SWAN GANZ CATHETERS

Introduction

- Introduced by Swan & associated in 1970
- Balloon tipped, flow directed catheters
- Rationale for use:
  - Clinical observation subjective/inadequate in critically ill
  - Allow measurements of determinants & consequences of cardiac performance

[Pre-load, Afterload, CO]

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Essential for management of unstable Patients

Indications

- Assessment of Shock:
  - Cardiogenic, Hypovolemic
  - Septic, Pul. Embolism
- Assessment of Resp. Distress:
  - Cardiogenic Vs Non-Cardiogenic
- Management of Complicated MI:
  - Hypovolemia Vs Cardiogenic Shock
  - VSD with MR
  - Severe LVF
  - RV Infarction

- Assessment of Therapy in Selected Individuals:
  - Afterload reduction in patients with severe LVF
  - Inotropic agent
  - Vasopressors
- Management of Post-Op Open Heart Surgical Pts.
  - Assessment of cardiac tamponade
  - Assessment of Valvular heart disease

- Assessment of Fluid Requirements in Critically Ill Pts.
  - GI hemorrhage
  - ARF
  - Decompensated Cirrhosis
  - Sepsis
  - Burns
  - Advanced peritonitis

Catheter Features & Types

- Made of PVC
- Coated with Heparin - Reduce Thrombogenicity
- Std length: 110cm - Ext-diameter; 5-7 Fr
- Balloon at tip - Guides the catheter
  (Air filled) Minimizes endocardial damage or arrhythmia
- Double lumen - Balloon inflation
  - Measure intravascular pressure/Sample blood

- Triple lumen - Simultaneous measurement of RA, PA pressure
- 4 Lumen - CO measurements via thermiostor (most commonly used)
- 5 lumen - Central venous access for fluid/ medicine infusion

<u>Special Purpose</u>

- Pacing Catheter - 2.4 Fr. bipolar pacing electrodes
  - Intra cardiac pacing
- Continuous SvO_2 - Catheter

Insertion Techniques

- Inserted percutaneously or via cut down into basilic, brachial, femoral, sub-clavian or internal jugular veins
- Internal jugular vein approach preferred:
  - Pt. Arm movements not encumbered
  - Used in pts. undergoing intra-thoracic Sx
  - Fewer thrombotic/septic complications may occur

- Insert Central Venous Cannula

Position the guidewire in vein

Vessel dilator sheath apparatus advanced into vessel

Remove guidewire and vessel dilator leaving introducer sheath in vessel

Pass the catheter through the introducer sheath into vein

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Advance it until tip reaches RA

(Antecubital fossa: 35-40cm, Int. Jugular vein 10-15cm, sub clavian vein 10cm, Femoral vein 35-40cm)

Obtain RA blood for O_2 saturation from distal port, record RA pressure

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Inflate balloon with recommended amount of air. Advance catheter until RV pressure tracing seen on monitor

Obtain and record RV pressures

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Advance into PA (Diastolic pressure tracing rises above that in RV)

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Further advancement results in fall in the pressure tracing from the systolic pressure in RV and PA, record PAWP. Deflate balloon

Secure catheter in position by suturing it to skin

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CXR: To confirm position

Catheter tip should appear 3–5 cm from midline

Checklist for Verifying Catheter Position

	Zone 3	Zone 2 or Zone 1
• PAWP countour	Cardiac Ripple (A+V waves)	Unnaturally smooth
• PAD Vs PAWP	PAD > PAWP	PAD < PAWP
• PEEP trial	△PAWP< ½ △PEEP	△PAWP> ½ △PEEP
• Catheter tip location	LA level or below	Above LA level

- PAWP correlates well with LVEDP [(N) MV, (N) LV function]
- PAWP interpretation done in end expiration

With PEEP application,

Pl. pressure ↑½ of applied PEEP : (n) Lungs

↑ ¼ of PEEP : ARDS

- Temporary disconnection of PEEP not recommend :

  1. PEEP discontinuation ↑ venous return - 'Auto trans fusion effect' → Cardio – Pulm. Decompensation

  2. Alter Resp. mechanics and gas exchange

Normal Resting Pressures Obtained During Right Heart Catheterization

Cardiac Chamber	Pressure (mmHg)
Right atrium	
Range	0 – 6
Mean	3
Right ventricle	
Systolic	17 – 30
Diastolic	0 – 6
Pulmonary artery	
Systolic	15 – 30
Diastolic	5 – 13
Mean	10 – 18
Pulmonary artery wedge (mean)	2 – 12

Approximate Normal Oxygen Saturation and Content Values

Chamber Sampled	Oxygen Content (Volume %)	Oxygen Saturation (%)
Superior vena cava	14.0	70
Inferior vena cava	16.0	80
Right atrium	15.0	75
Right ventricle	15.0	75
Pulmonary artery	15.0	75
Pulmonary vein	20.0	98
Femoral artery	19.0	96
Atrioventricular oxygen content difference	3.5 – 5.5	-

