2023-12-16 KSHNE

12-lead ECG에서 관찰될 수 있는 여러 질환들의 마커와 그 임상적 의미

서울대학교병원 순환기내과 권순일

SNUH 서울대학교병원
SEOUL NATIONAL UNIVERSITY HOSPITAL

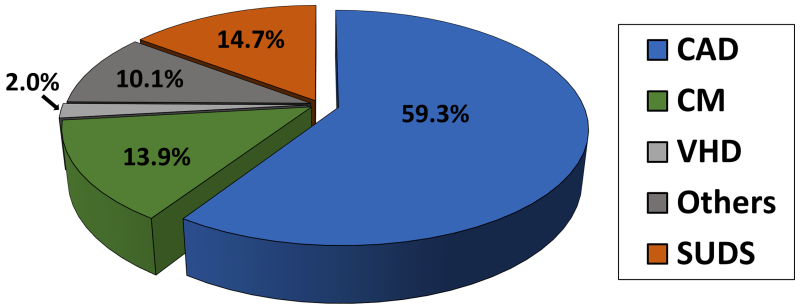
Contents

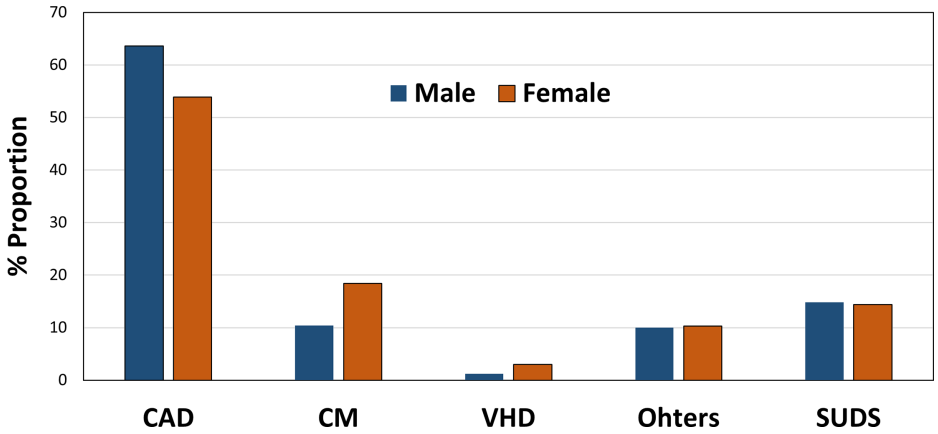
- Introduction
  - Causes of SCA and IA in Korea
- Traditional ECG markers for SCA
  - Fragmented QRS complex
  - Short-coupled PVC
  - Brugada syndrome
  - Early repolarization syndrome / J-wave syndrome
- Summary

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Causes of sudden cardiac arrest in Korea

- 2002~2013 Korean SCA data from NHIS database
- SCA incidence: 16.1 per 100,000 PY



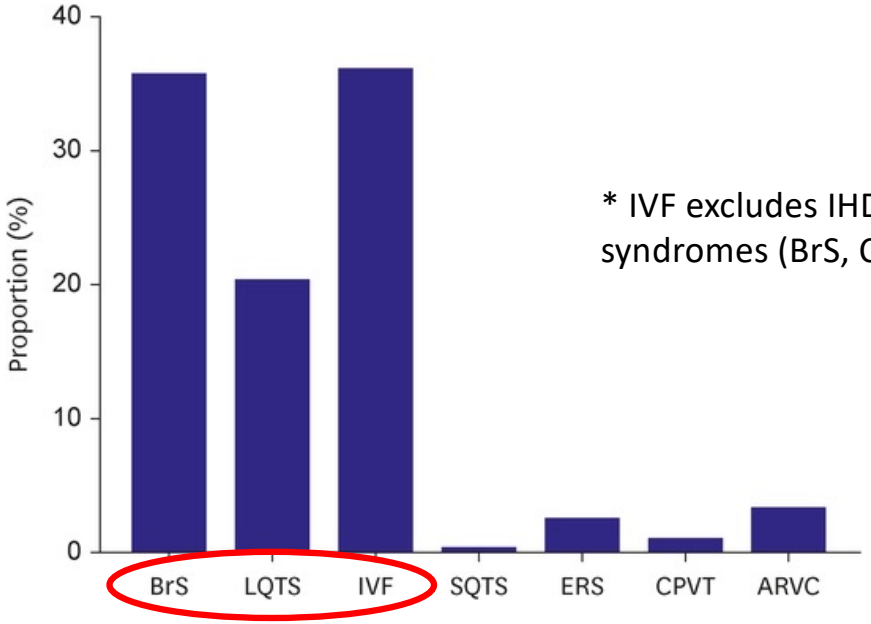


* SUDS: sudden unexplained death syndrome
Roh SY et al. PLoS One. 2020 Nov 25;15(11):e0242799

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Inherited arrhythmias in Korean

- 2014~2017 Korean IA Registry
- NGS performed in 265 IA probands



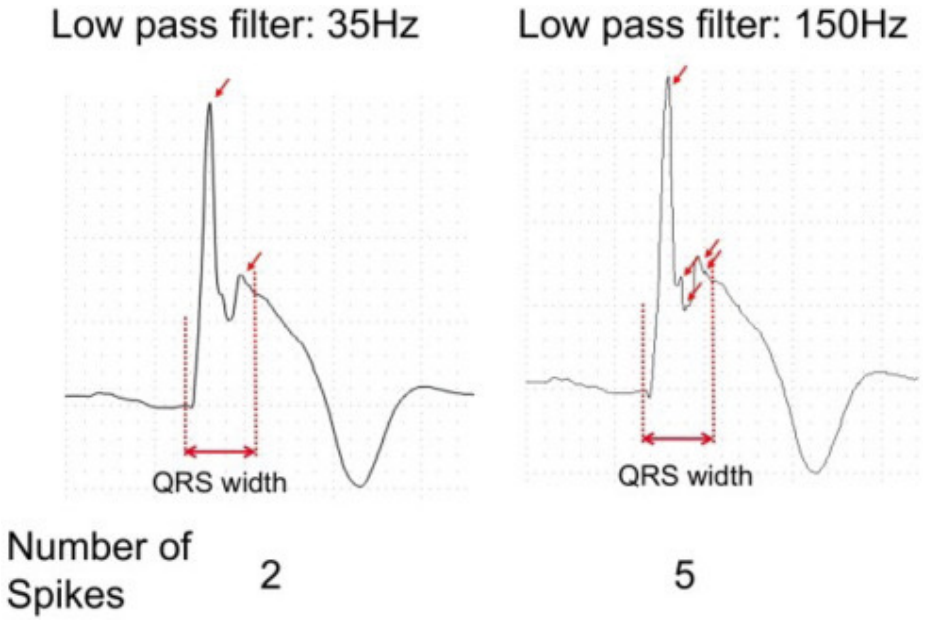
* IVF excludes IHD, SHD, and primary arrhythmia syndromes (BrS, CPVT, LQT, SQT, ERS …)

Jeong JH, et al. Korean Circ J. 2023 Oct;53(10):693-707

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Fragmented QRS: *impact of bandpass filter setting*

- Usual 12-lead ECG setting
  - High-pass filter: 0.05–20 Hz
  - Low-pass filter: 100–150 Hz
  - AC filter: 50 or 60 Hz

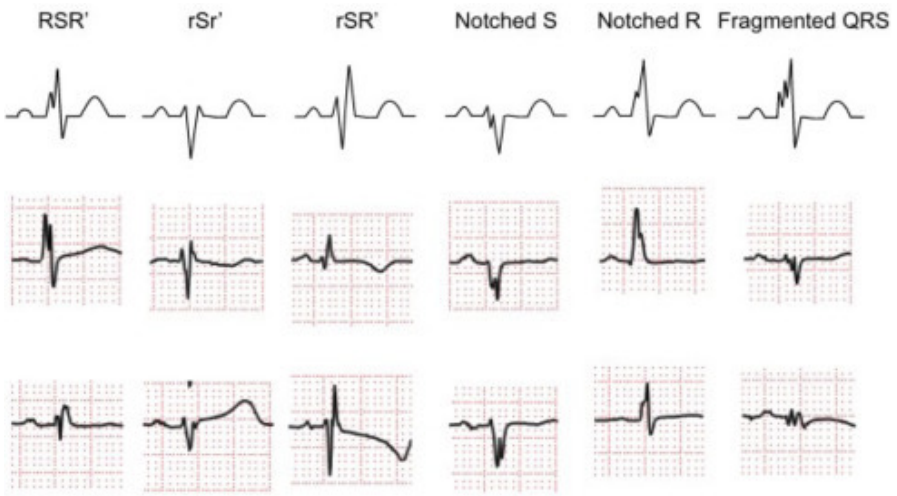


Take Y, et al. Indian Pacing Electrophysiol J. 2012 Sep;12(5):213-25

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Fragmented QRS: *definition*

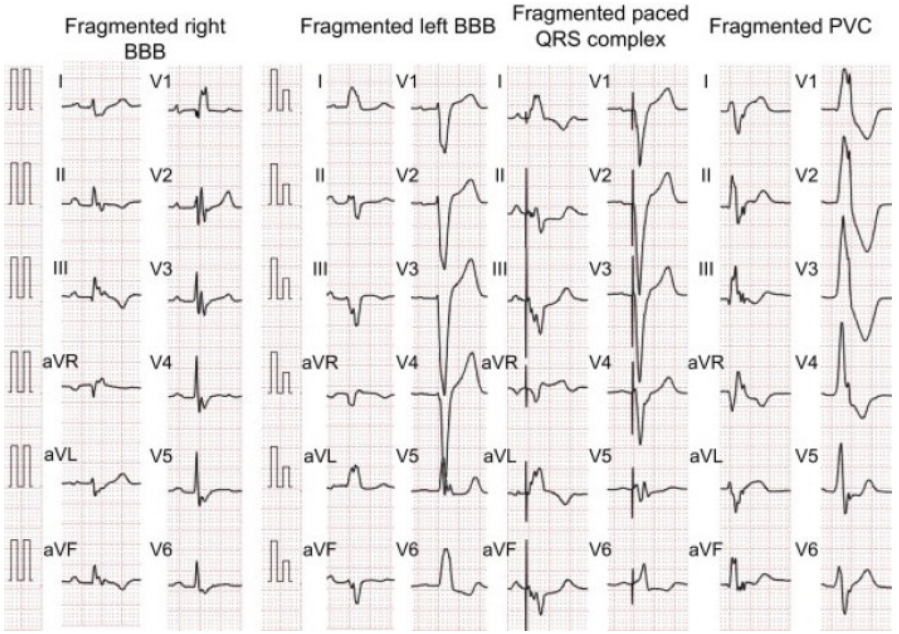
<Narrow QRS complex>



- Additional R wave (R′)
- Notching in S wave or R wave
- Presence of more than one R′(fragmentation) in two contiguous leads

Take Y, et al. Indian Pacing Electrophysiol J. 2012 Sep;12(5):213-25
Das MK, et al. Circulation. 2006 May 30;113(21):2495-501
Das MK, et al. Circ Arrhythm Electrophysiol. 2008 Oct;1(4):258-68

<Wide QRS complex>



- > 2 R′ waves or notches in the R or S wave in a wide QRS complex of BBB, or paced QRS, or PVC in 2 contiguous leads
- If PVC only has 2 notches in the R waves, fQRS-positive when the notches were > 40 ms apart and present in 2 contiguous leads

