

CARDIAC FAILURE

- ✗ *Inability of heart to maintain an output,*
necessary for metabolic needs of body
(**systolic failure**) &
- ✗ inability to receive blood into ventricular
cavities at low pressure during diastole
(**diastolic failure**)

✗ *X ray chest*

- to assess cardiac size& pulmonary congestion
- exclude pulmonary etiology
- detect congenital heart disease

✗ *ECG*

- may show nonspecific T & ST segment changes
- tall P wave
- specific patterns of congenital&aquired heart dis

✗ *Echocardiography*

- most useful,widely available,low cost test
- provides immediate data on
 - cardiac morphology& structure,
 - chamber volumes/diameters,
 - wall thickness,
 - ventricular systolic/diastolic function,
 - pulmonary pressure

OTHERS

- ✕ Hemogram
- ✕ Serum electrolytes
- ✕ Blood gas analysis
- ✕ Renal function test
- ✕ Blood culture

AIM OF TREATMENT

✕ *Correction of inadequate cardiac output*

1. Correction
of underlying
cause

2. Reduce
cardiac work

3. Augment
myocardial
contractility

4. Improve
cardiac
performance

Important when CCF is caused or precipitated by:

- Anemia
- Nephrosis
- Overloading of circulation
- Severe chest infection
- Hypertension
- Fever
- Arrhythmias
- Pulmonary embolism
- Infective endocarditis
- Thyrotoxicosis
- Drug toxicity etc.

Surgically treatable causes:

- Valvular lesions
- Obstructive lesions
- Shunts

Conditions that might be missed :

- sustained tachyarrhythmias,
- coarctation of aorta.& obstructive aortitis,
- anomalous origin of LCA from pulm artery,
- hypocalcemia

- ✗ Uncommon causes of CCF in children:
 - upper respiratory obstruction
 - hypoglycemia
 - hypocalcemia
 - neonatal asphyxia

REDUCTION OF CARDIAC WORK

- ✗ Restrict patient activities
- ✗ Sedatives
- ✗ Rx of conditions causing stress to heart
- ✗ Vasodilators
- ✗ Mechanical ventilation

Mx of NEONATE WITH HEART FAILURE

- *Nursed in an incubator & handled minimally*
- *Baby is kept propped up at an incline of about 30°.*
(Pooling of edema fluid in the dependant areas → ↓fluid collection in lungs → reduce work of breathing)
- *Temp – 36-37 C* (overall circulatory and metabolic needs are minimal → reduce work of heart)
- *Humidified oxygen* to maintain a conc.of 40-50%
(improves impaired oxygenation due to pulm congestion)

SEDATIVES

- ✗ If infant or child is restless or dyspneic
- ✗ Opiates (morphine)
Benzodiazepine(midazolam)
- ✗ To reduce anxiety & lower catecholamine secretion



Reduce –physical activity ,
-- respiratory rate ,
--heart rate

RX OF CONDITIONS CAUSING STRESS TO HEART

- ✗ Fever
- ✗ Infection
- ✗ Anemia
- ✗ Obesity
- ✗ Thyrotoxicosis
- ✗ Repeated pulmonary emboli

RX OF CONDITIONS CAUSING STRESS TO HEART

INFECTIONS

- ✗ In infants & small children, presence of superadded pulmonary infection is difficult to recognise. Therefore , antibiotics administered empirically
- ✗ In older children, antibiotics are used only if evidence of infection is present

RX OF CONDITIONS CAUSING STRESS TO HEART

Anemia

- ✖ stress on heart bcoz of decreased oxygen carrying capacity of heart
- ✖ Anemia leads to tachycardia & hyperkinetic circulatory state
- ✖ Correction of anemia decrease cardiac work
- ✖ Packed cell volumes of 10-20 mL/kg are required to correct severe anemia
(single dose furosemide iv is given prior to transfusion)

- ✘ Counteract inappropriately excessive compensatory mechanisms in heart failure & improve cardiac output

