

Heart Failure

The questions signed by * are hard: read their explanation. ● Past Years ● TBL ● Others

This file belongs to the PULSE Cardiology question book: the explanations of the multiple choice answers and the model answers of the essay questions, in the words of the handout.

Answer Key | Multiple Choice Questions

Question no.	1	2	3	4	5	6	7	8	9	10	11	12
Answer	a	c	c	a	b	c	e	c	d	c	b	c

Question no.	13	14	15	16	17	18	19	20	21	22	23	24
Answer	b	c	c	d	d	d	d	c	d	c	a	a

Question no.	25	26	27	28	29	30	31	32	33	34	35	36
Answer	c	d	c	c	a	c	c	d	b	d	c	a

Question no.	37	38	39	40	41	42	43	44	45	46	47	48
Answer	a	d	a	d	c	a	c	a	c	c	b	b

Question no.	49
Answer	a

► Second | Questions with a Note

Question no.	1	2	3	4	5	6	7	8
Answer	a	b	d	d	a+b	c	d	c

► Why this answer?

1 Which of the following is not a manifestation of heart failure in children?

(a) Large volume pulse

In heart failure the pulse is weak because of the low COP, so a large volume pulse is not a feature. Tachycardia, oliguria and an enlarged tender liver are all features of H.F..

- 2 *Causes of acute right sided heart failure are all of the following except:*
(c) Malignant hypertension
 Malignant hypertension is systemic HPN, a pressure overload on the left ventricle. Pulm. HPN, tricuspid incompetence and right ventricular myocardial disease (the same like Lt. v., e.g. infarction) are causes of right ventricular failure.
- 3 *Systemic congestive manifestations (right-sided heart failure) do not include:*
(c) Bilateral basal crepitations
 Bilateral basal crepitations are a backwards sign of left-sided H.F., due to pulmonary congestion. Oedema of the lower limbs, ascites and pain in the Rt. hypochondrium are systemic congestion features of right-sided H.F..
- 4 *Regarding selective beta-1 blockers use in heart failure, which is incorrect?*
(a) Beta-1 blockers increase the deleterious effects of...
 Nothing in the handout says beta-blockers increase the harmful effects of the sympathetic system; they can be used in treatment of stable HF, so (a) is incorrect. -ve inotropic agents e.g. B-blockers are a precipitating factor of H.F., which supports (c) and (d).
- 5 *Which of the following is not considered a cause of acute left-sided heart failure?*
(b) Acute pulmonary embolism-induced pulmonary hypertension.
 Pulm. HPN is a pressure overload on the right ventricle, so pulmonary embolism-induced pulmonary hypertension causes right-sided, not left-sided, failure. Systemic HPN, myocardial infarction and myocarditis are causes of left ventricular failure.
- 6 *What is the primary role of diuretics in the management of heart failure?*
(c) Control pulmonary or systemic congestion.
 Diuretics promote loss of salt and H₂O, so they reduce the preload, circulatory and pulmonary congestion and oedema. The only drug class that showed mortality benefit in HFpEF is SGLT2i, not diuretics.
- 7 *Causes of acute right sided heart failure are all of the following except:*
(e) None of the above
 Pulm. HPN is a pressure overload and tricuspid incompetence a volume overload on the right ventricle, and its myocardial disease is 'the same like Lt. v.' (e.g. infarction), so a, b and d are causes of right ventricular failure. Pulmonary regurgitation is not in this list, but it also returns blood to the right ventricle (a volume overload), so all four are causes and the answer is 'None of the above'.
- 8 *Which of the following drugs is not a treatment of heart failure in children?*
(c) Hydrocortisone
 Corticosteroids are an iatrogenic precipitating factor of heart failure. Diuretics, digitalis (digoxin) and ACE inhibitors such as captopril are lines of treatment of H.F..
- 9 *The drug classes that showed benefit in heart failure management are:*
(d) All of the above
 ACE inhibitors in H.F. have a better effect than other vasodilators, and ARBs act as ACE inhibitors. SGLT2i is the only drug class that showed mortality benefit in HFmrEF and HFpEF. So all three classes have benefit.
- 10 *Regarding selective beta blockers, all are true except:*
(c) BB increase the deleterious effects of sympathetic nervous...
 Beta-blockers e.g. carvedilol and bisoprolol can be used in treatment of stable HF; nothing in the handout says they increase the harmful effects of the sympathetic system, so (c) is false. Options b and d are true: -ve inotropic agents e.g. B-blockers are an iatrogenic precipitating factor of H.F..
- 11 *All of the following are symptoms of right-sided heart failure except:*
(b) Left hypochondrial pain
 The pain of right-sided H.F. is in the Rt. hypochondrium and epigastrium, not the left. Oedema of the lower limbs, congested neck veins and an enlarged tender liver are right-sided features.
- 12 *Switching from ACE inhibitor to an ARB improves:*
(c) Dry cough
 Cough with ACE inhibitors is due to increased bradykinin; ARBs act as ACE inhibitors with fewer side effects and no cough. Hyperkalaemia, hypotension and renal failure are side effects of ACE inhibitors that ARBs share.

