heparin & extracorporeal circulation

an overview of bleeding & clotting during extracorporeal circulation
about my person

- 1974
- perfusionist since 2000
- eccp 2003
- triemli: 2003-2010
- DAS medical technology 2009 (Berner FH)
- klinik hirslanden zürich: 2010-today

swiss society of perfusion:

- 2002-2007: board member, delegate german part of switzerland
- 2013-today: president, together with j.consiglio (bern, insel)
content

- factors influencing haemostasis associated with cardiopulmonary bypass

- activation of coagulation on cardiopulmonary bypass

- unfractioned heparin, antithrombin, protamine

- choice of cardiopulmonary bypass setup: influence on coagulation?

- standard sequence for anticoagulation management during cardiac surgery

- surveillance of anticoagulation during ecc: poc-devices

- heparin, ecc & special challenges
Factors influencing haemostasis associated with cardiopulmonary bypass

- Blood loss
- CPB
- Time
- Heparin
- Systemic hypo-thermia
- SIRS
- Hemodilution
- Platelet dysfunction & fibrinolysis
interdependency of artificial surfaces and blood

1. transformation of proteins
   - enhancement of coagulation
   - activation of complement system
   - generation of vasoactive mediators

2. activation and destruction of blood components

3. toxicity e.g. sterilisation process, plasticiser
unfractioned heparin (ufh)

heparin properties

- anticoagulating
- antithrombotic
- antiinflammatory
- increases platelet aggregation (low dose)
- decreases platelet aggregation (high dose)
- increases fibrinolysis

heparin effect: influencing factors

- body weight & blood volume
- platelet count
- at III concentration: heparin resistance
- other binding proteins: heparin rebound
- liver & kidney function

disadvantages

- coagulation still occurs
- thrombin formation still occurs
antithrombin

- serpin (serine protease inhibitor), produced by the liver, normal activity 80-120%
- slow inhibitor; immediately and massively enhanced when binded to heparin
- main targets: \textbf{thrombin, f Xa}
- usually not determined preoperatively!
- causes of atIII deficiency:

  drug induced (\textbf{heparin resistance})
  accelerated consumption: sepsis, dic
  \textbf{dilution: cpb}
  decreased synthesis: liver cirrhosis
  increased excretion: protein-losing states
  familial
protamine

- 5 kda, positively charged polypeptide derived from salmon sperm
- antidot to ufh
- usually 1mg protamine per 100 i.u. ufh (1:1 reversal)
- **excessive administration**: unbound protamine inhibits fibrin generation, platelet reactivity, adhesion and aggregation associated with increased bleeding
- **heparin rebound**: heparin released from protein binding sites after protamine reversal associated with increased bleeding
- **adverse side effects**: arterial hypotension, pulmonary vasoconstriction, reduced cardiac output, anaphylaxis
- **cave**: cardiotomy suction!
cpb-setup: influence on coagulation?

clinical outcome:

NO EVIDENCE

standard sequence for anticoagulation management during cpb

- art. blood sample for baseline act  \( \text{normal act baseline-value: 100-140s} \)
- systemic administration of 300-400 i.u.kg\(^{-1}\) ufh  \( \text{responsability?} \)
- art. blood sample for act after 3-5 min  \( \text{start sucker activity? when?} \)
- \( \text{act}>480s \) before initiating cpb  \( \text{are 3 min worth the risk?} \)
- 5000-10000 i.u. ufh in prime solution  \( \text{not only the perfusionists insurance!} \)
- maintain act-level >480s during cpb, control act-level \( \text{at least} \) every 30 min  \( \text{do it every 20 min!} \)
- reverse heparin with protamin after cpb 1-1.5 protamin:1 heparin
- art. blood sample after 3-5 min  \( \text{stop sucker activity? when? cell saver!!!} \)
- **10000 i.u. heparin in the machine after retransfusion!!!**
surveillance of anticoagulation during ecc: POC-devices

Activated coagulation time
- hemochron®
- act plus®

Individual heparin dosing:
- hepcon®
- hemochron RxDx®

Visco-elastic tests:
- sonoclot®
- ROTEM®
act: activated coagulation time

- Hattersley 1967, Bull 1975
- standard whole blood test
- different tests, different activators, wide ranges
- susceptible to variation
- maintain act > 480 s during cpb
- no direct correlation with anti-Xa measures
- no evidence regarding the minimal, safe or ideal target of each test
individual heparin/protamine dosing

- measures patient’s heparin sensitivity to a known quantity of heparin

- 3-point-dose-response curve:

- protamine dose response similarly

- more expensive than ACT

- blood loss and transfusions can be reduced: Jobes 1995, Despotis 1995

- less protamine doses: Shore-Lesserson 1998

Medtronic Hepcon®
sgk/sghc-workshop: bleeding & transfusion

visco-elastic tests

**sonoclot®**
- tubular probe oscillating up & down within blood sample
- impedance corresponding clotting process
- graph: clot signal values vs time
- information on entire haemostasis including coagulation factors, fibrin gel formation, clot retraction, fibrinolysis

**rotem®**
- measurement of clot strength
- information on hyperfibrinolysis, substitution of factors, fibrinogen and platelets, heparin- & protamine dosage
heparin, ecc & special challenges

- avoidance of heparine
- define standards and use protocols
- team work
references (1)


references (2)


references (3)


