



Managing Complications During Minimally Invasive Mitral Surgery

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Conflict of Interest Disclosures

- Abiomed, Atricure, Abbott





Goals of Minimally Invasive Mitral Valve Surgery

- Achieve excellent results and outcomes
 - (Similar high repair rates and ***patient safety***)
- Optimal visualization
- Minimize surgical trauma (Avoid complications)
- Avoid a sternotomy



Complications

- Peripheral Cannulation Complications
- Cerebrovascular Accident
- Phrenic Nerve Injury
- Aortic Dissection
- Left Atrial Appendage Injury
- Pulmonary Artery Injury
- Coronary Artery Injury - Circumflex Artery / Right Coronary Artery
- Inadequate Mitral Valve Repair
- Bleeding Complications
- SAM
- Liver/Diaphragm Injury
- LV Dissection
- Unilateral Lung Pulmonary Edema
- Lung Injury
- Aortic Valve Injury





Peripheral Cannulation Complications

- Inadequate drainage
- Insufficient flow
- Vessel injury



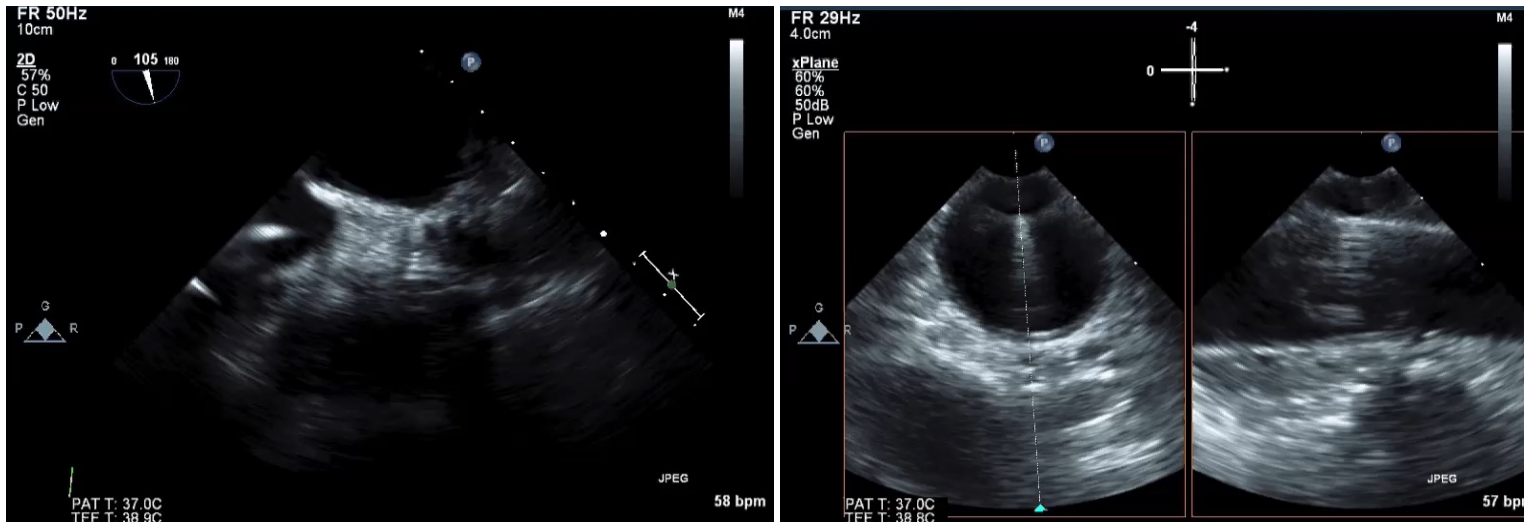
Peripheral Cannulation Complications

- Inadequate drainage/Insufficient flow
 - Both are usually a result of inappropriate cannula positioning and or sizing

	Size	BSA (m ²)	Max. Flow (L/min)
Arterial	17 Fr	1.3 to 1.7	4.2
	18 Fr	1.7 to 2.2	5.3
	20 Fr	≥ 2.2	6.5
Venous	23/25 Fr Dual Stage	≤ 2.3	For Tricuspid cases
	25 Fr Multiport	> 2.3	All other cases

Peripheral Cannulation Complications

- Vessel injury/structure injury
 - Utilize imaging to minimize injury
 - Pre-operative CT and intraoperative Echo +/- fluoro

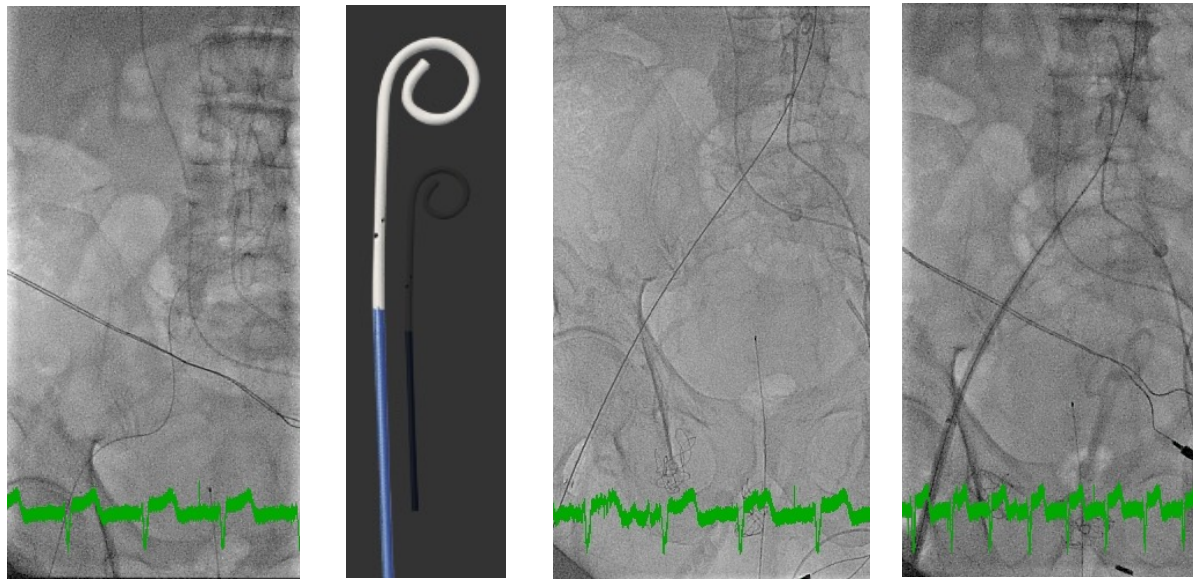


Peripheral Cannulation Complications

- Pre-Operative CT
 - Three reasons
 - 1) Looking for Calcium in the femoral vessels and in the rest of the aorta
 - 2) Looking for arterial tortuosity and caval anatomic issues.
 - 3) Looking for severity of atherosclerosis



Peripheral Cannulation Complications



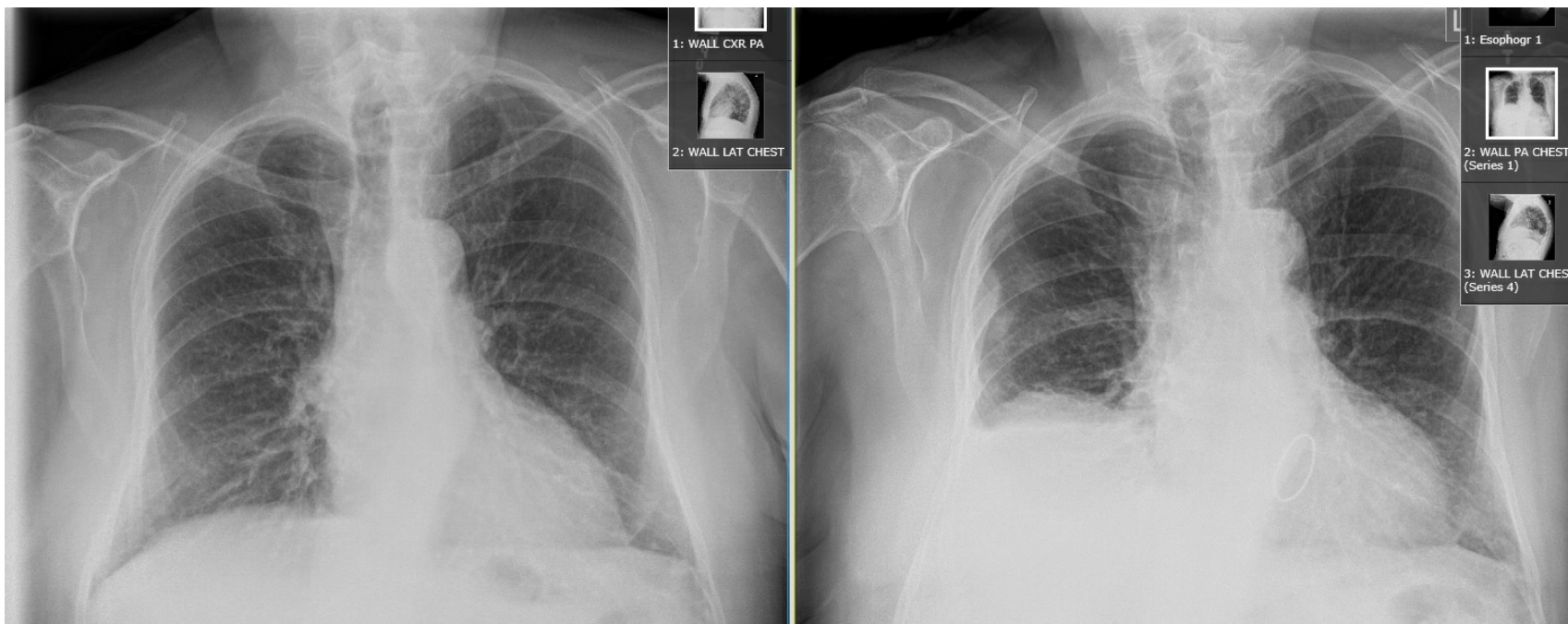


Peripheral Cannulation Complications

- How to avoid
 - Preoperative imaging
 - Intraoperative image guidance
 - May have to use alternative approaches (axillary artery)
 - In rare cases may need to abort the Robotic option
- When injury occurs
 - Earlier recognition and repair
 - Change cannulation site
 - Abandon robotic approach

