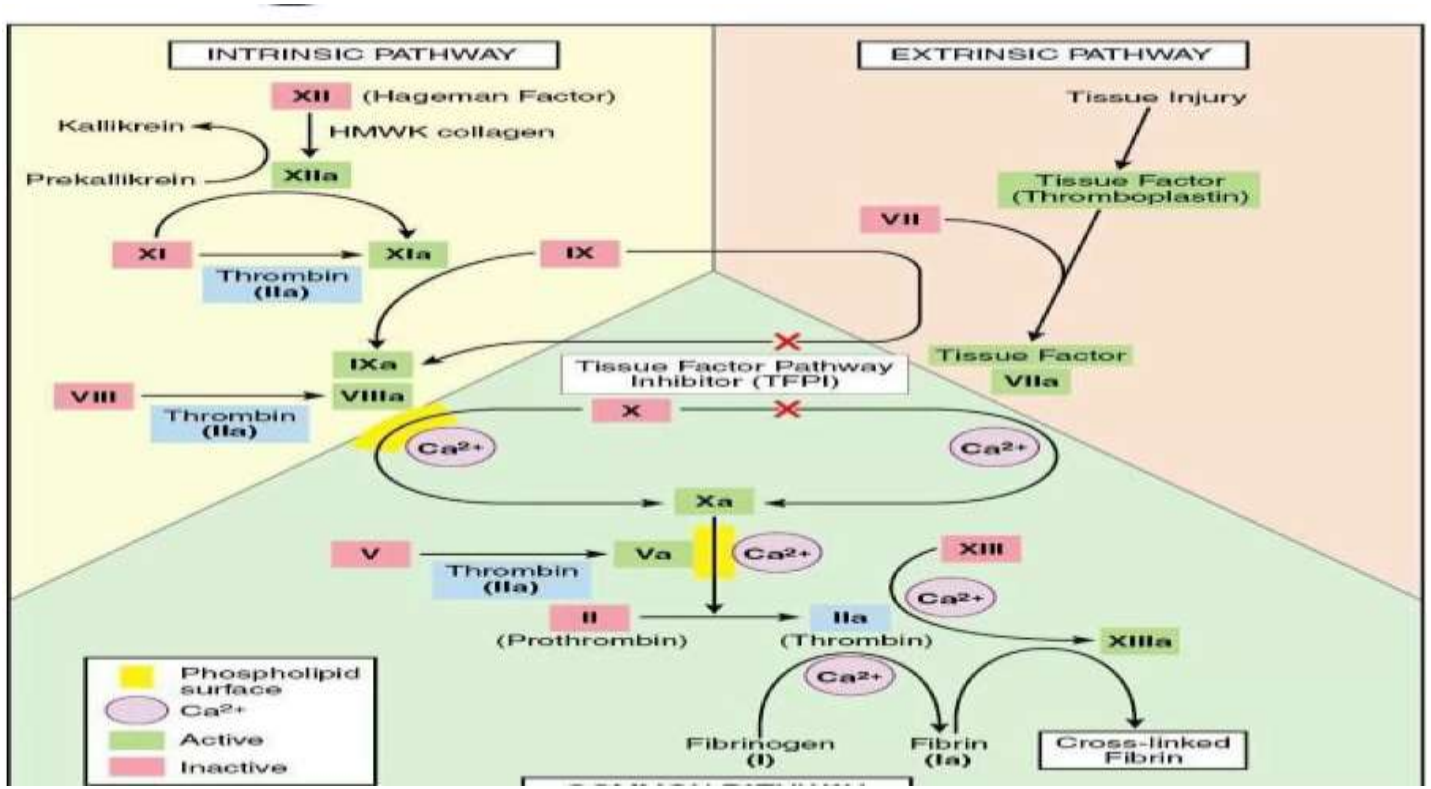
Coagulation Management During and After Cardiopulmonary Bypass

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Coagulation Management During and After Cardiopulmonary Bypass

- Coagulation Cascade:



