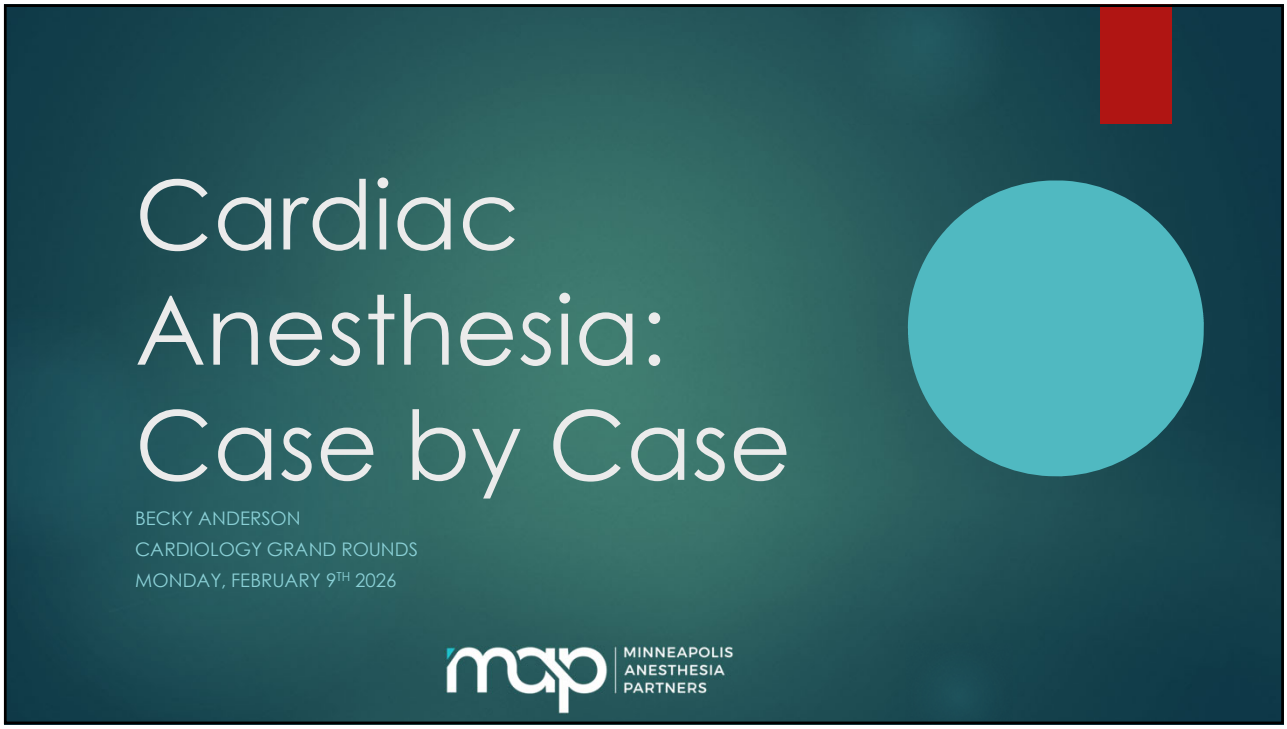

Minneapolis Heart Institute Foundation
GRAND ROUNDS

1


Cardiac Anesthesia: Case by Case
BECKY ANDERSON
CARDIOLOGY GRAND ROUNDS
MONDAY, FEBRUARY 9TH 2026
map
MINNEAPOLIS ANESTHESIA PARTNERS

2

Disclosures

- I have no financial disclosures.

3

Objectives

- Describe pre-operative anesthesia considerations.
- Perform anesthesia risk assessment.
- Define anesthesia management strategies.

4

Cases

- Heart Transplant
- Biventricular ICD Placement
- Pericardial Effusion Drainage
- Transesophageal Echocardiogram
- Non-cardiac surgery in patient with LVAD
- Anesthesia complications

5

Heart Transplant

- 55 yo M with NICM s/p HM3 LVAD; a suitable donor has been identified.
- Comorbidities: obesity, HTN, HLD, type 2 diabetes mellitus, stage 3 CKD, anemia.
- **Pre-operative considerations**
  - Start NPO status
  - Draw labs: CBC, BMP, INR, fibrinogen, type & screen
  - Further medical history including imaging, studies, labs, etc.
  - Physical examination: Airway evaluation, current access?
  - Reprogram ICD
  - Immunosuppression agents & antibiotics

6

Heart Transplant continued

- **Anesthesia Setup**
- Airway
  - Low threshold for video laryngoscopy
  - 8.0 ETT
- Infusions
  - Vasoactive agents
  - Antifibrinolytic
  - Insulin
  - Anesthetic agent for ICU
  - Pulmonary vasodilator
- Access
- Blood products

7

Heart Transplant continued

- Pre-induction arterial line
- Initiate pressors +/- inotropes
- Induction
- **Propofol**
  - MOA: enhances the inhibitory effects of GABA in the CNS
  - Rapid onset (lipid solubility across BBB) and offset (redistributes to tissues)
  - Physiologic effects: hypotension, cardiac depression
- **Ketamine**
  - MOA: blocks excitatory pathways in CNS via NMDA receptor antagonism
  - Rapid onset, longer half-life (2-4 hours)
  - Physiologic effects: increases HR, blood pressure & CO
    - Also shown to cause bradycardia, arrhythmias, hypotension, cardiac decompensation
- **Etomidate**
  - MOA: enhances the inhibitory effects of GABA in the CNS
  - Rapid onset, rapid offset (hepatic esterases)
  - Physiologic effects: minimally impacts HR, blood pressure, CO
    - Inhibits cortisol production > adrenal suppression

