Role of Non-Implantable Defibrillators in the Management of Patients at High Risk for Sudden Cardiac Death

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Sudden Cardiac Death: Background

- 1/3 of SCA events are unwitnessed
- Impossible to restrict the definition of SCA to documented VF since rhythm at clinical presentation is unknown in many cases
- Operational criteria for SCA and SCD do not rely upon the cardiac rhythm at the time of the event
- Duration of symptoms (< 1 hr) prior to SCA generally defines the suddenness of death

Sudden Cardiac Death: Definitions

- Out-of-hospital occurrence of a presumed sudden pulseless condition in the absence of evidence of a noncardiac condition (e.g., pulmonary, CVA, PE) as the cause of collapse
- WHO definition of SCD:
  - Unexpected death within 1 h of symptom onset if witnessed
  - Unexpected death within 24 h of having been observed alive and sx-free if unwitnessed
Magnitude of Sudden Cardiac Death in the U.S.

- AIDS
- Breast Cancer
- Lung Cancer
- Stroke
- SCD

# deaths/year

3 2002 Heart and Stroke Statistical Update, American Heart Association.
4 Circulation, 2001;104:2158-2163.

SCD Rates in the Developed World

- AGE-ADJUSTED RATE/100,000 POPULATION

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Etiology of Sudden Cardiac Death

Incidence of SCD in Specific Populations

GROUP

- General population
- Patients with high coronary-risk profile
- Patients with previous coronary event
- Patients with EF < 35%, congestive heart failure
- Patients with previous out-of-hospital cardiac arrest
- Patients with previous MI, low EF and VT

[Graph showing incidence of sudden cardiac death in different groups with corresponding risk factors and outcomes]
SCA Survival

- Survival from OOH SCA remains poor
- In most studies, <10% of pts in any cardiac rhythm and 20% with VF survive
- In-hospital SCA similar survival (14-20%)
- Although several interventions can improve the likelihood of VF resuscitation, the single most important is early delivery of an external electric shock
- Early defibrillation is consistently associated with greater likelihood of survival

Resuscitation from VF

- Early time to defibrillation is key to survival

Resuscitation from VF

Automated External Defibrillator

- Assess cardiac rhythm and advise on whether to deliver shock
- Modern AEDs 2-4 kg, <$1000
- AED standard: >90% sensitivity, >95% specificity for coarse VF
- 120-360 J, biphasic waveform
- Only effective for VT or VF, does not treat asystole (pace)
AED Allocation

- VF/VT arrests are declining relative to nonshockable rhythms, but still account for up to 100,000 deaths/yr
- Early resuscitation by AEDs can have significant impact on public health
- Increases pool of potential rescuers
- Goal: maximize efficient distribution of AEDS to minimize cost, resource allocation, programmatic support
- EMS, police, firefighters, public locations, hospitals, homes

AED Use by EMS

- 1980’s-1990’s: EMS first responders
- Meta-analyses: EMS AED programs → 9% increase in SCA survival
- However, in some reports, SCA survival due to VF did not improve despite reductions in the time to defibrillation with AED, possibly due to CPR interruption
- Before and after training in “minimally interrupted CPR” 1.8% vs. 5.4% survival to hospital discharge
AED Use by Police

- Police are often first responders to SCAs
- MN pilot program in 1988: police defibrillated pts ~5.5 min after collapse
- Survival from witnessed VF to hospital D/C: 46% (most neurologically intact)
- Survival from SCA not due to VF: 5%
- Pittsburgh and Miami → increased SCA survival, other cities no benefit
- Key to success: committed city and police leaders with goal of early police response to medical calls

Public Access AEDs

- SCA clustering in public transit terminals, malls, sports venues
- PAD (Public Access Defibrillation) trial, NEJM 2004:
  - 1,000 North American communities, 526 SCAs treated
  - Survival to discharge: 23% vs 14% for AED + CPR trained lay responders vs CPR only trained responders
  - Cost effectiveness: $35k-$57k per QALY, similar to dialysis
- Cohort studies: 13,000 SCAs → Survival to hospital discharge 38% versus 9% for AED shock vs. CPR only
- Nationwide distribution of AEDs in public places in Japan 2005-07: mean time to shock halved, survival w/o neurologic sequelae tripled
AED Use in Private Homes

Most cardiac arrests occur at home
HAT (Home External Defibrillator Trial) Bardy G et al. NEJM 2008
- 7,001 pts with anterior MI randomized to home AED vs. no AED
- All pts had spouse/companion undergo CPR training
- Median F/U 37 mo → no difference in mortality (6.4% vs. 6.5%)
- Only 38% of deaths due to VT/VF

Why negative results?
- Less power due to substantially lower overall mortality and SCA than anticipated
- All received CPR training
- Only 50% of home SCA were witnessed