Coagulation Management During and After Cardiopulmonary Bypass

Hemostatic Evaluation

A. Platelets

- **1. Platelet count 150,000 -400,000/µl**
- **2. Bleeding time (BT) 1- 8 min**

B.Coagulation System

- **1. Coagulation Time (CT) 2.5 – 4.5 min**
- **2. Prothrombin time (PT) 12- 15 sec; compaired to control used for warfarin anticoagulation monitor & test for clotting factor deficiencies or circulating anticoagulants in extrinsic system. INR 0.8-1.1 or depends on laboratories reference.**
- **3. Activated Partial Thromboplastin Time (aPTT) 35 – 45 sec; used to monitor Heparin anticoagulation & deficiencies of clotting factors or anticoagulant in intrinsic system.**
- **4. Thrombin Time < 17 sec; prolong by Heparin or abnormal fibrinogen**
- **6. Fibrinogen 250 – 500 mg/dl, Decreased in DIC.**

C. Fibrinolytic System

- **1. Fibrin Split product < 10 µg/ml, increased during fibrinolysis**
- **2. d- Dimer < 0.5 µg / ml, increased during fibrinolysis; specific assay of cross –linked fibrin degradation.**

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Pre –Bypass Heparin Loading Phase:

- **Target ACT > 400 – 450 seconds safe.**
- **Check ACT after 3 to 5 minutes**
- **Re- dosing Rules: If the measured ACT below the < 450 seconds, additional bolus 50-100 units /kg should be given immediately or 5000 units bolus and recheck ACT.**
- **Heparinization: Initial Dose: 300-400 units/kg of iv unfractionated Heparin through CVP catheter with flash. Usually Actual Body Weight (ABW) is used for calculation, Lean Body Weight (LBW) can be used for minimize bleeding risk in specific Patient.**
- **Heparinization during Priming CPB circuit: Bypass priming 5000 – 10,000 units of heparin directly in to fluid column of the CPB circuit**

Intraoperative Maintenance Phase

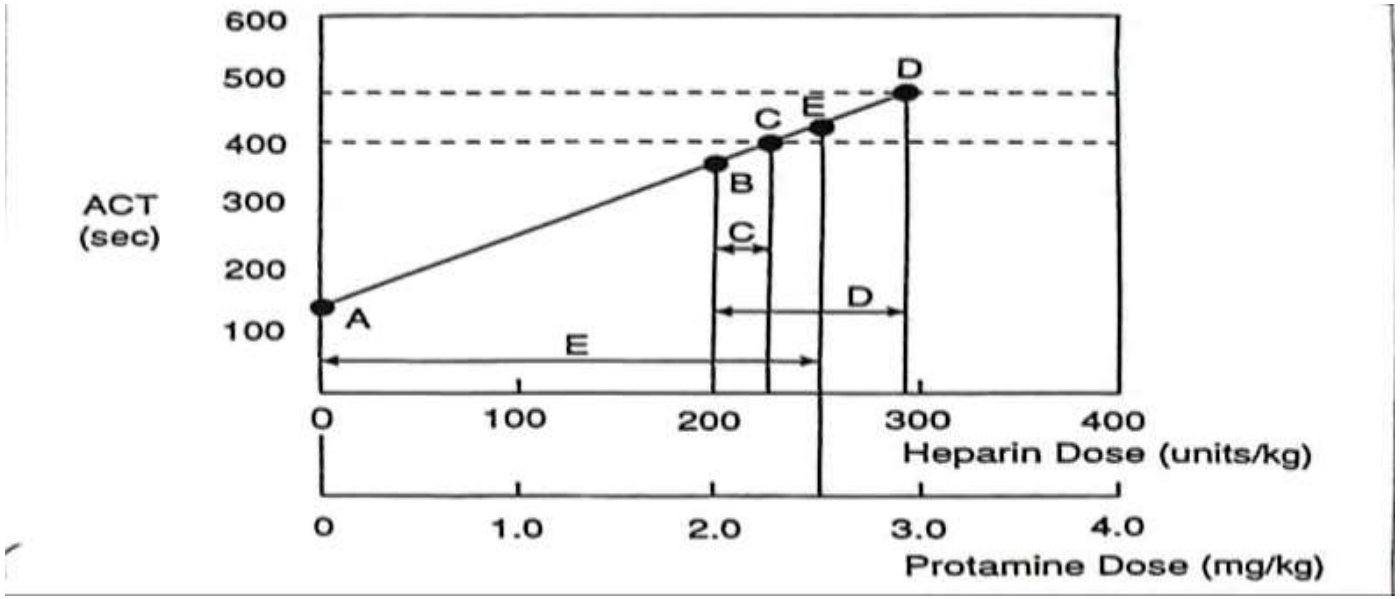
- **Every 30-60 minutes interval anticoagulation status should be assessed routinely .The Target Range must be preserved until the patient is completely separated from the CPB circuit.**

