The American Academy
of
Cardiovascular Perfusion
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The Academy Newsletter

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Academy City Limits

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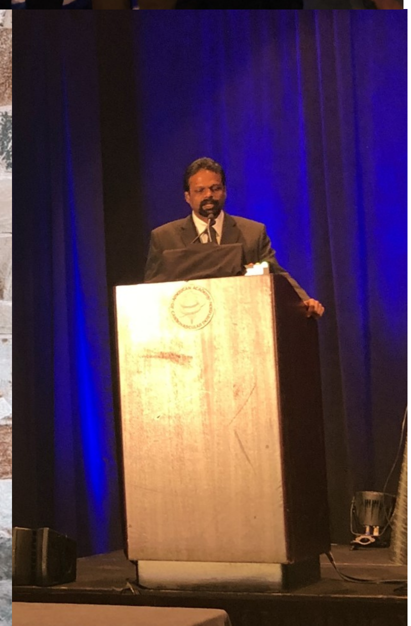
Mechanical Assist Pumps in theTreatment
of Congestive Heart Failure




2022 AACP Wharton Lecture
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The full manuscript of this article has been submitted to the journal Perfusion for possible publication.

Review of the ECMO "Mixing Cloud" Phenomenon and Comparison of Harvi and Califia Simulators to Diagnose Differential Hypoxia in Adult Peripheral V-A ECMO Models

Introduction:
There is a paucity of published literature on the effectiveness of commercially available high-fidelity simulation software in duplicating the "mixing cloud" phenomenon during peripheral ECMO support. The objective of this study is to evaluate the strengths and limitations of virtual, simulation models in diagnosing differential hypoxia in adult peripheral veno-arterial ECMO models. Specifically, the Harvi- ECMO and Califia 2.0 online simulators were used to simulate "mixing cloud" effects that result in differential hypoxia.

Methods:
The Harvi-ECMO web-based model and Califia 2.0 online simulator were used to simulate a "mixing cloud" phenomenon. Parameters for cardiac output, ventilator fiO2, and ECMO flow were altered the same way on each simulator to achieve comparable results. To determine differential hypoxia, simulated blood gases were taken, and oxygen saturations from different collection sites were observed.

Results:
The Harvi and Califia simulators were both able to adequately reproduce the "mixing cloud" phenomenon. Due to differences and limitations within both simulators, the results were not exactly the same between the two simulators, but they shared similar trends that showed when native cardiac output increased and ECMO flows decreased, the arterial saturations decreased. This confirmed that by altering the cardiac output, ECMO flow, and ventilator FiO2 it is possible to reproduce the "mixing cloud" for training and educational purposes.

Conclusions:
The assessment of both high-fidelity simulators shows promising data on simulating differential hypoxia, although both simulators are not very similar themselves. Educational opportunities are available to simulate differential hypoxia using either simulator, which will aid in the diagnosis of this phenomenon in a real-life setting.

Table 1
Califia and Harvi Baseline Parameters and Baseline Arterial Blood Gases

	Califia 2.0	Harvi
ECMO Variables		
Sweep	1L/min	1L/min
Fi02	100%	1
Ventilator Variables		
Shunt Fraction	60%	60%
Fi02	21%	21%
RR	16	16
I time	1.6 seconds	-
PIP	35mmHg	-
PEEP	10mmHg	-
DLCO	-	100%
TV	-	350ml
Patient Variables		
CO	5LPM (without ECMO support)	5LPM (without ECMO support)
LV Contractility	87.7 dynes/sec/cm^{-5}	2.64 mmHg/ml
RV Contractility	84 dynes/sec/cm^{-5}	0.74mmHg/ml
Oxygenator Variables		
Oxygenator	-	8mmHg*min/L
Diffusion	-	1 dL/min/mmHg
Radial Baseline Arterial Blood Gas		
pH	7.44	7.36
pC02	35	44
p02	32	39
SaO2	-	73%