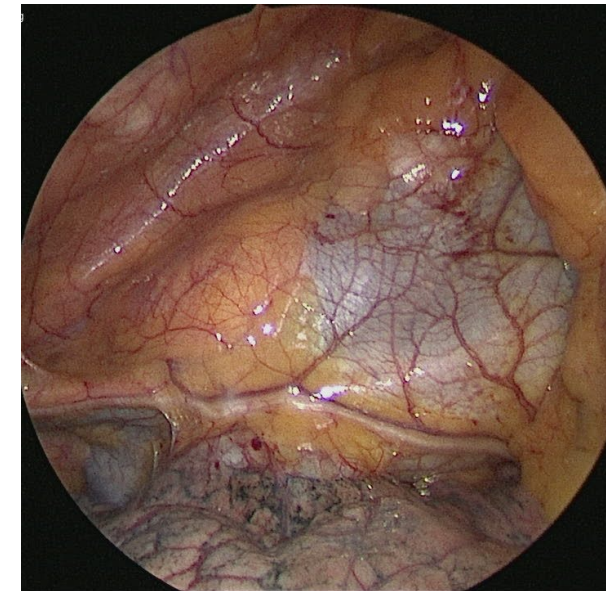


Phrenic Nerve injury



Phrenic Nerve injury

- Visualize the nerve
- Open several cm above the nerve at least 4cm
- Avoid stretching the nerve





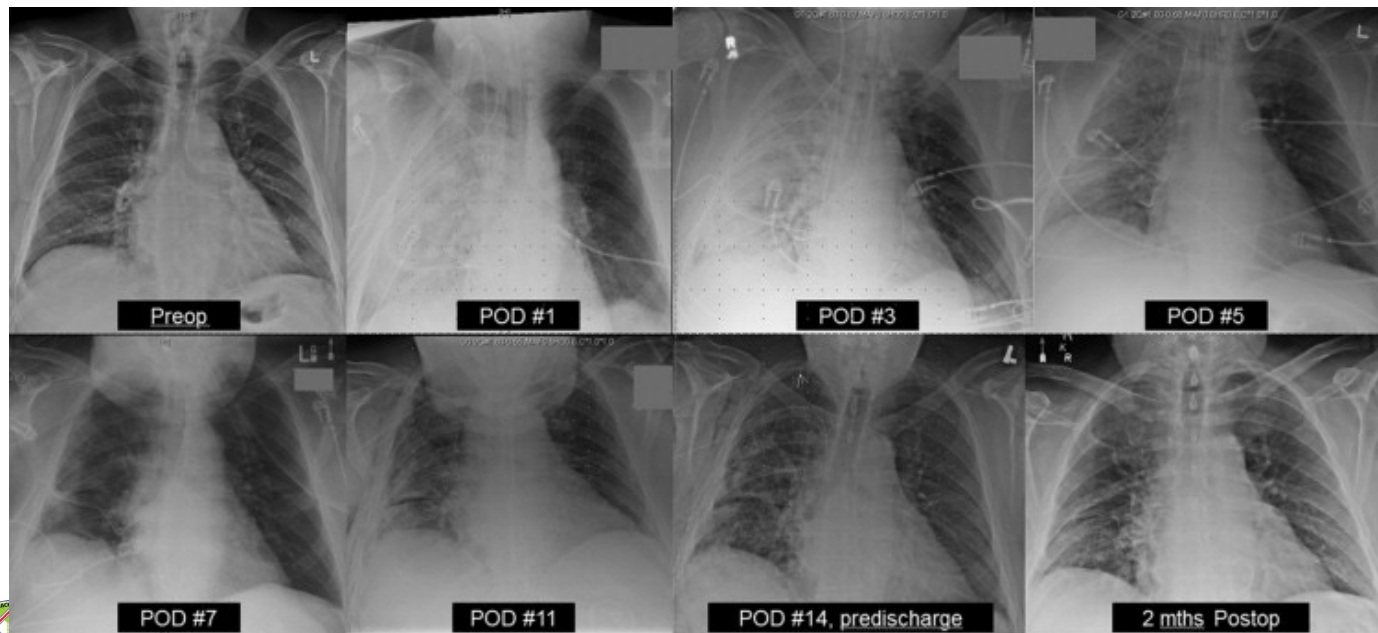
Diaphragm/Liver injury

- All port/trocar must be placed under direct visualization or direct palpation



Unilateral Pulmonary Edema

- Truly the only unique complication of robotic surgery – Never seen in a sternotomy approach. Poorly understood etiology.



Tutschka et al., Annals 2015



Unilateral Pulmonary Edema

- Common complication which can occur in up to 25% of cases. Most cases are not clinically relevant
- Severity ranges from insignificant only seen on CXR, mild (Lasix) to severe/life threatening (VVECMO) or even death.
- Not seen in conventional mitral surgery.





Unilateral Pulmonary Edema

- Risk factors
 - Double lumen ETT
 - Longer CPB
 - COPD
 - Preexisting pulmonary HTN
 - RV dysfunction
 - Not cooling





Unilateral Pulmonary Edema

- Risk factors
 - Double lumen ETT -- Single lumen
 - Never seen with single lumen
 - Prolonged one lung ventilation
 - Longer CPB -- minimize CBP
 - COPD
 - Preexisting pulmonary HTN
 - RV dysfunction
 - Not cooling -- Cool to 30-32 degrees
 - Never seen with cooling to 30




Type A Dissection



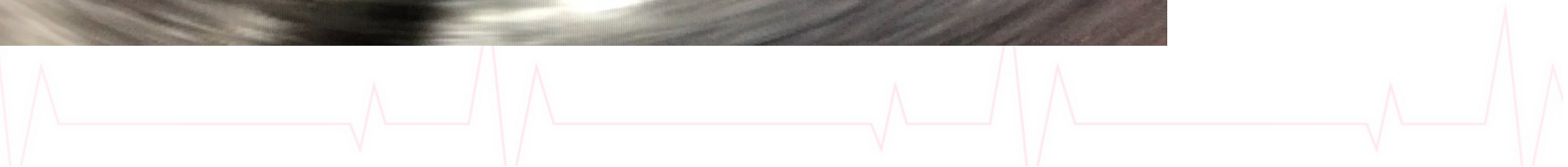


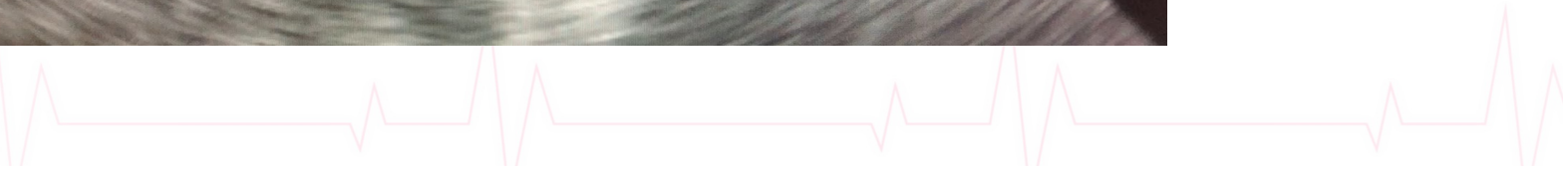
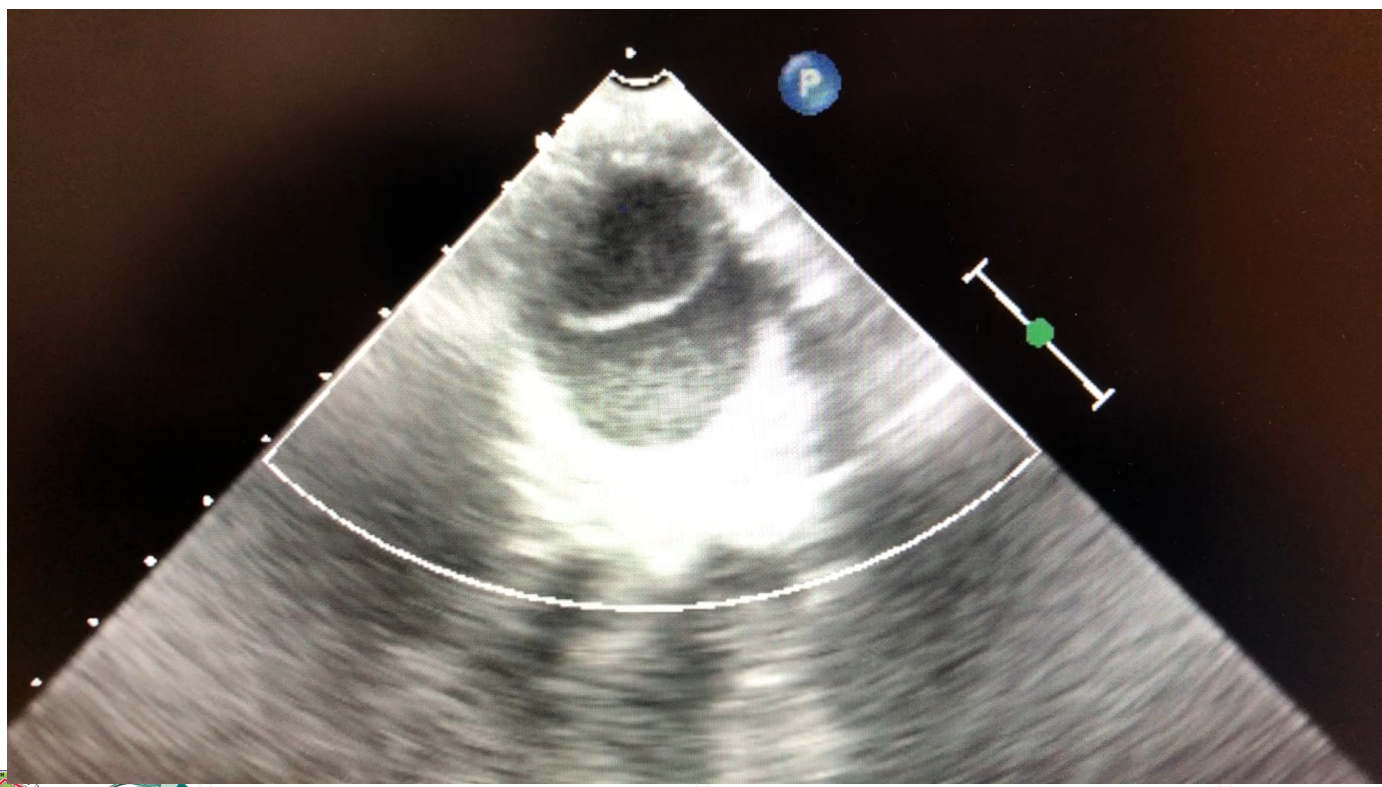
Type A Dissection