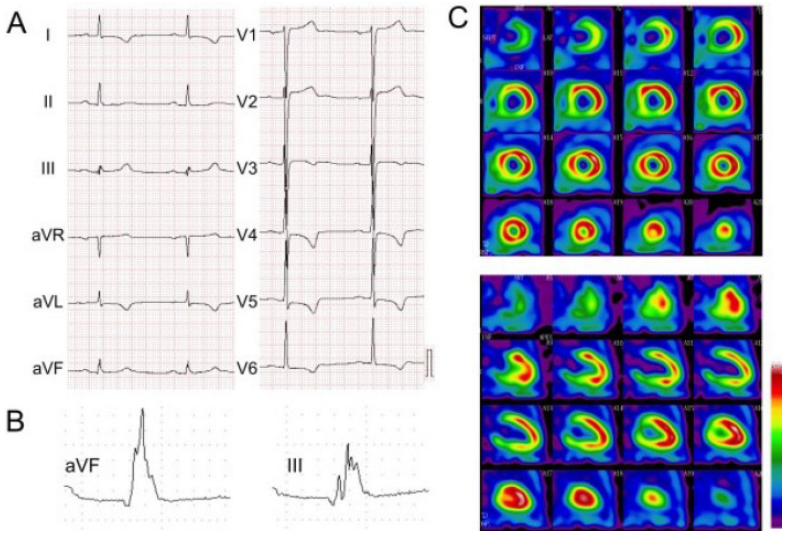
Fragmented QRS: *mechanism*

Myocardial scar
Intracardiac conduction abnormality

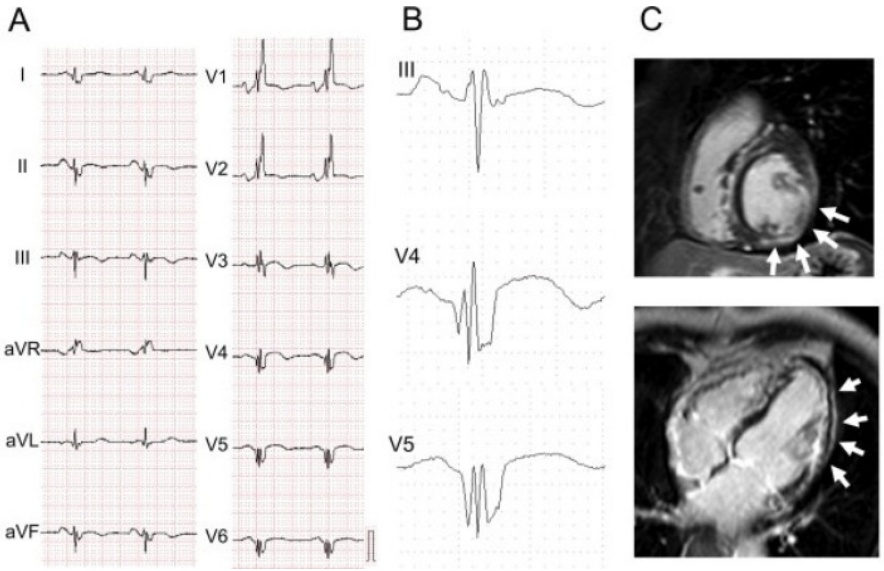
→

Substrate for ventricular arrhythmia

<MI with inferior perfusion defect>



<DCM with inferolateral LGE >

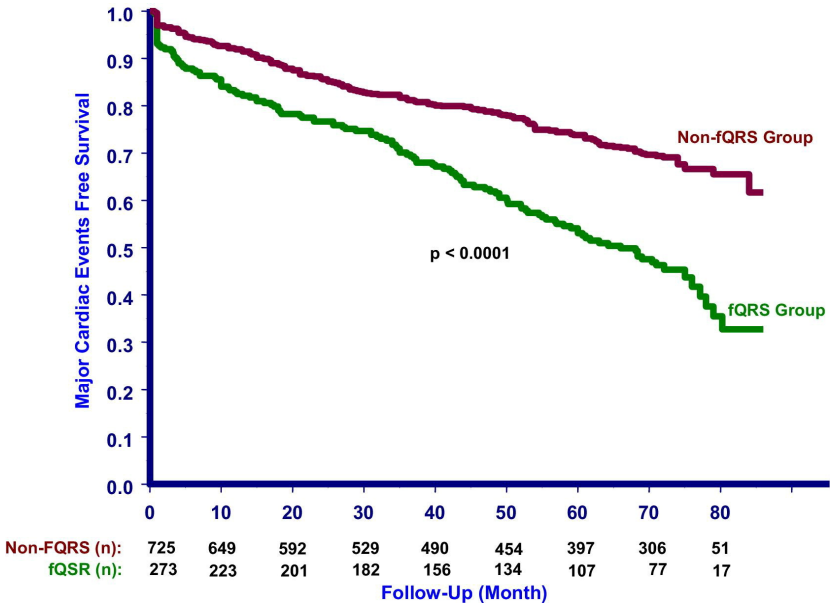


Take Y, et al. Indian Pacing Electrophysiol J. 2012 Sep;12(5):213-25

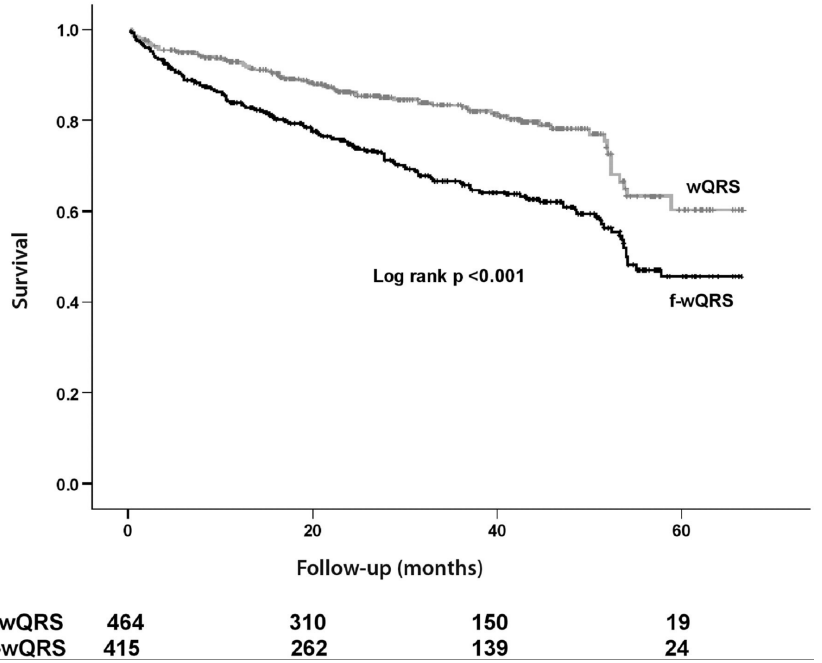
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Fragmented QRS: *clinical impact*

<MI: Narrow QRS complex>



<MI: Wide QRS complex>

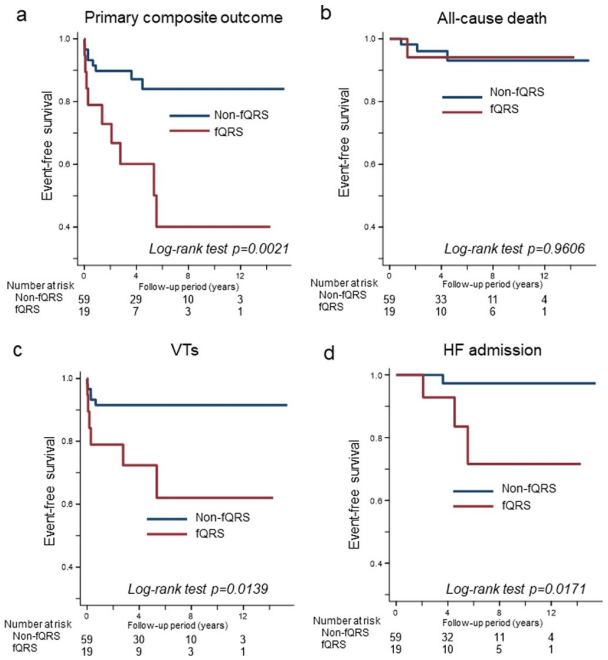


Das MK, et al. Circulation. 2006 May 30;113(21):2495-501
Das MK, et al. Heart Rhythm. 2007 Nov;4(11):1385-92
Das MK, et al. Circ Arrhythm Electrophysiol. 2008 Oct;1(4):258-68

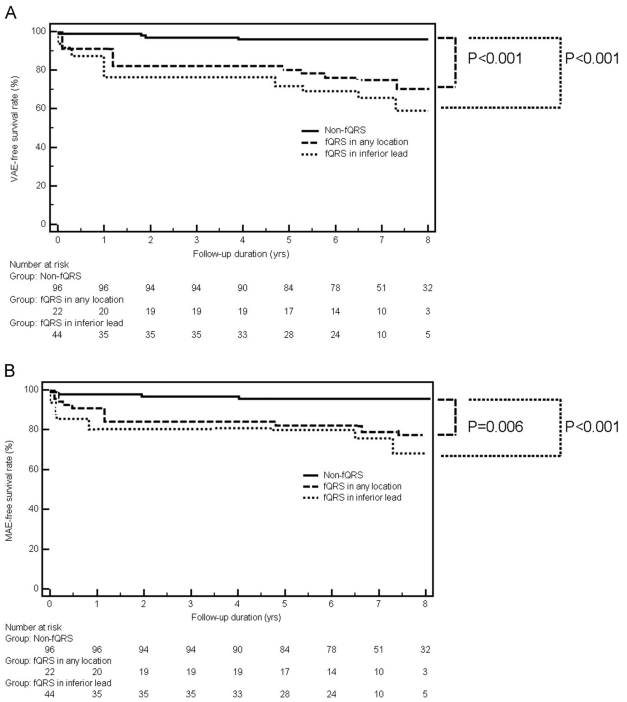
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Fragmented QRS: *clinical impact*

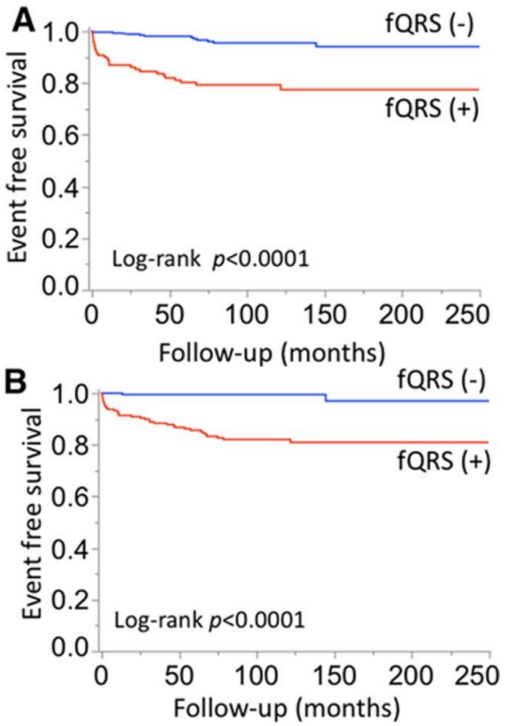
<Cardiac sarcoidosis>



<HCM>



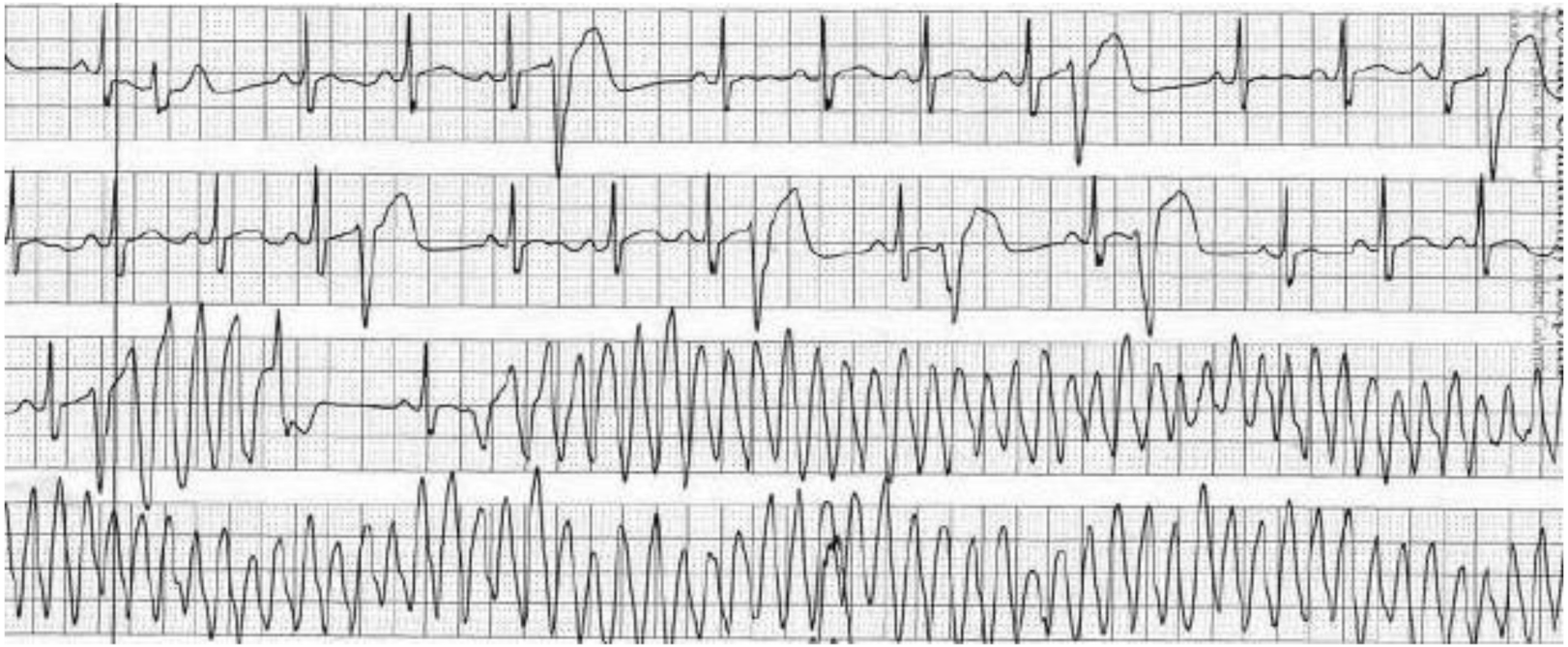
<BrS>



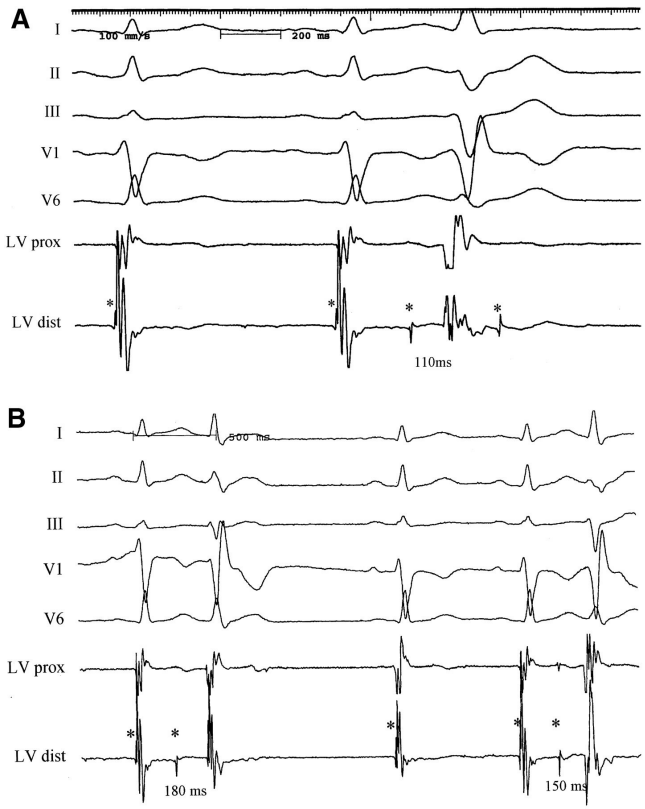
Hagiwara H, et al. Heart Vessels. 2023 Jun;38(6):803-816
Morita H, et al. Circ Arrhythm Electrophysiol. 2017 Mar;10(3):e004765
Kang KW, et al. Heart Rhythm. 2014 Aug;11(8):1433-40

