
THE ANESTHETIC IMPLICATIONS OF VENTRICULAR ASSIST DEVICES



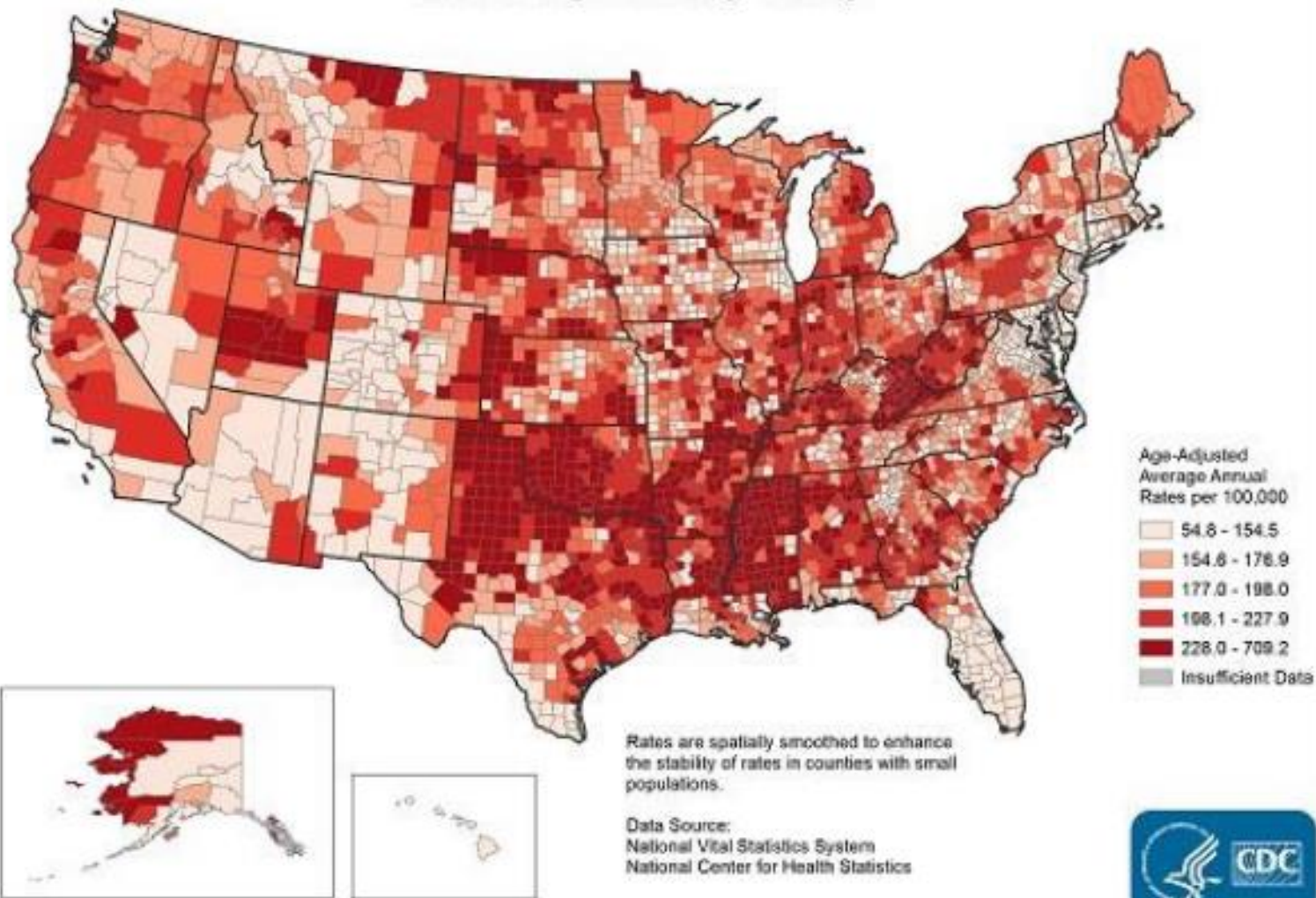
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YCP/Wellspan Health Nurse Anesthesia
Program

Objectives (Goals really...)

- Describe indications for and complications of VAD placement
- Describe the physiologic underpinnings of VAD therapy
- Discuss the Pre-operative evaluation of the VAD patient
- Explore Intra-operative monitoring strategies and goals
- Consider Post-operative management issues
- Case study

Heart Failure

**Heart Failure Death Rates, 2011-2013
Adults, Ages 35+, by County**



Heart Failure

“A complex pathophysiologic process that causes a clinical syndrome characterized by pulmonary congestion resulting from the heart’s inability to fill with or eject blood in a sufficient quantity to meet tissue requirements.”

(Nagelhout, p. 513)



