Ventricular Tachycardia: the clinician's perspective

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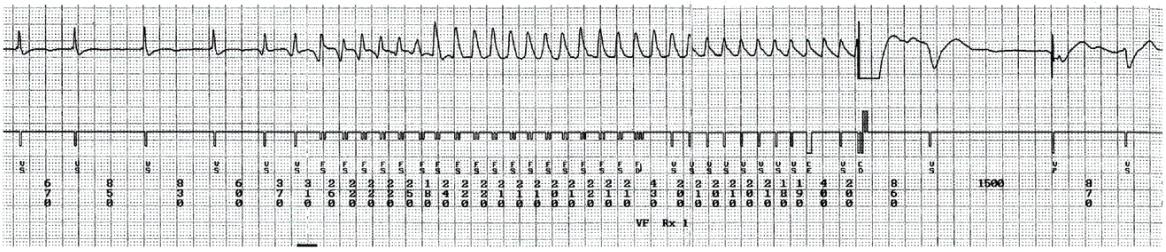
Sudden Death: 300,000 / year in US



Reducing Sudden Death From Ventricular Arrhythmias

- Effective treatment when the arrhythmia occurs
- Prevent the arrhythmia

Reducing sudden death: Effective resuscitation

	Candidates
▪ Emergency medical systems	▪ Everyone
▪ Automatic external defibrillators	▪ Everyone
▪ Implantable defibrillators	▪ Selected high risk pts

Reducing sudden death: Prevent arrhythmias

- Prevent the arrhythmia substrate from developing – prevent heart disease

- Antiarrhythmic drugs
- Ablation procedures

Candidates

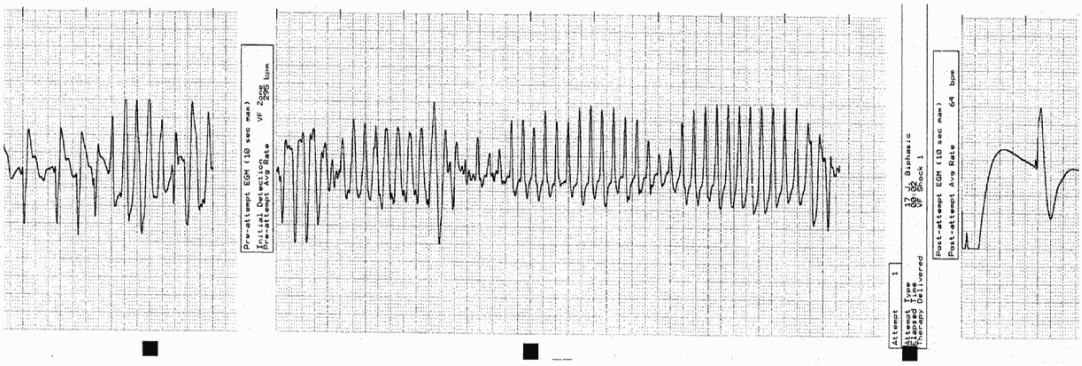
- Everyone

- Selected high risk patients

Ventricular Fibrillation

Body surface ECG

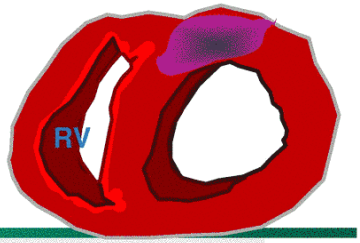
Intracardiac tracing from an ICD



Mechanisms of Arrhythmic Sudden Death

Implications for Prevention

Ventricular fibrillation caused by acute ischemia



- Most common cause of cardiac arrest
- Presents with ventricular fibrillation
- Can occur despite previously normal ventricular myocardium

- The bad news: occurrence is not predictable
- The good news: lucky survivors who have VF due to an acute thrombotic infarct have a low risk of recurrence – long term antiarrhythmic therapy is not usually warranted

Preventing ischemic VF

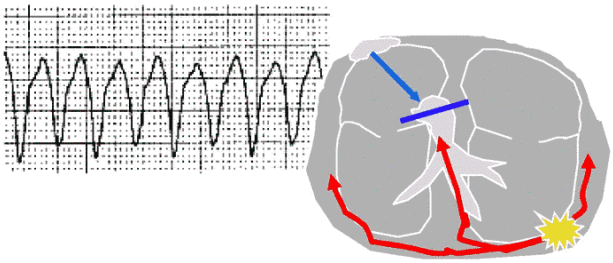
- Address modifiable coronary risk factors
  - smoking
  - hypertension
  - cholesterol
- Therapies
  - statins
  - aspirin
  - beta-blockers

Other causes of VF

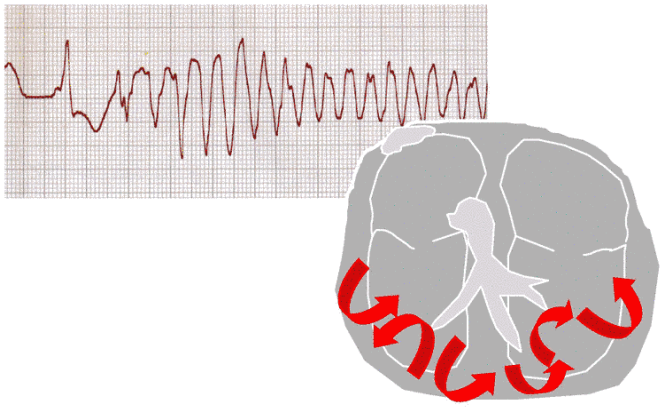
- **Ventricular tachycardia from any cause**
- **Electrolyte abnormalities**
- **Drug toxicity**
- **Cardiomyopathy / hypertrophy**
- **Familial syndromes associated with sudden death**
  - **-Long QT syndrome**
  - **-Familial catecholamine induced VT**
  - **-Brugada syndrome**
  - **-Arrhythmogenic RV dysplasia**

Wide QRS Tachycardias

- **Monomorphic**
  - -Substrate present
    - -(scar vs idiopathic)
  - -High risk of recurrence



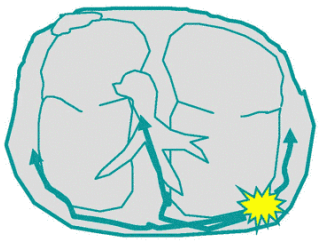
- **Polymorphic**
  - Ischemic VT
  - torsade de pointes VT
  - Familial sudden death syndromes



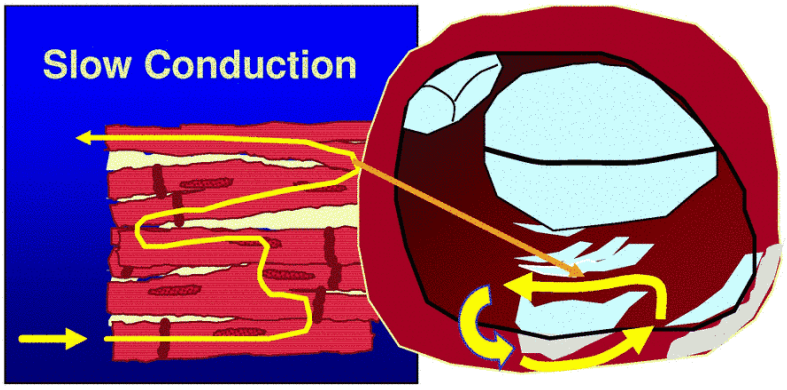
Monomorphic Ventricular Tachycardia

- **Scar related reentry**

- **Purkinje system**
  - –automaticity
  - –reentry
- **Idiopathic VT**
  - – no structural heart disease

