Haemodynamic Support for the Elderly

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Conflicts of Interest

- Nil current

- Last ten years:
  - Overseas conferences: Fresenius-Kabi, Adcock Ingram Critical Care, Aspen
  - Lecturing honoraria: Fresenius-Kabi, B Braun
  - Advisory board: Fresenius-Kabi

“Haemodynamic Support for the Elderly”

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“U becomes V”

“Closer to the edge of the cliff”

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Ageing

"Physiological involution"

Years

40	Start
65	Statistical
80	Obvious
120	End

Parallel

Cumulative comorbidities

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Other organ systems : Renal

- **GFR falls**
  - …Water retention
  - …Less clearance
- **Tubule dysfunction**
  - …Less water resorption
  - …Electrolyte handling poor

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Other organ systems : Body

- **Less muscle** …Weak
- **Connective tissue** …Less fat / mass
- **Changed water/kg** …Altered Vd

Other organ systems : CNS

- **Neurochemicals** …Delirium risk
- **Altered receptors** …Oversedation
- **Altered ANS tone** …“Weak” SNS

Other organ systems : Lungs

- **Structural changes** …Hypoxaemia risk
- **Muscle weakness** …Less efficient respiration
- **Hyperinflation**

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CVS Aging

Vessels

- Thicker walls
  - fibrosis
- Less elastic
- Narrower lumen
- Endothelial senescence
  - Less NO

Vessels

- *Lower arterial compliance*
  - *Increased LV afterload*
- *Lower venous compliance*
  - *Impaired RV preload handling*
    - *Less reservoir*
    - *Less buffer*
- *Impaired delivery at tissues*

Systolic Hypertension

- Aorta loses elasticity
- LV systole and ejection : less stretch
  - Higher Systolic Blood Pressure
- LV diastole : less “bounce-back”
  - Lower Diastolic Blood Pressure generated
- LV perfused in diastole : DBP = driving pressure

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Effects of Systolic Hypertension

- *Increased LV work during systole*
  - *↑ O_2 demand*
- *Poorer LV perfusion during systole*
  - *↓ O_2 supply*
- *↑ myocardial ischaemia risk*
- *↑ pulse pressure : AKI risk*
- *Lower DBP implies WORSE disease*

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Ventricles

- ↑ Afterload → concentric hypertrophy
  - Pressure overload : Laplace's Law
- Myocyte necrosis & apoptosis
  - Replacement fibrosis
  - Survivors hypertrophy ("erratic hypertrophy")
- Thicker wall
  - Smaller chamber

Ventricles

- *Impaired DO_2 from coronaries*
  - *Thick wall : ↑ diffusion distance*
  - *Endo-ischaemia*
- *Systolic dysfunction*
  - *Limited contractile reserve*
- ***Diastolic dysfunction***
  - ***Preload variation intolerance***