<http://pre-wedding.net/article/Tired-Heart-Guy-Graphics-Code-127451>

UNOSSM

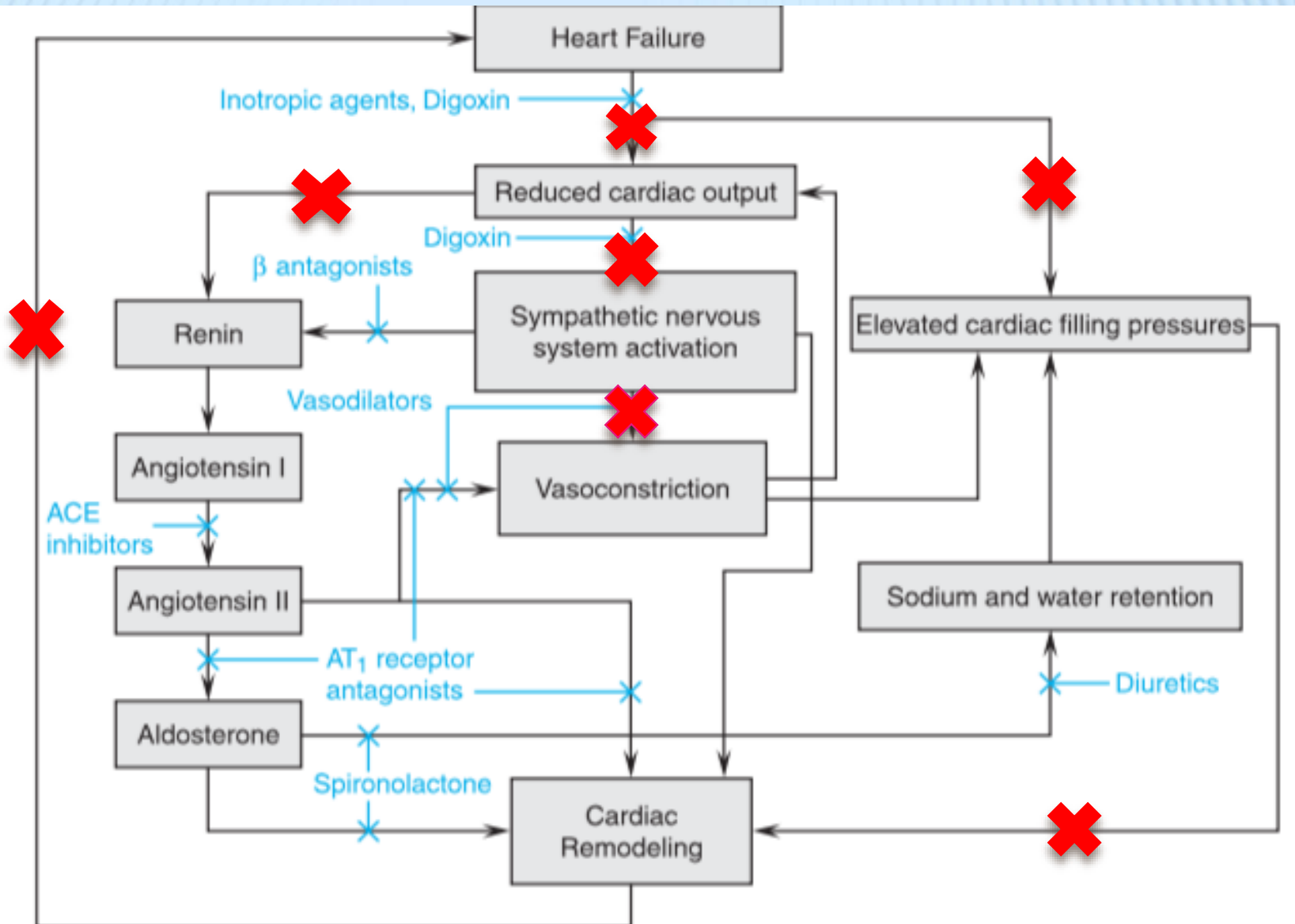
UNITED NETWORK FOR ORGAN SHARING

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<http://www>

<https://www.unos.org/>

Heart Failure

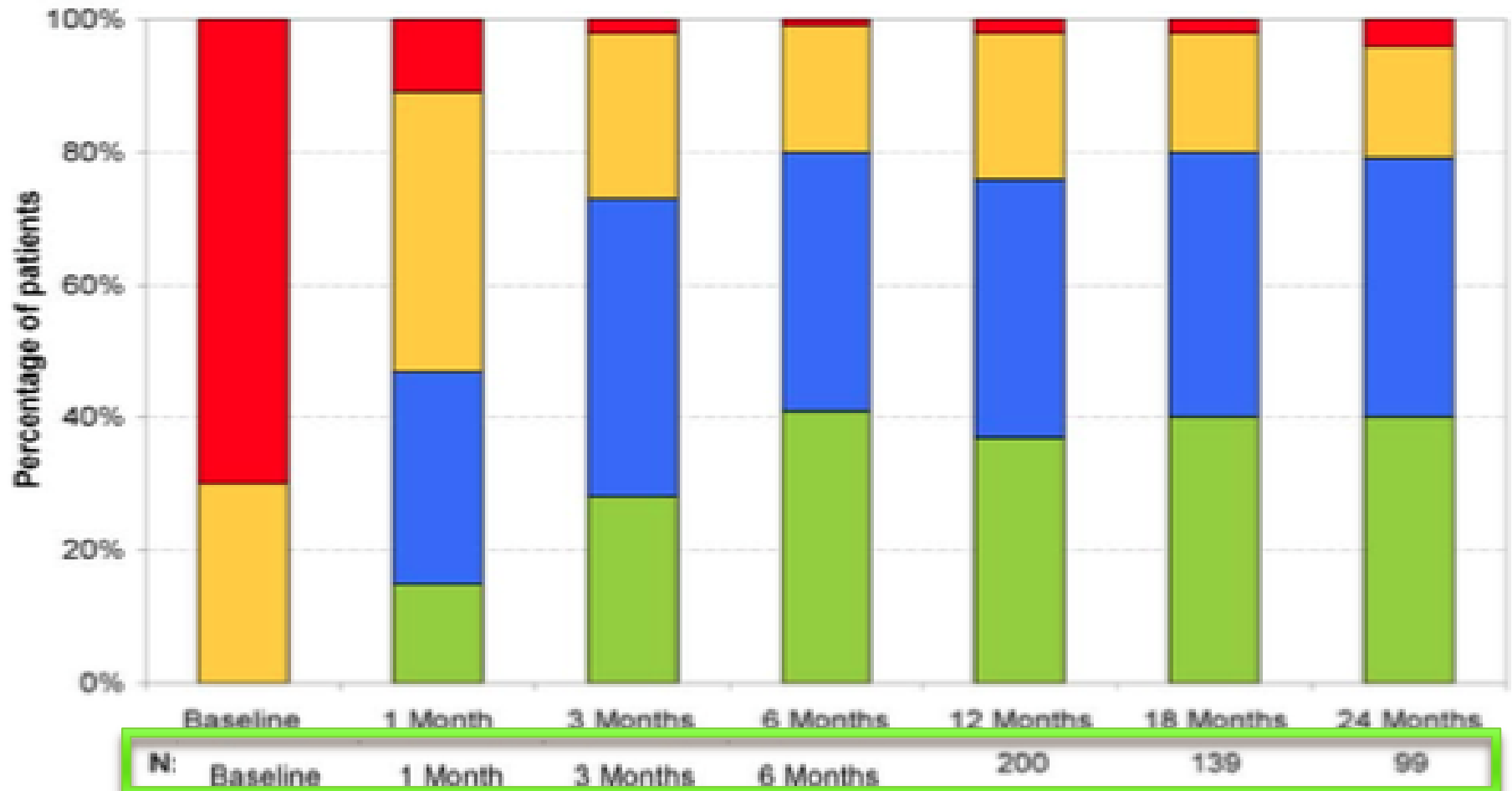


Heart Failure



Figure 2 Changes in Functional Class Following LVAD

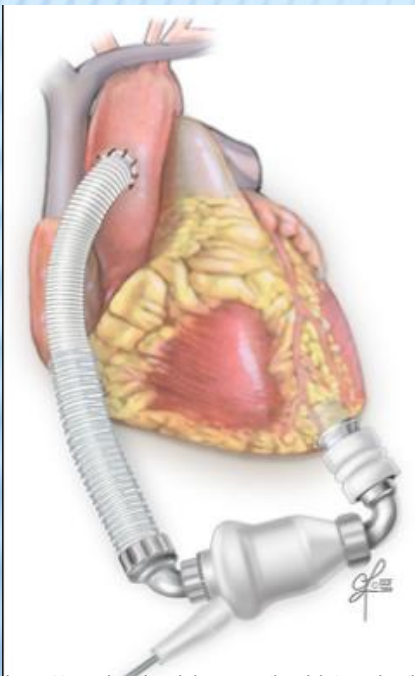
DT



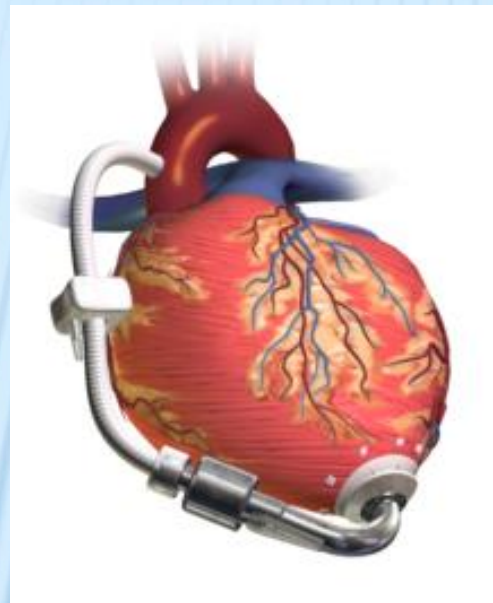
VADs

“A type of mechanical circulatory support that aids in systemic perfusion by maintaining unidirectional flow while reducing the oxygen demand of the failing ventricle and allowing the heart to heal.”