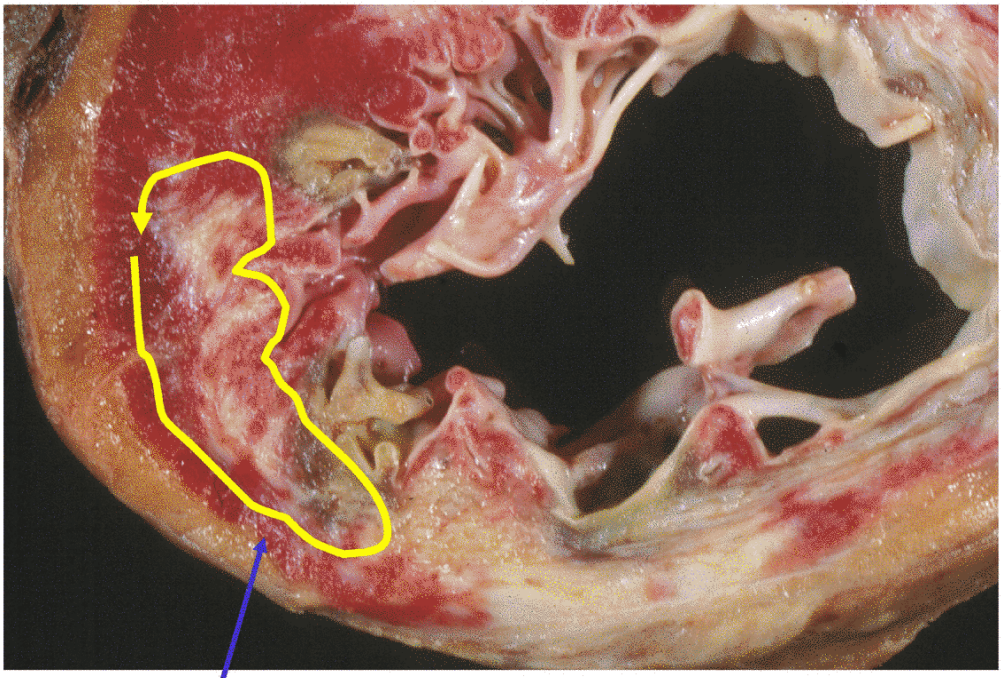


Scar-related VT



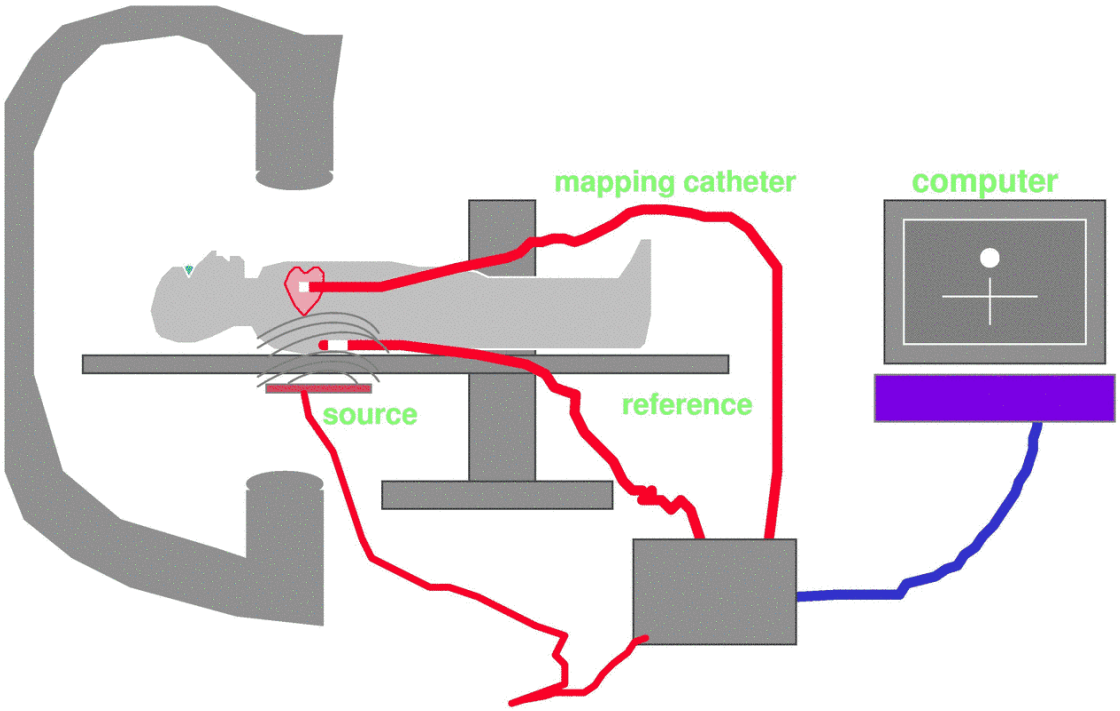
Reentry involving regions of scar
- stable reentry substrate
- VT inducible with programmed stimulation
- risk of recurrent VT > 40%

Causes of scar
- infarction
- cardiomyopathies
  - sarcoidosis, Chagas, idiopathic, viral
- surgery (Tetralogy of Fallot)