8

Heart Transplant continued

- Maintenance of Anesthesia
- **Inhalational anesthetic**
  - Isoflurane
  - Decreased myocardial injury
  - Decreased inotrope requirement
  - Reduced mortality
- **Total Intravenous Anesthesia: TIVA**
  - Propofol
  - Necessary if maintaining patient on ICU ventilator
    - Inhaled Veletri

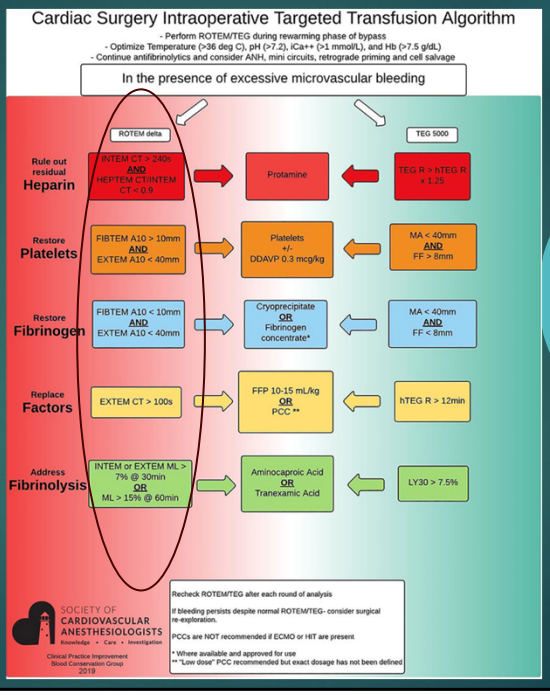
9

Heart Transplant continued

- Rewarming
- **Labs**
  - ROTEM
  - Platelet
  - Fibrinogen
- **Vasoplegia**
  - Pressors
  - Hydroxocobalamin **(Cyanokit)**
    - NO scavenger
    - ~$1000 per dose
  - Methylene Blue
    - Competitive NO antagonist
  - Angiotensin II (Giapreza)
    - Vasoconstriction, increases sympathetic tone, sodium/water retention, vasopressin release
    - ~ $1900
  - Steroids

10

ROTEM



11

Blood Products

12

Factor Concentrates

- **Prothrombin Complex Concentrate**: Kcentra
  - Factors II, VII, IX, X; proteins C & S
  - Maximum 50 units/kg in 24 hours
  - $1.70/unit (~2000-4000u: $3,400-6,800)
- Recombinant Factor VII: NovoSeven
  - High risk of thromboembolic events
  - Usual dose 1-5 mg (~ $2900-14,500)
- Andexanet alfa: Andexxa
  - Binds & sequesters Factor Xa inhibitors
  - ~$2500 per 200 mg, usual dose 400-800 mg ($5000-10,000)

13

Desmopressin acetate: DDAVP

- Releases stored vWF and Factor VIII from endothelium
- Enhances platelet adhesion to vascular endothelium and vWF, strengthening clots
- Studies suggest decreased bleeding and blood transfusion in major cardiac surgery
- Concern for possible impact on renal function post-operatively

14

Heart Transplant continued

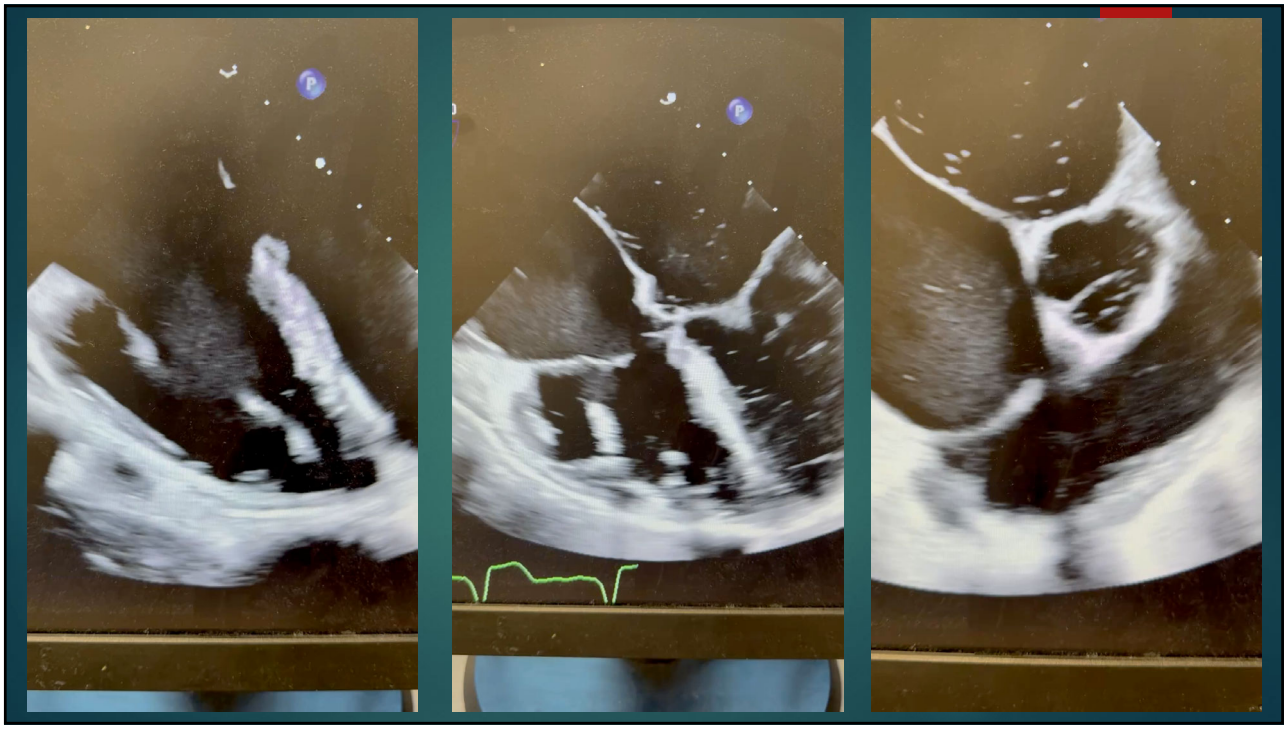
- Weaning from cardiopulmonary bypass
- **Inotropes**
  - Dobutamine
  - Epinephrine
  - Milrinone
- **Inhalational pulmonary vasodilator**
  - Inhaled epoprostenol: Veletri
    - Synthetic prostaglandin binds prostacyclin > increases cAMP > relaxes smooth muscle in pulmonary vasculature > decreases PVR > improves oxygenation > reduces RV strain
    - Inhibits platelet aggregation
  - Nitric Oxide
    - Activates guanylate cyclase > increases cGMP > reduces intracellular calcium > vascular smooth muscle cells relax > decreases PVR > improves oxygenation > reduces RV strain
- Possible pacing
  - Faster heart rate aids RV function

