

Mechanical Circulatory Support

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Learning Objectives

- ^ Describe devices used in noninvasive mechanical circulatory support (MCS).
- ^ Describe patients who are likely to benefit from invasive MCS.
- ^ Describe the components, operation and problems for the intra-aortic counterpulsation system.
- ^ Describe the components, operation and problems for an extracorporeal membrane oxygenator.
- ^ Describe examples of ventricular assist devices and total artificial hearts.

Learning Objectives

- ^ Describe examples of the following invasive MCS systems:
 - ◆ ventricular assist devices
 - ◆ total artificial hearts

Noninvasive Mechanical Support Devices

Mechanical aids to external massage

- Automatic resuscitator- 'Thumper'
 - ◆ Pneumatically-powered compressor positioned over patient

Mechanical aids to external massage

- Automatic resuscitator- Michigan Instruments Thumper (TM)
 - ◆ Advantage
 - f* consistent compression, without fatigue
 - f* frees personnel for other actions
 - ◆ Problem- patient tends to be moved out of correct position

Mechanical aids to external massage

- ^ Ambu Cardiopump (TM)
 - ◆ Suction cup attaches to chest, permitting upward traction
 - ◆ Active compression & decompression

Mechanical aids to external massage

- ^ Ambu Cardiopump (TM)
 - ◆ Advantages
 - f* Decompression increases refill of ventricles and lungs
 - f* May effectively ventilate
 - f* Small
 - f* Inexpensive
 - f* Research- improves short-term survival

Mechanical aids to external massage

- ^ Difficulties with use
 - ◆ body hair- maintaining a seal
 - ◆ moisture- maintaining position
- ^ Initial trials- encouraging
- ^ Requires more study
- ^ Not available in US

Mechanical aids to external massage

- ^ CPR vest (Zoll AutoPulse)
 - ◆ Vest surrounds body- intermittent inflation & deflation provides chest compression

<http://www.zoll.com/product.aspx?id=84>

Mechanical aids to external massage

- ^ CPR vest (Zoll AutoPulse)
 - ◆ Advantages
 - f* Less traumatic than manual
 - f* Can incorporate defibrillator
 - f* No fatigue
 - f* Frees personnel for other actions
 - f* Research- increased short-term survival
 - f* May be effective without ventilation

Mechanical aids to external massage

- ^ CPR vest (Zoll AutoPulse)
 - ◆ Disadvantages
 - f* Large
 - f* Expensive
 - ◆ Requires more study

Mechanical aids to external massage

^ Medical antishock trousers

(MAST)

◆ Functions

f prevent blood loss from lower limbs

f increase central circulation

f stabilize pelvic fractures

Invasive Circulatory Support

Open Chest Cardiac Massage

^ Greater cardiac output than
with closed-chest

^ Requires surgeon to perform

Open Chest Cardiac Massage

^ Indications

◆ tamponade

◆ penetrating chest injury

◆ hypothermia

◆ chest deformity- e.g. kyphoscoliosis

Intra-aortic Balloon Pump (IABP)

^ Most commonly used circulatory
support

^ Balloon inserted through femoral
artery to descending aorta

◆ Balloon inflated during diastole
(with Helium)

◆ Balloon deflated at end-diastole

IABP

^ Effects

◆ increases coronary blood flow

◆ increases diastolic filling

◆ decreases left ventricular
afterload and work

◆ increases cardiac output

IABP

- ^ Indications- short-term support
 - ◆ cardiogenic shock
 - ◆ acute myocardial infarction
 - ◆ failure to wean from bypass
 - ◆ bridge to transplant
- ^ Permanent implantable pump is currently under study

IABP

- ^ Limitation- provides only partial (1.5 L/min) cardiac output support
- ^ Complications
 - ◆ limb ischemia
 - ◆ renal ischemia

IABP

- ^ Balloon insertion techniques
 - ◆ percutaneous- least invasive
 - ◆ cutdown
 - ◆ transthoracic- only after cardiac surgery
- ^ Position confirmed with fluoroscopy, chest radiograph

IABP

- ^ Settings
 - ◆ Trigger mode
 - f* ECG
 - f* arterial waveform
 - ◆ Support ratio- inflations: heart rate
 - f* start with 1:1
 - f* wean as indicated, to removal

IABP

- ^ Timing
 - ◆ Significance
 - f* early inflation impedes coronary blood flow
 - f* early deflation reduces effectiveness in reducing afterload

IABP

- ^ Timing
 - ◆ Appropriate inflation- right after aortic notch of arterial wave form
 - ◆ Appropriate deflation- end-diastole on arterial wave form

**Extracorporeal Membrane
Oxygenation (ECMO)**

- ^ **Definition-** a modified form of heart lung bypass that supports patients with severe respiratory or cardiorespiratory failure.
- ^ **Current indications** are primarily for neonatal and pediatric patients.

ECMO

- ^ **Description-** Venous blood is drained via a cannula to a circuit containing an artificial membrane for gas exchange.