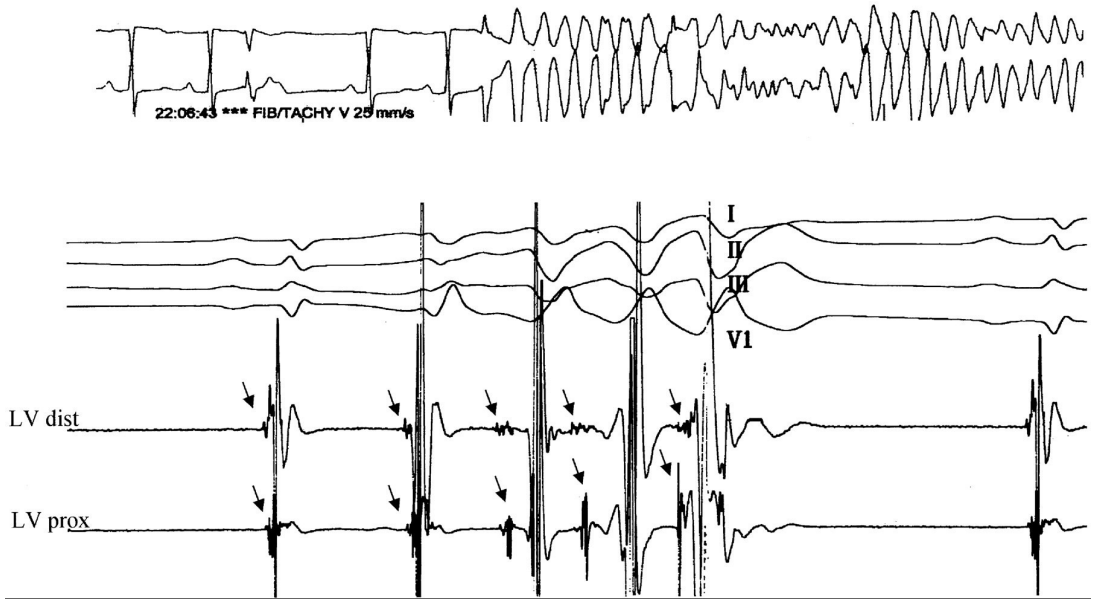
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Short-coupled PVC



Short-coupled PVC: *scPVC-induced VT/VF, mechanism*

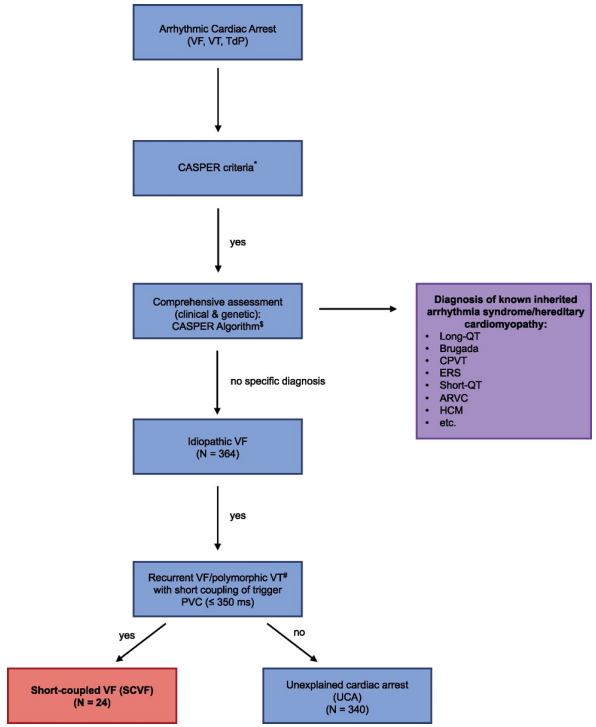




Haïssaguerre M, et al. Circulation. 2002 Aug 20;106(8):962-7

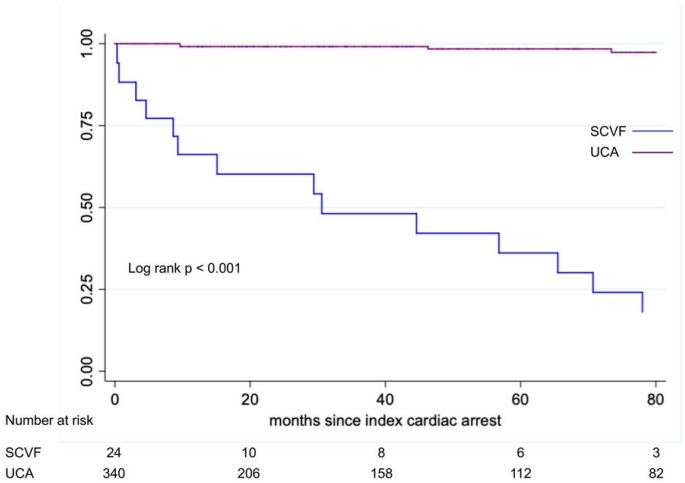
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Short-coupled PVC: *clinical significance*

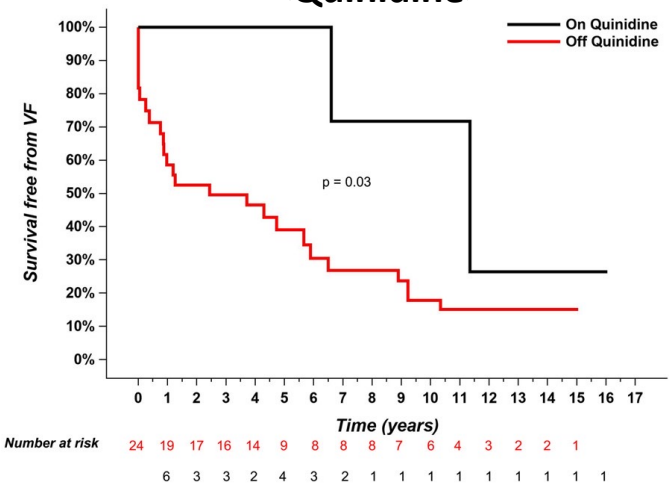


24/350 (6.9%)

<VA-free survival>



<Quinidine>



* UCA: unexplained cardiac arrest

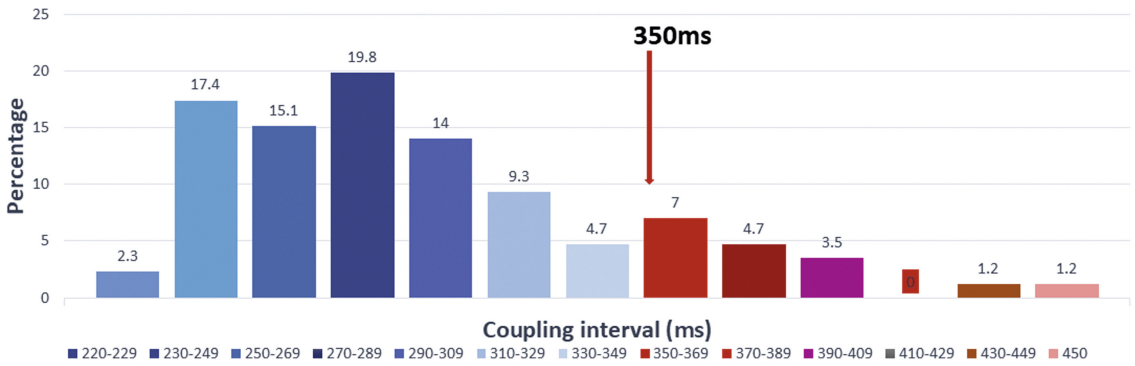
Steinberg C, et al. Eur Heart J. 2021 Jul 31;42(29):2827-2838

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

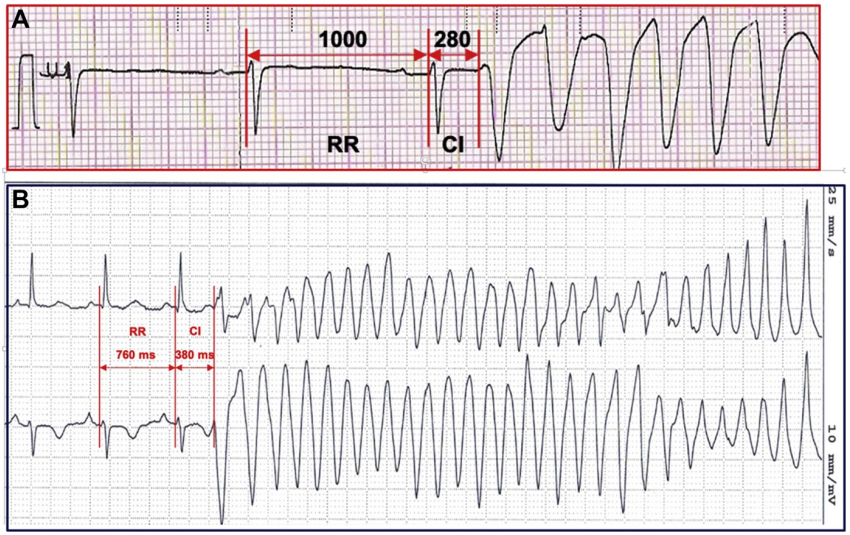
Short-coupled PVC: *how short is 'short'?*

- Review of 86 case reports

<Distribution of CI of PVCs triggering PVT/VF>



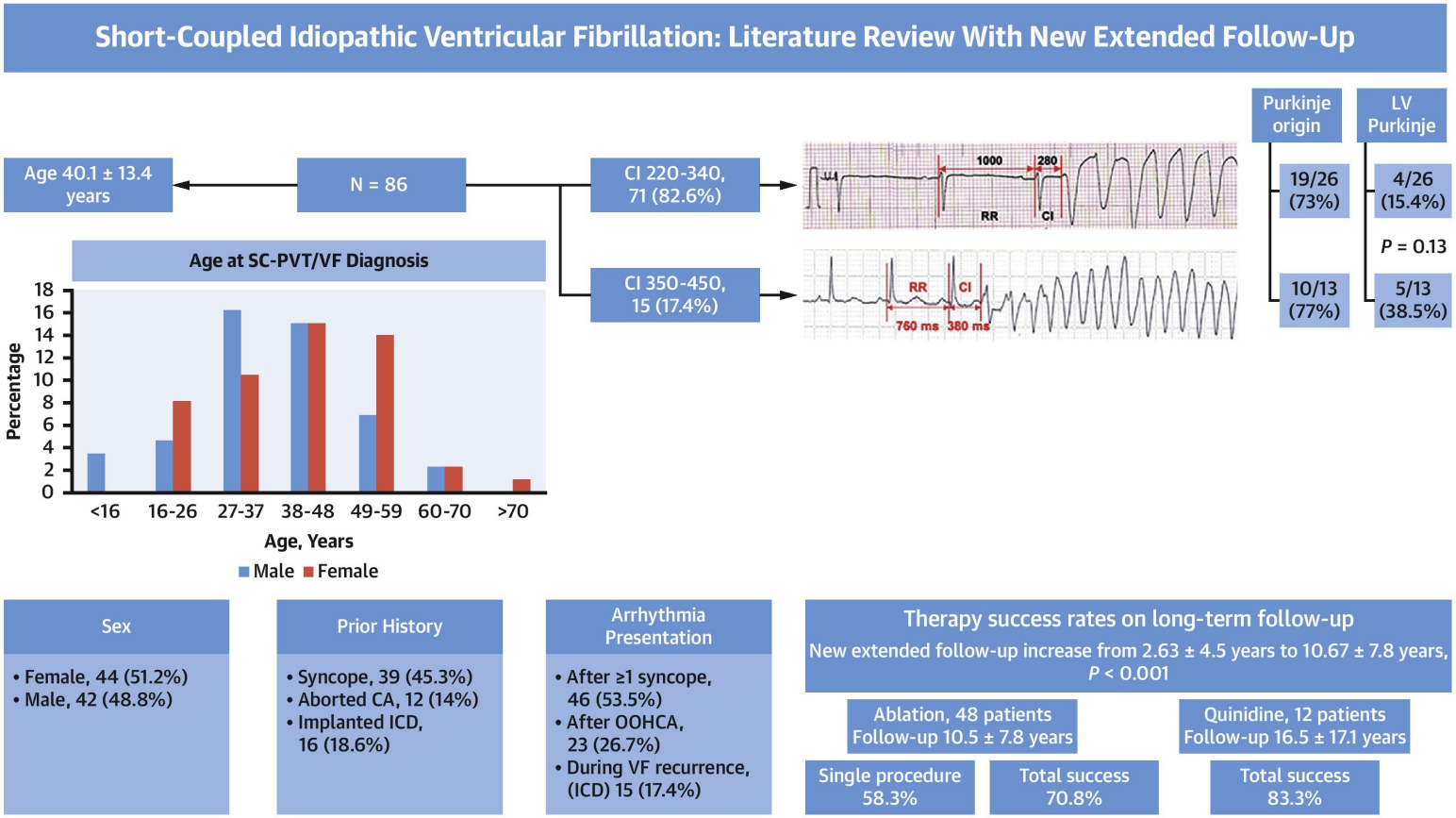
<Examples of scPVC induced PVT/VF>



Belhassen B, et al. JACC Clin Electrophysiol. 2022 Jul;8(7):918-936

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Short-coupled PVC: *long-term follow-up data*