15

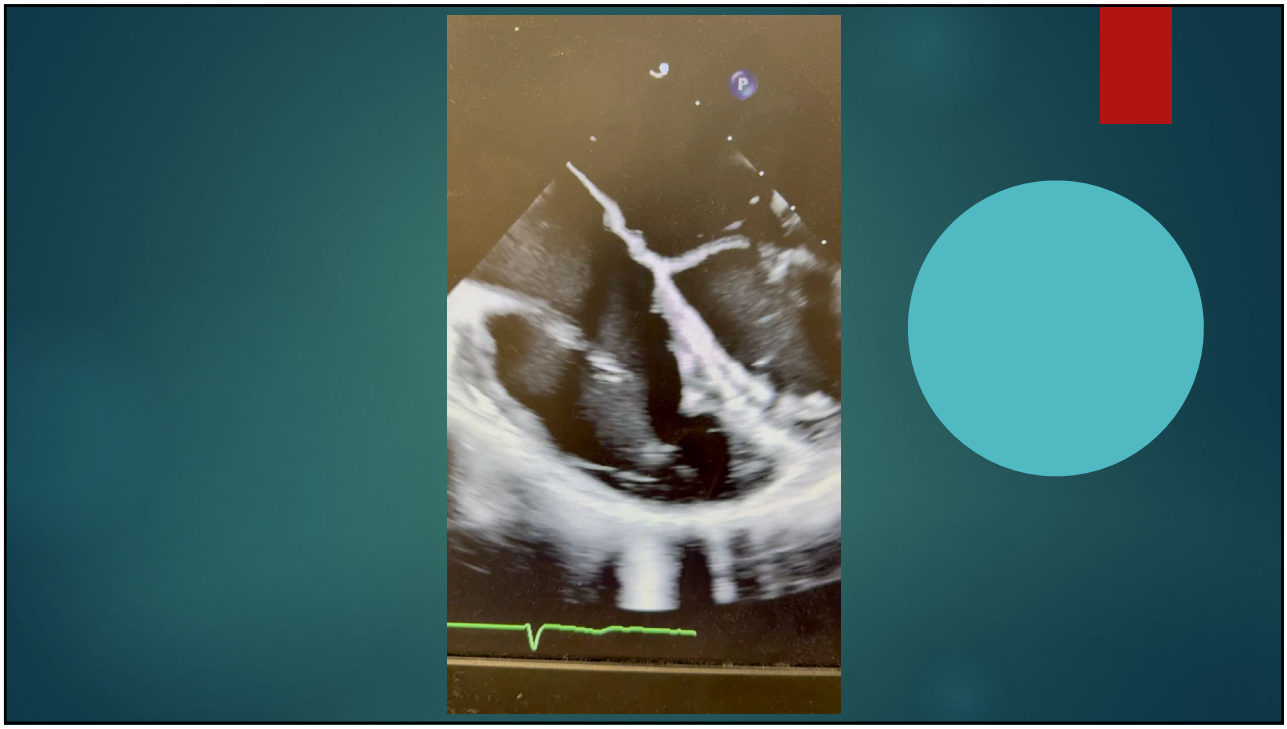
Heart Transplant continued

- **Right Ventricular Dysfunction**
- Common upon weaning from CPB
- **Dynamic**
  - Air into right coronary artery
  - Resuscitation
  - Variable heart rate and rhythm
  - Periods of hypotension
    - Arrythmia
    - Blood loss
    - Surgical manipulation
    - Packing
  - Chest closure
- Lower threshold for RVAD, particularly in DCD organ

16



17



18

Heart Transplant continued

- Post Operative Cognitive Dysfunction

The main risk factor for POCD preoperative, intraoperative, and postoperative.