Table 2
Califia Collected Data

Ventilator FiO2		21%			60%			100%		
	Sampling site	Right Radial	Left radial	Femoral	Right Radial	Left radial	Femoral	Right Radial	Left radial	Femoral
Flow: 4.0 CO: 1.0	pH	7.47	7.41	7.3	7.48	7.41	7.3	7.48	7.41	7.3
	paCO2	31	38	56	30	38	56	30	38	56
	paO2	50	75	528	54	86	535	60	105	538
	SaO2	89%	96%	100	91%	97%	100%	94%	98%	100%
Flow: 3.0 CO: 2.0	pH	7.48	7.48	7.38	7.48	7.48	7.38	7.48	7.48	7.38
	paCO2	30	30	44	30	30	44	30	30	44
	paO2	45	45	500	48	48	506	51	52	512
	SaO2	86%	86%	100%	88%	88%	100%	90%	91%	100%
Flow: 2.0 CO: 3.0	pH	7.47	7.47	7.41	7.47	7.47	7.41	7.47	7.47	7.41
	paCO2	31	31	39	31	31	39	31	31	39
	paO2	43	41	458	43	44	468	46	47	479
	SaO2	84%	81%	100%	84%	84%	100%	87%	87%	100%
Flow: 1.0 CO: 4.0	pH	7.47	7.47	7.44	7.47	7.47	7.44	7.46	7.46	7.43
	paCO2	32	32	36	32	32	36	32	32	36
	paO2	37	37	400	38	38	417	41	43	434
	SaO2	75%	75%	100	78	79	100	82	82	100

Table 3
Harvi Collected Data

Table 3.

Ventilator FiO2		21%			60%			100%		
	Sampling Site	Radial/ CA	Femoral	ECMO	Radial/CA	Femoral	ECMO	Radial/CA	Femoral	ECMO
	pH	7.39	7.36	7.37	7.41	7.37	7.37	7.41	7.37	7.37
Flow: 4.0	paCO2	40	44	43	37	43	43	37	43	43
CO: 1	paO2	69	433	627	82	467	627	100	492	627
	SaO2	93%	100%	100%	96%	100%	100%	98%	100%	100%
	pH	7.46	7.44	7.37	7.46	7.44	7.37	7.46	7.44	7.37
Flow: 3.0	paCO2	32	34	43	33	34	43	33	34	43
CO: 2	paO2	61	212	627	69	270	627	78	312	627
	SaO2	91%	100%	100%	93%	100%	100%	95%	100%	100%
	pH	7.46	7.47	7.37	7.46	7.47	7.37	7.46	7.47	7.37
Flow 2.0	paCO2	32	32	43	32	32	43	32	32	43
CO 3.0	paO2	54	84	627	59	101	627	66	124	627
	SaO2	88%	96%	100%	89%	98%	100%	92%	99%	100%
	pH	7.45	7.47	7.37	7.45	7.47	7.37	7.45	7.47	7.37
Flow 1.0	paCO2	33	32	43	33	32	43	33	32	43
CO 4.0	paO2	46	54	627	51	59	627	57	69	627
	SaO2	82%	88%	100%	85%	89%	100%	89%	93	100%

