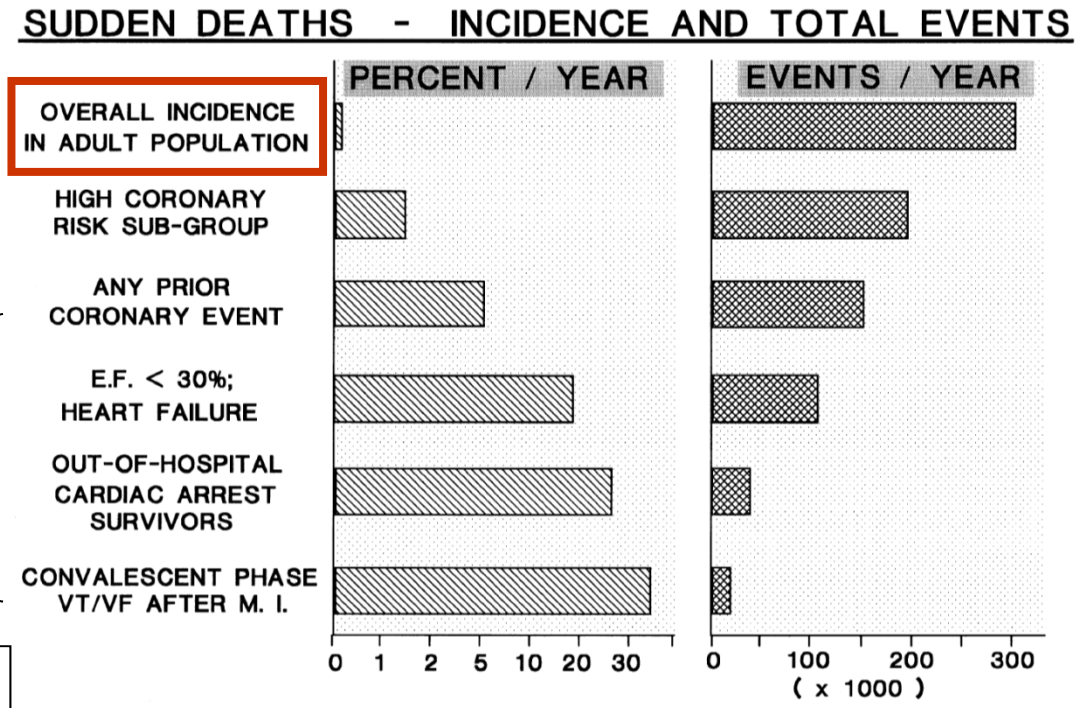
ECG Markers of Sudden Cardiac Death

남기병
울산대, 서울아산병원

Sudden cardiac death: epidemiology

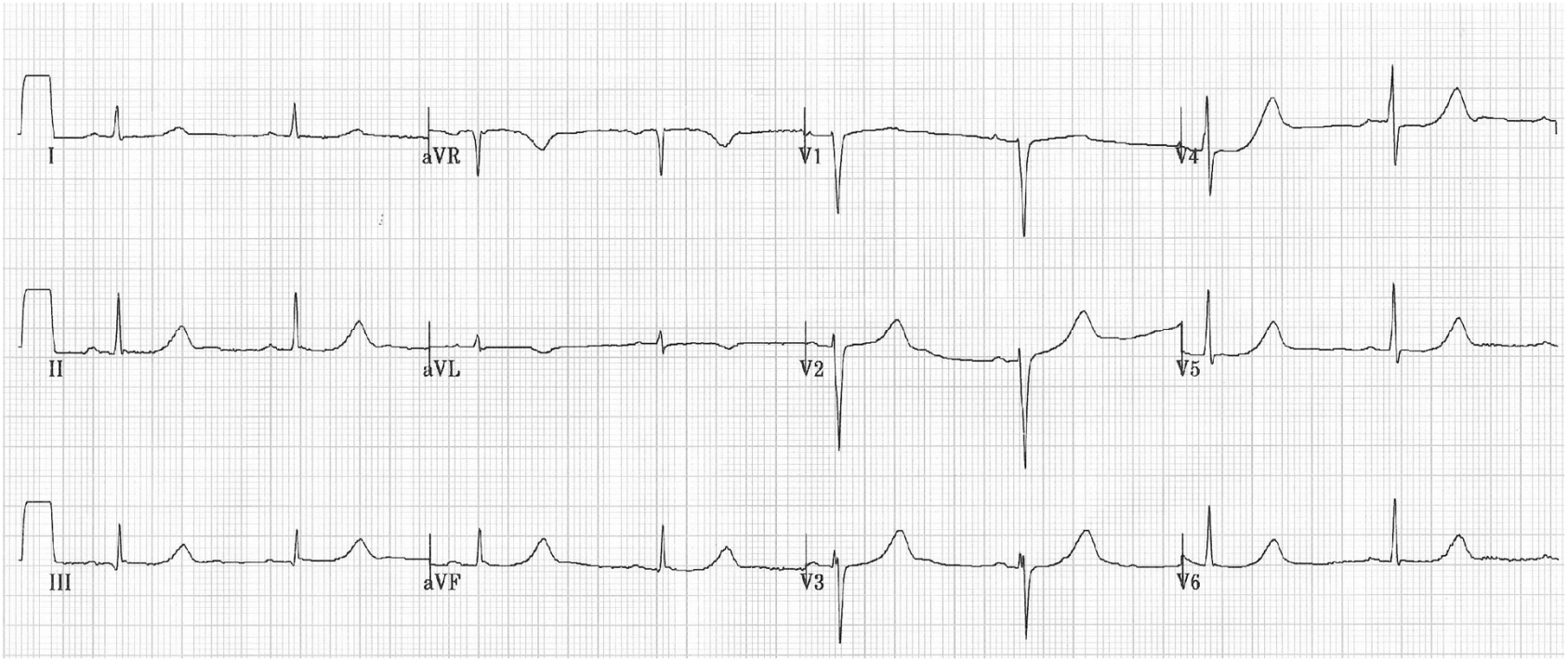


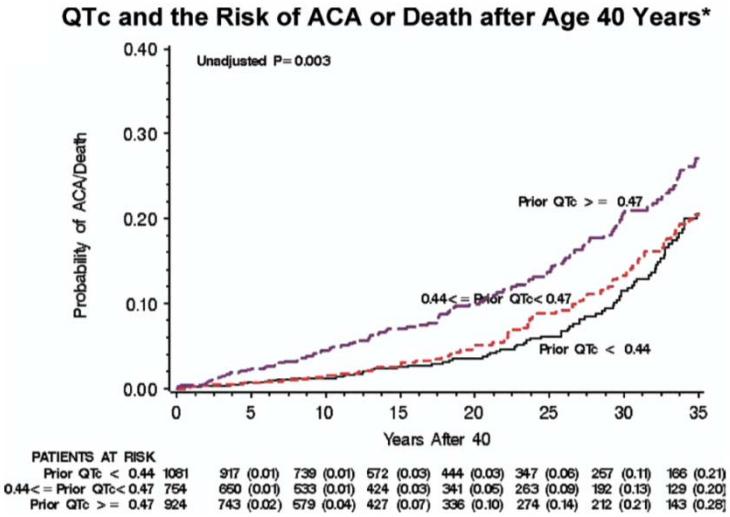
Myocardial infarction
Cardiomyopathy: hypertrophic, dilated
Arrhythmogenic RV Dysplasia

Long QT syndrome
Short QT syndrome
Brugada syndrome
Early repolarization syndrome
Fragmented QRS
Idiopathic VF
WPW, CPVT, Complete AV block