Coagulation Management During and After Cardiopulmonary Bypass

Baseline ACT record before heparinization

- **According to base line ACT we can titrate heparin dose for achieving target ACT. Initial dose can be given from 200 units /Kg then monitor ACT and may additional dose heparin for target ACT.**
- **May be used Graph of heparin and protamine dosing algorithm.**
- **By using the graph of Heparin and Protamine dosing algorithm we can calculate subsequent heparin and protamine doses after the response to a small dose of heparin is used.**
- **To estimate heparin level and calculate protamine dose at the time of heparin neutralization , most recently measured ACT value is plotted on the dose response line (point in the example) The heparin level present theoretically is represented by the difference between points E and A on the horizontal axis (arrow E) . The protamine dose required to calculate for every 100 mg /kg of remaining heparin neutralization.**

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Baseline ACT record before heparinazation

According to base line ACT we can titrate heparin dose for achieving target ACT. Initial dose can be given from 200 units /Kg then monitor ACT and may additional dose heparin for target ACT.

In the graph, the control ACT shows in point A and ACT in point B resulting from initial heparin bolus of 200 units per kg. The line connecting A and B then is extrapolated, and a desired ACT is selected. Point C represents the ACT 400 seconds and theoretically requiring additional heparin dose represented by the difference between points C and B on the horizontal axis (Arrow C). Similarly to achieve ACT 480 seconds, one would administer the additional heparin dose represented by arrow D.

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Neutralization of Heparin with protamine

- **Protamine Sulfate Dose: For every 100 units of the initial heparin loading dose 1mg to 1.3 mg Protamine intravenously given.**
- **Goal: ACT back to < 120-140 seconds or within 10% of their unique baseline value.**

Monitoring Heparin Neutralization

- **ACT (normal value or ±10% Baseline value)**

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- **<u>Special Clinical Variations:</u>**

A. Failure to reach a target ACT of >450 sec despite receiving a massive collective dose of heparin.

- **Management: Anti thrombin iii (AT iii) concentrates or Fresh FROZEN plasma (FFP)**

B. Sudden recurrence of elevated ACT after successful protamine reversal

- **1. Heparin Rebound.**
- **2. Protamine over dose**
- **3. Profound Dilution Coagulopathy or Factor Deficits**
- **4. Severe Hypothermia and acidosis**
- **5. Severe Thrombocytopenia or Platelet Dysfunction**

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1. Heparin Rebound

- **Usually occurs within 1 to 6 hours post protamine administration.**
- **Diagnosis: confirmed if ACT drops back to baseline after adding small amount of protamine in a vitro test tube (heparinase cup) or by measuring a anti – Xa level.**

2. Protamine over dose:

- **ACT is elevated**
- **Causes: more than 1:1 or 1.3: 1 or rapid empirical boluses protamine**
- **Diagnosis: Elevated Heparinase ACT elevated and Standard ACT elevated**
- **Management: Wait and allow protamine clear naturally, avoid giving more Protamine.**

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3. Profound Dilution Coagulopathy or Factor Deficits:

- **Cause: Severe depletion of coagulation factors due to CPB Circuit priming impairs the clotting cascade.**
- **Diagnosis: Heparinase ACT elevated and Standard ACT elevated, check PT/INR, PTT, Fibrinogen or TEG/ROTEM (thromboelastography/ rotational thromboelastography)**
- **Management: Transfuse FFP or Cryoprecipitate.**

4. Severe Hypothermia and acidosis:

- **Causes: If PH <7.2 or Core temperature < 35◦c creates an artificially elevated ACT reading due to enzymatic dysfunction rather than active heparinization.**
- **Management: Correction of ABG and Temperature Warmer may be helpful.**

5. Severe Thrombocytopenia or Platelet Dysfunction:

- **Preoperative antiplatelet medications like aspirin or clopidogrel can cause platelet dysfunction.**
- **Diagnosis: Low Platelet count <50,000µ/l**
- **Management: Transfuse Platelet concentrate**

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Heparin Resistance:

Definition in practice: failure to achieve the desired anticoagulation response despite an appropriate heparin dose.

