Optimizing TAVI: Utilizing Standardized Invasive Hemodynamics

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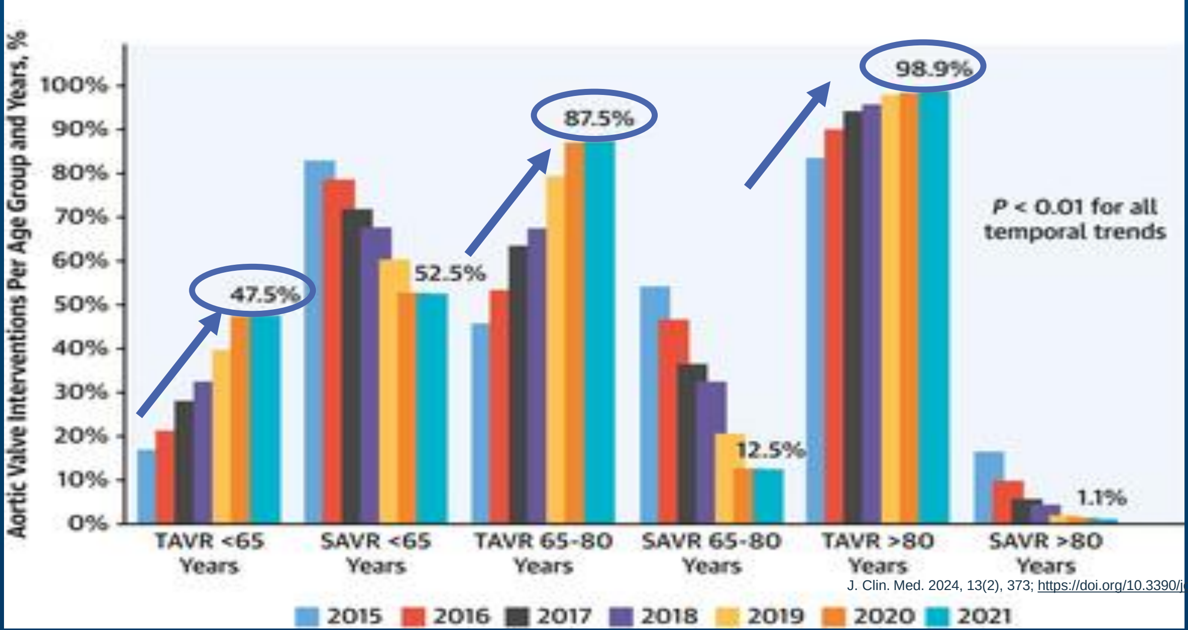
This presentation is intended for healthcare professionals only.

>20 Years of TAVI: Advancing AS Management

Advances in TAVI & clinical evidence have transformed the treatment landscape and TAVR has become the standard of care



J. Clin. Med. 2024, 13(2), 373; https://doi.org/10.3390/j

Toishi Sharma et al. J Am Coll Cardiol 2022; 80:2054-2056.

>20 Years of TAVI: A Shift in Focus

- Advances in valve design, improved imaging and technical enhancements have contributed to increased safety and a decline in procedural complications
- The focus of TAVI is now shifting towards procedural efficiency and lifetime patient management

SAFETY & OUTCOMES		PROCEDURAL EFFICIENCY & LIFETIME MANAGEMENT
Mortality		Streamlined Procedures
Morbidity	FOCUS →	Hemodynamic Performance
Quality of Life		PVL and Valve Durability

>20 Years of TAVI: A Shift in Focus

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SAFETY & OUTCOMES

- Mortality
- Morbidity
- Quality of Life

SHORT TERM outcomes

FOCUS →

PROCEDURAL EFFICIENCY & LIFETIME MANAGEMENT

- Streamlined Procedures
- Hemodynamic Performance
- PVL and Valve Durability

LONG TERM outcomes

But… are we as good …

NEWS Conference News EACTS 2025

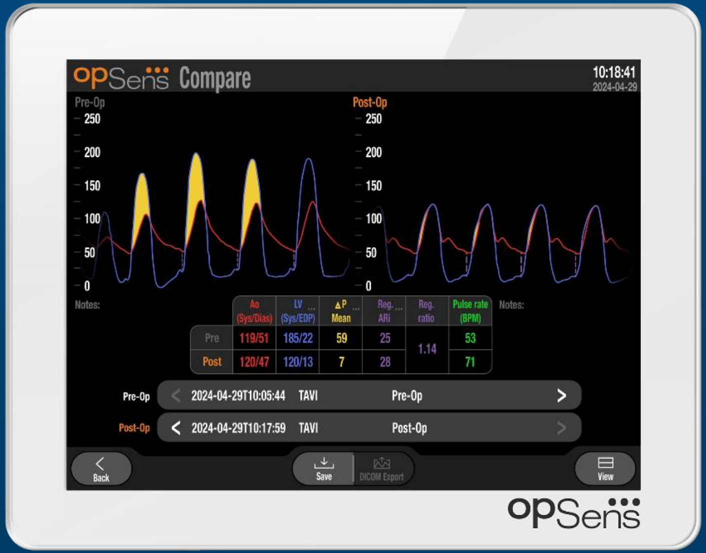
SAVR Bests TAVI for 5-Year Survival in Combined RCT, Observational Data

But… are we as good as we think we are???

Hemodynamic Performance

The importance of hemodynamics

- *Observed discrepancies between echo and invasive gradients*
- *Invasive measurements are accurate but:*
  - *Take time to setup*
  - *Need wire and pigtail exchanges*
- *LV pressure is not monitored constantly during TAVI*
- *Large-amplitude LV pressure creates artifacts in fluid-filled lines*
- *Assessing and treating lower risk and younger patients*
- *Assessing and treating ASYMPTOMATIC AS*



