cause (lack of VF re-initiation) for the defibrillation threshold (DFT). We tested these hypotheses by interrogating if Bi shocks are less able to induce VF than Mo shocks. Ten isolated Langendorff-perfused rabbit hearts were immersed in a tank flanked by shock electrodes and paced at 500 ms cycle length. Mo and Bi T wave shocks of 5 ms overall duration were applied at randomly varied shock strengths and coupling intervals (CI) to determine the two-dimensional "area of vulnerability" (AOV), defined horizontally by the shortest and longest VF inducing CI and vertically by the ULV and the lower limit of vulnerability (LLV). The DFT was measured using the delayed up-down algorithm.

Results. A total of 1,576 T wave shocks (Mo: 788; Bi: 788) were applied. For Bi shocks, the ULV was lower (372 ± 62 vs 412 ± 75 V, p = 0.02), the LLV higher (228 ± 56 vs 192 ± 38 V, p = 0.04), and the width of the vulnerable period smaller (24.0 ± 13.5 vs 30.0 ± 11.5 ms, p = 0.05), resulting in a smaller AOV for Bi than for Mo shocks (8.9 ± 4.2 vs 14.3 ± 6.9 VF inducing shocks, p = 0.02). Bi shocks shifted the AOV to longer CI by 12 ± 8 ms (p = 0.001). The DFT was lower for Bi shocks (274 ± 66 vs 353 ± 70V, p < 0.01) confirming its higher defibrillation efficacy.

Conclusions. Bi T wave shocks create a smaller AOV which is shifted towards longer CI as compared to Mo shocks. These findings suggest that Bi shocks exhibit less arrhythmogeneity by being less able to excite partially refractory myocardium. In keeping with the ULV hypothesis, these findings may help explain the different efficacy of Mo and Bi defibrillation shocks.

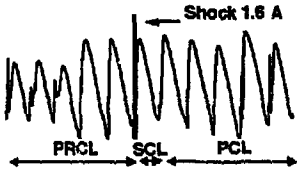
739 ICDS/Defibrillation

Tuesday, March 26, 1996, 8:30 a.m.–10:00 a.m.
Orange County Convention Center, Room 414B

8:30

739-1 Unsuccessful Defibrillation: Reinitiation or Continuation of Fibrillation?

Oscar H. Tovar, Janice L. Jones. *Georgetown University, Washington, D.C.; Department of Veterans Affairs Medical Center, Washington, D.C.*



It remains uncertain whether unsuccessful defibrillating shocks defibrillate and reinitiate ventricular fibrillation (VF) or whether VF continues after the shock. We tested the hypothesis that unsuccessful defibrillation occurs when insufficient extension of refractoriness in at least one region of the heart allows fibrillation to continue. VF (111 episodes, unsuccessful = 50, successful = 61) was induced in 5 isolated, Langendorff perfused, rabbit hearts. After 10 sec VF, defibrillation was attempted through 2 epicardial patches with an 8 ms (65% tilt) monophasic shock of 0.8–3.2 A. Action potentials (AP) were recorded with a MAP electrode placed in a low current density region between the 2 patches. An ECG was recorded simultaneously. We compared mean cycle length (5 cycles) previous to the shock (PRCL), during (SCL) and postshock (PCL) in 13 out of 50 episodes of failed defibrillation for which the randomly delivered shock coincided with AP phase 0. Cycle length was measured from the beginning of the AP to maximal repolarization. Defibrillation threshold (I_{50}) was 1.8 A. The number of episodes (n) at each current intensity was: 0.8 A (1), 1.2 A (4), 1.6 A (3), 2 A (4), 2.4 A (1) PRCL (97.4 ± 2 ms), SCL (98.7 ± 3 ms), and PCL (101 ± 2 ms) were similar (by ANOVA, p = NS).

These results confirm that if the defibrillating shock fails to prolong refractoriness in at least one low voltage gradient region, previous fibrillation wavefronts continue in that region and sustain fibrillation, regardless of shock intensity.