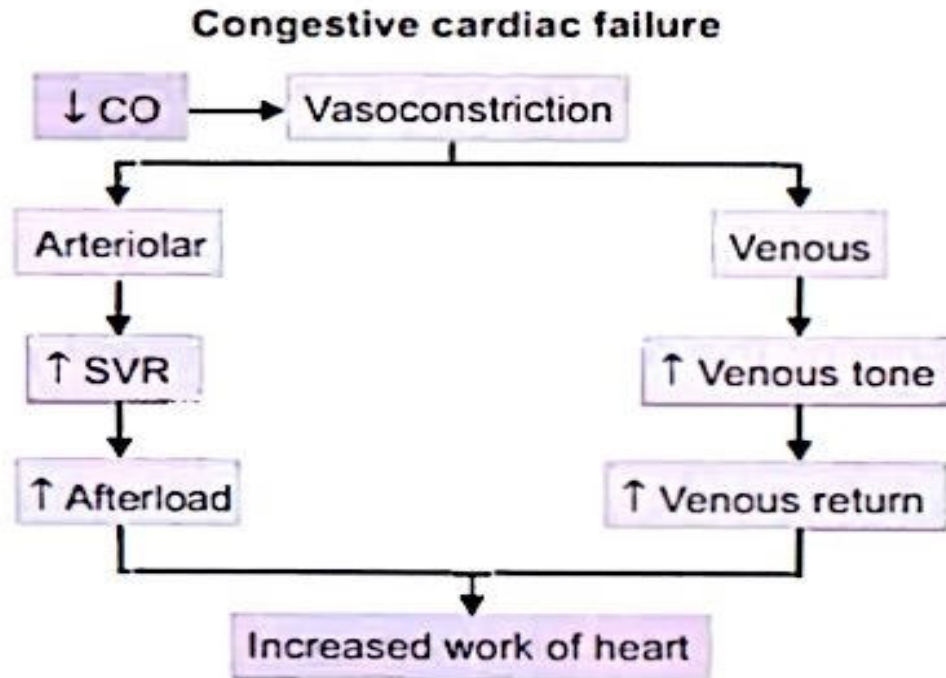


Fig. 15.2: Low cardiac output (CO) results in vasoconstriction, increasing systemic vascular resistance (SVR) and venous tone leading to increase in the work of heart