Hemodynamic Performance

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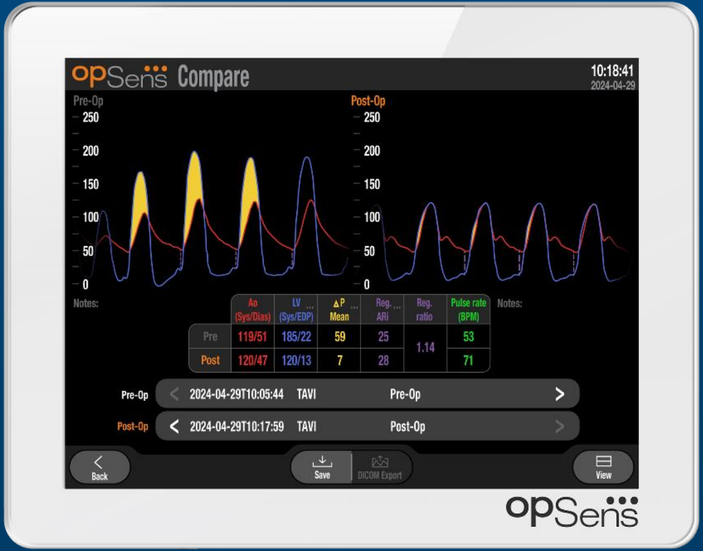
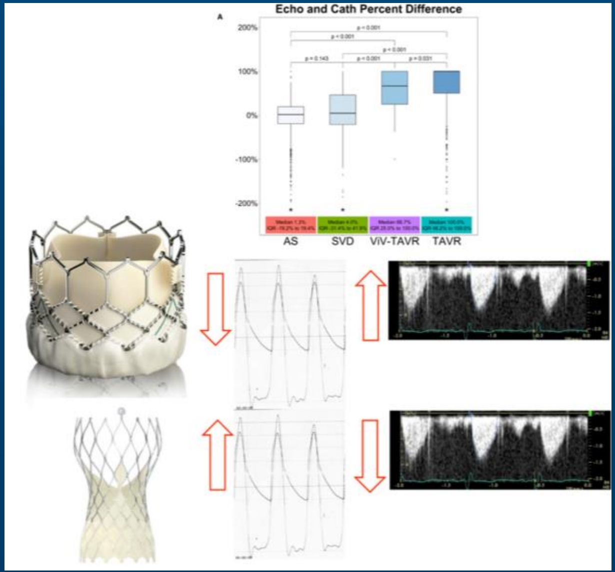


We must not only be good, but we need to be nearly "perfect"

Echo Versus Invasive Gradients

Echocardiographic Versus Invasive Aortic Valve Gradients in Different Clinical Scenarios

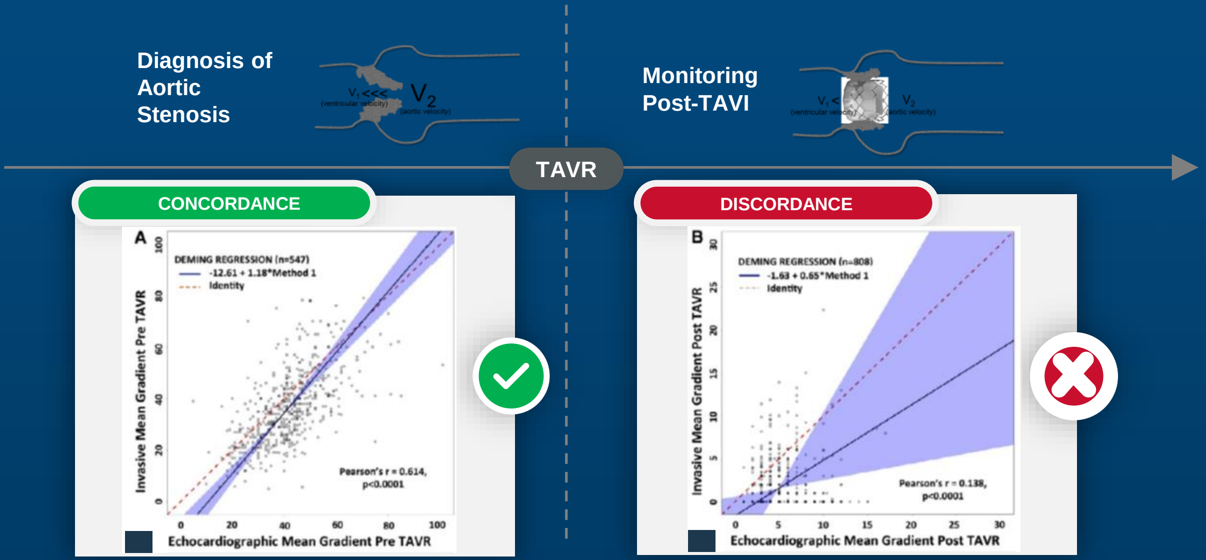
- *Echo is non-invasive but can be inaccurate*
- *Pre-procedure gradients/ViV-TAVI impact both echo/invasive post-procedure gradients*
- *TAVI valve types impact echo/invasive mean gradients differently*



Abbas, Amr E. et al. Echocardiographic Versus Invasive Aortic Valve Gradients in Different Clinical Scenarios. Journal of the American Society of Echocardiography, Volume 36, Issue 12, 1302 - 1314

Abbas AE, Khalili H, Madanat L, et al. Echocardiographic Versus Invasive Aortic Valve Gradients in Different Clinical Scenarios. J Am Soc Echocardiogr. 2023;36(12):1302-1314. doi:10.1016/j.echo.2023.06.016

Echo-derived Gradients Do Not Correlate with Invasive Normal Functioning Transcatheter Heart Valves



- **Post-TAVR echo overestimates transvalvular mean gradients compared with invasive measurements**

And poor correlation suggests these modalities cannot be used interchangeably

Abbas, AE. *et al.* Comparison of Transvalvular Aortic Mean Gradients Obtained by Intraprocedural Echocardiography and Invasive Measurement in Balloon and Self-Expanding Transcatheter Valves. *JAHA*. 2021; 10:e021014.

Echo-Derived Gradients Overestimate True Cath Gradient by ~1.6x for Balloon Expandable TAVR Valves

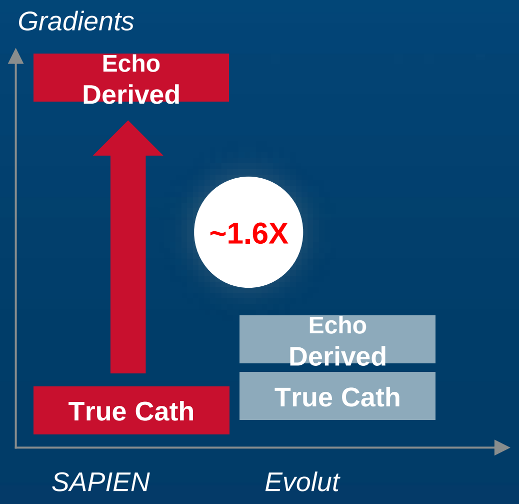


Table 1. Comparison of invasive transvalvular gradients of similar-sized balloon-expandable and self-expanding transcatheter heart valves immediately post implantation.

