Sudden Cardiac Death (SCD): Causes, Clinical Evaluation, and Treatment

William Whang, MD, MS
Outline

• Definition of SCD
• Conditions associated with SCD
• Evaluation for risk prediction
• Therapy for prevention of SCD
Definition

- Death within 1 hour of the onset of symptoms, without preceding heart failure
Immediate Causes

- Ventricular arrhythmias – ventricular tachycardia or ventricular fibrillation - in initial studies 75-84% of SCD cases, but this proportion has declined in past 2 decades

- Bradycardia
- Pulmonary embolism
- Acute respiratory failure
- Intracranial/vascular catastrophe
Burden of SCD

• Incidence: 41-89 per 100,000 per year in general population

• 180,000 to 250,000 per year in US

• Survival to hospital discharge: 4.4%*

Normal Sinus Rhythm

Ventricular Tachycardia
Typical sequence of SCD episode

Total: 9 minutes
Etiologies of SCD

SCD and Age

Arrhythmic Substrate in Coronary Artery Disease

• Post-myocardial infarction
  – fibrous tissue replaces necrotic myocardium
  – collagen and myocardium intermingled, results in conduction delay
  – Reduced/redistributed connexin expression
  – Reduced Na⁺ channel density

deBakker 2006.

Arrhythmic Substrate in Coronary Artery Disease

Stevenson WG. JACC 1997.
Non CAD-related Causes of SCD

• Structural Heart Disease
  – Hypertrophic Cardiomyopathy
  – Arrhythmogenic Right Ventricular Cardiomyopathy
  – Cardiac Sarcoidosis
  – Cardiac Amyloidosis
  – Anomalous Coronary Arteries
  – Adult Congenital Heart Disease

• Electrical Disease
  – Long QT syndromes
  – Brugada syndrome
  – Familial catecholaminergic polymorphic VT
  – Short QT syndrome
  – Wolff-Parkinson-White syndrome
Structural heart disease: Hypertrophic Cardiomyopathy

- Incidence of SCD ~1-5 % per year depending on number of risk factors
- Risk factors for SCD – family history of SCD, history of ventricular tachycardia by ambulatory monitoring, history of syncope, septal thickness ≥30 mm, drop in BP with exercise
Electrical: Brugada Syndrome

- ~20% of sudden deaths in patients with a structurally normal heart
- SCN5A mutation
  - Reduced channel function
  - Coved ST segment on ECG
- SCD risk higher with spontaneous ST coving, history of syncope
Electrical: Wolff-Parkinson-White

Accessory pathways - aberrant cardiac muscle bundles capable of rapid conduction that connect the atrium to the ventricle.
Electrical: WPW
Electrical ‘malfunction’: Commotio Cordis


Who gets risk stratified?

• Individuals who have survived SCD event
• Relatives of SCD victims
• Individuals with clinical history of ventricular arrhythmia or syncope
• Individuals with cardiomyopathy

The evaluation of any patient is tailored to his/her pre-test risk profile.
Workup for SCD risk

- History and physical, family history
- Electrocardiogram (ECG)

**Structural**
- Echocardiogram/cardiac MRI

**Provocative**
- Exercise test
- Electrophysiology study

**Electrical substrate**
- Holter monitor (ambulatory ECG monitoring)
- T wave alternans test
- Signal-averaged ECG

**Genetic testing**
History

- Documented arrhythmia, particularly ventricular tachycardia
  - History of fainting (syncope) without warning, especially with exertion
  - Palpitations/lightheadedness
- Structural heart disease – history of myocardial infarction
  - Symptoms of shortness of breath
- Family history of SCD
Structural Disease

- Left ventricular dysfunction is best available risk predictor based on positive predictive value/specificity, especially in CAD

Provocative testing: Exercise test

• Purpose
  – to evaluate for evidence of coronary artery disease
  – To evaluate for exercise-induced arrhythmias (e.g. catecholaminergic VT)
Ambulatory ECG monitoring

- Monitors can be worn from 24 hours to 4 weeks
- Event monitor systems allow for time-stamping of symptomatic episodes, in order to correlate with presence of arrhythmia
Microvolt T wave alternans

