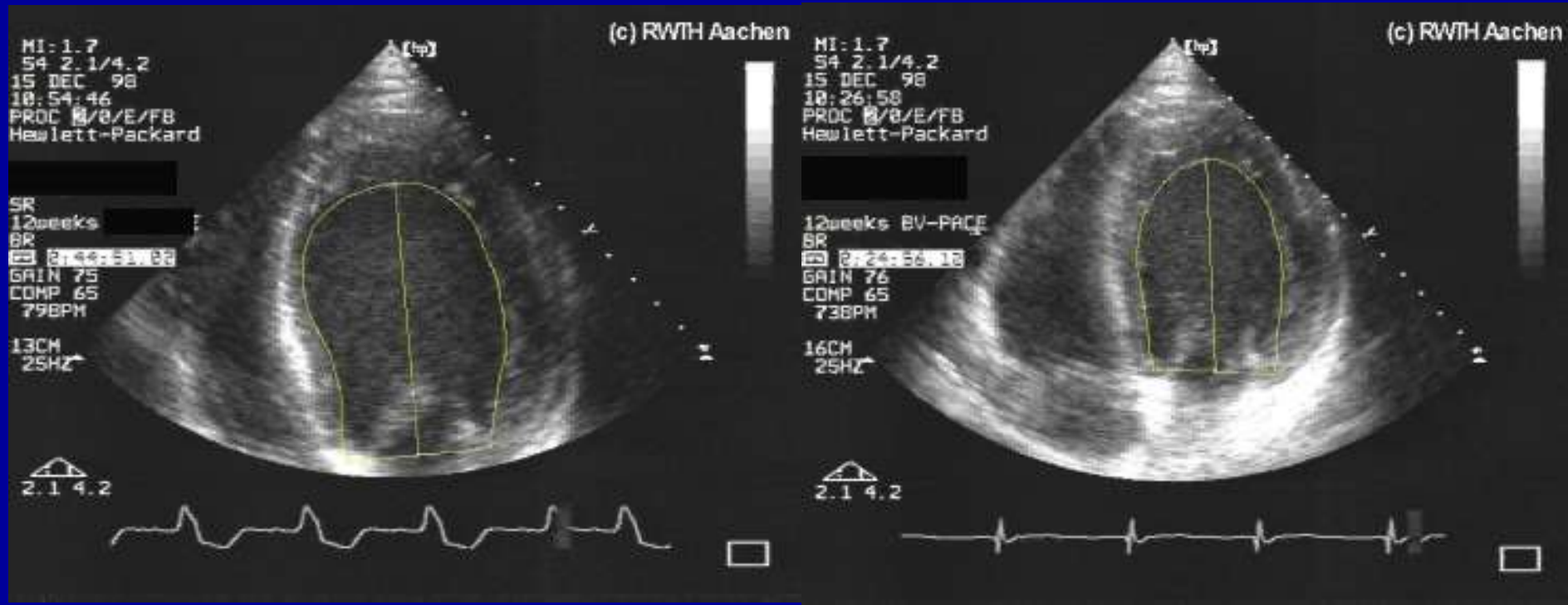
Biventricular Pacing

Ventricular Dysynchrony

- Abnormal ventricular conduction resulting in a mechanical delay and dyssynchronous contraction