Preoperative	Intraoperative	Postoperative
Older age	Duration of surgery	Length of stay
Preexisting cognitive dysfunction	Type of anesthesia	Pain management
Comorbidities	Blood loss	Delirium
Low educational level	Surgical stress response	Sleep disturbances
Functional dependence	Intraoperative complications	Mental health issues
Use of certain meds	hypoxia	Poor nutrition
History of stroke	Level of surgical complexity	Social support

19

TABLE 2.

Clinical studies evaluating the effect of midazolam on cognitive function.

Study	Year	Design	Sample size	Groups	DEX outcomes
Rajaei et al. (2019)	2018	RCT	42	Midazolam (0.05–0.1 mg/kg) vs. DEX (1 μg/kg)	DEX might have a lower impact on cognitive function than might midazolam among patients undergoing CABG
Taipale et al. (2012)	2012	Observational study	122	Midazolam	Logistic regression models revealed that for every additional milligram of midazolam administered, the patients were 7%–8% more likely to develop delirium
Yoshimura et al. (2023)	2023	RCT	16185	Midazolam vs. no midazolam	Intraoperative administration of midazolam may not induce postoperative delirium in patients undergoing cardiac surgery
Erol et al. (2020)	2020	RCT	50	Midazolam vs. no midazolam	The use of midazolam in induction and perfusion in patients undergoing CPB could reduce the development of delirium in the postoperative period

20

Biventricular ICD

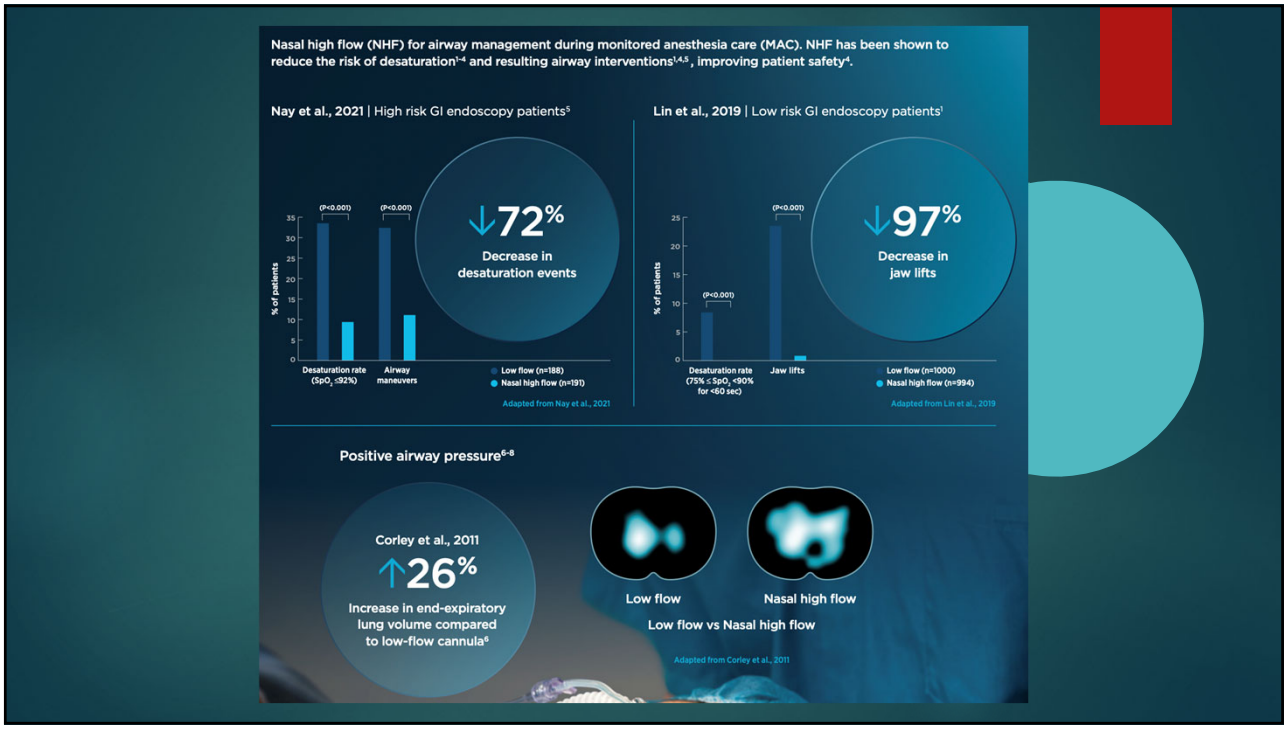
- 75 yo F w/ ICM and LBBB, presents for BiV ICD
- Comorbidities: morbid obesity (**BMI 47**), **OSA** on CPAP, **pulmonary hypertension** with mild RV dysfunction, GERD, chronic low back pain.
- **Pre-operative considerations**
  - General vs MAC
  - How to manage airway
    - LMA vs ETT?
    - Oral airway once sedation deep enough
    - Optiflow HFNC
  - Vasoactive agents