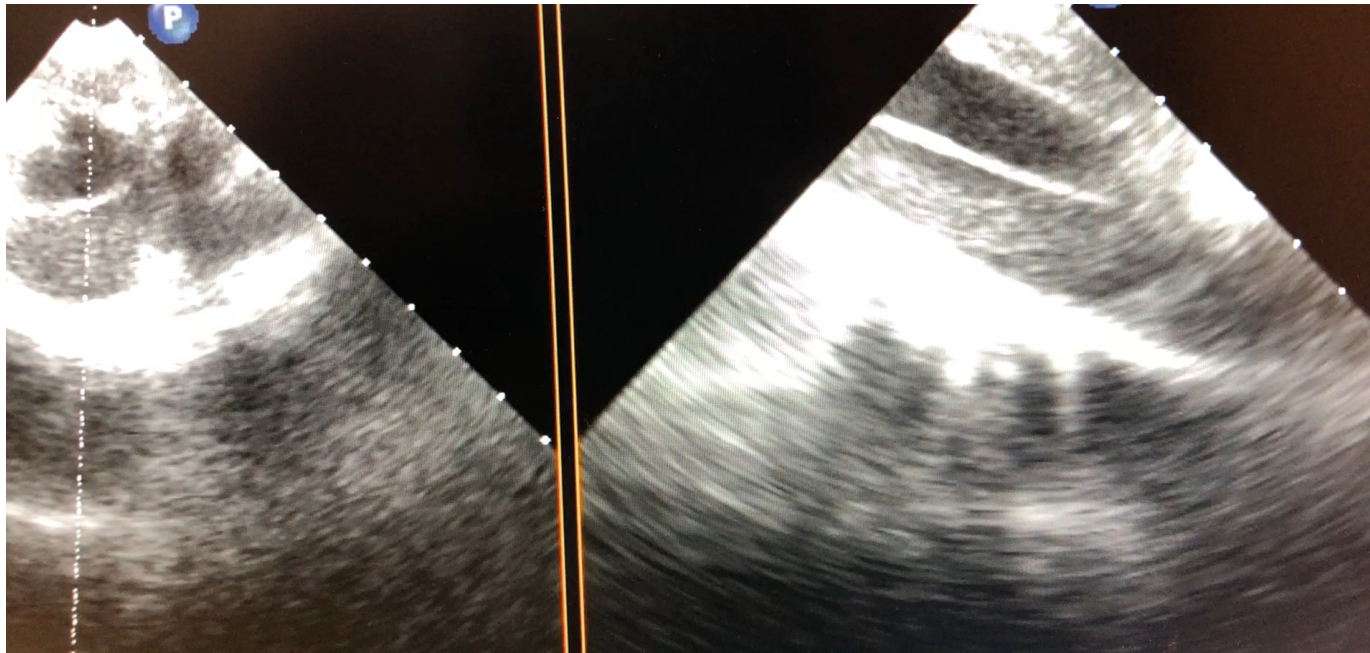
- Rare (0.06-0.3%)
 - Leontyev et al., all dissection occurred in patient with ascending aorta > 4.0cm
- Occurs during
 - Cannulation
 - Start of CPB
 - Crossclamp Application/Removal
 - Decannulation



Leontyev et al., 2011









Management

- Convert to full sternotomy
- Perform a standard Type A repair





Type A Dissection

- How to avoid
 - Preop CT looking for ascending aneurysm – Greatest risk occurs when >4cm
 - When using the Chitwood clamp place in the 2nd interspace if possible and low towards the axilla. Secure with umbilical tape to avoid torqueing
 - Care must be taken to avoid manipulating the clamp
 - Endoballoon. Use fluorescence to help guide optimal position and avoid inadvertent manipulation.





Type B Dissection

- Only seen with peripheral cannulation
 - Conservative management
 - Abandon the procedure (if possible)
 - Early postop imaging
 - If it occurs after crossclamp release – immediate separation from CPB and reverse with protamine
- Method to avoid –
 - Preoperative CT
 - Meticulous technique
 - Image guided insertion



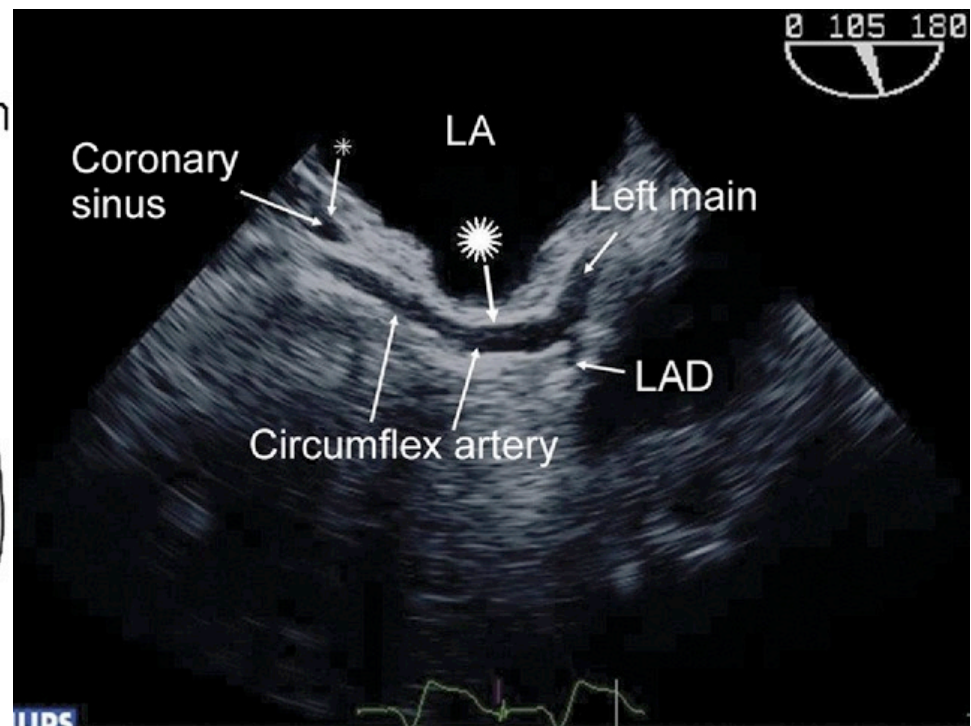
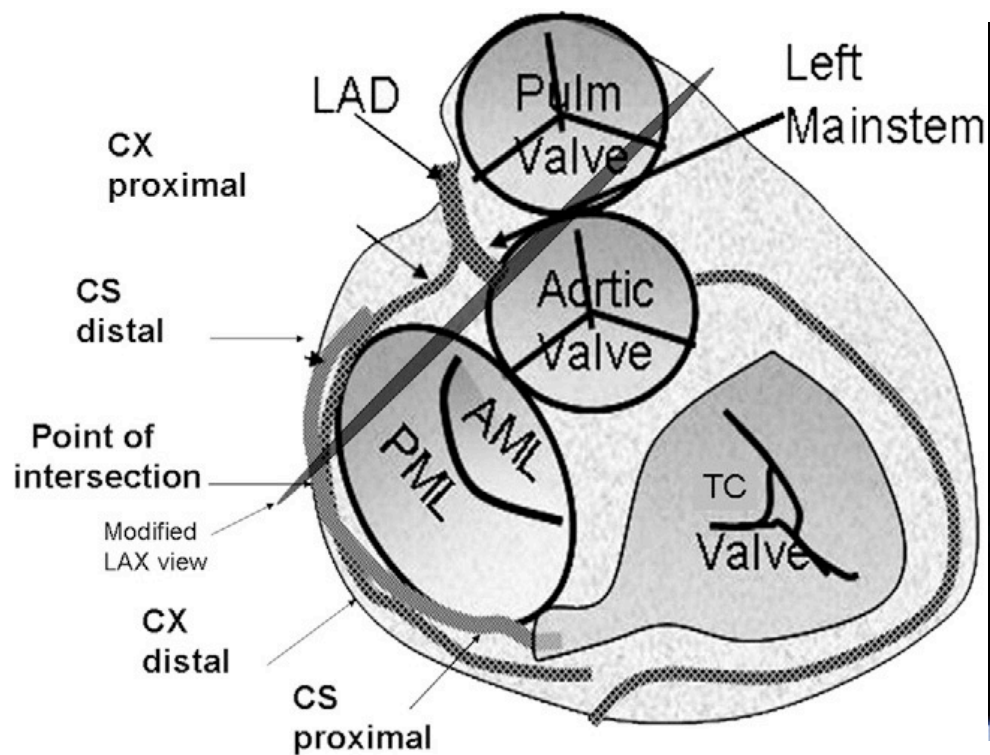


Coronary Artery Injury

- Recent literature suggest that CxA injury occurs in 0.3%–1.8% of patients
- This number may be underestimated due to publication bias and also the fact that symptoms of CxA injury may be misinterpreted in patients with other perioperative complications.
- In patients with coronary anomalies, the risk is even greater.



Most likely to occur at the P1 level





Circumflex injury

- Predominantly injured by kinking
 - Annuloplasty
 - Annular plication
 - Valve replacement
- Can be directly injured or ligated
 - Valve replacement
 - Annular decalcification or debridement
 - Ablation (Isthmus line)
 - LAA ligation





Pre op TEE

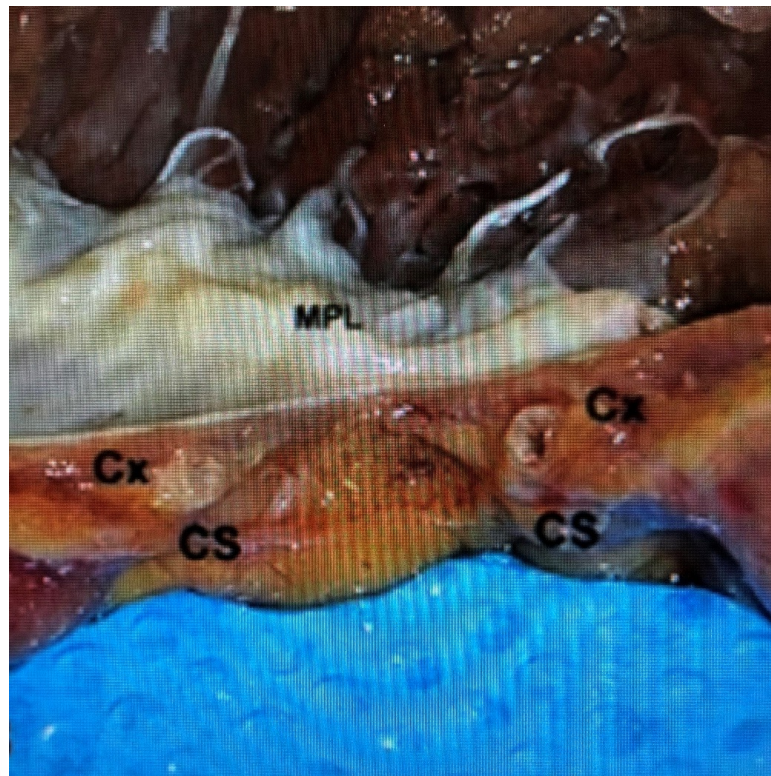
- Visualization of the circumflex
 - >6 mm from the annulus – No risk
 - 3-6 mm from the annulus – little risk
 - < 3 mm from the annulus – High risk
- Dominance
 - May affect the risk (data inconclusive)
- Coronary Anomaly
 - Increases risk