Belhassen B, et al. JACC Clin Electrophysiol. 2022 Jul;8(7):918-936

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Short-coupled PVC: *medical treatment*

PO Drug	N	Success Rate (%)	*P* Value
Beta blockers	30	13.30	<0.001
Verapamil	24	50	0.053
Procainamide	15	26.70	0.003
Quinidine	12	83.30	
Amiodarone	5	60	0.30
Flecainide	5	60	0.30
Cibenzoline	3	0	
Pilsicainide	1	100	
Sotalol	1	0	
Disopyramide	1	0	
Bepridil	1	Acute success late failure	
Propafenone	1	100	

Belhassen B, et al. JACC Clin Electrophysiol. 2022 Jul;8(7):918-936

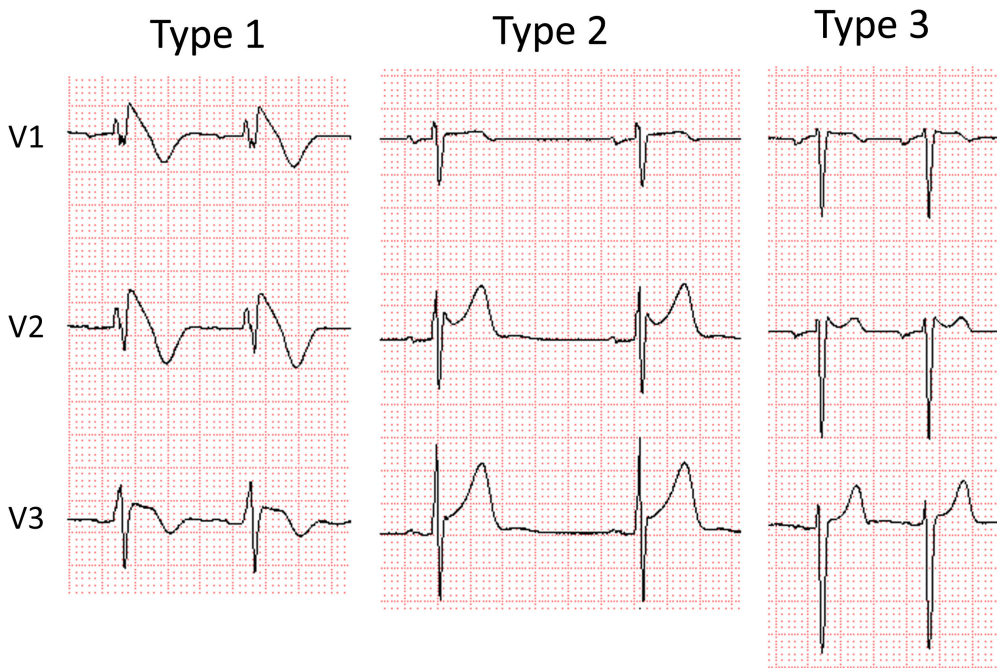
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Short-coupled PVC

- Short-coupled premature ventricular contractions (scPVCs) leading to ventricular fibrillation (VF) is an uncommon etiology of cardiac arrest in patients without structural heart disease
- The arrhythmia is characterized by a PVC coupling interval of <350 ms, a relatively short QRS duration, and a normal QT interval
- Genetic and electrophysiologic testing have increasingly implicated the Purkinje system as the source of scPVCs
- Verapamil and quinidine have demonstrated efficacy in reducing the arrhythmogenic burden, with catheter ablation having additional long-term success

Brugada syndrome: *diagnosis*

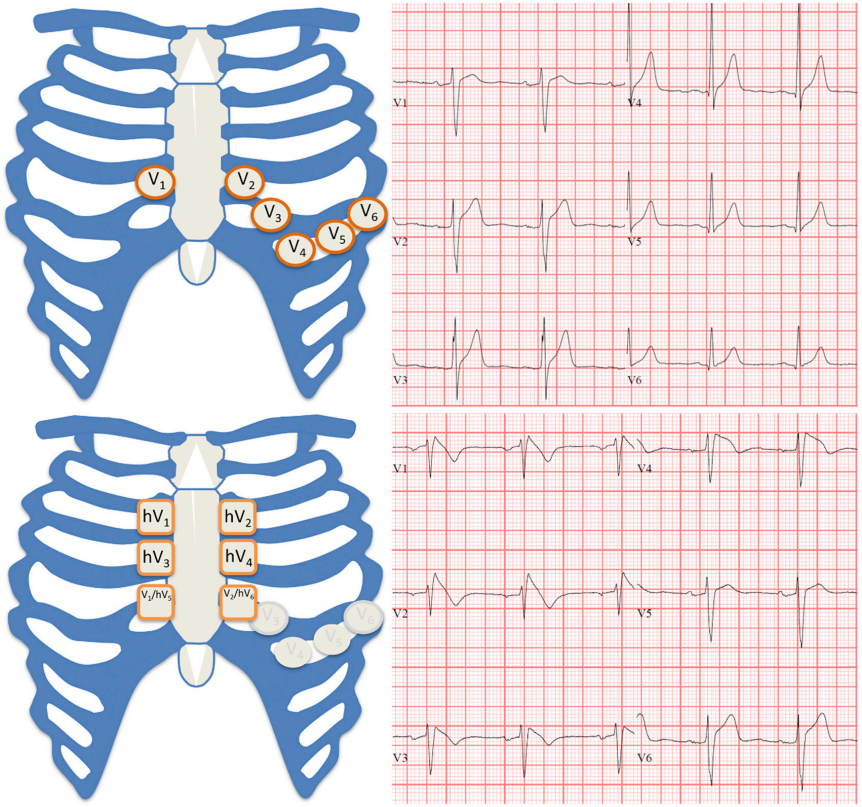
- Type 1 is the only ECG criterion that is diagnostic of BrS (Type 2 and 3 needs SCB provocation test)
- J elevation ≥0.2 mV, a coved type ST segment followed by a negative T wave
- Brugada syndrome is definitively diagnosed when a type 1 ST-segment is observed in >1 right precordial lead (V1 to V3) in the presence or absence of a sodium channel–blocking agent, and in conjunction with one of the following:
  - PMT, VF
  - a family history of sudden cardiac death at <45 years old
  - coved-type ECGs in family members
  - inducibility of VT with programmed electrical stimulation
  - syncope
  - nocturnal agonal respiration



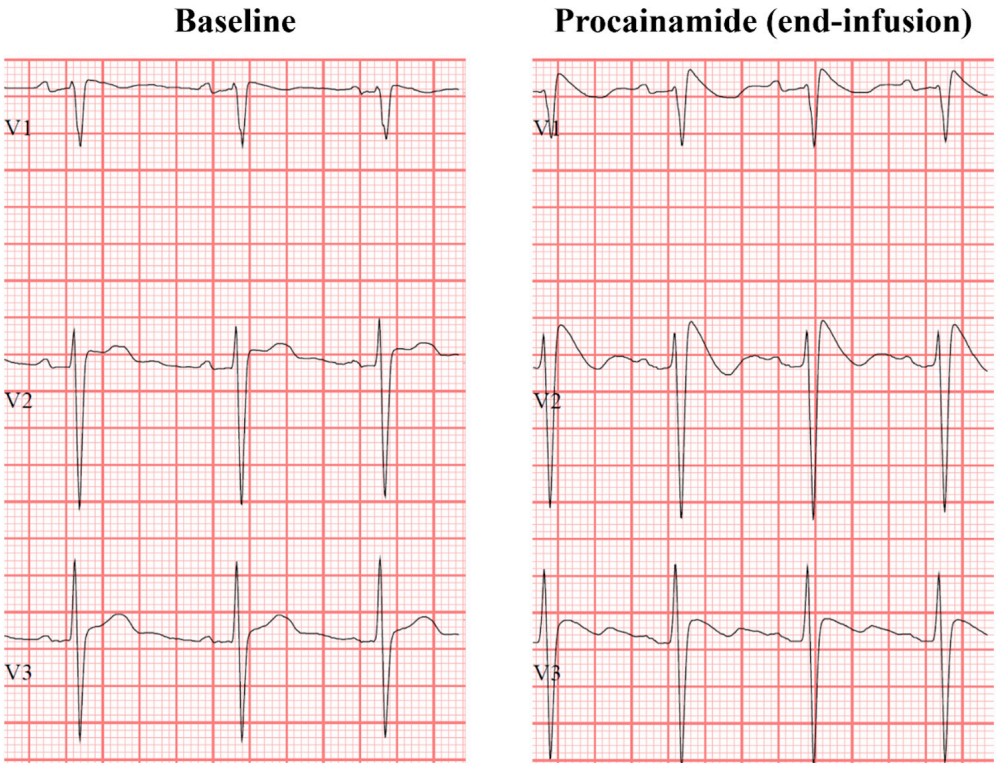
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *diagnosis*

<High-lead ECG>



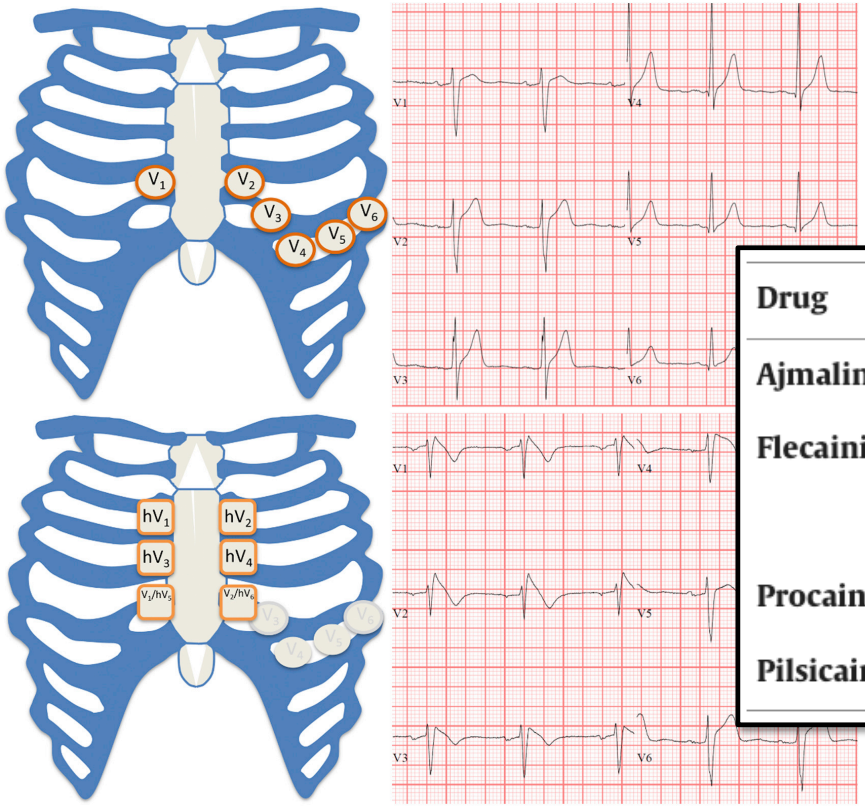
<Sodium channel blocker provocation test>



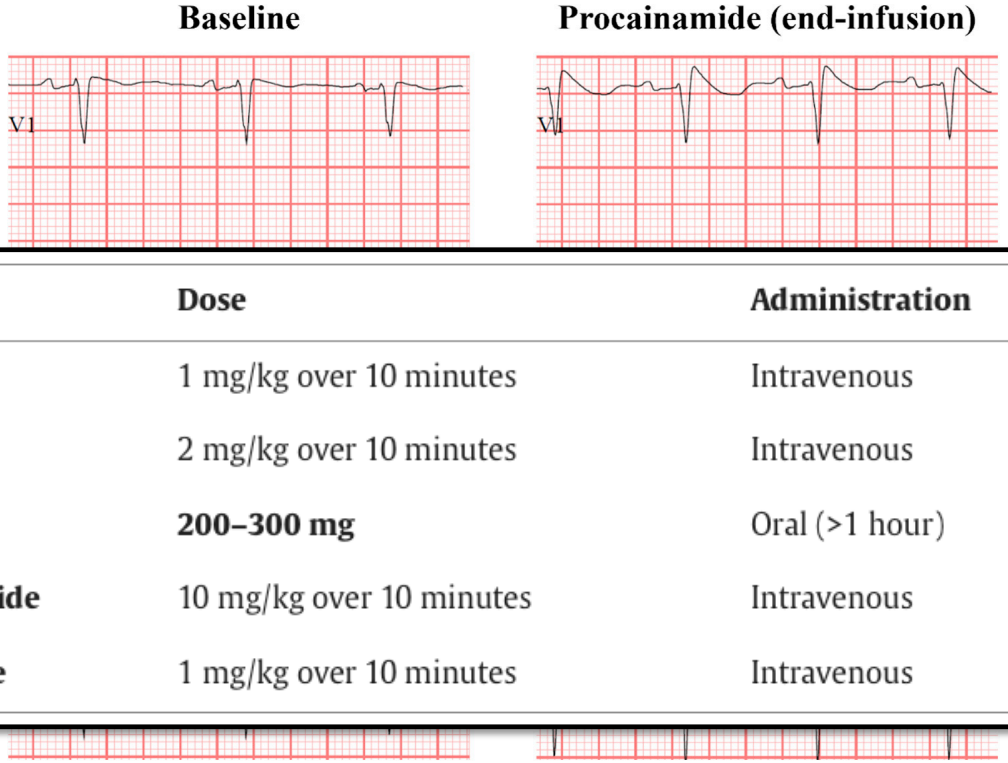
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *diagnosis*