VASODILATORS

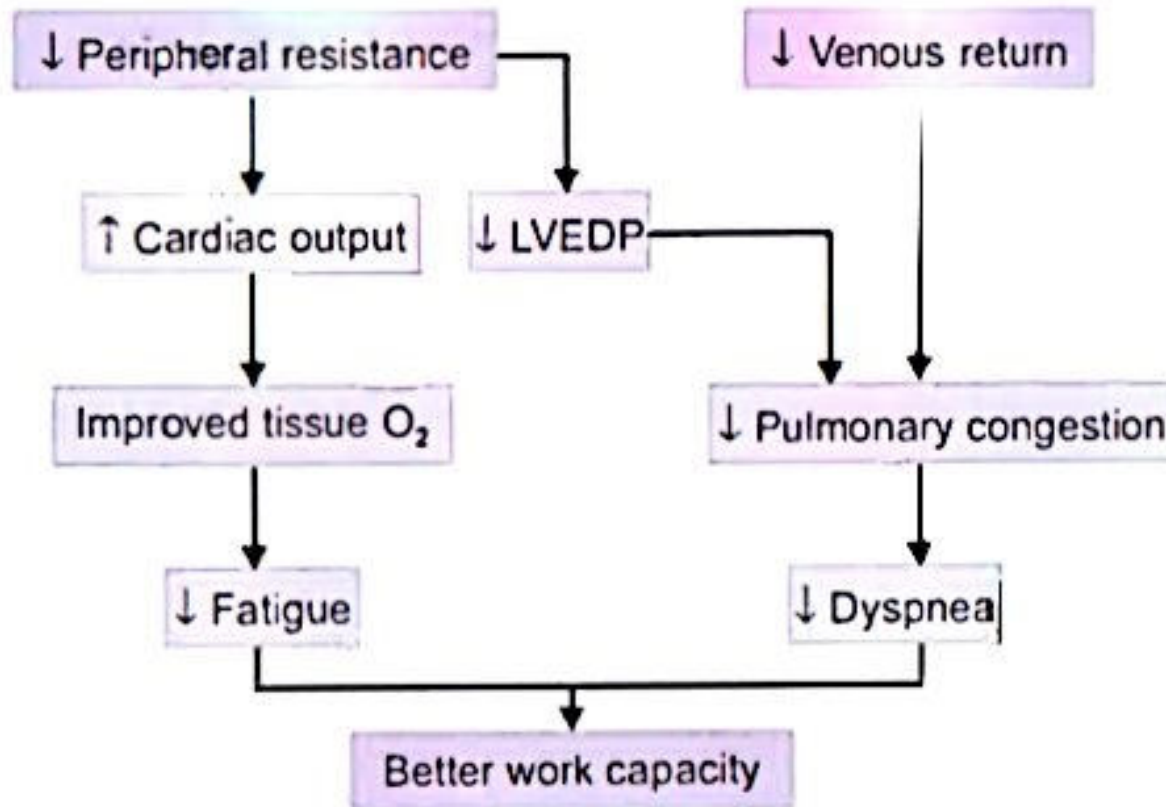


Fig. 15.1: By reducing the systemic vascular resistance and decreasing the venous tone vasodilators provide better work capacity. LVEDP left ventricular end-diastolic pressure

VASODILATORS

- ✗ **Nitrates** are used as preferential venodilators
- ✗ In acute care setting, **sodium nitroprusside** is used since it is a mixed arterio & venodilator
- ✗ Phospho diesterase inhibitors (milrinone) & Calcium sensitisers(levosimendan)
 - popular especially in post op period
 - have powerful vasodilatory and inotropic effects

VASODILATORS

SPECIFIC INDICATIONS

- ❑ Acute mitral or aortic regurgitation
- ❑ Ventricular dysfunction due to myocarditis
- ❑ Anomalous coronary artery from pulmonary artery
- ❑ Early postoperative setting

ACE INHIBITORS

- ✗ Eg: Captopril, Enalapril
- ✗ Effective for treating heart failure in infants and children
- ✗ Prevent cardiac remodelling
- ✗ They suppress RAAS



Reduce vasoconstriction & salt and water retention →
reduce work of heart

- ✗ By suppressing catecholamines, they prevent arrhythmias and other adverse effects on myocardium
- ✗ S/E--- Cough

~~(persistent cough → use angiotensin receptor blocker-
Losartan)~~

BETA BLOCKERS

- ✗ Improve symptoms especially in patients with dilated cardiomyopathy, who continue to have tachycardia
- ✗ Metoprolol , Carvedilol
- ✗ Carvedilol – preferred---since it has properties of beta blockers with peripheral vasodilation
- ✗ Treatment- started at low dose & increased depending on tolerability
- ✗ Dose--0.08 - 0.4 mg/kg/day

