**HEART FAILURE**

HF occurs when the **heart cannot deliver adequate cardiac output to meet the metabolic needs of the body**. In the early stages of HF, various **compensatory mechanisms** are evoked to maintain normal metabolic function e.g. sympatho-adrenal axis, renin-angiotensin system & adaptation at the molecular/cellular level. Later on however, these mechanisms will become ineffective or even may harm the heart & body. ***Note:*** *Chronic exposure of heart to catecholamines → ↓ number of cardiac β-*

*adrenergic receptors and direct myocardial cell damage. There are also polymorphisms in the genes encoding proteins involved in sympathetic signaling which can alter the patient response to medical Rx, thus can predict the risk of HF worsening*. **Path.** The following are some hemodynamics:- ***Frank-Starling Relationship:*** cardiac output is proportional to the left ventricular end-diastolic pressure (to certain limits) & inversely proportional to the systemic or pulmonary vascular resistance. Cardiac Output (CO) = HR × stroke volume. Stroke volume is depend on the afterload (pressure work), preload

(volume work), and contractility (intrinsic myocardial function). Systemic oxygen transport = CO × systemic oxygen content. **Et.** Causes of HF depend on age:- **Fetal;** Severe anemia (e.g. HDN), Arrythmia (e.g. SVT, VT, Complete

heart block), CHD, Myocarditis. **Premature newborn;** Fluid overload, PDA, VSD, Cor-pulmonale, Hypertension, Myocarditis, Genetic cardiomyopathy. **Full-Term newborn;** Asphyxial cardiomyopathy, A-V malformations, Left-sided obstructive CHD, Large mixing CHD, Myocarditis, Genetic

cardiomyopathy. **Infant-Toddler;** Left-to-right cardiac shunts (e.g. VSD), A-V

malformations, ALCAPA, Genetic or metabolic cardiomyopathy, Acute hypertension, SVT, Myocarditis, Kawasaki disease. **Child-Adolescent;** Rheumatic fever, Acute hypertension, Myocarditis, Thyrotoxicosis, Hemochromatosis-hemosiderosis, Cancer therapy, SCA, Endocarditis, Cor-pulmonale, Genetic or metabolic cardiomyopathy.

HF can be divided into low or high output failure.  ***Low output failure*** usually due to **causes intrinsic to the heart** e.g. CHD, myocarditis, arrhythmias …etc.

 ***High output failure*** usually due to **causes outside the heart** e.g. anemia, hypoxia, A-V fistula, hyperthyroidism….etc.

**C.M.** The 4 major features of HF are: **Tachycardia, Tachypnea, Cardiomegaly, & Hepatomegaly.** However, the manifestations are vary according to the severity of HF; In ***mild*** degree, patient may have **subtle** symptoms that may not be

recognized by the parents. In ***moderate*** degree, patient may have symptoms only **after exertion**, whereas in ***severe*** degree, patient has symptoms **during rest**.

Manifestations of HF are also vary according to the age:-  **INFANTS**; manifestations may be difficult to recognized, but generally it include:- **Hx.** Tachypnea, irritability, weak cry, dyspnea, profuse perspiration, poor sucking, poor feeding, & poor weight gain. **Ex.** Flaring of alae nasi, dyspnea, intercostal and subcostal retractions, wheezing or crepitations in lungs, tachycardia, gallop rhythm, cardiomegaly, & hepatomegaly; edema may be 1st noticed on the eyelids or sacrum (the dependant part) then may become generalized. ***Note:*** *Rised JVP is difficult to rcognised in infants.*  **CHILDREN**; manifestations include:- **Hx.** Fatigue, effort intolerance, anorexia, abdominal pain, dyspnea, and cough. Many children (as well as adolescents) may have primarily abdominal symptoms with (surprisingly) lack of respiratory complaints!. **Ex.** ↑ JVP, tachycardia, gallop rhythm, basal crepitations, cardiomegaly, hepatomegaly, edema of the feet (the dependant part) or may be generalized. There may be holosystolic murmur due to mitral or tricuspid

insufficiency after severe cardiac dilatation. **Inv.**  **CXR; Cardiomegaly is invariably present**. Pneumonitis +/_ atelectasis is common (especially of right middle and lower lobes) due to **bronchial compression** by the enlarged heart. Large left-to-right

