12월 11일

Heart Rate Variability

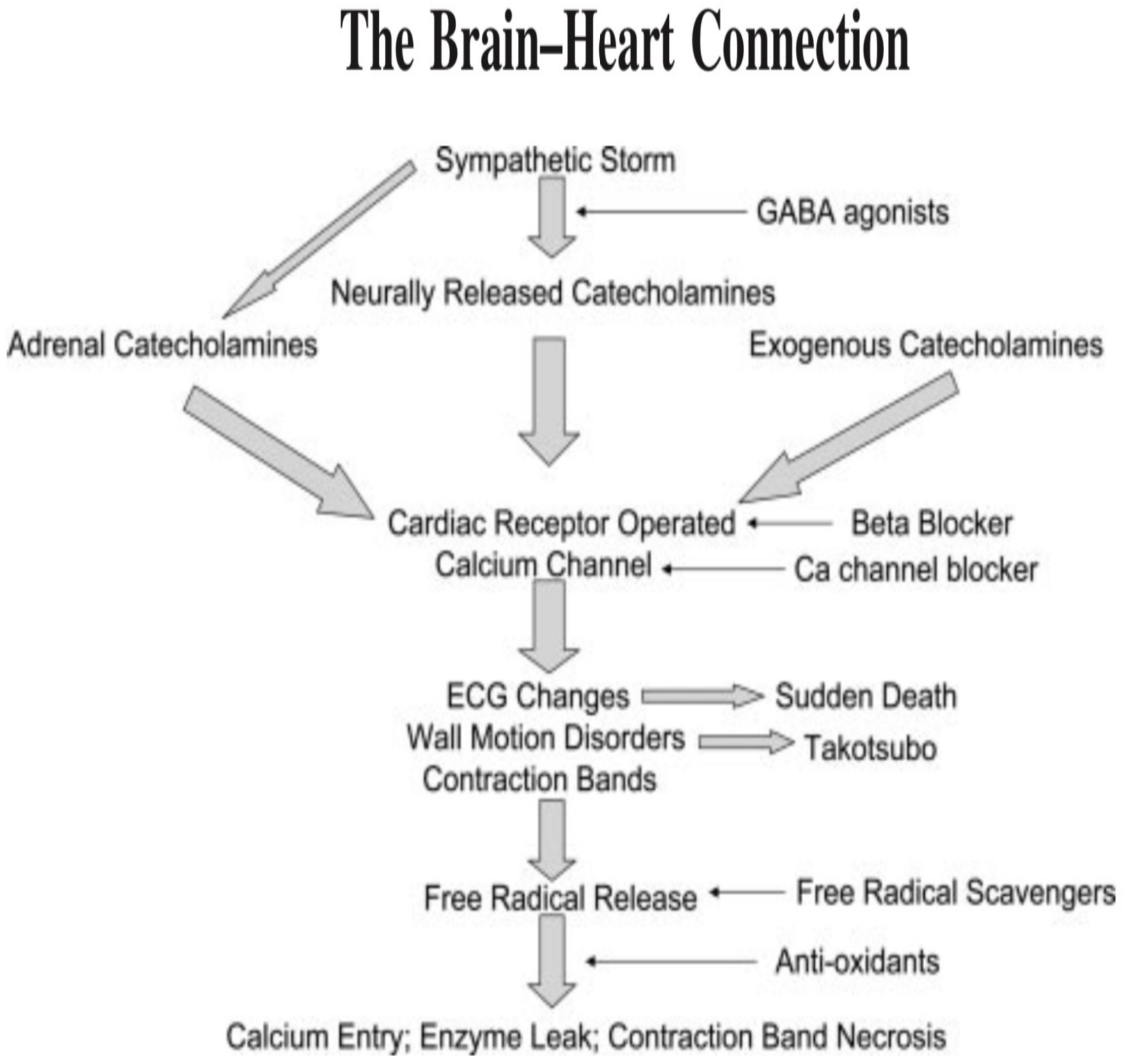
적응증 과 해석

중앙의대

강기운

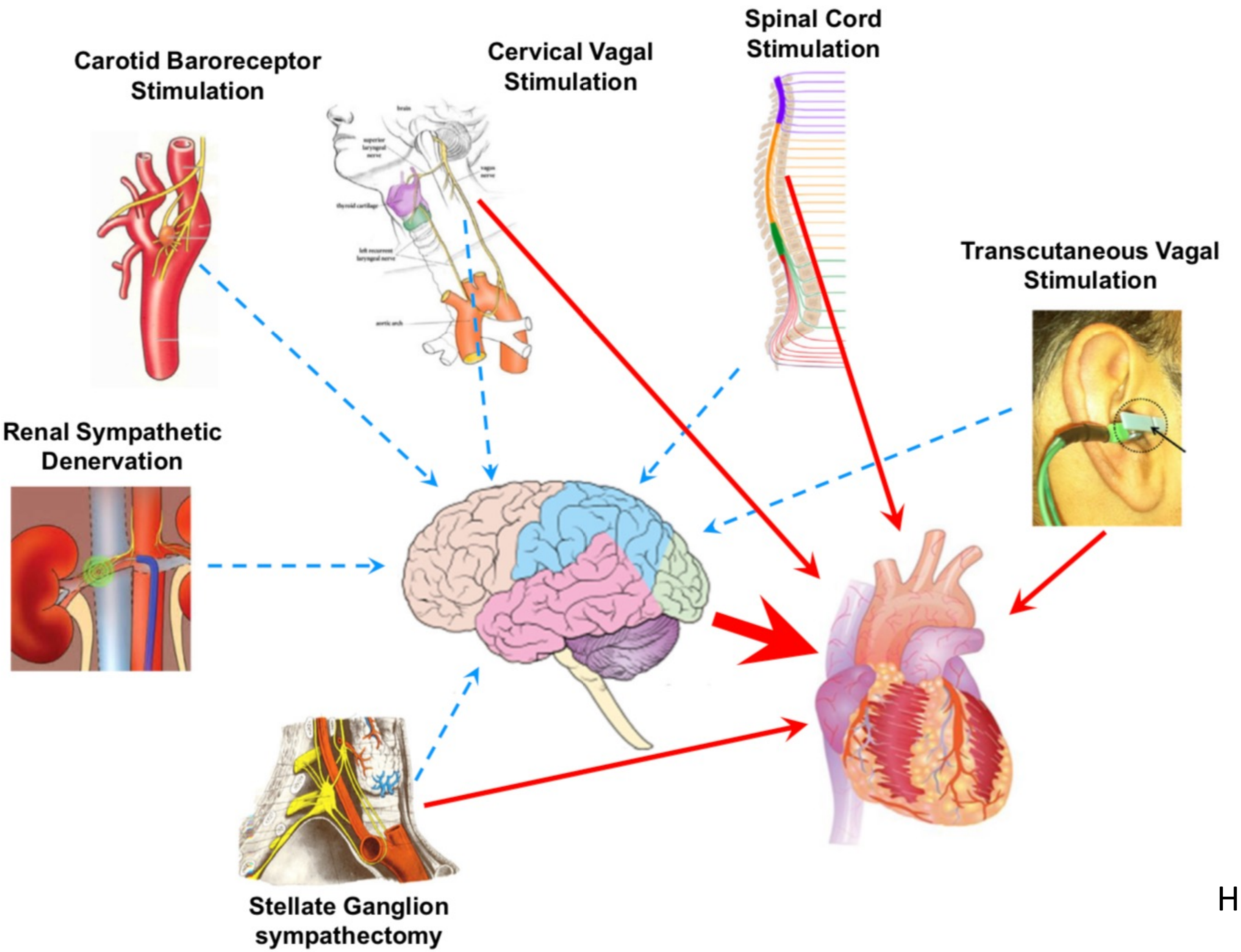
Heart Rate Variability (HRV) 적 응 증

- Monitor Fitness Change
- Monitor Training Status
- Monitor Mental stress
- Monitor Sleep or Fatigue
- Psychological disorders
- Cardiovascular and Arrhythmia disorders
- Chronic Illness



