

# NEW TECHNOLOGY FOR CARDIAC CHARACTERIZATION



# COROVENTIS COROFLOW CARDIOVASCULAR SYSTEM

Coroventis CoroFlow Cardiovascular System is an advanced platform for assessment of coronary physiology.

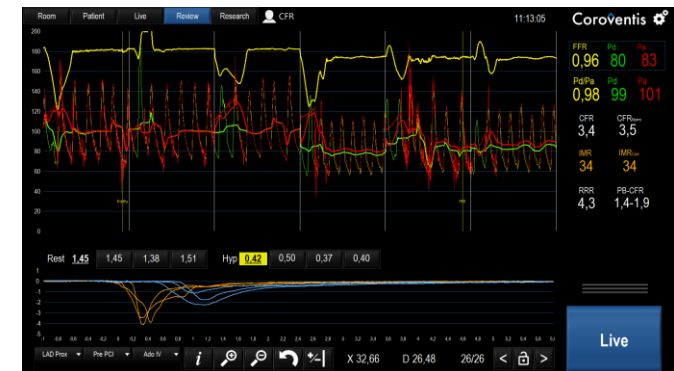
Designed to communicate with Abbott Vascular's wireless PressureWire<sup>®</sup> X, CoroFlow is easy to use for daily clinical practice at the same time as it provides powerful tools for advanced physiologic research.



# OVERVIEW

CoroFlow provides an unmatched number of hemodynamic parameters, covering both epicardial disease states as well as unique tools for assessment of the micro-circulation, providing the means for a near Complete Cardiac Characterization.

- FFR (Fractional Flow Reserve), Pd/Pa at rest
- Absolute coronary flow (L/min)
- Absolute Microvascular Resistance (mmHg/L/min)
- IMR & Corrected IMR (Index of Microvascular Resistance)
- CFR & Normalized CFR (Coronary Flow Reserve)
- PB-CFR (Pressure bounded CFR)
- RRR (Resistive Reserve Ratio)
- Intravascular temperature
- Intra-coronary/ventricular dP/dt
- Diastolic relaxation constant Tau
- Systolic/diastolic/end-diastolic pressures and ratios
- Channel phase synchronization
- DICOM Worklist