Figure 1
Califia Portrait

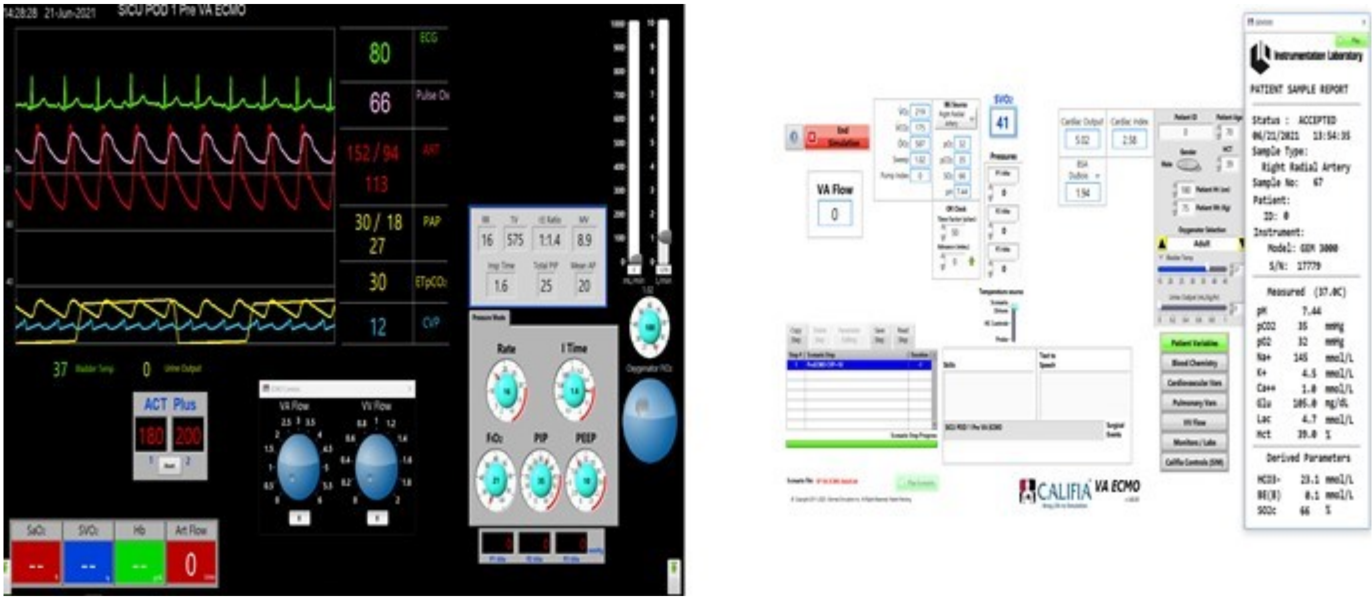
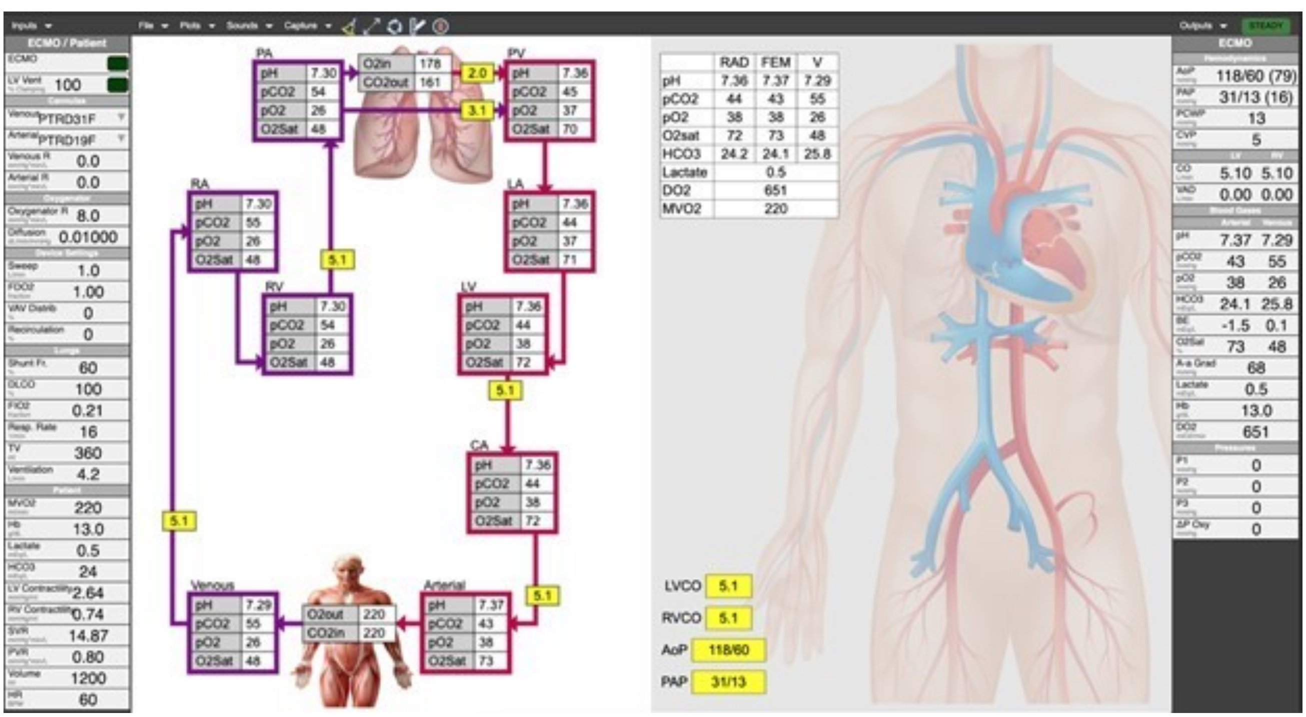