Maximum—1 mg/kg/day

AUGMENTING MYOCARDIAL CONTRACTILITY

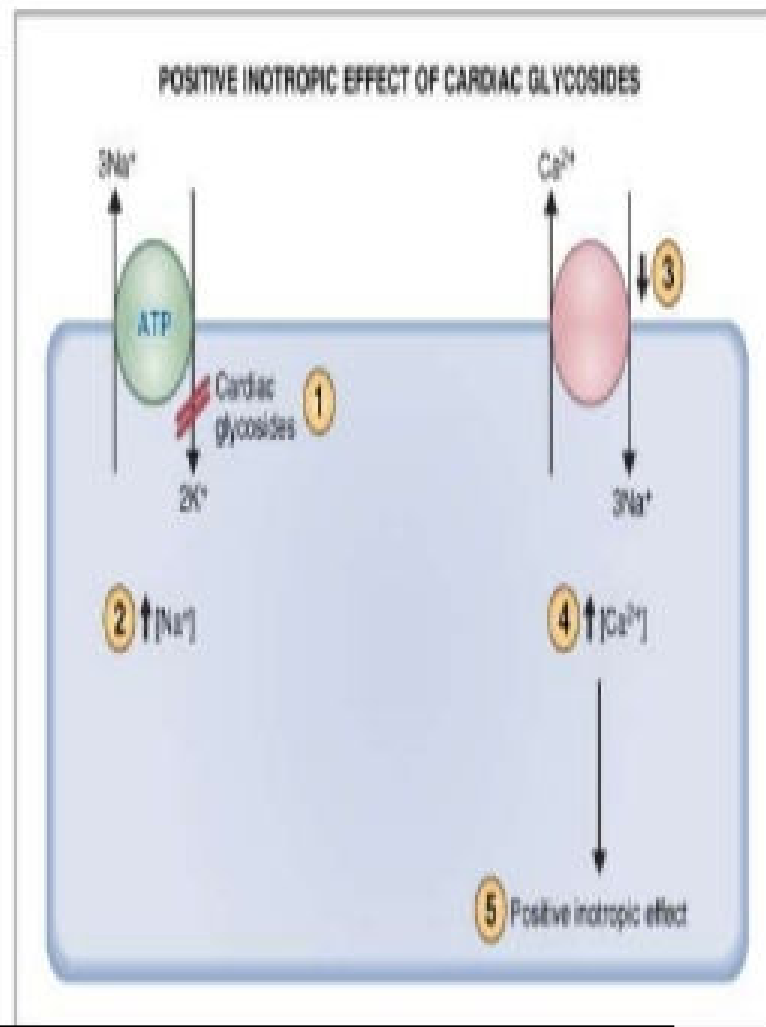
INOTROPIC AGENTS

DIGOXIN

- ✗ Rapid onset of action
- ✗ Eliminated quickly
- ✗ Available as oral & parenteral
- ✗ Oral digoxin---available as 0.25 mg tablets & digoxin elixir (1 ml = 0.05 mg)
- ✗ Parenteral---(0.5 mg/2 ml)
 - dose- 70% of oral dose
- ✗ Beneficial for symptom relief
- ✗ Can be combined with ACE inhibitors for synergistic effect

Cardiac glycosides : Digoxin (DIGITALIS)

- ☐ It inhibits the $\text{Na}^+, \text{K}^+ \text{ATPase}$ pump which
 - Functions in the exchange of Na^+ for K^+ ions.
 - Such blockage results in intracellular accumulation of Na^+ ions .
 - These ions are then exchanged with Ca_2^+ ions through $\text{Na}^+ - \text{Ca}_2^+$ exchange carries.
 - These Ca_2^+ ions increase the contractility of the myocardium which is beneficial to the failing heart.
- ☐ Digoxin enhances the cholinergic activity which reduces the HR and AV conduction .
 - Due to this the time required for diastolic filling gets enhanced while the myocardial O_2 consumption is retarded.
- ☐ The sympathetic outflow comprising renin, aldosterone is also decreased by dioxin



× DOSAGE

	<i>Digitalizing dose, mg/kg</i>	<i>Maintenance dose $\mu\text{g/kg/day}$</i>
Digoxin		
Premature, neonates	0.04	0.01
1 month to one year	0.08	0.02–0.025
1 to 3 years	0.06	0.015–0.02
Above 3 years	0.04	0.017

- ✗ Children are digitalised within 24 hour period
- ✗ $1/2$ of calculated digitalising dose is given initially



Followed by $1/4$ in 6-8 hours



Final $1/4$ after another 6-8 hours

- ✗ Maintenance dose is usually $1/4$ of digitalising dose

Table 3. Common Signs and Symptoms of Digoxin Toxicity

Noncardiac Adverse Effects	Cardiac Adverse Effects
Anorexia	Ventricular arrhythmias
Nausea/vomiting	Atrioventricular block
Abdominal pain	Atrial arrhythmias
Visual disturbances: halos, photophobia, red-green or yellow-green vision	Sinus bradycardia
Fatigue, weakness	
Confusion, delirium, psychosis	

Rx --

DIGIBIND

- before 3rd daily dose an ECG is done to rule out digitalis toxicity
- Toxicity can be controlled by omitting next one or two doses
- PR interval is a useful indicator; if it exceeds initial interval by 50%, digitalis toxicity is present

Digitalis is used with caution in:

1. Premature neonates
2. Heart failure due to myocarditis
3. Very cyanotic patients

New Intravenous inotropic agents

1. Catecholamine inotropes:
Dopamine, Dobutamine, Adrenaline
2. Phosphodiesterase inhibitors:
Amrinone, Milrinone
3. *Levosimendan* (calcium sensitiser)
4. *Xamoterol* (β agonist- cardiac stimulant)
5. *Flosequinan*