21

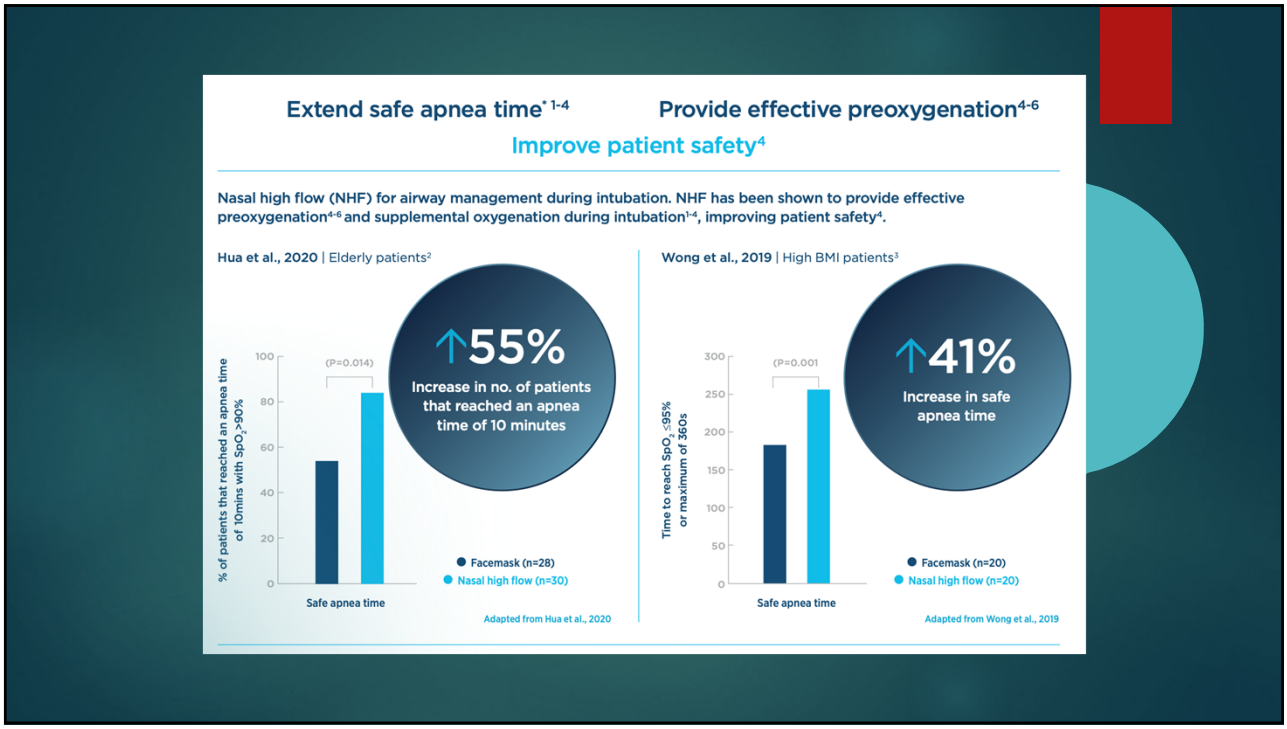
Biventricular ICD continued

- Optiflow High Flow Nasal Cannula

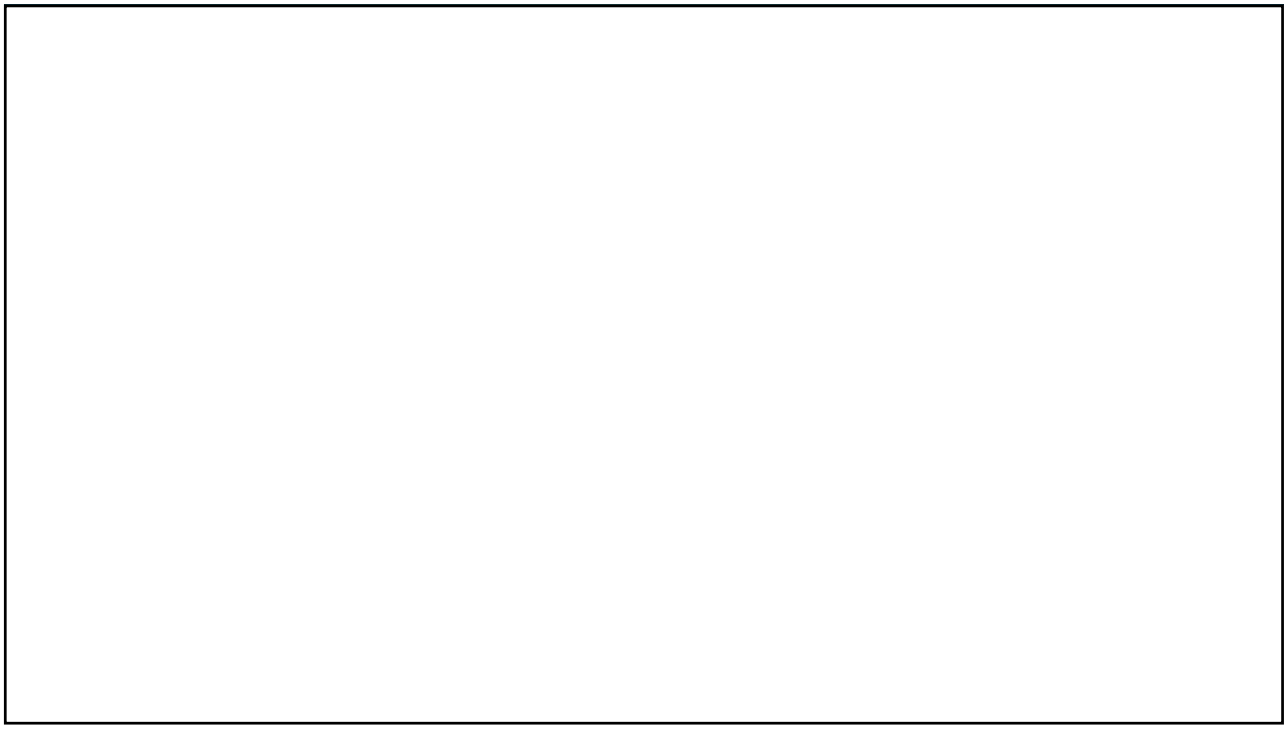
22


Nasal high flow (NHF) for airway management during monitored anesthesia care (MAC). NHF has been shown to reduce the risk of desaturation[1-4] and resulting airway interventions[1,4,5], improving patient safety[4].
Nay et al., 2021 | High risk GI endoscopy patients[5]
↓72%
Decrease in desaturation events
% of patients
(P<0.001)
(P<0.001)
Desaturation rate (SpO_2 ≤92%)
Airway maneuvers
Low flow (n=188)
Nasal high flow (n=191)
Adapted from Nay et al., 2021
Lin et al., 2019 | Low risk GI endoscopy patients[1]
↓97%
Decrease in jaw lifts
% of patients
(P<0.001)
(P<0.001)
Desaturation rate (75% ≤ SpO_2 <90% for <60 sec)
Jaw lifts
Low flow (n=1000)
Nasal high flow (n=994)
Adapted from Lin et al., 2019
Positive airway pressure[6-8]
Corley et al., 2011
↑26%
Increase in end-expiratory lung volume compared to low-flow cannula[6]
Low flow
Nasal high flow
Low flow vs Nasal high flow
Adapted from Corley et al., 2011

23


Extend safe apnea time* [1-4]
Provide effective preoxygenation[4-6]
Improve patient safety[4]
Nasal high flow (NHF) for airway management during intubation. NHF has been shown to provide effective preoxygenation[4-6] and supplemental oxygenation during intubation[1-4], improving patient safety[4].
Hua et al., 2020 | Elderly patients[2]
↑55%
Increase in no. of patients that reached an apnea time of 10 minutes
% of patients that reached an apnea time of 10mins with SpO_2 >90%
(P=0.014)
Safe apnea time
Facemask (n=28)
Nasal high flow (n=30)
Adapted from Hua et al., 2020
Wong et al., 2019 | High BMI patients[3]
↑41%
Increase in safe apnea time
Time to reach SpO_2 ≤95% or maximum of 360s
(P=0.001
Safe apnea time
Facemask (n=20)
Nasal high flow (n=20)
Adapted from Wong et al., 2019

24



25

Biventricular ICD continued

- **Anesthetic Plan**
- Discuss patient's willingness to proceed with lighter sedation
  - Can easily become too deep of sedation and inadequate oxygenation/ventilation
- **HFNC**
  - Flows upwards of 70 l/min
  - Fire risk
    - Effective communication with CRNA to ensure FiO2 decreased
  - Difficulty assessing ventilation
- **Laryngeal mask airway (LMA)**
  - Theoretically similar risk with elevated FiO2 if seal of LMA imperfect
- **Endotracheal Tube**
  - Most secure
  - Ability to control oxygenation/ventilation
  - Requires largest induction medications
    - Hemodynamic instability with low ejection fraction

26

Tamponade

- 45 yo M POD #5 s/p mechanical AVR, now w/ hemodynamic instability and POCUS showing large pericardial effusion