Thermodilution Techniques

- Principle: Known quantity of cold solution introduced into circulation and adequately mixed, the resultant cooling cure recorded at downstream site allows calculation of net blood flow.
- Thermiostor placed in the distal port (4 cm from catheter tip)
- Procedure : 10ml D_5W (0-24^{0}C) injected into RA

  Baseline PA blood temp. } Recorded by → Curve analyzed
  Subsequent temp. change } Thermiostor by computer

- Average of 3 evenly spaced determinations represent accurate estimate of CO.
- should be done end expiration
- Inaccurate in low cardiac output states/TR/ASD or VSD

Fick Techniques

- Principle : Total release or uptake of a substance by organ equals product of blood flow through that organ X diff. of arteriovenous conc. of the substance.

$$CO = \frac{O_2 \text{ Consumption (ml/min)}}{CaO_2 - CvO_2}$$

- O_2 consumption (VO_2) = 70Kg man : 250ml/min

  130ml x BSA [if Fat ≥ 15% of BW]

  140ml x BSA [if Fat < 5% of BW]

- O2 Content = % Saturation x Hb (g/dl) x 1.39 (ml O_2/g Hb) x 10
- Cannot be used in Intra cardiac shunt

Analysis of Mixed Venous Blood

- CO directly proportional to mixed venous O_2 partial pressure.
- Serial measurements of SVO_2 may display trends in CO

SvO_2 :	70-75%	-	(n)
	< 60%	-	Heart failure
	< 40%	-	Shock

Derived Parameters

- Cardiac Index : CO (L/min)/BSA (m^2)
- Stroke volume: CO (L/min)/HR (beats/min)
- Stroke index: CO (L/min)/HR (beats/min) x BSA (m^2)
- Mean Arterial pressure: (2x diastolic) + systolic/3
  [MAP] (mm Hg)
- Systemic vascular Resistance (dyne/sec/cm^{-5}):
  MAP – mean RA pressure/CO (L/min) x 80
- Pulmonary arteriolar resistance (dyne/sec/cm^{-5})
  mean PA pressure – PAWP/CO x 80
- Total pulmonary resistance: Mean PA pressure/ CO x 80
- DO_2 (ml/min/m^2) = Cardiac index x CaO_2

Clinical Applications

- **Hypovolemia :** ↓ CI, RAP, PAWP, ↓ SBP

  PAWP: 15-18mmHg in AMI and ↓ LV compliance

  small amt. Fluid infusions

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  (Higher Lt. heart filling pressure, 18-24 mmHg in Pts. With hypovolemia in AMI – optimal for improving CI)

- **Pul. congestion :**
  - Increased PAWP (>18mmHg)
    - Causes : LVF or fluid overload
    - Diuretics, intotropic drugs, vasodilator agents
  - PAWP: (N)/ ↓
    - Pul. Congestion due to : changes in pul. Capillary memb.

- **<u>Heart failure:</u>** S/o peripheral hypoperfusion/shock
  ↓ CI, ↑ PAWP
  RV Failure: ↑ Mean RAP,
  [Pul. Vascular disease ↑ RV end diastolic pressure
  RV Infraction]
- **<u>Tricuspid Insufficiency:</u>** Seen in RV dilatation Pul. HT
  ↑ V wave & steep y descent RA waves
  ↑ Mean RAP
- **<u>Ac. Mitral Regurgitation:</u>** Giant 'V' wave in PAWP tracing
  Bifid PA waveform
- **<u>Ac. VSD:</u>** Marked O2 saturation step-up in PA or RV compared to RA
  O2 step-up > 10% bet. RA & RV → Significant L → R Ventr. Shunt

- **<u>RV infarction:</u>** - ↑ RAP
  RA waveforms: Prominent x & y descent
  RAP ↑ inspiration : Kussmaul's sign
  ↓ RV stroke volume
- **<u>Cardiac Tamponade:</u>** Elevation & Equalization of RA, RV diastolic, PA diastolic, mean PAWP
  RA waveform: Dominant x descent
  Mean RA pressure ↓ inspiration
- **<u>Pulmonary Embolism:</u>** Mean PA pressure : 20-40 mmHg
  RV, PA syst. Pressure: 50mmHg
  ↑ PVR
  PAWP: low/normal
  a & v wavesmay disappear