Figure 2
Harvi Portrait



COMPARING RECOMMENDED LIMITS OF NADIR DO2I BETWEEN ADULT AND PEDIATRIC PATIENTS DURING CARDIOPULMONARY BYPASS: A META-ANALYSIS

Kris Fischer

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During cardiac surgery the oxygenation of tissues to avoid ischemic injury is an important role of the perfusionist. No measurement better quantifies this directive than the delivery of oxygen indexed (DO2i). The variables perfusionist's use to control DO2i are hemoglobin and flow. Maintaining a DO2i above a certain threshold is an important aspect of CPB related injury prevention. A broad meta-analysis was performed compiling DO2i data which has followed the landmark 2005 Ranucci et al., study. Two separate data-sets were extracted, one consisting of adult patients (>18yrs) and one of pediatric patients (<18yrs).

This meta-analysis was designed to answer the following research questions: What is the current average safe nadir DO2i of both the adult and pediatric populations during CPB? And is there a difference in the current average safe nadir DO2i between the adult and pediatric populations? Traditionally literature to date has often referenced the 2005 DO2i target of 272 ml/min/m2 as a standard of practice for adults. This meta-analysis attempts to provide an updated target for both adult and pediatric patients.

Eleven studies were included in the adult data set totaling 4179 individual patients. Five studies were included in the pediatric data set totaling 690 patients. Results of the meta analysis are found in Table 1. The weighted average sans Ranucci 2005 was compared to the updated weighted mean DO2i. This produced a p-value of .0857 which is not significant at a 95% confidence interval yet suggests a difference. The weighted mean safe nadir DO2is of the total adult and the total pediatric populations were then compared. This produced a significant p-value of <.0001.

To date no meta-analysis has been performed on the studies reporting safe nadir DO2i in the adult and pediatric populations. This study provides updated DO2i targets for perfusionists to follow based on modern literature.

Table 1

Results from the collected data-sets compiled to create updated weighted mean safe nadir DO_2i targets for both adult and pediatric perfusionists.

Data-set	# of Studies	Range (ml/min/m2)	Weighted Mean Safe Nadir DO2i (ml/min/m2)
Adults (2005-2020)	11	225-310	271
Adults (2011-2020)	10	" "	277
Pediatrics	5	310-377	350

The full manuscript of this article has been submitted to the journal Perfusion for possible publication.

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Important Academy Dates

The ACADEMY ANNUAL MEETING DEADLINES

ABSTRACT DEADLINE	**October 15, 2022**
MEMBERSHIP DEADLINE	**December 1, 2022**
PRE-REGISTRATION	**January 6, 2023**
HOTEL REGISTRATION	**January 6, 2023**
2023 ANNUAL MEETING	**February 1-4, 2023**

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Awards Committee Selects Winning Student Paper Presentations

Michelle McArdle

Megan Thorbahn

Trevor Millikan

Three students received **Lawrence Awards** for their paper presentations at the Annual Seminar in Lost Pines.

Michelle McArdle - Hemostatic Complications On ECMO In COVID-19 (Sars-CoV-2) Negative Versus COVID-19 (Sars-CoV-2) Positive Patients

Megan Thorbahn - Using Circulating ACE2 Products To Predict Prognosis And Determine Efficacy Of Treatment For ARDS Patients Receiving VV ECMO Therapy

Trevor Millikan - Comparison of Alternative Anticoagulation Strategies for Extracorporeal Membrane Oxygenation

The Lawrence Award is a $500 cash award for the best student paper presentations.

Welcome to New Members

The American Academy of Cardiovascular Perfusion would like to welcome the following individuals whom were voted into membership at the Closing Business Meeting of our annual meeting in Lost Pines, Texas.