- 13 The main antidote in digitalis toxicity is:
(b) Fab fragments
 Treatment of digitalis toxicity includes digitalis antibodies, and Fab fragments are these antibodies. Naloxone, flumazenil and BAL are antidotes of other poisons.
- 14 All the following are signs of digitalis toxicity except:
(c) Sinus tachycardia
 Digitalis toxicity gives a slow heart rate, arrhythmias and heart block, vomiting, and blurring of vision with coloured vision; digitalis slows the heart (-ve chronotropic effect). So sinus tachycardia is not a sign.
- 15 A 6-month-old infant presenting to the ER with respiratory distress. Which of the following is true in heart...
(c) Tachycardia
 Heart failure causes tachycardia because of increased sympathetic activity, and in an infant with respiratory distress tachycardia with tachypnea is the typical finding. Cyanosis is not a feature of heart failure itself in an infant; it points to cyanotic heart disease or severe lung disease. Bradycardia and polyuria do not occur (heart failure causes oliguria).
- 16 Which of the following drugs is NOT used in management of heart failure?
(d) Calcium channel blockers (CCBs)
 Ca-channel blockers are not used in H.F. due to their -ve inotropic effect. ACE inhibitors, ARBs and SGLT2i are used.
- 17 Which of the following is NOT a feature of low cardiac output symptoms of heart failure?
(d) Bilateral pitting lower limb edema
 Oedema of the lower limbs is a backwards manifestation of right-sided H.F., due to systemic congestion. Easy fatigability, dizziness and syncope, and coldness of the extremities are forwards (low COP) manifestations.
- 18 Which of the following is NOT a feature of left ventricular enlargement?
(d) The apex usually is diffuse and is shifted outwards
 A diffuse apex displaced outwards is a sign of right ventricular enlargement. In left ventricular enlargement the apex is directed outwards and downwards and is localized, sustained (heaving) in hypertrophy and hyperdynamic in dilatation, as in aortic stenosis and aortic regurgitation.
- 19 Low cardiac output and hypotension lead to reflex sympathetic activation which leads to all of the following...
(d) Vasoconstriction decreases the pressure overload in front...
 In the neurohormonal diagram, neurohumoral activation causes vasoconstriction, which leads to increased afterload on the failing heart, so it does not improve H.F.. This is why vasodilators are used to decrease the after-load.
- 20 As regards heart failure pathophysiology, angiotensin II leads to all of the following except:
(c) Increased urine output
 Angiotensin II causes salt and water retention, peripheral vasoconstriction and activation of the sympathetic system, which ACE inhibitors counteract, and the renin-angiotensin system leads to sodium and water retention. So urine output falls, it does not rise.
- 21 * Digitalis poisoning can develop as a result of:
(d) All of the above
 The handout gives only that digoxin is excreted mainly by the kidney; the answer is inferred from this line, as renal malfunction lets the drug accumulate. Accidental ingestion and deliberate overdose are the acute forms of poisoning, so all three are true.
- 22 The following are signs of right-sided heart failure except:
(c) Pulmonary edema
 Acute pulmonary oedema is a backwards sign of left-sided H.F., due to pulmonary congestion. Oedema of the lower limbs and ascites are backwards signs of right-sided H.F., and oliguria is a forwards (low COP) manifestation found in both sides.
- 23 Which of the following is not a cause of systolic dysfunction in the pediatric population?
(a) Hypertrophic cardiomyopathy
 The handout puts HOCM under diastolic failure, while DCM causes systolic failure. Myocarditis is a myocardial disease that causes ventricular failure. Malnutrition is not mentioned in the handout.