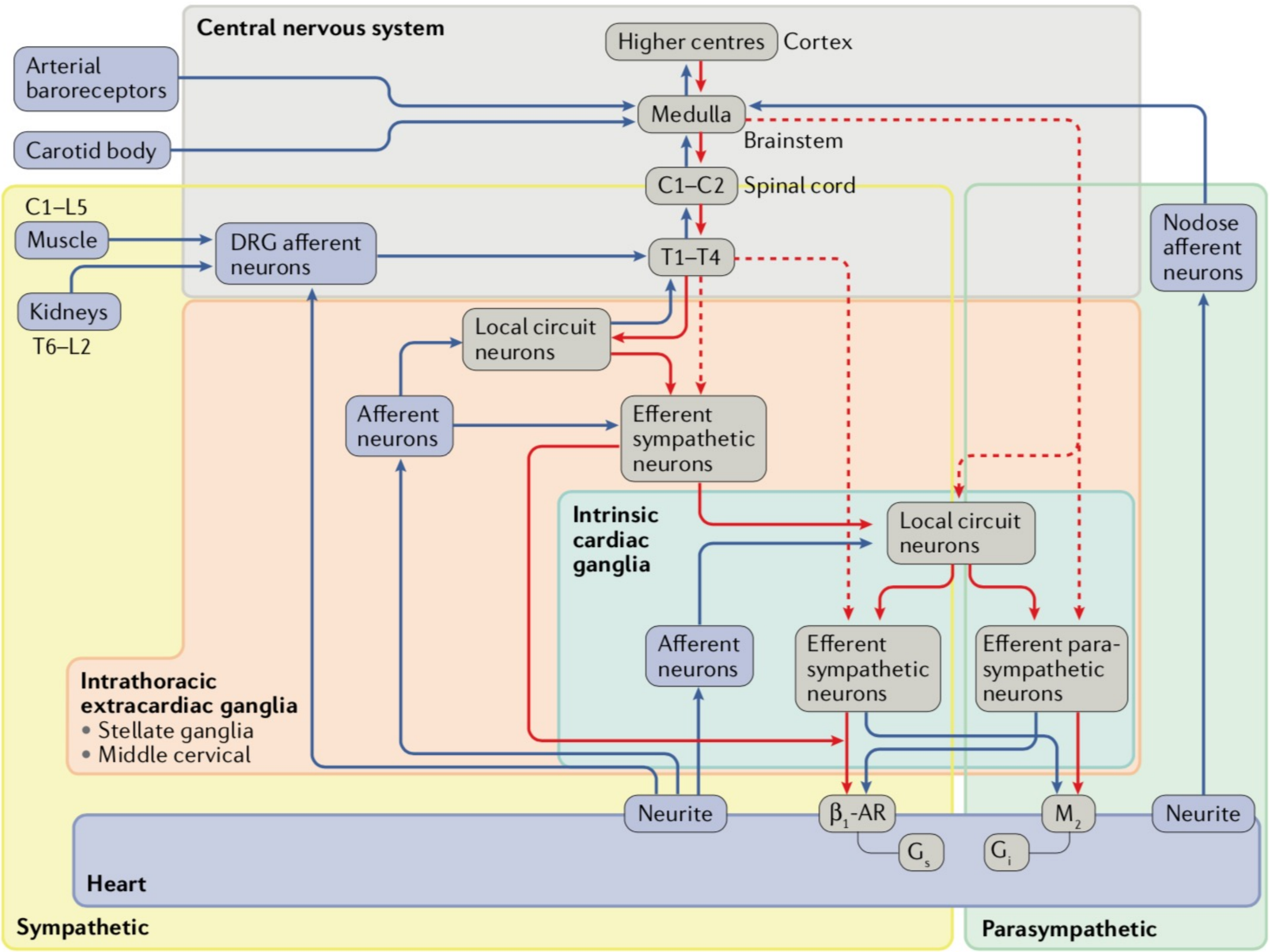
Martin Samuels Circulation 2007

Neural Network: Autonomic nerve traffic



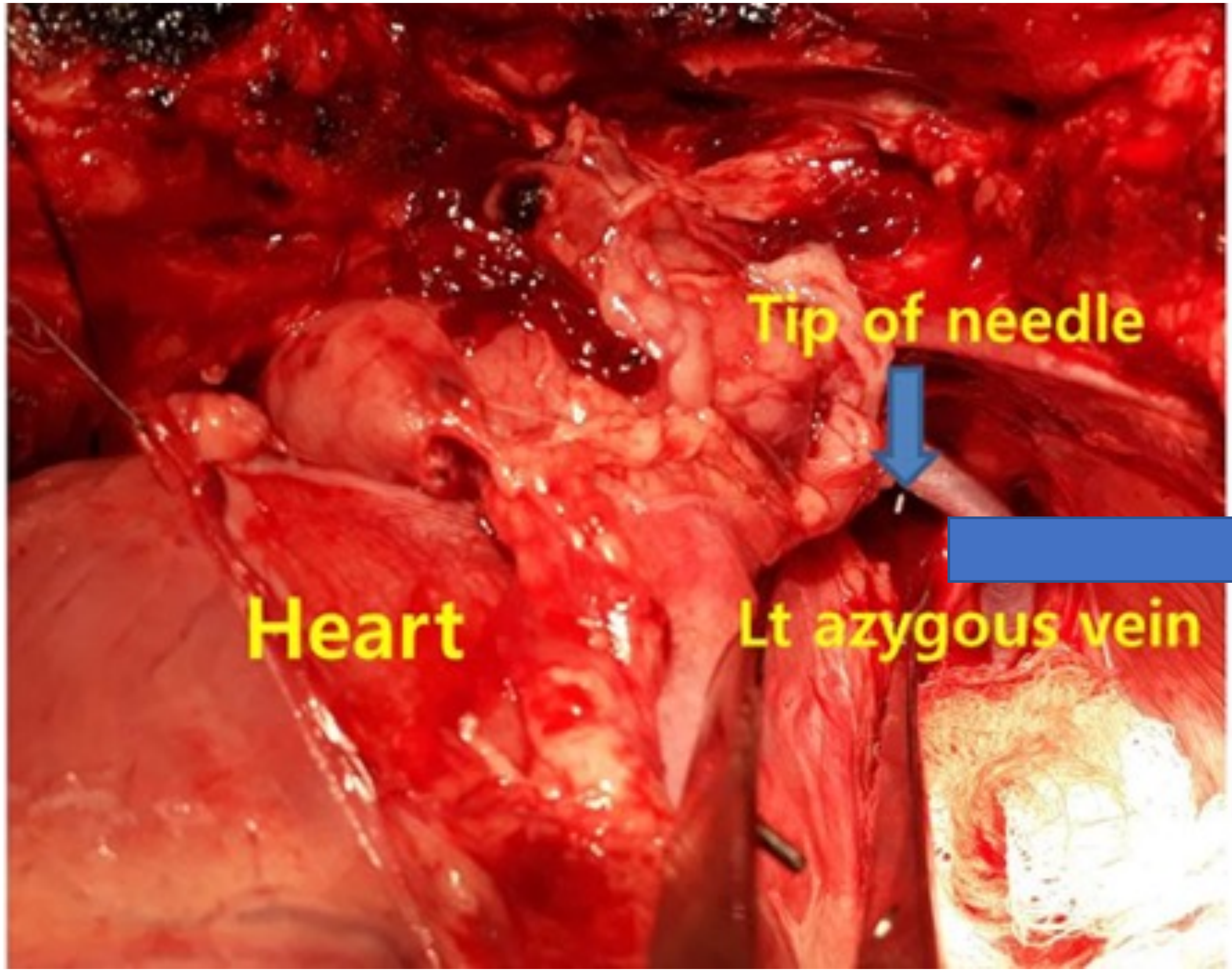
Hou et al Heart Rhythm 2016

Cardio-neural hierarchy

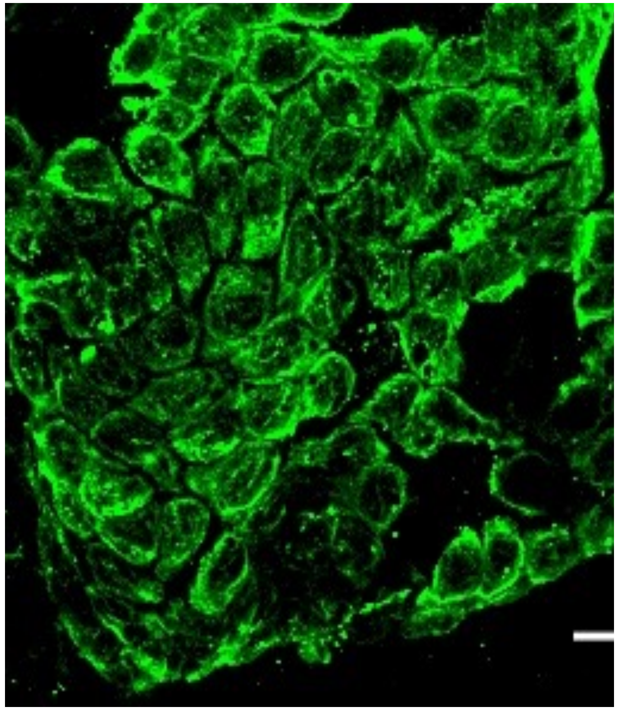


Herring N et al
Nat Rev Cardiol
2019

Stellate ganglion (T1)-T4

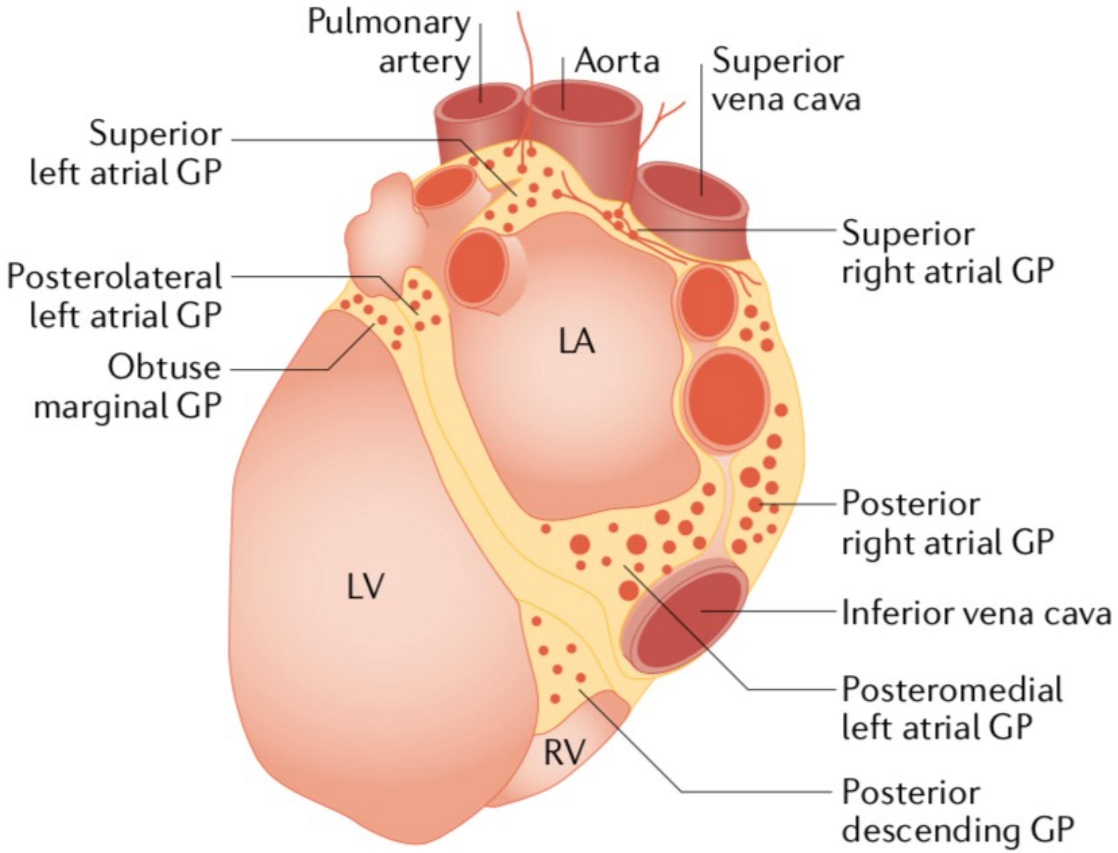


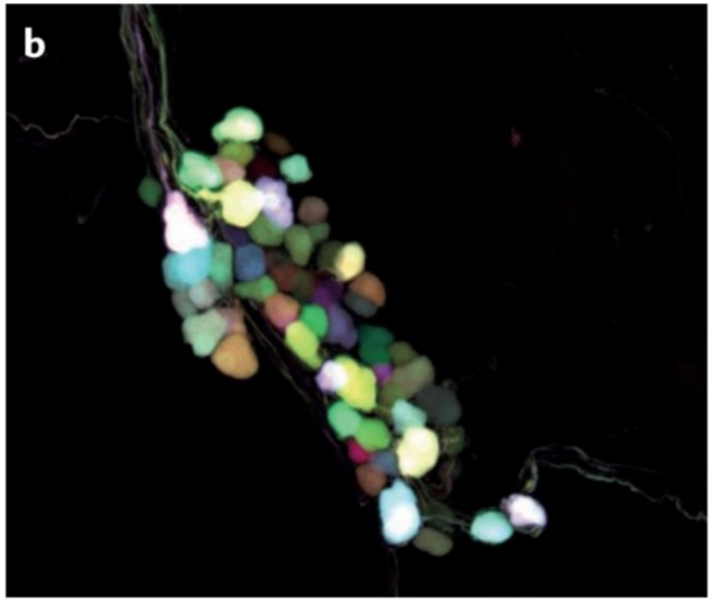
Stellate ganglion



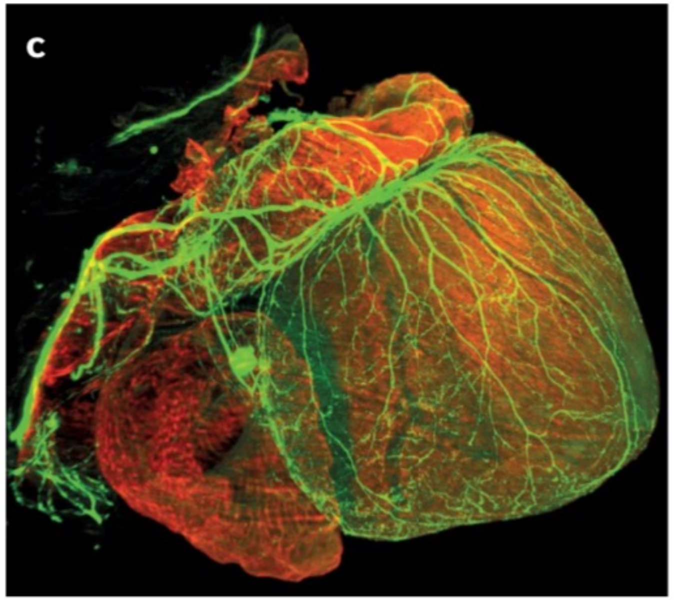
KW Kang, EY Lee unpublished data 2021

Autonomic innervation (posterior view)