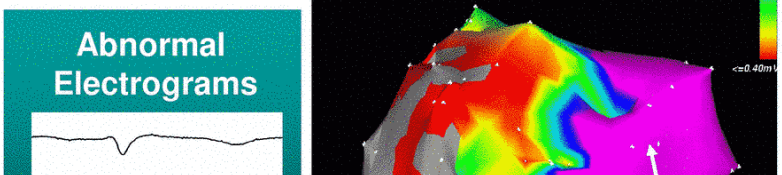


Potential Reentry Circuit paths

Electroanatomic mapping system

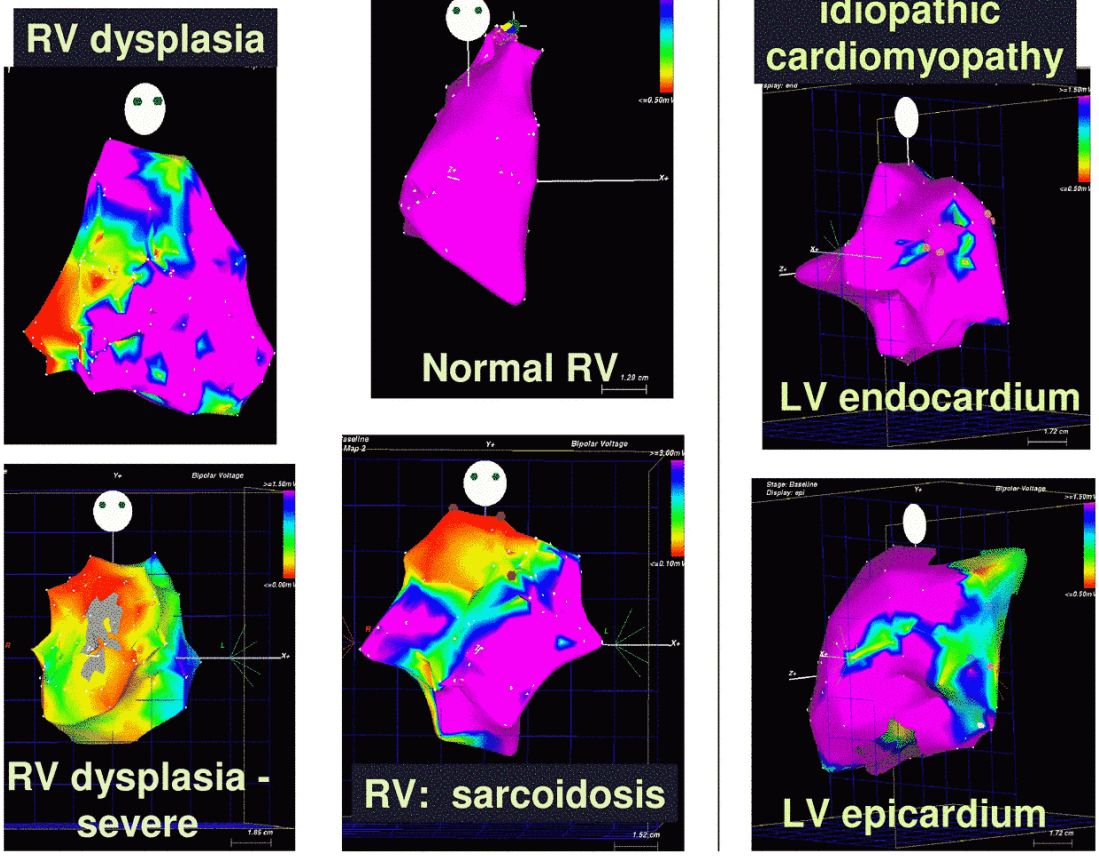


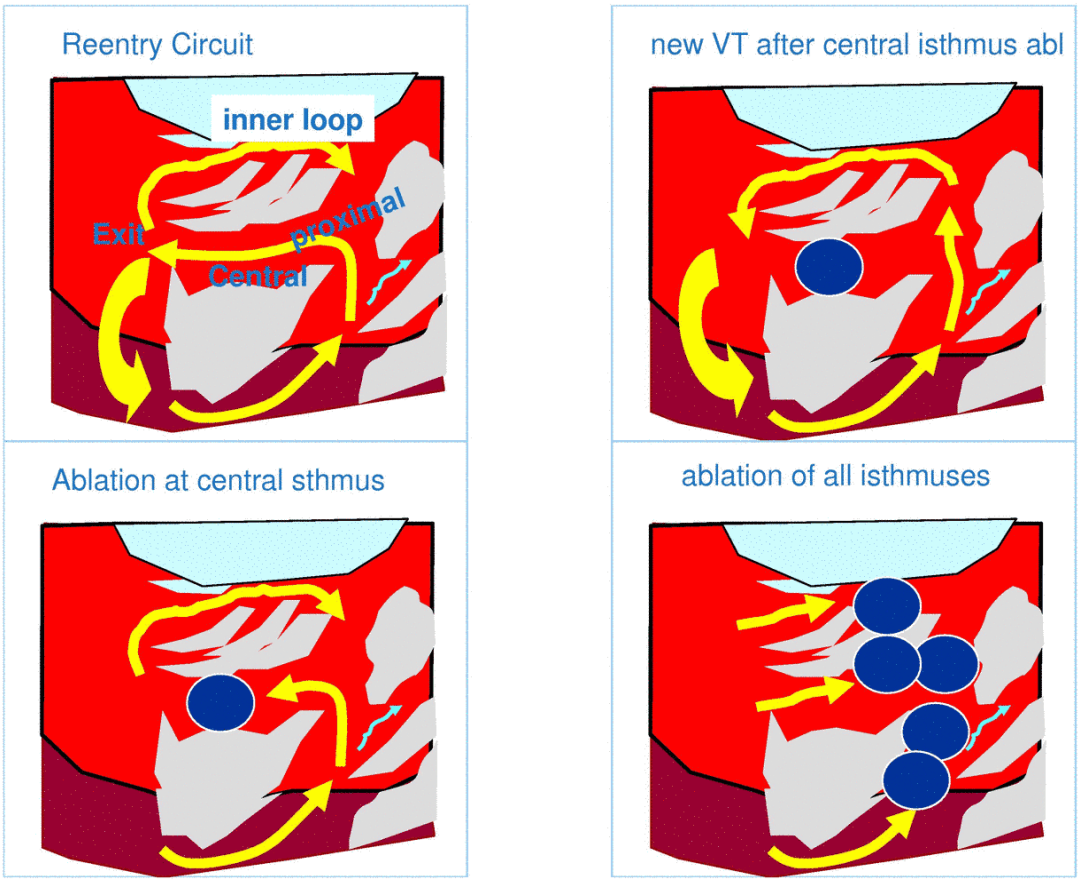
Sinus rhythm voltage map (electrogram amplitude)



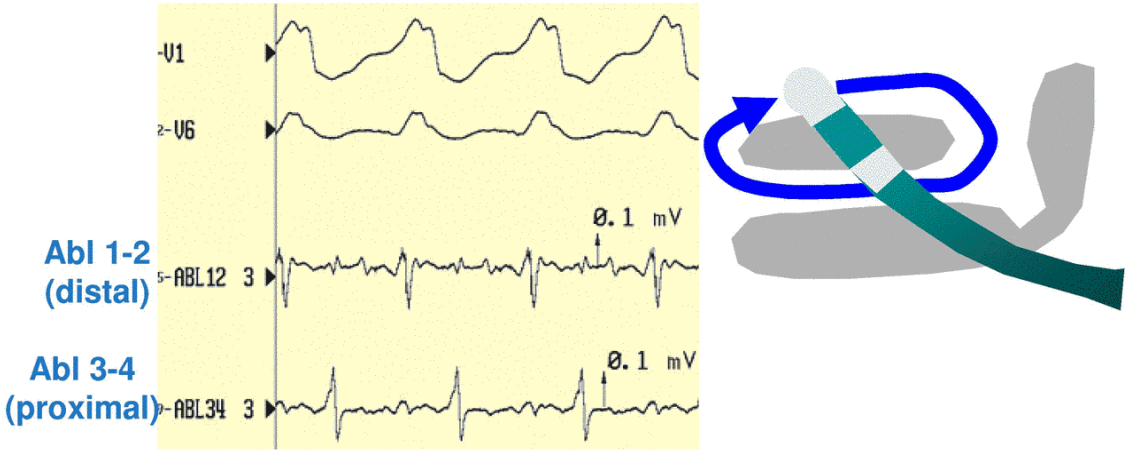
- Normal Electrogram amplitude
  - LV 4.8 ± 3.1 mV (0.6 to 20.5 mV)
  - 95% of normal LV electrograms > 1.55 mv
  - bipolar 4 mm tip electrode - 1 mm spacing
  - filtered 10 to 400 Hz

Marchlinski et al Circulation 2000;101:1288


RV dysplasia
Normal RV
idiopathic cardiomyopathy
LV endocardium
RV dysplasia - severe
RV: sarcoidosis
LV epicardium


Reentry Circuit
inner loop
Exit
proximal
Central
new VT after central isthmus abl
Ablation at central sthmus
ablation of all isthmuses