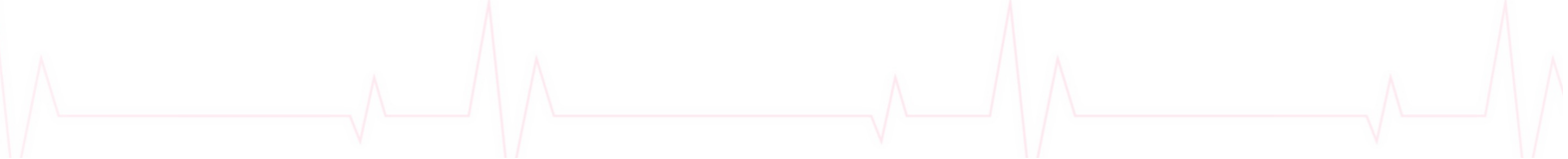
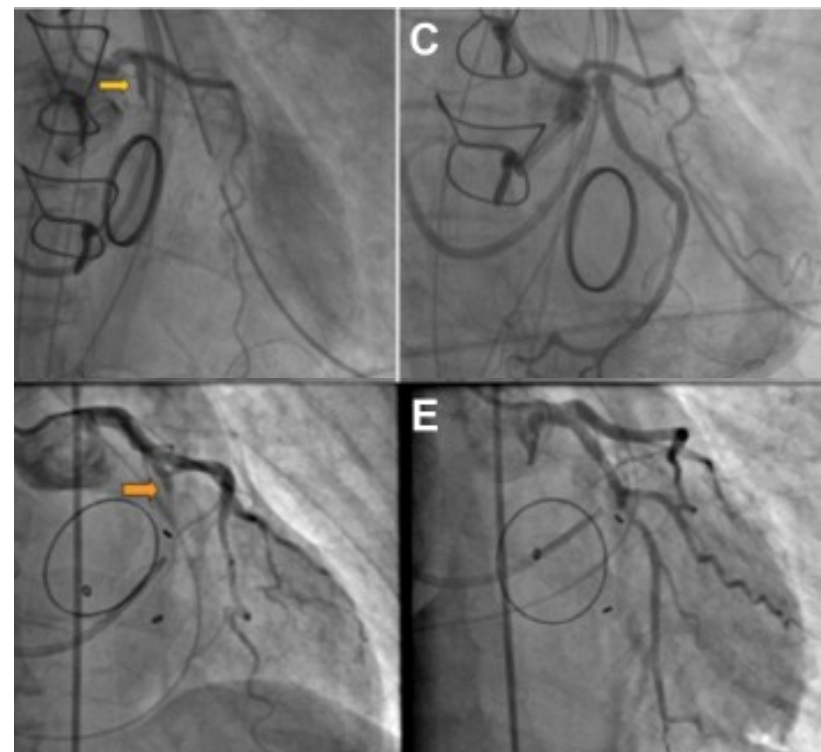
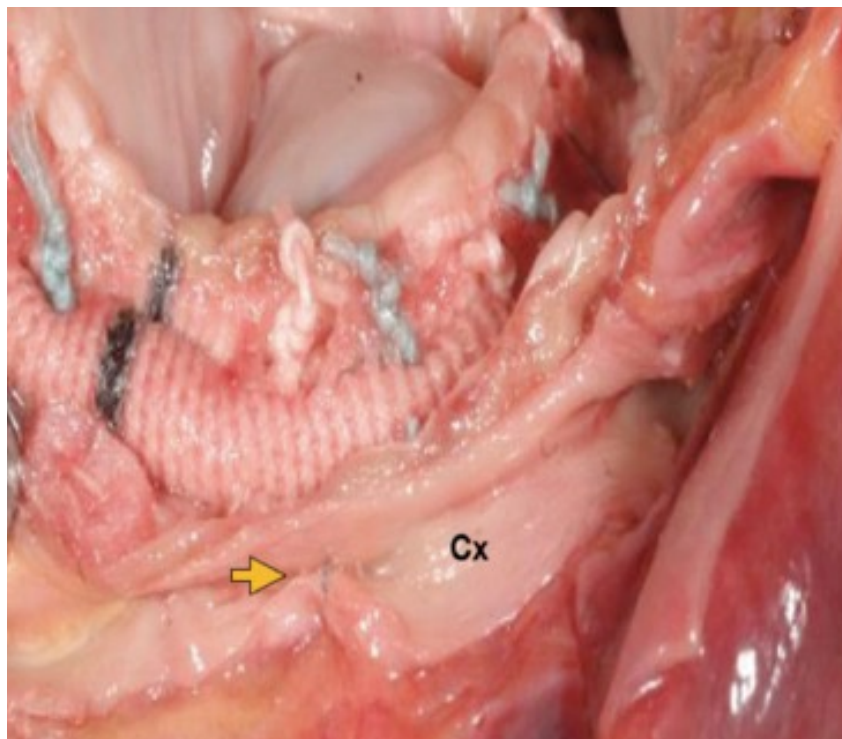