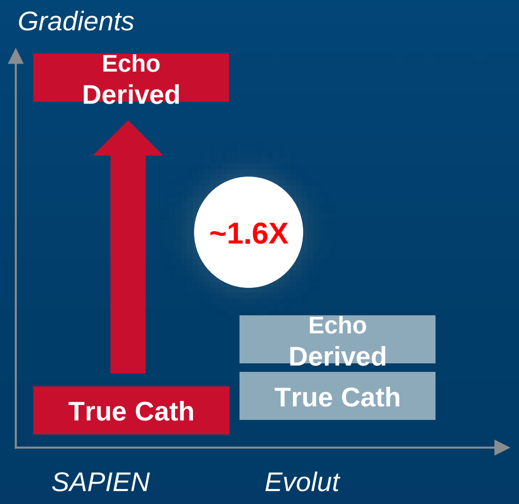
	N	CT Area (mm²)	Area-Derived Diameter (mm)	CT Perimeter (mm)	Perimeter-Derived Diameter (mm)	Invasive Gradient	Doppler Gradient	*P*-Value
Small Valve								
Total	128	370.7 ± 33.8	21.7 ± 1.0	66.6 ± 3.2	22.2 ± 1.0	7.7 ± 3.8	10.3 ± 5.4	<.001
BEV	61	371.8 ± 30.6	21.7 ± 0.9	69.8 ± 3.0	22.2 ± 0.9	8.1 ± 3.6	13.3 ± 5.3	<.001
SEV	67	369.7 ± 36.6	21.7 ± 1.1	69.5 ± 3.5	22.1 ± 1.1	7.4 ± 3.9	7.5 ± 4.0	.87
P-value		.74	.70	.57	.57	.31	<.001	
Medium Valve								
Total	240	464.8±39.1	24.3 ± 1.0	77.9 ± 3.2	24.8 ± 1.0	7.9 ± 4.1	10.3 ± 4.1	<.001
BEV	164	467.1±36.4	24.4 ± 0.9	78.1 ± 3.1	24.9 ± 1.0	7.6 ± 4.0	11.0 ± 3.8	<.001
SEV	76	459.9±44.3	24.2 ± 1.2	77.4 ± 3.6	24.7 ± 1.2	8.7 ± 4.3	8.6 ± 4.2	.94
P-value		.26	.24	.22	.22	.05	<.001	
Large Valve								
Total	131	576.3 ± 49.3	27.1 ± 1.1	86.7 ± 3.6	27.6 ± 1.1	7.2 ± 3.0	9.2 ± 3.9	<.001
BEV	95	578.8 ± 48.7	27.1 ± 1.1	86.8 ± 3.6	27.6 ± 11	6.9 ± 3.0	10.0 ± 3.8	<.01
SEV	36	569.4 ± 51.1	26.9 ± 1.2	86.6 ± 3.5	27.6 ± 1.1	8.1 ± 2.8	7.2 ± 3.3	.21
P-value		.38	.37	.74	.74	.05	<.001	

BEV = balloon-expandable valve; CT = computed tomography; SEV = self-expanding valve.

Bavry, AA. *et al.* Transvalvular Gradients for Balloon-Expandable and Self-Expanding Valves. *J Invasive Cardiol.* 2020; 32(10)

Echo-Derived Gradients Overestimate True Cath Gradient by ~1.6x for Balloon Expandable TAVR Valves

No Difference in Invasive Gradients Between BEV and SEV



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Why?:

2D Echo Methods of AVA Calculation may not account for Valve Design

$$AVA = \frac{\pi(radius\ LVOT)^2 \times (Vmax_{LVOT})}{(Vmax_{AV})}$$

Actual Valve EOA

EOA Reported by ECHO

- Also, ECHO VELOCITY is a proxy for PRESSURE

1344 JACC Vol. 12, No. 5 November 1988:1344–53

Review of Hydrodynamic Principles for the Cardiologist: Applications to the Study of Blood Flow and Jets by Imaging Techniques

AJIT P. YOGANATHAN, PHD, EDWARD G. CAPE, BS, HSING-WEN SUNG, PHD, FRANK P. WILLIAMS, PHD, ABDUL JIMOH, MS

Atlanta, Georgia

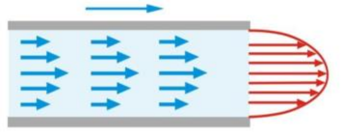
An understandi… blood flow is of … she attempts to … such as Dopple… nance imaging. … and its limitatio… calculations and … applications in … example, mitral … free jet theory.

When does the simplified Bernoulli equation "not work"? (i.e., $\Delta P_{peak} = 4V^2_{2,\ peak}$). 1) When the proximal velocity is of the same order of magnitude as the distal velocity (1–3). Examples are: a) aortic regurgitation in combination with aortic stenosis; and b) prosthetic heart valves. Note, that a 1 to 2 m/s proximal velocity leads to a 4 to 16 mm Hg decrease in pressure gradient. In such cases use equation 3, that is, the Bernoulli equation.

Why?:
Flow Pattern Influence how Echo Measures Velocity

Laminar flow

An **efficient** design results in laminar flow and maintained velocity between the LV and the aorta.



Laminar flow = higher velocity

Higher echo derived gradient

Turbulent flow

An **inefficient** design results in turbulent flow and inconsistent velocity between LV and the aorta.

Turbulent flow = lower velocity

Lower echo derived gradient

Because laminar flow maintains velocity, **echo overestimates the pressure gradient in a valve with laminar flow** compared to a valve with turbulent flow perversely rewarding valve design with turbulent flow.

What does all mean?

- I don’t know….

What does all mean?

- I don’t know….

But, more data is a good thing.

The Importance of Hemodynamics

Prognostic value of invasive versus echocardiography-derived aortic gradient in patients undergoing TAVI

- ***806 TAVI patients: EDW S3 Balloon Expandable Valves (BEV, n=474) or MDT Evolut Self-Expanding Valves (SEV, n=332) from 2014 to 2023***

- ***Examined the prognostic value of invasive and echo-derived gradients after implantation of SEV and BEV and to compare gradients for SEV versus BEV***

EuroIntervention
2025;21:**e411-e425**
published online e-edition April 2025
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ORIGINAL RESEARCH

Prognostic value of invasive versus echocardiography-derived aortic gradient in patients undergoing TAVI

Mark M.P. van den Dorpel[1], MD; Sraman Chatterjee[1], BSc; Rik Adrichem[1], MD; Sarah Verhemel[1], MD; Isabella Kardys[1], MD, PhD; Rutger-Jan Nuis[1], MD, PhD; Joost Daemen[1], MD, PhD; Claire Ben Ren[1], MD, PhD; Alexander Hirsch[1,2], MD, PhD; Marcel L. Geleijnse[1], MD, PhD; Nicolas M. Van Mieghem[1]*, MD, PhD

*Corresponding author: Department of Cardiology, Thoraxcenter, Erasmus University Medical Center, office Nt-645, Dr. Molewaterplein 40, 3015 GD, Rotterdam, the Netherlands. E-mail: n.vanmieghem@erasmusmc.nl

This paper also includes supplementary data published online at: https://eurointervention.pcronline.com/doi/10.4244/EIJ-D-24-00341

ABSTRACT

BACKGROUND: Recent studies report a discordance between invasive and echocardiography-derived gradients after transcatheter aortic valve implantation (TAVI) with balloon-expandable (BEV) and self-expanding valves (SEV). There are limited data on the determinants and clinical implications of this discordance.

AIMS: We aimed to examine the prognostic value of invasive and echocardiography-derived gradients after implantation of SEV and BEV and to compare gradients for SEV versus BEV.