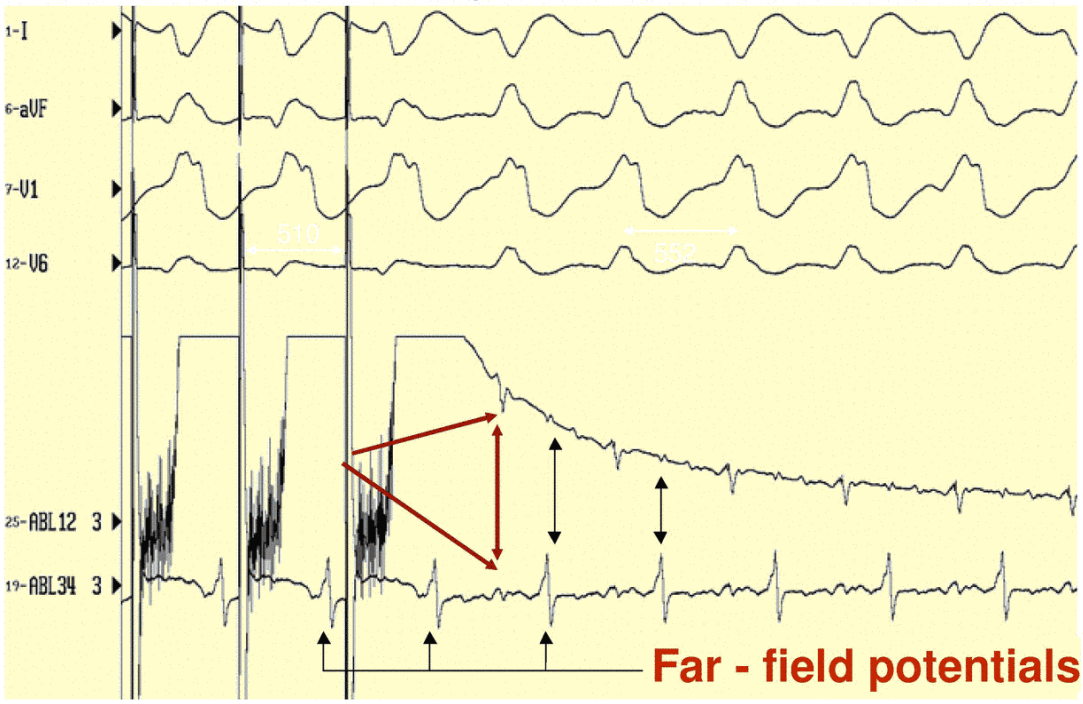
Complex multipotential electrograms in regions of infarction or scar



Far-field Electrograms Compromise Entrainment Mapping
Tung et al JACC 2002

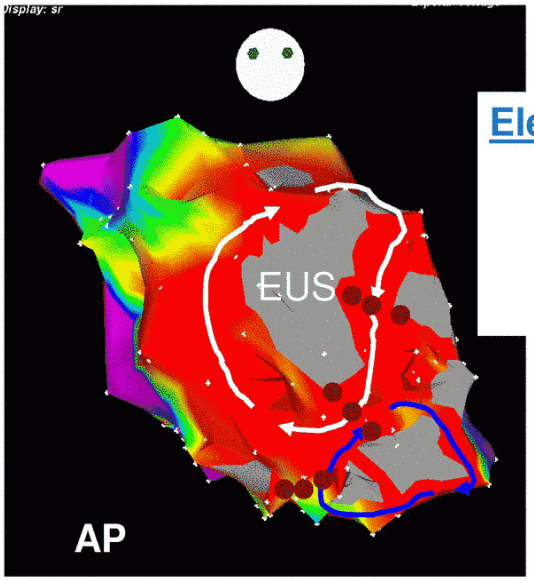
Far-field Electrograms Compromise Entrainment Mapping

Tung et al 2002



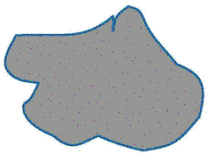
Anatomically guided approaches to catheter ablation of VT

Sinus Rhythm Voltage Map - anterior wall infarct



Electrically inexcitable scar (EUS):

unipolar pacing threshold
> 10 ma at pulse width 2 ms



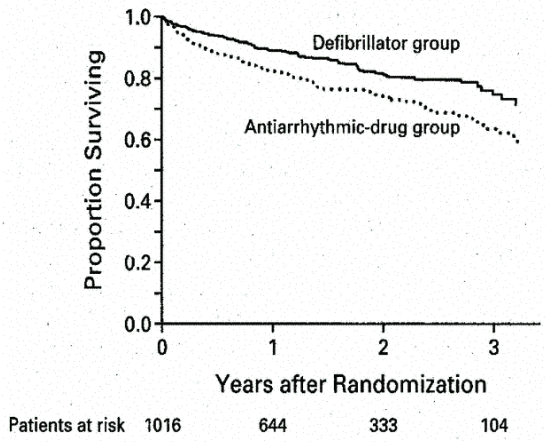
Soejima et al Circulation 106:1678, 2002

VT or VF associated with ventricular scar / infarct (typically indicated by poor ventricular function)

- Risk of recurrence: > 10% annually
- First line therapy:
  - Implantable cardioverter defibrillator (ICD)
    - reduces sudden death to < 5%
    - treats arrhythmia when it occurs
    - approximately a third of patients require additional therapy to control symptomatic arrhythmias
      - antiarrhythmic drugs
      - catheter ablation

Sustained VT or cardiac arrest with heart disease *not due to a reversible cause*: an ICD is the answer

– **AVID trial** NEJM 1997

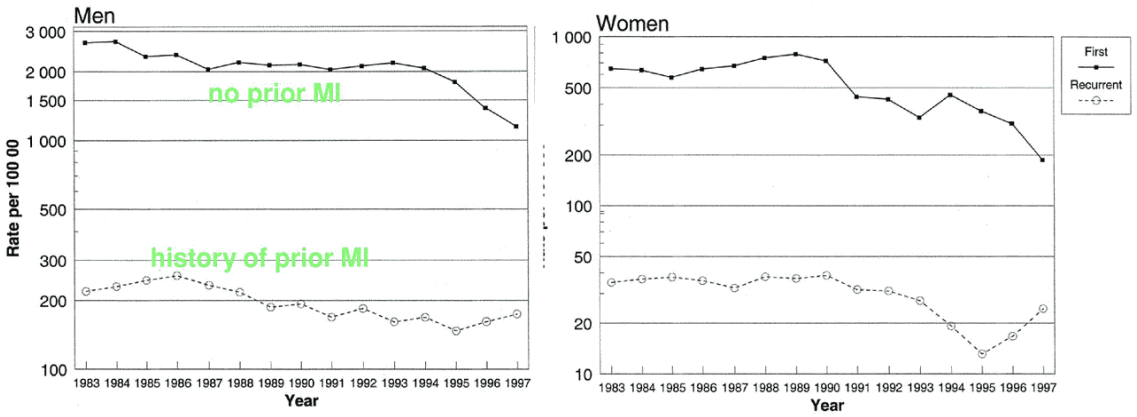


Patients randomized	1016
Age (years)	65
Male	79%
LV ejection fraction	.31
Coronary disease	81%

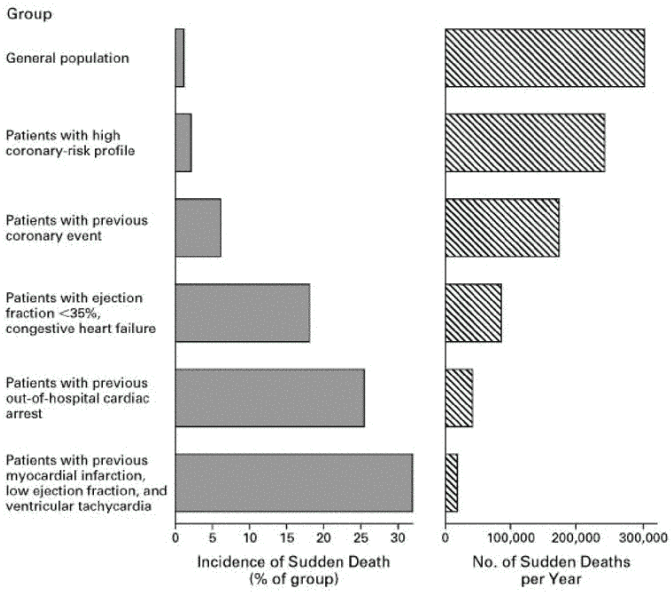
3 year survival: ICD 75%
Drug 64% (amiodarone / sotalol) p = 0.012

Age-standardized rates (3-yr moving avg) for out-of-hospital CHD deaths from first and recurrent CHD events for ages 45 - 64 yrs in Finland