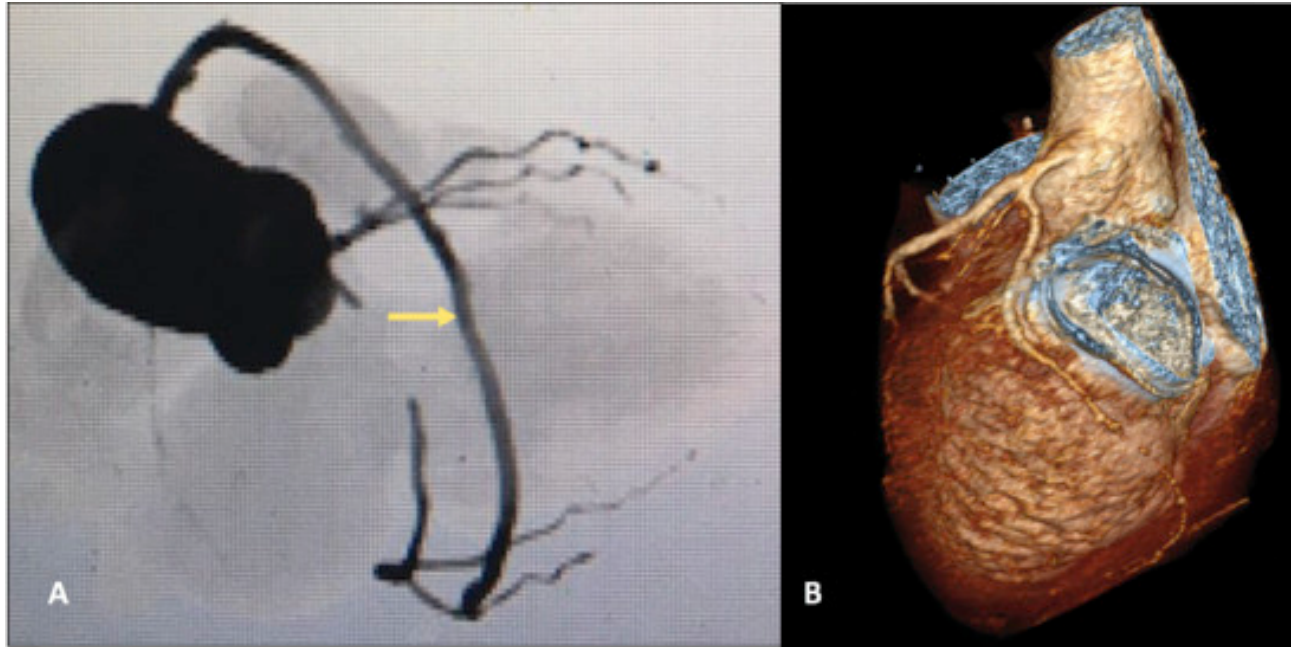
Circumflex injury

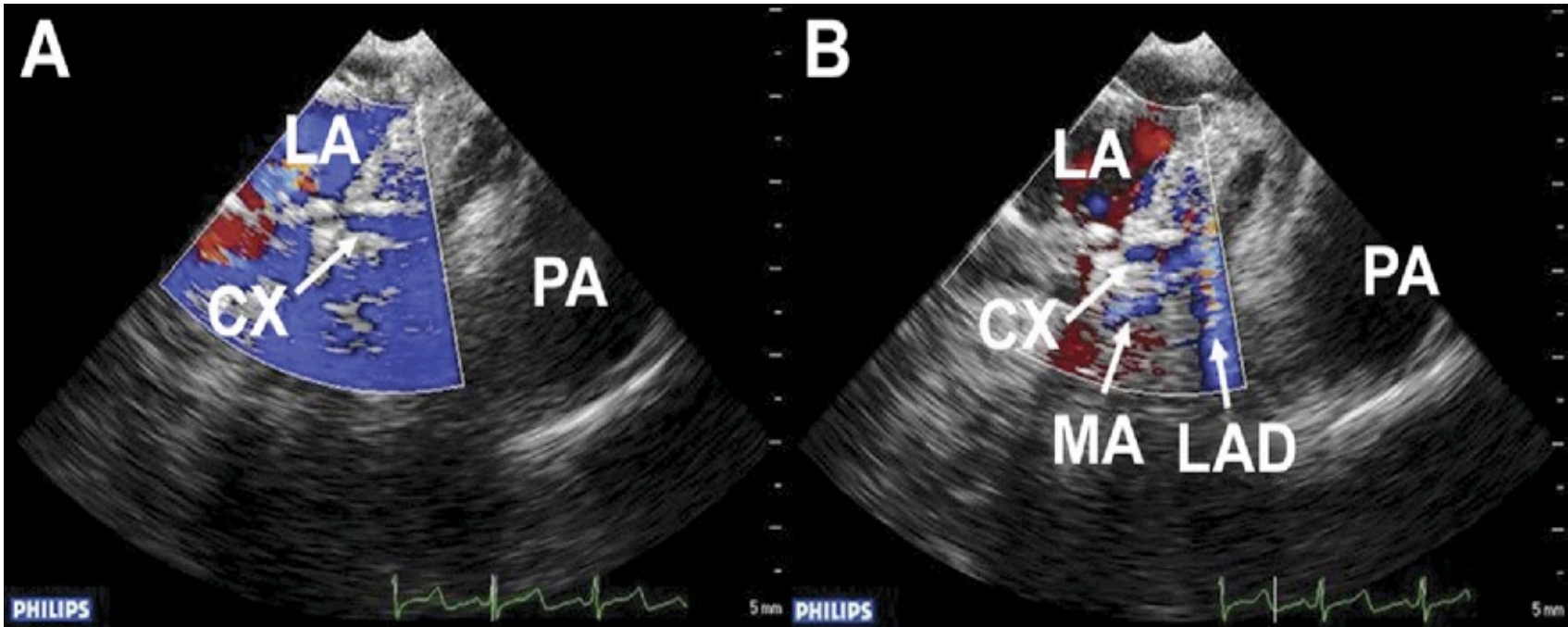


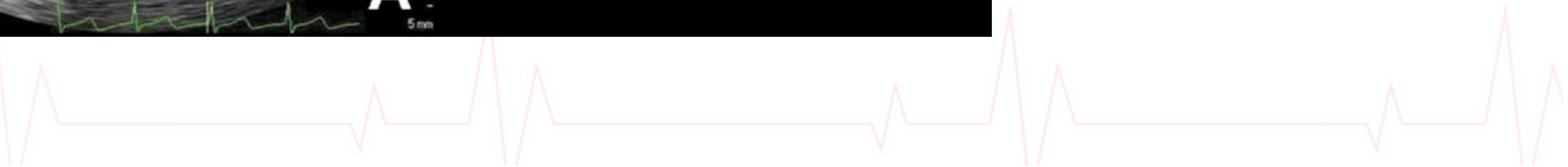
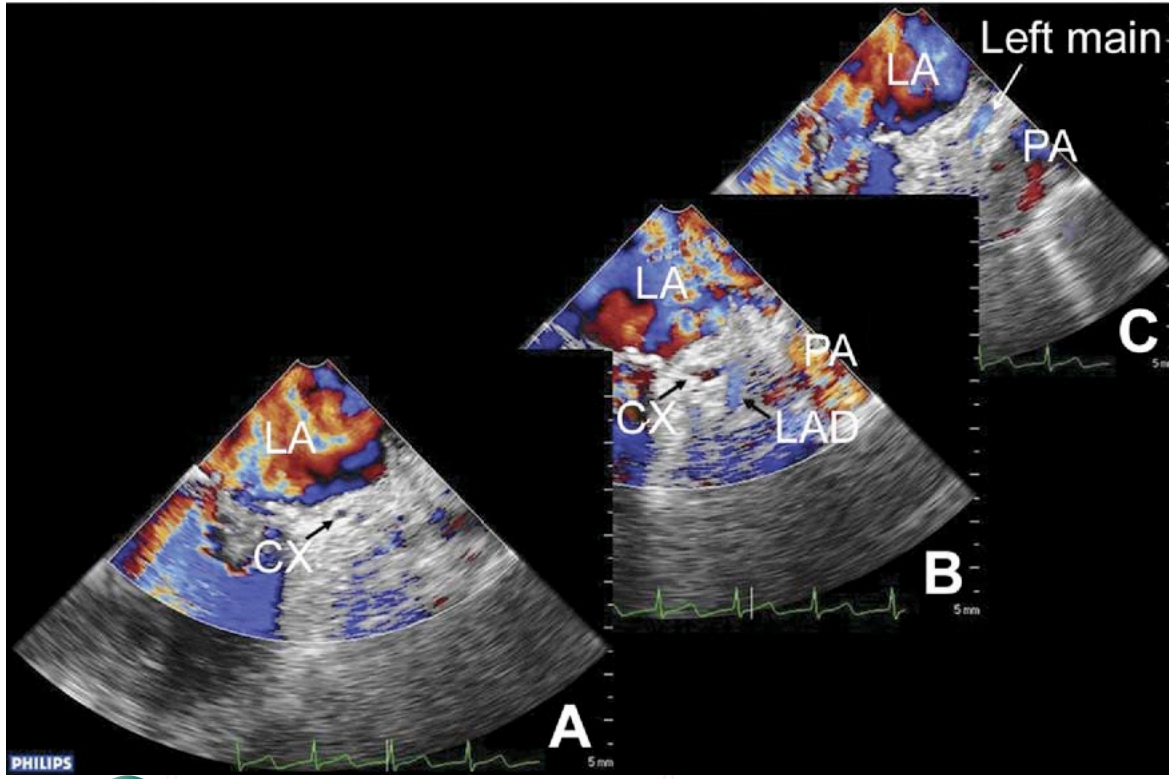
Circumflex Artery







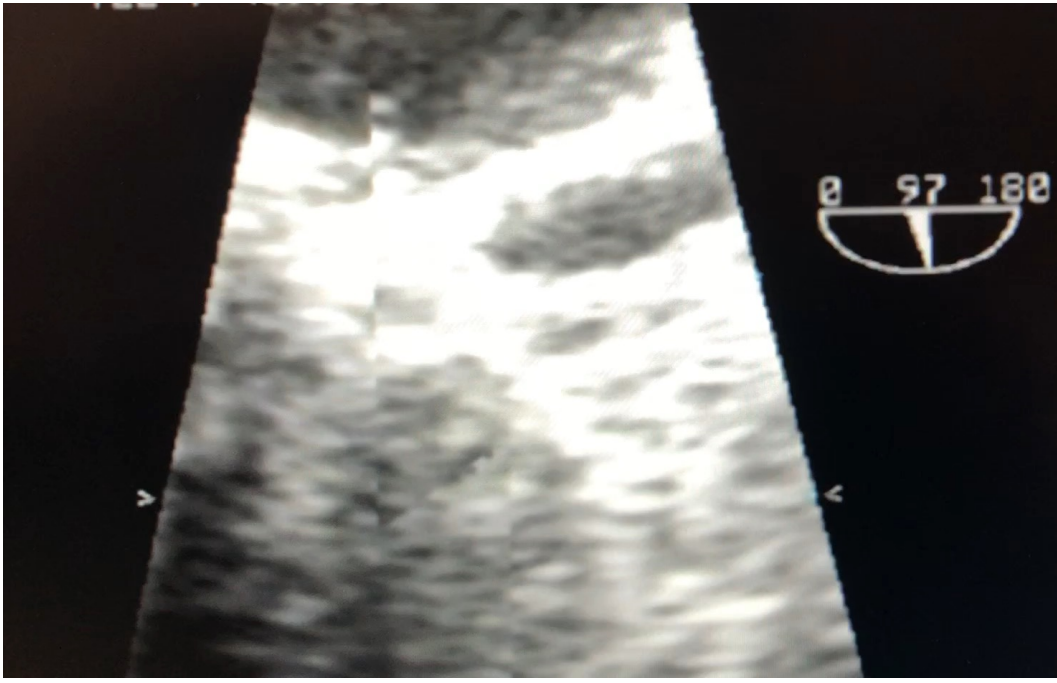


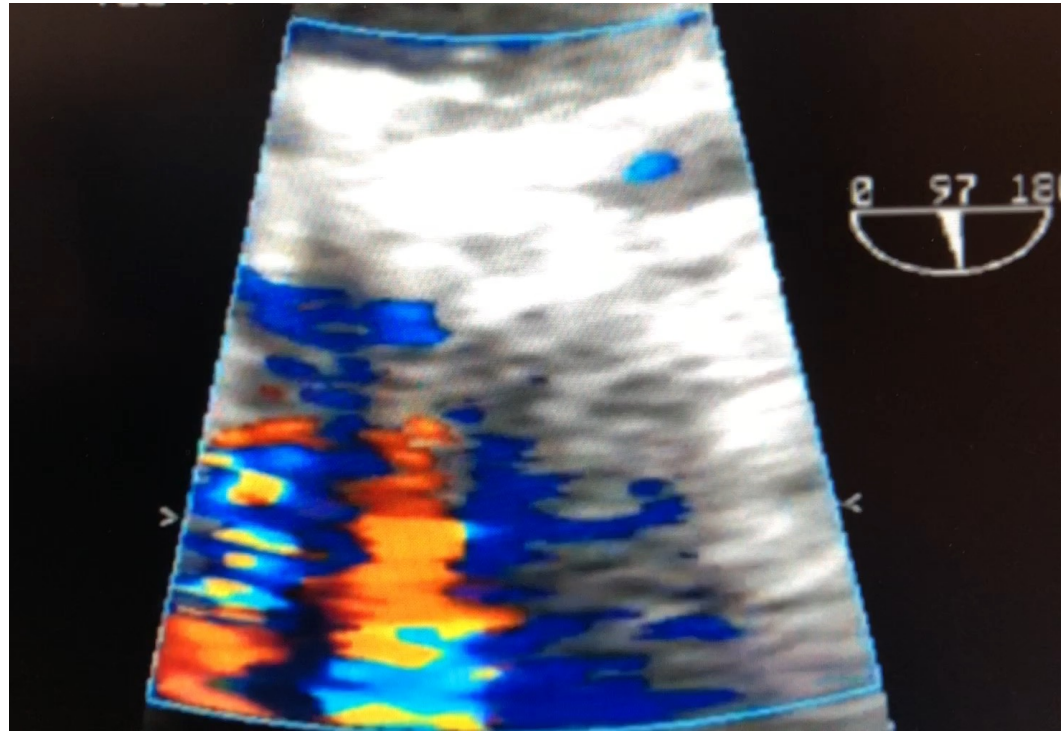




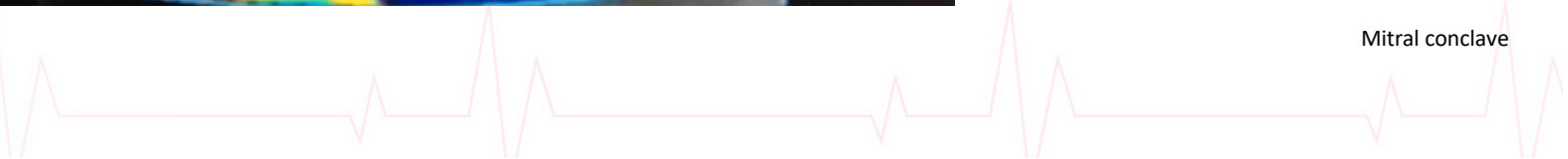
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- **Modified midesophageal aortic valve long-axis view with a transducer angle of 110-120 degrees and counterclockwise rotation of the probe permits best visualization of the circumflex artery.**
 - **The circumflex artery can be distinguished from the coronary sinus by measuring the differences in the diameter of the respective vessels, and the coronary dominance pattern can be ascertained.**