**shunts** have exaggeration of the **pulmonary arterial vessels to the periphery** of the lung fields. Fluffy **perihilar** pulmonary markings suggestive of **venous congestion** and acute **pulmonary edema** are seen only with more **severe** degrees of HF.  **ECG;** show chamber **hypertrophy** & may detect **rhythm** disorder.  **Echo;** in children, ***Fractional Shortening*** may be better than ***Ejection***

***Fraction*** in evaluating L.V. function. N.R. of FS is **28-40%,** whereas EF is

**55-65%. Doppler** studies can be used to estimate C.O.  **MRA;** useful in quantifying left and right **ventricular function and**

**mass** and also the **regurgitant** fraction.  **BGA;** O2 saturation may ↓ → respiratory or metabolic **acidosis** or both.  **BNP** (serum *B-type Natriuretic Peptide*), cardiac **neurohormone** may ↑.

**Rx.** The underlying cause of HF must be removed or alleviated if possible, otherwise consider heart transplantation. Generally however, therapy of HF include:- **1. *General measures*** include: **Strict bed rest is rarely necessary** except in extreme cases. **Sleeping in semi-upright position** is comfortable for

patient with orthopnea. Pulmonary edema may require **positive pressure ventilation**.

**2. *Diet;*** Most infants with HF have **FTT** due to ↓ caloric intake & ↑

metabolic demand, thus need to **increase number of calories per ounce** of infant formula or supplementing breast-feeding & if not tolerated, **NGT feeding** (even at night by pump). GERD should be

treated if present. Use ***"No added salt"*** in diet, the use of low salt diet or low sodium formulas is not recommended because these preparations are usually not palatable and may exacerbate diuretic-induced hyponatremia. **3. *Diuretics;*** include:-  **Furosemide**; 0.5-1 mg/kg/dose IV or 1-4 mg/kg/day orally ÷ 1-4 times. It is the most commonly used diuretic; it inhibits the reabsorption of Na & Cl in the distal tubules and loop of Henle. SE; hypokalemia, hypocalcemia, & contraction alkalosis of extracellular fluid.  **Spironolactone**; 2 mg/kg/day ÷ 2. It is an inhibitor of aldosterone and thus it enhances potassium retention.

 **Thiazide**; 10-40 mg/kg/day ÷ 2. It is less potent than lasix but also cause hypokalemia. **4. *ACE Inhibitors;*** These drugs reduce ventricular afterload by ↓

peripheral vascular resistance and some are also reduce the preload by ↓ systemic venous tone; they include:-  **Captopril**; 1.5-6 mg/kg/day ÷ 2-4. SE; 1st dose hypotension, chronic

cough, pruritic rash, neutropenia, and renal toxicity.  **Enalapril**; has a longer duration of action, thus can be taken once or

twice daily.  **Angiotensin II receptor blocking drugs** e.g. losartan & valsartan have also recently been introduced in Rx of HF. **5. *Digoxin;*** It is the mainstay of Rx of HF although currently it is less used

due to its SE. Its **half life ≈ 36 hr** (1.5 day) & 60% is excreted unchanged in **urine** (hence it may accumulate in renal diseases). It can **cross** the placenta. The dose of digoxin is as follow:-  **Oral digitalization dose** is age-dependant :-  Premature: 20 µg/kg.

 Full-term newborn (up to 1 mo):20–30 µg/kg.

 Infant or child: 30–40 µg/kg.

After calculation of total digitalization dose, give **½ dose initially**, then after 12 hr, give **¼ dose** & repeat the **¼ dose** in the next 12 hr; then after that give the maintenance dose after 12 hr of the 3rd dose.  **Oral maintenance dose** is 5–10 µg/kg/day, divided every 12 hr.