Salomaa et al *Circulation.* 2003;108:691

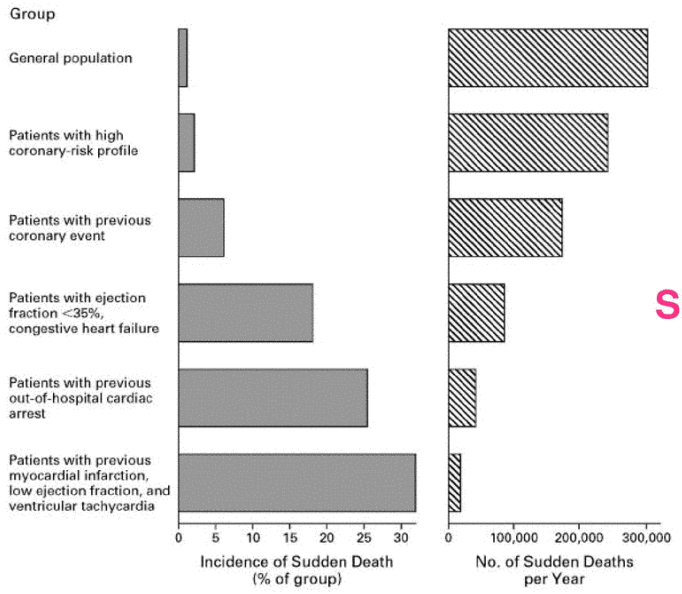


Sudden Death: Individual Risk vs Societal Impact



Myerburg R et al Circulation 1998;97:1514-1521

Tolerance for potential adverse effects and cost of therapies to Prevent Sudden Death



Acceptable Toxicity

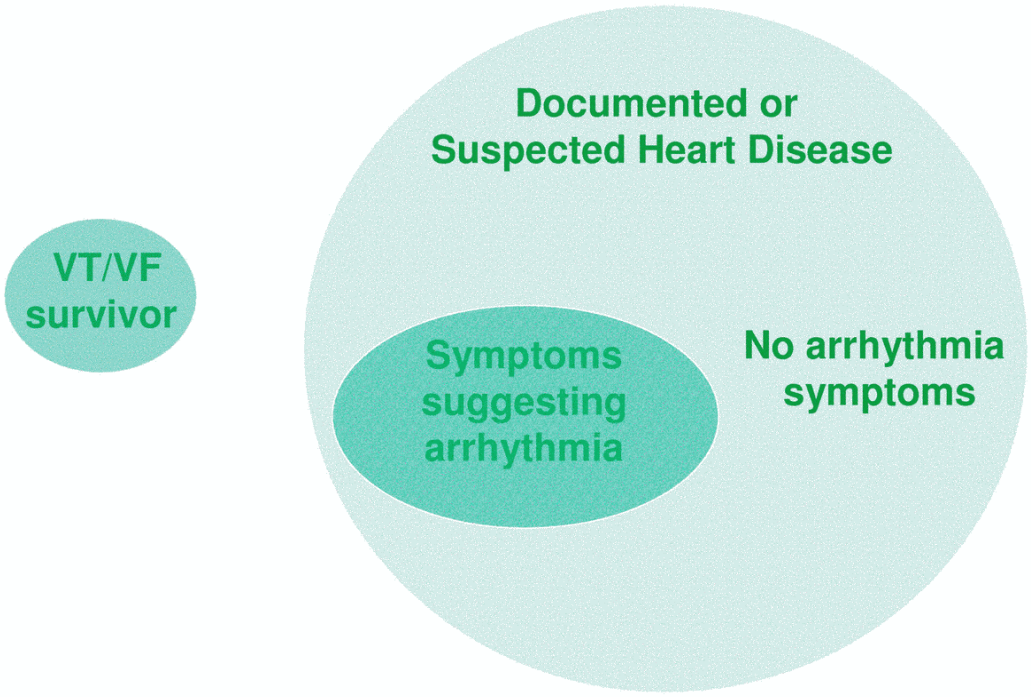
None: water

Minimal: aspirin
statins
beta - blocker

Significant: ICDs
amiodarone

Myerburg R et al Circulation 1998;97:1514-1521

Patient presentations



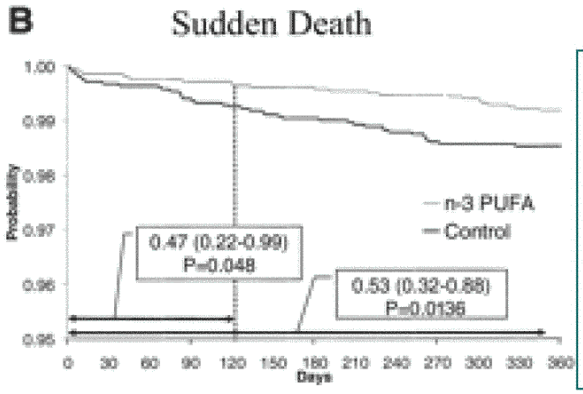
Low risk for patients with stable coronary artery disease with preserved LV function

Heart Outcomes Prevention Evaluation Trial:
9297 patients
N Engl J Med 342:145, 2000

- History of coronary artery disease or stroke
- Normal LV EF: 92%
- History of MI: 52%
- Mean follow-up 5 years
- Mortality due to cardiovascular causes:
  1 – 1.5% per year

Low sudden death risk for infarct survivors treated with reperfusion

Early Protection Against Sudden Death by n-3 Polyunsaturated Fatty Acids After MI
GISSI-Prevenzione Circulation 2002;105:1897

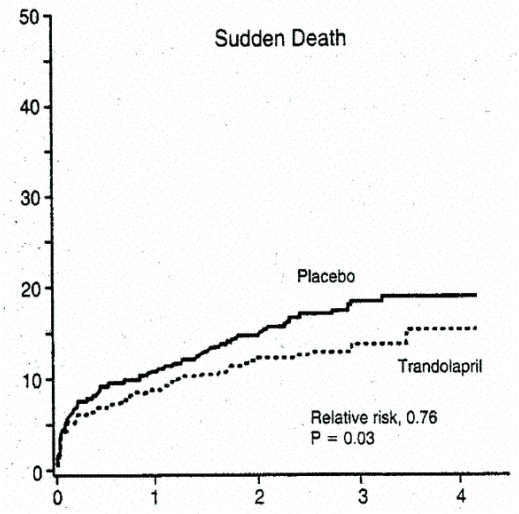


Patients	11, 232
Age	59 yrs
Time from Index MI	16 days
Prior MI	12%
LVEF > 0.40	86%
PVCs > 10/hr	13%

Sudden death risk for infarct survivors with depressed LV function

Trandolapril in patients with LV dysfunction after MI

Kober et al N Engl J Med 1995



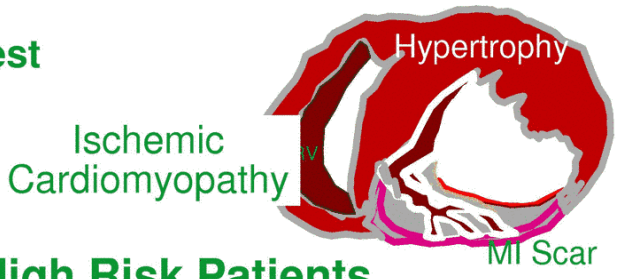
1749 patients

2 - 6 days after acute MI

LV ejection fraction ≤ 0.35

Primary Prevention

- no prior cardiac arrest



ICDs for Selected High Risk Patients

- coronary artery disease
- LV ejection fraction < 0.40
- Nonsustained VT
- Inducible sustained VT
- class IV heart failure excluded
  - Trials: MADIT I and MUSTT

MADIT II

Moss et al ***NEJM 2002; 346:877***

- MI > 1 month prior
- LV ejection fraction </= 0.30
- No accepted ICD indication
- No CABG within 3 months