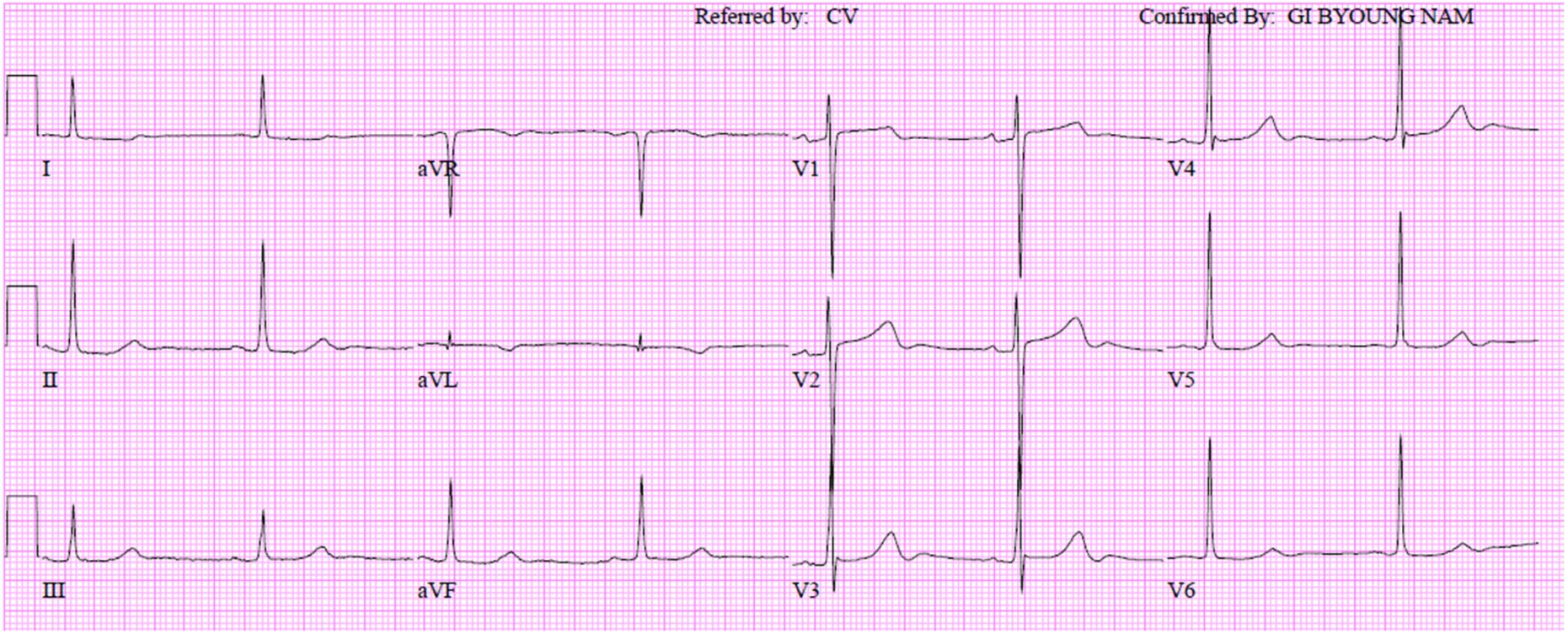
Am J Cardiol 1997;80(5B):10F–19F

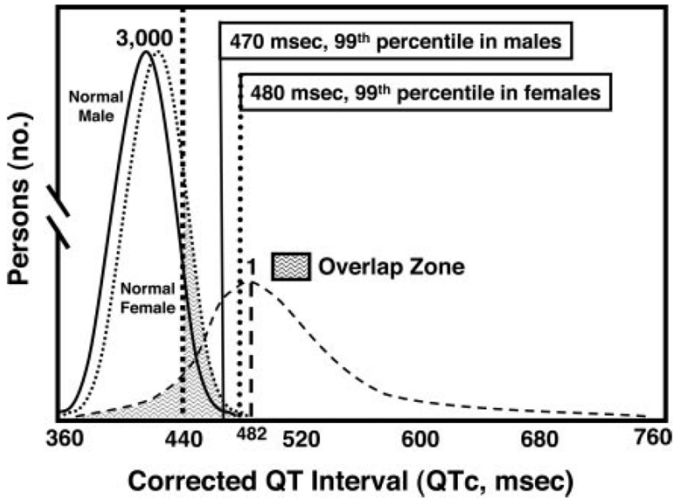
Case 1. 38/F with recurrent syncope





78/F, previously healthy





Borderline QT prolongation

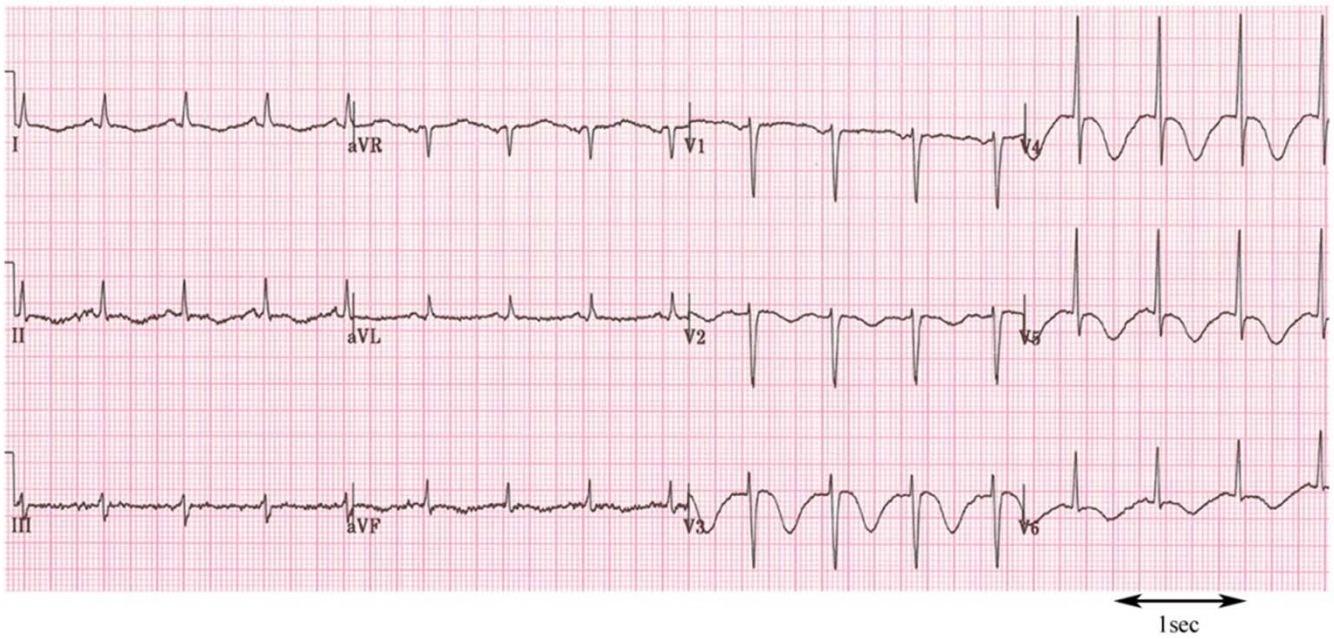
QTc 440-470ms: 15% of the general population

< QTc 440ms : 30% of LQTS-causing mutation
"silent carriers" or "concealed LQTS

Importance of QT interval in daily practice

78/F with osteomyelitis, on ciprofloxacin
On HD 37, Severe dyspnea and palpitation
Apical ballooning, EF 60 to 15%
ECG: marked QT prolongation and T wave inv
initial QT 486 ms, f/u QT 623 ms

A



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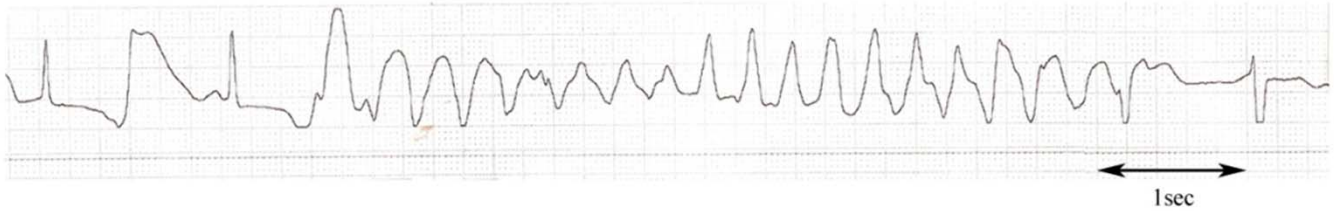


Risk Amplifiers for Drug-induced QTc Prolongation

1. Genetic predisposition (subclinical forms of genetic LQTS)
2. Various drug-drug interactions
3. Female gender: ca. 70%
4. Age
5. Electrolyte imbalance: K, Mg
6. Bradycardia
7. Underlying structural heart disease

Circulation 2010;122;1426-1435

QT interval variables from 24 hour electrocardiography and the two year risk of sudden death.

Algra A, Tijssen JG, Roelandt JR, Pool J, Lubsen J.
Department of Cardiology, Erasmus University Rotterdam, The Netherlands.

Cohort of 6693 consecutive patients who underwent 24 hour electrocardiography, and followed up for two years.

Patients with a ***prolonged*** mean QTc over 24 hours (> or = 440 ms) had a 2.3 times higher risk of SCD than patients with a normal mean QTc (400-440 ms).
Patients with a ***shortened*** mean QTc (< 400 ms) also had a higher risk (relative risk 2.4).

A prolonged and a shortened mean QTc interval over 24 hours was associated with a more than twofold risk of sudden death compared with intermediate mean QTc values (400-440 ms).

Br Heart J. 1993 Jul;70(1):43-8.