- 24** What is the most probable diagnosis?
(a) Heart failure with preserved ejection fraction (HFpEF)
 The ejection fraction is 60% with poor diastolic function, and the handout defines HFpEF as EF > 50% and HFrEF as EF < 40%. Basal crepitations (pulmonary congestion) with congested neck veins and an enlarged tender liver (systemic congestion) show that both sides are affected, so it is not isolated right ventricular failure.
- 25** Which of the following is the most approved to improve the prognosis in such a patient?
(c) Dapagliflozin
 This patient has HFpEF. The only drug class that showed mortality benefit in HFmrEF and HFpEF is SGLT2i, e.g. empagliflozin / dapagliflozin; the role of the other disease-modifying drugs in HFpEF is still unclear.
- 26** The following medication is recommended for our patient, but hypokalemia is a common side effect:
(d) Torsemide
 Torsemide is a loop diuretic, and loop diuretics cause hypokalaemia. Spironolactone causes hyperkalaemia; ACE inhibitors cause hyperkalaemia and ARBs such as valsartan act as ACE inhibitors. Nebivolol is a beta-blocker with no effect on potassium in the handout.
- 27** What is the added value of sacubitril to valsartan in ARNI?
(c) Has indirect diuretic and vasodilator effect
 Sacubitril is an endopeptidase inhibitor that increases ANP. It is the natriuretic peptide, not sacubitril itself, that inhibits Na reabsorption and increases Na and H₂O excretion, so its effect is indirect.
- 28** Which of the following could predict higher risk of stroke in such a patient?
(c) Dilated left atrium
 As left atrial pressure remains elevated, the left atrium increases in size and there is a greater chance of developing atrial fibrillation, and stroke is a complication of AF. A dilated left atrium > 50 mm is an indication for oral anticoagulation.
- 29** Tachycardia in children with congestive heart failure is due to:
(a) Increased catecholamine release
 Tachycardia in H.F. occurs as a result of sympathetic stimulation by Marey's law & Bainbridge reflex, that is, by catecholamine release. The renin-angiotensin system leads to sodium and water retention and vasoconstriction, not tachycardia.
- 30** Which of the following could lead to increased volume overload on the left ventricle?
(c) Aortic regurgitation
 Aortic incompetence is a volume overload on the left ventricle. Aortic stenosis is a pressure overload, mitral stenosis causes left atrial failure, and tricuspid incompetence is a volume overload on the right ventricle.
- 31** The following medications are approved to improve the prognosis of heart failure except:
(c) Digoxin
 The handout states that the disease-modifying drugs decrease mortality in patients with HFrEF. Ramipril (ACE inhibitor), metoprolol succinate (beta-blocker) and eplerenone (aldosterone antagonist) are disease-modifying drugs, while digoxin improves symptoms but does not improve survival.
- 32** The following medication is recommended for this patient, but hypokalemia is a common side effect:
(d) Frusemide
 Frusemide is a loop diuretic, and loop diuretics cause hypokalaemia. Spironolactone causes hyperkalaemia, and candesartan, an ARB, acts as ACE inhibitors, which cause hyperkalaemia.
- 33** The patient started medical treatment of heart failure and started to experience dry cough. Which of the...
(b) Sacubitril-valsartan
 Cough with ACE inhibitors is due to increased bradykinin, and ARBs such as valsartan give no cough. Sacubitril is an endopeptidase inhibitor; the same enzyme also breaks down bradykinin, so sacubitril-valsartan can cause dry cough. Eplerenone, carvedilol and dapagliflozin do not cause cough.
- 34** Which of the following could cause congestive heart failure in an 8-month-old infant?
(d) All of the above
 VSD is a volume overload and myocarditis a myocardial disease cause of heart failure, and anaemia causes hyperdynamic circulation with high COP failure. So all three can cause heart failure.