- **Pre-operative considerations**
  - NPO status
  - Current vasoactive agent requirements
  - Respiratory status
  - Evaluate access
  - Review Labs (type and screen, INR)
  - Pre-load with volume

27

Tamponade continued

- Pre-induction
  - Arterial line
  - Surgeon in room prior to induction
  - Epinephrine infusion & pre-load with crystalloid/colloid
  - TEE available
- Induction
  - **Inhalational agent** (acts on GABA and NMDA receptors)
    - Physiologic effects: vasodilatation and hypotension, tachycardia/bradycardia
  - **Ketamine**
    - Maintains spontaneous respiration, airway reflexes
    - Secretions can be significant > glycopyrrolate
- Attempt positive pressure ventilation
- Video laryngoscopy (avoid neuromuscular blockade)
- **Pericardial window under local anesthesia**

28

TEE Patient

- 42 yo F w/ concern for endocarditis, presents for TEE
- Comorbidities: morbid obesity w/ **prior bariatric surgery**, on **GLP-1** last taken 4 days ago, **OSA** non-compliant w/ CPAP
- **Pre-procedural considerations**
  - Discuss urgency of case
  - Evaluate for symptoms of gastroparesis
  - Risk/benefit conversation with the patient
  - Communicate prior gastric bypass surgery with cardiologist

29

TEE Patient continued

Recommendation 1	Standardized preoperative assessment for risk of delayed gastric emptying (yes/no): 1. Presence of gastrointestinal symptoms suggesting delayed gastric emptying; recent dose increases, higher doses, and weekly administered medications may increase the risk of gastrointestinal symptoms 2. Medical conditions beyond GLP-1RA usage, which may also delay gastric emptying
Recommendation 2	Selective preoperative care plan based on delayed gastric emptying assessment and shared decision-making: 1. Continue GLP-1RA therapy preoperatively if there is no concern for delayed gastric emptying 2. If elevated risk of delayed gastric emptying exists: a. Recommend liquid only diet for at least 24 h before procedure with usual recommended fasting protocol, or b. Evaluation of the feasibility of medication bridging if GLP-1RAs need to be discontinued
Recommendation 3	On the day of procedure, reassess for delayed gastric emptying and mitigate risk if clinical concern: 1. Proceed with procedure as planned if there is no concern for delayed gastric emptying 2. If elevated risk of delayed gastric emptying exists: a. Consider point-of-care gastric ultrasound and/or b. Consider rapid sequence induction of general anesthesia, if appropriate c. Minimize procedure cancellation when possible

GLP-1RA, glucagon-like peptide-1 receptor agonist.