ICD
742

No ICD (conventional)
490

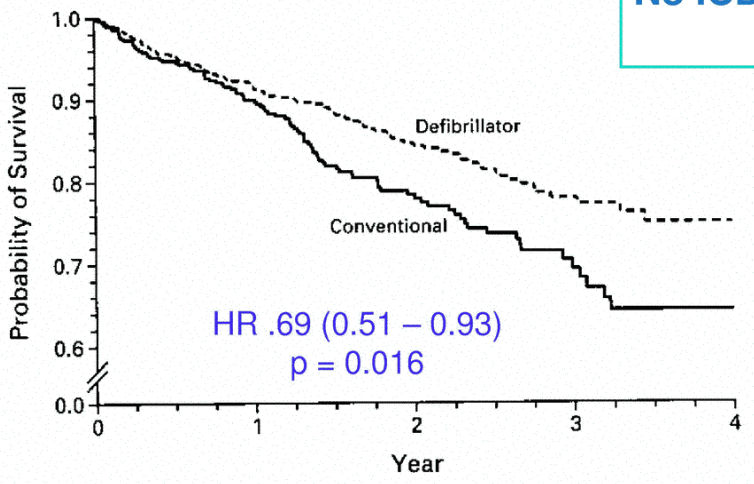
sequential design – repeated assessments of outcome with predefined stopping rules

MADIT II - Survival

Moss et al *NEJM 2002; 346:877*

mean follow – up 20 mo

	Mortality
ICD	14.2 %
No ICD	19.8 %



No. at Risk					
Defibrillator	742	503 (0.91)	274 (0.84)	110 (0.78)	9
Conventional	490	329 (0.90)	170 (0.78)	65 (0.69)	3

Should every patient with depressed ventricular function receive an ICD?

Adverse Events With Transvenous ICDs

Rosenqvist et al Circ1998;98:663

Patients	**778**	
Any adverse event	**259**	**(33%)**
Hemodynamic Deterioration	**1.2%**	
Pneumothorax or tamponade	**1.8%**	
Lead or connector problem	**4.0%**	
Increase in DF threshold	**1.4%**	
Inappropriate therapy	**14.3%**	

Medtronic 7219C, 7219D

Indications for ICD for Primary Sudden Death Prevention in CAD

CMS Decision June 2003

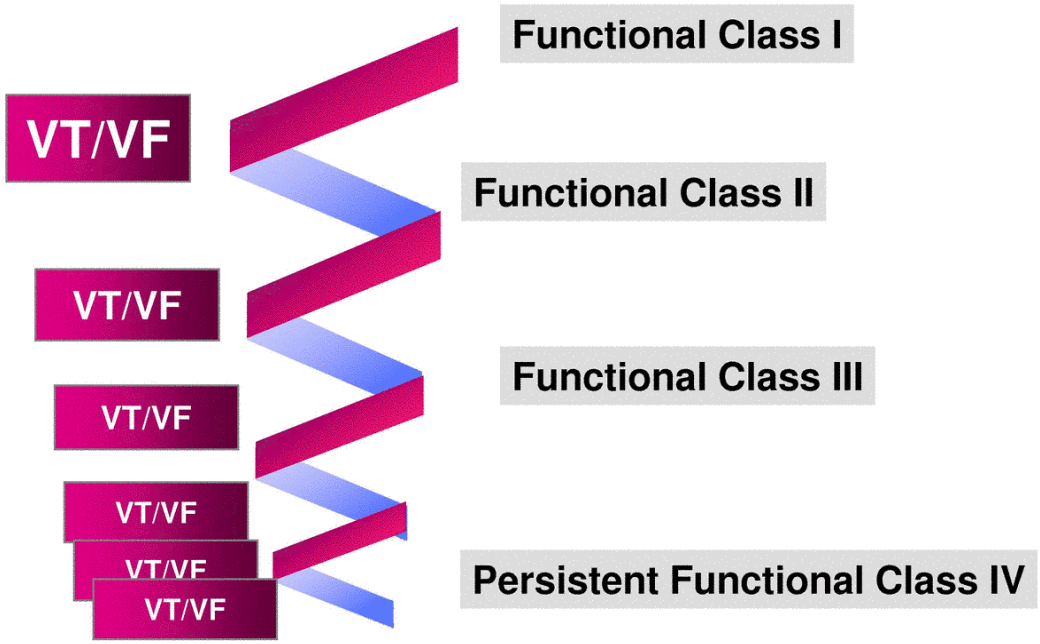
- LVEF < 0.30
  - \+ QRS duration > 120 ms
- LVEF $\leq$ 0.35
  - \+ Inducible VT or VF at EP study

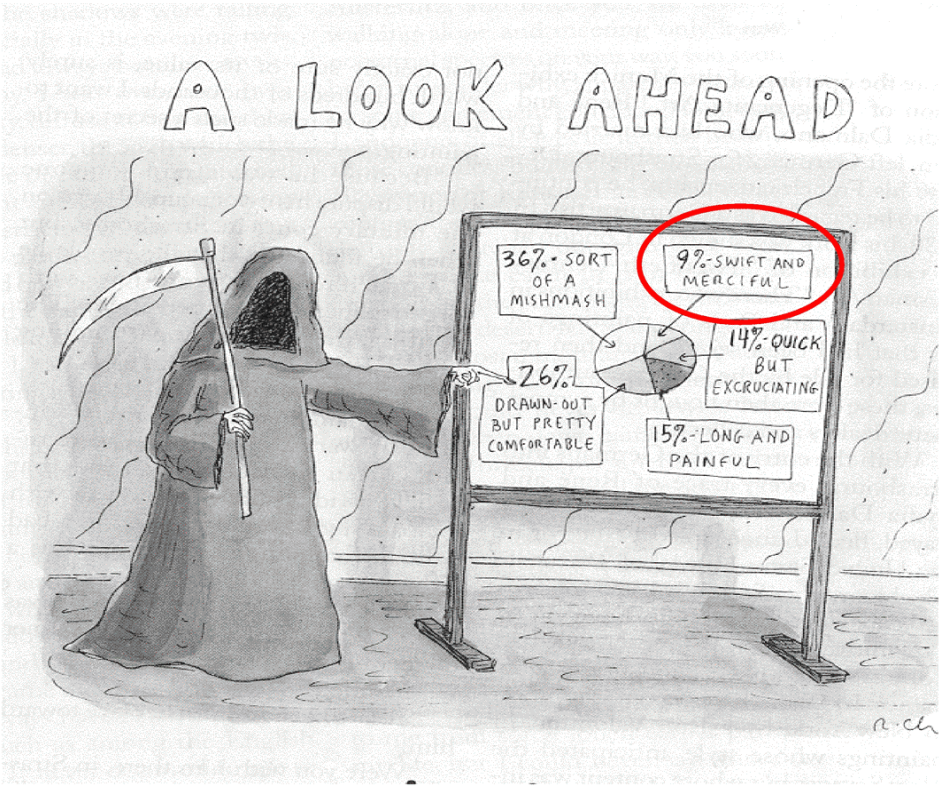
Exclusions:
- CABG within 3 months
- indication for revascularization
- Any disease associated with < 1 year survival
- NYHA Class IV

Regardless of arrhythmia risk some patients should not receive an ICD

- Bed ridden with Class IV symptoms
- Awaiting transplantation in hospital
- Incessant VT
  - (ICD may be warranted after VT controlled)