<High-lead ECG>



<Sodium channel blocker provocation test>

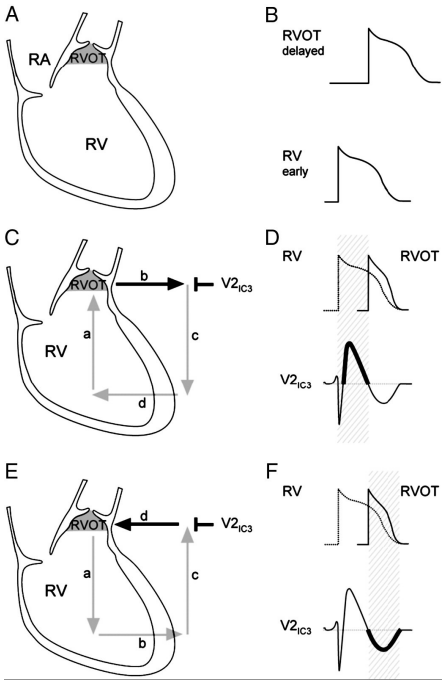


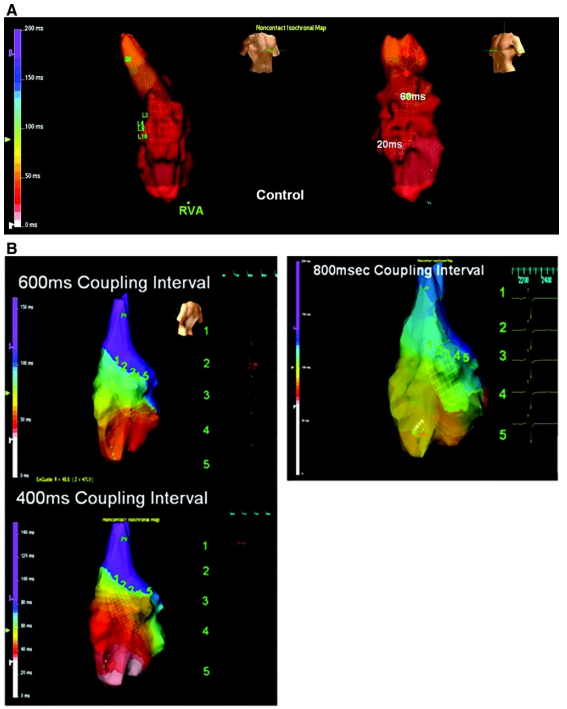
Drug	Dose	Administration
Ajmaline	1 mg/kg over 10 minutes	Intravenous
Flecainide	2 mg/kg over 10 minutes	Intravenous
	200–300 mg	Oral (>1 hour)
Procainamide	10 mg/kg over 10 minutes	Intravenous
Pilsicainide	1 mg/kg over 10 minutes	Intravenous

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *two hypotheses*

- Hypothesis 1: Primary depolarization disorder d/t reduced I_{na}
  - Conduction delay in RVOT → heterogeneity of depol. around RVOT → Arrhythmogenic



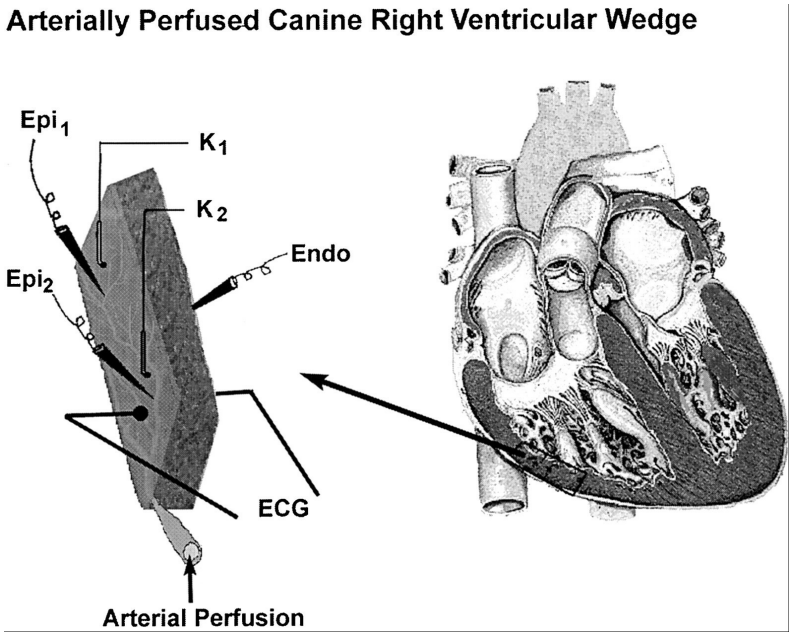


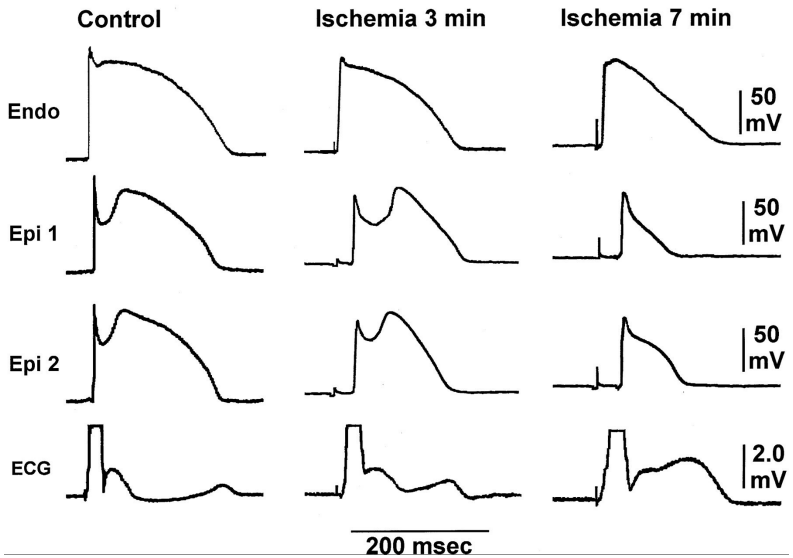
Wilde AA, et al. J Mol Cell Cardiol. 2010 Oct;49(4):543-53
Lambiase PD, et al. Circulation. 2009 Jul 14;120(2):106-17

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *two hypotheses*

- Hypothesis 2: Primary repolarization disorder d/t increased I_{to}
  - Heterogeneity of repol. between epi and endocardium → arrhythmogenic by phase 2 reentry





Yan GX, et al. Circulation. 2004 Aug 31;110(9):1036-41

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *genetics*

Genetic Defects Associated with BrS

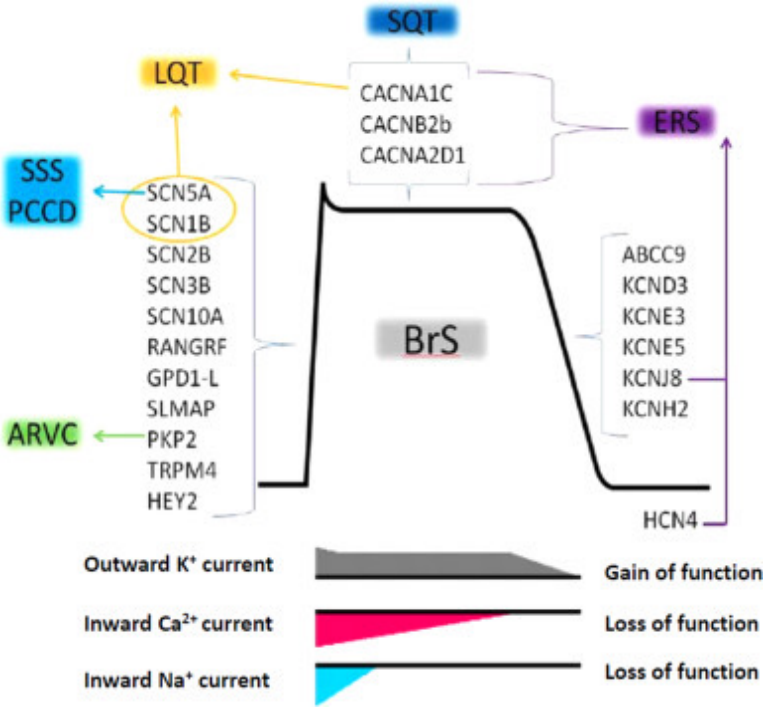
	Locus	Gene/protein	Ion channel	Percent of probands
BrS1	3p21	*SCN5A, $Na_v1.5$*	↓ I_{Na}	11%–28%
BrS2	3p24	*GPD1L*	↓ I_{Na}	Rare
BrS3	12p13.3	*CACNA1C, $Ca_v1.2$*	↓ I_{Ca}	6.6%
BrS4	10p12.33	*CACNB2b, Ca_vß2b*	↓ I_{Ca}	4.8%
BrS5	19q13.1	*SCN1B, Na_vß1*	↓ I_{Na}	1.1%
BrS6	11q13-14	*KCNE3, MiRP2*	↑ I_{to}	Rare
BrS7	11q23.3	*SCN3B, Na_vß3*	↓ I_{Na}	Rare
BrS8	12p11.23	*KCNJ8, Kir6.1*	↑ $I_{K\text{-}ATP}$	2%
BrS9	7q21.11	*CACNA2D1, Ca_v a2δ1*	↓ I_{Ca}	1.8%
BrS10	1p13.2	*KCND3, $K_v4.3$*	↑ I_{to}	Rare
BrS11	17p13.1	*RANGRF, MOG1*	↓ I_{Na}	Rare
BrS12	3p21.2-p14.3	*SLMAP*	↓ I_{Na}	Rare
BrS13	12p12.1	*ABCC9, SUR2A*	↑ $I_{K\text{-}ATP}$	Rare
BrS14	11q23	*SCN2B, Na_vß2*	↓ I_{Na}	Rare
BrS15	12p11	*PKP2, Plakophillin-2*	↓ I_{Na}	Rare
BrS16	3q28	*FGF12, FHAF1*	↓ I_{Na}	Rare
BrS17	3p22.2	*SCN10A, $Na_v1.8$*	↓ I_{Na}	5%–16.7%
BrS18	6q	*HEY2 (transcriptional factor)*	↑ I_{Na}	Rare

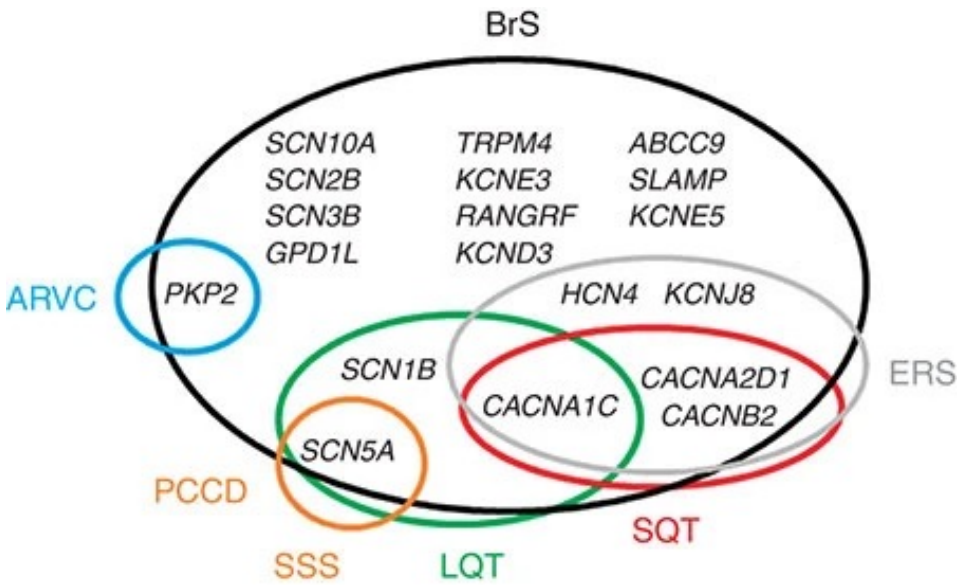
Major: Loss-of-mutation of SCN5A

Antzelevitch C, et al. Heart Rhythm. 2016 Oct;13(10):e295-324

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *genetics*



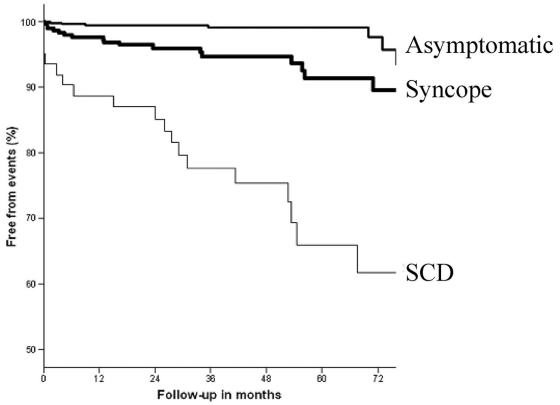


Sarquella-Brugada G, et al. Genet Med. 2016 Jan;18(1):3-12
Juang JJ, et al. J Arrhythm. 2016 Oct;32(5):418-425