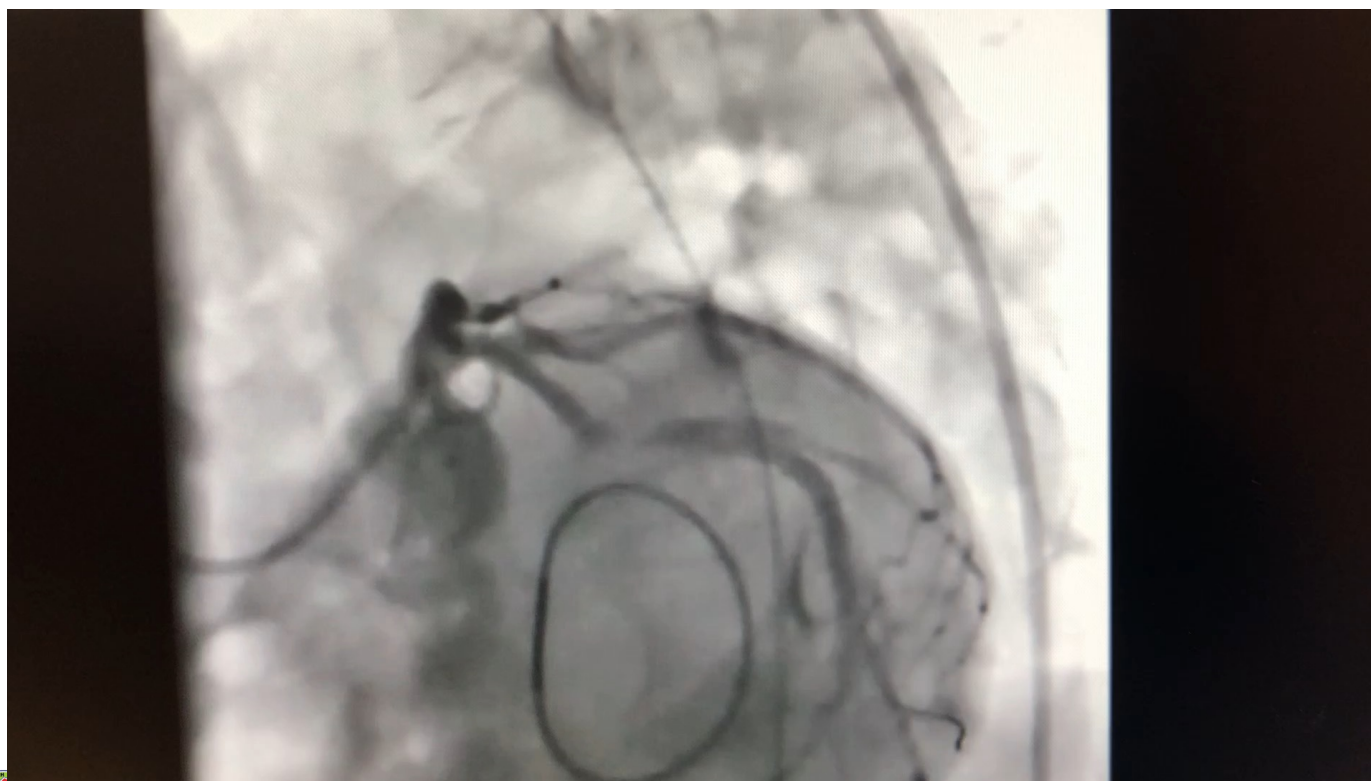




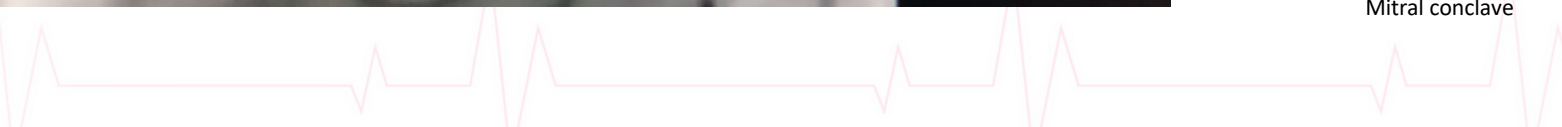


Mitral conclave





Mitral conclave





- Presentation

- Ventricular arrhythmia
 - Low Cardiac Output Syndrome
 - LV dysfunction
 - Regional Wall Motion Abnormality
 - ECG Changes
-
- Direct ligation – usually immediate and profound
 - Kinking – immediate or delayed



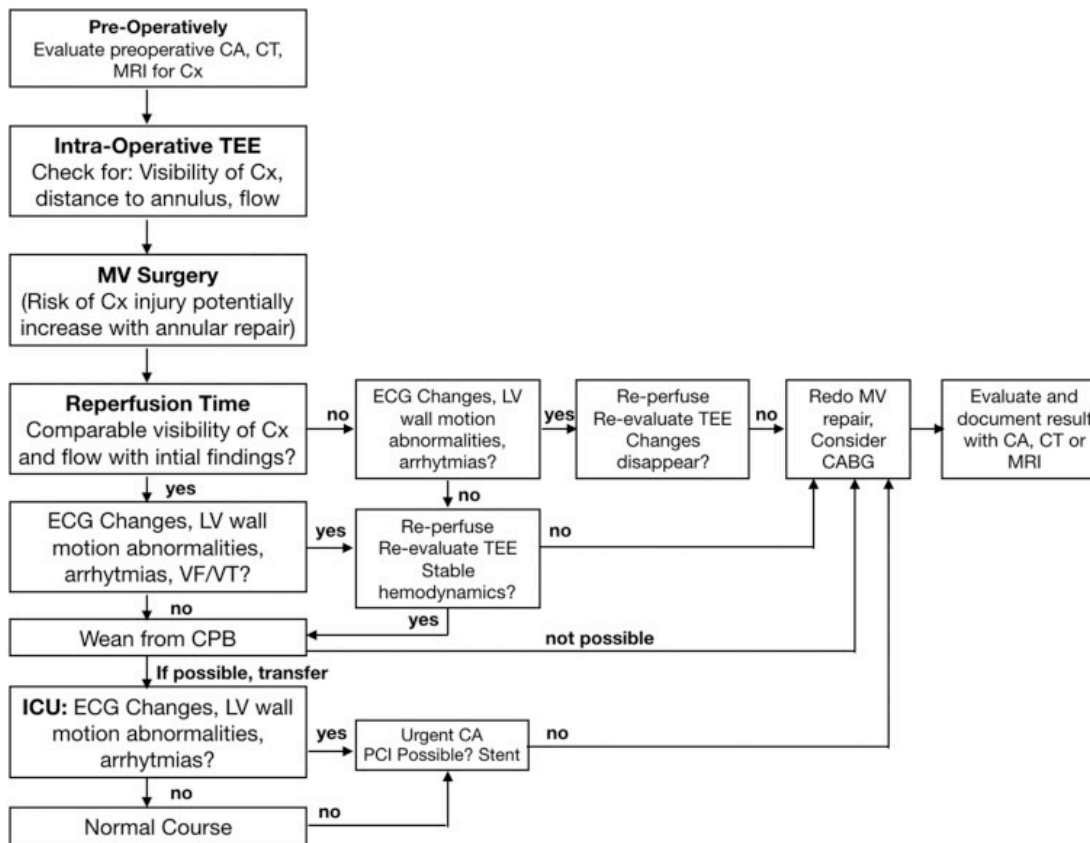


- DX

- ECHO
- Cath
- Autopsy

- CABG – Sternotomy
- PCI – Cath lab with risk of return to the OR is unable to cross the injury
- Reop and remove offending suture/s
- Modified annuloplasty





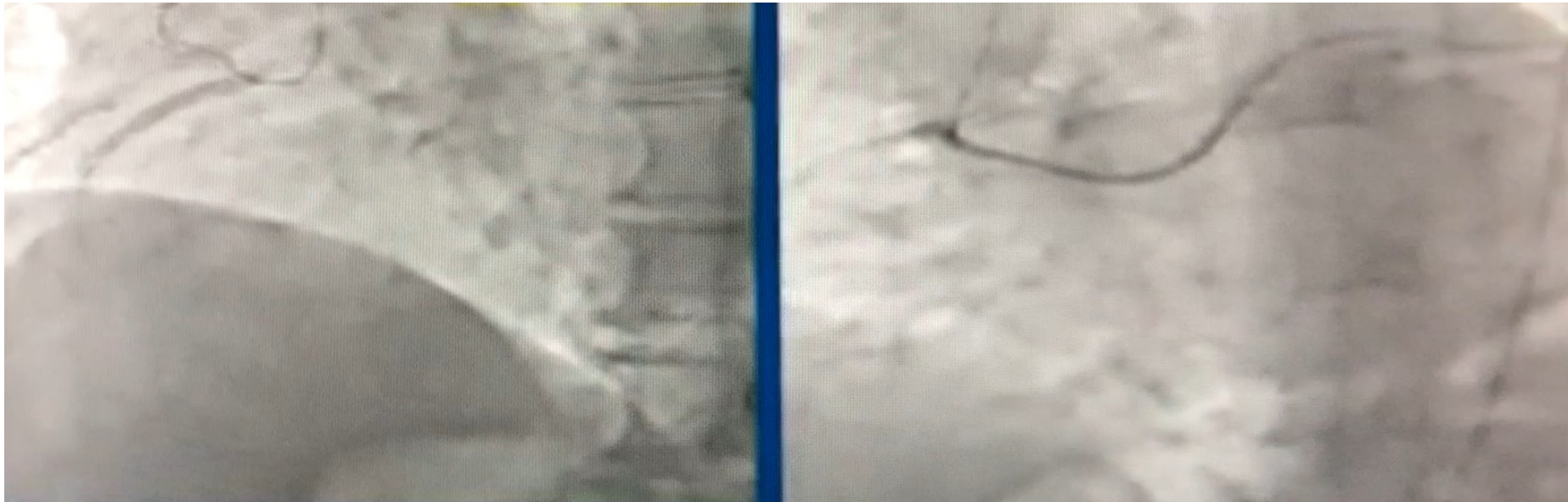


How to Avoid

- Avoid deep sutures in P1.
- Circumflex is in the atrial side of the annulus if suture are mostly ventricular decreases risk of injury.
- Understanding preoperative imaging will greatly reduce the risk.