***Notes on digoxin:-***  **If digoxin given IV**, you must give only **75%** of digitalization or

maintenance oral dose.  The initial effect of IV digoxin ≈ **15-30 min** & the peak after **1-4 hr**,

whereas after oral dose **30 min** & **2-6 hr** respectively.  After **oral route**, digitalization is completed within **24 hr**, but when **slow digitalization** is desirable, initiation of **maintenance** digoxin

schedule (without digitalization) achieves full digitalization after **7–10**

**days.**

 **Heart rhythm** must be closely monitored after each of the 3 digitalization doses & discontinue digoxin if any new rhythm develop

**except** with prolongation of P-R interval, just delay in administering (or

reduce) the next dose. ST segment or T-wave changes are common & of no significance.  Serum electrolytes also should be measured before & after digitalization because **hypokalemia, hypercalcemia,** and **hypomagnisemia** may enhance digoxin toxicity.  Other factors that enhance digoxin toxicity are **myocarditis &**

**prematurity.**  **Serum digoxin** levels are measured in following circumstances; **toxicity**, **impaired renal function, drug interaction**, **non-compliance**,

or when **unknown amount** of digoxin has been administered accidentally. Blood level should not exceed 2–4 ng/ml in infants and 1–2 ng/ml in

older children; however, toxicity should be interpreted with clinical &

ECG changes.  **SE of digoxin** are anorexia, nausea, vomiting, diarrhea, lethargy, blurred vision, photophobia, xanthopsia, bradycardia, or various arrhythmias. ***6. β-Blockers;*** These agents can be used only in chronic (not acute) HF because they have many beneficial effects on heart:-  **Metoprolol**; β1-adrenergic receptor selective antagonist.  **Carvedilol**; α- and β-adrenergic receptor blocking; it also has free radical scavenging effects. **7. The following drugs are only given in the ICU** & used by IV or

infusion route with continuous monitoring of BP (better by Swan-Ganz catheter) to avoid hypotension; these include:-  ***Vasodilaters;*** They cause arteriodilation (↓ afterload) & sometimes venodilation (↓ preload). **Nitroprusside** has short half-life but contraindicated in patient with pre-existing hypotension. SE; cyanide

toxicity.  ***α- and β-Adrenergic Agonists;*** include:-  **Dopamine**; 2–10 µg/kg/min, it predominantly β-adrenergic receptor

agonist, but it has α-adrenergic effects at higher doses, it also selective

renal vasodilator. Fenoldopam is more than dopamine in increasing the renal blood flow and urine output.  **Dobutamine**; 2–20 µg/kg/min, it has direct inotropic effects with moderate reduction in peripheral vascular resistance.

 **Isoproterenol**; it is a pure β-adrenergic agonist that has marked

chronotropic effect; it is most effective in patients with slow HRs.  **Adrenaline & Nor-adrenaline**; 0.1-1 µg/kg/min & 0.1-2 µg/kg/min, respectively. They mainly used in cardiogenic shock. They have mixed α- and β-adrenergic receptor agonist with +ve inotropic &

chronotropic effects on the heart as well as ↑ systemic vascular resistance.  ***Phosphodiesterase Inhibitors*** e.g. **Milrinone**, they prevents the degradation of intracellular cAMP, they have +ve inotropic with significant peripheral vasodilator effects. They mainly used in refractory HF & after open heart surgery. **8. *Other methods:-***  **Antiarrhythmic drugs** for arrhythmias or for patient who experienced "missed sudden death" episode.

 **Implantable Cardioverter-Defibrillator** (ICD) may be lifesaving in

patient with severe or recurrent arrhythmias.  **Biventricular Resynchronization Pacing** (BiVP) can be used as a

bridge before cardiac transplantation. It has been used in dilated cardiomyopathy & complex CHD.

**INFECTIVE ENDOCARDITIS** IE is a **significant cause of morbidity and mortality** in children and

adolescents, although it is **rare in infancy**. It is often a complication of congenital or rheumatic heart disease but can also occur in children

**without** any abnormal valves or cardiac malformations. **Et.** IE includes acute and subacute bacterial endocarditis, as well as nonbacterial endocarditis caused by viruses, fungi, and other microbiologic agents. The most common cause of IE in pediatric patients include: **viridans-**

**type** (or α-hemolytic) **streptococci** e.g. *Streptococcus mutans*,

*Streptococcus sanguinis*, *Streptococcus mitis*; ***Staphylococcus aureus***, and

**Group D streptococcus** (or enterococcus) e.g. *Streptococcus bovis*,

*Streptococcus faecalis*.