- 35 * The following drug/s improve prognosis of patient with dilated cardiomyopathy:
(c) Carvedilol
 Inferred from the handout: DCM causes systolic failure, and carvedilol is a beta-blocker that can be used in treatment of stable HF. Nicorandil and ranolazine are 3rd line anti-anginal drugs.
- 36 Following up creatinine showed that it rose to 3.5 mg/dl. Which of the following drugs must be stopped:
(a) Candesartan
 ACE inhibitors can cause acute renal failure (vasodilatation of the efferent arteriole → decreased GFR), and renal functions must be monitored; ARBs such as candesartan act as ACE inhibitors. So candesartan must be stopped when creatinine rises to 3.5 mg/dl. Aspirin, clopidogrel and metoprolol do not act this way.
- 37 Hepatomegaly in children with congestive heart failure is due to:
(a) Systemic venous congestion
 Enlarged tender liver is a backwards manifestation of right-sided H.F., due to systemic congestion. Pulmonary congestion gives the backwards manifestations of left-sided H.F., and low COP gives the forwards manifestations.
- 38 The following medication must be avoided in the treatment of such a patient:
(d) Amlodipine
 Ca-channel blockers are not used in H.F. due to their -ve inotropic effect, and amlodipine is a Ca-channel blocker. In mitral stenosis, diuretics and betablockers (to slow heart rate and increase the diastolic time) are used to control pulmonary congestion.
- 39 As regards natriuretic peptides, all of the following are true except:
(a) Decreased intracardiac pressures lead to increased release...
 Overload on the left ventricle increases BNP, so natriuretic peptides rise with increased, not decreased, intracardiac pressure. The natriuretic hormone inhibits Na reabsorption and increases Na and H₂O excretion, and sacubitril is an endopeptidase inhibitor that increases ANP.
- 40 Sodium-glucose cotransporter-2 inhibitors (SGLT2i): all are true except:
(d) SGLT2i are diuretics that cause severe electrolyte...
 SGLT2i work by inhibiting SGLT-2 in the proximal tubules, reducing renal reabsorption of glucose and increasing urinary excretion of glucose. The handout does not describe them as diuretics with severe electrolyte disturbance, and they are the only drug class that showed mortality benefit in HFmrEF and HFpEF.
- 41 Objectives of treatment of heart failure include all of the following except:
(c) No role for interventional and surgical options
 Interventional and surgical options do have a role: surgical treatment e.g. for valvular and congenital lesions, mechanical assistance of circulation using intra-aortic balloon counterpulsation, and cardiac transplantation.
- 42 Which of the following medication must be avoided in the treatment of this patient?
(a) Verapamil.
 Non-DHP CCBs (verapamil and diltiazem) must be avoided in heart failure with reduced systolic function as they worsen heart failure; Ca-channel blockers are not used in H.F. due to their -ve inotropic effect. Metoprolol, spironolactone and candesartan are used in H.F..
- 43 Which of the following is NOT a feature of right-sided heart failure?
(c) Paroxysmal nocturnal dyspnea (PND)
 PND is due to aggravation of pulmonary congestion and occurs more commonly in Lt. VF, so it belongs to left-sided H.F. Oedema of the lower limbs, enlarged tender liver and pain in the Rt. hypochondrium are right-sided features.
- 44 In medical treatment of heart failure, which is false?
(a) Selective beta-1 blockers (carvedilol / bisoprolol / ...)
 Beta-blockers e.g. carvedilol and bisoprolol can be used in treatment of stable HF, so (a) is false. Loop diuretics are the most potent diuretics, ACE inhibitors prevent conversion of angiotensin I to II, and sacubitril is an endopeptidase inhibitor that increases ANP.

- 45 *Tachycardia in children with congestive heart failure is due to:*
(c) Increased catecholamine release from suprarenal medulla
 Tachycardia in H.F. occurs as a result of sympathetic stimulation by Marey's law & Bainbridge reflex, that is, by catecholamine release. Low COP and venous congestion act only through these reflexes, and renin acts through salt and water retention.
- 46 *A 9-month-old infant presenting to the ER with congestive heart failure. Which of the following is true?*
(c) Tachycardia
 Tachycardia is present in H.F. due to sympathetic stimulation. H.F. gives coldness of the extremities and oliguria, so warm extremities, polyuria and bradycardia are the opposite.
- 47 *Pulsus alternans is produced by:*
(b) Left-sided heart failure
 Pulsus alternans (alternating strong & weak beats) is a cardiovascular sign of left-sided H.F.. Pericardial effusion gives low voltage ECG and sometimes electrical alternans, not pulsus alternans.
- 48 *In a patient with history of shortness of breath, which of the following signs indicates left heart failure?*
(b) Basal crepitations
 Bilateral basal crepitations are a backwards sign of left-sided H.F., due to pulmonary congestion. Ascites, oedema of the lower limbs and congested neck veins are backwards signs of right-sided H.F..
- 49 *The action of digitalis is augmented by:*
(a) Calcium
 Digitalis inhibits Na-K/ATPase → increased intracellular Na → increased intracellular Ca → increased force of contraction, so calcium augments its action. Hypokalaemia must be corrected in digitalis toxicity.