DOPAMINE

- ✗ Used if B.P is low
- ✗ At a dose less than 5 $\mu\text{g}/\text{kg}/\text{min}$ → peripheral vasodilation & increase myocardial contractility

DOBUTAMINE

- ✗ Dose—2.5- 15 $\mu\text{g}/\text{kg}/\text{min}$
- ✗ In pts with dilated cardiomyopathy, it is used as 24 hr infusion once or twice a week

MILRINONE

- ✗ Infusion 0.3-0.7 $\mu\text{g}/\text{kg}/\text{min}$ following a loading dose of 50 $\mu\text{g}/\text{kg}$

LEVOSIMENDAN

- ✗ 6- 12 $\mu\text{g}/\text{kg}$ loading dose over 10 minutes followed by
0.05-0.2 $\mu\text{g}/\text{kg}/\text{min}$

IMPROVING CARDIAC PERFORMANCE

BY REDUCING SIZE OF HEART

- ❑ **DIURETICS**
- ❑ **DIGOXIN**
- ❑ **DIET**

× BY REDUCING VENOUS RETURN(PRELOAD)



DIURETICS

(first line of management in congestive failure)

MECHANISM OF ACTION

(i) Reduce blood volume, reduce venous return & ventricular filling



Reduce heart size & volume



Wall tension decrease



Improves myocardial function & cardiac output

(ii) reduce total body sodium



Reduce B.P & peripheral vascular resistance



Increase cardiac output & reduce work of heart

DOSAGE OF DIURETICS

× Furosemide

1 -3 mg/kg/day orally OR

1 mg/kg/dose IV

× Spironolactone

1 mg/kg orally every 12 hr

DIET

- ✖ Sodium restriction is recommended ;but difficult to implement in infants and young children
- ✖ Since heart failure increases calorie requirements,adequate intake is adviced (150 kcal/kg/day)(small and frequent meals are given)
- ✖ Severely ill- not able to suck,nasogastric tube

NEW THERAPIES

- ✕ Ivabradine
- ✕ Neprilysin inhibitor & valsartan
- ✕ Device therapy
 1. Implantable cardioverter defibrillator
 2. Cardiac resynchronisation therapy

Box 22.2: Stepwise-treatment of pediatric CCF

Step 1: Diuretics (frusemide) which improve the cardiac performance by reducing blood volume, peripheral vascular resistance and increasing the cardiac output

Step 2: Digoxin which improves cardiac contractility by its inotropic action, reduces cardiac work and decreases cardiac size.

Step 3: ACE inhibitors (captopril, enalapril) with withdrawal of potassium-sparing diuretics or supplementary potassium if given with other diuretics

Step 4: Vasodilators, preferably nitrates e.g. Isosorbide nitrate (O) or sodium nitropruside (IV)

Step 5: Intermittent IV dopamine or dobutamine

Step 6: Beta-blockers (propranolol) or steroids if active myocarditis present

Step 7: Heart transplantation

Note: Steps 5-7 are usually needed in dilated cardiomyopathy

REFRACTORY CCF

Children with CCF that is refractory to above mentioned measures need:

- ✗ Re-evaluation with a special search for unrecognised precipitating/underlying factor
- ✗ Therapy with a
 - vasodilator nitroprusside
 - iv inotropic(dopamine)
 - beta blocker(propranolol)under strict hemodynamic monitoring
- ✗ Ultrafiltration or dialysis in the presence of renal shutdown
- ✗ Cardiac transplantation

- ✖ 8 wks old baby with fast breathing and resp distress.O/E, resp rate -78, HR-172, temp-103,SP02-84, BP-94/60,MODERATE RETRACION,cardiomegaly wiyh pan systolic murmur of grade 5 in lower left sternal border,tender hepatomegaly present

- ✗ 8 month old baby with ,admitted with resp distress. O/E, severe pallor ,tachypnea,tachycardia,cardiomegaly &tender hepatomegaly.on evaluation, hb was found to be 3

✕ 4 month old baby admitted with 3 days upper resp tract infection, O/E, there is tachypnea, tachycardia, hypotension, cardiomegaly

ECG showed ST-T CHANGES and echocardiogram showed dilated cardiomyopathy with LV dysfunction