Fellow Members

Allyson Aquino
Keith Bryant
Chloe Choi

Members

Allen, Mikaela
Bertrand, Katie
Carey, Lauren
Carmody, Willow
Carroll, David
Cheek, Christopher T.
Church, Howard
Dance, Garland
Duarte, Mellissa
Duong, Olivia
Fristoe, Lance
Frohn, Chasity
Gamez, Jacob
Gayeski, Stephanie
Gubits, Meghan
Holt, Dorothy
Jahadi, Ozzie
Keller, Dan
Kress, Nicholas
Marflak, John
Myles, Richard
Pagel, Anthony
Paugh, Theron
Reitsma, Matthew
Reyes, Christopher
Rusk, Thomas
Vespe, Michael
Ward, Gabrielle

Students

Alfieris, Madeline
Amadi, Adannaya
Anderson, Josefine
Azeem, Iram
Bangasser, McKenzie
Barrett, Melinda
Beers, Stephanie
Bernu, Matt
Bolick, Jeremy
Burns, Brianna
Centrone, Nicholas
Chamberlain, Cameron
Chaney , Charles
Childers, Alexander
Chow, Christine
Christensen, Lauren
Clark, Jarad
Collins, Kayla
Coombs, Taylor
Cronin, Michael
Curcio, Sabino
Curtis, Shelby
Detweiler, Annie
DiCapna, Mary
Dotson, Zachary
Dressler, Hillary
Driscoll, John
Eby, Allison
Fang, Hannah
Finch, Joshua
Fine, Joshua
Finley, Adam
Fischer, Kris
French, J. Maxwell
Fugitt, Hunter
Godfrey, Benjamin
Goodrich, Sarah
Guzman, Keila
Hackett, Matthew
Harris, Erin
Hays, Kasey
Hedtke, Hannah
Hughes, Grayson
Hulbert, Ian
Jaramillo, Sydney
Johnides, Brian
Koroghlian, Daleth
Layeghy, Alborz
Lee, Jennifer
Leone, Jamie
Lewis, Frances
Matthews, Danielle
Mauntel, Emily
McAlpin, Christopher
McArdle, Michelle
McArthy, Cory
McDonald, Daytona
McIntyre, Angela
Milestone, Kalli
Montesano, Matthew
Nguyen, Daniel
Nix, Sarah
Olm-Trujillo, Noelle
Olvey, Tyler
Owens, Grayce
Pagano, Nathan
Phillips, Jacob
Powell, Tyler
Rechin, Saskia
Redford, Christine
Robinson, Tyler
Rogers, Emily
Saraf, Tullika
Schmeck, Carson
Schroder, Garrett
Shastri, Karmali
Shields, Desiree
Silverio, John
Simpson, Heather
Singh, Joshua
Stuart, Caleb
Sun, Helen
Syquia, Jose Antonio
Thorbahn, Megan
Thornton, Sable
Webb, Johntez
Wilder, Joseph
Williams, Carly
Wong, Ethan
Wong, Ka-Kit

The Impella: A Mechanical Circulatory Support Device

Kaitlin Bannon, BSN, RN

Cardiovascular Perfusion Program

Quinnipiac University

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Heart failure is one of the leading causes of death throughout the world that affects over six million adults in the United States,[1] with an estimated 8 million Americans by 2030[2]. When traditional pharmacological therapy fails, a form of advanced hemodynamic support may be required. Since at most only 2,300 donor hearts become available for transplantation each year, temporary mechanical devices have become vital to support those with advanced heart failure[2]. AbioMed's Impella heart pump is one of the leading invasive mechanical circulatory support devices since 2008[2]. The Impella is used as a temporary assist device that is most often placed in the left ventricle and aorta to allow for forward flow, while also providing hemodynamic support after acute injury. The Impella has also been shown to improve native heart function after cardiac compromise. The Impella has many indications and can be utilized during refractory cardiogenic shock, a high risk PCI, post MI, post cardiotomy, OPCABG support, or as a bridge to transplant. This device has also been shown to decrease hospital stay, as well as morbidity and mortality in patients undergoing non-emergent PCI[4].