METHODS: We performed a retrospective, propensity score-matched study. Invasive measurements were obtained before and immediately after TAVI. Echocardiography was performed before and within 24 hours after TAVI, and at 1 year. Clinical outcomes were assessed at 30 days, 1 year, and 2 years.

RESULTS: The 1:1 propensity score matching resulted in 436 matched pairs (436 SAPIEN 3 and 436 Evolut). Invasive gradients post-TAVI independently predicted higher risk for all-cause mortality at 30 days, 1 year and 2 years as a continuous variable (hazard ratio [HR] 1.07, 95% confidence interval [CI]: 1.00-1.14; p=0.038; HR 1.06, 95% CI: 1.01-1.11; p=0.007; HR 1.05, 95% CI: 1.01-1.09; p=0.011, respectively) and by using >10 mmHg as a cutoff (HR 1.95, 95% CI: 1.13-4.78; p=0.028; HR 1.91, 95% CI: 1.11-3.65; p=0.030; HR 1.61, 95% CI: 1.03-2.96; p=0.021, respectively), but echocardiography-derived gradients did not (HR 1.13, 95% CI: 0.87-1.75; p=0.247; HR 1.02, 95% CI: 0.95-1.10; p=0.639; HR 0.99, 95% CI: 0.94-1.07; p=0.979, respectively). Mean gradients before and after TAVI were higher by echocardiography than by invasive measurements. The difference was more pronounced after implantation with BEV than SEV (7.0 [25th-75th percentile: 4.0-11.0] mmHg vs 5.0 [2.0-7.0] mmHg; p<0.001). Smaller valve size, higher ejection fraction and higher stroke volume amplified the discordance. Invasive mean gradients were similar after SEV and BEV (3.0 [0.0-6.0] mmHg vs 3.0 [0.0-6.0] mmHg; p=0.166), but echo-derived mean gradients were lower after SEV versus BEV (8.0 [6.0-11.0] mmHg vs 11.0 [8.0-14.0] mmHg; p<0.001).

CONCLUSIONS: Only invasively measured but not echocardiography-derived transvalvular mean gradients correlate with 30-day, 1-year and 2-year mortality. Aortic gradient measurements are higher by echocardiography than by invasive assessment and more so for BEV than SEV. Smaller valve size, higher ejection fraction and higher stroke volume increase this discordance between echocardiography and invasive assessment.

KEYWORDS: balloon-expandable valve; echocardiography; invasive; pressure gradient; self-expanding valve; TAVI

Van den Dorpel MMP, Chatterjee S, Adrichem R, et al.
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The Importance of Hemodynamics

Prognostic value of invasive versus echocardiography-derived aortic gradient in patients undergoing TAVI

Echo overestimates gradients

- ***SEV: Echo pressure gradient (PG) 8.0 mmHg vs Invasive PG 3.0 mmHg***
- ***BEV: Echo PG 11.0 mmHg vs Invasive PG 3.0 mmHg***

Contributing factors

- ***Small valve size***
- ***High LVEF***
- ***High stroke volume***

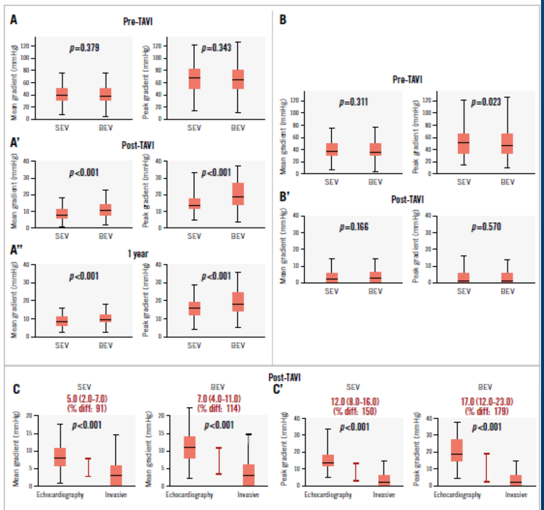

Figure 1. *Echocardiographic and invasive pressure gradient measurements in self-expanding valve and balloon-expandable valve patients. A) Echocardiographic mean and peak pressure gradients pre-TAVI. A') Echocardiographic mean and peak pressure gradients post-TAVI. A'') Echocardiographic mean and peak pressure gradients at 1 year. B) Invasive mean and peak pressure gradients pre-TAVI. B') Invasive mean and peak pressure gradients post-TAVI. C) Difference between post-TAVI invasive and echocardiographic mean gradients. C') Difference between post-TAVI invasive and echocardiographic peak gradients. BEV: balloon-expandable valve; diff: difference; SEV: self-expanding valve; TAVI: transcatheter aortic valve implantation*

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Independent Predictors of Mortality

Table 5. Cox proportional hazards regression model for all-cause mortality.

Univariable	30 days		1 year		2 years	
	HR (95% CI)	*p*-value	HR (95% CI)	*p*-value	HR (95% CI)	*p*-value
Echo gradients						
Echo mean gradient post-TAVI (continuous)	1.13 (0.87-1.75)	0.248	1.02 (0.95-1.10)	0.639	0.99 (0.94-1.07)	0.979
Echo mean gradient post-TAVI >10 mmHg	1.07 (0.95-1.19)	0.189	1.76 (0.51-7.66)	0.309	1.32 (0.66-11.02)	0.573
Echo mean gradient post-TAVI >20 mmHg	1.05 (0.[illegible]-1.14)	0.205	2.37 (0.33-17.23)	0.394	2.33 (0.32-16.90)	0.404
Invasive gradients						
Invasive mean gradient post-TAVI (continuous)	1.08 (1.01-1.15)	0.034[&]	1.05 (1.00-1.10)	0.047[&]	1.05 (1.01-1.09)	0.009[&]
Invasive mean gradient post-TAVI >10 mmHg	2.94 (1.12-8.31)	0.030[&]	1.83 (1.07-3.31)	0.042[&]	1.71 (1.04-2.82)	0.036[&]

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The Importance of Hemodynamics

Conclusions:

Prognostic value of invasive versus echocardiography-derived aortic gradient in patients undergoing TAVI

- ***Invasive mean pressure gradients correlated with all-cause mortality***
  - ***At 30 days: HR 1.95 (p=0.028);***
  - ***At 1 year: HR 1.91 (p=0.030);***
  - ***At 2 years: HR 1.61***

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ORIGINAL RESEARCH

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This paper also includes supplementary data published online at: https://eurointervention.pcronline.com/doi/10.4244/EIJ-D-24-00341

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AIMS: We aimed to examine the prognostic value of invasive and echocardiography-derived gradients after implantation of SEV and BEV and to compare gradients for SEV versus BEV.

METHODS: We performed a retrospective, propensity score-matched study. Invasive measurements were obtained before and immediately after TAVI. Echocardiography was performed before and within 24 hours after TAVI, and at 1 year. Clinical outcomes were assessed at 30 days, 1 year, and 2 years.