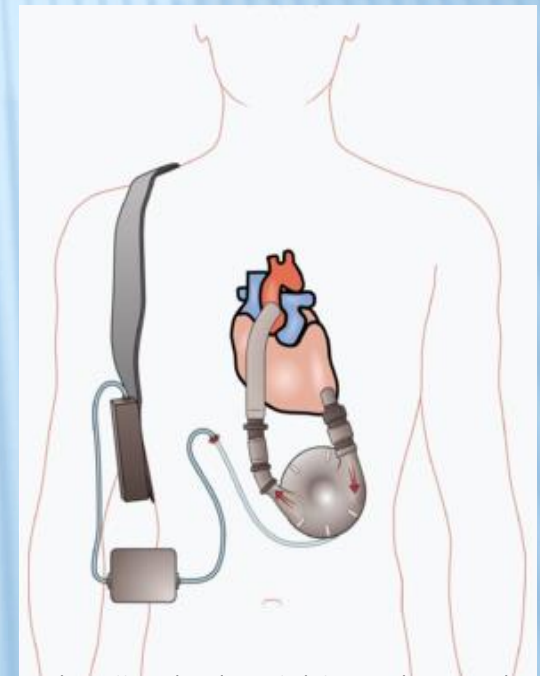
(Khoo, 2010, p. 484)



<http://my.clevelandclinic.org/health/articles/lvad-devices>



https://en.wikipedia.org/wiki/Ventricular_assist_device



https://en.wikipedia.org/wiki/Ventricular_assist_device

“Mechanical systems that reduce the workload of the heart, permitting the ventricle to rest, whilst maintaining cardiac output and perfusion of vital organs.”

(Harris & Kuppurao, 2012, p. 145)

Clinical Application

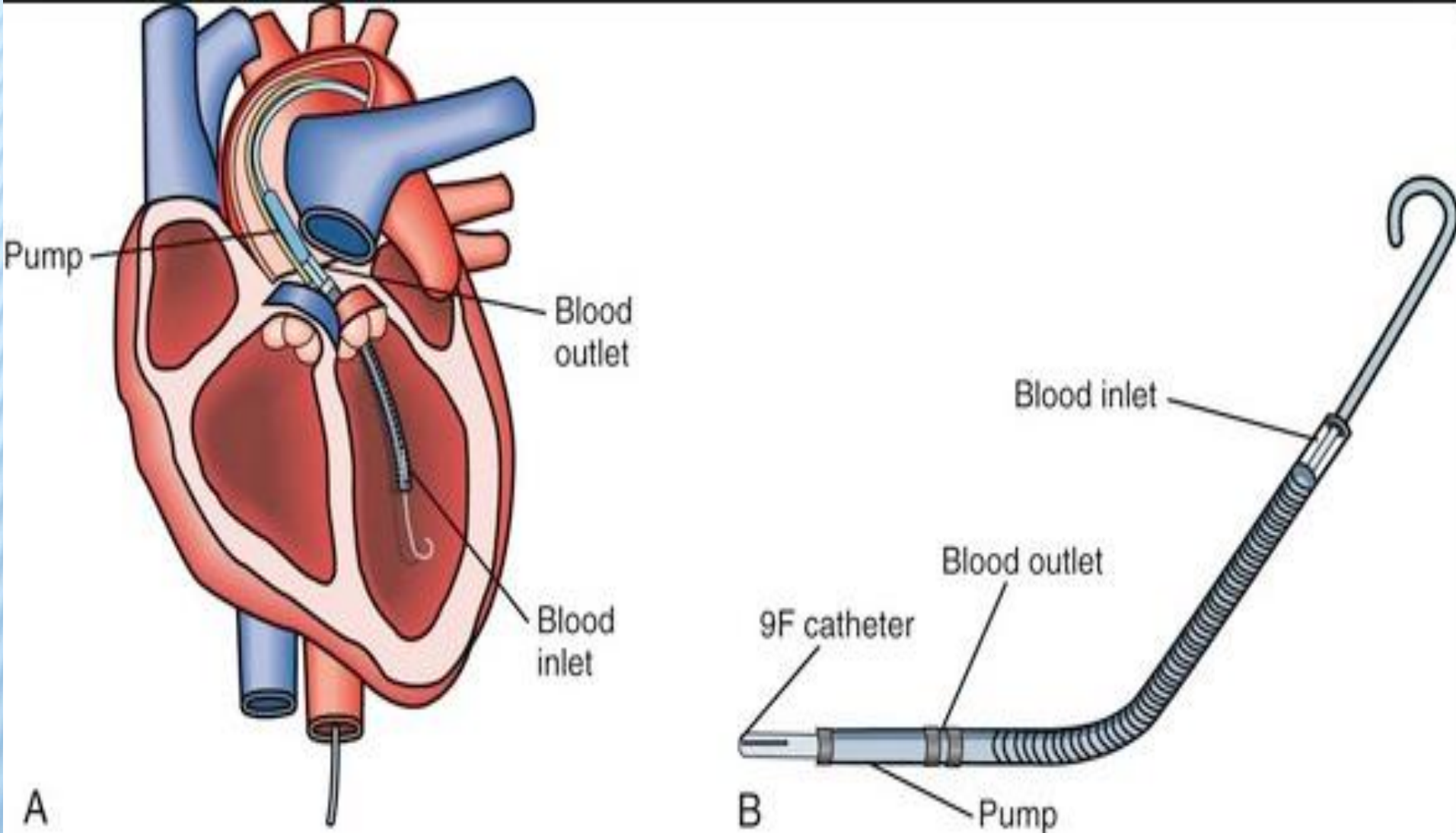


Table 2. First-Generation VADs

Device	Length of Support	Position	Ventricles Supported	Drive Mechanism
Thoratec PVAD and IVAD	Short to medium	PVAD extracorporeal, IVAD intracorporeal	LV, RV, BV	Pneumatic, pulsatile
HeartMate I (XVE)	Long (BTT and DT)	Intracorporeal, abdominal (pre- or intraperitoneal)	LV	Electric, pulsatile
Abiomed BVS5000 and AB5000	Short	Extracorporeal	LV, RV, BV	Pneumatic

Abbreviations: LV, left ventricle; RV, right ventricle; BV, biventricular.