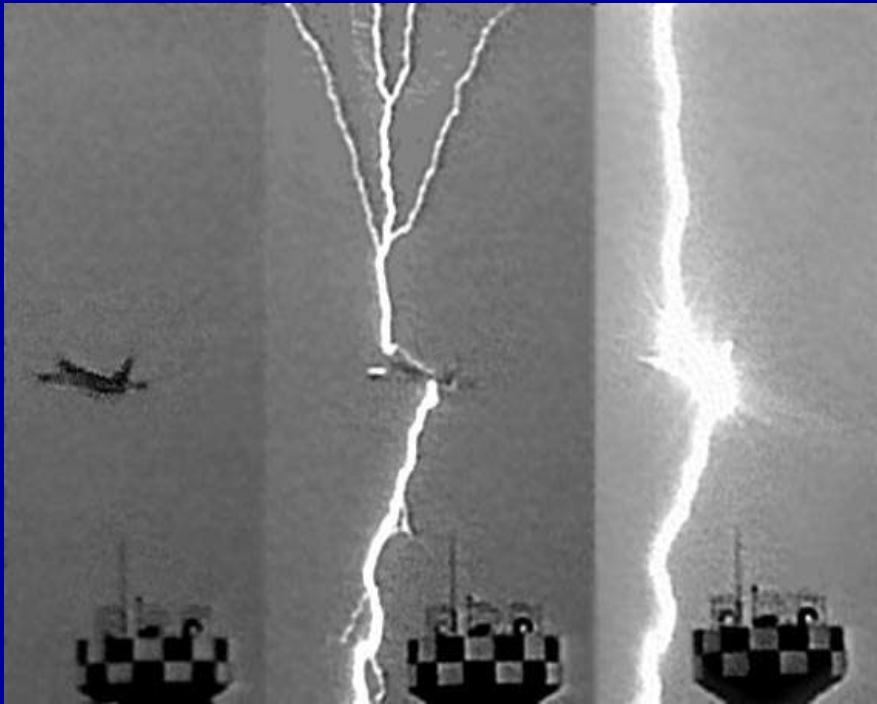
BiV Pacing



Cardiac Resynchronization Therapy: Indications

- Moderate to severe CHF who have failed **optimal** medical therapy
- EF < 30%
- Evidence of electrical conduction delay

Current Indications for Implantable cardioverter-defibrillator (ICD)



- Patients at high risk for ventricular arrhythmias
- Patients with EF < 35% and NYHA class II or III heart failure
- Patients with a history of MI and EF < 30%

Goldberger, Z, Implantable Cardioverter-Defibrillators, JAMA, February 15, 2006; 295:7, pp 809 - 818

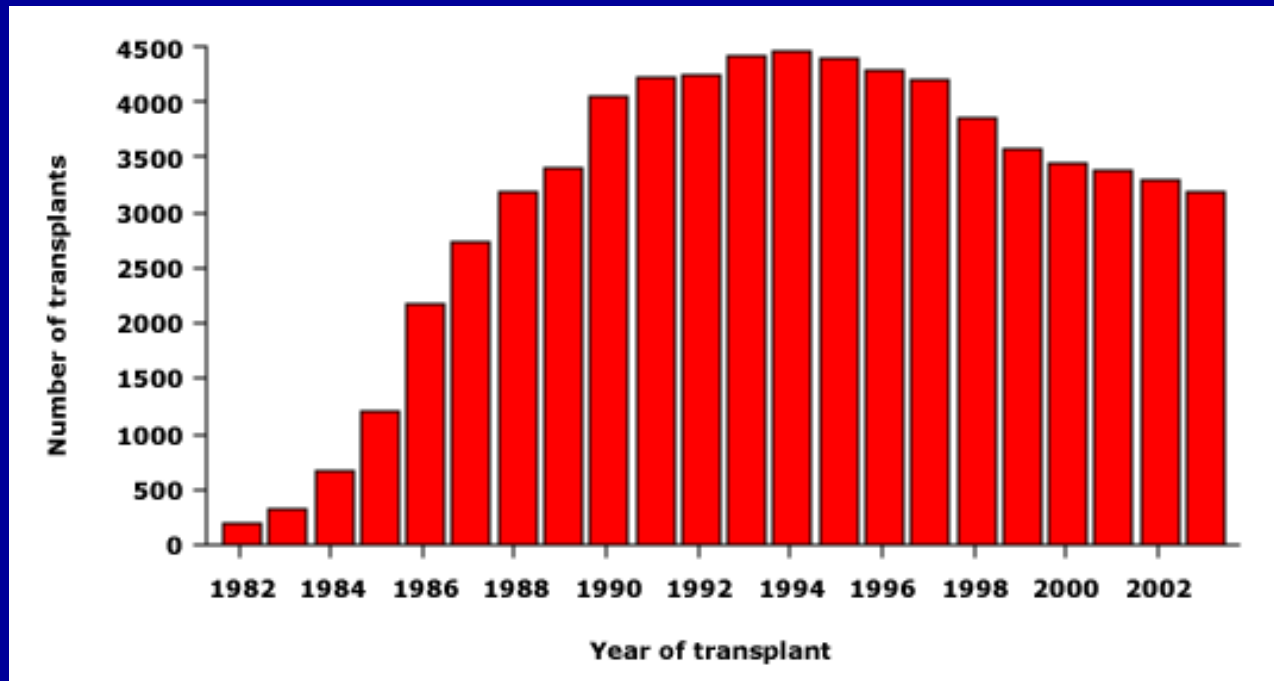
Other Therapies?