RESULTS: The 1:1 propensity score matching resulted in 436 matched pairs (436 SAPIEN 3 and 436 Evolut). Invasive gradients post-TAVI independently predicted higher risk for all-cause mortality at 30 days, 1 year and 2 years as a continuous variable (hazard ratio [HR] 1.07, 95% confidence interval [CI]: 1.00-1.14; p=0.038; HR 1.06, 95% CI: 1.01-1.11; p=0.007; HR 1.05, 95% CI: 1.01-1.09; p=0.011, respectively) and by using >10 mmHg as a cutoff (HR 1.95, 95% CI: 1.13-4.78; p=0.028; HR 1.91, 95% CI: 1.11-3.65; p=0.030; HR 1.61, 95% CI: 1.03-2.96; p=0.021, respectively), but echocardiography-derived gradients did not (HR 1.13, 95% CI: 0.87-1.75; p=0.247; HR 1.02, 95% CI: 0.95-1.10; p=0.639; HR 0.99, 95% CI: 0.94-1.07; p=0.979, respectively). Mean gradients before and after TAVI were higher by echocardiography than by invasive measurements. The difference was more pronounced after implantation with BEV than SEV (7.0 [25th-75th percentile: 4.0-11.0] mmHg vs 5.0 [2.0-7.0] mmHg; p<0.001). Smaller valve size, higher ejection fraction and higher stroke volume amplified the discordance. Invasive mean gradients were similar after SEV and BEV (3.0 [0.0-6.0] mmHg vs 3.0 [0.0-6.0] mmHg; p=0.166), but echo-derived mean gradients were lower after SEV versus BEV (8.0 [6.0-11.0] mmHg vs 11.0 [8.0-14.0] mmHg; p<0.001).

CONCLUSIONS: Only invasively measured but not echocardiography-derived transvalvular mean gradients correlate with 30-day, 1-year and 2-year mortality. Aortic gradient measurements are higher by echocardiography than by invasive assessment and more so for BEV than SEV. Smaller valve size, higher ejection fraction and higher stroke volume increase this discordance between echocardiography and invasive assessment.

KEYWORDS: balloon-expandable valve; echocardiography; invasive; pressure gradient; self-expanding valve; TAVI

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Van den Dorpel MMP, Chatterjee S, Adrichem R, et al.
Prognostic value of invasive versus echocardiography-derived aortic gradient in patients undergoing TAVI.
EuroIntervention. 2025;21:e411–e425. doi: 10.4244/EIJ-D-24-00341

Aortic Regurgitation Index - ARi

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CLINICAL RESEARCH — **Valvular Heart Disease**

Aortic Regurgitation Index Defines Severity of Peri-Prosthetic Regurgitation and Predicts Outcome in Patients After Transcatheter Aortic Valve Implantation

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Bonn, Germany

- 141 TAVR patients by ECHO, Angiogram and ARi
- ARi = [(DBP-LVEDP)/SBP] x 100

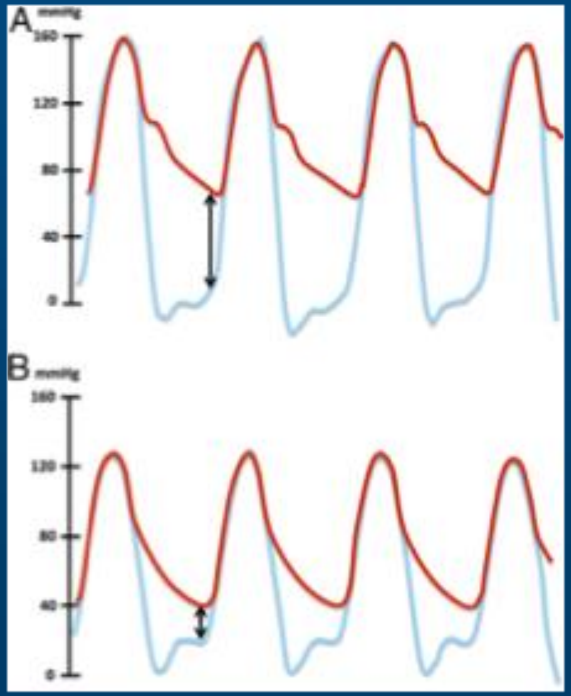


Figure 1 **Calculation of the AR Index**

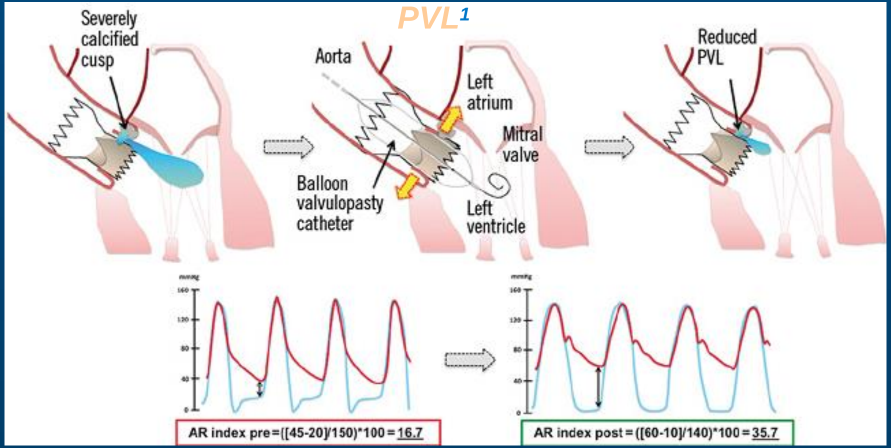
Simultaneous determination of left ventricular end-diastolic pressure (LVEDP) **(blue line)** and diastolic blood pressure (DBP) in the aorta **(red line)** in a patient without peri-prosthetic aortic regurgitation (periAR) **(A)** and in a patient with moderate periAR **(B)** for the calculation of the aortic regurgitation (AR) index: ([DBP − LVEDP]/SBP) × 100. **(A)** AR index = ([65 − 10]/160) × 100 = 34.4. **(B)** AR index = ([40 − 20]/130) × 100 = 15.4.

