983-36 Quantitative Analysis of How Epicardial Activation Changes With Time During Ventricular Fibrillation

Jian Huang, Jack M. Rogers, Bruce H. KenKnight, William M. Smith, Raymond E. Ideker. *University of Alabama at Birmingham*

Few details are known about the behavior of activation fronts (AFs) during ventricular fibrillation (VF). Therefore, we developed computerized methods to quantitate (I) the number of AFs per s, (II) the number of AFs passing each epicardial site per s, (III) the conduction velocity of the AFs in m/s, (IV) the number of AFs that fragment into 2 AFs per s because of block, and (V) the number of AFs that collide and coalesce into a single AF per s. Unipolar potentials were recorded from a 504 (21X24) electrode plaque (2 mm interelectrode spacing) covering ≈ 20 cm2 of the anterior RV and LV in 5 pigs. In each animal, six episodes of VF were induced by premature stimulation (1–12 mA). Segments of VF (1 s) starting 0, 10, 20, 30 and 40 s post-induction were analyzed.

	0–1′	10–11′	20–21′	30–31′	40–41′
I	50 ± 16*	77 ± 13*	74 ± 13*	66 ± 11	61 ± 14
II	8.9 ± 1.4	8.0 ± 1.4*	7.6 ± 1.1*	7.4 ± 1.0	7.2 ± 1.0
III	0.33 ± 0.8*	0.25 ± 0.1*	0.21 ± 0.04	0.21 ± 0.04	0.20 ± 0.04
IV	8.0 ± 3.8*	11.5 ± 4.3	11.7 ± 5.5	11.6 ± 4.2	11.2 ± 5.2
V	5.5 ± 2.9*	11.3 ± 4.6*	9.8 ± 3.4	9.2 ± 5.5	8.2 ± 3.8

*Data are mean ± SD; *denotes p < 0.05, repeated measures ANOVA.*

Over the first 41 s of VF, (1) the number of AFs and the number of AF collisions first increases and then decreases, (2) the number of AF fragmentations increases early and then stabilizes, and (3) the conduction velocity continuously decreases. Thus, the nature of activation changes with time during VF and these changes can be quantified using computer techniques.

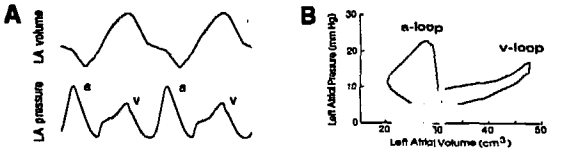
984 Left Atrial and Left Ventricular Function

Tuesday, March 26, 1996, 3:00 p.m.–5:00 p.m.
Orange County Convention Center, Hall E
Presentation Hour: 4:00 p.m.–5:00 p.m.

984-109 Left Atrial Pressure-Volume Relation in Humans: A New Method Based on Direct Nontransseptal Left Atrial Catheterization and Echocardiography

Costas Stratos, Christodoulos Stefanadis, Asimakis Sideris, Charalambos Vlachopoulos, Anastasios Antoniou, Konstantinos Toutouzas, Spyros Lambrou, Harisios Boudoulas, Pavlos Toutouzas. *Athens University, Greece*

To obtain left atrial (LA) pressure-volume loops, simultaneous LA pressure and volume tracings were recorded in 25 patients during cardiac catheterization. LA pressure was measured by a catheter-tip micromanometer, which was inserted retrogradely into the LA cavity, using a purely retrograde nontransseptal LA catheterization technique based on a steerable catheter developed in our institution. Instantaneous LA volume measurements were obtained by application of real-time two-dimensional echocardiographic automatic boundary detection technique. The pressure and volume signals were stored in a computer, and the simultaneous LA volume and pressure tracings (fig A) and LA pressure-volume loops (fig B) were derived by processing of stored data. Moreover, measurement of the a-loop area (fig B), corresponding to LA contraction, provided LA systolic work. All clinical applications were fast, easy and uncomplicated.



This new method provides a safe and easy way for the determination of LA pressure-volume relation in conscious humans during cardiac catheterizations. Study of this relation may provide insight into the LA mechanics in various normal and diseased conditions.