The design of the Impella maximizes cardiac output while also reducing the workload of the myocardium. The Impella continuously draws blood from the left ventricle via the inlet port and then expels it into the ascending aorta via the outlet port (see Figure 1). The unloading of the left ventricle decreases the myocardial oxygen demand while also increasing cardiac output and coronary perfusion. Various performance levels (P1-P9) allow for a broad range of support. With AbioMed's new Smart Assist technology on the device, it is now easier than ever to assess placement and cardiac function, which decreases complications and allows for better management. The overall intent is to reduce ventricular work and provide circulatory support to allow for heart recovery.

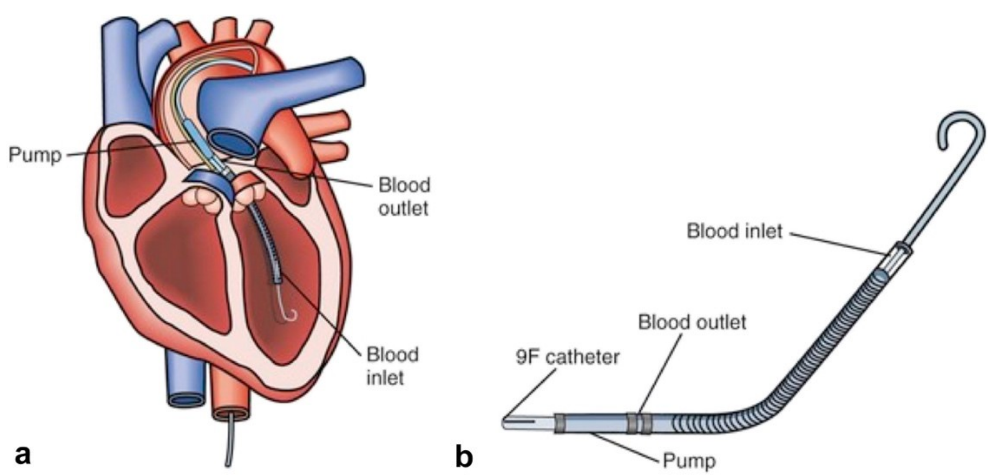
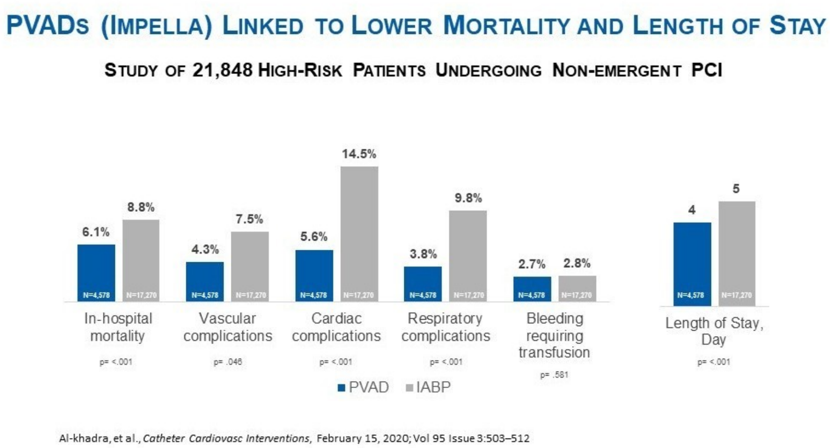


Figure 1.

When assessing the capabilities of a mechanical circulatory device, the Impella provides a higher level of hemodynamic support when compared to the Intra-Aortic balloon pump. A 2019 study evaluating patients who underwent PCI requiring mechanical circulatory support either the IABP or Impella, those who received the Impella had lower in-hospital mortality, vascular complications, cardiac complications, and respiratory complications compared to those with the IABP, despite having more complications including COPD, renal failure, diabetes and hypertension[4]. Overall for patients suffering with cardiogenic shock, the Impella decreases preload, increases cardiac output, and improves coronary circulation[5].