Thunberg et al., 2010

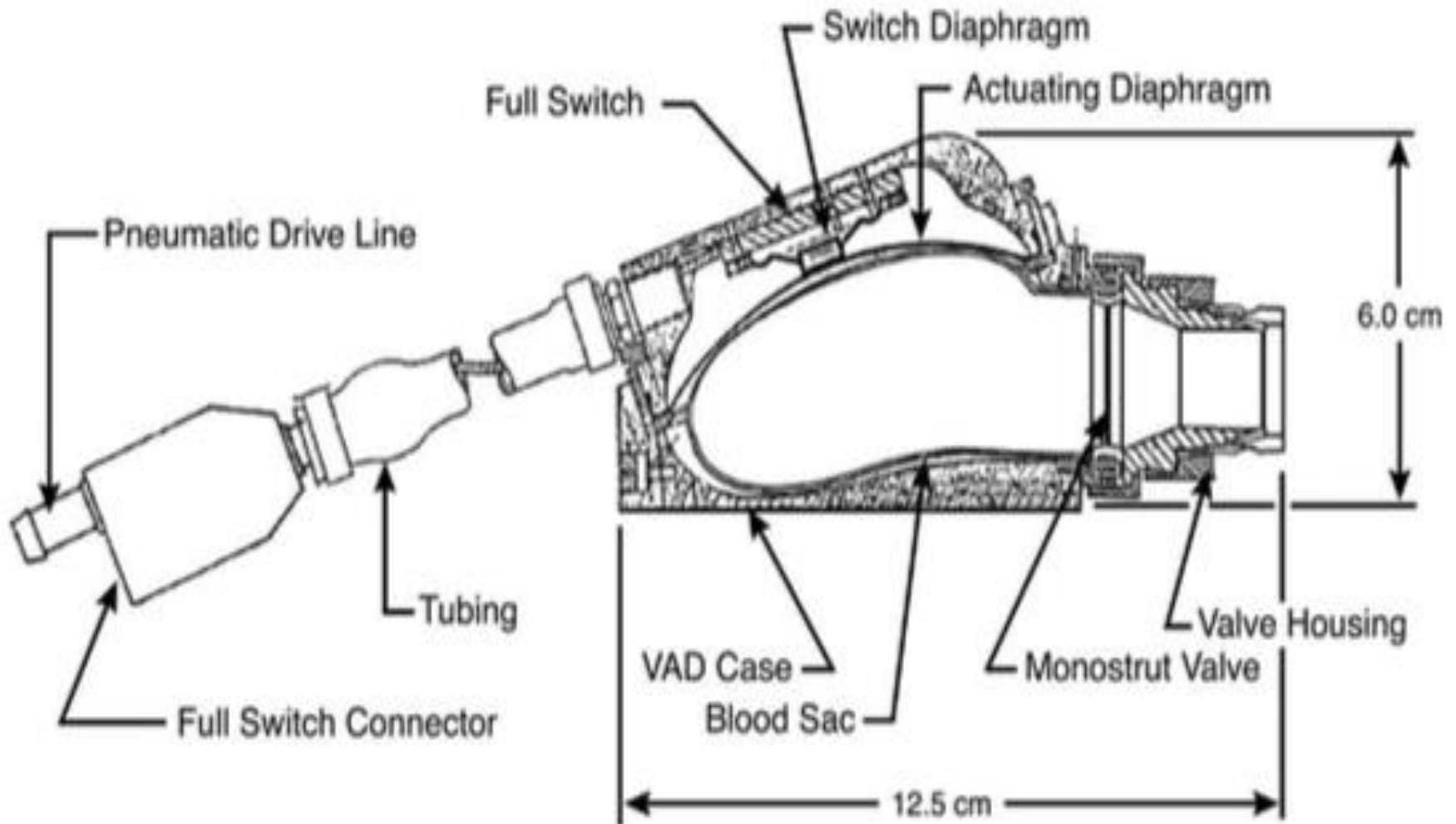


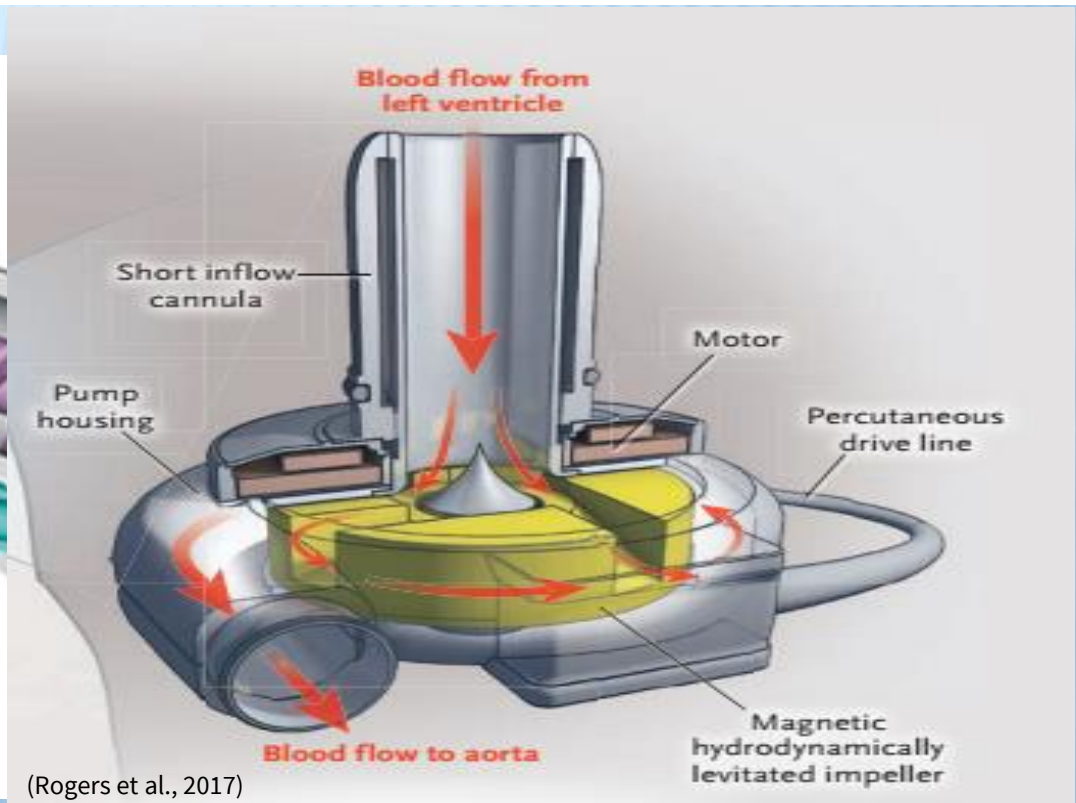
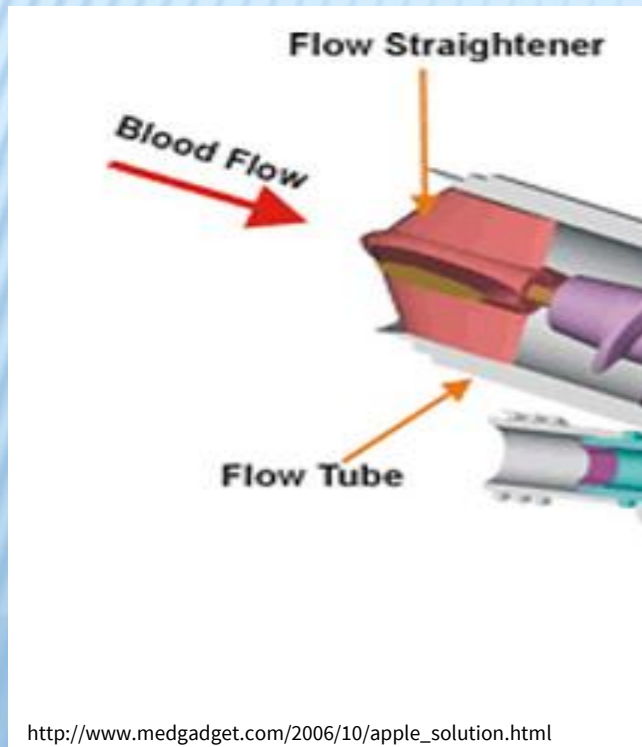
Table 3. Second-Generation VADs

Device	Flow Type	Length of Support	Position	Ventricle	Drive Mechanism
Impella Recover LP 2.5, 5.0, and LD	Axial	Short	Extracorporeal	LV	Electric
Levitronix CentriMag	Centrifugal	Short	Extracorporeal	LV, RV, BV	Electric
TandemHeart (pVAD)	Centrifugal	Short	Extracorporeal	LV	Electric
HeartMate II	Axial	Long	Intracorporeal	LV	Electric
Jarvik 2000	Axial	Long	Intracardiac	LV	Electric
MicroMed DeBakey	Axial	Long	Intracorporeal	LV	Electric

Table 4. Third-Generation VADs

Device Name	Manufacturer	Intended Use	Pump Type/Characteristics	Status
HVAD	HeartWare International, Sydney, Australia	Long-term support for DT and BTT	Centrifugal, magnetic, and hydrodynamic bearing	International BTT trial completed 2006; US BTT trial started 11/2008