8:45

739-2 Evaluation of a New System for Transtelephonic Interrogation of Implantable Cardioverter-Defibrillators

Roger A. Winkle, Jonathan J. Langberg, Tom T. Hee, Robert C. Bernstein, Robert G. Hauser on behalf of the Housecall Clinical Investigators. *Sequoia Hospital, Redwood City, CA*

We evaluated a new system for transtelephonic ICD interrogation (Housecall; Ventritex, Inc; Sunnyvale, CA). The receiver is a customized computer. The transmitter incorporates a telemetry wand, a status display, and a speaker for communicating with the patient. Transmitted data include real-time measurements; real-time and stored electrograms; detection, therapy, and charge history; and programmed ICD settings. Weekly transmissions were scheduled, and patients made additional transmissions as desired. Accuracy was determined by comparing data obtained using Housecall to corresponding data from the ICD programmer. Twenty-three patients (66 ± 8 years) were enrolled. Transmitters were located up to 350 miles from receivers. Patients had been implanted with Cadence ICDs (52% model V-100, 48% model V-110) a mean of 9.1 months before enrollment (range, 1 day to 23.1 mo). During 4.8 ± 0.9 weeks, 486 transmissions occurred, which included data from 12 spontaneous tachyarrhythmic episodes. All patients were able to use the Housecall system, and all data were accurately transmitted. The transmitter was operated by the patient in 98.3% of transmissions and by a family member in 1.7%. Transtelephonic ICD follow-up could provide a means of reducing the incidence of routine and emergency clinic visits, more rapidly identifying and characterizing tachyarrhythmic episodes, and decreasing patient anxiety.

9:00

739-3 Syncopes in Patients With Implantable Cardioverter Defibrillators

Dietmar Bänsch, Michael Block, Jürgen Brunn, Max Weber, Marco Castrucci, Dirk Böcker, Günter Breithardt. *Westfälische-Wilhelms-University, Münster, Germany*

Treatment of ventricular tachyarrhythmias with implantable cardioverter defibrillators does not abolish the risk of syncope. However, incidence and risk factors of syncope are unknown. This study retrospectively analysed the occurrence of syncope in 421 patients with ICDs (follow-up 25 ± 17 months). 229 patients had recurrent VT and 62 patients suffered syncope. Patients with low ejection fraction (EF), inducible fast VT (> 200 bpm) or paroxysmal/chronic atrial fibrillation (AF) had a higher risk of syncope than patients with high EF, not inducible or with slow VT (≤ 200 bpm) induced and no atrial fibrillation in history. The absence of all three risk factors in 122 patients implied a very low risk of syncope, whereas risk of syncope was high in 123 patients with at least two risk factors.

Proportion free of syncope:	12 90%	24 85%	36 months 80%	
• EF > 40%	93%	88%	86%	
• *EF ≤ 40%*	*87%*	*82%*	*75%*	p = 0.014
• no VT induced	93%	89%	80%	
• slow VT induced	92%	80%	83%	
• *fast VT induced*	*81%*	*78%*	*74%*	p < 0.011
• no AF	91%	86%	84%	
• *AF*	*89%*	*83%*	*71%*	n.s.
• no risk factor	97%	92%	92%	
• *≥ two risk factors*	*84%*	*80%*	*73%*	p < 0.002

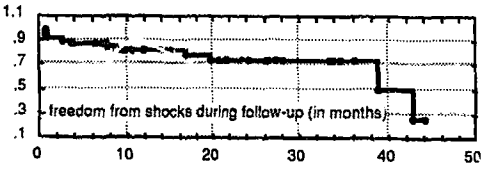
The risk of syncope is high in ICD-patients within the first year after implantation. A lower but still substantial risk to experience first syncope remains. Identification of patients with low and high risk of syncope seems to be feasable. Recommendations on restrictions for ICD-patients should rather be based on individual risk stratification than follow up time alone.

9:15

739-4 High Incidence of Appropriate ICD Shocks in Patients Presenting With Syncope

Mark S. Link, Xenophon Costeas, Caroline Foote, Munther Homoud, Hassan Rastegar, N. A. Mark Estes III, Paul J. Wang. *New England Medical Center, Boston, MA*

In patients with syncope, structural heart disease, and inducible ventricular arrhythmias at electrophysiologic studies (EPS), ICD implantation is an accepted therapy. However data documenting recurrent arrhythmias in this population is scant. We report on 41 such patients with a mean age of 59 (± 15) years and a mean EF of 35 (± 14)%. All patients had structural heart disease (29 with CAD and 12 with other cardiomyopathies). At EPS, 30 pa-



TUESDAY ORAL

tients had sustained VT, 7 had nonsustained VT, 3 had polymorphic VT, and 2 had VF.