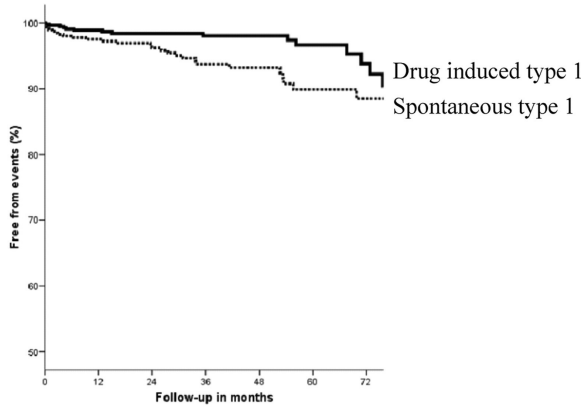
SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *clinical significance*

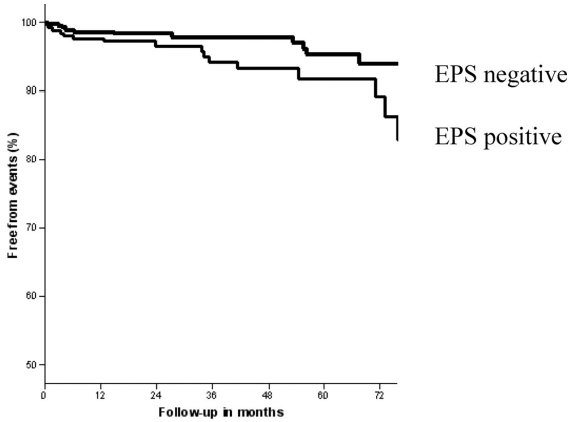
<FINGER Brugada Syndrome Registry>



	0	12	24	36	48	60	72
group A	62	54	47	36	29	18	15
group B	313	244	192	148	99	73	49
group C	654	505	379	275	195	109	54



	0	12	24	36	48	60	72
type1	468	350	269	200	135	88	58
no type 1	561	453	349	259	188	112	60



	0	12	24	36	48	60	72
negative	376	301	237	187	136	94	59
positive	262	212	161	113	81	52	34

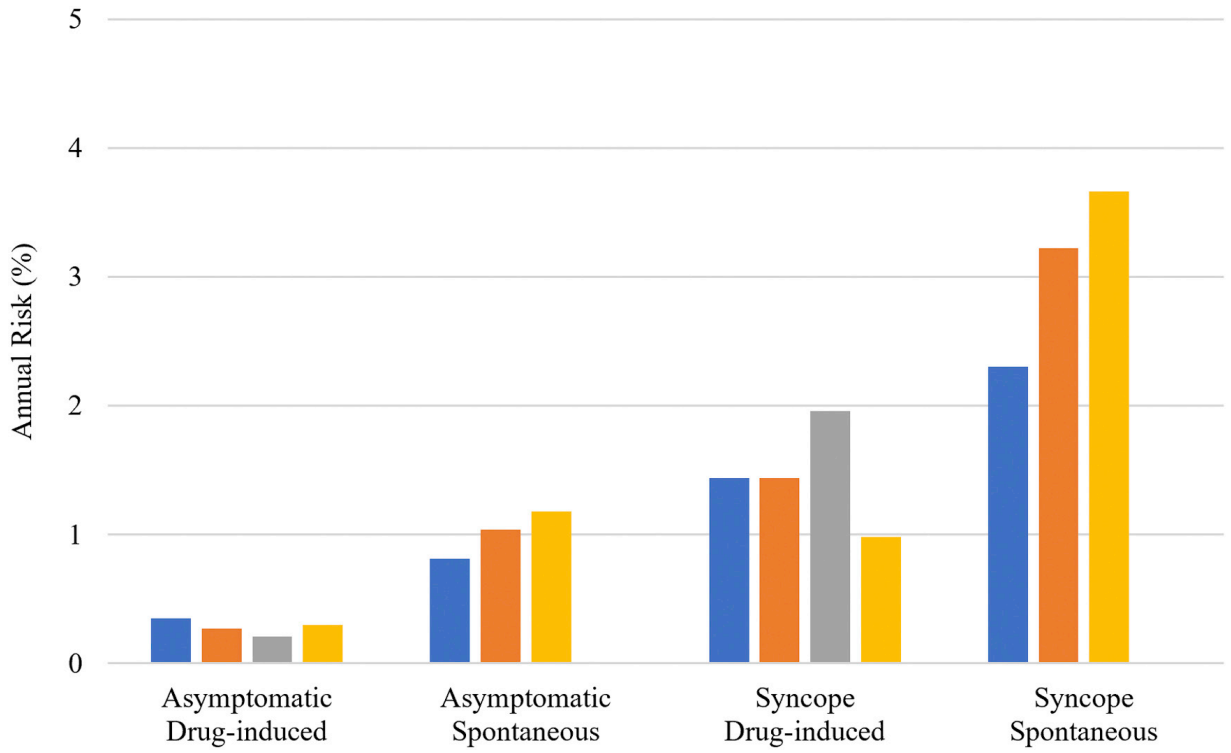
- Significant predictors
  - Symptoms and spontaneous type 1 BrS ECG
- Nonsignificant factors
  - Gender, Family history of SCD, Inducibility of VT/VF by EPS, SCN5A mutation

Probst V, et al. Circulation. 2010 Feb 9;121(5):635-43

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *clinical significance*

<Annual risk of serious arrhythmic events in BrS>



Krahn, A, et al. J Am Coll Cardiol EP. 2022 Mar, 8 (3) 386–405

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *Shanghai score*

		Points
ECG findings[a,b]		
A	Spontaneous type 1 ECG	3.5
B	Fever-induced type 1 ECG	3
C	Type 2/3 ECG that converts to type 1 ECG with SCB provocation	2
Clinical history[a]		
A	Unexplained cardiac arrest or documented VF/polymorphic VT	3
B	Nocturnal agonal respirations	2
C	Suspected arrhythmic syncope	2
D	Syncope of unclear etiology	1
E	AF/flutter age <30 y without clear etiology	0.5
Family history[a]		
A	First- or second-degree relative with definite BrS	2
B	Suspicious SCD (fever, nocturnal, Brugada-aggravating drug) in a first- or second-degree relative	1
C	Unexplained SCD age <45 y in first- or second-degree relative with negative autopsy	0.5
Genetic testing		
A	Probable pathogenic mutation in BrS susceptibility gene	0.5

- Requires ≥1 ECG finding
- ≥3.5 points: Probable/definite BrS
- 2-3 points: Possible BrS
- <2 points: Nondiagnostic

Antzelevitch C, et al. Heart Rhythm. 2016 Oct;13(10):e295-324

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Brugada syndrome: *clinical approach*

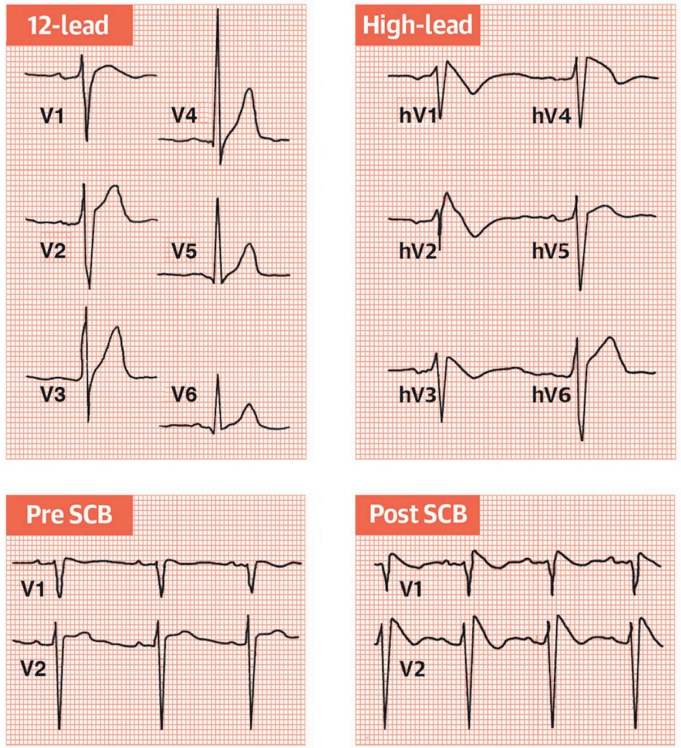
Assessment

Evaluation

- History and pedigree
- ECG:12-lead and high lead
- Provocation-SCB

Diagnosis

- Type 1 ECG changes in leads V_1-V_2 at ICS2-4



Risk Stratification

Established Markers

- Cardiac arrest
- Spontaneous type 1 ECG
- Cardiogenic syncope

Other Markers

- Age
- Male
- ECG features
- EP study

Treatment

Conservative

- Prompt fever treatment with antipyretics
- Avoid Brugada drugs

Pharmacological

- Quinidine

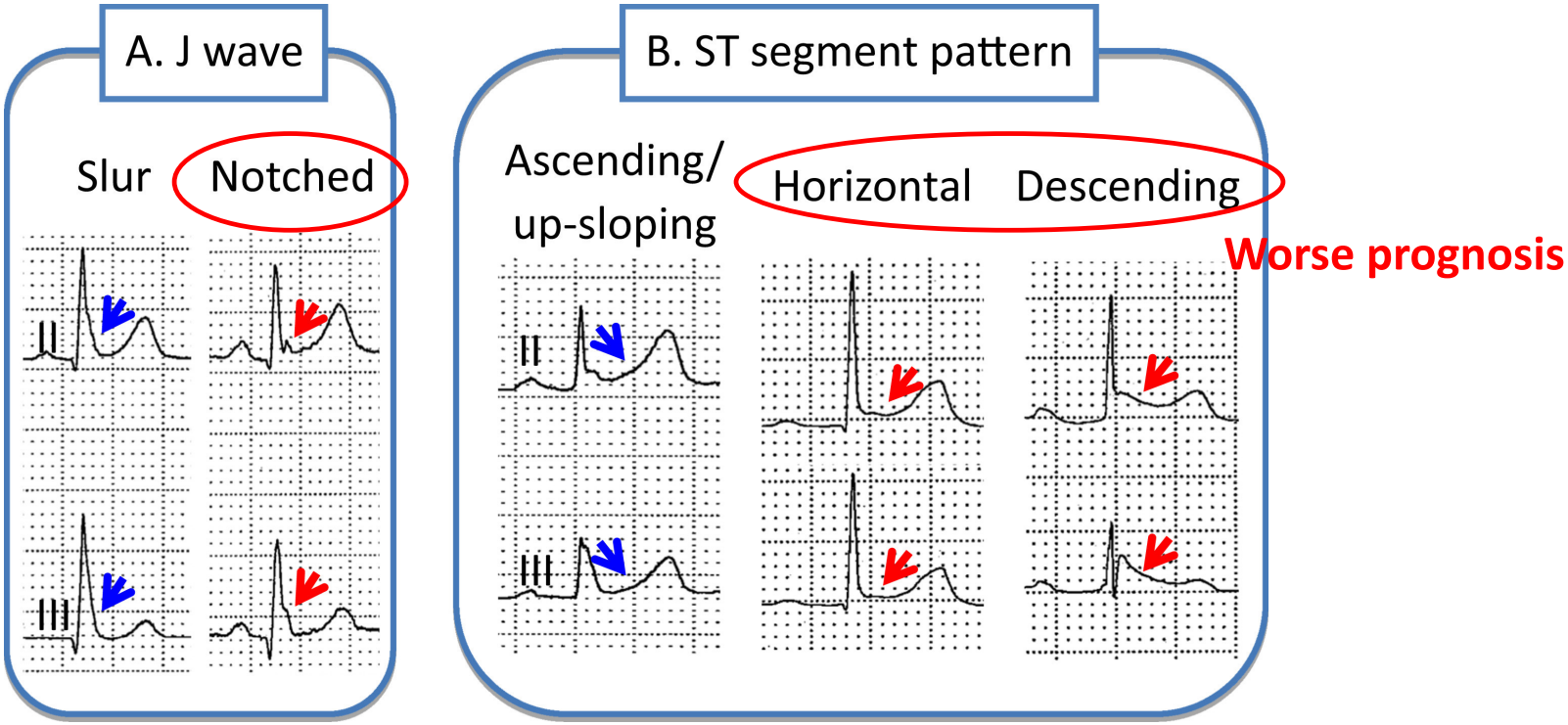
Interventional

- ICD
- Ablation

Krahn, A, et al. J Am Coll Cardiol EP. 2022 Mar, 8 (3) 386–405

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

ERS / J-wave syndrome: *diagnosis*



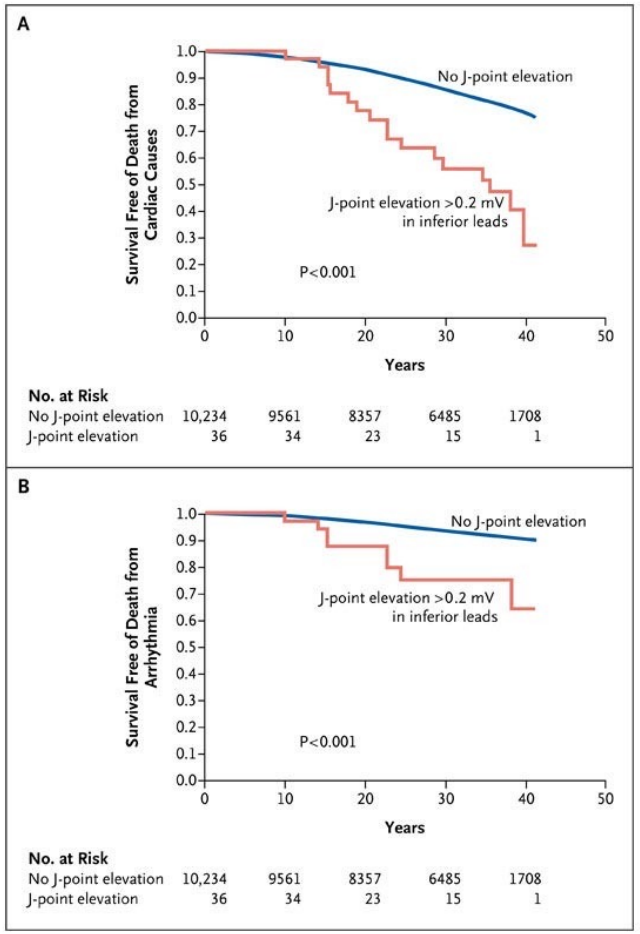
Antzelevitch C, et al. Heart Rhythm. 2016 Oct;13(10):e295-324

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

ERS / J-wave syndrome: *clinical significance*

Table 3. Adjusted Relative Risk of Death from Cardiac Causes in the Secondary Analysis.*

Variable	No. of Subjects	Relative Risk (95% CI)	P Value
Prolonged QTc interval	668	1.20 (1.02–1.42)	0.03
Left ventricular hypertrophy according to Sokolow–Lyon criteria	3410	1.16 (1.05–1.27)	0.004
J-point elevation in inferior leads			
≥0.1 mV	384	1.28 (1.04–1.59)	0.03
>0.2 mV	36	2.98 (1.85–4.92)	<0.001



Tikkanen JT, et al. N Engl J Med. 2009 Dec 24;361(26):2529-37

ERS / J-wave syndrome: *clinical significance*

- 조기 재분극이 있으면 누구나 심급사의 위험이 있는가?