J-shaped survival

Short QT Syndrome

A Familial Cause of Sudden Death

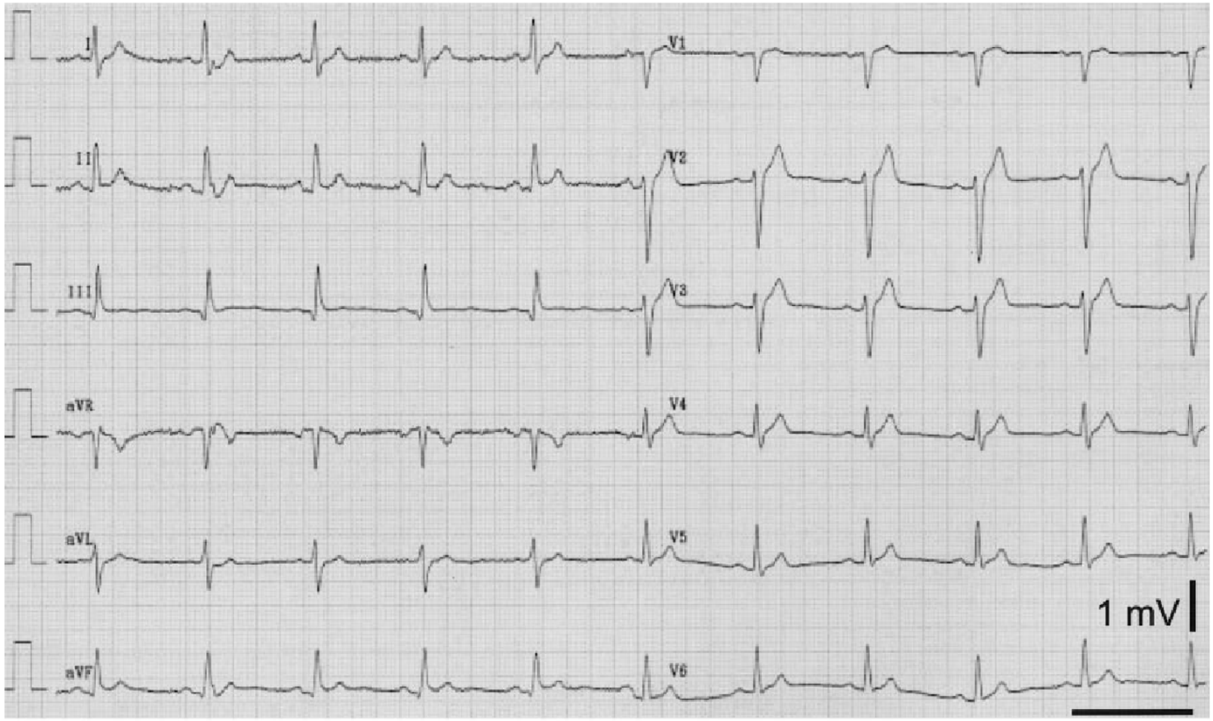
Fiorenzo Gaita, MD; Carla Giustetto, MD; Francesca Bianchi, MD; Christian Wolpert, MD; Rainer Schimpf, MD; Riccardo Riccardi, MD; Stefano Grossi, MD; Elena Richiardi, MD; Martin Borggrefe, MD

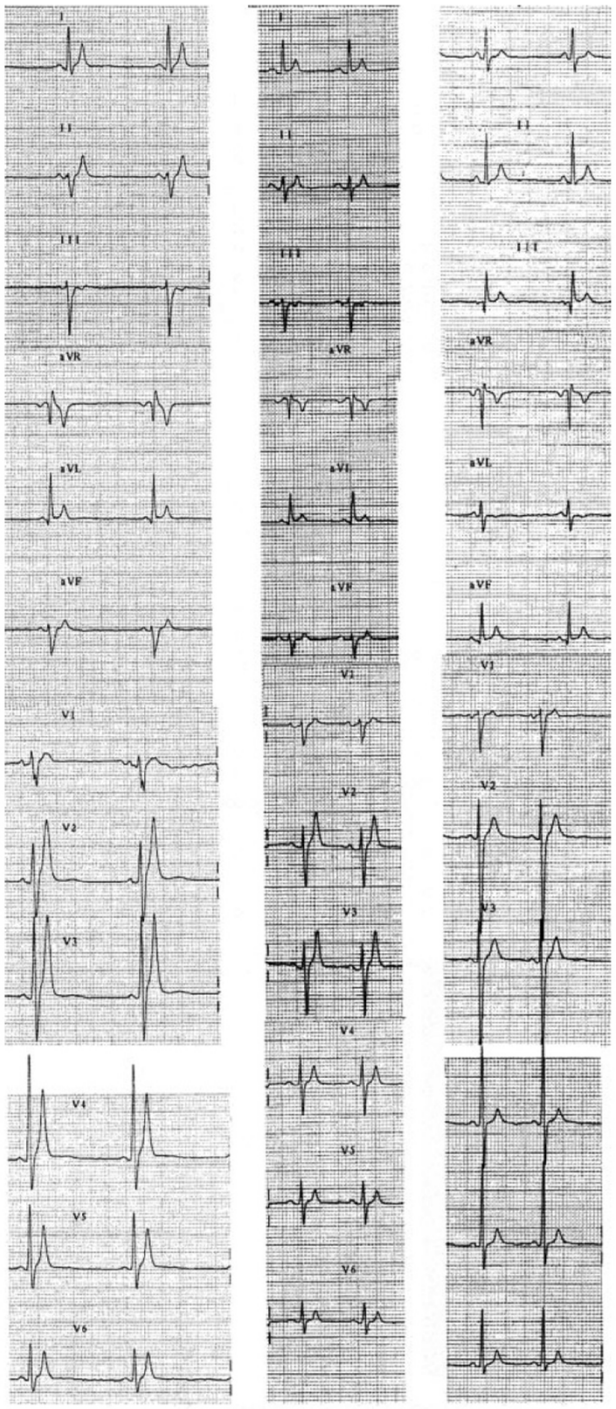
Background—A prolonged QT interval is associated with a risk for life-threatening events. However, little is known about prognostic implications of the reverse—a short QT interval. Several members of 2 different families were referred for syncope, palpitations, and resuscitated cardiac arrest in the presence of a positive family history for sudden cardiac death. Autopsy did not reveal any structural heart disease. All patients had a constantly and uniformly short QT interval at ECG.

Methods and Results—Six patients from both families were submitted to extensive noninvasive and invasive work-up, including serial resting ECGs, echocardiogram, cardiac MRI, exercise testing, Holter ECG, and signal-averaged ECG. Four of 6 patients underwent electrophysiological evaluation including programmed ventricular stimulation. In all subjects, a structural heart disease was excluded. At baseline ECG, all patients exhibited a QT interval ≤280 ms (QTc ≤300 ms). During electrophysiological study, short atrial and ventricular refractory periods were documented in all and increased ventricular vulnerability to fibrillation in 3 of 4 patients.

Conclusions—The short QT syndrome is characterized by familial sudden death, short refractory periods, and inducible ventricular fibrillation. It is important to recognize this ECG pattern because it is related to a high risk of sudden death in young, otherwise healthy subjects. **(*Circulation*. 2003;108:965-970.)**

Key Words: short QT interval ■ death, sudden ■ fibrillation





History
Syncope during exertion, SCD

Family history
Malignant family history
Autosomal dominant mode of inheritance

ECG features
tall, sharp, fine, positive and symmetrical T wave,
especially in the precordial leads (V2 to V4)
poor adaptation of the QT interval to the HR

Lab
cQT < 300 msec, little dynamic changes
often tall and peaked T waves

EPS
Very short ERP (<150 msec)
Inducible VF or very fast monomorphic VT
(CL 150 msec) with 2-3 extrastimulation

How short is “short” ?