At a mean follow up of 23 (± 13) months, 12 patients have had a total of 30 appropriate ICD firings (defined as shock with preceding symptoms (n = 6 pts) or shock with intracardiac recordings consistent with ventricular arrhythmia (n = 6 pts)). EF < 30%, age, and CAD were not predictors of arrhythmia recurrence.

There is a substantial incidence of recurrent arrhythmias in this population, supporting the current clinical practice of ICD implantation for this indication. Further studies should examine a larger population and examine predictors of arrhythmia recurrence.

9:30

739-5 Prospective Evaluation of the Defibrillation Success With Two Superior Vena Cava Electrodes: Comparison of Two Lead Positions

Andrea Natale, Margaret M. Kearney, M. Joan Brandon, Virginia Kent, Keith H. Newby. *VA Medical Center/Duke University, Durham, NC*

When the superior vena cava (SCV), right ventricular coil (RV) system does not provide adequate ventricular defibrillation, an additional SVC lead could be used to improve defibrillation efficacy. However, no data exists on the efficacy of this system and on the ideal position of the second SVC coil. In 17 patients undergoing defibrillator implant, we prospectively examined the defibrillation efficacy of the SVC/RV configuration as compared to a 2 SVC/RV configuration with the second SVC placed either "side by side" (SBS) with the first one, or with proximal end of the second SVC coil adjacent to the tip of the first SVC coil "head to tail". In the SVC/RV configuration, the SVC coil was in the innominate vein. The second SVC was in the same location in the "side by side" configuration and was advanced in the SVC in the "head to tail"(HTT) configuration. In each patient, all 3 configurations were tested randomly with biphasic shocks.

	SVC/RV	2SVC/SBS	2SVC/HTT
Energy	14.4 ± 7.9	12.4 ± 6.7	11.1 ± 7.1*
Voltage	485 ± 138	445 ± 118	415 ± 136*

*p < 0.0002

Conclusion: 1) the addition of a second SVC coil provides improved defibrillation efficacy. 2) However, the "head to tail" configuration appeared to require lower energy for defibrillation and should be preferred.

9:45

739-6 *In Situ* Optical and Bipolar Electrogram Recordings in Swine Show Parallel Reductions in Action Potential and Electrogram Amplitude Following High-Voltage Shocks

Volker Menz, John J. Michele, Stephen M. Dillon. *Philadelphia Heart Institute, Philadelphia, PA; Univ of Marburg, Marburg, Germany*

We and others have found shock strength-dependent reduction and time-dependent recovery of electrogram amplitude (EA) recorded by endocardial defibrillation lead systems following high voltage shocks. *In vitro* studies by others have shown related shock strength- and time-dependent changes in the action potential amplitude (APA). The purpose of the present study was to determine whether the reduction of EA we found *in vivo* could be correlated with a reduction of the APA. We recorded an optical signal and a bipolar electrogram at sites on the anterior left ventricular epicardium of swine (28 ± 12 kg, n = 8) during the application of epicardial shocks. Optical recordings of membrane responses were taken using a 1.5 mm fiber optic pickup after injection of a voltage-sensitive dye (di-4-ANEPPS, 21 μM in Ringers) into the LAD by coronary catheterization. Bipolar electrograms and shock voltage gradients (VGs) were recorded through 3 non-polarizable Ag/AgCl electrodes surrounding the fiberoptic pickup. Shocks were delivered through a pair of stainless steel mesh electrodes 50 mm long, 5 mm wide having a 40 mm edge separation. The recording site was halfway between the shock electrodes. Monophasic shocks (5 ms width, 100 to 990 V) were delivered during the diastole of sinus rhythm 400 ms after the sensed depolarization. *Result:* The EAs and APAs showed parallel reductions with increasing shock strength and parallel recoveries with increasing time after the shock. Significant reductions in both the APA and EA were observed at VG > 70 V/cm ($p < 0.03$). *Conclusion:* Our results suggest that the decrease of EA recorded by endocardial defibrillation leads may be caused by transient membrane damage rather than instrumental factors and that this effect may be related to that observed using microelectrode recordings *in vitro*.