Diagnostic power of J-point elevation

As mentioned previously (see "Statistics"), the estimated risk for idiopathic VF in the general population, ages 35 to 45 years, is roughly 3.4 of 100,000 individuals. On the basis of the results of our study, the probability of having J-point elevation is 0.42 for idiopathic VF patients and 0.13 for control subjects. According to the Bayes' formula of conditional probabilities, finding a J-wave in the ECG of an individual in the 35 to 45 years age range increases the chances of having idiopathic VF from 3.4 of 100,000 individuals to only 11 of 100,000.

Rosso R, et al. J Am Coll Cardiol. 2008 Oct 7;52(15):1231-8

ERS / J-wave syndrome: *genetics*

Genetic Defects Associated with ERS

	Locus	Gene/protein	Ion channel	Percent of Probands
ERS1	12p11.23	*KCNJ8, Kir6.1*	$\uparrow I_{K\text{-}ATP}$	Rare
ERS2	12p13.3	*CACNA1C, $Ca_v1.2$*	$\downarrow I_{Ca}$	4.1%
ERS3	10p12.33	*CACNB2b, Ca_vß2b*	$\downarrow I_{Ca}$	8.3%
ERS4	7q21.11	*CACNA2D1, $Ca_v\alpha 2\delta 1$*	$\downarrow I_{Ca}$	4.1%
ERS5	12p12.1	*ABCC9, SUR2A*	$\uparrow I_{K\text{-}ATP}$	Rare
ERS6	3p21	*SCN5A, $Na_v1.5$*	$\downarrow I_{Na}$	Rare
ERS7	3p22.2	*SCN10A, $Na_v1.8$*	$\downarrow I_{Na}$	Rare

Genetic Defects Associated with BrS

	Locus	Gene/protein	Ion channel	Percent of probands
BrS1	3p21	*SCN5A, $Na_v1.5$*	$\downarrow I_{Na}$	11%–28%
BrS2	3p24	*GPD1L*	$\downarrow I_{Na}$	Rare
BrS3	12p13.3	*CACNA1C, $Ca_v1.2$*	$\downarrow I_{Ca}$	6.6%
BrS4	10p12.33	*CACNB2b, Ca_vß2b*	$\downarrow I_{Ca}$	4.8%
BrS5	19q13.1	*SCN1B, Na_vß1*	$\downarrow I_{Na}$	1.1%
BrS6	11q13-14	*KCNE3, MiRP2*	$\uparrow I_{to}$	Rare
BrS7	11q23.3	*SCN3B, Na_vß3*	$\downarrow I_{Na}$	Rare
BrS8	12p11.23	*KCNJ8, Kir6.1*	$\uparrow I_{K\text{-}ATP}$	2%
BrS9	7q21.11	*CACNA2D1, $Ca_v\ \alpha 2\delta 1$*	$\downarrow I_{Ca}$	1.8%
BrS10	1p13.2	*KCND3, $K_v4.3$*	$\uparrow I_{to}$	Rare
BrS11	17p13.1	*RANGRF, MOG1*	$\downarrow I_{Na}$	Rare
BrS12	3p21.2-p14.3	*SLMAP*	$\downarrow I_{Na}$	Rare
BrS13	12p12.1	*ABCC9, SUR2A*	$\uparrow I_{K\text{-}ATP}$	Rare
BrS14	11q23	*SCN2B, Na_vß2*	$\downarrow I_{Na}$	Rare
BrS15	12p11	*PKP2, Plakophillin-2*	$\downarrow I_{Na}$	Rare
BrS16	3q28	*FGF12, FHAF1*	$\downarrow I_{Na}$	Rare
BrS17	3p22.2	*SCN10A, $Na_v1.8$*	$\downarrow I_{Na}$	5%–16.7%
BrS18	6q	*HEY2 (transcriptional factor)*	$\uparrow I_{Na}$	Rare

Antzelevitch C, et al. Heart Rhythm. 2016 Oct;13(10):e295-324

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

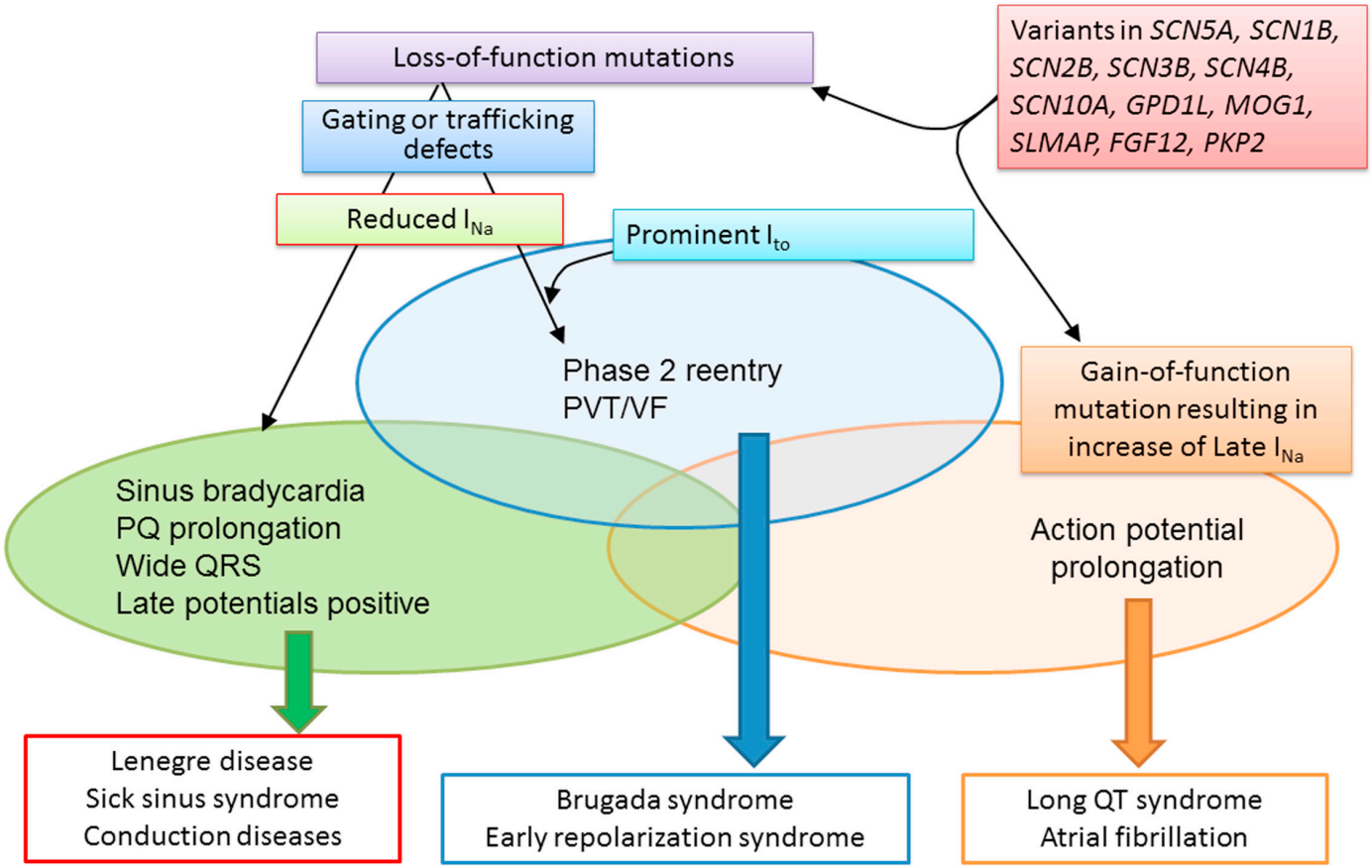
ERS / J-wave syndrome: *ERS vs. BrS*

Differences	BrS	ERS	Possible mechanisms
Region most involved	RVOT	Inferior LV wall	Higher levels of I_{to} and/or differences in conduction
Leads affected	V_1–V_3	II, II a, VF, V_4, V_5, V_6; I, aVL, Both: inferolateral	
Regional difference in prevalence			Europe: BrS = ERS Asia: BrS > ERS
Incidence of late potential in signal-averaged ECG	Higher	Lower	
Prevalence of atrial fibrillation	Higher	Lower	
Effect of sodium channel blockers on surface ECG	Increased J-wave manifestation	Reduced J-wave manifestation	Reduction of J wave in the setting of ER is thought to be due largely to prolongation of QRS. Accentuation of repolarization defects predominates in BrS, whereas accentuation of depolarization defects predominates in ERS.
Structural changes, including mild fibrosis and reduced expression of Cx43 in RVOT or fibrofatty infiltration in cases of arrhythmogenic right ventricular cardiomyopathy. Imaging studies have also revealed wall motion abnormalities and mild dilation in the region of the RVOT.	Higher in some forms of the syndrome	Unknown	Some investigators have hypothesized that some of these changes may be the result of, rather than the cause of the BrS substrate, which may create a hibernation-like state due to loss of contractility in the RVOT secondary to loss of the AP dome.

Antzelevitch C, et al. Heart Rhythm. 2016 Oct;13(10):e295-324

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

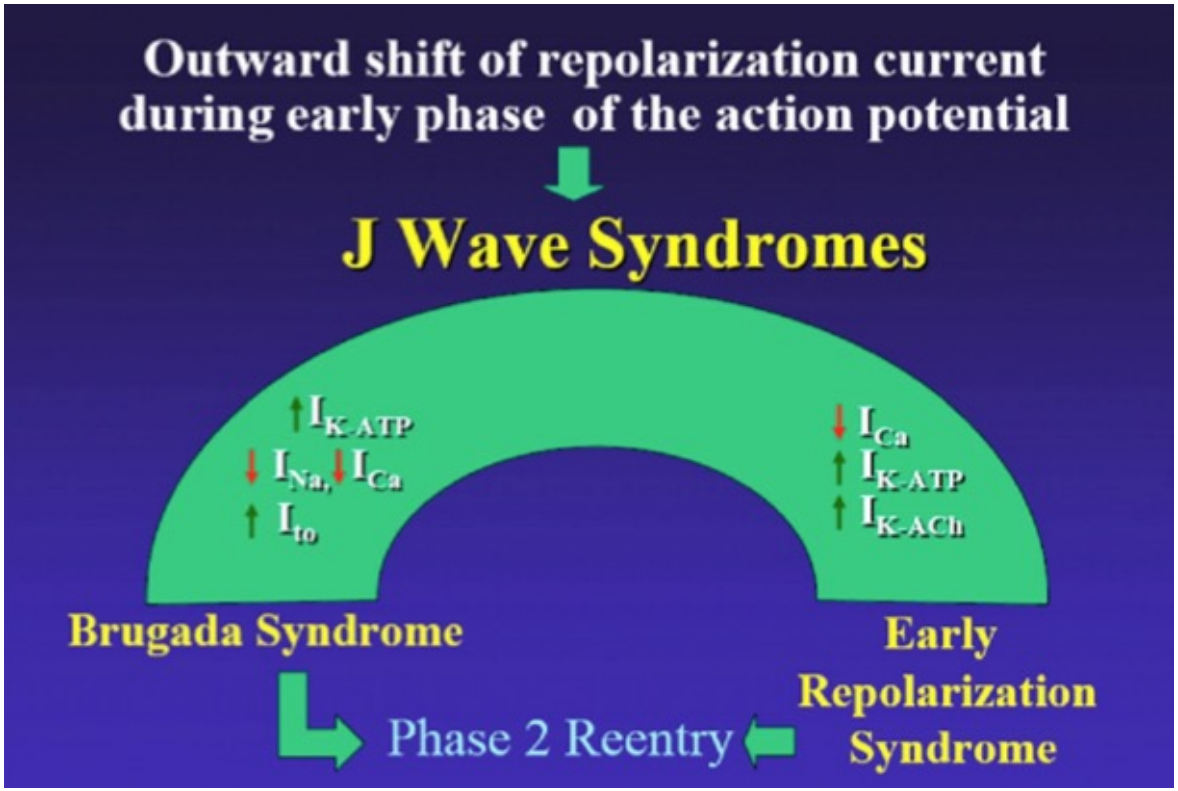
ERS / J-wave syndrome: *current concept*