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Transesophageal Echocardiography: Essential Monitoring for Cardiac Surgery Applied to Valve Integrity

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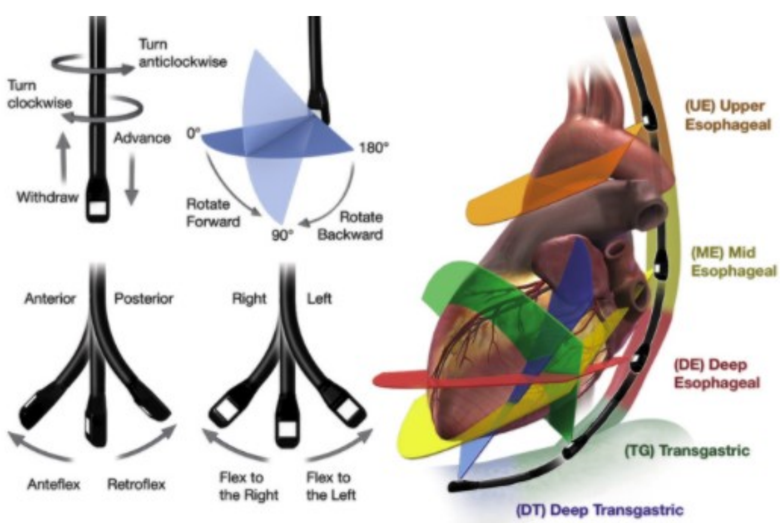
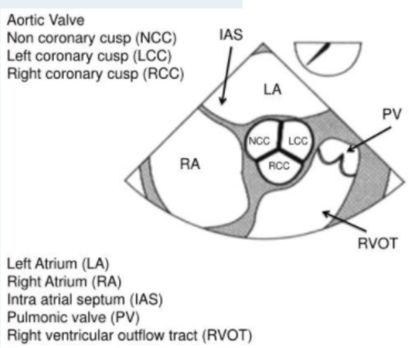
Transesophageal Echocardiography is a semi-invasive diagnostic and intraoperative ultrasound that was developed in the late 1970s, commonly used today in both inpatient and outpatient settings. The echocardiogram evaluation known as TEE has become a standard of practice monitoring tool for cardiac anesthesiology. The American Society of Anesthesiologists and Society of Cardiovascular Anesthesiologist Practice Guidelines of Perioperative TEE state that TEE should be used in all open heart and thoracic aortic surgical procedures and should be highly considered for coronary artery bypass graft surgeries.[1] TEE is performed by inserting a transducer probe into the esophagus to view the posterior structures of the heart and is utilized before cardiopulmonary bypass (CPB) to establish the patient's structural and functional baseline. After CPB, TEE will assess the interventions, any new abnormalities, and will have the patient's baseline for reference. Sometimes additional or often neglected findings, such as a patent foramen ovale, can even change the course of a planned procedure.[2] TEE has intraoperative monitoring applications that help determine preload and volume status, intracardiac pressure measurement, cardiac output, and patient hemodynamics, especially when weaning from CPB.[1] This article will apply the basics of TEE examination through assessing valve integrity.

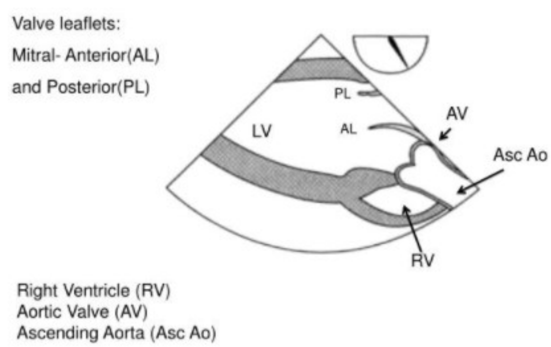
An intraoperative TEE is comprised of a core twenty views for a comprehensive examination. With the TEE probe positioned posterior to the left atrium, the mid-esophageal view captures the majority of these. This view alone covers the cardiac chambers and valves in most patients. Additionally, the upper esophageal view, achieved with the probe at the aortic arch level, is used to visualize the aortic arch, pulmonary artery, and pulmonic valve. The transgastric view captures a superior image plane through the diaphragm by TEE placement inside the stomach below the heart to view the left ventricle, right ventricle, mitral valve, and tricuspid valve. The deep transgastric view can capture the left ventricular outflow tract, the aortic valve, the ascending aorta, and arch.[1] The utility of the TEE probe and respective angles are displayed in the graphic below:



For valve repair or replacement, TEE will help provide a better understanding of the feasibility of the repair by a baseline assessment. The baseline valve assessment will provide a surgeon with information on the feasibility of a repair based on the mechanism and etiology of lesions, the type of repair that is needed, and the assessment of the intervention after CPB.[1] Valve repairs are primarily assessed for residual regurgitation and stenosis. Evaluated by TEE color flow doppler, residual regurgitation that is determined moderate or more should have a repair revision or a valve replacement. TEE color flow doppler is used to assess the valve annulus for paravalvular leaks after valve replacement. It is important to note that some prosthetic valves may show non-pathologic regurgitation patterns, such as bileaflet mechanical valves with one immobile leaflet. In some applications of the aortic valve, TEE color flow doppler will detect regurgitation of homograft and stentless bioprostheses if they are inserted incorrectly.[1]

The aortic valve is assessed using the mid-esophageal AV short and long axis TEE views and may be done so with or without the use of color flow doppler. TEE assesses the severity of aortic regurgitation based on the size of the jet and depth into the left ventricle. Using 2D echocardiography in the mid-esophageal AV short axis view, the valve cusps are evaluated for how they come together as a unit and any perforations should be noted. This technique is also used for evaluating the aortic valve area by planimetry and continuity, with the understanding that the same flow passing through the left ventricular outflow tract should be equal to that passing through the aortic valve per stroke.[4] Doppler flow velocity is used in the transgastric long axis view to assess transaortic gradients by using an ultrasound beam parallel to aortic valve flow. This application is essential for evaluating the aortic valve for stenosis. Mid-esophageal AV short axis and transgastric long axis views are displayed respectively in the graphics below[5]:





TEE is an invaluable tool both preoperatively and intraoperatively given its ability to assess valve integrity. Second to ultrasound imaging, TEE should be considered as a tool used for hemodynamic monitoring applications.

TEE provides the most accurate assessment of cardiac preload and volume status. Pulmonary artery catheter filling pressures may or may not reflect the true ventricular volume status, while the TEE can accurately assess preload. As for volume status, the TEE is most reliable in comparison to central venous and pulmonary capillary wedge pressures as true volume status is overestimated by these values. The transgastric mid short axis view is used to assess the preload and volume status that is essential to CPB weaning, in addition to estimating end-diastolic volume and left ventricular distention.[1] Using fluid dynamics, intracardiac pressure can be measured using TEE doppler technology by applying a modified Bernoulli's principle. This will show the relationship between the flow velocity through a stenosis and the pressure gradient across a stenosis.[6] Cardiac output can be calculated by TEE doppler using stroke volume to create a velocity-time integral, or by estimation using 2D area of flow by dividing the left ventricle into discs by the Simpson rule.[1] Optimization of the TEE views for monitoring applications is most valuable pre and post CPB, as TEE utility is lost during CPB with cardioplegia delivery. Additionally, ultrasound definition is lost with empty cardiac chambers due to loss of ultrasonographic contrast and doppler functionality is unavailable in this state. As the heart is filled during the process of weaning from CPB, TEE will guide effective air evacuation before termination.[7]

The use of TEE during cardiac surgery is a staple to anesthesia practice guidelines for its well-known use to identify pathology and to assess surgical interventions. The monitoring capabilities of TEE should not be overlooked, but rather optimized by the core comprehensive views. With the help of TEE, we can better understand preload and volume status that can supplement pulmonary artery catheter measurements and assist in the process of weaning from CPB. While recommended for coronary artery bypass procedures, the capability of TEE technology is best showcased by viewing an open heart. The most current and foreseeable future of TEE technology, the utilization of 3D imaging, will only provide greater perspective into both minimally invasive and open-heart cardiac surgery.

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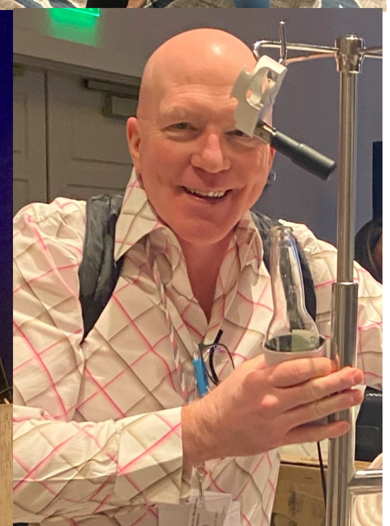










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