ECMO

- ^ **Rationale-** ECMO assumes heart and/or lung function, allowing organs to rest and preventing:
 - ◆ ventilator-induced volutrauma, barotrauma
 - ◆ oxygen toxicity
 - ◆ damaging effects of prolonged use of inotropic agents

ECMO

- ^ **Indications-** neonates
 - ◆ Gestational Age >34 weeks
 - ◆ Weight > 2 kg
 - ◆ Reversible lung disease
 - ◆ No major (>grade 1) intracranial hemorrhage
 - ◆ No lethal congenital abnormalities

ECMO

- ^ **Specific conditions**
 - ◆ meconium aspiration
 - ◆ congenital diaphragmatic hernia
 - ◆ persistent pulmonary hypertension
 - ◆ RDS

ECMO

- ^ **General indications-** adults & pediatric patients
 - ◆ potentially reversible disease
 - ◆ failure to respond to maximal, less-invasive therapy

ECMO

^ Specific conditions- adults & pediatrics

- ◆ pneumonia, pneumonitis
- ◆ bronchiolitis
- ◆ septic shock
- ◆ ARDS
- ◆ aspiration pneumonia
- ◆ severe trauma
- ◆ post cardiac surgery

ECMO

^ Contraindications

- ◆ irreversible CNS injury
- ◆ immunocompromise
- ◆ coagulopathy

ECMO

^ System circuit components & direction of flow

- ◆ venous line
- ◆ blood pump
- ◆ oxygenator
- ◆ heat exchanger
- ◆ arterial line

ECMO

^ System controller unit- monitors and controls function

^ Mechanical ventilator

- ◆ maintain pulmonary expansion
- ◆ minimal settings to avoid barotrauma and oxygen toxicity

ECMO

^ Complications

- ◆ bleeding- including cerebral
- ◆ risk from blood products
- ◆ emboli
- ◆ equipment malfunctions
- ◆ infection through cannulation sites

Ventricular assist device

^ Description

- ◆ pump from ventricle(s) to aorta
- ◆ increases stroke volume
- ◆ native heart remains in place

Ventricular assist device

- △ Indication- ventricular failure
 - ◆ failure to wean from IABP
 - ◆ bridge to transplant
 - ◆ destination therapy- patients with contraindications to transplant

Ventricular assist device

- △ Complications
 - ◆ Bleeding due to heparinization
 - ◆ Clots
 - ◆ Recurrent chest explorations
 - ◆ Infection
 - ◆ Hemolysis
 - ◆ Device malfunction

Ventricular assist device

- △ Thoratec (TM) VAD
 - ◆ external placement
 - ◆ univentricular, biventricular support
 - ◆ inpatients only- patients can walk around
 - ◆ supplanted by implantable devices

Ventricular assist device

- △ Thoratec (TM) VAD- external

Link to Thoratec (TM)
<http://www.thoratec.com/medical-professionals/index.htm>

Ventricular assist device

- △ Thoratec Heartmate (TM) vented electric VAD
 - ◆ internal placement
 - ◆ portable- patient can go home
 - ◆ least thrombogenic
 - ◆ pulsatile flow
 - ◆ high cardiac output (>9 L/min)

Ventricular assist device

- △ Worldheart Novacor (TM) VAD
 - ◆ internal placement- peritoneum
 - ◆ portable- patient can go home
 - ◆ high cardiac output
 - ◆ most thrombogenic
 - ◆ one patient survived three years
 - ◆ currently Worldheart Novacor (TM)

Ventricular assist device

Link to Worldheart Novacor to see newer devices
http://www.worldheart.com/products/novacor_lvas.cfm

Ventricular assist device

- ▲ **Abiomed BVS 5000**
 - ◆ external placement
 - ◆ non-portable
 - ◆ inpatients only- patient confined to bed
 - ◆ requires anticoagulation

Ventricular assist device

- ▲ **Jarvik 2000**
 - ◆ recent device
 - ◆ internal placement
 - ◆ small
 - ◆ portable

Ventricular assist device

- ▲ **Jarvik 2000 Flowmaker (TM)**

Link to Jarvikheart (TM)
<http://www.jarvikheart.com/basic.asp?id=19>

Ventricular assist device

- ▲ **Berlin heart- various models**
 - ◆ Incor- impeller-type pump
 - ◆ Excor- includes pediatric sizes

Link to Berlin heart website
<http://www.berlinheart.com/englisch/medpro/index.php>

Total Artificial Heart

- ▲ **Description- replaces native heart, which is removed**
- ▲ **Purposes**
 - ◆ failure to wean from IABP
 - ◆ bridge to transplant
 - ◆ destination therapy- patients with contraindications to transplant
 - ◆ commonly needed for dilational cardiomyopathy

Total Artificial Heart

^ Complications

- ◆ same as VAD
- ◆ native heart is removed

Total Artificial Heart

^ Issues in MCS devices

- ◆ need for anticoagulants
- ◆ response to increased demand
- ◆ portability
- ◆ reliability
- ◆ pulsatile flow
 - f* increased flow per unit of pressure
 - f* strengthens vascular wall muscles

Total Artificial Heart

^ Abiomed Abiomed (™) replacement heart

- ◆ in the 2001 news media
- ◆ internal placement
- ◆ alternative to transplant
- ◆ portable

Link to Abiomed (™)

http://www.abiomed.com/products/heart_replacement.cfm

Total Artificial Heart

^ Cardiowest- formerly Jarvik 7

- ◆ first implanted in 1982
- ◆ effective bridge to transplant
- ◆ non-portable

Link to Cardiowest videos

<http://www.syncardia.com/videocenter/index.php>

Summary & Review

^ Non-invasive devices

- ◆ Thumper
- ◆ Ambu Cardiopump
- ◆ CPR vest
- ◆ MAST

Summary & Review

- ^ Open-chest cardiac massage
- ^ Intra-aortic counterpulsation
- ^ Extracorporeal membrane oxygenator
- ^ Ventricular assist devices
- ^ Total artificial heart

References

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