► Second | Questions with a Note: why this answer?

- 1 *Which of the following is not a manifestation of heart failure in children?*
(a) Splenomegaly
 Oliguria (low COP), tachycardia and an enlarged tender liver (systemic congestion) are manifestations of H.F.. Splenomegaly is not among them; the handout mentions hepatosplenomegaly only when pulmonary hypertension is accompanied by RV failure.
- 2 *Heaving apex is found in:*
(b) Aortic regurgitation
 A sustained (heaving) apex is a sign of left ventricular hypertrophy, while dilatation gives a hyperdynamic apex. In AR the left ventricle is enlarged, so (b) is the expected answer, although the handout gives AR a hyperdynamic apex. Pulmonary stenosis loads the right ventricle and gives a left parasternal heave, not a heaving apex.
- 3 *In case of acute digitalis poisoning, toxicity is mainly due to its action on:*
(d) Cardiac muscle
 Digitalis increases the excitability of atria and ventricles, which may be complicated by arrhythmia, and its toxicity is shown mainly by arrhythmias and heart block. The handout also gives a vagal action, so (c) is the tempting option.
- 4 *The following are signs of digitalis toxicity except:*
(d) Diarrhea
 The GIT manifestations of digitalis toxicity are anorexia (usually the 1st symptom), nausea and vomiting, and arrhythmias are its cardiovascular manifestations. Diarrhoea is not in this list.
- 5 *The following are heart failure causes with intermittent intracardiac obstruction (choose all that apply):*
(a) Left atrial myxoma + (b) Hypertrophic obstructive cardiomyopathy
 A left atrial myxoma moves with each beat and blocks the mitral valve only at times (ball valve), and the outflow obstruction in HOCM is dynamic, changing with load and contractility. Tetralogy of Fallot has right ventricular outflow obstruction, but it is mainly fixed and Fallot does not usually cause heart failure, because the large VSD lets the right ventricle empty into the aorta. Calcific aortic stenosis is a fixed obstruction.

6 The following are manifestations of acute congestive heart failure in children except:

(c) Splenomegaly

Tachycardia, tachypnea and an enlarged tender liver are manifestations of H.F. Splenomegaly is not among them; the handout mentions hepatosplenomegaly only when pulmonary hypertension is accompanied by RV failure.

7 Drug therapy of congestive heart failure in children includes all of the following drugs except:

(d) Alpha adrenergic blockers

Furosemide, digitalis (digoxin) and captopril are drugs of H.F.. (d) is the printed answer, although the handout lists alpha blockers e.g. prazosin among the types of vasodilators in H.F..

8 A 6-month-old infant presenting to the ER with congestive heart failure. Which of the following is not true?

(c) Splenomegaly

Oliguria, tachypnea and an enlarged tender liver are manifestations of H.F. Splenomegaly is not among them; the handout mentions hepatosplenomegaly only when pulmonary hypertension is accompanied by RV failure.

Model Answers | Essay Questions

1 Outline the management of a patient with acute heart failure.

- ① Hospitalization:** preferably in ICU and bed rest in sitting position.
- ② Oxygen inhalation:** 100% if no pre-existing lung disease.
- ③ Furosemide:** **40-80 mg** I.V. and could be repeated every 30 minutes according to the response.
- ④ Morphine:** **5-10 mg** I.V. [caution in liver failure & COPD]. Action:
 - Relieves anxiety.
 - Decreases sensitivity of the respiratory centre to reflex stimulation from the congested lungs.
 - Decreases venous return (through venodilatation).
- ⑤ Vasodilators:** Na nitroprusside 0.5-10 µg/kg/min I.V. infusion or nitroglycerine I.V. infusion (Tridil) or sublingually [not given if systolic BP < **90 mm Hg**].
- ⑥ Aminophylline:** 5.6 mg/kg slowly I.V. over 20 min (average dose: 250-500 mg).
- ⑦ Positive inotropics** [if systolic BP < **100 mm Hg**]:
 - I.V. digitalization may be used especially in cases associated with AF.
 - Other parenteral inotropics may be needed e.g. dopamine and dobutamine.
- ⑧ Correction of the cause and precipitating factors** e.g. AF.
- ⑨ Aspiration of respiratory secretions.**
- ⑩** If there is no response, the following measures may be used:
 - Mechanical ventilation [e.g. CPAP].
 - Mechanical removal of fluid using phlebotomy or dialysis.
 - Mechanical assistance of circulation using intra-aortic balloon counterpulsation: the balloon is automatically inflated with CO₂ at the onset of diastole and rapidly deflated just before the onset of systole. The diastolic inflation will help in pushing blood in the aorta and tissues.