Aortic Regurgitation Index - ARi

- In Aortic Regurgitation, blood flow backwards into the left ventricle: aortic diastolic pressure decreases while LVEDP increases

- ARi ↓ as AR/PVL ↑

Balloon post-dilation for reduction of PVL[1]



$$\boldsymbol{ARi} = 100\ x\ \frac{Ao\ diastolic - LVEDP}{Ao\ systolic}$$

1. Sinning J-M et al. 2012. Aortic regurgitation index defines severity of peri-prosthetic regurgitation and predicts outcome in patients after TAVI. JACC. Vol. 59 (13): 1134-41.
2. Van Wely et al. 2020. Aortic Regurgitation Index Ratio Is a Strong Predictor of 1-Year Mortality After TAVI Using Self-Expanding Devices. Semin Thoracic Surg 33:923–930
3. Sinning J-M et al. 2016. Balloon post-dilation and valve-in-valve implantation for the reduction of paravalvular leakage with use of the self-expanding CoreValve prosthesis; EuroIntervention 2016;11:1140-1147

ARi Identifies Patients at Highest Risk of Mortality After TAVI

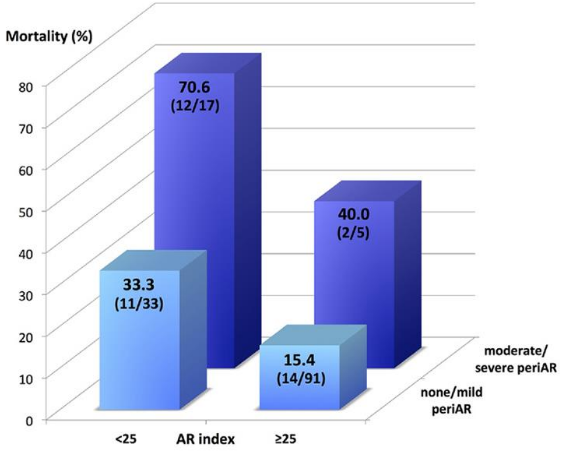


Figure 4 **1-Year Mortality According to Severity of PeriAR and the AR Index**

1-year all-cause mortality (%) according to the severity of periAR (none/mild vs. moderate/severe) and the AR index cutoff value. Abbreviations as in Figures 1 and 2.

- ***ARi > 25 → 1-yr mortality 15.4%***
- ***ARi ≤ 25 → 1-yr mortality 33.3% (2x higher)***
- ***Moderate/Severe periAR + ARi ≤ 25 → 1-yr mortality 70.6%***

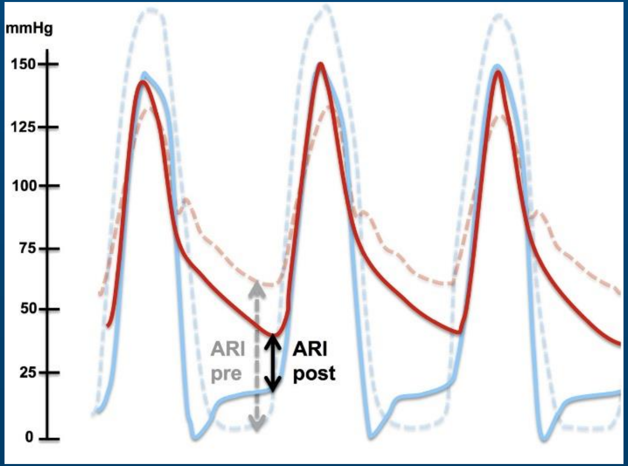
1. Sinning, Jan-Malte, et al. "Aortic Regurgitation Index Defines Severity of Peri-Prosthetic Regurgitation and Predicts Outcome in Patients After Transcatheter Aortic Valve Implantation." Journal of the American College of Cardiology, vol. 59, no. 13, 2012, pp. 1134–1141. Elsevier, doi:10.1016/j.jacc.2011.11.048

Aortic Regurgitation Index Ratio – ARi Ratio

- The ARi ratio, which reflects acute hemodynamic changes after TAVI, is useful to identify patients with negative outcomes[1]

- So, associated with ≥ moderate PVL and increased one-year mortality:[2]
  - Post procedural ARi values <25 AND
  - ARi ratio of <0.6 (or <0.5)

Calculation of the Aortic Regurgitation Index Ratio[1]

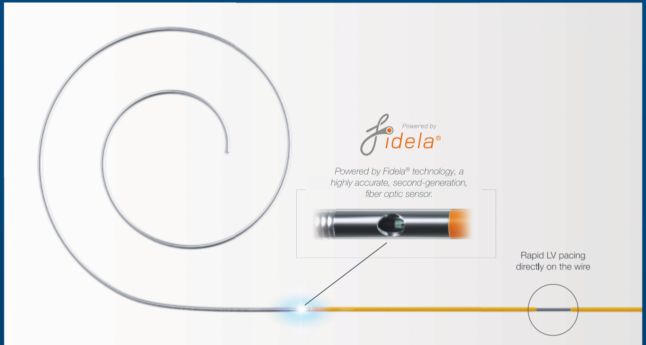


$$\text{ARi ratio} = \frac{ARi\ post}{ARi\ pre}$$

Note:
Haemodynamic parameters such as ARi alone cannot provide basis for clinical decision and their interpretation is left to physicians. Values should be interpreted by comparing pre- to post procedural measurements, along with other information available such as imaging modalities.

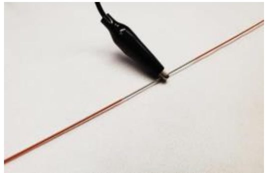
1. *Sinning J-M et al. 2016. Pre-Procedural Hemodynamic Status Improves the Discriminatory Value of the Aortic Regurgitation Index in Patients Undergoing Transcatheter Aortic Valve Replacement*
2. *Aortic Valve Transcatheter Intervention: Complications and Solutions, Marco Zimarino (Editor), Dr. Ron Waksman (Editor), Ignacio J. Amat-Santos (Editor), Corrado Tamburino (Editor), ISBN: 978-1-119-72059-1, May 2021, Wiley-Blackwell*

SavvyWire® Guidewire – Hemodynamics

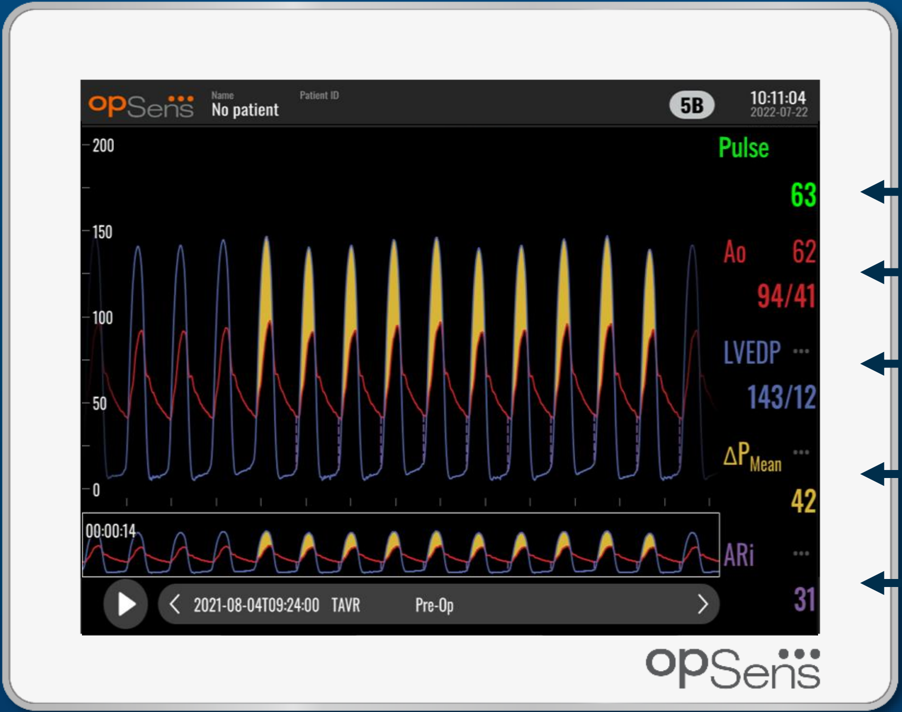


Unipolar left ventricular pacing, at anytime without catheter

- Built-in shaft insulation supports consistent capture and low thresholds
- Eliminates RV access for eligible patients
- Simply attach alligator clips to an external pulse generator