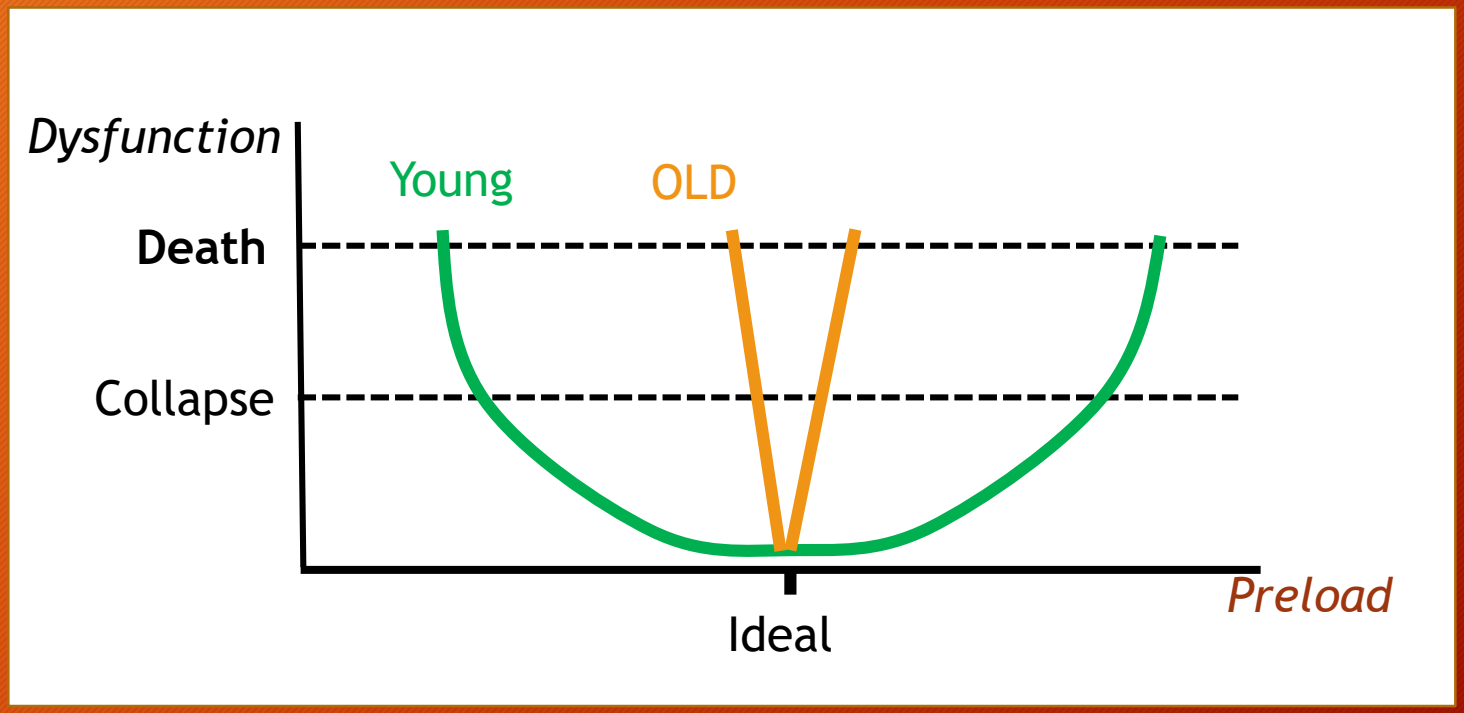
Diastolic dysfunction

- *Left Ventricular End-Diastolic Volume (preload) must be "**just right**"*

- *LVEDV a bit low : SV drops*
- *LVEDV a bit large : back-pressure, congestion*
  - *Pulmonary oedema*

- *Passive LV filling in early diastole reduced*
- ***LV filling depends on atrial contraction***

U → V concept



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Valves

- Sclerosis
  - Fibrose, calcify
- *Aortic sclerosis*
  - *Bark worse than bite*
  - *But adds to LV afterload*
  - *Limits ability to increase Cardiac Output if afterload drop*
- Papillary muscle dysfunction

Conduction

- SA nodal cells involute
- Atrial fibrosis
- Shrinkage of conduction tracts
- *Long intervals, arrhythmias, blocks*
- *Atrial arrhythmias (eg AF) : loss of atrial filling*

Innervation

- Beta adrenoceptors reduced function & number
  - *Reduced SNS cardioacceleration*
  - *Reduced agonist response*

- Alpha adrenoceptors slight reduction
  - *Vasoplegia risk*

Closer to the cliff-edge

- High afterload
- “Inappropriate” preload
- Diastolic dysfunction
- Valve problems
- Arrhythmia & block risk
- Dependent on atrial “kick”
- Poor inotrope response

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Loss of reserve

- Maximum heart rate
  - “220-age”
- Stroke Volume augmentation limited
- Maximum Cardiac Index falls with age
  - 8+ → 3 L/min/m^2
- Less cardiac output reserve
- Cardiac failure “just waiting to happen”.

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Myocardial ischaemia risk

- Inevitable **coronary artery** narrowing with age
  - Worse if atherosclerosis too
  - Limits blood supply
- Increased Cardiac Output → worse supply/demand imbalance
  - Tachycardia increases demand, decreases supply
- → Myocardial infarction : "NSTEMI type"
  - COMMON! POOR OUTCOMES! Missed unless troponin done

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Elective anaesthesia

Staying away from the cliff-edge

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Anaesthesia choice

- Try regional!
- Induction agent choice
- Maintenance choice
- *Contracted Vd, more sensitive, less clearance*

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Setting targets

- Sinus rhythm
- Heart rate
- Fluid status
- Mean arterial pressure

Mean Arterial Pressure

- Set a target range and actively maintain it
  - 65-70?
  - 70-75?
  - 80% of pre-induction value?
- Most accurate measure : A line mandated?
- High BP spikes … undesirable
- Post-Induction Hypotension … WORSE
  - Pre-emptive vasopressor?
    - Phenylephrine 0.1-1mg/kg/min?