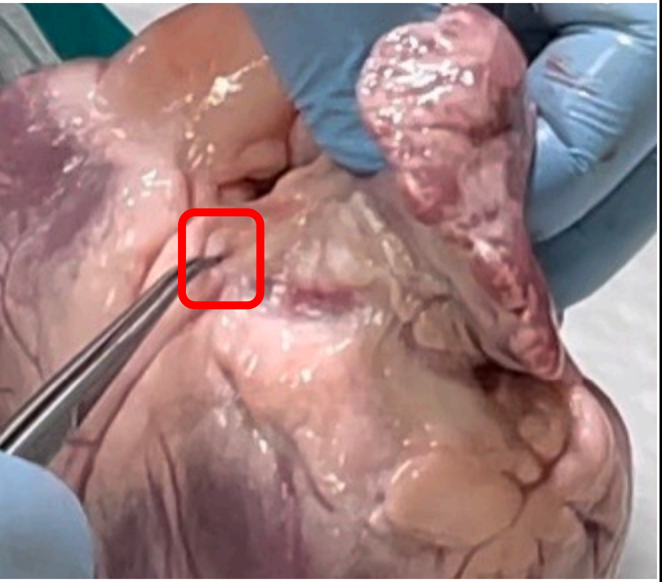
Confocal image of ICN
in the Mice

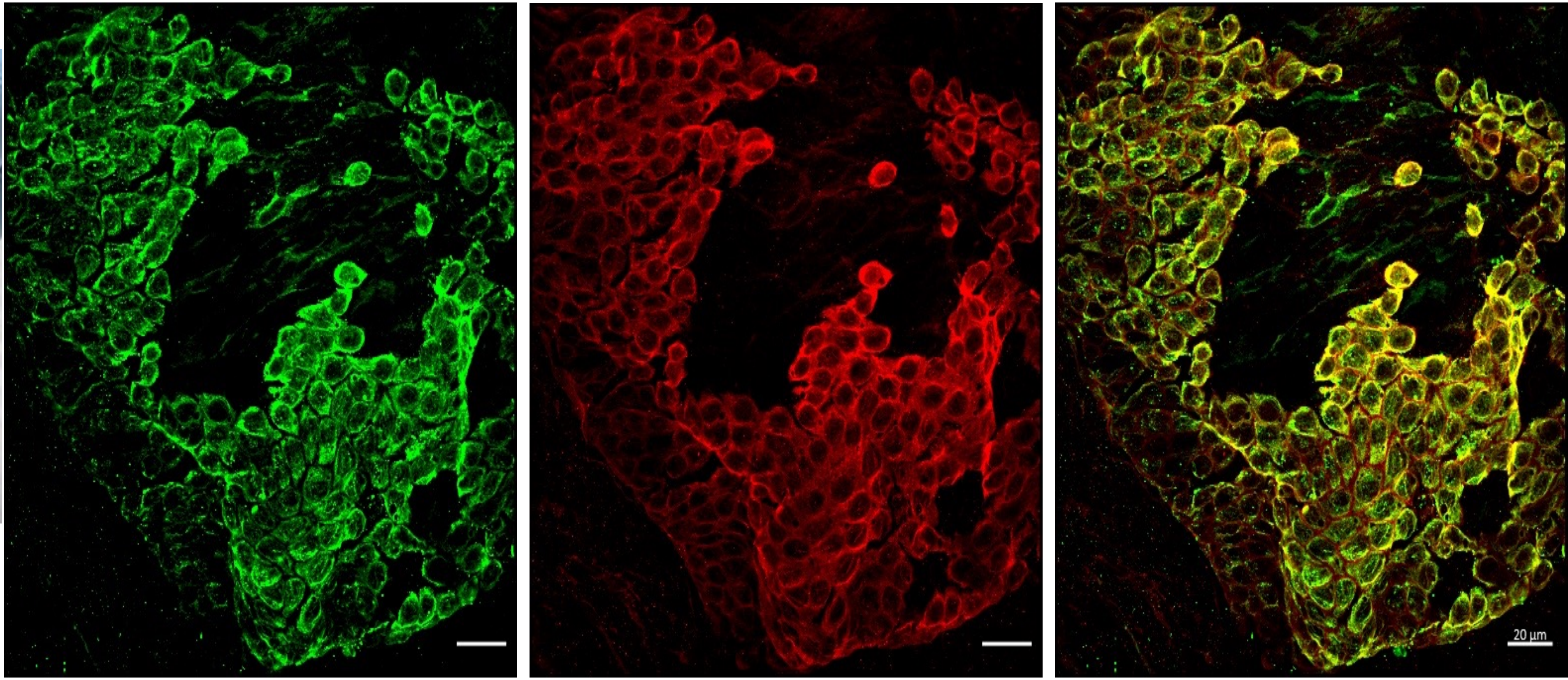


Tyrosine Hydroxylase
in the Mice

Herring N et al *Nat Rev Cardiol* 2019

Anterior Superior LA Ganglion Plexus (GP)