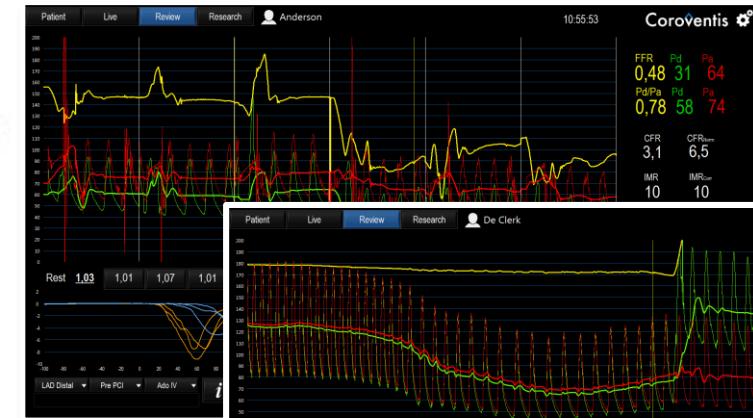
# CARDIAC CHARACTERIZATION

## Epicardial disease

- FFR
- Pd/Pa, Pd/Pa\_Min

## Micro-vascular disease

- IMR
- CFR, RRR, PB-CFR
- Absolute Flow/Resistance

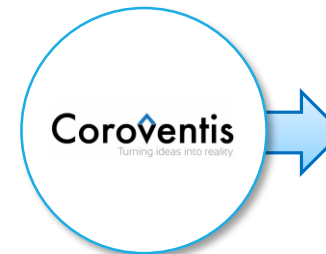
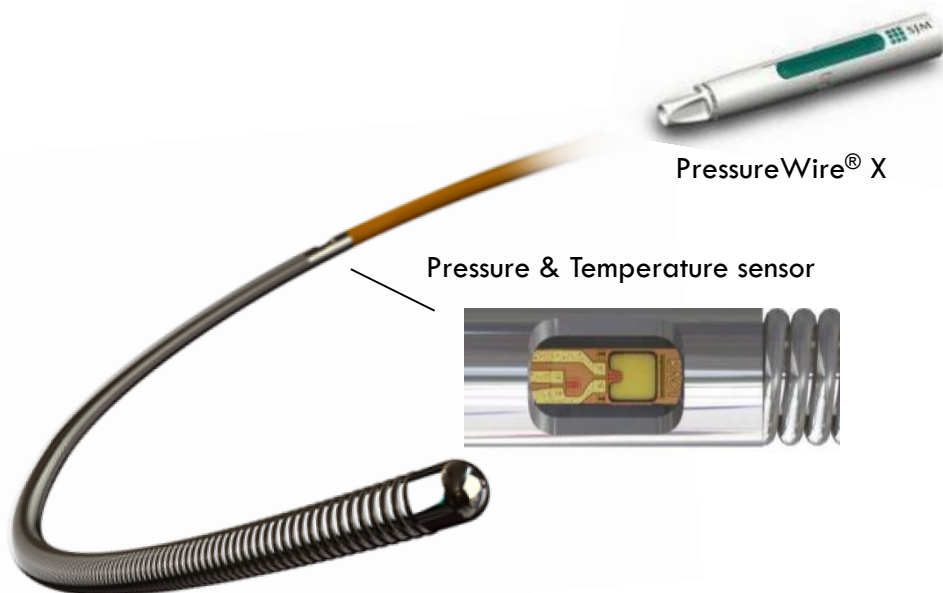


## Ventricle function

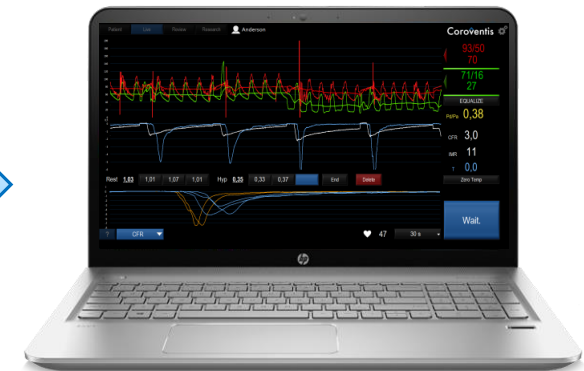
- dP/dt
- Relaxation constant Tau