Note The handout has no section on acute heart failure; this is its treatment of acute pulmonary oedema.

2 Classify heart failure according to anatomy and cardiac output.

Classification of H.F.

- ①** Left-sided H.F., right-sided H.F. and combined (left → right = **CHF**).

- ② According to cardiac output (COP):
- (A) **Low COP failure:**
 - There is decrease of COP below normal.
 - This type occurs in most cases of H.F.
 - (B) **High COP failure:**
 - There is increase of COP, however insufficient for metabolic needs of tissues.
 - Occurs in hyperdynamic circulation (HDC):
 - 3 A: Anaemia, A.V. fistula, AR.
 - 3 H: Hyperthyroidism, hypoxic cor pulmonale and hepatic failure.
 - 3 P: PDA, Paget's disease of bone, beriberi.

3 Mention the causes of acute heart failure.

Precipitating factors (3 I, 3 P, 2 A)

- ① **Infections:** esp. infective endocarditis, rheumatic activity, chest infections.
- ② **Myocardial infarction.**
- ③ **Iatrogenic** factors:
 - Discontinuation of anti-failure therapy.
 - Excessive salt intake.
 - I.V. fluids.
 - Corticosteroids.
 - -ve inotropic agents e.g. B-blockers.
- ④ **Physical & emotional stress.**
- ⑤ **Pregnancy & labour.**
- ⑥ **Pulmonary embolism.**
- ⑦ **Arrhythmias** e.g. marked tachycardia or bradycardia.
- ⑧ **Anaemia**, thyrotoxicosis & other causes of hyperdynamic circulation.

Acute H.F.

- * Acute H.F. e.g. in **M.I.**
- * In patients with **acute severe AR**, left ventricular diastolic pressures rise rapidly and may lead to acute heart failure (acute pulmonary edema ± cardiogenic shock).
- * **Pulmonary embolism:** rapid appearance of manifestations of pulmonary hypertension & right ventricular failure (acute cor pulmonale).

Note The handout has no single list of the causes of acute heart failure; the answer is collected from several topics.

4 Heart failure with reduced EF is a multifactorial process. Enumerate 3 underlying pathophysiological mechanisms and their effects.

Compensatory mechanisms (cardiac reserve)

Several mechanisms become operable to compensate for the reduction in the cardiac output. These mechanisms are beneficial within certain limits. If they exceed these limits, they will aggravate H.F.

	When / why it occurs	Benefit	If it exceeds the limits
(1) Tachycardia	Occurs as a result of sympathetic stimulation by Marey's law & Bainbridge reflex.	It increases COP.	If tachycardia is marked (e.g. > 160/m) → decreases COP due to shortening of diastole & impairment of cardiac filling.
(2) Dilatation	Occurs mainly in volume overload.	It increases the force of contraction (according to Starling's law).	It will diminish contraction.
(3) Hypertrophy	Occurs mainly in pressure overload.	It increases the force of contraction.	The cardiac muscle will be ischaemic leading to decreased contraction.
(4) Hypervolemia	Occurs due to salt & H ₂ O retention.	It increases the preload & force of contraction.	It will aggravate heart failure.
(5) Redistribution of blood flow	There is diversion of blood from less vital organs (e.g. skin) to more vital organs (e.g. brain & heart).		

Neurohormonal and compensatory mechanisms in heart failure

- * Reduced cardiac output → **neurohumoral activation**: sympathetic nervous system, renin-angiotensin system, vasopressin system, endothelin system.
- * Vasoconstriction → increased afterload.
- * Sodium and water retention → increased intravascular volume.