**Other less common organisms** include: *Streptococcus pneumoniae*,

*Haemophilus influenzae*, *Coagulase-negative staphylococci*, *Neisseria gonorrhoeae*, *Coxiella burnetii*, *Brucella*, *Chlamydia* (*psittaci*, *trachomatis*,

*pneumoniae)*, *Legionella*, *Bartonella*, and other organisms including HACEK group of bacteria and fungi. ***Note:*** *About 6% of cases, blood cultures are negative for any organisms.*

Staphylococcal endocarditis is more common in patients with no

underlying heart disease; viridans group streptococcal infection is more common after dental procedures; group D enterococci are seen more often after lower bowel or genitourinary manipulation; Coagulase-

negative staphylococci are common in the presence of an indwelling central venous catheter; *Pseudomonas aeruginosa* or *Serratia marcescens*

is seen more frequently in IV drug users; and fungal organisms are encountered after open heart surgery, severely debilitated or immunosuppressed patients, and in those on prolonged courses of antibiotics. **Path.** Patients with CHD where there is **turbulent blood flow through a**

**hole or stenotic orifice** are most susceptible to IE because this turbulent flow **traumatizes** the vascular endothelium, creating a substrate for deposition of fibrin and platelets, leading to the formation of a **nonbacterial thrombotic embolus** (NBTE) that is thought to be the initiating lesion for IE. **Biofilms** form on the surface of implanted

mechanical devices e.g. valves, catheters, or pacemaker wires also serve

as adhesive substrate for infection. The development of **transient bacteremia** then colonizes this NBTE or biofilm, leading to proliferation of bacteria within the lesion. The disease represents a complex interplay between a pathogen and host factors. ***Predisposing factors for IE:*** Children at highest risk include most **structural CHD** (especially those associated with high velocity blood

flow e.g. VSD & aortic stenosis), **unrepaired cyanotic CHD**, any **prosthetic material** used in cardiac surgery (especially prosthetic

valves), **rheumatic** heart disease, and **previous hx** of IE. ***Note:*** *Surgical correction of CHD may reduce but not eliminate the risk of IE.* **Additional predisposing factors** include: preceding dental, urinary tract, or intestinal procedure, IV drug use, central venous catheter, and primary bacteremia with *Staphylococcus aureus* (which can cause IE even without recognizable heart lesion). The predisposing factors are **not include** those with completely repaired

CHD by a prosthetic material or device after 6 mo of the procedure (if the

operation is successful & the prosthetic material do not inhibit endothelization) and those with repair of a simple ASD or PDA without prosthetic material. **C.M.** Dx of IE is most often depend on a **high index of suspicion** during evaluation of an infection in a child with underlying risk factor because early manifestations are usually mild & nonspecific (especially with viridans group streptococci). **Low-grade fever** with afternoon elevations without other

manifestations (**FUO**) that persists for as long as **several months** may be the only symptom. Alternatively, the onset may be **acute and severe**,

with high, intermittent fever and prostration. However, the onset and

course vary between these two extremes. Other manifestations include:- **Hx.** Fatigue, malaise, weight loss, night sweats, myalgia, arthralgia, headache, dyspnea, chest & abdominal pain, and occasionally chills, nausea, and vomiting. **Ex.** Pyrexia, tachycardia, new or changing murmur, splenomegaly, embolic phenomena (Roth spots, petechiae, splinter hemorrhages, Osler

nodes, CNS or ocular lesions), Janeway lesions, and clubbing.

***Note:*** *Many of the classic skin findings represent vasculitis produced by circulating antigen-antibody complexes; they develop late in the course of*

*disease; thus, they are seldom seen in appropriately treated patients.* **Cx.** Untreated IE has many Cxs especially if associated with staphylococcal disease, these include:- **Cardiac Cxs;** heart failure is the most common; it usually caused by vegetations involving the aortic or mitral valve; less commonly HF is

due to myocardial abscesses, toxic myocarditis, or life-threatening arrhythmias. Other cardiac Cxs include: mycotic aneurysms, rupture of sinus of Valsalva, obstruction of valve secondary to large vegetations, acquired