# TECHNOLOGY

- Abbott Vascular's PressureWire<sup>®</sup> X measures intra-coronary pressure and temperatures which are broadcasted using secure frequency hopping radio technology
- Coroventis CoroFlow<sup>™</sup> receives the transmitted pressure and temperature wirelessly from PressureWire<sup>®</sup> X and calculates pressure and flow parameters using thermo-dilution techniques



CoroHub Receiver



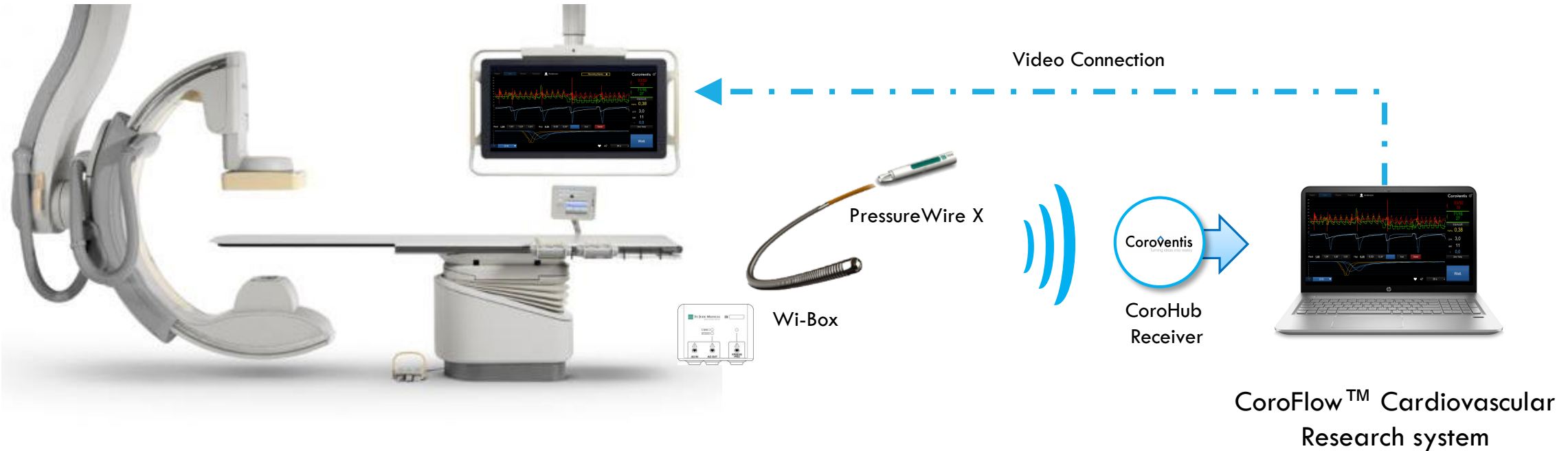
Coroventis CoroFlow<sup>™</sup>  
Workstation