- Transplant
- Artificial hearts

Heart Transplantation

- A good solution to the failing heart— get a new heart
- Unfortunately we are limited by supply, not demand
- Approximately 2200 transplants are performed yearly in the US, and this number has been stable for the past 20 years.

Worldwide Heart Transplants



Newer Generation Artificial Hearts

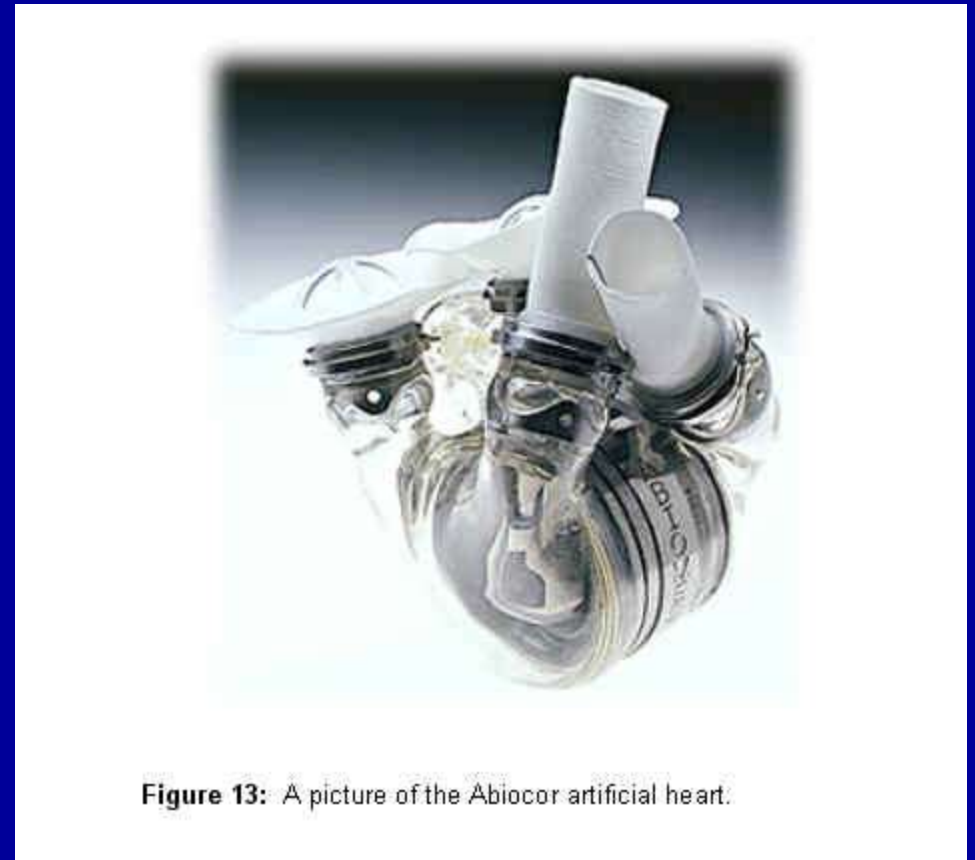


Figure 13: A picture of the Abiocor artificial heart.

DECEMBER 10, 1984

\$1.95

TIME

THE TAX WAR BEGINS
Reagan Weighs
A Sweeping
Reform



MEDICAL MIRACLES

**But How to
Pay the Bill?**

Surgeon
DeVries
With
Artificial
Heart