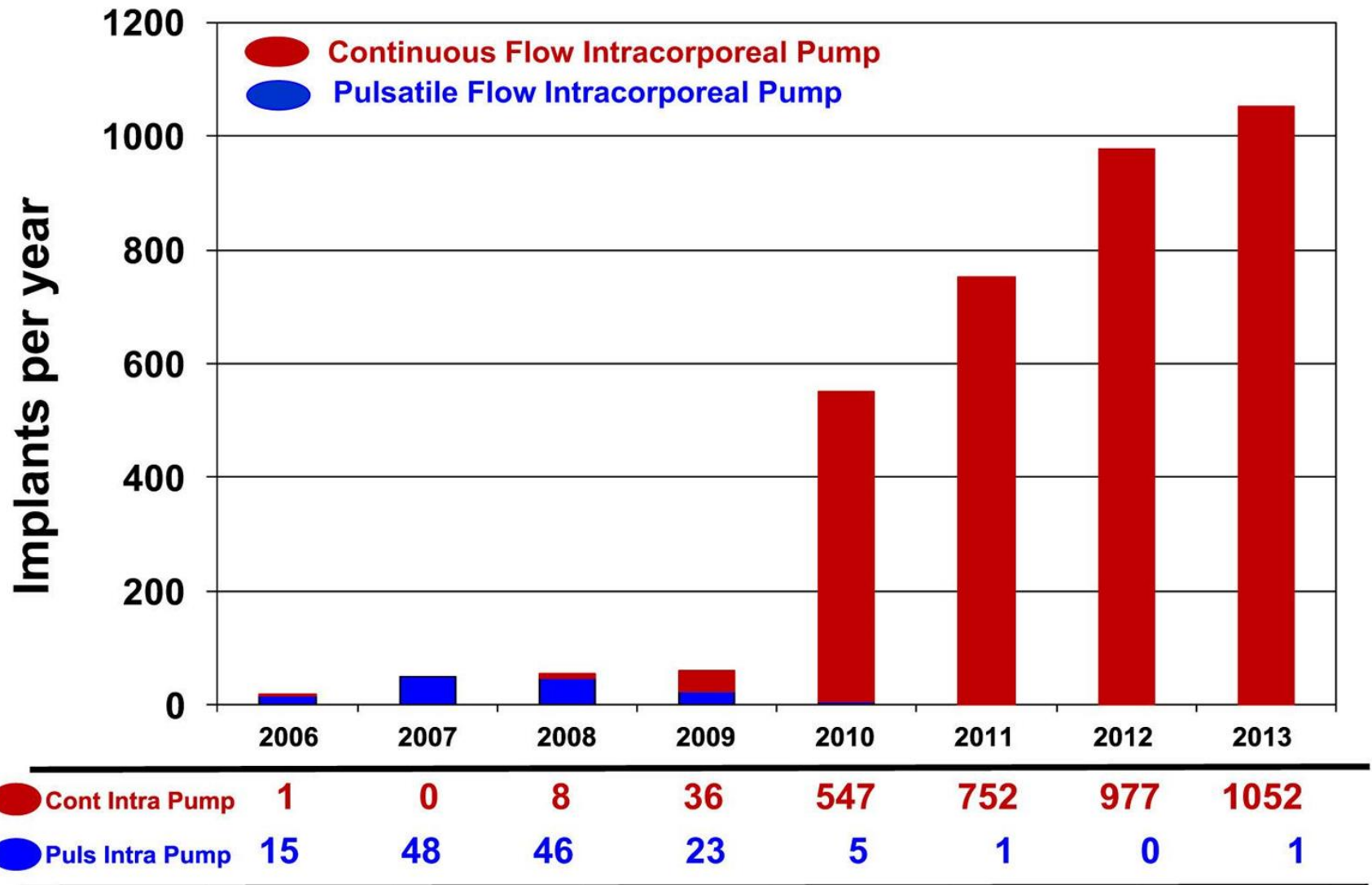
Thunberg et al., 2010



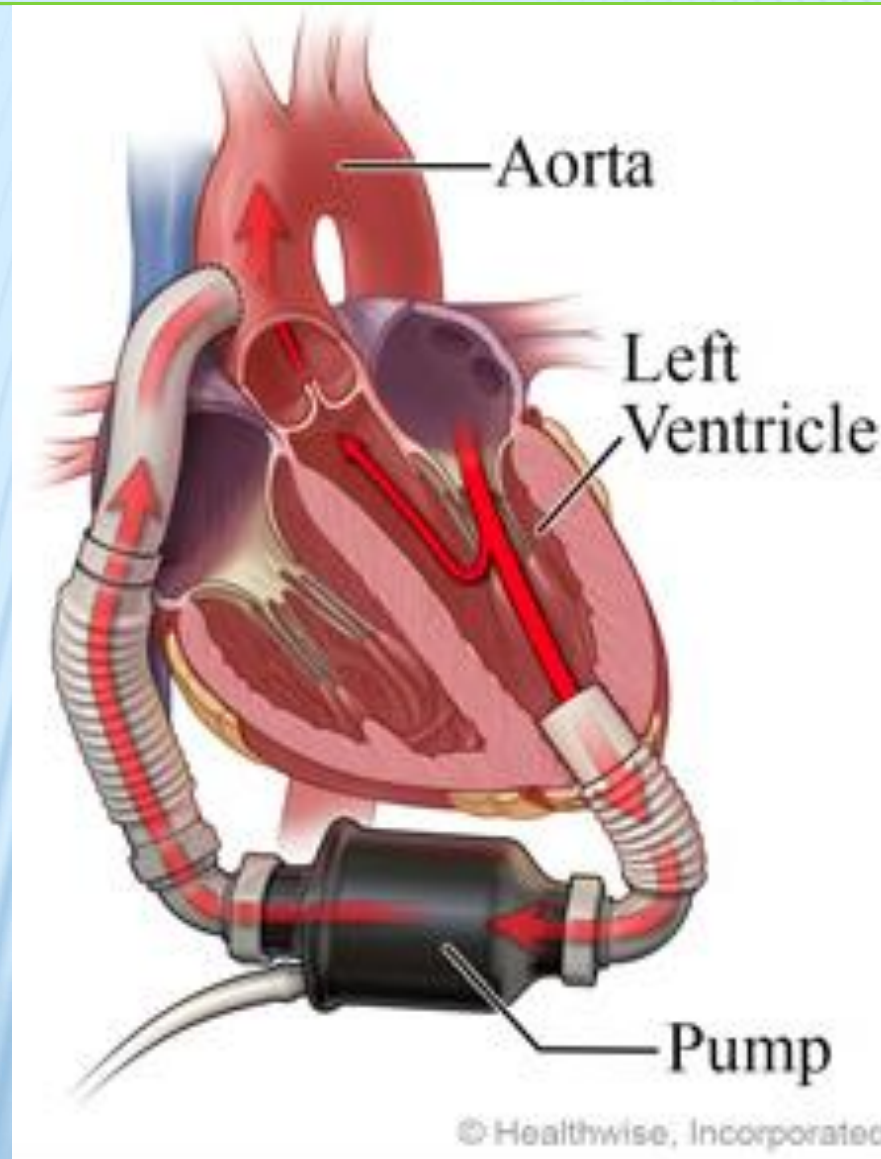
(Rogers et al., 2017)

Implanted VADs

Intermedics Implants for **Destination Therapy**: June 2006 – December 2013, n = 3516



VAD Physiology



Complications

Table 2. Adverse Events in the First 12 Months Following Destination Therapy With Continuous Flow Devices (1160 Patients)³.

Event	Event/100 Patient Months
Bleeding	11.9
Infection	8.1
Arrhythmia	3.9
Respiratory failure	2.6
Neurologic dysfunction	1.9
Right heart failure	1.7
Renal dysfunction	1.6
Device malfunction	1.15
Psychiatric	0.9
Hypertension	0.8
Venous thrombotic	0.6
Hemolysis	0.6
Pericardial drainage	0.6
Hepatic dysfunction	0.6
Wound dehiscence	0.2
Non-CNS arterial thrombosis	0.2
Myocardial infarction	0.03
All events	37.6

Abbreviation: CNS, central nervous system.