QT < 320ms, QTc<340ms

Causes of (transient) QT shortening

hyperkalemia, hypercalcemia, acidosis, digoxin overdose, fever, tachycardia, vagal or sympathetic hypertonia, and acute ischemia

* Early repolarization

Prevalence

Reinig & Engel Gallagher , QTc <300msec

none in 479,120 ECGs from 106,432 patients,

Gallagher, QTc < 330 msec

none in 12,012 apparently healthy subjects

Moriya et al, QTc <350 msec

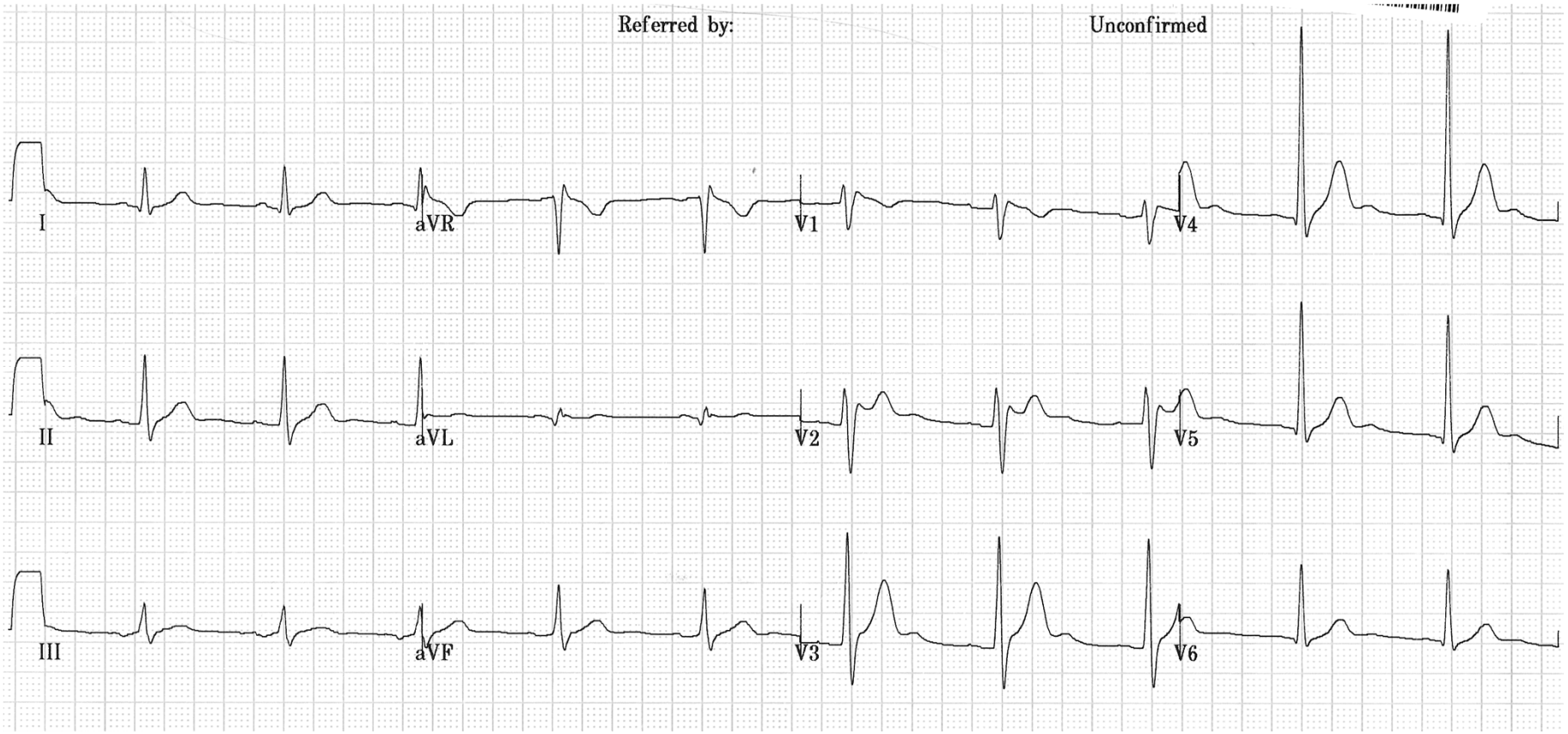
2 in 19,153 middle-aged Japanese people.

Brugada syndrome

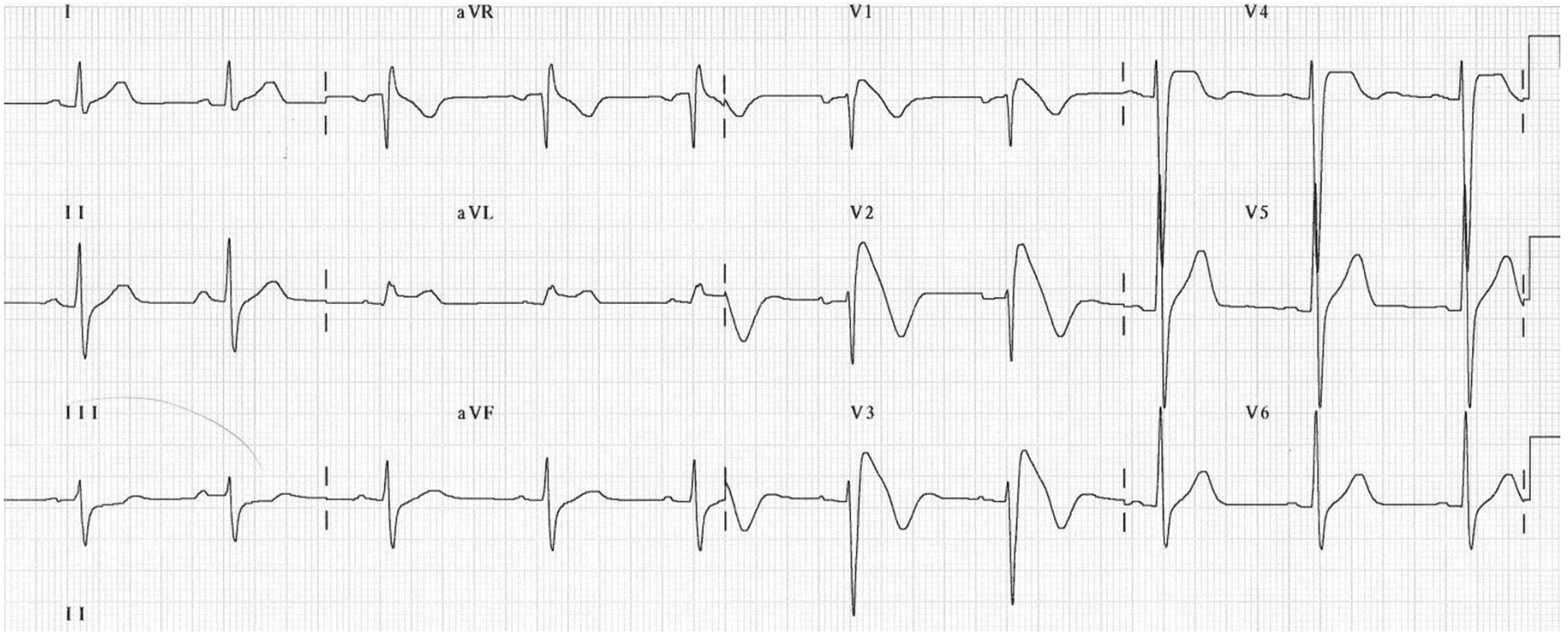
Case 3. 24/M, Asymptomatic ECG abnormality