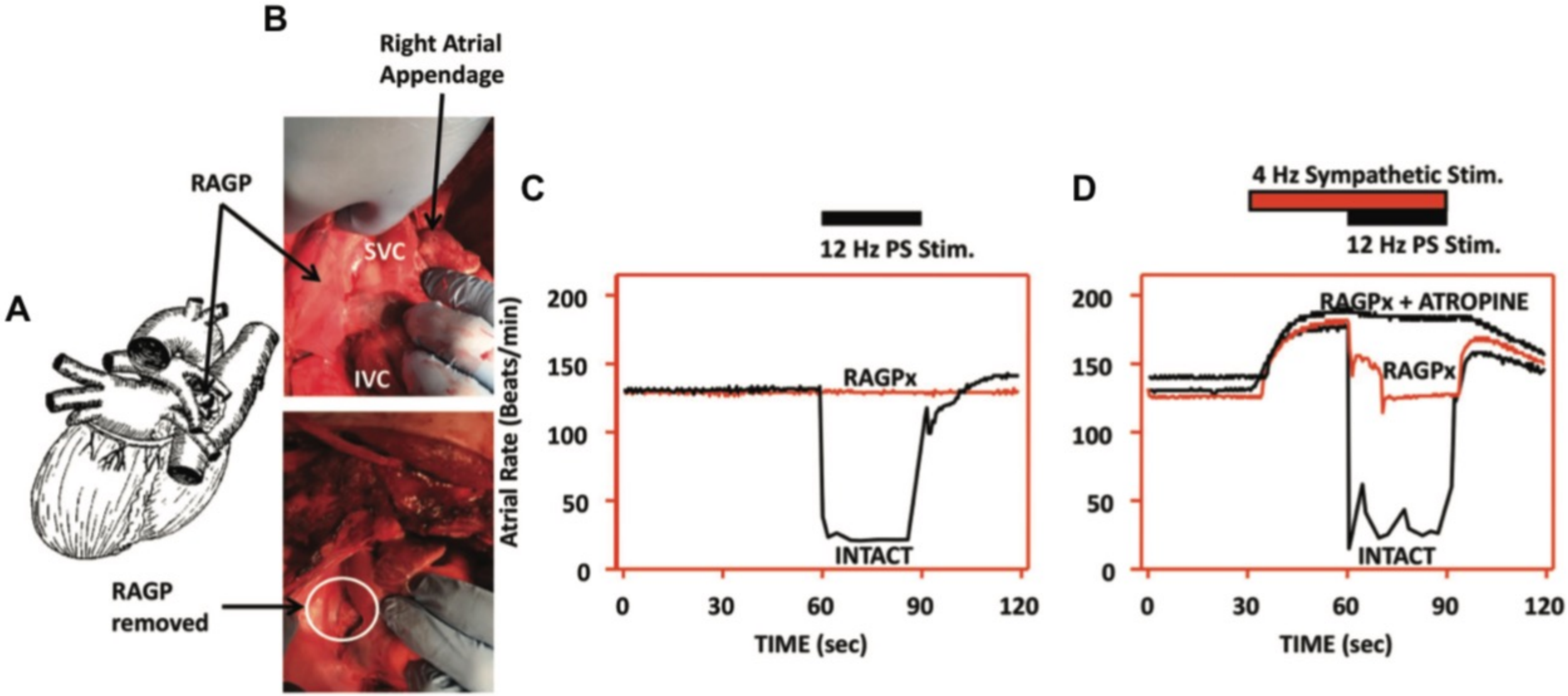




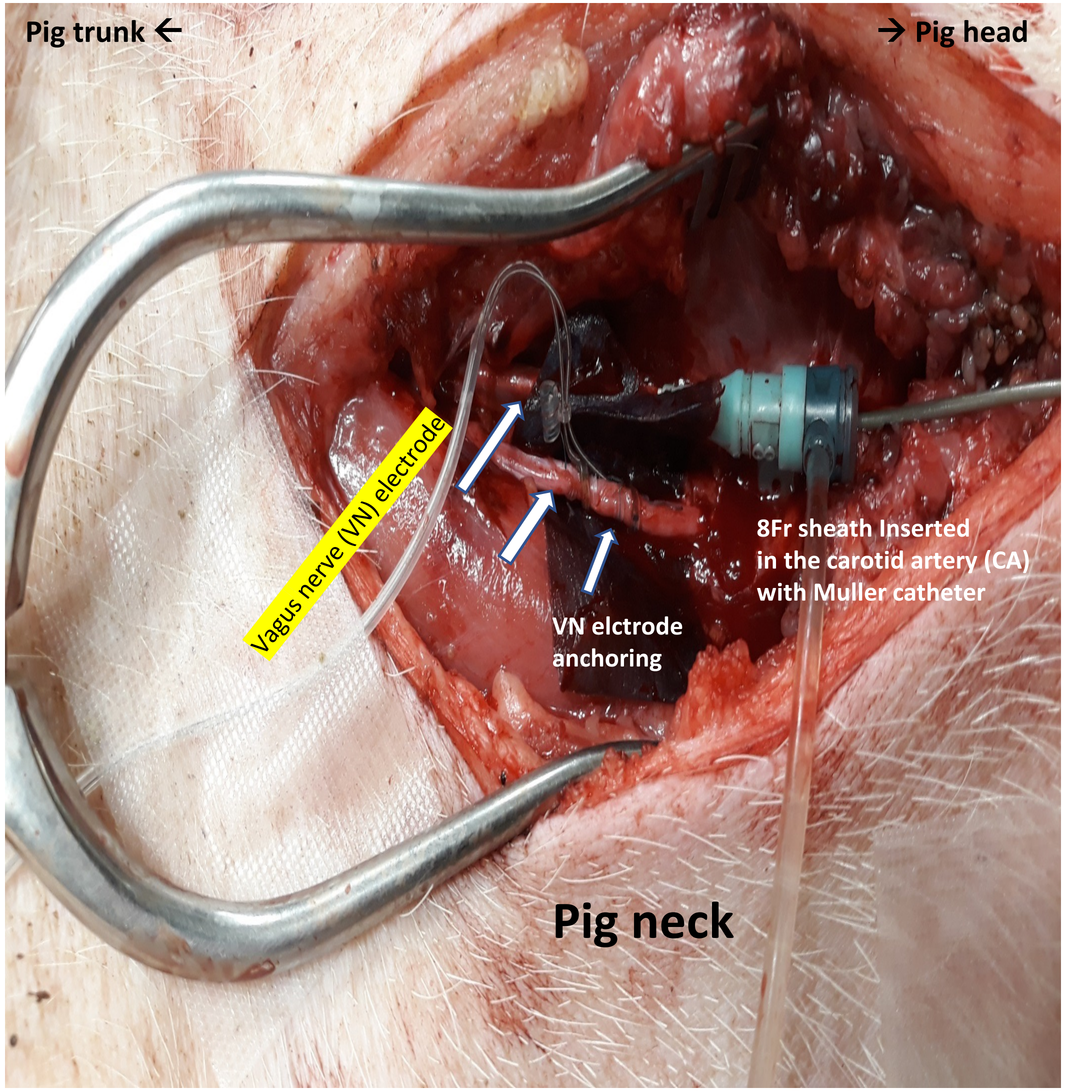
NF200 ChAT Merge

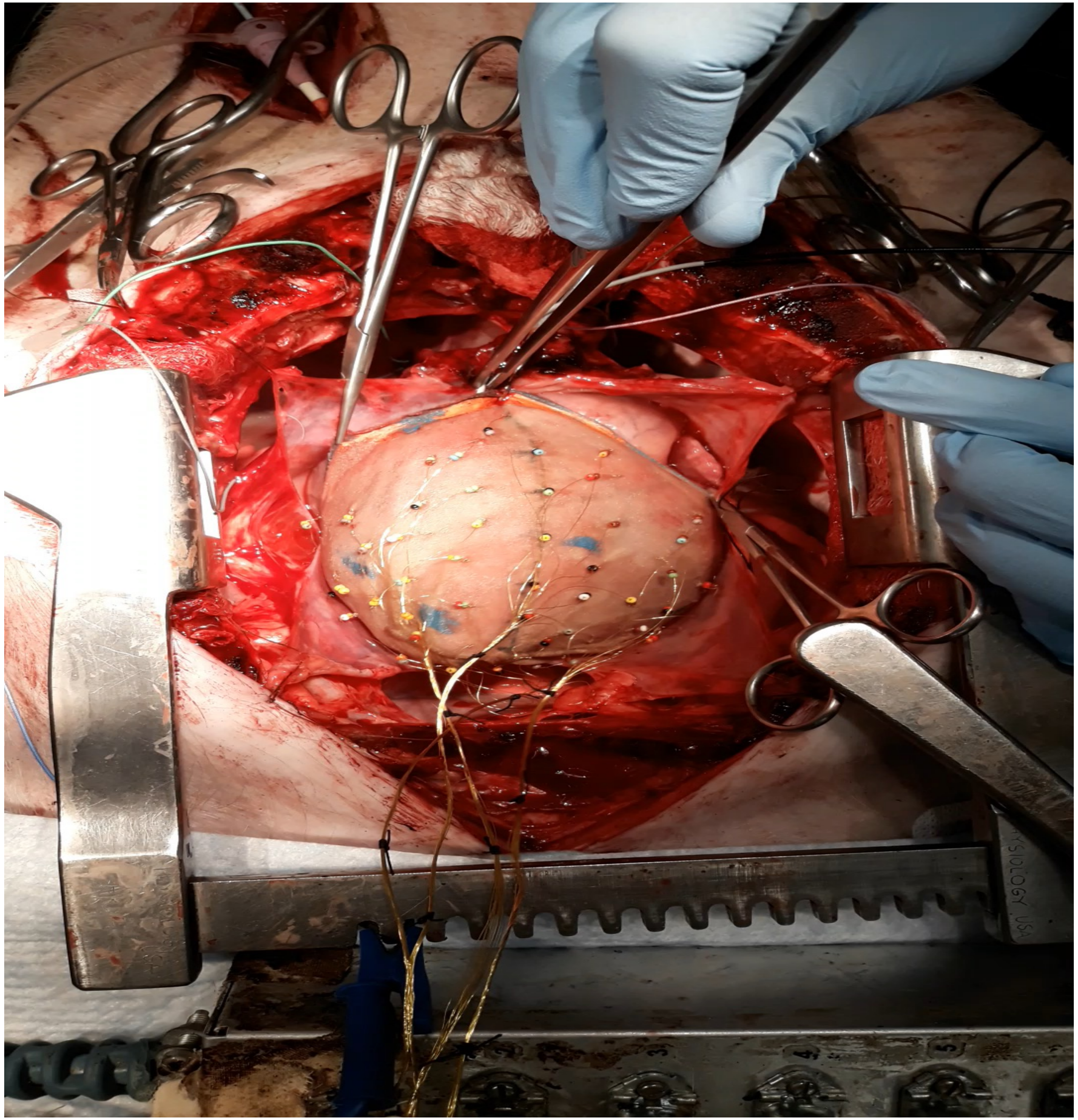
KW Kang, EY Lee unpublished data 2021

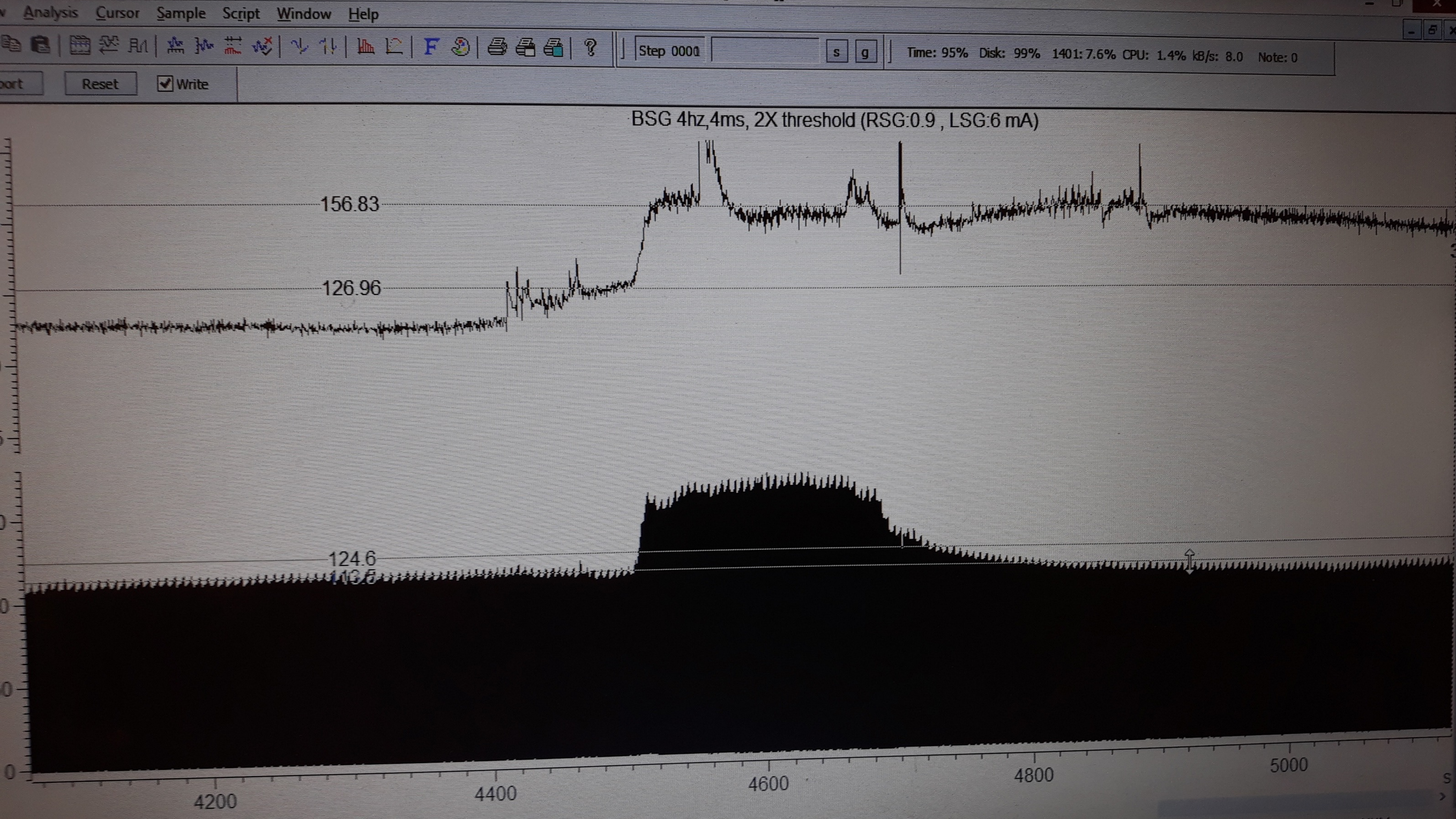
Intra-cardiac neural recording during stimulation



Hadaya J. et al Frontier Physiology 2020


Pig trunk ←
→ Pig head
Vagus nerve (VN) electrode
8Fr sheath Inserted
in the carotid artery (CA)
with Muller catheter
VN elctrode
anchoring
Pig neck




Analysis Cursor Sample Script Window Help
Step 0000
s g
Time: 95% Disk: 99% 1401: 7.6% CPU: 1.4% kB/s: 8.0 Note: 0
Reset
Write
BSG 4hz,4ms, 2X threshold (RSG:0.9 , LSG:6 mA)
156.83
126.96
124.6
4200
4400
4600
4800
5000

European Heart Journal (1996) **17**, 354–381

Guidelines

Heart rate variability

Standards of measurement, physiological interpretation, and clinical use

Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology (Membership of the Task Force listed in the Appendix)

Europace
doi:10.1093/europace/euv015

EHRA POSITION PAPER

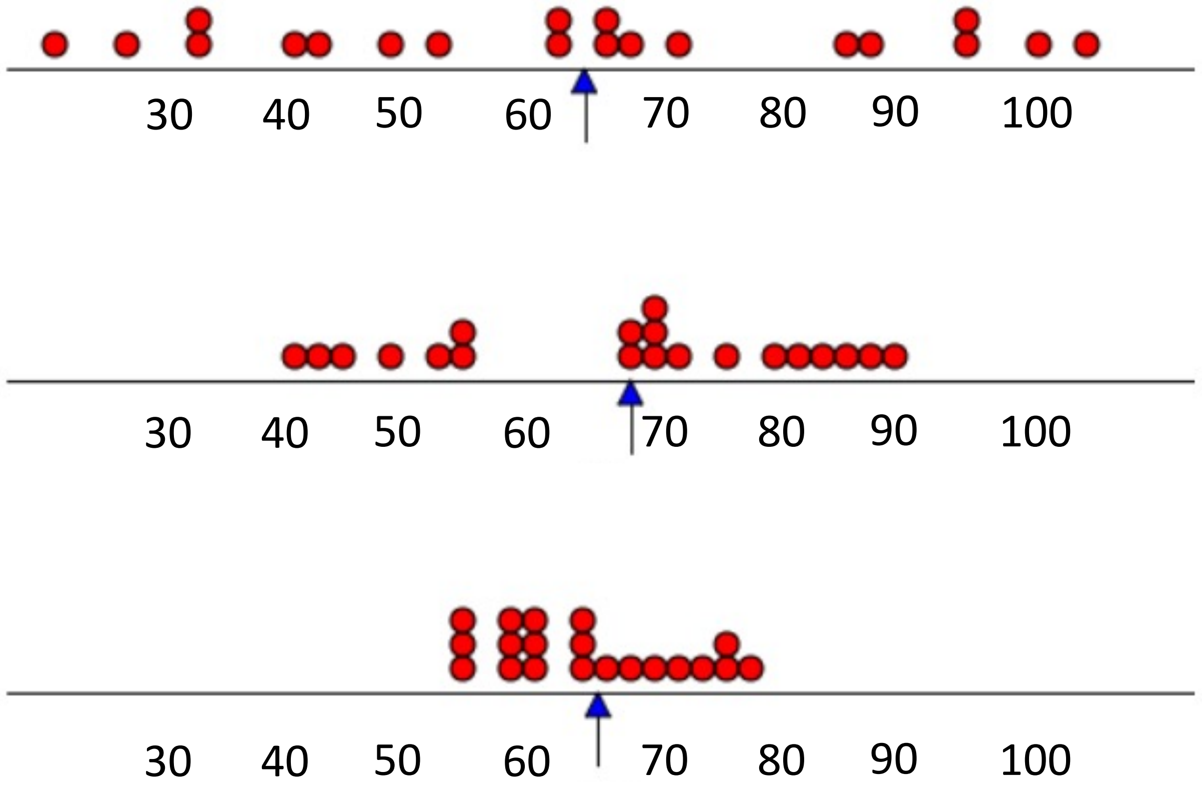
Advances in heart rate variability signal analysis: joint position statement by the e-Cardiology ESC Working Group and the European Heart Rhythm Association co-endorsed by the Asia Pacific Heart Rhythm Society

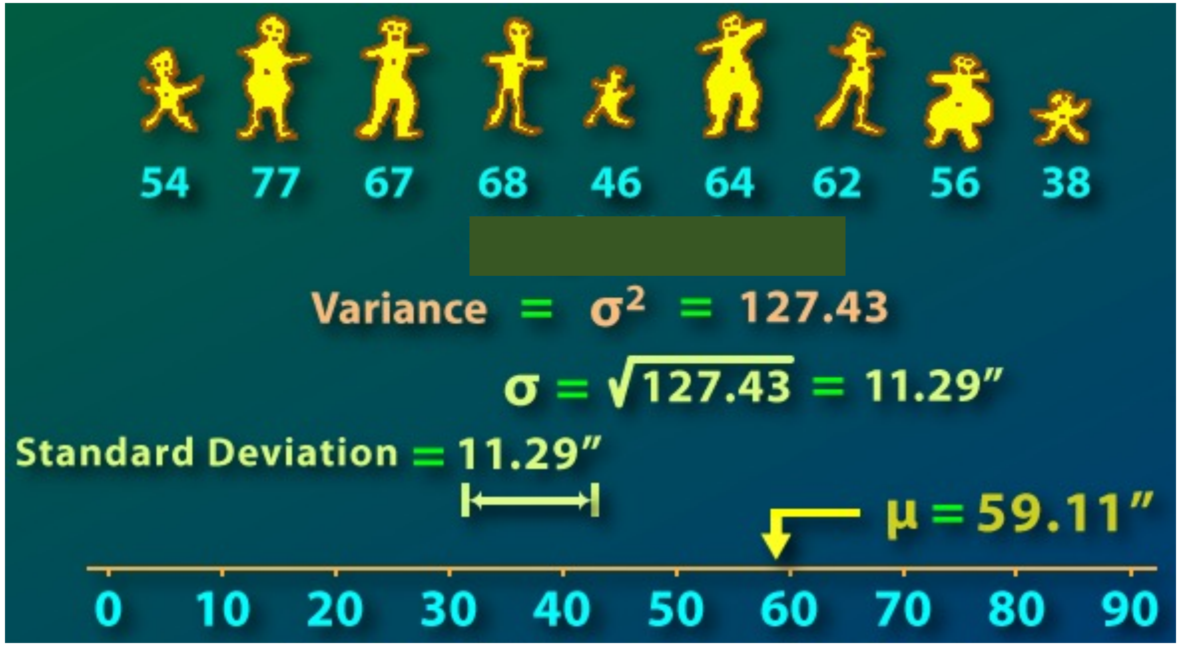
Roberto Sassi[1], Sergio Cerutti[2], Federico Lombardi[3], Marek Malik (Chair of the writing committee)[4*], Heikki V. Huikuri[5], Chung-Kang Peng[6,7], Georg Schmidt[8,9], and Yoshiharu Yamamoto[10]

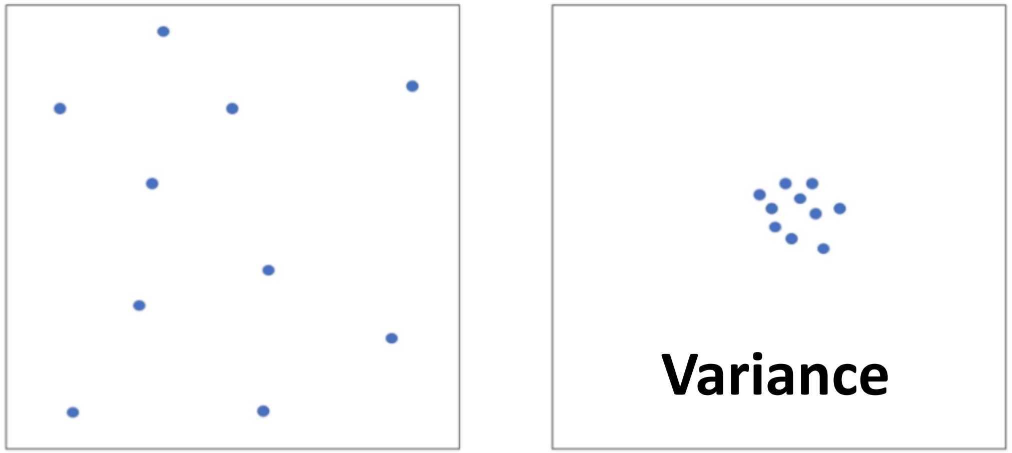
Time domain, statistical measures		
SDNN	ms	Standard deviation of all NN intervals
SDANN	ms	Standard deviation of the averages of NN intervals in all 5-min segments of the entire recording
RMSSD	ms	The square root of the mean of the sum of the squares of differences between adjacent NN intervals
SDNN index	ms	Mean of the standard deviations of all NN intervals for all 5-min segments of the entire recording
SDSD	ms	Standard deviation of differences between adjacent NN intervals
NN50 count		Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording
pNN50	%	NN50 count divided by the total number of all NN intervals