³Modified from Table 4 in Kirklin et al.⁴⁰

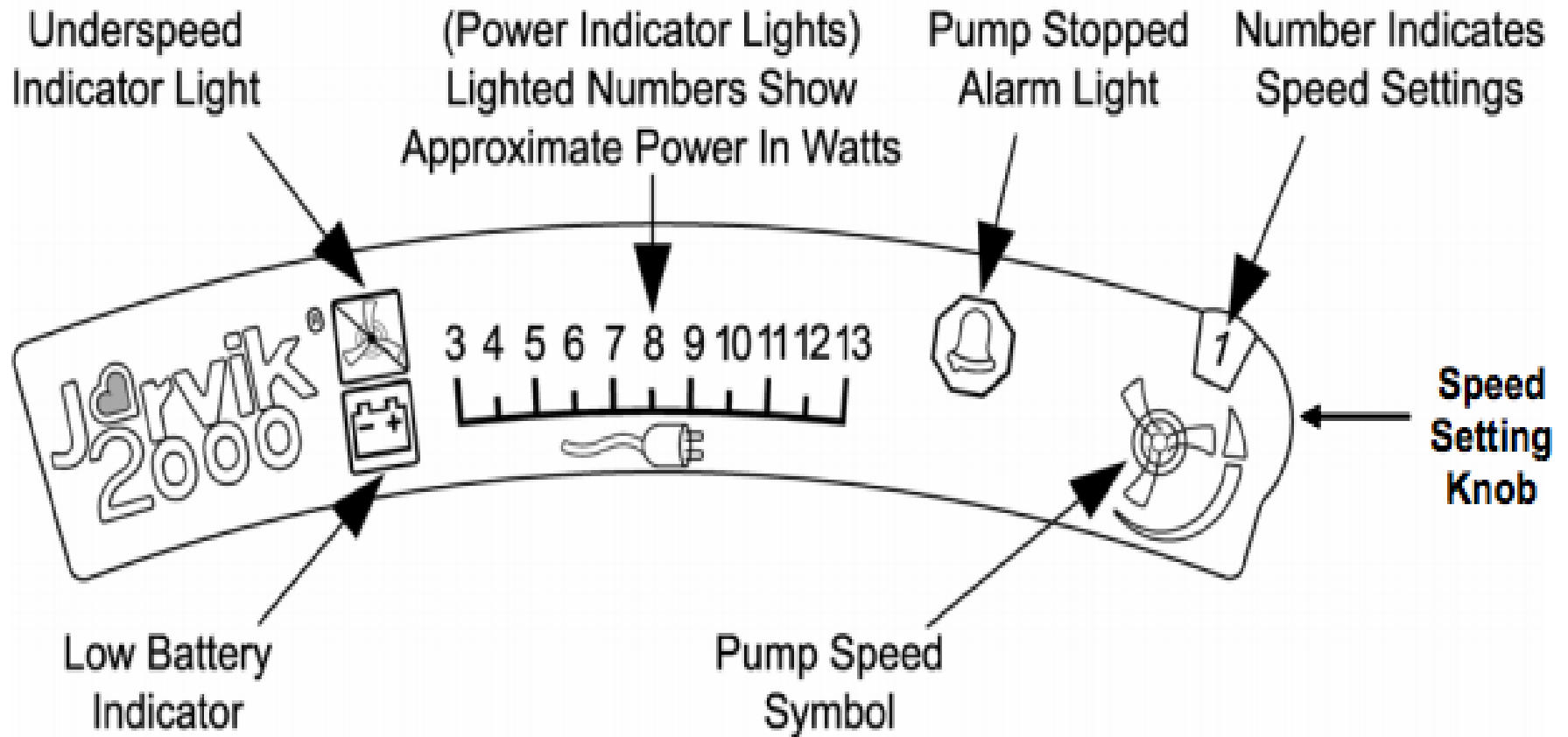
Table	Des	(17)	Cau	ths
Arr	Infe	CN	Ble	
Right	Mul	Res	Wit	
Dev	Arterial embolism	3		
	Renal failure	2		
	Hepatic failure	2		
	Malignancy	2		
	Other (including suicide)	19		

Abbreviations: CNS, central nervous system; GI, gastrointestinal.

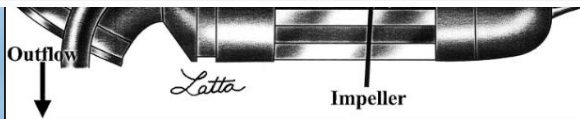
⁴⁰Modified from Table 6 in Kirklin et al.