No abnormal finding in Treadmill test, echocardiogram, EF 68%

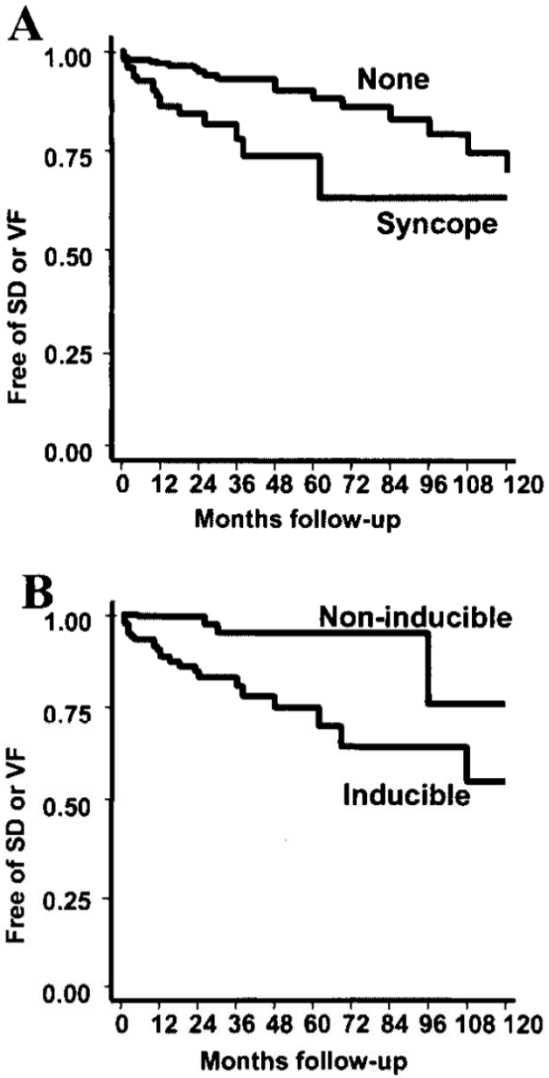
No family Hx of SCD

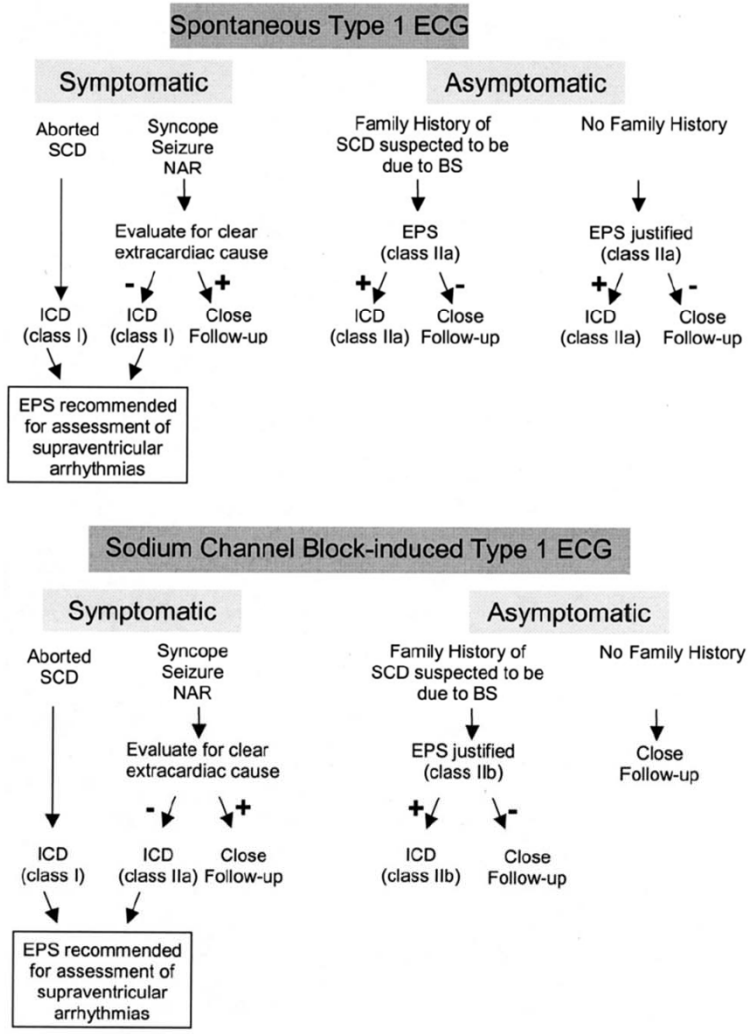


After flecainide infusion.



Brugada syndrome: management





Long-Term Prognosis of Patients Diagnosed With Brugada Syndrome

Results From the FINGER Brugada Syndrome Registry

V. Probst, MD, PhD*; C. Veltmann, MD*; L. Eckardt, MD*; P.G. Meregalli, MD*; F. Gaita, MD; H.L. Tan, MD, PhD; D. Babuty, MD, PhD; F. Sacher, MD; C. Giustetto, MD; E. Schulze-Bahr, MD, PhD; M. Borggrefe, MD, PhD; M. Haissaguerre, MD; P. Mabo, MD, PhD; H. Le Marec, MD, PhD; C. Wolpert, MD, PhD; A.A.M. Wilde, MD, PhD

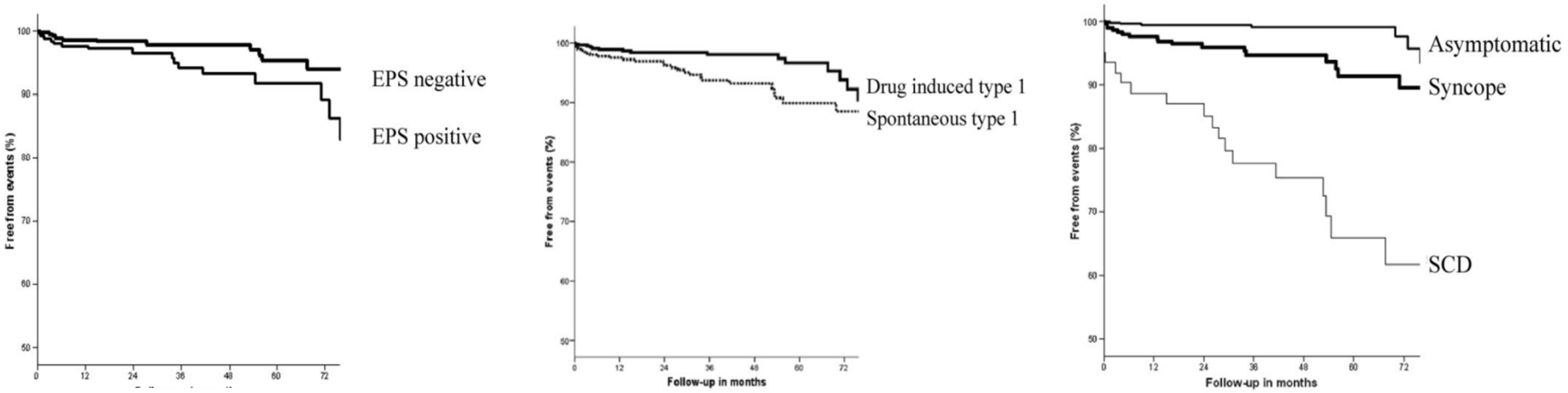
Background—Brugada syndrome is characterized by ST-segment elevation in the right precordial leads and an increased risk of sudden cardiac death (SCD). Fundamental questions remain on the best strategy for assessing the real disease-associated arrhythmic risk, especially in asymptomatic patients. The aim of the present study was to evaluate the prognosis and risk factors of SCD in Brugada syndrome patients in the FINGER (France, Italy, Netherlands, Germany) Brugada syndrome registry.

Methods and Results—Patients were recruited in 11 tertiary centers in 4 European countries. Inclusion criteria consisted of a type 1 ECG present either at baseline or after drug challenge, after exclusion of diseases that mimic Brugada syndrome. The registry included 1029 consecutive individuals (745 men; 72%) with a median age of 45 (35 to 55) years. Diagnosis was based on (1) aborted SCD (6%); (2) syncope, otherwise unexplained (30%); and (3) asymptomatic patients (64%). During a median follow-up of 31.9 (14 to 54.4) months, 51 cardiac events (5%) occurred (44 patients experienced appropriate implantable cardioverter-defibrillator shocks, and 7 died suddenly). The cardiac event rate per year was 7.7% in patients with aborted SCD, 1.9% in patients with syncope, and 0.5% in asymptomatic patients. Symptoms and spontaneous type 1 ECG were predictors of arrhythmic events, whereas gender, familial history of SCD, inducibility of ventricular tachyarrhythmias during electrophysiological study, and the presence of an *SCN5A* mutation were not predictive of arrhythmic events.

Conclusions—In the largest series of Brugada syndrome patients thus far, event rates in asymptomatic patients were low. Inducibility of ventricular tachyarrhythmia and family history of SCD were not predictors of cardiac events. **(*Circulation*. 2010;121:635-643.)**

Key Words: Brugada syndrome ■ death, sudden ■ electrophysiology ■ genetics ■ tachyarrhythmias

Brugada syndrome: FINGER registry



유의: Symptoms, Spontaneous type 1 ECG
무의미: Gender, familial history of SCD, inducibility, and *SCN5A mutation were not predictive of* arrhythmic events.

* The rate of cardiac events in the asymptomatic Brugada syndrome patients was low, and the inducibility of ventricular tachyarrhythmias during electrophysiological study did not properly stratify the arrhythmic risk.

Early repolarization syndrome, J wave syndrome

J-Point Elevation in Survivors of Primary VF and Matched Control Subjects

Table 1 Incidence of J-Point Elevation Among 45 Patients With Idiopathic VF and 124 Healthy Control Subjects Matched for Age and Gender

	Idiopathic VF		Control Subjects				
	n	%	n	%	p Value*	OR	95% CI
Any lead							
Any J-point elevation	19	42.2%	16	13.0%	0.001	3.2	1.7–6.3
J-point >1.0 mm	14	31.1%	11	8.9%	0.002	3.4	1.5–7.5
Inferior leads							
Any J-point elevation	12	26.7%	10	8.1%	0.006	3.2	1.4–7.5
J-point >1.0 mm	8	17.8%	8	6.5%	0.052	2.6	1.0–7.1
Leads I and aVL							
Any J-point elevation	6	13.3%	1	0.8%	0.009	16.9	2.0–140.3
J-point >1.0 mm	5	11.1%	0	0			
Leads V_4 to V_6							
Any J-point elevation	3	6.7%	9	7.3%	0.860	0.9	0.2–3.3
J-point >1.0 mm	3	6.7%	6	4.9%	0.686	1.3	0.3–5.3

All electrocardiograms were recorded at standard gain (10 mm = 1 mV). *p value calculated with conditional logistic regression.
CI = confidence interval; OR = odds ratio; VF = ventricular fibrillation.

