B24 - Intravenous fluids

(a) To describe the composition, pH and osmolality of crystalloids and colloids used in clinical practice.

- role = plasma expanders

Colloids

=
- part way between a suspesion and a fluid

(1) albumin
(2) gelatine derivatives

- haemaccel
- gelofusion

(3) polysacchardie derivatives

- dextran 40
- dextran 70

(4) starch solutions

- hetastarch
- pentastarch

Crystalloids

=

(1) hartmans
(2) normal saline
(3) 5% dextrose
(4) dextrose saline (4% dex, 1/5 N/S)
(5) hypertonic saline (7.5% & 3%)

Albumin

Composition

- protein solution
- clear, straw coloured solution

- 4, 5, 20 & 20% protein
- 96% albumin
- sodium bicarbonate, sodium carbonate and or acetic acid -> adjust pH to 6.4 to 7.4
- no preservatives
- prepared from pooled venous blood
- pasturised at 60 C for 10hrs
- Na+ 130 to 160mmol/L
- pH = 6.4 to 7.4

Osmolality - isoosmotic

Haemaccel

Composition

- gelatine derivative
- polypeptide produced by the thermal degradation of bovine gelatin -> cross linked with urea
- 500mL plastic bottles containing a sterile, pyrogen free, straw coloured solution.
- pH = 7.2
- 35g of polygeline
- 145 mmol/L of NaCl
- 5.1mmol of K+
- 6.25mmol of Ca2+

Osmolality = 7.4

Gelofusion

Composition

- gelatine derivative
- Na+ 154 & Cl 120 mmol/L
- 1.2g of sodium hydroxide
- pH = 7.4

Osmolality = 274mosmol/L

Dextran 40

Composition

- polysaccharide derivative

- polysaccharide derived from sucrose by the action of the bacterium *Leuconostoc mesenteroides* -> further processed by hydrolysis & fractionation.
- clear, colourless 10% solution
- in either 5% dextrose or 0.9% saline
- pH = 3 to 7

Osmolality - 300 mosmol/L

Dextran 70

Composition

- polysaccharide derivative
- polysaccharide derived from sucrose by the action of the bacterium *Leuconostoc mesenteroides* -> further processed by hydrolysis & fractionation.
- 6% solution
- with either 5% dextrose or 0.9% saline
- pH = 4 to 7

Osmolality = 300mosmol/L

Hetastarch

Composition

- starch solution
- synthetic polymer derived from amylopectin
- hydroxyethyl groups are substituted into the glucose units to retard degradation by serum amylase.
- clear, pale yellow 6% solution of hetastarch in 0.9% saline.
- also contains: NaCl 154 mmol/L

Osmolarity = 300mosmol/L

Normal Saline

Composition

- 0.9%
- 150mmol of NaCl
- an inorganic salt
- pH = 4.5 to 7
- no preservatives & no microbial agents

5% Dextrose

Composition

- monosaccharide obtained by the hydrolysis of cornstarch
- clear, colourless sterile solution
- contains 5% dextrose in H2O
- no buffers or bacteriostatic agents
- pH 3.5 to 6.5

Osmolality = 250mosmol/L

Dextrose saline (4% dex, 1/5 N/S)

Composition

- 56mmol/L of dextrose
- pH =

Osmolality = 310mosmol/L

Hartmans solution

Composition

- compound sodium lactate
- clear, colourless solution
- Na+ 131 mmol/L
- Cl- 111mmol/L
- Ca2+ 2mmol/L
- K+ 5mmol/L
- lactate 29mmol/L -> converted to HCO3- in liver
- pH = 6 to 7.3

Osmolality = 274mosmol/L

(b) To evaluate their effects and fate when used in volume replacement.

Albumin

- 5% = iso-oncotic
- 20% and above = draws 3 times its volume of tissue fluid into the vascular space in 15min.

- when 1L administed:

- tonicity unaltered
- no change in osmolality
- 20% increase in blood volume

-> detected by volume receptors (above 7-10%) ->

(1) fall in ADH -> excretion of H2O
(2) H2O loss increases the plasma oncotic pressure -> water moves from ISF to IVF

Gelatine derivatives

- equilibrates throughout the body

- 30% in circulating blood
- 30% in interstitial fluid
- 40% in urine

-> restores haemodynamic status after a period of hypovolaemia

Polysaccharide derivatives

- by its osmotic effect it will hold H2O in the vascular space
- 500mL of dextran -> increase the plasma volume by 1000mL

- infusion of 1L of Dextran:

- increase in blood volume by 20%
- no change in osmolarity
- sensed by volume receptors (change in >7-10% occured) -> increased ANP secretion, renal afferent arteriolar vasodilation -> increased GFR, decreased ADH, decreased DCT Na+ reabsorption -> increased urine output

(1) in the hypovolaemic there will be a return towards normal of haemodynamic parameters.
(2) decrease in ADH secretion

Starch derivatives

See previous for colloids effect.