Frequency domain, long-term recordings (24 h)		
Total power	ms^2	Variance of all NN intervals ($\approx \leq 0.4$ Hz)
ULF	ms^2	Power in the ULF range ($f \leq 0.003$ Hz)
VLF	ms^2	Power in the VLF range ($0.003 \leq f \leq 0.04$ Hz)
LF	ms^2	Power in the LF range ($0.04 \leq f \leq 0.15$ Hz)
HF	ms^2	Power in the HF range ($0.15 \leq f \leq 0.4$ Hz)
α		Slope of the linear interpolation of the spectrum in a log–log scale ($f \leq 0.01$ Hz)

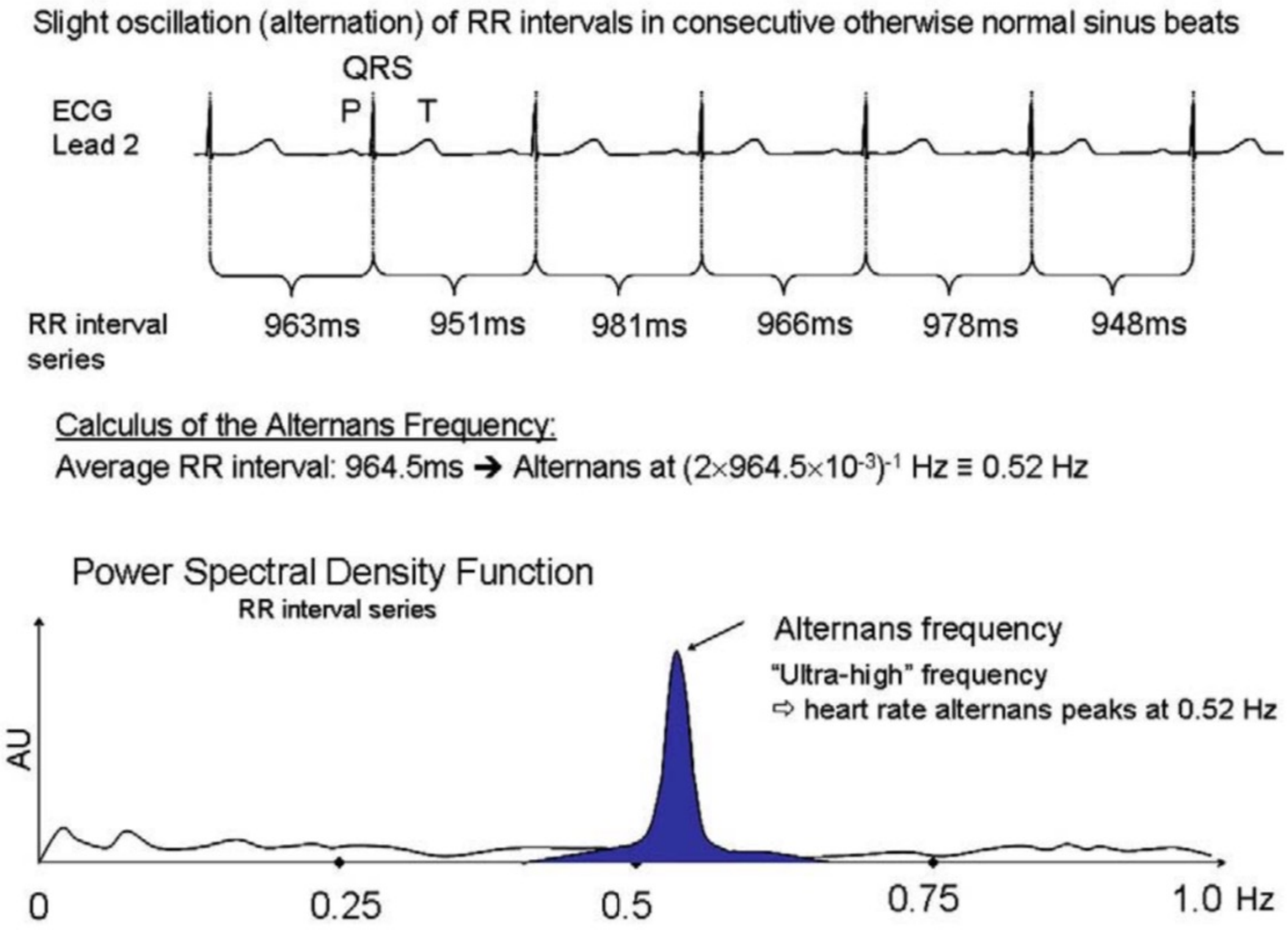
Mean Heart Rate ⊘ Autonomic status





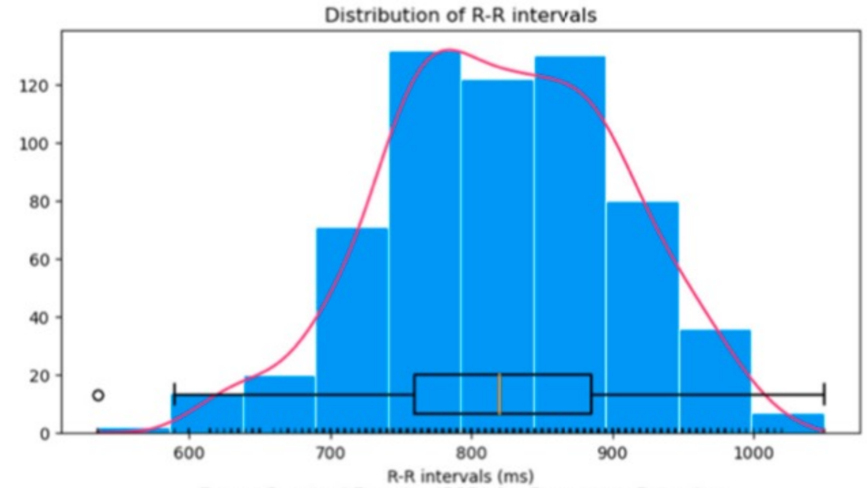


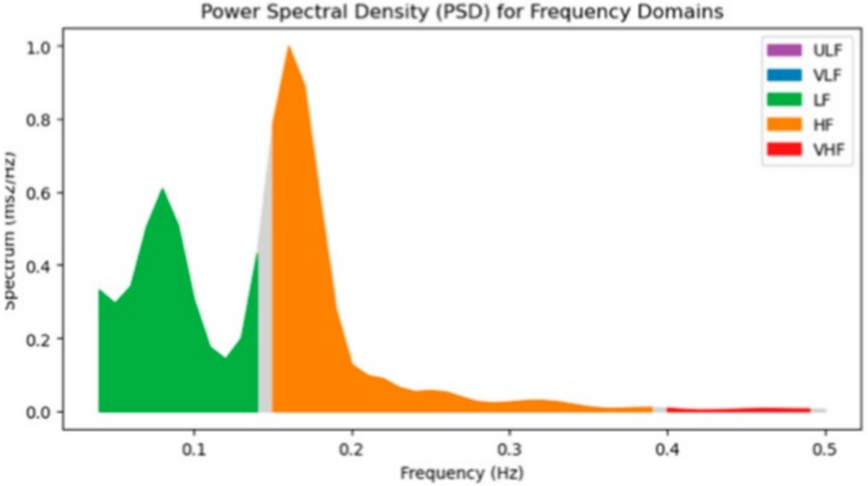
Case Report



Robrto et al IJC 2007

Classical Normal Value on the HRV
Time-, Frequency- domain correlation

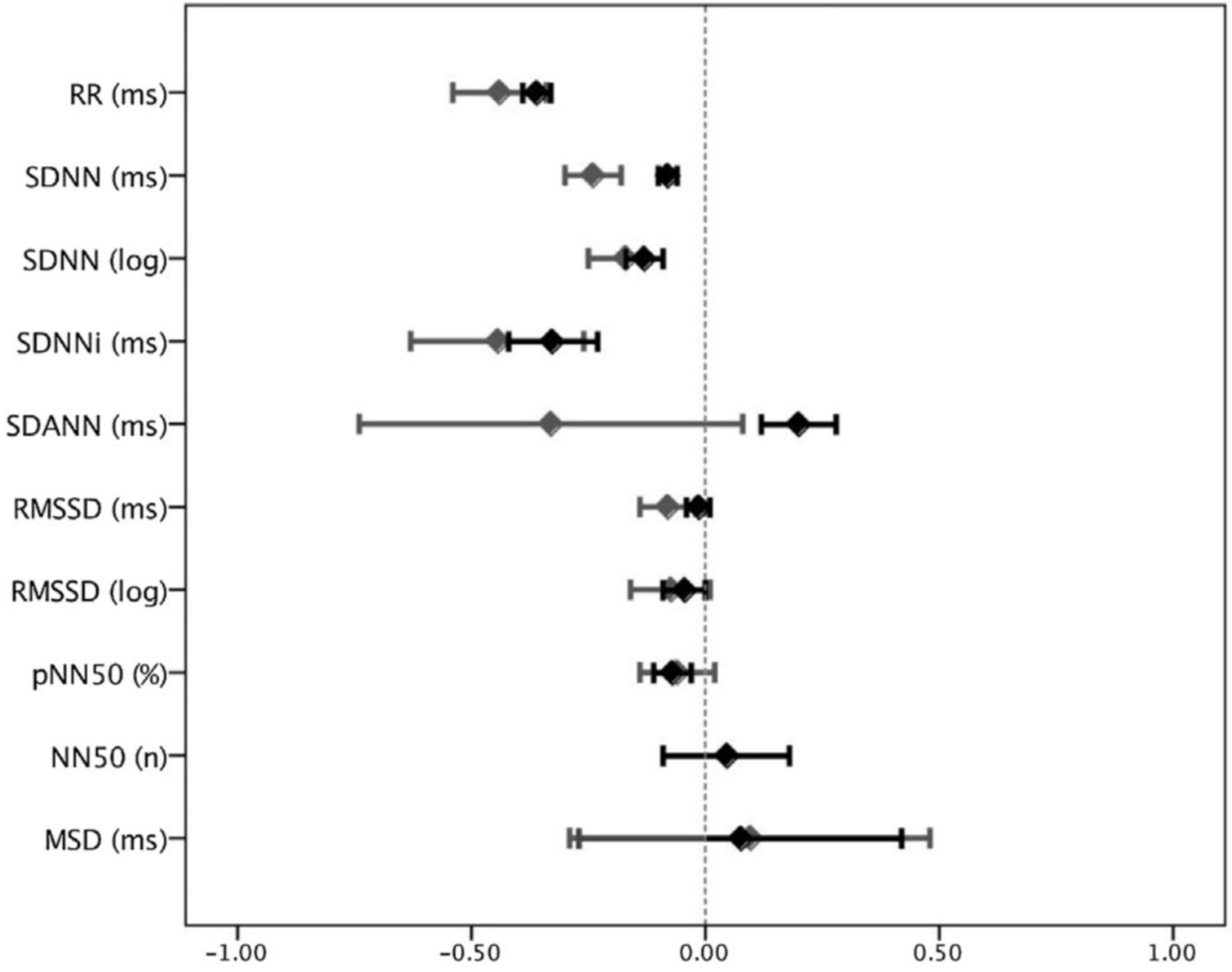


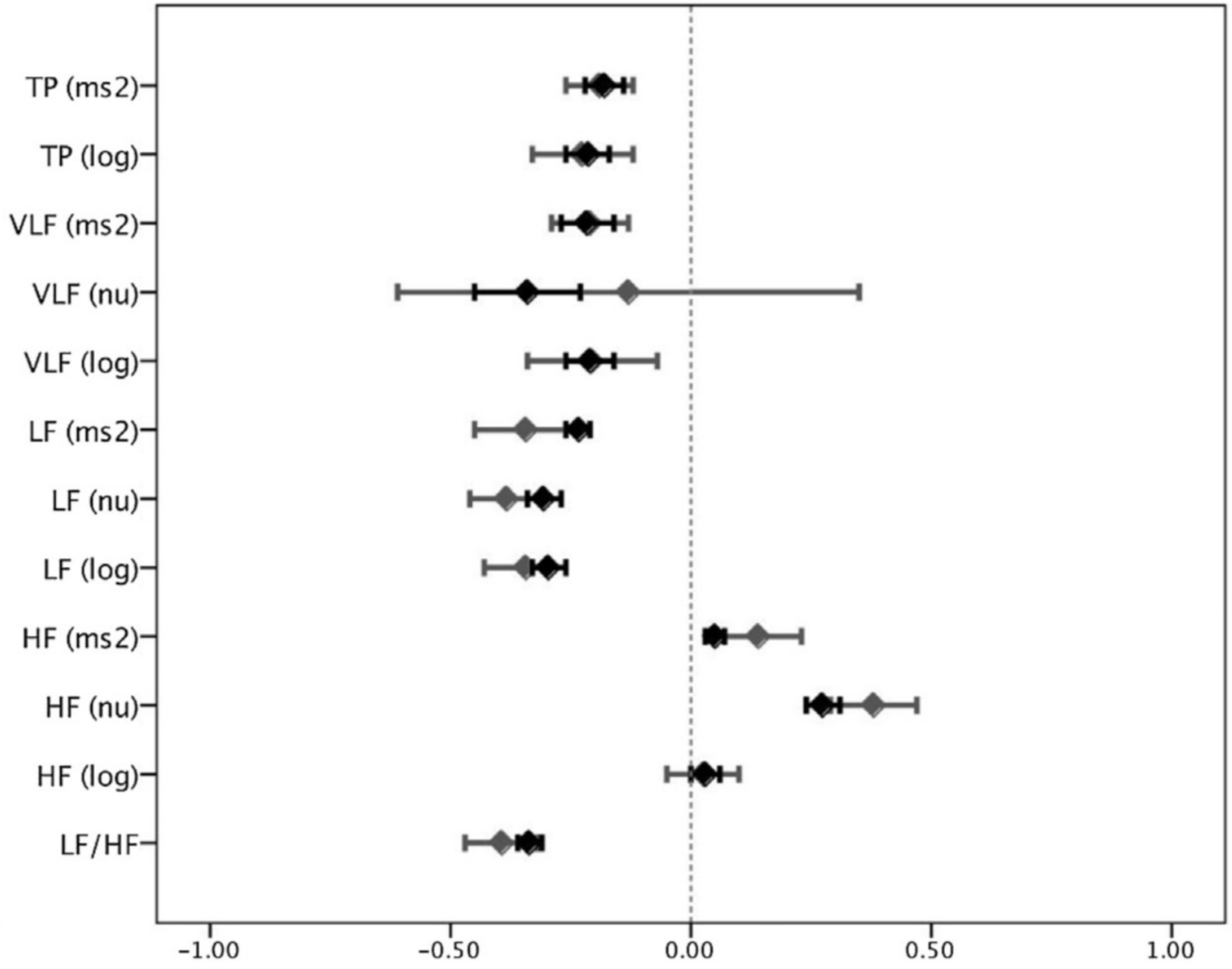


Variable	Units	Normal values (mean ± SD)
Time domain analysis of nominal 24 h[181]		
SDNN	ms	141 ± 39
SDANN	ms	127 ± 35
RMSSD	ms	27 ± 12
HRV triangular index		37 ± 15
Spectral analysis of stationary supine 5-min recording		
total power	ms^2	3466 ± 1018
LF	ms^2	1170 ± 416
HF	ms^2	975 ± 203
LF	n.u.	54 ± 4
HF	n.u.	29 ± 3
LF/HF ratio		1·5–2·0

Pam et al Sensors 2021
HRV Consensus Circulation 1996

Sex difference on the HRV





. Koenig, J.F. Thayer / Neuroscience and Biobehavioral Reviews 64 (2016)

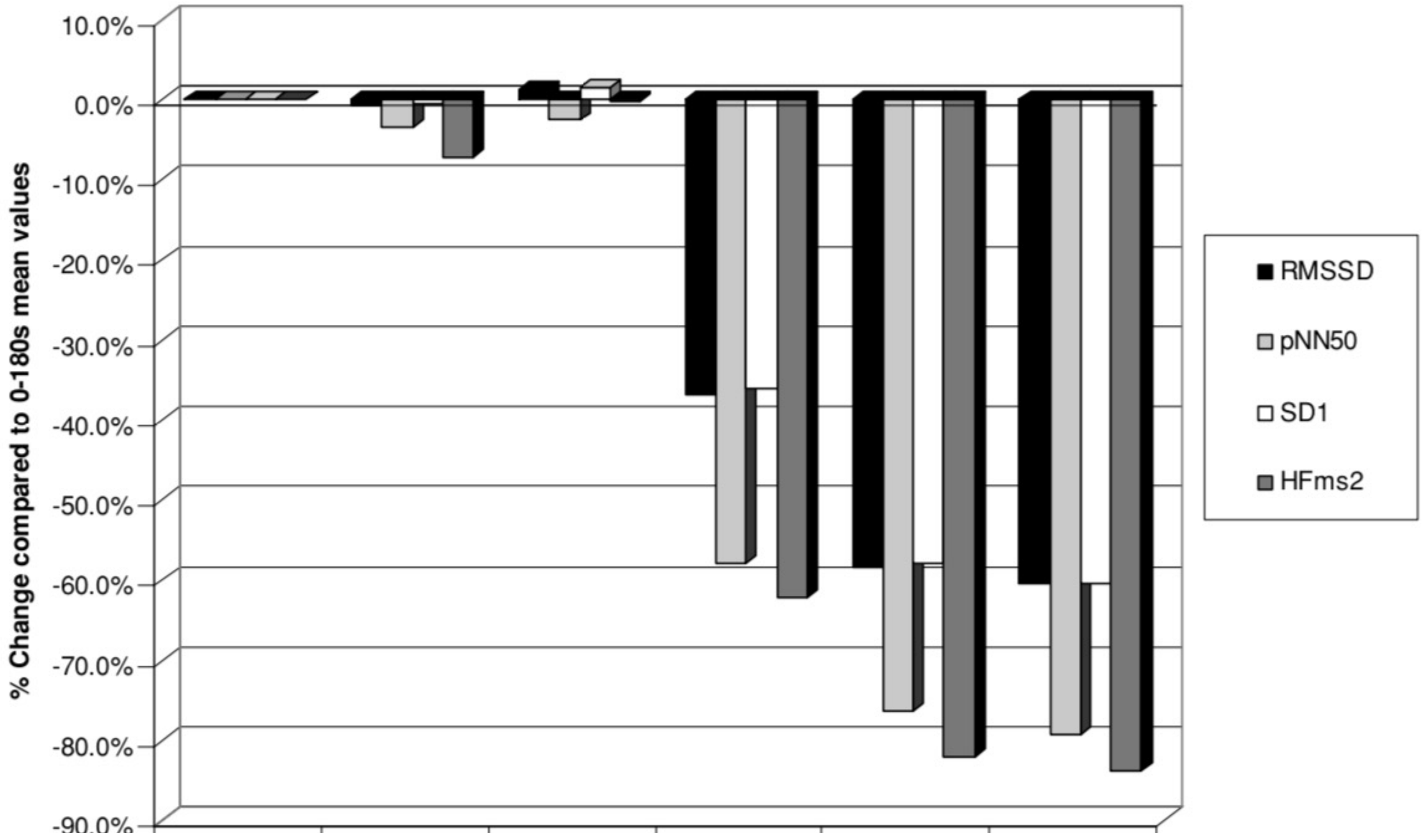
Short-term recording on the HRV

Author and Date	Number of Participants	mRR (ms)	SDNN (ms)	rMSSD (ms)	LF (ms^2)	LFnu	HF (ms^2)	HFnu	LF:HF
Agelink et al.[13] (1998)	69	NR	NR	6.9–99.4	NR	NR	NR	NR	0.29–11.00
Fagard et al.[11] (1998)	587	NR	NR	NR	4–6,397* 1–6,924*	NR	4–10,751* 2–7,513*	NR	NR
Sinnreich et al.[16] (1998)	293	NR	3.39–4.05 ln†	2.88–3.57 ln†	4.63–6.24 ln†	NR	4.07–5.49 ln†	NR	NR
Pikkujämsä et al.[23] (2001)	392	573–1,402	13–168	NR	35–5,941 3.56–8.69 ln	11–98	10–7,231 2.30–8.89 ln	3–72	0.24–17.10
Sucharita et al.[25] (2002)	93	NR	NR	NR	NR	NR	13- 6,830	19–93	NR
Rajendra Acharya[10] et al. (2004) (*mean lower and upper values from three age groups*)	125	NR	41–67	53.6–70.4	NR	NR	NR	NR	1.6–1.9
Kurosawa et al.[45] (2007)	66	NR	NR	NR	86–1,874‡	NR	98–3,938‡	NR	NR