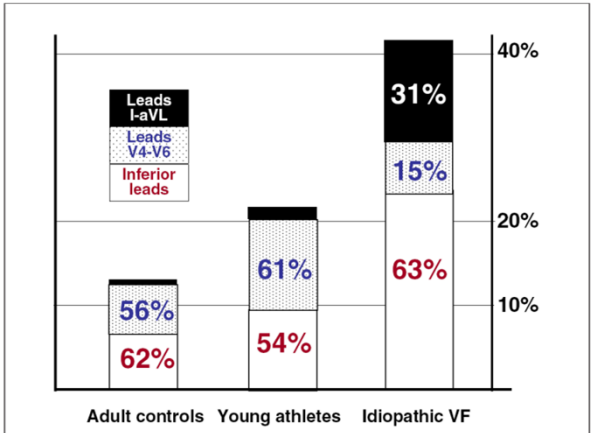


Figure 4 Distribution of J Waves Among Patients With Idiopathic VF, Matched Control Subjects, and Healthy Athletes

The **bars** show the percentage of individuals with J-point elevation in each of the 3 patient groups. The **y axis** denotes the percentage of patients with J-point elevation in any lead. The **partition of each bar** demonstrates the distribution of J-point elevation in the different leads (the **numbers within the bars** exceed 100%, because some patients had J-point elevation in more than 1 group of leads). VF = ventricular fibrillation.

(J Am Coll Cardiol 2008;52:1231–8)

Long-term Outcome in Patients with Early repolarization

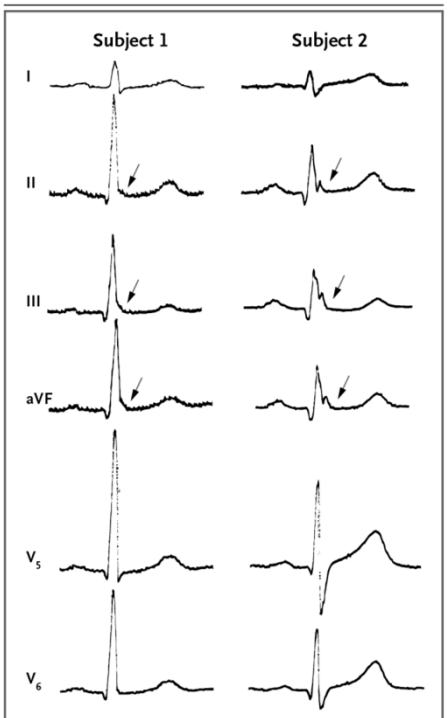


Figure 2. Baseline Electrocardiograms of Two Male Subjects with J-Point Elevation of More Than 0.2 mV in the Inferior Leads.

In two subjects with J-point elevation of more than 0.2 mV in the inferior leads, Subject 1 has a slurred elevation (arrows) and Subject 2 has a notched elevation (arrows). Both subjects died from arrhythmia during the follow-up period.

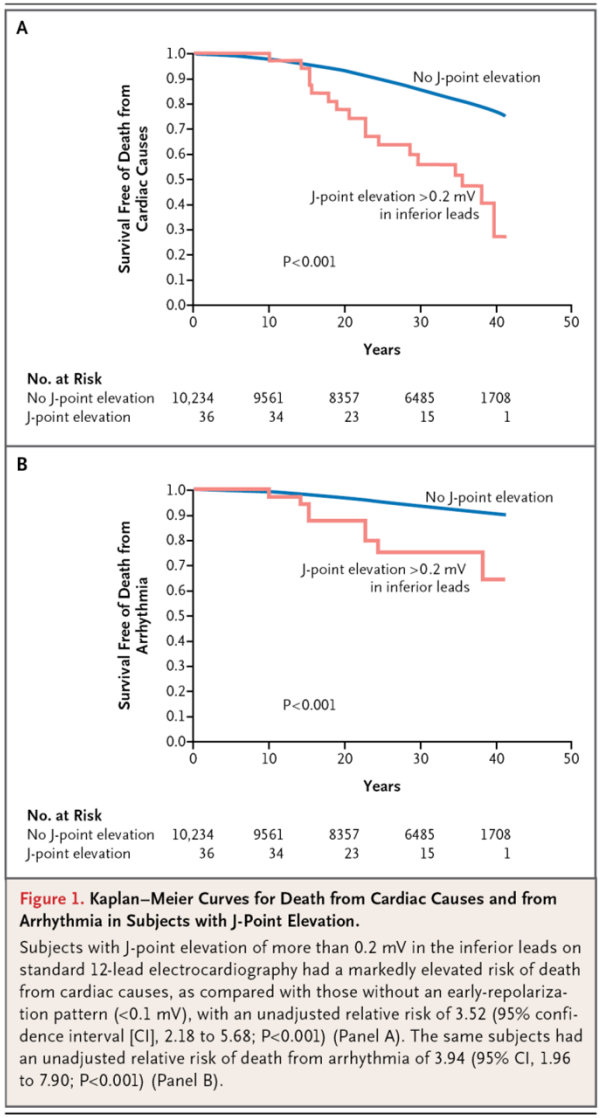


Figure 1. Kaplan–Meier Curves for Death from Cardiac Causes and from Arrhythmia in Subjects with J-Point Elevation.

Subjects with J-point elevation of more than 0.2 mV in the inferior leads on standard 12-lead electrocardiography had a markedly elevated risk of death from cardiac causes, as compared with those without an early-repolarization pattern (<0.1 mV), with an unadjusted relative risk of 3.52 (95% confidence interval [CI], 2.18 to 5.68; P<0.001) (Panel A). The same subjects had an unadjusted relative risk of death from arrhythmia of 3.94 (95% CI, 1.96 to 7.90; P<0.001) (Panel B).

Heikki V. Huikuri, et. al. N Engl J Med 2009;361-1

조기 재분극을 보이는 환자는 누구나 다 심실세동, 급사의 위험이 있는가?

Diagnostic power of J-point elevation

:Estimated risk for IVF

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.

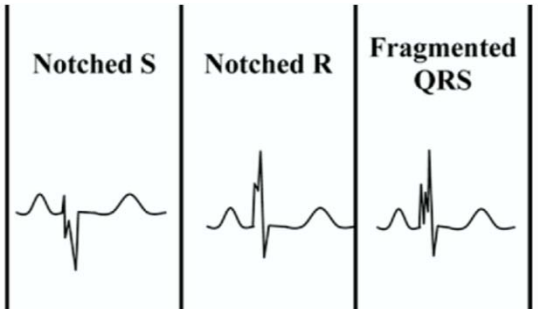
Rosso, Viskin. J Am Coll Cardiol 2008;52:1231–8

Fragmented QRS: A predictor of mortality and SCD

Fragmented QRS: ECG criteria

Narrow QRS

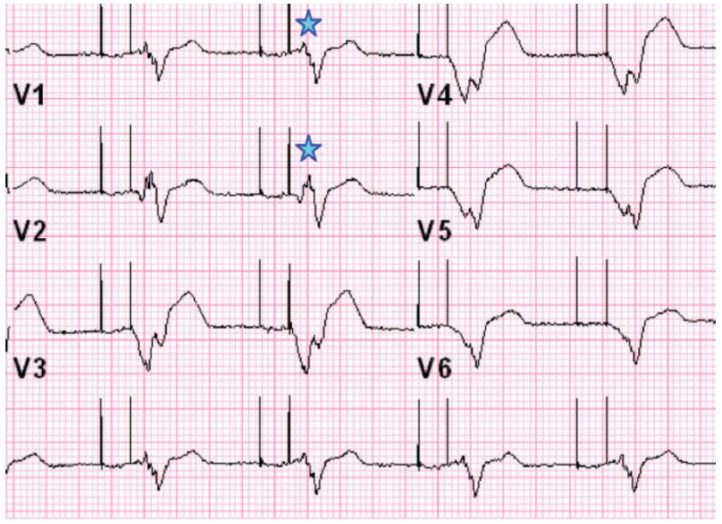
additional R wave (R'),
notching in S wave or R wave,
presence of more than one R'(fragmentation)
in two contiguous leads