The downward spiral

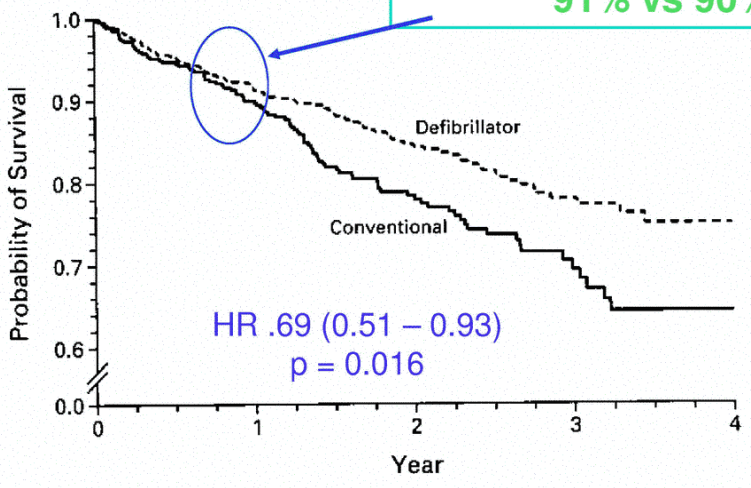




MADIT II - Survival

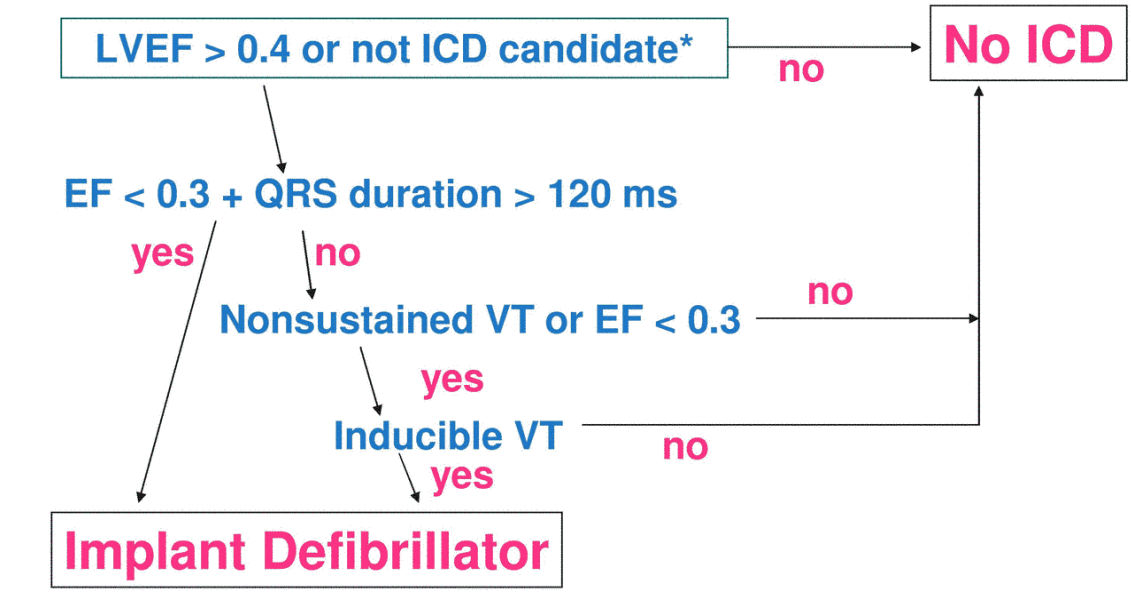
Moss et al *NEJM 2002; 346:877*

No difference in survival at one year
91% vs 90%

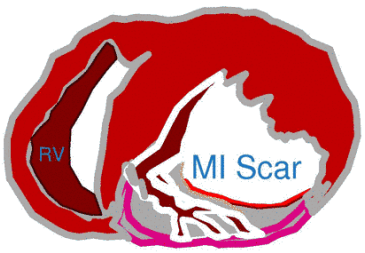


No. at Risk					
Defibrillator	742	503 (0.91)	274 (0.84)	110 (0.78)	9
Conventional	490	329 (0.90)	170 (0.78)	65 (0.69)	3

Primary Prevention of Sudden Death: CAD late after MI without recent revascularization



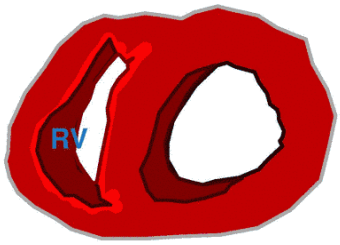
* comorbidities / class IV + no transplant option



Ischemic Cardiomyopathy

- infarct scar

- epicardial coronary disease



Nonischemic Cardiomyopathy

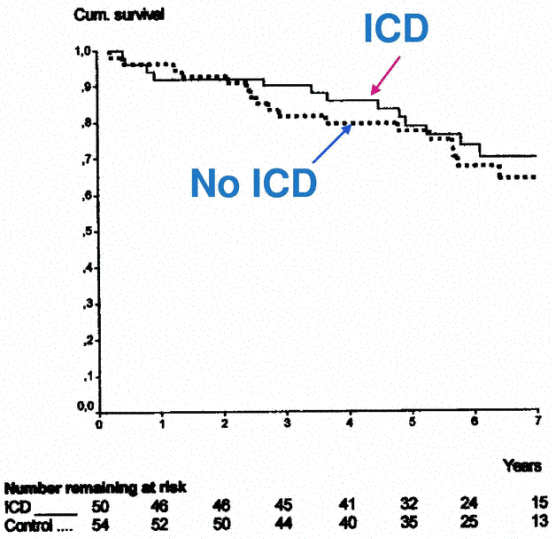
Primary Prevention of Sudden Cardiac Death in Idiopathic Dilated Cardiomyopathy (CAT)

Circulation 2002;105:1453

- Nonischemic CM
- Symptoms < 9 mo
- NYHA II or III
- LVEF ≤ 0.30

Randomized

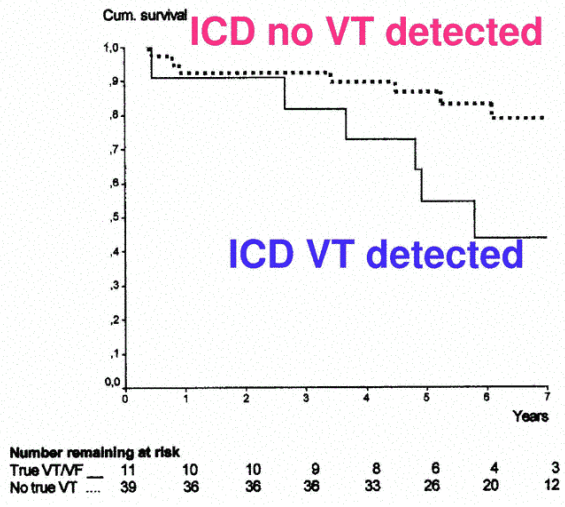
ICD **No ICD**



Primary Prevention of Sudden Cardiac Death in Idiopathic Dilated Cardiomyopathy (CAT)

Circulation 2002;105:1453

Limited benefit of ICDs in patients with spontaneous sustained VT/VF terminated by ICDs



AMIOVIRT:
nonischemic cardiomyopathy + NSVT:
ICD vs Amiodarone - Strickberger et al AHA 2000

	Randomized
n	103
Age (yrs)	59.0±11.4
LVEF	0.22±0.09
NYHA (%)	
I	15
II	64
III	20
Medications (%)	
ACE	85
Digoxin	73
Diuretic	87
Spironalactone	12
b-blocker	21