# DATA MANAGEMENT

CoroFlow is designed to handle large number of subjects and facilities effective and secure data management both for regular practice as well as in single or multi-center research projects.

- Local or distributed network/cloud database
- Unlimited number of remote review stations
- Unlimited number of subjects and recordings (based on network storage capacity)
- Adaptive database filtering and automated bulk extraction and export of key study parameters
- Up to 2 hours uninterrupted recording time per recording
- Extensive case annotation and configurable event markers
- Multiple data export formats

# WIRELESS LAB INTEGRATION



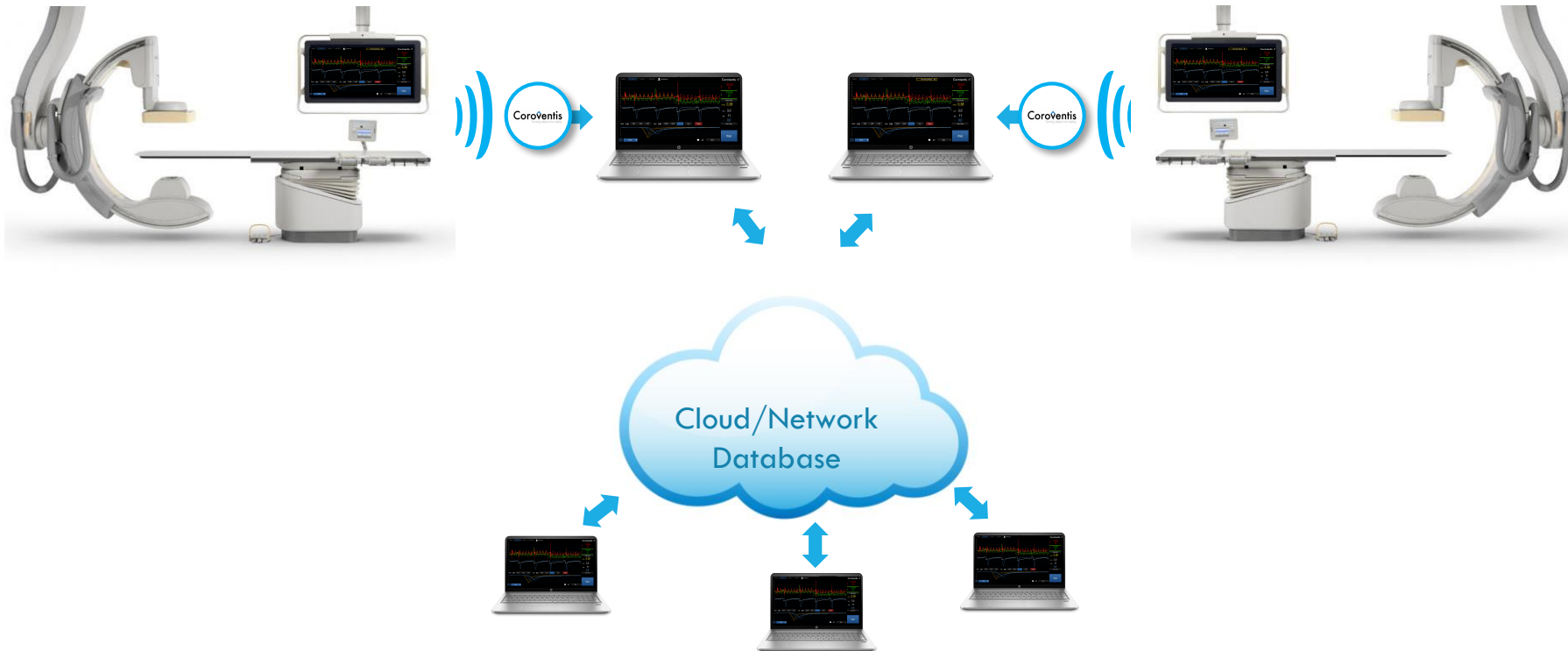
- Wireless communication with pressure sources in the lab (PressureWire/Wi-Box)
- Optional boom monitor display
- Network connectivity for data storage and DICOM Worklist retrieval