VSD, and heart block as a result of involvement of the conduction system by abscess which may rupture into the pericardium and produce purulent pericarditis. **CNS Cxs** are usually late manifestations due to systemic emboli, these include: embolic strokes, cerebral abscesses, meningitis, mycotic

arterial aneurysms, and hemorrhage. These Cxs usually manifested as meningismus, ↑ ICP, altered sensorium, seizures, and focal neurologic

signs. **Pulmonary and other** systemic emboli are less frequent, except with fungal disease. However, pulmonary emboli may occur in children with VSD or TOF. **Additional Cxs** include: arthritis, osteomyelitis, renal abscess, and immune complex-mediated glomerulonephritis. **Inv. Blood culture is the most important** test for IE, whereas all other laboratory data are secondary in importance. Blood specimens for

culture should be obtained as **promptly** as possible by **3-5 separate**

blood collections after careful preparation of the phlebotomy site

(because contamination presents a special problem). In 90% of cases, the causative agent is recovered from the 1st 2 blood

cultures; whereas antimicrobial pretreatment ↓ the rate to 50-60%. ***Note:*** *Laboratory staff should be notified that endocarditis is suspected so that,*

*if necessary, the blood can be cultured on enriched media for longer period (>1wk) to detect fastidious bacteria or fungi*

***Other specimens*** *that can be cultured (other than blood) include: scrapings from cutaneous lesions, urine, synovial fluid, abscesses, or CSF (in the presence of manifestations of meningitis). Some microorganisms may produce* ***culture-negative endocarditis***

*e.g. Coxiella, Brucella, Chlamydia, Legionella, Bartonella, Mycoplasma,*

*and fungi. These unusual or fastidious organisms are usually require*

***specific tests*** *for Dx including: special culture media, serology, immunohistology, or PCR of surgical material (e.g. resected valve*

*tissues).*

 ***Hematological evidence of inflammation*** *include: elevated ESR & CRP (although ESR may be low with heart or renal failure), Immune complexes, Hypergammaglobulinemia, Hypocomplementemia, Cryoglobulinemia, Rheumatoid factor, as well as Anemia &*

*Leukocytosis.*  ***Renal involvement*** *is manifested as hematuria, azotemia, or renal failure (due to glomerulonephritis).*  ***CXR finding*** *include: bilateral infiltrates, nodules, or pleural effusions.*  ***2D Echo +/_ Doppler study*** *can identify the size, shape, location, and*

*mobility of the lesion, especially if combined with transesophageal probe.* ***Echocardiographic evidence of IE*** *include: intracardiac mass on a*

*valve or other site, regurgitant flow near a prosthesis, abscess, partial*

*dehiscence of prosthetic valves, or new valve regurgitant flow. However, the absence of vegetations does not exclude IE. Echo may also be helpful in predicting the embolic Cxs e.g. lesions >1 cm or fungating masses.*  ***Duke Criteria:*** *2 major, 1 major + 3 minor, or 5 minor criteria suggest definite IE.*

 ***Major criteria*** *include:* ***Positive blood cultures*** *(2 separate cultures for a usual pathogen, or ≥2 for less typical pathogens), and*

***Echocardiographic evidence of IE*** *(see above).*  ***Minor criteria*** *include: single positive blood culture or serologic evidence of infection, echocardiographic signs not meeting the major criteria, predisposing conditions, fever, presence of newly diagnosed clubbing, splenomegaly, splinter hemorrhages, petechiae, embolic-*

*vascular signs, immune complex phenomena (glomerulonephritis,*

*arthritis, RF, Osler nodes, Roth spots), microscopic hematuria, high ESR, high CRP, peripheral lines, and presence of central non-feeding lines.* ***Rx.***

ॐ ***Antibiotic therapy should be instituted immediately*** *once a definitive diagnosis of IE is made as the delay in Rx will predispose the patient to severe Cxs.* ***High serum bactericidal levels*** *must be*

*maintained* ***long*** *enough to eradicate organisms that are growing in a*

*relatively inaccessible avascular vegetations.* ***Empirical therapy*** *before the identifiable agent is recovered may be*