Modified Summary Recommendations from the Multisociety Clinical Practice Guidance on Periprocedural Use of GLP-1RAs

30

TEE Patient continued

Non-insulin Injectable Medications – Drug name (Trade name)		
GLP-1/GIP Receptor Agonists (Weekly) Exenatide ER (Bydureon) Dulaglutide (Trulicity) Semaglutide (Ozempic, Wegovy) Tirzepatide (Mounjaro, Zepbound) -GLP-1/GIPRA	**Option 1**: HOLD seven (7) days prior to procedure requiring general anesthesia, deep sedation or moderate sedation (last dose should be at least 8 days prior to procedure). Contact prescribing provider for glycemic management alternatives to prevent hyperglycemia before surgery. **Option 2**: CONTINUE with modification to clear liquid diet for 24 hours prior to procedure. **If clear liquid diet is not planned**: contact site anesthesia before continuing medication.	Delays gastric emptying. Patients following a clear liquid diet for at least 24 hours prior to a procedure (e.g., colonoscopy, bariatric surgery) may routinely continue GLP-1RA. Decision to continue vs hold based on risk assessment (see narrative section below).
GLP-1 Receptor Agonists (Daily) Exenatide (Byetta) Liraglutide (Victoza) Liraglutide with insulin degludec* (Xultophy) Lixisenatide with insulin glargine* (Soliqua)	**Option 1:** HOLD day before and day of procedure. **Option 2**: CONTINUE with modification to clear liquid diet for 24 hours prior to procedure. **If clear liquid diet is not planned**: contact site anesthesia before continuing medication. *- Liragutide with degludec AND lixisenatide with glargine: If held, refer patient to prescribing provider for glargine dosing prior to procedure.	Delays gastric emptying. Patients following a clear liquid diet for at least 24 hours prior to a procedure (e.g., colonoscopy, bariatric surgery) may routinely continue GLP-1RA. Decision to continue vs hold based on risk assessment (see narrative section below).

31

TEE Patient

- Pre-induction
  - Emergency airway setup, emergency medications, suction, defibrillator pads?
- Airway
  - Optiflow HFNC
- Induction
  - Propofol
    - Implications of too little vs too much
  - Could also use ketamine (secretions); etomidate
- Complication
  - Aspiration
    - Rapid sequence induction & intubation
    - Video laryngoscopy
    - Suction

32

Cholecystectomy in patient with LVAD

- 63 yo F w/ LVAD 2/2 NICM, presents with acute cholecystitis
- Comorbidities: prior smoker with COPD, PUD s/p **Billroth procedure**, CKD, anemia
- **Pre-operative considerations**
  - NPO status
  - Further medical history, labs, imaging, studies
    - Echo
    - INR
  - Device reprogramming
- Surgical planning
  - Open vs laparoscopic procedure

33

Cholecystectomy in patient with LVAD continued

- **Induction**
  - Pre-induction arterial line
  - Access
  - Vasoactive agents
  - Propofol vs ketamine vs etomidate
- **Maintenance of anesthesia**
  - Inhalational agents
  - TIVA
- TEE available in room
- Pain Control
  - Opioid sparing given COPD
  - Consider TAP block if open procedure

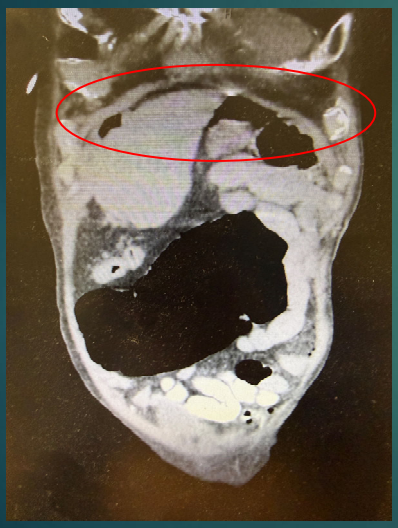
34

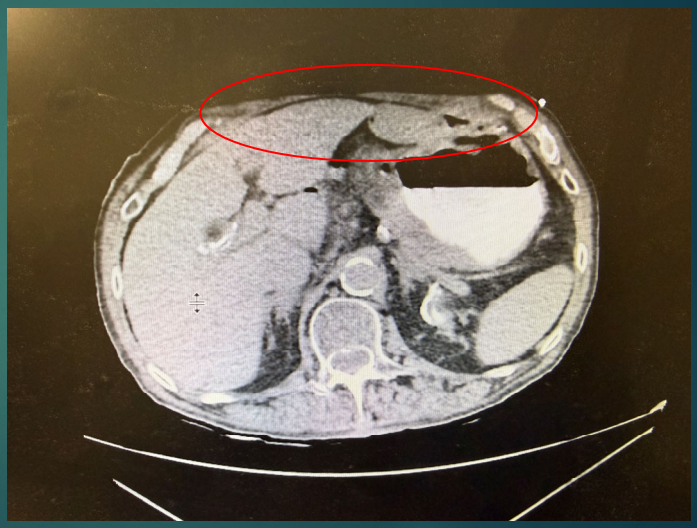
Cholecystectomy in patient with LVAD continued