<http://link.springer.com/article/10.1186/1745-6990-9-40>

Jarvik 2000



Li-ion Battery



<http://www.mylvad.com/content/jarvik-2000-flowmaker%C2%AE-lvad>

<http://www.mylvad.com/content/jarvik-2000-flowmaker%C2%AE-lvad>

Heartmate II



$$PI = [(Q_{max} - Q_{min}) / Q_{avg}] \times 10$$

Figure 4.8 Clinical Screen

Heartware HVAD

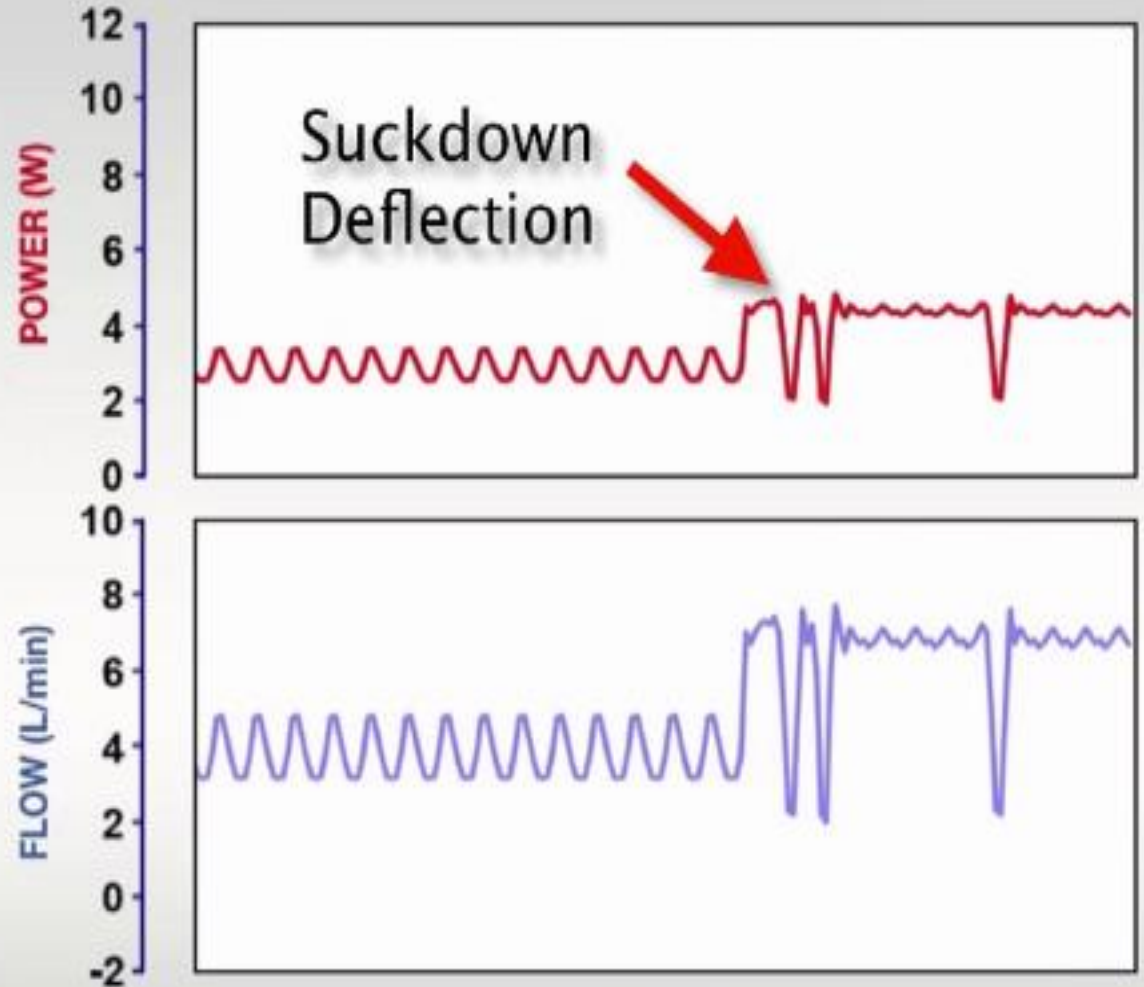
5.5
L/min

3100
RPM

4.8
Watts

Fixed

Sx On





**Anesthetic
Considerations**

Common Procedures

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"I'd like to do some exploratory surgery. Not because there's anything wrong, just because I'm naturally curious."

Early

Period Tracheostomy

- Wound debridement
- Thoracic procedures
 - Bleeding
 - Device correction

Late

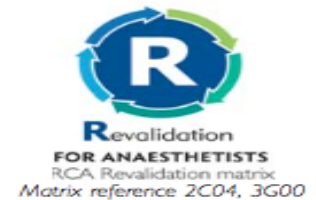
Period Cholecystectomy

- Hernia repair
- Explorative Laparoscopy
- Orthopedic procedures
- Craniotomy
- Thromboembolectomy
- Endoscopy

Preoperative Evaluation

Ventricular assist devices

Paul Harris MBChB FRCA FFICM EDICM
Lakshminarasimhan Kuppurao MD DA DNB FRCA



Volume overload	Physical examination, echocardiography	Fluid restriction, diuretics, haemodialysis
Hypertension	Arterial pressure monitoring Decrease in pump flow and power	Increase pump speed under echo guidance Consider vasodilators, diuretics
Dehydration	Physical examination, echocardiography Suction events in device (pump speed higher than volume in LV)	Fluid administration, adjust diuretics Reduce pump speed
Hypotension	Arterial pressure monitoring, symptoms Increase in pump flow and power	Adjust cardioactive drugs, fluid administration
Heart failure recurrence	Physical examination, liver function, RV failure Decrease in pump flow	As for fluid overload Assess VAD speed settings and cannulae RV support, e.g. vasodilators, angiography
Arrhythmias	ECG, telemetry Suction events, reduced device flow/power	Consider anti-arrhythmics, cardioversion, ICD Evaluate pump speed under echocardiography
Haematological		
Stroke or TIA	Coagulation profile, CT head	Ensure anticoagulation therapeutic Excess anticoagulation risks haemorrhagic stroke
Bleeding diatheses	Coagulation profile, TEG	Multidisciplinary input for surgery proposed Balance between safe surgery and safe VAD support
Haemolysis	Plasma-free haemoglobin	Evaluate causes, e.g. cannulae occlusions CT scanning useful
Microbiological	Percutaneous lead examination Culture and sensitivity Pocket collections	Antibiotics Drain collections
Renal	Urea and electrolytes, renal ultrasound	Improve wound care and lead immobilization Fluid optimization, stop nephrotoxins if possible
Hepatic	Liver enzymes, ultrasound Echocardiography for RV failure	Exclude hepatic congestion and treat RV failure

Intraoperative Considerations

Setu

- VAD personnel present
- Alternative power source

Monitorm

- NIBP vs A-line



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5.1
6

4.9
9

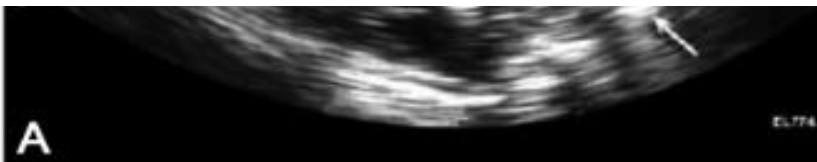
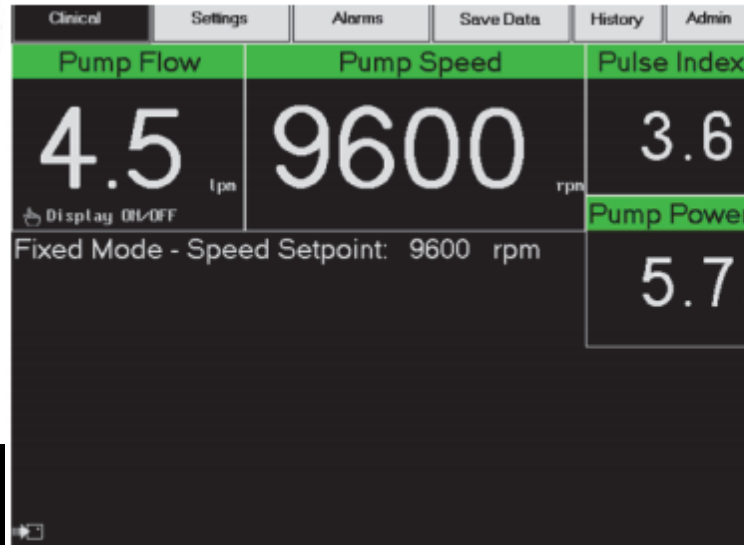