CoroFlow™ Cardiovascular  
Research system

Windows® 7,8,10  
Laptop/Server/Surface Pad

# CLOUD DATA MANAGEMENT

One or  
Multiple  
Labs





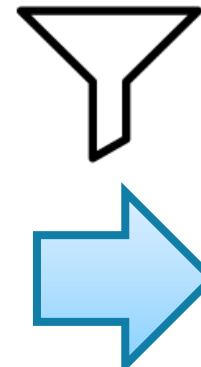
# AUTOMATED KEY DATA EXTRACTION

## Measurements



## Automated Data Indexing

FFR	Pd	Pa		
Pd/Pa	Pd	Pa		
CFR	CFR <sub>Norm</sub>	PBCFR		
IMR	IMR <sub>Corr</sub>		FR	
BRI	RRR			FR
TMN1	TMN2	TMN3		
Pre	Post		13	
LAD	RCA	LCX		13
Prox	Mid	Dist		
Gender	Age	ID		
...	...	...		



## Study Level Data Filtering/Anonymization Export to Excel/Matlab

#	STUDY	SUBJECT_CASE_ID	PAT_AGE	DOC	COMMENT	PAT_NAME	PAT_ID	DATE	TIME	FILE_NAME	REC_TYPE	POSITION	PROCEDURE	ACTION	REC_CON	INF_RATE	MIN	Q_NORM	Q_L	Q_U
1	FAME	Bernard	Test com1	Aalst test2	2016-04-25	15:33:05	C:\COROV	AbdFlow	LAD Prox	Pre drug	Rega IC	20	888,833	0,107	0,					
2	FAME	Bernard	Test com1	Aalst test2	2016-04-25	15:20:07	C:\COROV	AbdFlow	LAD Distal	Intrinsic n	Dobutamine	20	939,611	0,106	0,					
3	FAME	Bernard	Test com1	Aalst test2	2016-10-18	18:54:19	C:\COROV	AbdFlow	LAD Distal	Pre PCI	Ado IV	25	707,919	0,164	0,					
4	FAME	Bernard	Test com1	Aalst test2	2016-10-18	18:54:19	C:\COROV	AbdFlow	LAD Distal	Pre PCI	Ado IV	25	707,919	0,164	0,					
5	GENESIS_FAI	123456	43434354	43	Dox PHII	C B DeCau	19790319	2016-09-04	12:07:11	C:\COROV	FFR	LAD Prox	Pre PCI							
6	GENESIS_FAI	123456	43434354	43	Dox PHII	C B DeCau	19790319	2016-10-21	12:24:05	C:\COROV	FFR	LAD Prox	Pre PCI							
7	FAMES6	CAROL						2017-01-25	16:11:31	C:\COROV	FFR	LAD Mid	Post drug	Rega IC						
8	FAMES6	CAROL						2017-01-25	16:16:26	C:\COROV	AbdFlow	LAD Mid	Post drug	Rega IC	25	417,92	0,198	0,		
9	FAMES6	CAROL						2017-01-25	16:26:55	C:\COROV	CFR	LAD Mid	Post drug	Rega IC						
10	FAMES6	CAROL						2017-03-20	09:25:38	C:\COROV	FFR	LAD Mid	Post drug	Rega IC	25	469,167	0,176	0,		
11	FAME	GENFI#1	Nils	Danderyd	2016-08-25	08:44:26	C:\COROV	CFR	LAD Distal	Pre PCI	Dobutamine									
12	FAME	GENFI#1	Nils	Danderyd	2016-08-25	08:44:32	C:\COROV	CFR	LAD Mid	Pre PCI	Ado IV									
13	FAME	GENFI#1	Nils	Danderyd	2016-08-25	08:36:18	C:\COROV	FFR	LAD Distal	Post drug	ATP IC									
14	FAME	GENFI#1	Nils	Danderyd	2017-01-24	16:43:11	C:\COROV	FFR	LAD Distal	Pre PCI	Dobutamine									
15	FAME	GENFI#1	Nils	Danderyd	2017-01-24	16:44:41	C:\COROV	CFR	LAD Distal	Pre PCI	Dobutamine									
16	FAME	GENFI#1	Nils	Danderyd	2017-01-24	16:36:28	C:\COROV	CFR	LAD Distal	Pre PCI	Dobutamine									
17	FAME	GENFI#1	Nils	Danderyd	2017-01-24	17:04:28	C:\COROV	FFR	LAD Distal	Pre PCI	Dobutamine									
18	FAME	GENFI#1	Nils	Danderyd	2017-01-24	17:05:28	C:\COROV	FFR	LAD Distal	Pre PCI	Dobutamine									
19	FAME2	12	53	Nils	Daniele A PISANB71	2017-03-14	13:14:12	C:\COROV	FFR	LAD Prox	Post PCI	Rega IV								
20	FAME2	12	53	Nils	Daniele A PISANB71	2017-03-14	13:15:23	C:\COROV	FFR	LAD Prox	Post PCI	Rega IV								
21	FAME2	12	53	Nils	Daniele A PISANB71	2017-03-14	13:17:24	C:\COROV	AbdFlow	LAD Prox	Post PCI	Rega IV	25	NaN	NaN	NaN				
22	FAME2	12	53	Nils	Daniele A PISANB71	2017-03-14	13:18:16	C:\COROV	dp/dt	LAD Prox	Post PCI	Rega IV								
23	FAME	CORA#5	98323	52	Dox	Demorecordings	2016-04-05	11:56:15	C:\COROV	AbdFlow	LAD Prox	Pre PCI	Saline	This is a comment	25	412	0,168	0,		
24	FAME	CORA#5	98323	52	Dox	Demorecordings	2016-05-02	11:42:41	C:\COROV	FFR	LAD Prox	Pre PCI		This is a comment						
25	FAME	CORA#5	98323	52	Dox	Demorecordings	2016-05-02	11:42:53	C:\COROV	FFR	LAD Prox	Pre PCI		This is a comment						
26	FAME	CORA#5	98323	52	Dox	Demorecordings	2016-05-03	10:23:02	C:\COROV	FFR	LAD Prox	Pre PCI		This is a comment						
27	FAME	CORA#5	98323	52	Dox	Demorecordings	2016-09-01	10:38:21	C:\COROV	CFR	LAD Distal	Pre drug	Nitro IC							
28	FAME	#24	6456456	56	Carl	J Cox	2016-05-19	13:23:08	C:\COROV	FFR	LAD Prox	Resting	Rega IC							
29	FAME	#24	6456456	56	Carl	J Cox	2016-05-19	13:25:11	C:\COROV	CFR	LAD Prox	Resting	Rega IC							
30	FAME	#24	6456456	56	Carl	J Cox	2016-05-19	13:23:44	C:\COROV	AbdFlow	LAD Prox	Resting	Rega IC							
31	FAME	#24	6456456	56	Carl	J Cox	2016-05-19	13:42:19	C:\COROV	dp/dt	LAD Prox	Resting	Rega IC							