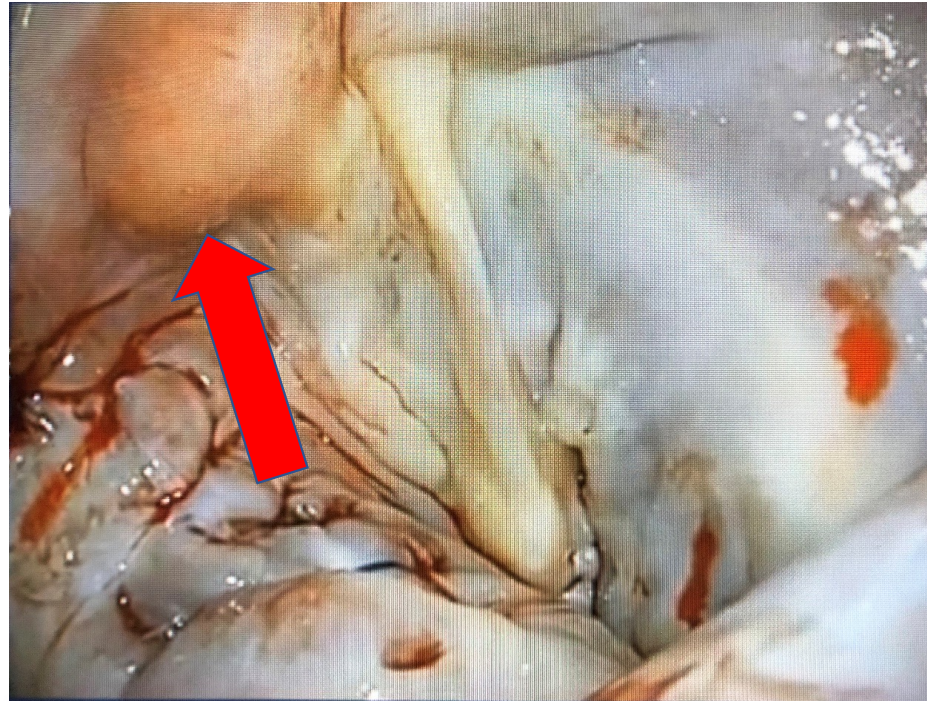


Anomalous Circumflex



Mitral conclave

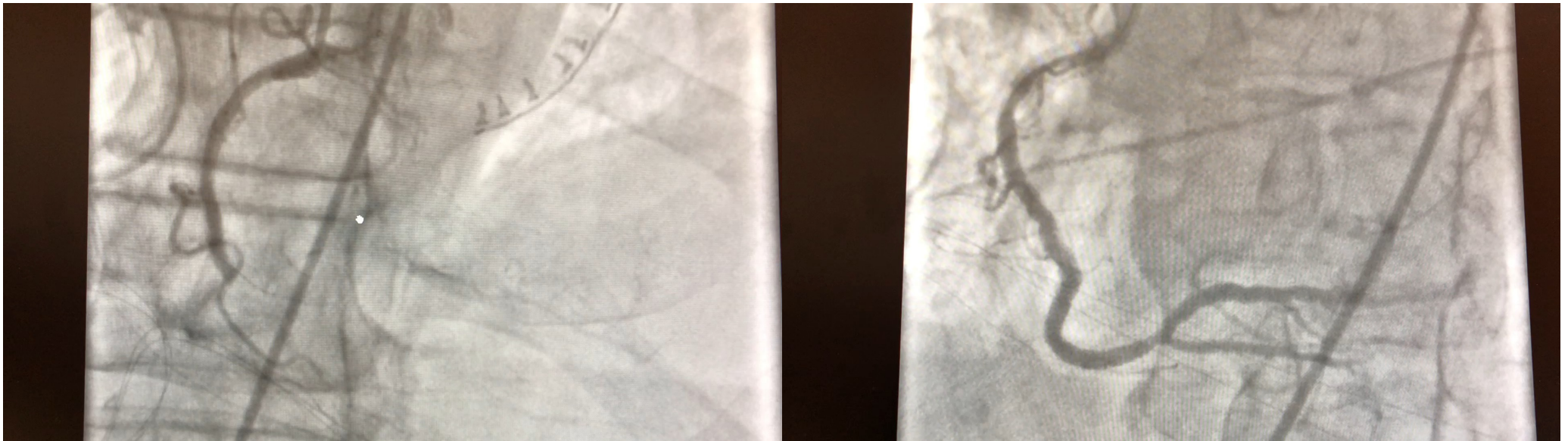
Modified Annuloplasty





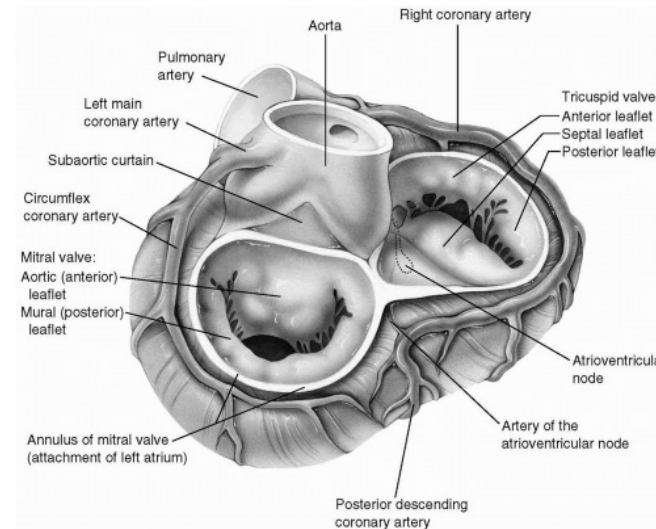
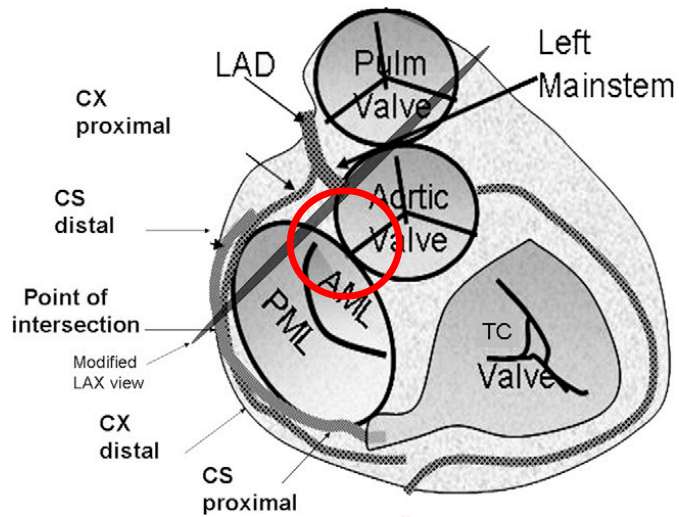
RCA Injury

- Can occur during tricuspid repair



Aortic valve injury

- Rare < 0.1%
- Identification with TEE





Aortic valve injury

- Injury can occur
 - In the non or right cups or at the non/right commissure
- Management
 - Sternotomy in most cases / Can also be approached via the enlargement of the right thoracotomy incision
 - LV vent / retrograde / direct ostial cardioplegia
 - AV repair possible if tear in is the belly of the leaflet
 - AVR if at of near the commissure



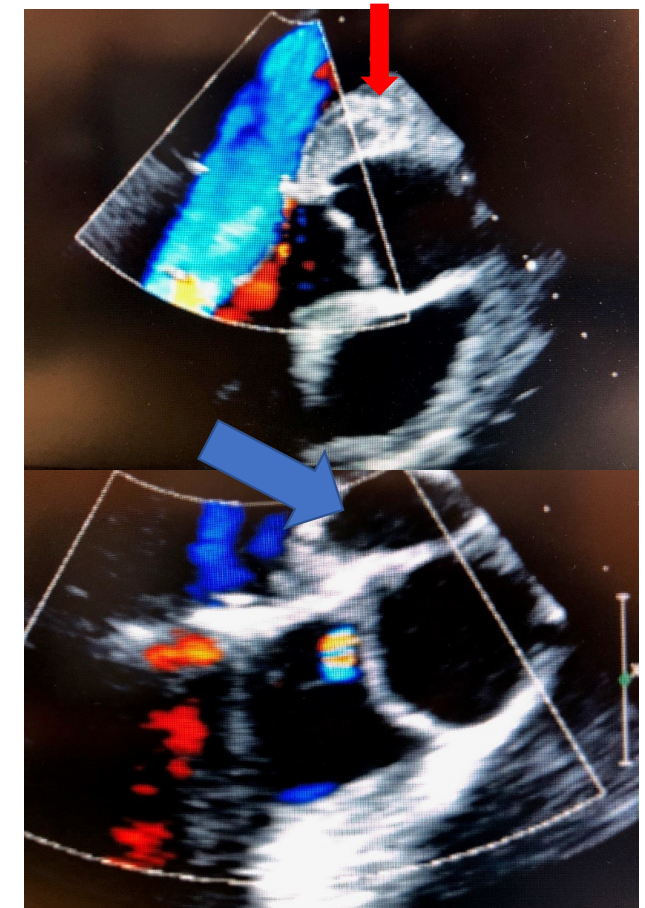
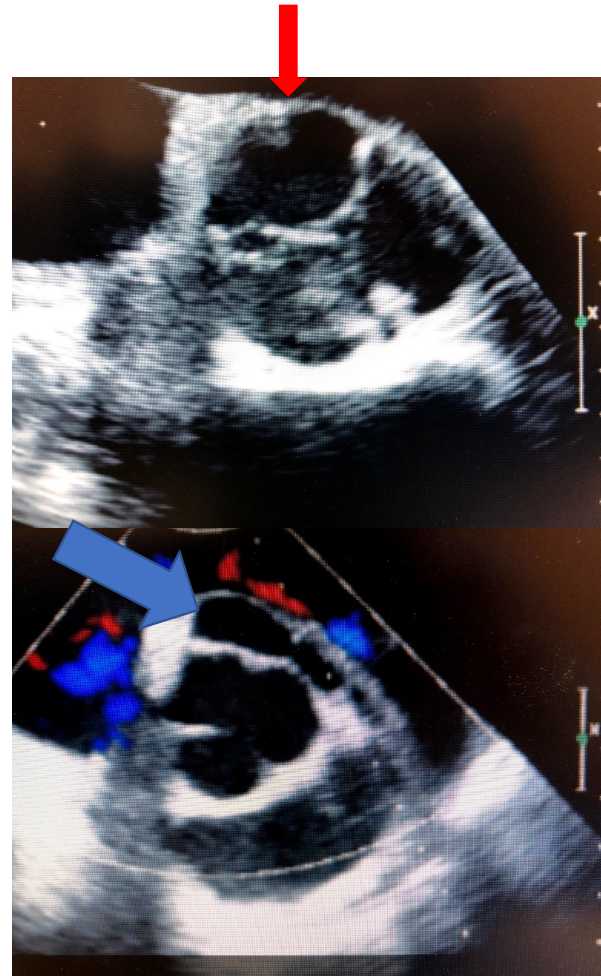
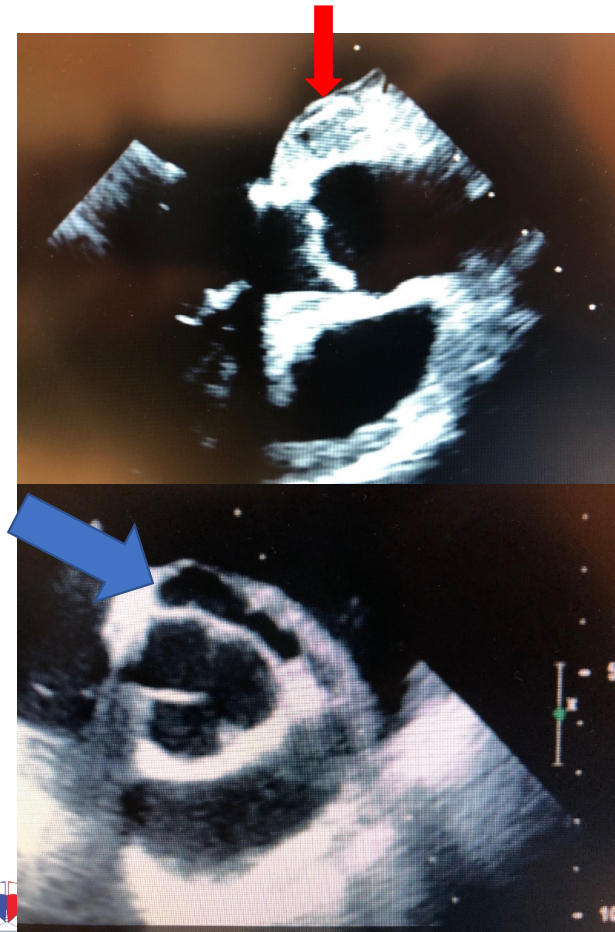