Common mechanism: reduced antithrombin activity (congenital or acquired).

Other contributors: increased heparin-binding proteins, recent heparin exposure, and assay-related factors.

Assess the actual heparin dose, ACT trend, timing, temperature, dilution, and antithrombin status where available.

Management : additional heparin, antithrombin concentrate, FFP or plasma in selected circumstances.

Potential causes of heparin resistance

Hypercoagulable states
Antithrombin III deficiency
Familial
Acquired
Arteriosclerotic disease
Unstable angina pectoris
Septicemia
Bacterial endocarditis
Pregnancy
HIT
Thrombocytosis
Drugs
Heparin
Nitroglycerin[a]
Protein binding
Acid glycoprotein
Histidine-rich glycoprotein
Immunoglobulins
Others
Neonates
Elderly patients

[a]Controversial cause. Probably not clinically significant.

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- **Heparin-induced thrombocytopenia (HIT)**

HIT type 1:

Benign thrombocytopenia, occurs within 1-2 days after heparin administration without thrombosis or immune response.

HIT type 2:

A severe condition that most often occurs after 5 continuous days of heparin administration (average onset time, 9days), and is immune mediated.

- Heparin and platelet factor 4 (PF4) is responsible for the syndrome
- Thrombosis rate 20%, the mortality as high as 40%.

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- Diagnosis : Thrombocytopenia (<100000 /Ul Platelet)

Tests:

- Heparin-induced serotonin release assay: a functional test & gold standard.
- Heparin-induced platelet activation test: functional, but nonspecific.
- Enzyme-linked immunosorbent assay (ELISA): specific for the heparin/PF4 complex or for PF4 alone.

Treatments for HIT:

- Plasmapheresis
- Heparin plus platelet inhibitors can be combined to reduce the aggregability of platelet.
- Hirudin, bivalirudin, and argatroban are direct thrombin inhibitors.

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A. Pre-operative Risk Assessment:

- Previous heparin use or ongoing infusion , Antiplatelet
- Oral contraceptive use or pregnancy,
- Anti-Thrombin iii deficiency,
- Intracardiac Thrombus, Elderly patient,
- Infective endocarditis,
- Diabetes, H/O insulin
- Shock
- Low grade DIC

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B. Pre-operative test for hemostatic function:

- Platelet count 150,000 -400,000/µl
- Bleeding time (BT) 1- 8 min
- Coagulation Time (CT) 2.5 – 4.5 min
- Prothrombin time (PT) 12- 15 sec; compaired to control used for warfarin anticoagulation monitor & test for clotting factor deficiencies or circulating anticoagulants in extrinsic system.
- INR
- Activated Partial Thromboplastin Time (aPTT) 35 – 45 sec; used to monitor Heparin anticoagulation & deficiencies of clotting factors or anticoagulant in intrinsic system.
- Thrombin Time < 17 sec; prolong by Heparin or abnormal fibrinogen
- Fibrinogen 250 – 500 mg/dl, Decreased in DIC.

C. Storage of Heparin

- Store in Refrigarator in normal chamber till to give patient.

Take Home Message

- **Pre operative hemostatic evaluation**
- **Ensure quality heparin & ACT tube**
- **Ensure modern facilities for coagulation management.**
- **Standardise heparin administration and ACT monitoring.**
- **ACT is affected by more than heparin; an abnormal ACT is not a diagnosis by itself.**
- **Individualise protamine and avoid excess dosing.**
- **Classify bleeding before treating: surgical, coagulopathic or mixed.**
- **Correct the specific defect—fibrinogen, platelets, factors, fibrinolysis or physiology.**
- **Early surgical reassessment and timely re-exploration matter when the source is surgical.**