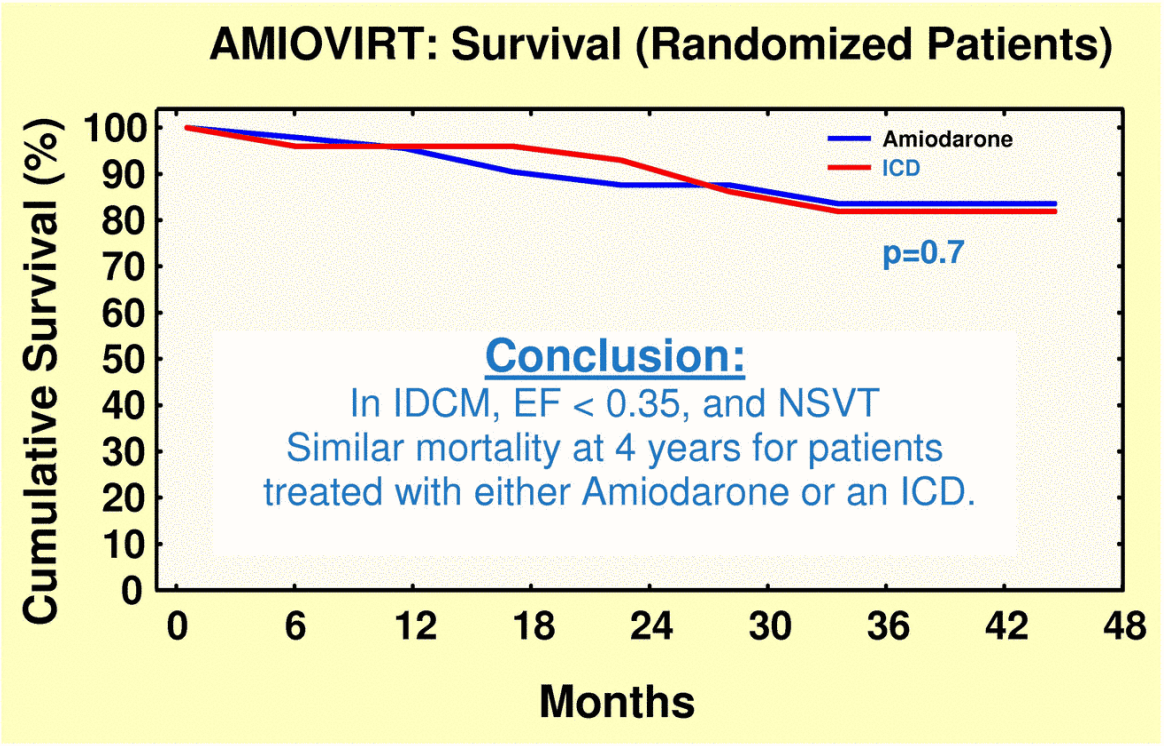
Randomized
n=103

Amiodarone n=52 | ICD n=51

Endpoints

1°-Total mortality

2 °- Mode of death; arrhythmia free survival; QOL



Familial syndromes associated with syncope and sudden death:

1. Hypertrophic cardiomyopathy
2. Congenital long QT syndrome
3. Arrhythmic right ventricular dysplasia
4. Brugada syndrome
5. Others:
   - familial dilated cardiomyopathy
   - congenital heart block
   - catecholamine triggered polymorphic VT

Can we better select patients who will benefit from ICDs?

- Can other high risk patients be identified?
  - ambient arrhythmia
  - signal averaged ECG
  - programmed stimulation
  - heart rate variability
  - QT dispersion
  - t-wave alternans

Clinical Utility of Risk Factors for Sudden Death: Stages of Development

1. Establish presence of marker in high risk populations (eg. cardiac arrest survivors)

2. Demonstration that the marker predicts sudden death in a prospective study

3. Demonstrate that for patients with the risk factor therapy that targets arrhythmias improves survival

- Markers of possible arrhythmia risk*
  - increase with severity of heart failure and ventricular dysfunction
  - also identify risk for pump failure death
  - Are not specific for arrhythmic death

*ventricular ectopy, heart rate variability, t-wave alternans, QRS duration, signal averaged ECG, inducible VT, natriuretic peptides

Nonsustained VT is a marker for heart failure severity and all causes of death in the PROMISE Study

- Sudden Death 1.16 (1.09 - 1.24)
- Overall Mortality 1.12 (1.07 - 1.17)
- Non-Sudden Death 1.16 (1.05 - 1.28)

* adjusted for EF, NYHA, CAD, age, milrinone, BP

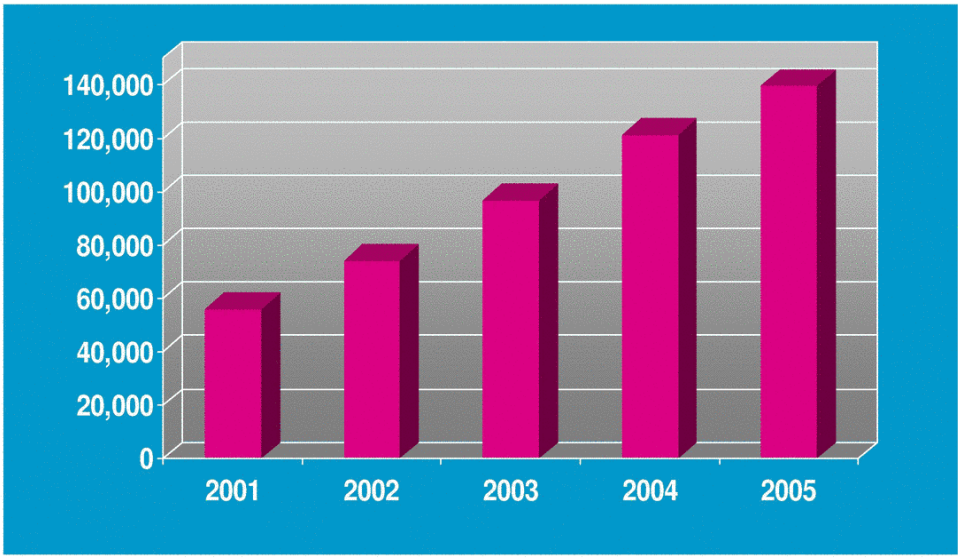
ICD Indications:

Acceptable functional capacity and prognosis from pump failure

- resuscitated from VT/VF without a clear correctable secondary cause
- Prior MI + LVEF $\leq$ 0.30 + QRS > 120 ms
- Prior MI + NSVT + inducible VT
- Nonischemic cardiomyopathy or heart failure with unexplained syncope
- Familial sudden death syndrome

US Annual ICD Implants:

projections of new implants (excluding replacements)



Bernstein Research Call March 2003

MADIT II - Potential Costs

number of ICDs implanted per life saved	= 18

18 x $25,000 = $450,000 / life saved in MADIT II

Costs for hardware only
Costs not included:

hospital charges
physician fees
follow-up care

Can we afford it?

Cost-effectiveness of ICDs from CIDS

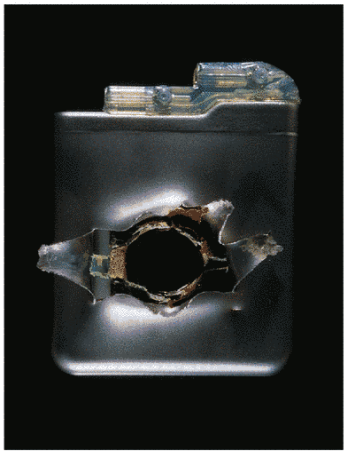
O'Brien et al Circ 2001;103:1416

Total Initial Hospital Costs **ICD Implantation $23,492**	**$ 31,768**
Follow - up Costs (6.3 yrs)	**25,246**
Total Costs	**57,014**

Gain in life - expectancy: 0.23 years

Incremental cost-effectiveness compared to amiodarone therapy in patients with VT/VF: $ 138,803

A transplant patient's thanks to his explanted ICD



There is room for improvement