*Value is geometric; †Values are 25^{th}–75^{th} percentile; ‡Values are 5 and 95 percentiles; NR = not reported; mRR = mean RR interval; SDNN = standard deviation of normal-to-normal intervals; rMSSD = root mean square of successive differences; LF = low-frequency spectral power; HF = high-frequency spectral power; LF:HF = ratio of low-frequency power to high-frequency power; nu = normalized units; ln = natural logarithm.

Nunan et al PACE 2010

HRV on the Supine and standing Position



	0-180s	180-360s	360-540s	600-780s	780-960s	960-1140s
	Supine			Standing		
RMSSD	0.0%	-0.7%	1.2%	-36.9%	-58.3%	-60.4%
pNN50	0.0%	-3.4%	-2.6%	-57.9%	-76.4%	-79.3%
SD1	0.0%	-0.4%	1.6%	-36.1%	-58.0%	-60.3%
HFms2	0.0%	-7.2%	-0.2%	-62.2%	-81.9%	-83.7%

Tachogram interval (s)

Grant et al. Ann Noninvasive Electrocardiol 2011

Recent HRV value on the healthy person

			5th	95th	Regression analysis with age as co-variable	Gender-related difference
SDANN [ms]	M	20-30	**95.06**	**232.19**		p < 0.001
		30-40	**94.91**	**221.53**	-1.336***	
		40-50	**77.64**	**184.38**	(r^2 = 0.122)	
		50-60	**66.24**	**172.74**		
	F	20-30	**84.03**	**213.85**		
		30-40	**69.93**	**182.48**	-0.894***	
		40-50	**72.92**	**168.91**	(r^2 = 0.094)	
		50-60	**67.74**	**163.92**		

			5th	95th	Regression analysis with age as co-variable	Gender-related difference
RMSSD [ms]	M	20-30	**24.84**	**100.02**		p = 0.014
		30-40	**21.97**	**74.33**	-0.798***	
		40-50	**18.25**	**66.75**	(r^2 = 0.181)	
		50-60	**14.66**	**56.18**		
	F	20-30	**22.37**	**89.81**		
		30-40	**20.16**	**71.14**	-0.717***	
		40-50	**15.48**	**53.27**	(r^2 = 0.216)	
		50-60	**15.94**	**54.46**		

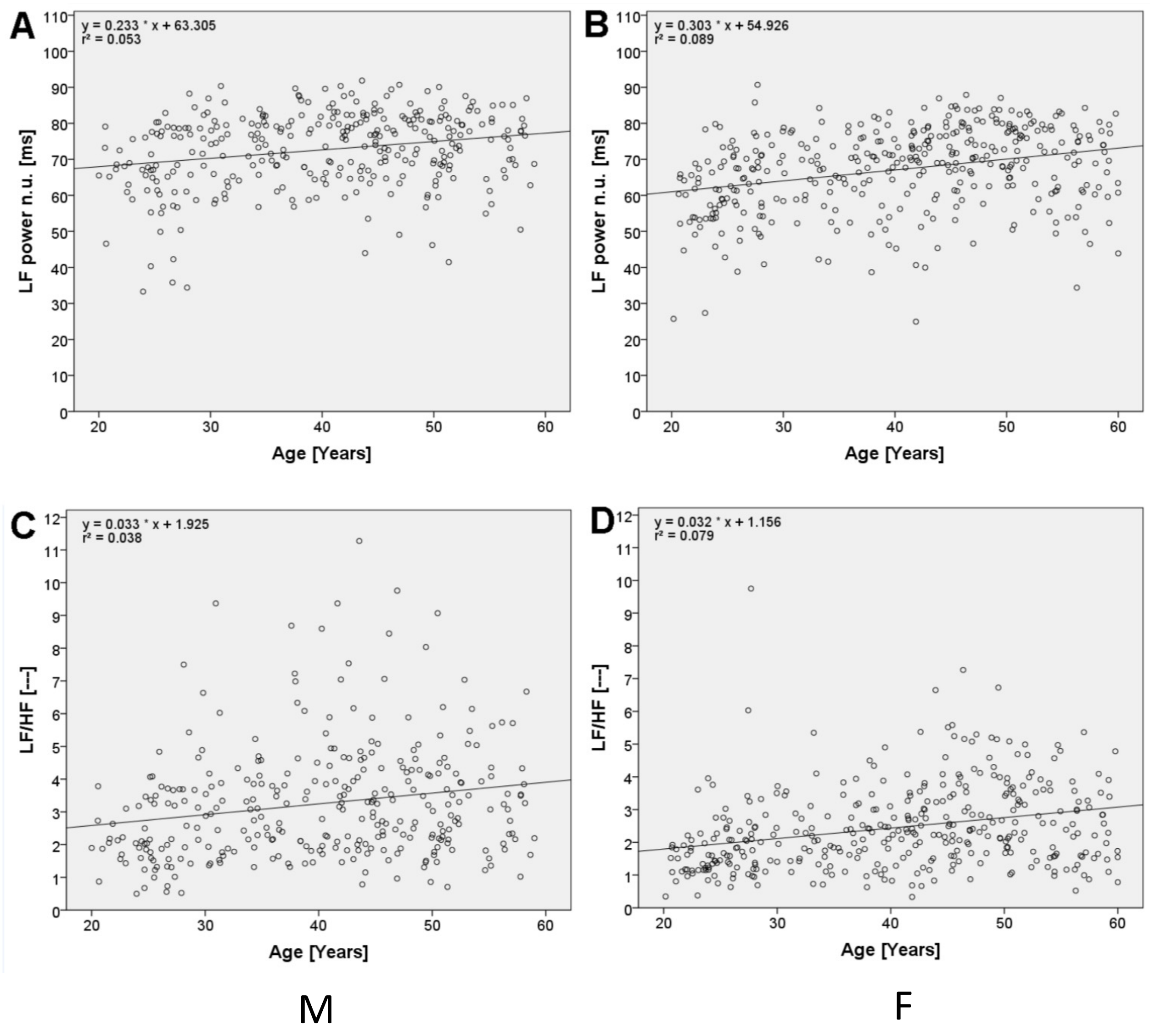
Sammito et al Heart Rhythm 2016

			5th	95th	Regression analysis with age as co-variable	Gender-related difference
LFnu [---]	M	20-30	**38.51**	**83.59**		**$p < 0.001$**
		30-40	**58.40**	**87.58**	0.233***	
		40-50	**57.49**	**89.27**	($r^2 = 0.053$)	
		50-60	**56.25**	**86.54**		
	F	20-30	**42.57**	**78.38**		
		30-40	**45.42**	**81.38**	0.303***	
		40-50	**45.99**	**84.48**	($r^2 = 0.089$)	
		50-60	**49.74**	**82.87**		