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Fluid status

- Hardest to guess
- Intravascular volume matters

- Systolic Pressure Variation / Pulse Pressure Variation / Stroke Volume Variation
  - … if ventilated
- PLR, TTE difficult during anaesthesia
- CVP ?
- Cardiac Output Monitor?

Central Venous Pressure

- Volume → Pressure
  - 2 wobbly chambers, across lungs, position
- Not predictive in most of its range
  - Do not chase a magic number
- Very low (0 / -ve): extreme depletion
- Very high: overload, cardiac failure.

Cardiac Output Monitoring

- Know the tool
  - Vigileo
  - PiCCO / LiDCO
  - **Cardio-Q**
  - Ultrasound – cardiac function monitor
- Which parameter to measure?
- >10% improvement in Stroke Volume
  - After 3ml/kg fluid CHALLENGE
  - … fluid WAS good

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The shocked elderly patient

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Circulatory shock

Life-threatening state
of
generalized acute circulatory failure
leading to
inadequate oxygen delivery to cells
relative to their needs
resulting in
cell dysfunction and death

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Or

$DO_2 < VO_2$

↓

death

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Systemic macrocirculation

Pump

Pipes

Arteries | Veins

Fluid

Shock mechanisms

- **Pump failure** — cardiogenic
- **Pipe expansion** — distributive
- **Fluid loss** — hypovolaemic
- **Blockage** — obstructive
  (intrinsic | extrinsic)

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Cardiogenic shock

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Acute Heart Failure with Reduced Ejection Fraction

- Fluid overload: congestion, pulmonary oedema
- Not severely hypotensive

- BNP : support diagnosis

- Troponin, CK-MB : ischaemic cause

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AHFrEF management

- Oxygen
- Furosemide diuresis
- Nitrate infusion
- Positive pressure : CPAP / PEEP+PS

Positive airway pressure

- Good for Left Ventricle with systolic failure
  - Reduces afterload (less transmural pressure gradient)
  - Reduces LV preload
  - **Front line in pulmonary oedema from LVSF**
- Less benefit in LV diastolic failure
- Risky in RV failure
  - Reduces preload, can increase afterload

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Cardiogenic shock

- Oxygen
- Positive airway pressure : mask CPAP / PS
- Dobutamine inotrope
  - Inevitable risk in ischaemic heart disease
- SBP < 90mmHg
  - Adrenaline?

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Combination shock states

Classical example : septic shock

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Combination shock

- Single initiating shock mechanism
- Aggravated by dysregulated immune response
  - ← Microbial products
  - ← Damaged tissue
- Develops into **combination shock state**

  hypovolaemic + distributive + cardiogenic ± obstructive

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Septic shock in elderly

- Premorbid compromise due to age

- + Hypovolaemic shock : capillary leak
- + Distributive shock : venous pooling
- + Cardiogenic shock : cardiodepressants

- "U → V" phenomenon
  - Minimal leeway until irretrievable collapse

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Lack of signs

- Septic shock in young adults : florid
  - Fluid depleted
  - Vasodilated, warm (unless grossly hypovolaemic)
  - Cardiac Index above normal
- Septic shock in elderly : missable
  - Fluid depleted … often occult
  - Less dilated … often shut down
  - Cardiac Index can’t increase

In elderly

Be suspicious!