# TECHNICAL SPECIFICATIONS

Index	Definition	References
FFR, Fractional Flow Reserve	$P_d/P_a$ at maximum hyperemia	FFR 1
Tmn, Transit Mean Time (s)	Inversely proportional to coronary blood flow. Point of balance of dilution curve from start of injection until temperature has returned to baseline	CFR 1
CFR, Coronary Flow Reserve	$T_{mn\_Rest}/T_{mn\_Hyp}$	CFR 1
CFR_Norm, CFR normalized for epicardial disease	CFR/FFR	CFR 5
PB-CFR, Pressure bounded CFR	Upper boundary = $\Delta P_{Hyp}/\Delta P_{Rest}$ Lower boundary = $\sqrt{(\Delta P_{Hyp}/\Delta P_{Rest})}$	PB-CFR 1
IMR, Index of Microvascular Resistance	$T_{mn\_Hyp} \times P_d_{Hyp}$	IMR 1
IMR_Corr, IMR corrected for influence from collateral supply	Two modes: Wedge: $P_a_{Hyp} \times T_{mn\_Hyp} \times [(P_d - P_W) / (P_a - P_W)]_{Hyp}$ Yong: $P_a_{Hyp} \times T_{mn\_Hyp} \times [1.34 * P_d_{Hyp} / P_a_{Hyp} - 0.32]$	IMR 6
BRI, Baseline resistance index. Microvascular Resistance at rest, corrected for collateral supply.	Two modes: Wedge: $P_a_{Rest} \times T_{mn\_Rest} \times [(P_d - P_W) / (P_a - P_W)]_{Rest}$ Yong: $P_a_{Rest} \times T_{mn\_Rest} \times [1.34 * P_d_{Rest} / P_a_{Rest} - 0.32]$	IMR 11 IMR 6
RRR, Resistance Reserve Ratio	BRI/IMR	IMR 11
Q, Absolute Flow (L/min)	$Q = 1.08 \times T_{inf}/T_{Mix} \times Inf\_rate$	ABS 1
Q_Norm, Normalized flow (L/min)	Q/FFR	ABS 4
R, Absolute Resistance (mmHg*min/L)	$P_d/Q$	ABS 4
Wot, Wash out time (s)	Time for temperature to return to baseline after bolus injection	Novel
Wor, Wash out ratio (s)	$Wot_{Rest}/Wot_{Hyp}$	Novel
Tau, Diastolic Relaxation constant (s)	Time for distal pressure to fall from point of $dP/dt_{Min}$ to a preset point. Three modes: 1/2 Time from $P[dP/dt_{min}]$ to $P[dP/dt_{min}]/2$ 1/e Time from $P[dP/dt_{min}]$ to $P[dP/dt_{min}]/e$ Diastolic/e Time from $P[dP/dt_{min}]$ to $[P[dP/dt_{min}] - P[Diastole]]/e$	Tau 1 Adapted.
dP/dt Max/Min	Max/Min dP/dt, with averaging	

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## FFR, Fractional Flow Reserve

1. Measurement of Fractional Flow Reserve to Assess the Functional Severity of Coronary-Artery Stenoses, Nico H.J. Pijls et al, N Engl J Med 1996; 334:1703-1708 June 27, 1996DOI: 10.1056/NEJM199606273342604

## Absolute Flow, Resistance and local hypothermia

1. Direct volumetric blood flow measurement in coronary arteries by thermodilution. Aarnoudse W et al. J Am Coll Cardiol. 2007 Dec 11;50(24):2294-304. PubMed PMID: 18068038.
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5. Pressure-derived measurement of coronary flow reserve. MacCarthy et al. *J Am Coll Cardiol*. 2005 Jan 18;45(2):216-20.

## IMR, BRI, RRR, Indices of Microcirculatory Resistance

1. Novel index for invasively assessing the coronary microcirculation. Fearon et al. *Circulation*. 2003;107:3129-3132. Originally published July 1, 2003
2. Invasive Assessment of the Coronary Microcirculation. Superior Reproducibility and Less Hemodynamic Dependence of Index of Microcirculatory Resistance Compared With Coronary Flow Reserve. Martin K.C et al. *Circulation*. 2006;113:2054-2061. Originally published May 1, 2006
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4. Quantitative assessment of coronary microvascular function in patients with and without epicardial atherosclerosis. Narbeh Melikian et al. *Eurointervention* 2010;5:939-945
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11. Vasodilatory capacity of the coronary microcirculation is preserved in selected patients with NSTEMI. Layland et al *Circ Cardiovasc Interv*. 2013 Jun;6(3):231-6.

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## PB-CFR, Pressure-Bounded CFR

1. What Can Intracoronary Pressure Tell Us about Flow Reserve? Pressure-Bounded Coronary Flow Reserve and Application to the DEFER Trial. Zimmer et al. Catheterization and Cardiovascular Interventions 00:00–00 (2017) DOI: 10.1002/ccd.26972
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3. Coronary Artery disease: physiology and prognosis. Colin Berry et al. European Heart Journal (2017) 0, 1–3

## Tau, Diastolic Relaxation constant

1. Assessment of diastolic function: suggested methods and future considerations. I Mirsky, Circulation. 1984;69:836-841, doi: 10.1161/01.CIR.69.4.836

# SYSTEM COMPONENTS



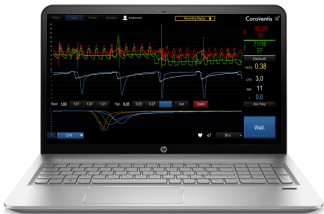
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One for each cathlab



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One for each cathlab



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Workstation PC  
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