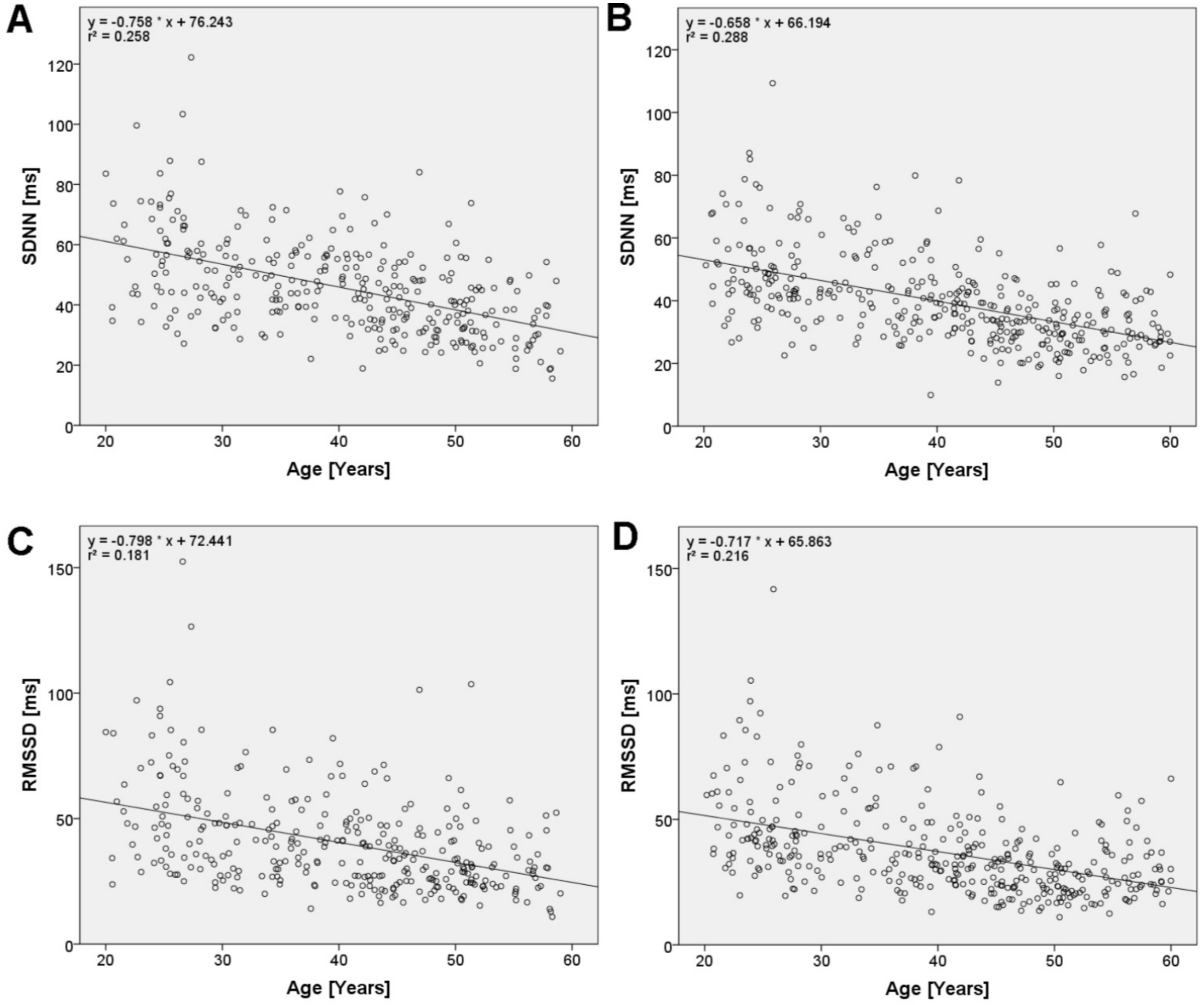
			5th	95th	Regression analysis with age as co-variable	Gender-related difference
HFnu [---]	M	20-30	**16.41**	**61.49**		**$p < 0.001$**
		30-40	**12.42**	**41.60**	-0.233***	
		40-50	**10.73**	**42.51**	($r^2 = 0.053$)	
		50-60	**13.46**	**43.75**		
	F	20-30	**21.62**	**57.43**		
		30-40	**18.62**	**54.58**	r =- 0.303***	
		40-50	**15.52**	**54.01**	($r^2 = 0.089$)	
		50-60	**17.13**	**50.26**		

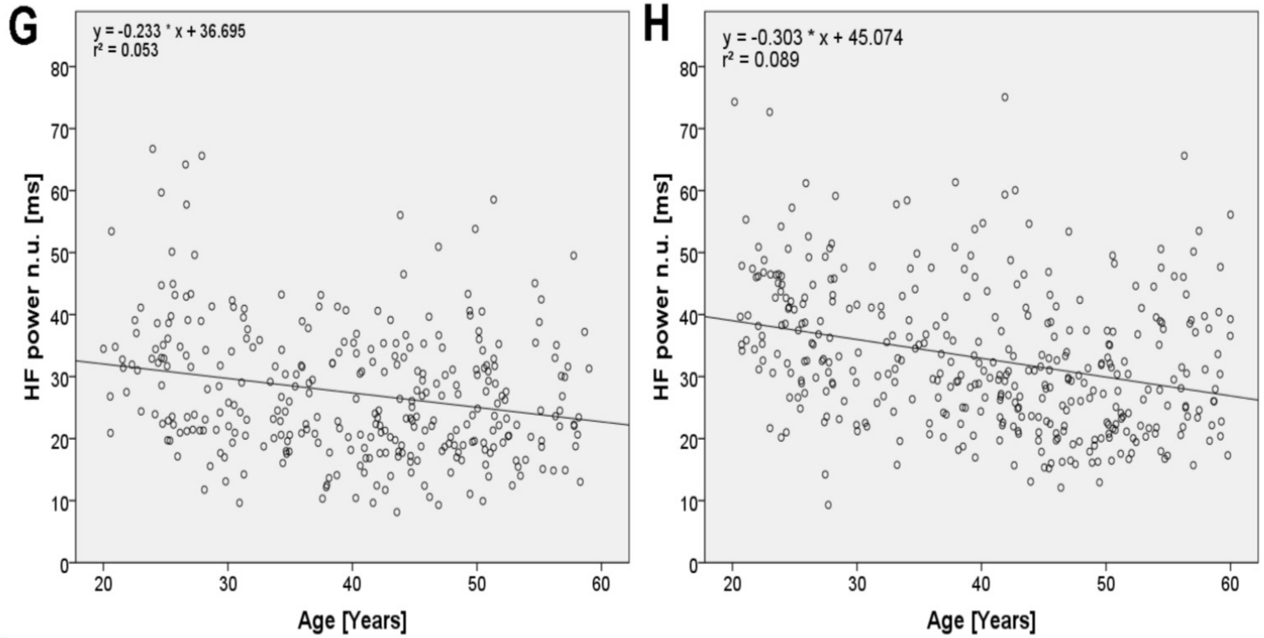
Sammito et al Heart Rhythm 2016

			5th	95th	Regression analysis with age as co-variable	Gender-related difference
LF/HF [---]	M	20-30	**0.63**	**5.10**	0.033*** ($r^2 = 0.038$)	**$p < 0.001$**
		30-40	**1.40**	**7.06**		
		40-50	**1.35**	**8.32**		
		50-60	**1.29**	**6.44**		
	F	20-30	**0.74**	**3.63**	0.032*** ($r^2 = 0.079$)	
		30-40	**0.83**	**4.37**		
		40-50	**0.85**	**5.44**		
		50-60	**0.99**	**4.84**		