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Supportive care

- Broad-spectrum empiric antibiotics 1st dose early
  - Culture first: Stop if non-septic cause found
- Appropriate analgesia (± sedation)

- REWARMING

- Glucose control (5-10mmol/l)
- Coagulation management
- Stress ulcer prophylaxis

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Arrhythmia management

- Bradyarrhythmias : pacing
  - Chemical (adrenaline) | TRANSCUTANEOUS | TV
- Tachyarrhythmias
    - Keep K^+ > 4mmol/l, Mg^{2+} > 1mmol/l
  - Early synchronized cardioversion
  - Amiodarone
    - 15-30min infusion 150mg for reversible causes
    - Full therapeutic load if several boluses needed, or “old heart”
    - Hypotension problem

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Work of Breathing

- Respiratory compensation for metabolic acidosis = hyperventilation
- High energy demand
  - Respiratory muscles can demand blood flow higher than elderly patient's maximum Cardiac Output
- Hyperventilation drives cardiac failure!

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Relieve Work of Breathing!

- Do early mechanical ventilation in shocked elderly : continue until shock resolved
  - Generally mandates invasive ventilation
  - NIV not good here
  - Controlled mode, fully offload the patient
- Lung-protective volumes (6ml/kg PMFH)
- AVOID HYPOCARBIA … cerebral vasoconstriction

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Patients will need…

- Fluids
  - Boluses to refill intravascular volume
  - Infusions to maintain intravascular volume
- Vasopressors
- Inotropes
  - More in elderly than in young

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We must pursue…

- A primary target
  - Mean Arterial Pressure
    - 65-70mmHg
    - Higher if previously hypertensive?
- A secondary target : balance fluids & vasoRx
  - Cardiac Index
- A tertiary target
  - Improved perfusion : lactate clearance, UO, GCS

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Fluids

- Get every monitor you can
  - Arterial line
  - Cardiac output monitor
  - Ultrasound
    - IVC
    - Cardiac filling
- Assess the effect of every bolus
  - Improving MAP and CI?
- “Baseline maintenance infusion” 1ml/kg/h

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Fluid types

- Ringer's Lactate default
  - Normal Saline ONLY if hyponatraemic
    - Chloride kills kidneys!
- Inflammatory states damage glycocalyx
  - Colloids leak too
- Haemoglobin target : 7g/dl for most
  - 10g/dl for cardiac becoming disputed

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Vasoactives : No

- Need: vasoconstriction + inotropy
- Noradrenaline international recommendation
  - Not available (practically) in SA
- Dopamine
  - Depresses thyroid function, impairs immunity
  - INDIRECT AGENT

Vasoactives : Not alone

- Dobutamine
  - Inotrope
  - Vasodilator
    - NOT AS FIRST THERAPY IN INFLAMMATORY SHOCK STATES
    - CAUTION IF PATIENT HYPOTENSIVE
- Phenylephrine
  - Vasoconstrictor (veins, ARTERIES)
  - Beyond 1mcg/kg/min, needs cardiac monitoring
  - Overconstriction → ↑ afterload → LV failure

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Vasoactives : OK

- Adrenaline
  - Inotrope, chronotrope (Beta receptors)
    - “Too much” … tachycardia
    - But Beta receptor downregulation
  - Vasoconstrictor (Alpha receptors)

  - Titrate in range 0.03-0.8mcg/kg/min in elderly
  - Can combine submaximal doses with DOBT / PHNL

- Phenylephrine + dobutamine
  - Less tachycardia risk
  - Must have Cardiac Output measurement

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Perpetual review process

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Cycle of constant challenges

- Set MAP goal
  - Achieve it using fluids and vasoactives
- When achieved : challenge and query
  - Is this fluid : vasoactive balance the best?

Example : baseline fluid

- Start 1ml / kg / h
- If multiple fluid boluses needed
  - Increase “Baseline Maintenance Infusion” rate
- Review in maximum 2 hours
- If no boluses were required
  - Decrease “Baseline Maintenance Infusion” rate
- Boluses were still needed – increase further
  - If not – decrease “Baseline Infusion” further

This is not easy

The V is narrow

- Actively monitor every intervention
- Clinical | Haemodynamic | Invasive
- **Cardiac & lung Ultrasound**
- Treat aggressively to targets
- Full attention required

The cliff phenomenon

- Elderly have less leeway before getting into irreversible failure.
- Some haemodynamic combinations are irreversible
  - “over the cliff”
- Myocardial ischaemia
  - After even short supply/demand imbalance
  - OCCULT MYOCARDIAL INFARCTION FREQUENT.

Often… no second chances

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Thank you.

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