SavvyWire® Guidewire – Hemodynamics

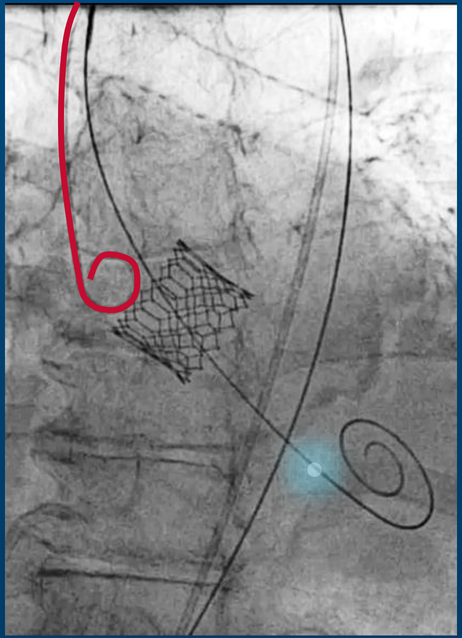


Continuous measurement and display

- *Pulse rate*
- *Aortic pressures (aortic pigtail/transducer)*
  - ✓ *Systolic, diastolic*
- *Left ventricular pressures*
  - ✓ *Systolic, diastolic, LVEDP*
- *Transvalvular gradients*
  - ✓ *Mean, peak-to-peak, instantaneous*
- *Aortic Regurgitation indices*
  - ✓ *ARi, ARi ratio*

SavvyWire® Guidewire – Hemodynamics

- Hemodynamics are always available, without exchange
  - At baseline
  - After pre-dilation
  - During partial deployment (self-expanding valves)
  - Before post-dilation
  - Final hemodynamic assessment
- Accurate, live diagnostics
  - Regurgitation – from diastolic gradient (Ao – LVEDP)

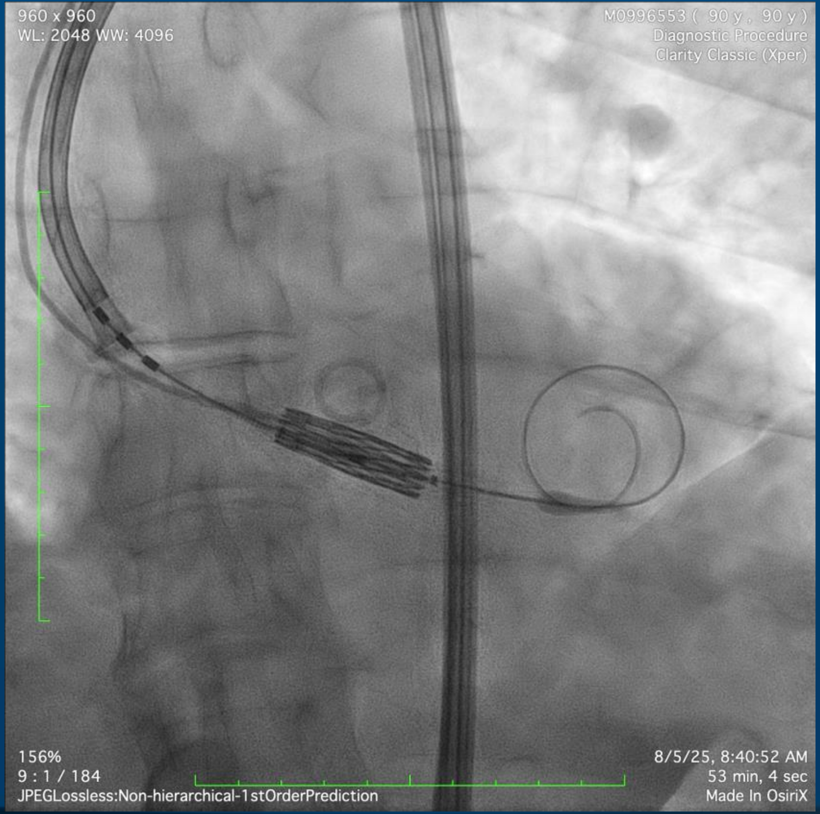


Case Presentation

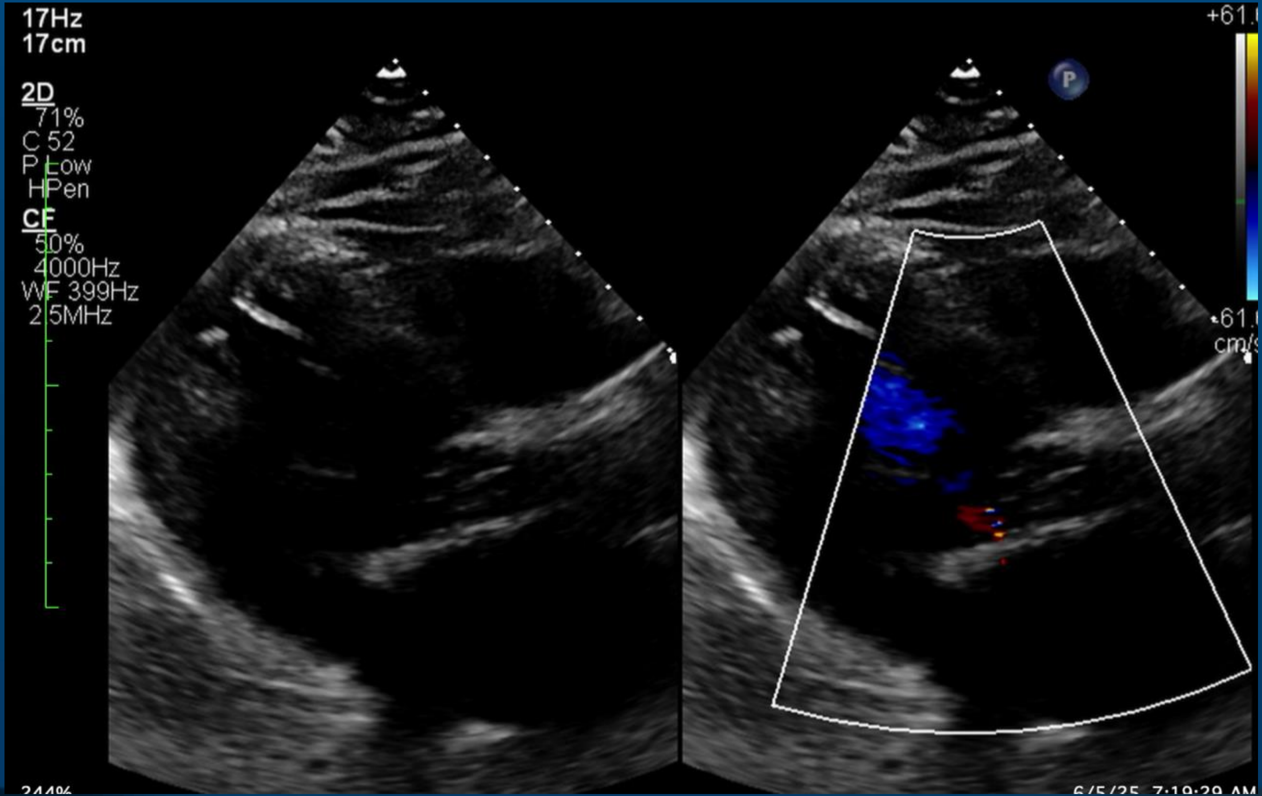
- 85yo F with Diastolic CHF, HTN, Frail reporting exertional dyspnea and edema. Progressive easy fatigue.