• Beat-to-beat fluctuation in T wave amplitude, ~0.02 mm amplitude on surface ECG
• Thought to reflect alternating action potential duration at the cellular level
• Demonstrated to be associated with elevated mortality especially in patients with reduced left ventricular ejection fraction
• Positive predictive value ~8-10%
Signal-averaged ECG

- Seek to detect late activation in myocardium (late potentials)
- 3 parameters are assessed – duration of the filtered QRS, duration of the low-amplitude signal, and root mean square voltage in the last 40 msec of the QRS complex.
- May be particularly useful for diagnosis in arrhythmogenic right ventricular cardiomyopathy
Electrophysiology (EP) Study

- Electrical stimulation of the ventricle via pacing catheters
- Attempt to induce ventricular tachycardia by programmed ventricular stimulation
- Sustained ventricular tachycardia at EP study is predictive of SCD in patients with reduced left ventricular ejection fraction and coronary artery disease
VT Induced at EP Study
Genetic testing

• Commercially available for long QT, hypertrophic cardiomyopathy, Brugada syndrome, ARVC

• Yield varies depending on population studied:
  – ~35% in patients referred for long QT testing
  – Limited by lack of sensitivity

• Mostly used to attempt diagnosis/risk stratification in relatives of individuals with known conditions
Treatments

- Treatment for underlying heart disease – e.g. aspirin, beta blockers, angiotensin converting-enzyme inhibitors for coronary artery disease
Treatments

- Antiarrhythmic therapy
- Defibrillator therapy
- Catheter ablation
Anti-arrhythmic medications

- Sodium channel blockers – lidocaine (IV), quinidine
- Potassium channel blockers – sotalol, dofetilide
- Sodium/potassium blockers – amiodarone

No medication is efficacious enough (~50-70%) for most conditions that predispose to SCD
Early ICDs

- Built from over-the-counter electronics
- Short-lived
- Shock only
- 250 g
- Nonprogrammable
- Required thoracotomy abdominal implant
Modern ICDs
ICD Benefit

- Normal Sinus Rhythm
- Potentially Fatal Ventricular Arrhythmia (~10 seconds in length; image truncated)
- ICD Shock Delivered (successfully terminated the arrhythmia)
- Return to Normal Sinus Rhythm
ICD Risks

- Procedural risk – bleeding, infection, perforation
- Infection
- Inappropriate shock
- Device failure
How does workup get integrated?

Brugada syndrome

Spontaneous Type 1 ECG

**Symptomatic**
- Aborted SCD
  - Syncope
  - Seizure
  - NAR
  - Evaluate for clear extracardiac cause
  - ICD (class I)
  - ICD (class I)
  - Close
  - Follow-up

**Asymptomatic**
- Family History of SCD suspected to be due to BS
  - EPS (class IIa)
  - +
  - -
  - ICD (class IIa)
  - Close
  - Follow-up

- No Family History
  - EPS justified (class IIa)
  - +
  - -
  - ICD (class IIa)
  - Close
  - Follow-up
The Conundrum of Risk Stratification in CAD

• Among all patients with coronary artery disease, depending on the age group, only 13% to 20% will have sudden cardiac arrest.
• Using left ventricular ejection fraction as a risk stratifier, ~15 ICDs need to be implanted to save one person’s life.
• How to identify those who are at high risk?
SCD-HeFT

All-cause mortality at 5 years
Amiodarone vs placebo
HR 1.06, p=0.529
ICD vs placebo
HR 0.77, p=0.007

Presented at ACC Scientific Sessions 2004
Conclusions

• SCD is caused by a variety of structural/electrical conditions, but most often associated with coronary artery disease.

• Risk evaluation for SCD depends on targeted assessment of different markers of arrhythmia likelihood.

• Treatments to prevent SCD include anti-arrhythmic medications and defibrillator therapy.

• ICD therapy has been shown to be effective at reducing mortality in selected populations.

• Further research is needed to determine optimal groups likely to benefit from ICD therapy.