Normal saline

- effects of 1L of normal saline:

(1) distributes to the into the plasma where it remains for 30min before being uniformly distrubuted throughout the ECF (intersitial fluid:plasma - 3:1) -> ISF increases by 750mL and plasma by 250mL = 5% increase in blood volume -> no volume effect as no greater than 7-10% change
(2) no change in osmolarity -> no osmoreceptor response
(3) N/S has no proteint -> lowered oncotic pressure -> increased GFR & smaller reabsorption of H2O in proximal tubule -> increased in urine output.

5% dextrose

= a maintenance fluid
- isotonic

- administration of 1L of Dextrose 5%:

(1) glucose quickly taken up by cells -> administration of pure H2O
(2) H2O distributed throughout TBW in proportions (TBW distribution) -> of 1000mL, 670mL to intracellular fluid & 330mL of ECF
(3) volume receptors not triggered c/o less thant 7-10% change (around 2%)
(4) 2.5% change in plasma osmolarity -> sensed by osmoreceptors (1-2% change enough) -> ADH decreases -> H2O excretion rises.

Dextrose saline

- handle as for dextrose & saline separately

Hartmans

- same as N/S
- except lactate -> HCO3- by liver

Hypertonic saline

- osmolarity is 3 times that of plasma (900mosomolL)

(1) Na+ contents limits distribution to the ECF -> osmolarity increases to 304mosmol/L
-> increased osmolarity sensed by osmoreceptors -> increased ADH secretion, increase in thirst

(2) increased osmolarity -> draws H2O out of cells by decreasing intracellular fluid volume -> increased ECF volume by 2L (only 500mL is in plasma) -> triggers volume receptors

-> ALD secretion will be suppressed
-> ANP will inhibit renin
-> natriuresis & excretion of H2O

Advantages of Colloids

- smaller volume to infuse
- higher MW molecules -> longer in plasma -> prolonged increase in plasma volume
- minimal peripheral oedema
- higher systemic O2 delivery
- may cross BBB less

Disadvantages of Colloids

- greater expense (volume for volume) -> 30x more expensive than crystalloids
- coagulopathy
- pulmonary oedema
- decreased Ca2+
- impaired cross-matching (dextran)
- osmotic diuresis
- anaphylactic/oid reactions
- no proven reduction in mortality

Advantages of Crystalloids

- low MW -> freely diffusable
- less expensive
- hypertonic saline good for traumatic brain injury
- greater urinary flow
- replaces sequestered intersitial fluid

Disadvantages of Crystalloids

- short-lived haemodynamic improvement
- peripheral oedema
- pulmonary oedema
- larger infused volume required

(c) To compare the pharmacology of colloids such as albumin, gelatin derivatives, polysaccharide derivatives and starch solutions with crystalloids such as lactate solutions & normal saline.

Albumin

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Osmolality - isoosmotic

PK

Metabolism - exogenous albumin enters the aa pool & undergoes biotransformation.

Elimination - t1/2 = 17 days

PD

Main action - plasma expansion

Mechanism

- exerts colloid oncotic pressure
- 5% = iso-oncotic
- 20 & 25% = will draw 3 x the administered volume into the circulation in 15 min.

CVS

- in context of hypovolaemia -> haemodynamic parameters towards normal
- myocardial depression

GU

- increased renal perfusion

Other adverse effects

- circulatory overload
- allergic reactions
- aluminium toxicity

Gelatin derivatives

Haemaccel

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Distribution

- t1/2 alpha = 7hrs
- Vd 0.7L/kg

Elimination

- 80% urinary excretion
- 10% faeces

Other adverse effects

- provoke histamine release (anaphylactoid 1:1000) -> bronchospasm, tachycardia, rash & severe hypotension.
- don't mix with citrated blood

Gelofusion

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Polysaccharide derivatives

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Osmolality - 300 mosmol/L

PK

Distribution - Vd = 6L

Metabolism - by dextranases present in lung, liver & spleen

Elimination

- biphasic
- 70% by renal
- 30% by metabolism to CO2 & H2O
- plasma t1/2 = 7hrs

PD

Main action = plasma expansion

Metabolic

- reduces serum lipid concentration
- reduction in serum albumin

Other side effects

- severe hypersensitivity reactions in 1:3300
- circulatory overload
- increased capillary oozing
- ARF

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See above for similar details

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Osmolarity = 300mosmol/L

Route - IV

Dose

- should not exceed 20mL/kg/day
- increased plasma volume lasts 24-36hrs

PK

Distribution

- small fraction taken up by spleen

Elimination

- hydrolysed by serum amylase into fragments
- renally excreted or removed by reticulo-endothelial compartments

PD

Main action - plasma expander

CVS

- circulatory overload

CNS

- headache

GI

- salivary gland enlargement
- vomiting

Haemopoietic

- interference with platelet function
- inhibits endothelial activation -> preventing neutrophil adhesion
- prolongation of APTT
- decreased FVIII, vWF & fibrinogen

Other adverse effects

- pyrexia
- itching
- anaphylactoid reaction 0.0005%

Hartmans

- overtransfusion -> hypernatraemia, pulmonary oedema & metabolic alkalosis
- not recommended in lactic acidosis

Normal saline

- overtranfusion -> oedema, hypernatraemia & hyperchloraemic acidosis.