- Intraoperative hemodynamic instability
  - TEE placed
  - Findings suggest further pre-load indicated
- Post-procedure patient has severe abdominal pain
  - Abdominal distention + tenderness to palpation on physical examination
  - Emergent CT

35

CT Imaging

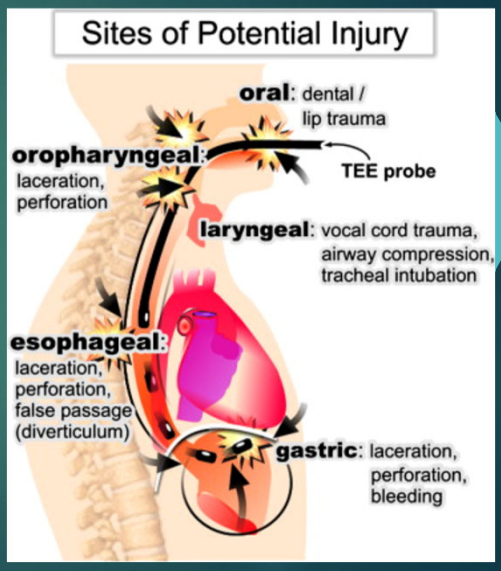




36

Cholecystectomy in patient with LVAD continued

- **Potential complications during TEE**
- Dental & oropharyngeal injury
- Laryngeal injury
- Esophageal injury
- Gastric injury
- Respiratory effects
  - Laryngospasm
  - Bronchospasm
  - Hypercapnia due to hypoventilation



37

Complications in Anesthesia

- Lip, dental, oropharyngeal injury
- Corneal abrasion
  - Airway manipulation under drapes
  - During emergence (PACU)
- IV infiltration
  - Protocol for vasoactive agents
- Tongue injury during cardioversion
  - Delayed extubation
- Aspiration
- Access injuries
  - Arterial central line placement
  - Pneumothorax

38

Review

- Pre-operative assessment
- Induction considerations
- Intra-operative management
- Anesthesia complications

MINNEAPOLIS ANESTHESIA PARTNERS

39

Questions?

40

Sources

- Safety of Transesophageal Echocardiography; Hilberath, Jan N. et al. Journal of the American Society of Echocardiography, Volume 23, Issue 11, 1115 – 1127
- Tabari M, Moradi A, Rezaieh GA, Aghasizadeh M. Effects of Midazolam and Dexmedetomidine on Cognitive Dysfunction Following Open-Heart Surgery: A Comprehensive Review. Brain Behav. 2025 Apr;15(4):e70421. doi: 10.1002/brb3.70421. PMID: 40200828; PMCID: PMC11979360.
- Bak MA, Smith JA, Murfin B, Chen Y. High-Dose Hydroxocobalamin for Refractory Vasoplegia Post Cardiac Surgery. Cureus. 2022 Aug 22;14(8):e28267. doi: 10.7759/cureus.28267. PMID: 36039127; PMCID: PMC9395213.
- Wademan BH, Galvin SD. Desmopressin for reducing postoperative blood loss and transfusion requirements following cardiac surgery in adults. Interact Cardiovasc Thorac Surg. 2014 Mar;18(3):360-70. doi: 10.1093/icvts/ivt491. Epub 2013 Nov 21. PMID: 24263581; PMCID: PMC3930208.
- Rosenbaum SB, Gupta V, Patel P, et al. Ketamine. [Updated 2024 Jan 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK470357/
- Tammy L. Kindel, Andrew Y. Wang, Anupama Wadhwa, Allison R. Schulman, Reem Z. Sharaiha, Matthew Kroh, Omar M. Ghanem, Shauna Levy, Girish P. Joshi, Teresa L. LaMasters, Multisociety clinical practice guidance for the safe use of glucagon-like peptide-1 receptor agonists in the perioperative period, Surgery for Obesity and Related Diseases, Volume 20, Issue 12, 2024, Pages 1183-1186, ISSN 1550-7289,
- Raphael, Jacob & Mazer, C. & Subramani, Sudhakar & Schroeder, Andrew & Abdalla, Mohamed & Ferreira, Renata & Roman, Philip & Patel, Nichlesh & Welsby, Ian & Greilich, Philip & Harvey, Reed & Ranucci, Marco & Heller, Lori & Boer, Christa & Wilkey, Andrew & Hill, Steven & Nuttall, Gregory & Palvadi, Raja & Patel, Prakash & Lau, W.. (2019). Society of Cardiovascular Anesthesiologists Clinical Practice Improvement Advisory for Management of Perioperative Bleeding and Hemostasis in Cardiac Surgery Patients. Anesthesia & Analgesia. 129. 1. 10.1213/ANE.0000000000004355.
- Society of Cardiovascular Anesthesiologists Clinical Practice Improvement Advisory for Management of Perioperative Bleeding and Hemostasis in Cardiac Surgery Patients. Raphael, Jacob et al. Journal of Cardiothoracic and Vascular Anesthesia, Volume 33, Issue 11, 2887 – 2899
- Allina Health. Endocrine Specialty Clinical Care Committee System-wide Consensus Guidelines: Pre-procedure and Pre-operative Diabetes Medication Management Guidelines. September 2025.
- Fisher & Paykel Healthcare, Optiflow Trace. Fphcare.com/thrive

41