Sammito et al Heart Rhythm 2016





M

F

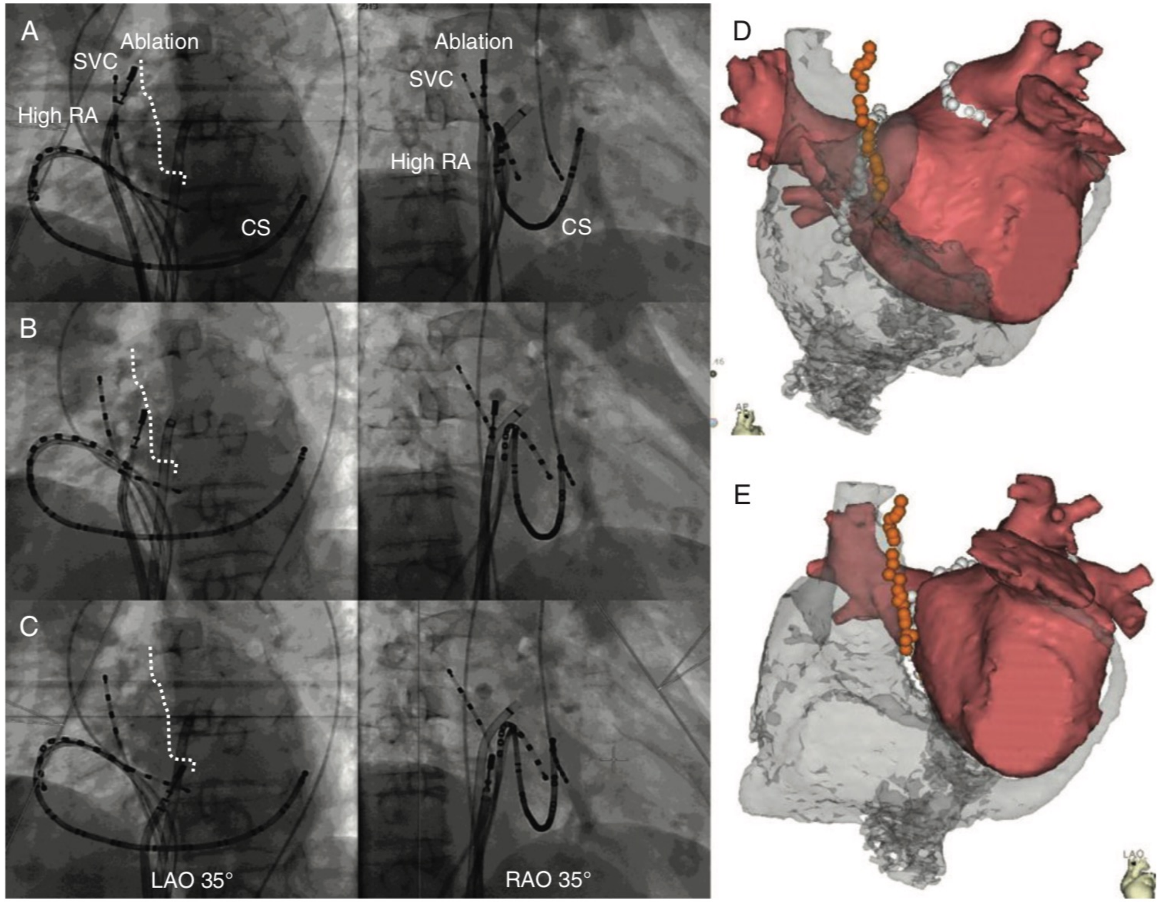
Sammito et al Heart Rhythm 2016

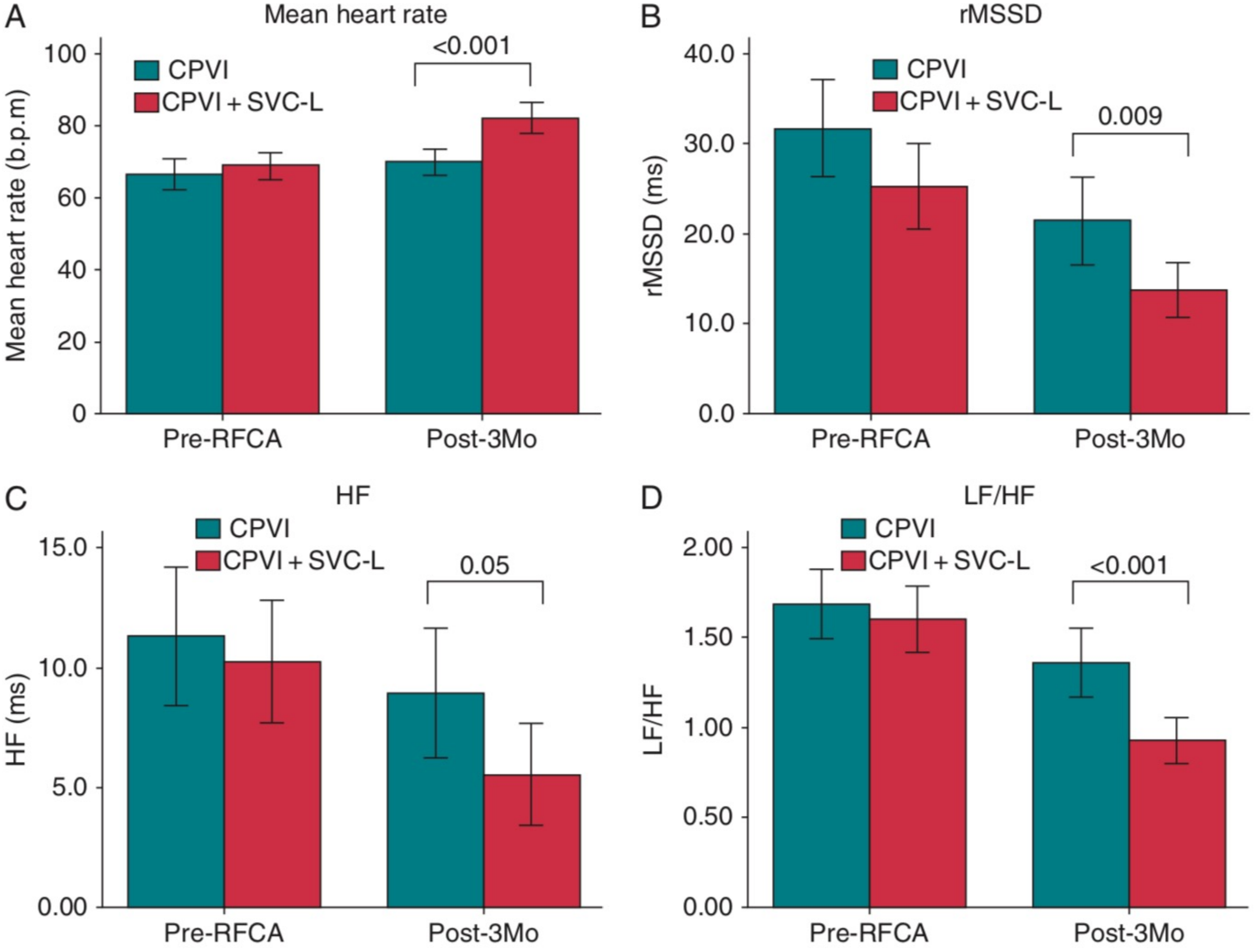
Utility of HRV on the AMI and HF

Authors	Population/size	Type of study	Follow-up period	Predictive results
Bigger et al. [49].	Post-MI/715 patients	Prospective	4 years	Total, ULF, and VLF power have strong association with mortality
La Rovere et al. [41].	Post-MI/1284 patients	Prospective	21 ± 8 months	Depressed HRV (SDNN < 70) was a strong predictor of cardiac mortality independently of LVEF and of ventricular arrhythmias
Stein et al. [36].	Post-MI/769 patients	Retrospective	–	Decreased HRV did not predict mortality for the entire study group. In CABG subgroup, decreased HRV was not associated with increased mortality. In patients without CABG or diabetes, decreased SDANN predicted mortality.
Malik et al. [37].	Post-MI/1216 patients	Retrospective	–	Patients with LVEF ≤ 40% and depressed HRV (SDNN < 50, HRV index < 20) benefit from prophylactic antiarrhythmic treatment with amiodarone.
La Rovere et al. [42].	Post-MI/1071 patients	Prospective	21 ± 8 months	Depressed HRV (SDNN < 70) was associated with increased mortality.
Hohnloser et al. [8].	Post-MI/674 patients	Prospective	30 ± 13 months	Decreased SDNN (with poor LVEF) did not demonstrate its usefulness in identifying post-MI patients at risk of increased mortality for ICD.
Camm et al. [9]	Post-MI/3717 patients	Prospective	1 year	Low HRV had a higher 1-year mortality than high HRV patients.
Nolan et al. [59].	CHF/433 patients	Prospective	482 ± 161 days	Reduced SDNN was a strong predictor of mortality due to progressive heart failure.
La Rovere et al. [60].	CHF/202 patients	Retrospective	–	Reduced short-term LF power during controlled breathing was a strong predictor of sudden death in CHF patients.
Aronson et al. [62].	Decompensated CHF/199 patients	Prospective	312 ± 150 days	SDNN, SDANN, total power, and ULF power were useful as predictors of survival after hospital discharge.
Anastasiou-Nana et al. [61].	CHF secondary to ischemic or idiopathic dilated cardiomyopathy/52 patients	Prospective	2 years	HRV parameters were not associated with all-cause mortality.

Chattipakon et al IJC 2007

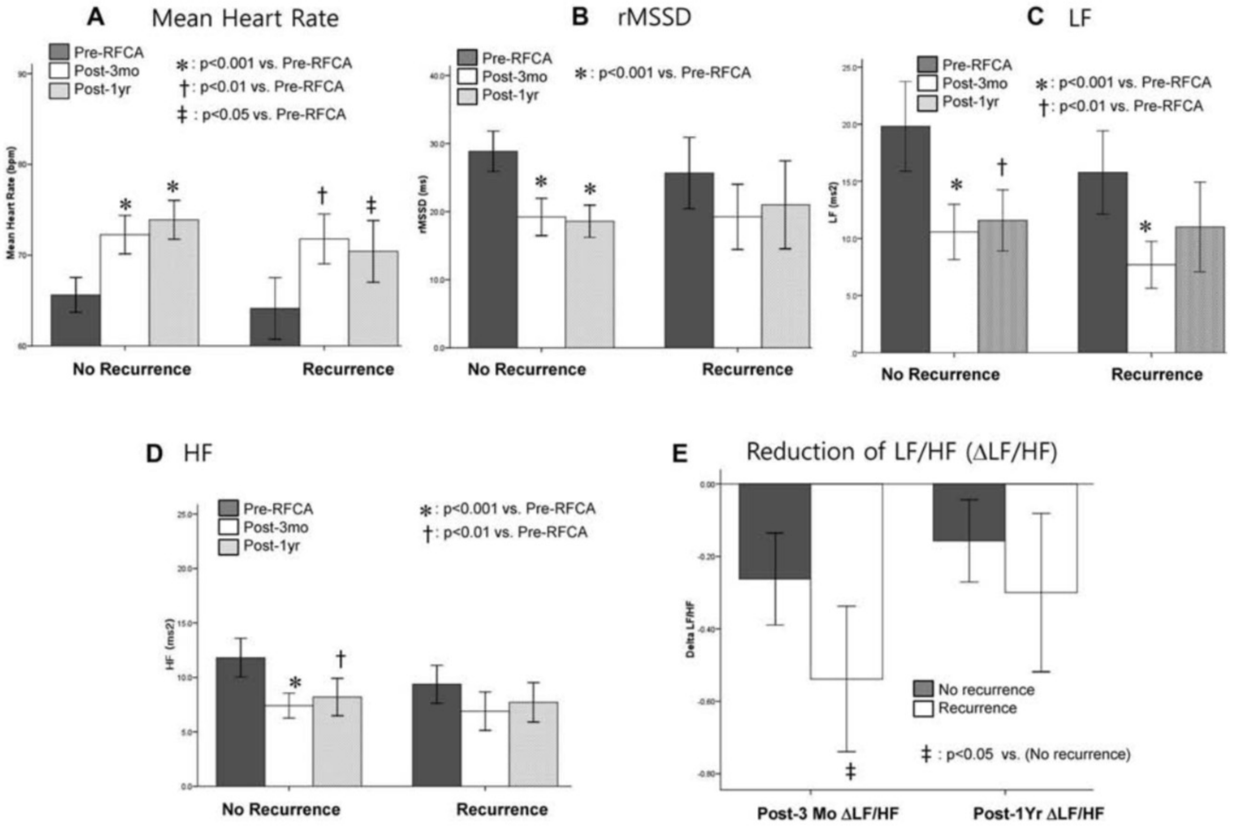
HRV difference on the post-RFCA in PAF

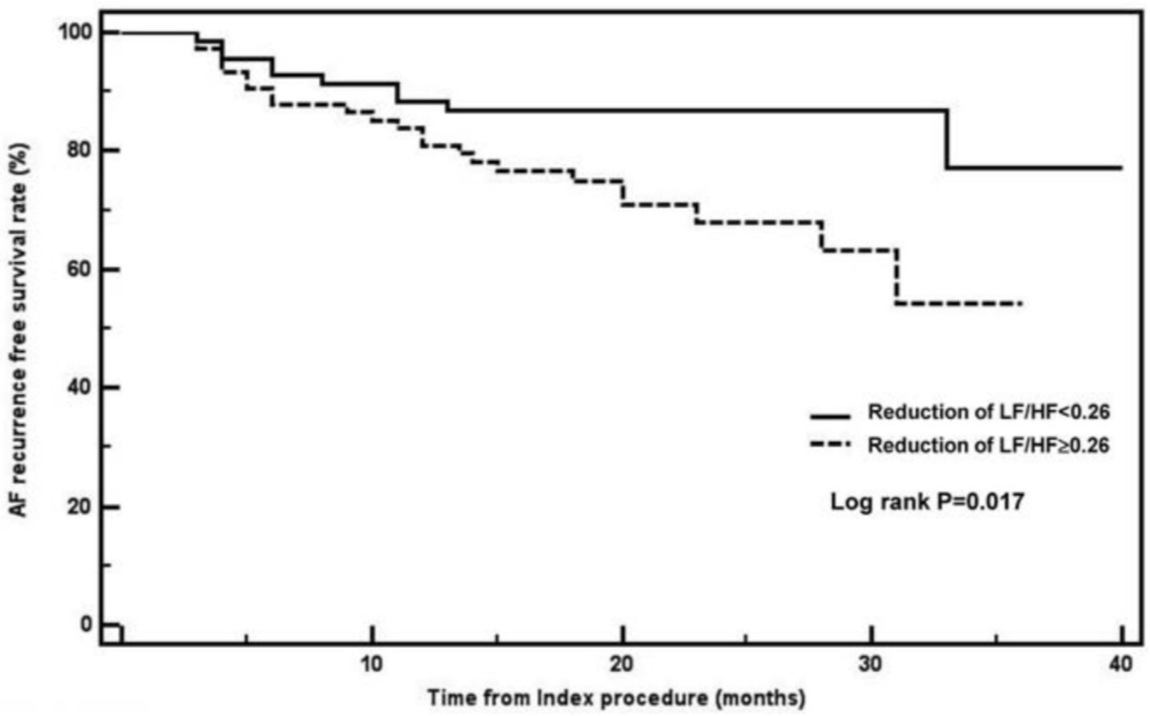




Kang KW et al Europace 2014

HRV on the Recurrence at the post-RFCA





Reduction of LF/HF < 0.26	70	62	44	12	0
Reduction of LF/HF ≥ 0.26	74	62	29	7	0

Kang KW et al JCE 2015

요 약

- 자율신경 (교감 및 부교감 신경) 상태를 반영하는 질환에서 HRV 가 유용하며 많은 질환에서 적응증이된다.
- HRV 지표는 통계적 및 수학적으로 Time-domain, Frequency-domain 으로 다양하게 환산할 수 있다.
- HRV 는 나이, 성별, 자세, 호흡 및 기록 시간에 따라서 달라 질 수 있다.
- HRV short-term 기록은 최소 5분은 되어야 되며, 아직 기준 자료 다양하다.
- HRV 지표는 임상적으로 심장 질환 뿐만 아니라 비심장 질환에서 많이 활용되고 있다.