*initiated with* ***Vancomycin + Gentamicin*** *when there is a high risk of S.*

*aureus, viridans, or enterococcus streptococci (the 3 most common organisms) in patients without a prosthetic valve. A total of* ***4-6 wk*** *of IV treatment is usually recommended. However, with highly sensitive*

*viridans group streptococcal infections, shortened regimens that include oral penicillin for some period have been recommended.* ***Other treatment options*** *include:-  Rx for patients with native valve endocarditis caused by highly penicillin-susceptible* ***viridans group streptococci & streptococcus bovis*** *include:- Crystalline Penicillin G, Ceftriaxone, or Vancomycin for 4 wk; or by Crystalline Penicillin G (or Ceftriaxone) + Gentamicin for 2 wk.  Rx for patients with endocarditis caused by* ***staphylococci*** *in the absence of prosthetic materials include:-  Oxacillin-susceptible strains: Nafcillin, Oxacillin, or Cefazolin (if penicilline allergic) for 6 wk +/_ Gentamicin for 3-5 days (optional).  Oxacillin-resistant strains: Vancomycin for 6 wk.  **Fungal endocarditis** is usually treated with Amphotericin B + 5-*

*Fluorocytosine.* ***Note:*** *See the text for doses of the above antibiotics.* ॐ ***If there is manifestations of HF****, appropriate Rx should be instituted including: diuretics, afterload reducing agents, and in some cases, digitalis.* ॐ ***Surgical intervention for IE may be lifesaving****; it is indicated in: severe aortic or mitral valve involvement with intractable HF,*

*myocardial abscess, recurrent emboli, failure to sterilize the blood despite adequate antibiotic levels, increasing size of vegetations while*

*receiving therapy, and fungal endocarditis.* ***Rarely****, a mycotic aneurysm, rupture of an aortic sinus, intraseptal abscess causing complete heart block, or dehiscence of an intracardiac patch requires an* ***emergency*** *operation.* ***Note:*** *Active infection is not a contraindication for surgery even if the patient is critically ill.* ***Recombinant tissue plasminogen activation*** *may help in lysing intracardiac vegetations to avoid surgery in some high-risk patients.* ***Pg.*** *Despite the use of antibiotics, the* ***mortality rate*** *with IE is still high (****20-25%****). In nonstaphylococcal disease, bacteremia usually resolves in*

*24-48 hr, whereas fever resolves in 5-6 days after appropriate antibiotic therapy. Resolution with staphylococcal disease takes longer. Fungal endocarditis is difficult to manage and it has a poorer prognosis.* ***Pv. All patients with predisposing factors for IE*** *(see above) need antibiotic Px. However, the current recommendations* ***limit*** *the use of Px in these patients before dental procedures for only those which involve*

*manipulation of gingival tissue or the periapical region of teeth or*

*perforation of the oral mucosa; whereas "placement of removable prosthodontic or endodontic appliances, adjustment of orthodontic*

*appliances, placement of orthodontic brackets, shedding of deciduous teeth and bleeding from trauma to the lips or oral mucosa" are* ***not***

*indications for Px. In contrast to prior recommendations, prophylaxis for gastrointestinal or genitourinary procedures is* ***no longer recommended*** *in the majority of cases; whereas many* ***respiratory tract procedures*** *can cause bacteremia, thus prophylaxis for of these procedures in considered*

*reasonable.* ***Antibiotic Px for most patients is by oral Amoxicillin****; for patients*

*allergic to penicillins, give Cephalexin, Clindamycin, or Azithromycin / Clarithromycin; for patients unable to take oral medication, give parenteral Ampicillin or Cephalosporin; for patients allergic to penicillins*

*& unable to take oral medication, give parenteral Cefazolin, Ceftriaxone, or Clindamycin.*

*All the above drugs are given in a dose 50 mg/kg, except clindamycin, 20 mg/kg and macrolides, 15 mg/kg. These antibiotics should be taken* ***1***

***hour before the procedure****. Prolonged or continuous antibiotic Px are* ***not*** *recommended.* ***Improving oral hygiene****, vigorous treatment of sepsis and local infections, and careful asepsis during any procedure are very important in reducing the risk of bacteremia & subsequent IE.* ***Continuing education*** *of patients with predisposing factors regarding the need for Px is also important.*