- ECHO revealed EF 65% with severe aortic stenosis (mAVG 38mmHg, Jet 4.2m/s, AVA 0.8cm2).
- Cath with mild non-obstructive CAD.
- CTA TAVR protocol suggest acceptable iliofemoral vascular.

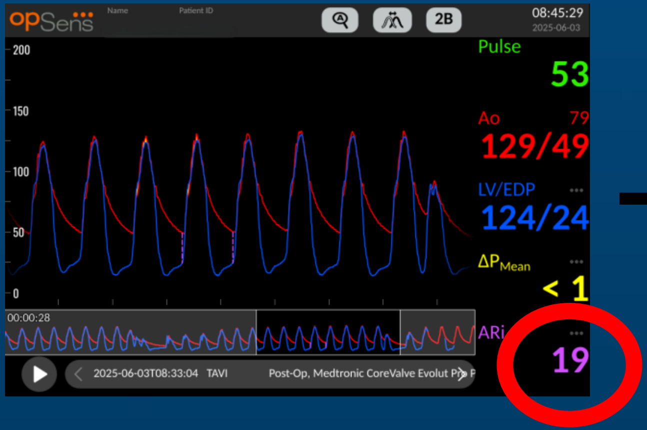
SavvyWire® Guidewire, During and Post Deployment



SavvyWire® Guidewire, During and Post Deployment

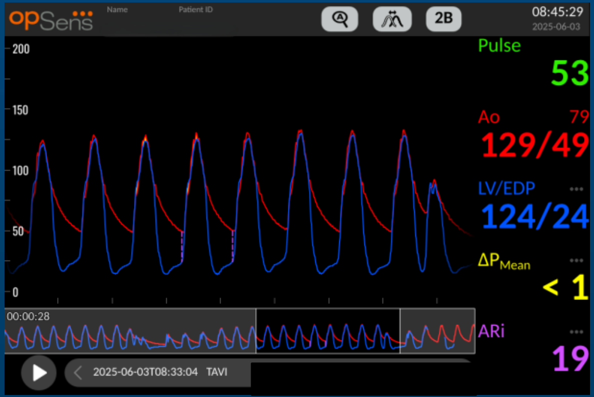


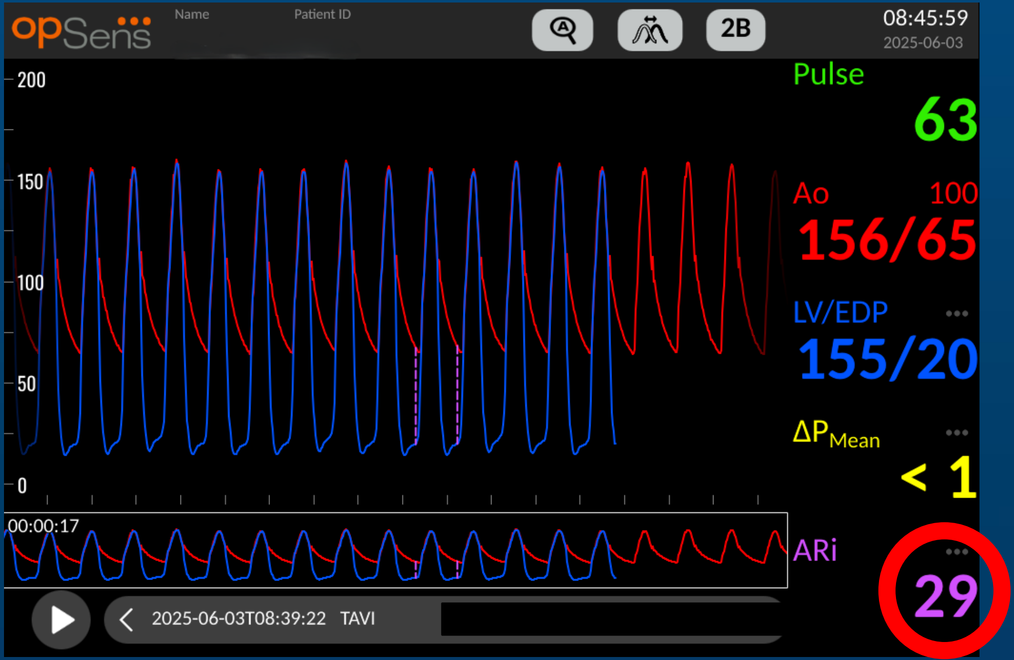
SavvyWire® Guidewire, Post-BAV Gradient and ARi



Post Dilate

SavvyWire® Guidewire, Post-BAV Gradient and ARi





SavvyWire® Guidewire – Hemodynamics

- What does it do for me?

SavvyWire® Guidewire – Hemodynamics

- What does it do for me?
  - Continuous, accurate measurement of hemodynamic pressure
  - Delivers “gold standard” invasive pressure measurements
  - Minimized exchanges for pressure readings
  - “Immediate” hemodynamic assessment of residual AI/PVL
  - Evidenced-based, reliable pacing (one less vessel sheath)
  - Increased lab efficiency

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Meaning: simpler, safer and accurate data

Science advances…

Realistic expectations for life are that we are going to be better today than we were yesterday, be better tomorrow than we were today. That's a plan for success. So [the key is] simple: just work.