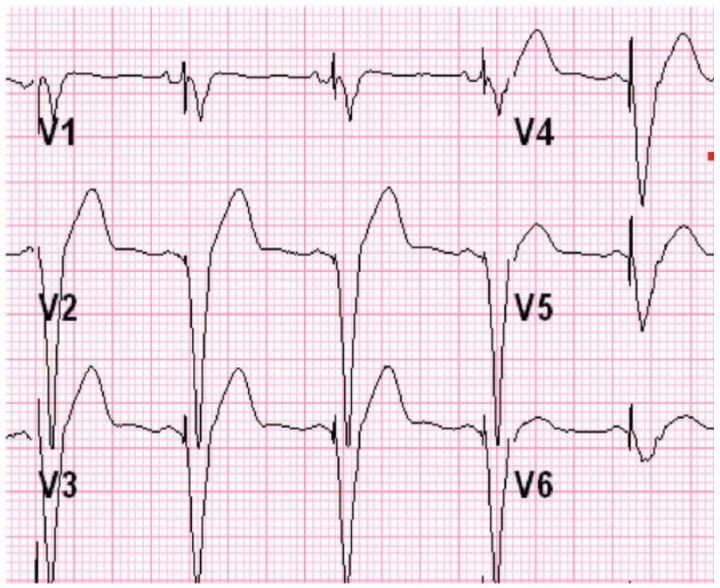


BBB morphology

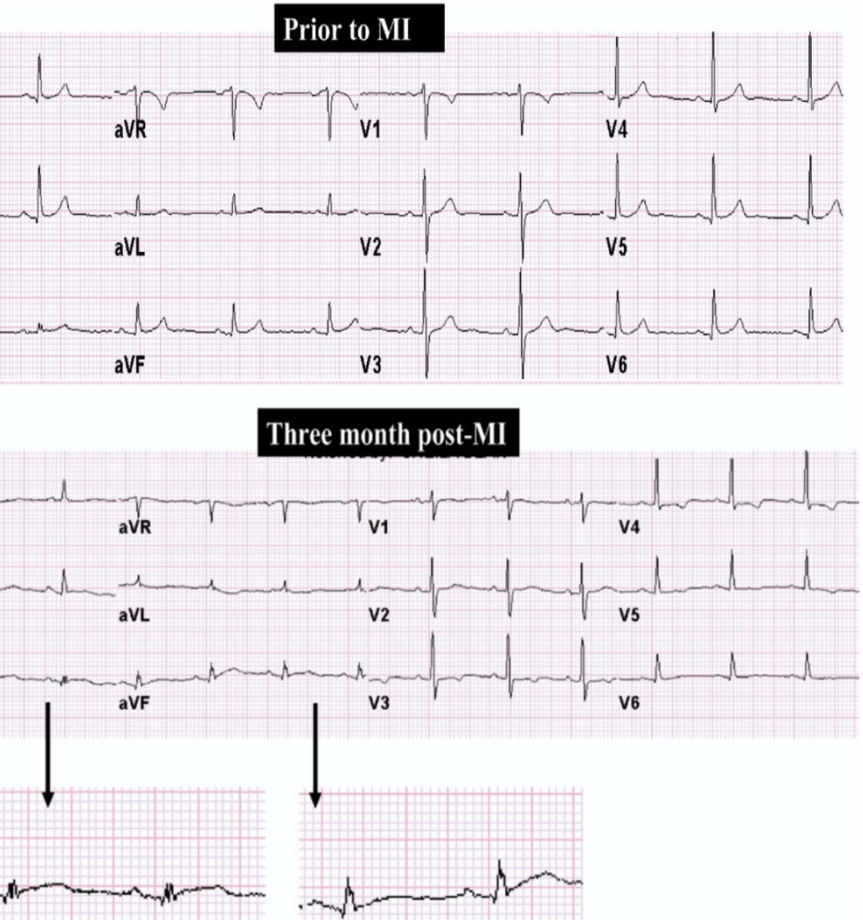
>2 notches (at least 1 notch
more than the typical BBB)

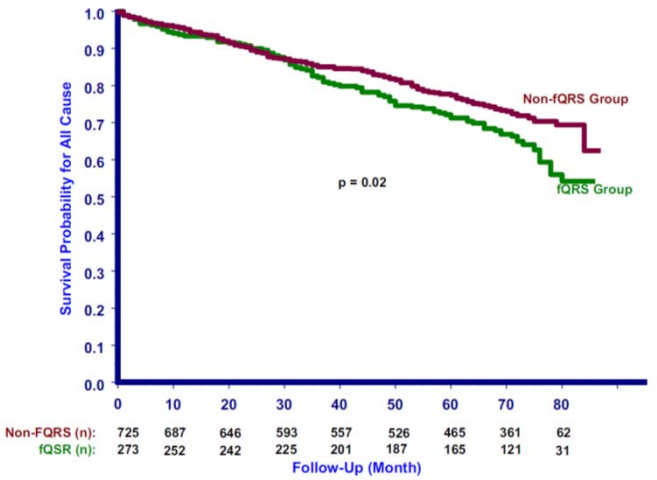
multiple notches of the R wave
or >2 notches in the nadir of the S wave.

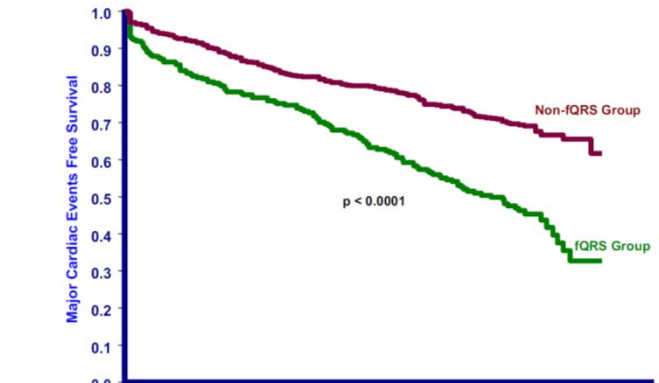




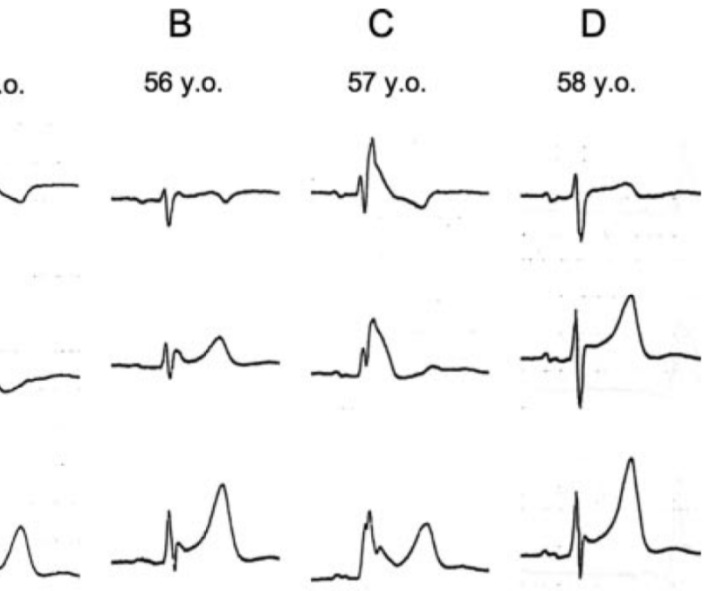
Fragmented QRS: in Myocardial infarction







Fragmented QRS: in Brugada syndrome



Spontaneous variations of f-QRS and ST elevation.
Gs were recorded in a patient who experienced car-
. A, ECG when patient was 55 years old (y.o.). Lead
RS at the late phase of the QRS complex (arrows).
nd V_2 showed coved-type ST elevation. B, ECG at
rs. ST elevation decreased and changed to the
k type. f-QRS was not observed. C, ECG at age 57
ed-type ST elevation reappeared, but f-QRS did not
ECG at age 58 years. ECG converted to normal pat-