Complications

Complications	Incidence %
• of vascular Access	
– Arterial puncture	1.1 – 1.3
– Bleeding at cutdown site	5.3
– Pneumothorax	0.3 – 4.5
– Air Embolism	0.5
• of placement	
– Minor dysrrhythmia	4.7 – 68.9
– Severe dysrrhythmia	0.3 – 62.7
– CHB	0 – 8.5
• of catheter residence	
– PA rupture	0.1 – 1.5
– Catheter related sepsis	0.7 – 11.4
– Thrombophlebitis	6.5
– Venous thrombosis	0.5 – 66.7
• Pul. infarction	0.1 – 5.6
• Endocarditis/valvular or Endocardial vegetation	2.2 – 100
• Deaths Attributed to PA Catheter	0.02 – 1.5

- **Balloon Rupture:** - When recommended inflation volumes exceeded

  - Air emboli → Access to arterial system balloon → embolize to distal pul. circulation
- **Knotting :** Occur when lops form in cardiac chamber and catheter repeatedly withdrawn & re-advance

  Removed: Transvenously, Guidewire placement, Venotomy
- **Pulmonary Infarction:** Peripheral migration of catheter tip
  - Inflated balloon wedged for long time
  - Thrombus formation around catheter or areas of endothelial damage
  - Lesion small asymptomatic
  - Avoided by: continuous heparin flush careful monitoring of PA waveform

- **<u>Pulmonary artery perforation:</u>**

  Mech. - Wedged catheter tip position favoring eccentric balloon inflation

  - Cardiac pulsations – catheter tip repeatedly contacts vessel wall

  - Catheter tip near arterial bifurcation (integrity compromised)

  - Lat. pressure on vessel wall
- **<u>Risk factors:</u>** Pul. HT/MVD/ ↑Age/ ↓Temp./Anti coagulant use
- **Massive haemoptysis**
- **<u>Mx:</u>** Immediate wedge arteriogram, bronchoscopy

  - Intubation of Unaffected lung

  - Emergency lobectomy/pneumonectomy

  - Other options: Application of PEEP

- **Thromboembolic :** Thrombi at catheter tip, endocardial sites

  phenomena - Suspect when: consistently dampened pressure tracing without peripheral catheter migration

  - Heparin bonded catheters reduce thrombogenecity

- **Rhythm disturbances:**
  - Commonly occur during insertion
  - Ventr. Arrhythmia:
    - Most are self limiting
    - Risk factors: AMI, Hypoxia, Acidosis, Hypocalcemia, Hypokalemia
    - Prophylactic use of lidocaine in high risk pts. will decrease incidence
  - Irritation of conducting system
  - Arrhythmia persists after lidocaine therapy associated with HD compromised } Remove catheter

- RBBB: Seen in ASMI/Ac. Pericarditis
- Preexisting LBBB: Complete heart block

- **<u>Infections:</u>** Incidence decreased
  in situ time > 72-96 hrs
  CO determinations repeatedly
  Freq. Blood withdrawals
  } ↑ Risk of sepsis
  Decreased inf.: - Sterile protective sleeve
  - Antibiotic bonding to catheter
  - Empiric changing of catheter over guidewire

Pul Artery Catheter Consensus Conference: Consensus Statement 1997

Does Management with PAC Improve Pt. Outcome

Disease/ disorder	Answer	Grade
1. MI with		
- Hypotension or cardiogenic Shock	Yes	E
- Mech complication	Yes	E
- RV Infarction	Yes	E
2. CCF	Uncertain	D
3. Shock/HD instability	Uncertain	E

4.	Cardiac Surgery		
	- Low Risk	No	C
	- High Risk	Uncertain	C
5.	Geriatric Pts undergoing Sx	No	E
6.	Trauma	Yes	E
7.	Sepsis/Septic Shock	Uncertain	D

Meta-Analysis for effectiveness of PAC

- 12 RCT, 1610 Pts.
- Morbidity events observed in 62.7% of PAC group 74.3% Control group. (p= 0.0168)
- Statistically significant reduction in morbidity using PAC guided strategies.

Ivanov R et al CCM 2000

4182 Pts.

Effect of Pulmonary Artery Catheter on intensive Care mortality in all Pts. Admitted to an ICU in a British Hospital examined.

No increased mortality attributable to use of PAC demonstrated.

Murdoch SD Br J Anaes 2000

Sepsis/Septic Shock

outcome better in patients with septic shock unresponsive to fluid resuscitation and vasopressors, if PAC prompts change in therapy

Mimoz et al CCM 1994

However, PAC placed in first 24 hrs. of ICU admission not shown to significantly alter outcome in general population of sepsis/septic shock.

No benefit in MOF and sepsis

Connors et al JAMA 1996

RCT of 1994 patients (High risk patients ≥ 60yrs. ASA class III or IV scheduled for urgent/elective Sx followed by ICU stay)

No benefit to therapy directed by PAC over standard care

Sandham J D et al NEJM 2003.

Case Control Study

- 141 pairs Mx with/without PAC
- Severe sepsis
- PAC use not associated with change in mortality rate or resource utilization

Yu DT et al. CCM 2003


Thank You