AED Limitations

- AEDs require the presence of a bystander
- Only ~50% of SCAs are witnessed
- AEDs require interruptions in CPR, typically longer than with manual defibrillators
- Cost: programs, support, distribution, upkeep, training
Wearable Defibrillator Vest

- 18 seconds total time to shock; overall efficacy > 99%

LifeVest Shock Terminates VF
Medicare Coverage of ICDs

- EF≤35%
- Class IV if candidate for CRT (BiV)
- Ischemic CM
  - CABG/PTCA >3 months prior
  - 40 days after MI
- Non-Ischemic CM
  - NICM >3 months

Rationale for 40 Day Waiting Period

- MADIT-II excluded patients within 1 month of MI
- Negative clinical data (DINAMIT)
- EF may improve in first few months post-MI
- Patients may die of CHF, PEA or reinfarction in the early post-MI period
DINAMIT

- Randomized patients immediate (6-40 days) post-MI to ICD or not
- EF≤35%
- Impaired autonomic function (Heart Rate Variability)
- 674 patients
- Endpoint —> Total Mortality

DINAMIT Trial

Hohnloser, et al. DINAMIT Trial NEJM 2004
Why was DINAMIT Negative?

- Decreased HRV early post MI may be a marker of increased non-arrhythmic mortality
- Possible adverse effects of anesthesia, VF and pain on early mechanical and vascular remodeling
- Too small to detect differences in first few months
VALIANT: SCD Post MI

Solomon, et al. VALIANT STUDY NEJM 2005

SCD Post MI Community Study

Abadag, et al. JAMA 2008
The ICD Conundrum

- MULTIPLE trials show benefit of ICD
- “Hole” in therapy for high SCD rate early post-MI
  - Data does not support early ICD implant
  - Some patients will improve EF
  - Some patients will die regardless of ICD implant

Incidence of SCD in Specific Populations

- General population
- Patients with high coronary-risk profile
- Patients with recent coronary event
  - Patients with EF < 35%, congestive heart failure
  - Patients with previous out-of-hospital cardiac arrest
  - Patients with previous MI, low EF and VT

VEST Trial Aims

- To determine whether a wearable defibrillator can decrease sudden death mortality without increasing non-sudden death mortality in the first 3 mo after MI, prior to the time ICD is indicated
- PI: Jeffrey Olgin, M.D. (UCSF)
- Co-PI: Byron Lee, M.D. (UCSF)

VEST Trial: Rationale

- High sudden death mortality in first 2-3 months post MI
- DINAMIT (and IRIS) negative
  - Adverse effects of ICD implant in early post MI (anesthesia, VF induction, surgery)
  - HRV or high HR may predict overall mortality but not arrhythmic mortality
- Wearable defibrillator is less expensive and less invasive
  - May be acceptable in setting of high overall mortality
  - Bridge those patients that will make it to 2 months for ICD implant
VEST: Design

- Randomized clinical trial—2:1 to Vest
- **Population:** Patients admitted with an MI & EF ≤35% (PCI ok)
- Vest monitors rhythm and compliance
  - Weekly transmissions from home via modem
- **Primary Outcome:** 3 month Sudden Death Mortality
- **Secondary Outcomes:** Non-sudden death mortality, total mortality, CV deaths, ventricular arrhythmias, nonfatal CV outcomes, QOL, compliance

VEST Trial

- **Risk Strat Testing:**
  - 60 DAYS post MI EF ≤35%
  - ENROLL→RANDOMIZE (2:1)
  - VEST
  - NO VEST
  - 90 DAYS HOSPITAL DISCHARGE
  - VEST End
  - ICD (EF ≤35%) or Reveal DX/XT (EF >35%)
  - 3-8 year follow-up (Cardlink)
- **PREDICTS**

YEARLY (for 2 years)
Wearable Defibrillator Limitations

- No pacing function
  - Asystole post VT/VF shock cannot be treated
  - No ATP for VT

- Patient compliance and complaints
  - Efficacy obviously dependent on total wear time
  - Typical compliance: 20-22 hours/day
  - Rash incidence: 6%
  - Overall pt withdrawal ~20% due to weight, rash
  - Chest circumference < 57 in
Take Home Points

- Survival from OOH SCA remains poor
- Early defibrillation is consistently associated with greater likelihood of survival
- AED use effective in EMS setting and selected deployment in public spaces, equivocal for police
- Home AED use not cost effective nor better than CPR alone
- Clear ICD mortality benefit in selected high risk populations, but “hole” in therapy for immediate post-MI pts with high SCD rate
- VEST trial results in 3 years will address this “hole”
- Defibrillator vest compliance may be a major limitation for trial results