Figure 4.8 Clinical Screen

Intraoperative Considerations

Anesthetic technique

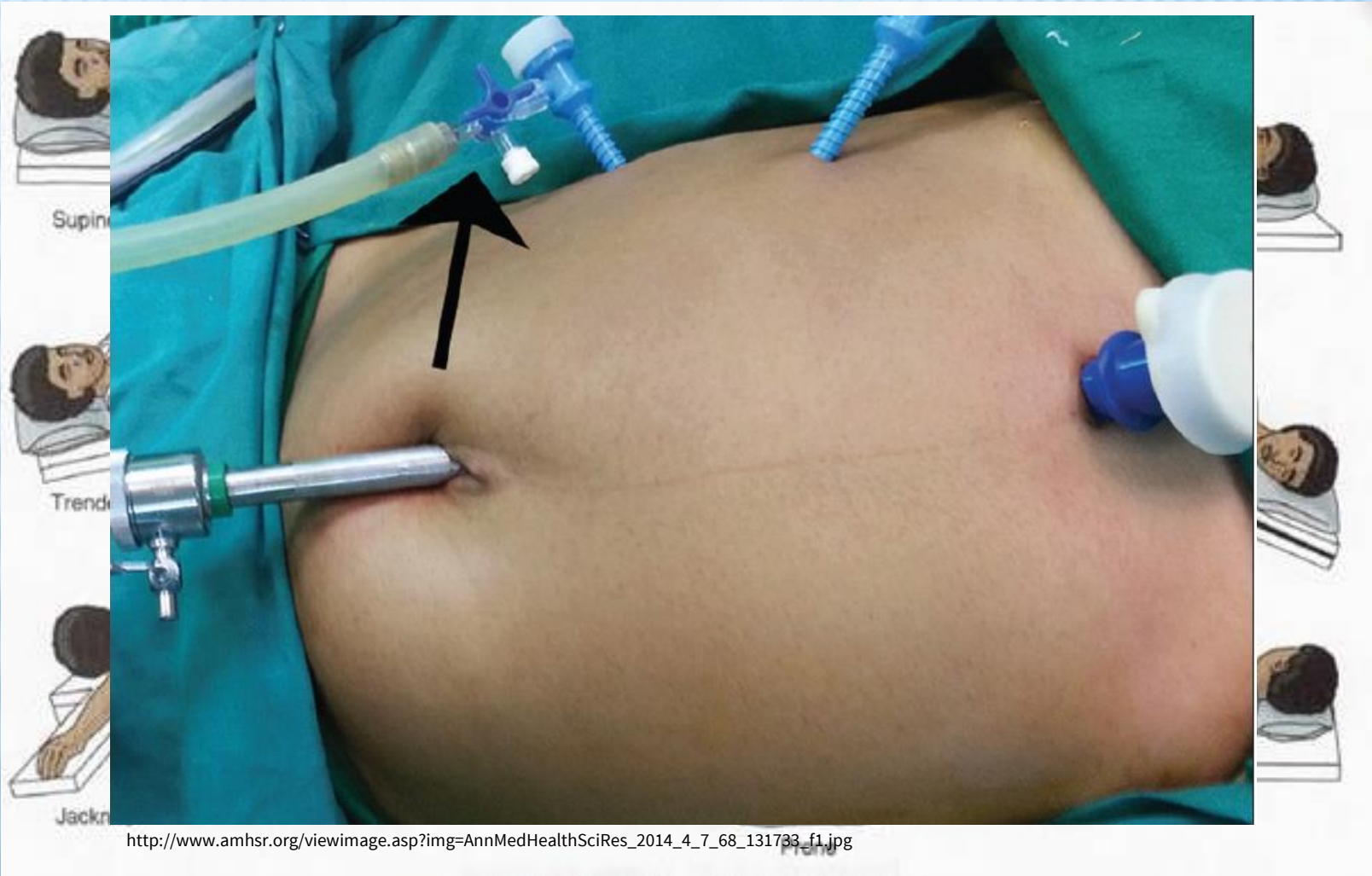
- General vs. Regional
- Induction
- RSI
- Maintenance
- Ventilation



Intraoperative Considerations

Positionin

g



http://www.amhsr.org/viewimage.asp?img=AnnMedHealthSciRes_2014_4_7_68_131733_f1.jpg

Intraoperative Considerations

EMI



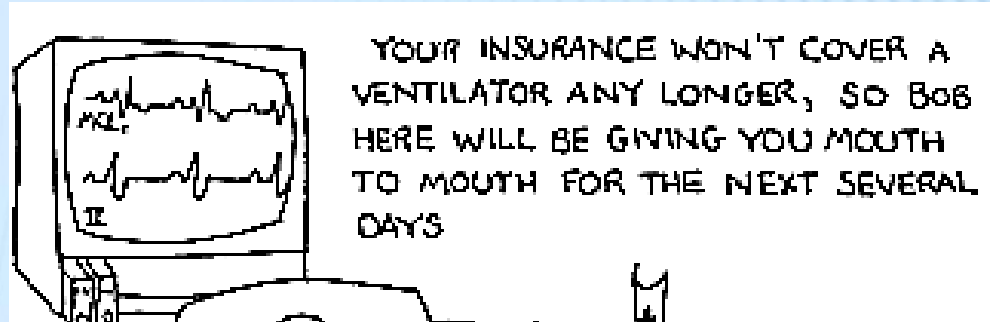
<http://www.indiamart.com/mg-instruments/bipolar-instrument.html>



<http://gsmedilinks.com/cautery-pencil-electro-surgical-pencil/>

Postoperative Considerations

- Extubation
- Transport
- Anticoagulation



<https://www.pint>

<http://newnurseblog.com/category/uncategorized/feed/>
<http://www.telegraph.co.uk/news/health/news/9240836/Aspirin-is-as-safe-and-just-as-effective-as-warfarin-research.html>

Case Study



Case Study

- **60 yo female presenting for R temporal brain tumor resection under GA**
- 155cm (5'1") 42.3kg (93lbs) BMI-17.6 (underweight)
- 102/69, 83, 18, 93% RA, GCS 14
- MHx
 - R temporal lobe lesion 4.4 x 5.3cm with uncal herniation and 8mm R to L shift
 - Persistent h/a's, int. confusion, and balance issues
 - Ischemic CM with Heartmate II implantation 2 years prior
 - MI/Arrhythmia/CHF
 - HTN
 - COPD
 - Prior GI bleeding
- SHx
 - Heartmate 2 LVAD implantation
 - R hip hemiarthroplasty

Case Study

- **60 yo female presenting for R temporal brain tumor resection under GA**

- 155cm (5'1") 42.3kg (93lbs) BMI-17.6 (underweight)
- 102/69, 83, 18, 93% RA, GCS 14

Meds

- Carvadilol
- Furosemide
- KCl
- Sildenafil
- Combivent inhaler
- Warfarin (INR 1.3-1.8)
- ASA 81mg
- Trazodone

Preop

- Consults: Neurosurgery, CT surgery, Cardiology, Anesthesiology, VAD RN
- LVAD: 8200RPM
4.7 Power
6.7 PI
- ASA/Warfarin withheld DoS
- FFP x 2 to further correct INR

Labs

- Hgb – 8.8
- Plt – 134 (s/p 2 unit trans.)
- INR – 1.6
- PT/PTT – 19.4/27

Monitoring

- VAD RN at bedside
- Standard ASA monitors
- A-line, CL/CVP placed
- TEE readily available

Case Study

- **60 yo female presenting for R temporal brain tumor resection under GA**

- 155cm (5'1") 42.3kg (93lbs) BMI-17.6 (underweight)
- 102/69, 83, 18, 93% RA, GCS 14

Induction

- Fentanyl 100mcg (2.5mcg/kg)
- Lidocaine 40mg (1mg/kg)
- Propofol 100mg (titrated slowly)
- Rocuronium 50mg (1.2mcg/kg)
- 7.0 ETT

Maintenance

- Sevoflurane 0.8-1 MAC
- 0.5 FiO₂
- Remifentanil 0.08-0.1mcg/kg/min

Intraop

- Slight Reverse Trendelenburg
- Furosemide 10mg
- PaCO₂ – 30-35
 - Reduce ICP
- MAP – 80-90
 - “few” Phenylephrine boluses
- Crystalloid – 500mL
- Neuromuscular blockade reversal
 - Neostigmine 2mg
 - Glycopyrolate 0.4mg
- Deep extubation
- Transferred to CICU
 - GCS 14
 - Slight L-sided weakness

Case Study





Resources

Heartmate II patient manual

http://www.thoratec.com/_assets/download-tracker/HMII/106020/106020_H.pdf

Heartmate II system

<https://www.youtube.com/watch?v=mu15tNUH4VU>

Heartware patient manual

http://www.heartware.com/sites/default/files/uploads/resources/ifu00184_rev07_patientmanual_uspma.pdf

Heartware system

<https://www.youtube.com/watch?v=k6rs1pRM6lg&list=PLRR3Bf4OzT8OkeK-EqNwjVm5qbmLNERlk>

Heartware waveform app.

https://www.heartware.com/sites/default/files/uploads/resources/gl1044_rev03_waveformappbrochure.pdf

Jarvik 2000 patient manual

<http://www.mylvad.com/content/jarvik-2000-flowmaker%C2%AE-lvad>

Jarvik 2000 implantation

<https://www.youtube.com/watch?v=GHI9-hdSD-E>

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