Antzelevitch C, et al. Heart Rhythm. 2016 Oct;13(10):e295-324

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

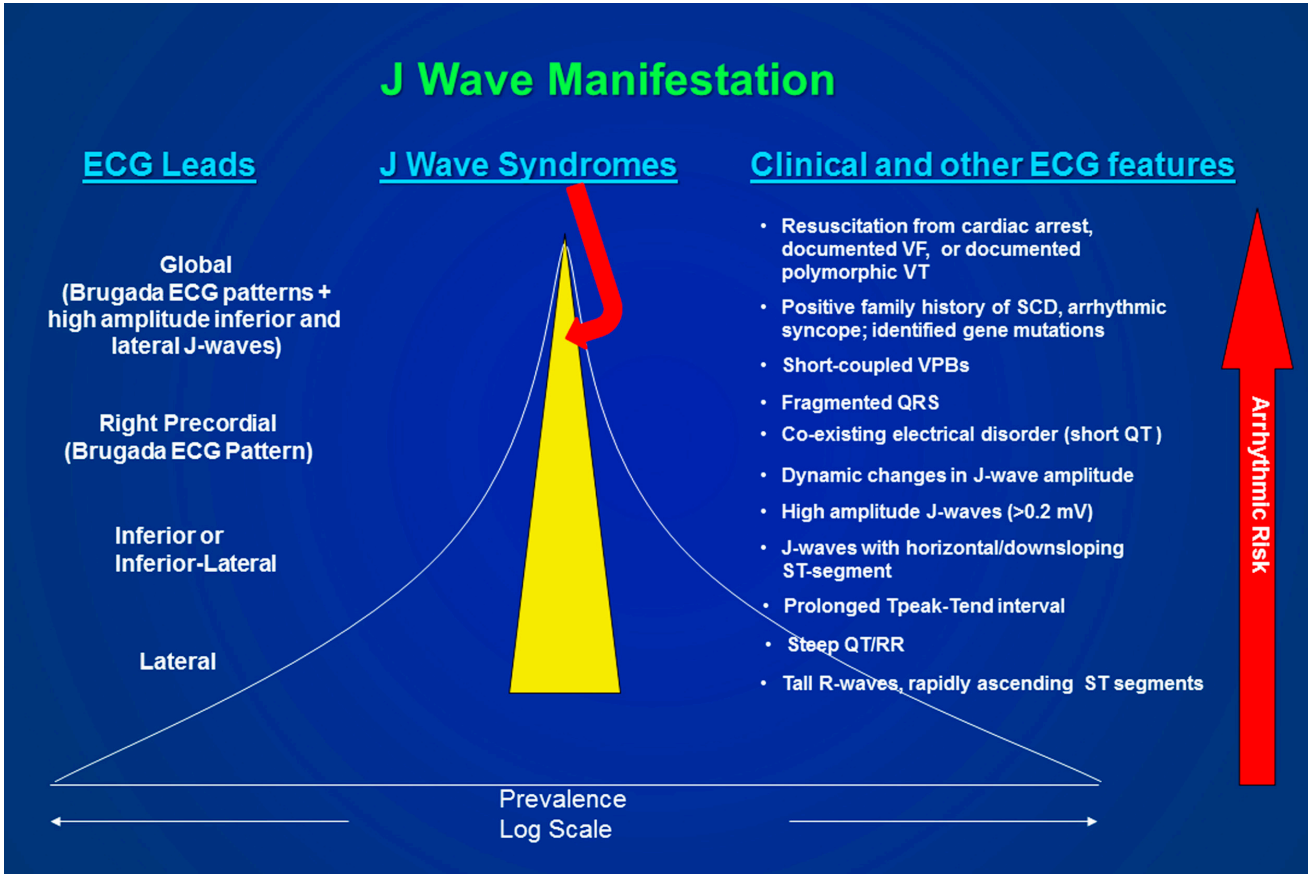
ERS / J-wave syndrome: *current concept*



Antzelevitch C, et al. Heart Rhythm 2010;7:549-558

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

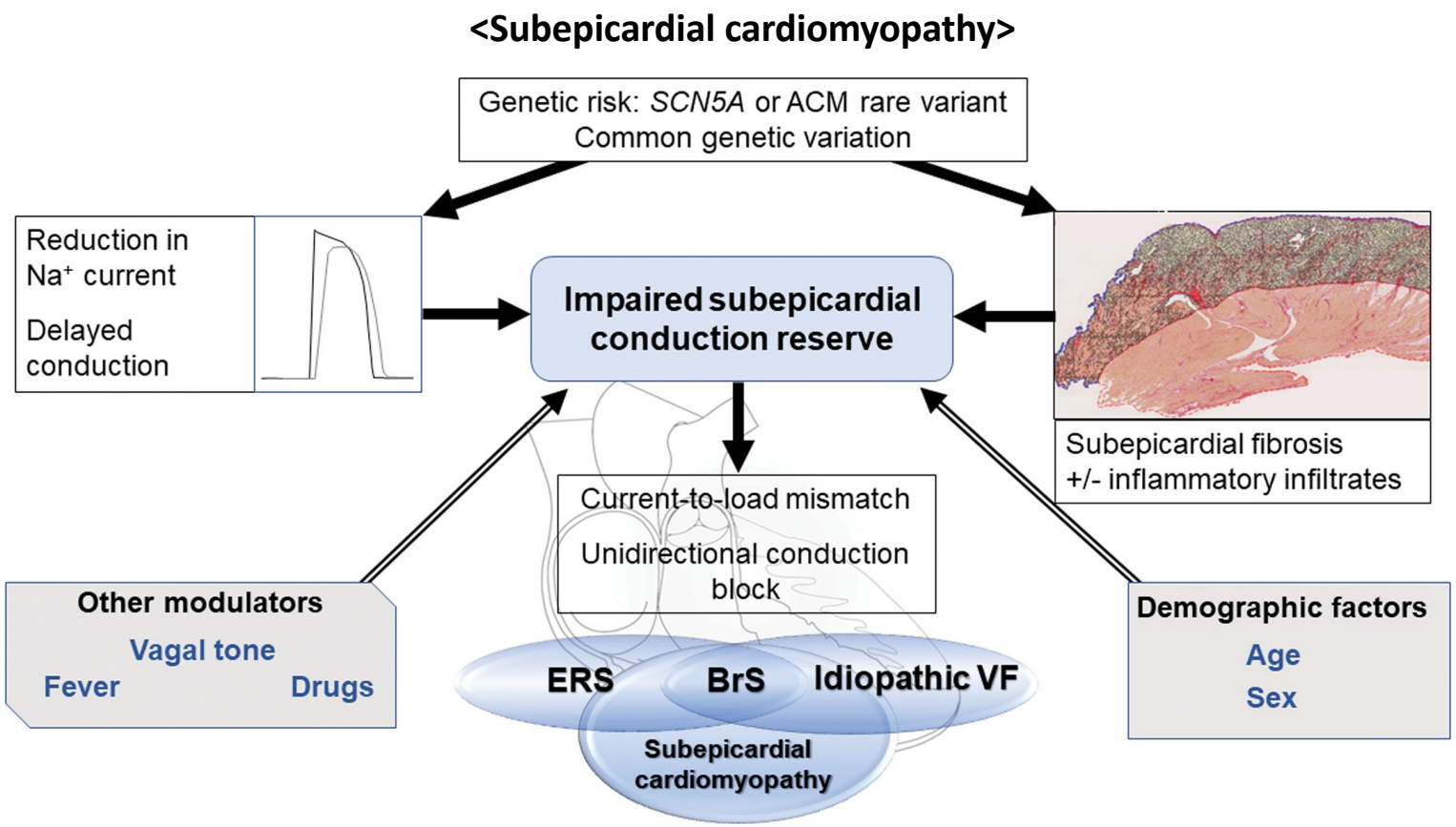
ERS / J-wave syndrome: *current concept*



Antzelevitch C, et al. Heart Rhythm. 2016 Oct;13(10):e295-324

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

ERS / J-wave syndrome: *new concept*

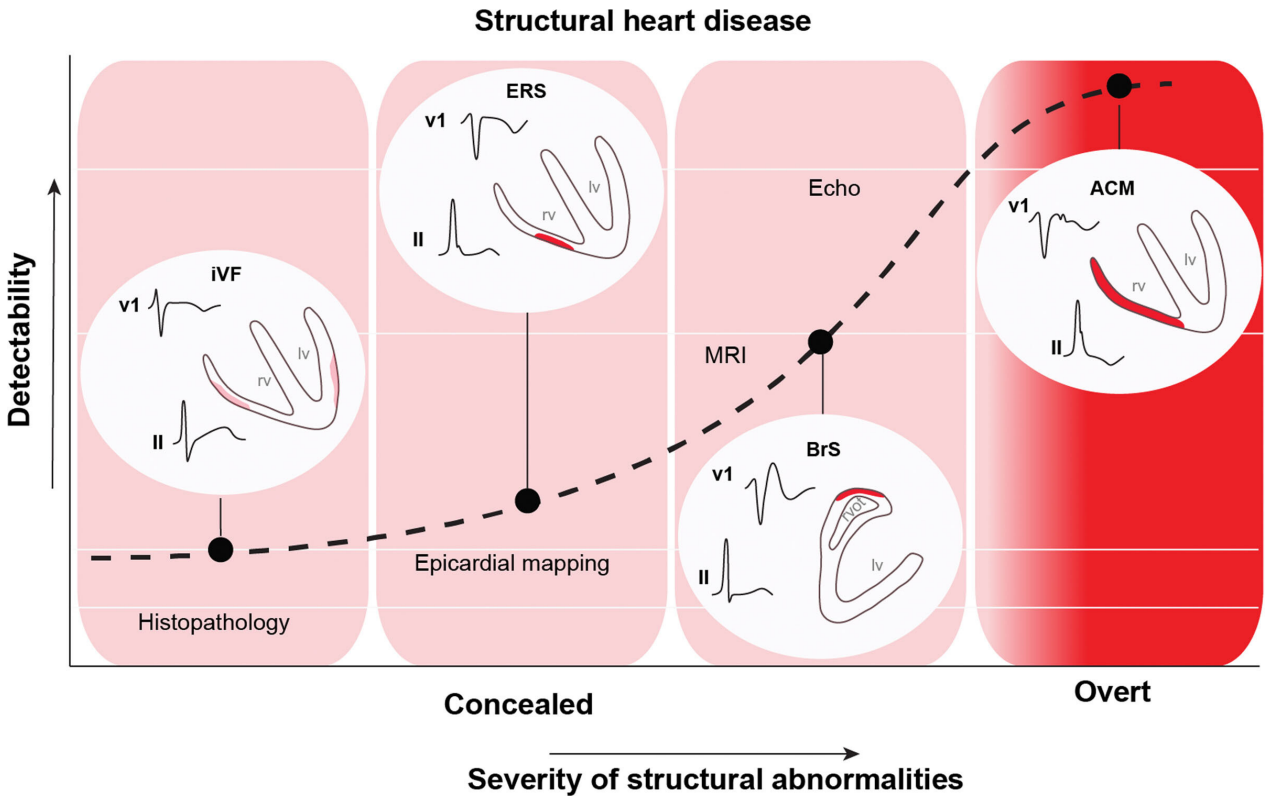


* ACM: arrhythmogenic cardiomyopathy

Miles C, et al. Circulation. 2023 May 23;147(21):1622-1633

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

ERS / J-wave syndrome: *new concept*



* ACM: arrhythmogenic cardiomyopathy

Miles C, et al. Circulation. 2023 May 23;147(21):1622-1633

SNUH 서울대학교병원 SEOUL NATIONAL UNIVERSITY HOSPITAL

Summary

- 한국인에서 가장 흔한 심인성 심정지 원인은 심혈관질환, 심근병증, 부정맥 순이다
- 한국인에서 가장 흔한 유전성 부정맥질환 3가지는 특발성심실세동, 브루가다증후군, QT연장증후군이다
- fQRS는 심장내 전도이상으로 발생하며 심근경색 뿐 아니라 다양한 심근병증에서 심장돌연사의 위험인자이다
- scPVC는 coupling interval 이 <350 ms 인 경우로 정의할 수 있으며 퍼킨지섬유 전도이상을 통해 심실부정맥을 일으킬 수 있고 심장돌연사의 위험인자이다
- 브루가다증후군은 주로 SCN5A 의 기능상실변이와 관련이 있으나 최근 다양한 유전자가 관여하는 것으로 알려지고 있다
- 브루가다증후군의 예후를 결정하는 가장 중요한 위험인자는 제1형 심전도 특징과 실신이다
- 조기재분극증후군이나 J파증후군은 다양한 유전자변이와 관련이 있으며 심장돌연사의 위험인자이나 절대위험도가 매우 낮기 때문에 증상이나 급사의 가족력이 없는 경우 심장돌연사의 고위험군으로 해석하면 안된다
- 최근에는 기존 질환을 포괄하는 개념으로 심외막하 심근병증 혹은 부정맥성 심근병증 개념이 등장하고 있다


Thank you for your attention
서울대학교병원
SEOUL NATIONAL UNIVERSITY HOSPITAL