740 Three-Dimensional Echocardiography: New Instrumentation and Clinical Applications

Tuesday, March 26, 1996, 8:30 a.m.–10:00 a.m.
Orange County Convention Center, Room 315

8:30

740-1 Accurate Quantitation of Right Ventricular Size and Function by Voxel-Based 3-Dimensional Echocardiography in Patients With Normal and Abnormal Ventricles (3DE): Comparison With Magnetic Resonance Imaging

H.J. Nesser, W. Tkalec, J. Niel, Navroz Masani, Natesa Pandian. *General Hospital St Elizabeth, Linz, Austria; Tufts-New England Medical Center, Boston, Massachusetts*

We have shown *in vitro* that voxel-based 3-dimensional echocardiography (3DE) could quantify RV volume (V). Work by others have dealt with in vivo dog studies, clinical study of normals or studies limited to quantitation without 3D display. How well voxel-based, tissue-depiction 3DE can quantify RV V and function (%EF) in pts with abnormal RVs by transesophageal (TEE) and transthoracic (TTE) approaches are not known. To assess this, we studied 20 pts (age 23 to 76 yrs) including those with abnormal RV. 3DE data were compared to data from MRI. 3DE studies were performed from TTE windows by rotational scanning *and* from TEE window with a multiplane probe. *Results:* Dynamic 3DE images of the RV, displayed in a variety of projections both by TEE-3DE and by TTE-3DE, facilitated qualitative assessment of RV size, geometry, morphology and motion. Quantitative data were (mean ± sd): MRI (x) vs. TEE-3DE (y): *EDV in ml:* 109 ± 34 [range 60–191] vs 108 ± 30; *Correlation:* $y = 0.7x + 27$, $r = 0.86$, [$p < 0.0001$, *mean diff:* 1.3 ml. *ESV:* 59 ± 31 [range 20–130] vs 62 ± 31; *Correlation:* $y = 0.9x + 8$, $r = 0.92$, $p < 0.0001$, mean diff 2.7 ml. *%EF:* 48 ± 17 [range 16–75] vs 43 ± 12; *Correlation:* $y = 0.58x + 15$, $r = 0.84$, $p < 0.0001$, *mean diff* 4.5 ± 10%. *Similar values and excellent correlations (vs MRI) were obtained by TTE: %EF:* $y = 0.57x + 18$, $r = 0.85$, $p < 0.0001$, *mean diff* 2.5 ± 9%. We conclude that, in addition to dynamic displays of the RV interior, voxel-based 3DE provides accurate quantitation of both normal and abnormal RV volume and function.

8:45

740-2 Voxel Reconstruction of Mitral Valves and Left Ventricles From Limited Sets of Rotationally Scanned Transesophageal Images

Xiang-Ning Li, Roy W. Martin, Malcolm Legget, Brad Munt, Murali Sivarajan, Gerard Bashein, Daniel F. Leotta, Florence H. Sheehan, Edward Bolson, Catherine M. Otto. *University of Washington, Seattle, WA*

Voxel reconstruction usually requires high image density, e.g., ninety rotationally scans at two degree angular increments. Acquisition of such dense data requires seven to ten minutes with respiratory gating. We analyzed the feasibility of volumetric reconstruction from a less dense data set so that image acquisition can be completed within a single mechanical ventilation pause. *Method:* Eighteen patients (10 normal and 8 with heart disease) were scanned under general anesthesia with a 5 MHz Hewlett Packard multiplane transesophageal echocardiographic (TEE) probe. Images from 28–40 planes at 5–10 degree angular increments, with 24 to 35 consecutive video frames per cardiac cycle, were digitized. We applied linear interpolation along the polar space to fill the void volumetric space. Reconstruction of the mitral valves and left ventricle was accomplished for every 33 ms of a cardiac cycle. *Results:* All anatomical landmarks of the left ventricle were clearly identifiable from volume rendered images. With animation from selected views cardiac function could be assessed. Stereographic visualization added further clarity. *Conclusion:* With linear interpolation in polar space voxel reconstruction can be performed from lower density 3D TEE scans. This approach may increase accuracy in 3D imaging by permitting the image acquisition during a single ventilation pause.

9:00

740-3 Real-Time, Three-Dimensional Echo: System Improvements, Scanning Methods and Normal Cardiac Anatomy

Craig E. Fleishman, Takahiro Ota, Jennifer Li, A. Resai Bengur, Olaf von Ramm, Joseph Kisslo. *Duke University, Durham, NC*

On the hypothesis that gross normal cardiac anatomic structures could be defined using real-time, three-dimensional echo (RT3D), studies were performed on 33 subjects (ages 1–48 years). Images were obtained using a