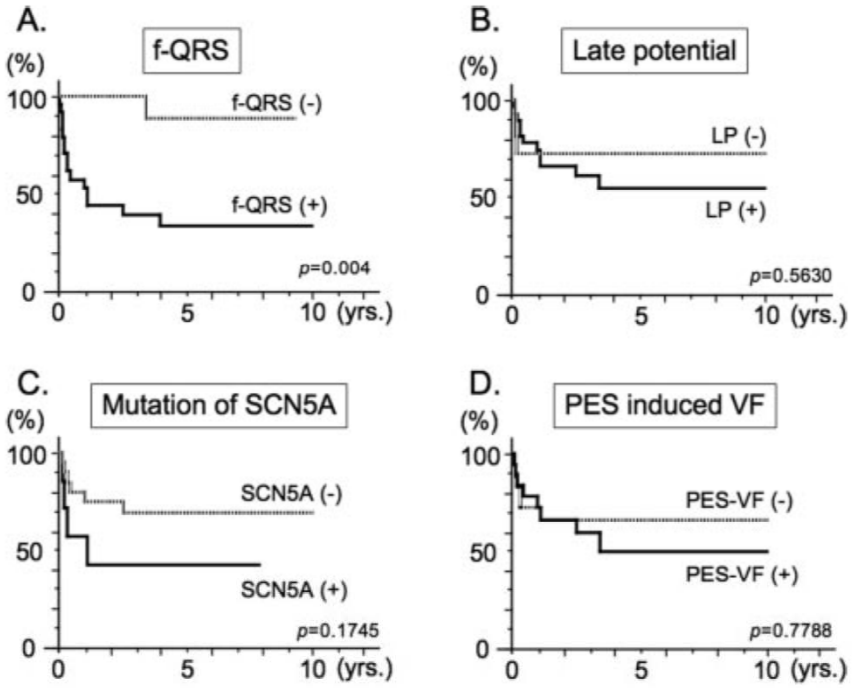
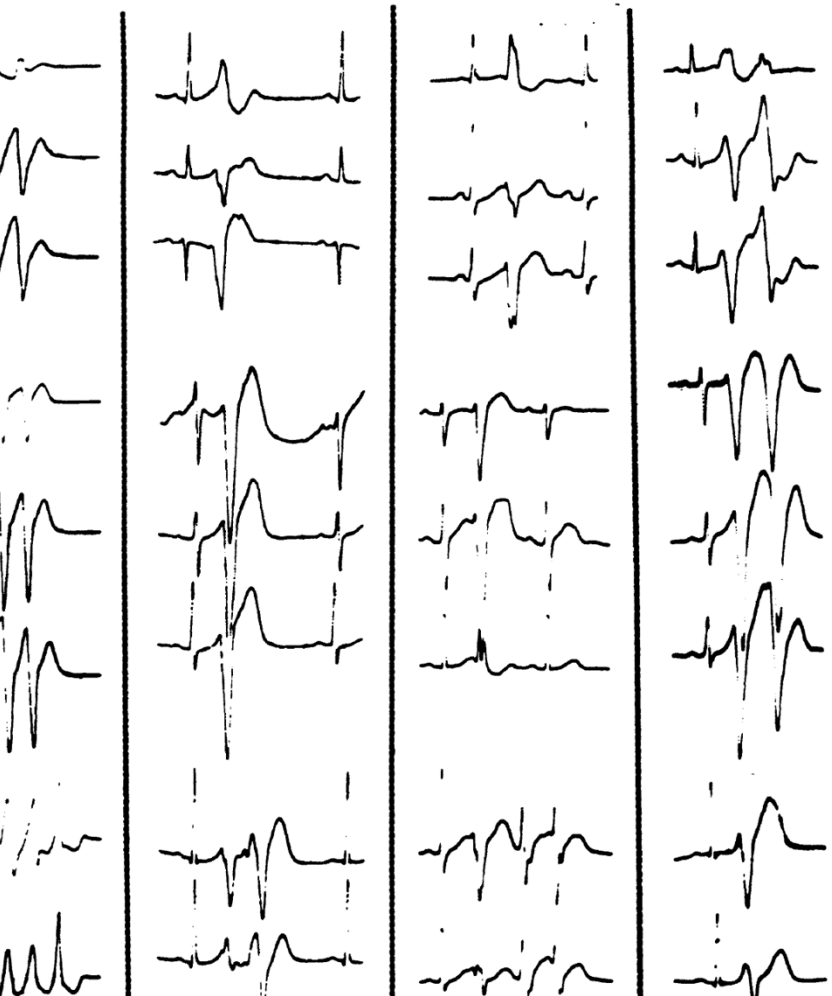


Figure 7. Recurrence of syncope due to ventricular arrhythmia. A, Freedom from events for patients with and without f-QRS. Patients with f-QRS often experienced recurrent syncope due to VF within 4 years from the first episode. The existence of LPs (B), mutation of SCN5A (C), and VF induced by programmed electrical stimulation (PES; D) did not predict the recurrence of

PVC with extremely short coupling intervals

Short-coupled variant of torsade de pointes

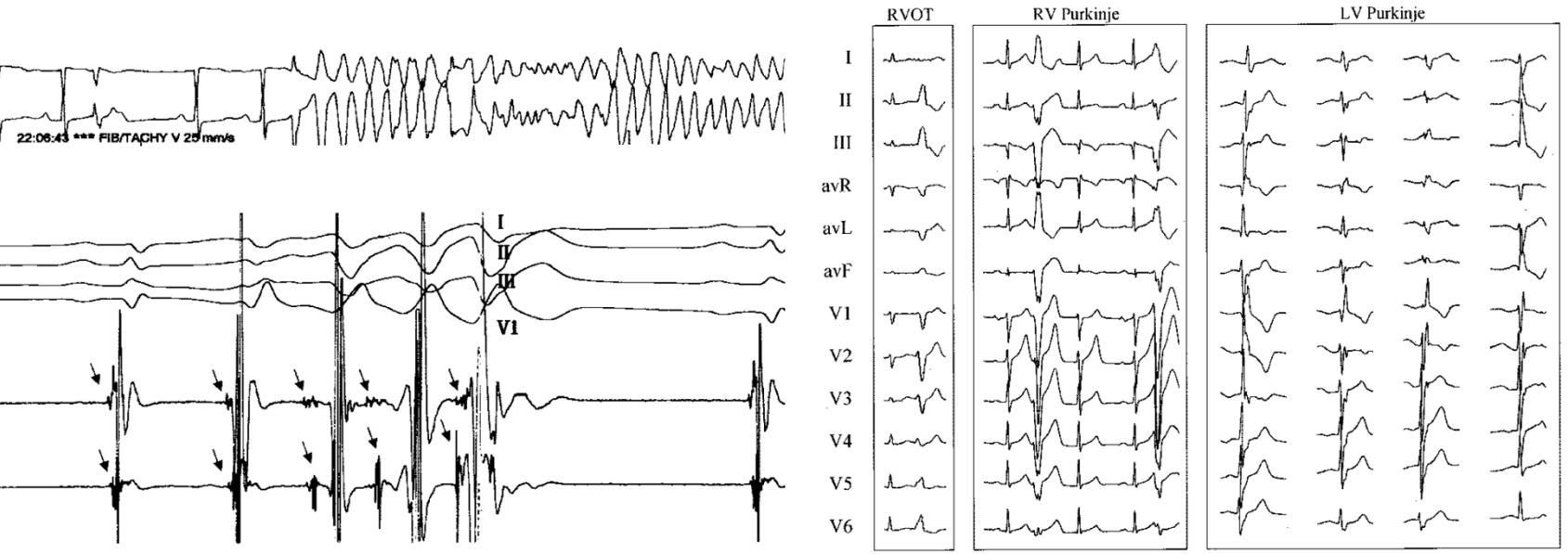


14 patients, 34.6±10 years
4 patients, FHx of SCD
coupling interval (245±28 msec)
238 beat per min (range, 180 to 300)

10 cases, deteriorated into VF
9/14: LBBB, LAD (-45degree)

F/U 7 years: 5 deaths (4 SCD)
3/9 ICD, 6/9 verapamil

Ablation of Idiopathic Ventricular Fibrillation

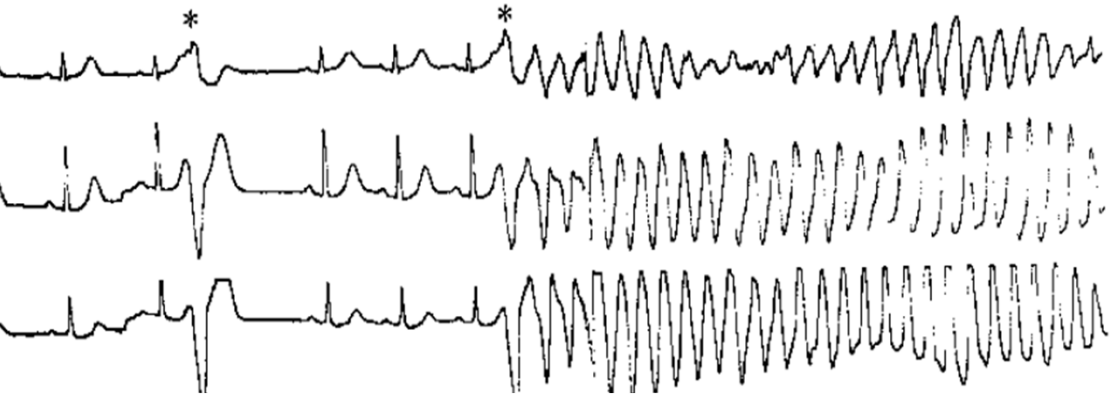


4/27: RVOT muscle (CI, 355±30 msec)

23/27: Purkinje fiber (CI, 280±26 msec)

9/23- anterior RV


aVR
V1
V4
aVL
V2
V5
aVF
V3
V6
I
aVR
V1
II
aVL
V2
III
aVF
V3
II



Conclusion

CG has a limited role predicting SCA due to low
ensitivity and specificity, but may be useful
entifying high-risk group of patients.

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athologic Q
seudo-infarction Q wave
elta wave
ragmented QRS
psilon wave
rugada type ST elevation
wave with/without ST elevation (ER)