Very rare Complication

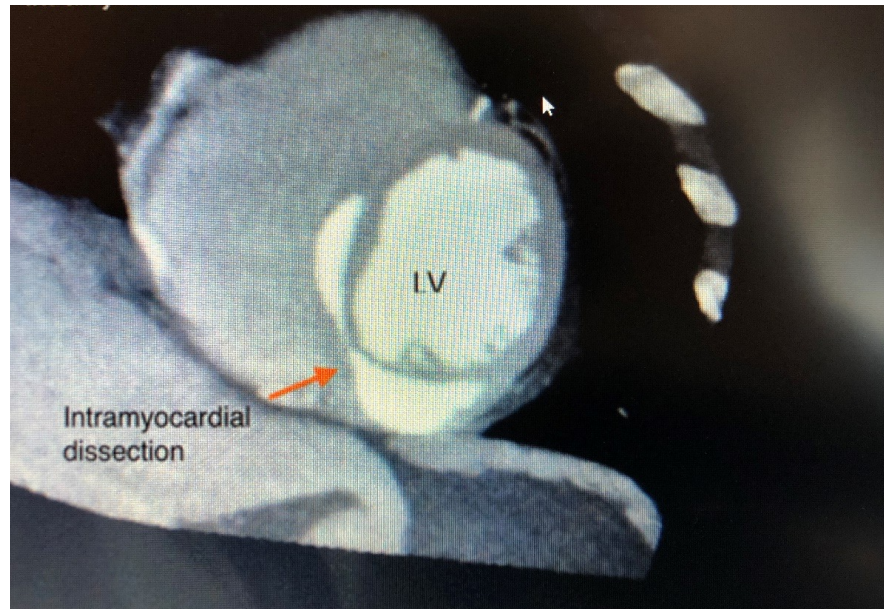
- Aortic root injury – Mitral or tricuspid
- LV dissection – LA retraction



Aortic root injury



LV dissection



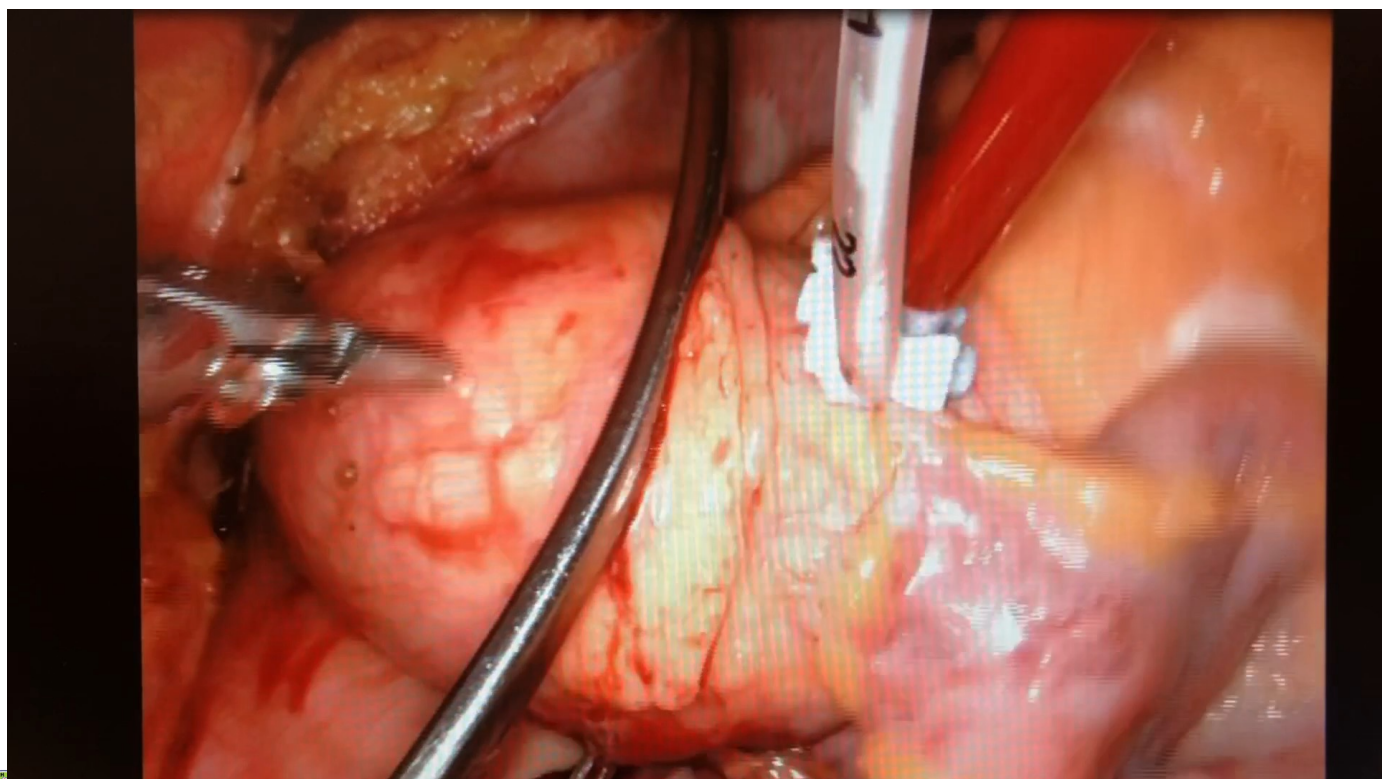


Injury to the Pulmonary Artery



- Occurs during cross-clamp placement
- Avoid placing clamp deep across the ascending aorta to avoid clamping the pulmonary artery







Antegrade Cardioplegia

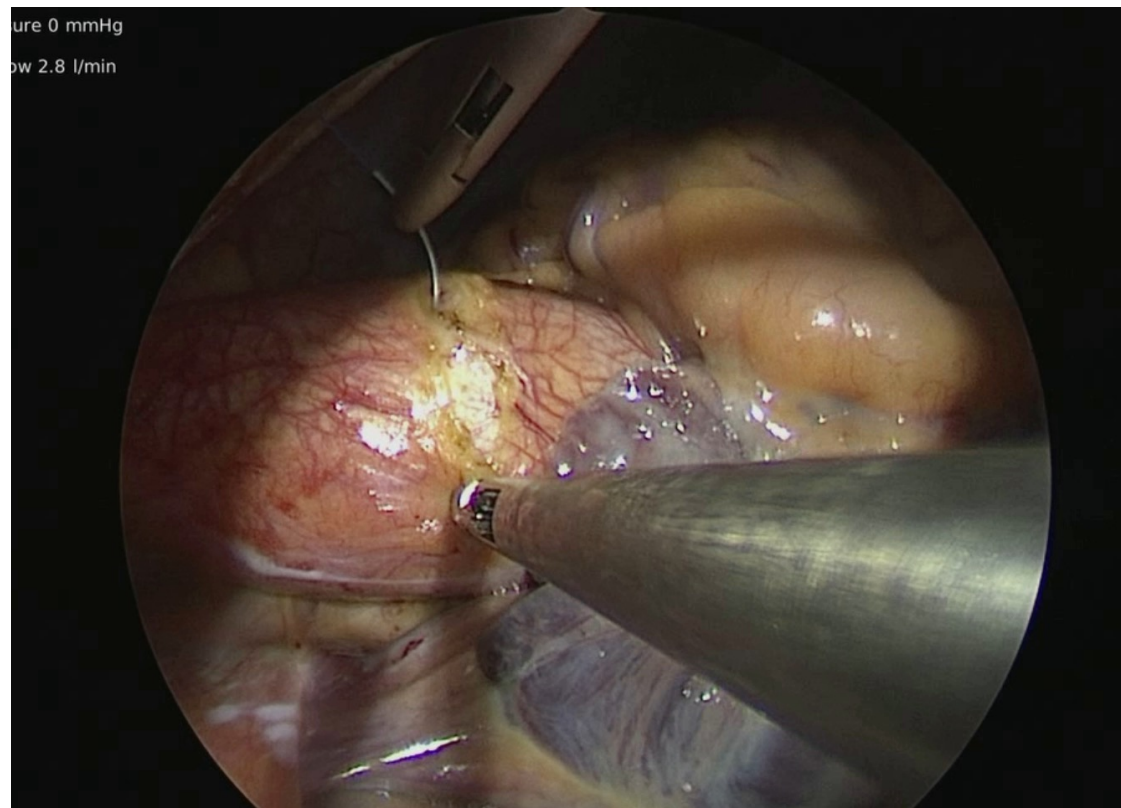
- Can be a source of significant issues.
- Bleeding that is difficult to control and may require opening
- If placed too low may injure the commissure





Antegrade Cardioplegia

Commonly used suture is a 4-0 gortex or prolene instrument tied

Currently strategy is 2-0 Ethibond and Cor-Knot





Conversion to a sternotomy

- Injury to the Pulmonary Artery
- Type A Aortic Dissection
- Injury to the Left Atrial Appendage
- Injury to the Circumflex (SVG to OM)
- Uncontrollable bleeding (antegrade site, pacing wire site, etc)
- Inadequate Exposure to perform a good MV repair - Rare





Sternotomy vs minimally invasive case

- Ascending Aorta > 40 mm
- Connective Tissue Disorder
- Mitral Annular Calcification
- Complex MV Pathology
- STS Risk > 4%
- Breast Implants
- Significant Pectus excavatum
- Left Diaphragm Paralysis
- Previous Right Thoracotomy
- Previous Sternotomy
- Low EF/Cardiomyopathy
- Possible Need for a Myectomy





Summary

- In experienced hands, minimally invasive approach is safe and offers multiple advantages, mainly an earlier return to work and active lifestyle
- Vigilant awareness of certain pitfalls helps to prevent a vast majority of potential complications from happening
- Close attention to detail, accurate technique, no shortcuts, excellent exposure, knowledge how to troubleshoot problems





Thank You