984-110 The Stagnation of Left Atrial Appendage Blood During Sinus Rhythm in Patients With Transient Atrial Fibrillation Assessed by Transpulmonary Contrast Echocardiography

Shiro Izumi, Tetsuro Ohta, Shigeo Kobayashi, Hiromi Shimizu, Shigenori Ishikawa, Hiroshi Nosaka. *Matsue Municipal Hospital, Matsue, Japan*

The purpose of this study is to clarify the flow pattern of left atrial appendage (LAA) in patients (pts) with transient atrial fibrillation (AF) during sinus rhythm (SR). We performed transesophageal echocardiography in 15 pts with transient AF during SR (Group SAF), 14 pts with chronic AF (Group CAF) and 5 healthy subjects (Group NSR). The flow in LAA was visualized by injection of Albunex (0.15 ml/kg) from the right internal jugular vein. The following parameters were measured: the peak contrast intensity (PI) in basal half of LAA (A1) and apical half of LAA (A2) by videodensitometry (Freeland System), the flow velocity in A1 and A2 by pulsed Doppler echocardiography and the left atrial volume by transthoracic echocardiography. *Result:* In Group CAF, the peak intensity of A1 and A2 was significantly low compared with Group SAF ($p < 0.05$)and Group NSR ($p < 0.05$), respectively. In pts with SR, Group SAF and Group NSR, there were significant negative correlations between LA volume and PI of A1 and A2, respectively ($r = -0.55$, $p < 0.05$ and $r = -0.75$, $p < 0.001$). In Group SAF, eight of 15 pts had large LA (volume > 20 ml) and PI of A1 and A2 was low. There was no significant difference between the flow velocity of LAA in the eight pts and the other. *Conclusion:* In the pts with transient AF, the blood in LAA stagnates even during SR. This stagnation in LAA was associated with left atrial enlargement.

984-111 Echocardiographic Assessment of Left Atrial Volume: Determining Optimal Technique

Lisa Welikovitch, Sally E. Ford, Anthony J. Sanfilippo. *Queen's University, Kingston, Ontario, Canada*

Left atrial volume (LAV) is a commonly reported echocardiographic measurement. Although a number of methods have been used to measure it, none has been objectively validated.

Methods: A number of techniques commonly used to measure LAV were evaluated in a series of 12 excised post mortem human hearts. The mitral valve was sewn closed. Soft rubber balloons were passed through a pulmonary vein into the left atrium, filled with water and sealed. The heart was immersed in a water bath and imaged in 3 orthogonal planes analogous to the parasternal (PS), apical 4 chamber (A4C) and 2 chamber (A2C). Diameters and volumes were measured in each plane. LAV was estimated by 3 methods, including: cubing of single diameters, prolate ellipsoid method (PE), and Simpson's rule volume determination. The volume of water in the balloon was then measured to determine true LAV.

Results: The following table shows correlation by linear regression analysis for each method with respect to true LAV.

	Diameter cubed Method			PE	Simpson's Volume		
	PS	A4C	A2C		PS	A4C	A2C
R	0.74	0.50	0.63	0.73	0.88	0.82	0.90
sig.	0.009	0.120	0.035	0.010	0.001	0.002	0.001
S.D.	30.8	53.2	48.4	21.4	11.2	12.4	11.4

Conclusions: LAV is most reliably estimated echocardiographically by Simpson's rule volume calculations obtained in apical imaging planes.

984-112 Left Atrial Dysfunction in Heart Failure Patients With Restrictive Transmitral Flow Pattern by Doppler Echo

Gong-Yuan Xie, Andrew J. Fiedler, Peter M. Sapin, Gregory B. Clarke, Helen Preston, Charles Lin, Mikel D. Smith. *University of Kentucky, Lexington, KY*

Heart failure patients (pts) with the restrictive transmitral flow pattern by Doppler echo have been demonstrated to have increased functional impairment and higher mortality. However, the role of left atrial transport in contributing to LV dysfunction in such patients is unknown. Therefore, we analyzed the relation of transmitral flow (TMF) patterns and pulmonary venous flow (PVF) velocities in 51 heart failure pts (29 men, 22 women; age 61 ± 9 yrs) with an ejection fraction (EF) < 40%. Transthoracic echo and pulsed Doppler were performed from the apical 4-chamber view at the mitral annulus level for TMF, and at the orifice of the right upper pulmonary vein using color flow guidance for PVF. Measurements: TMF early (E) and late (A) velocities; PVF systolic (S), diastolic (D), atrial reversal (Ar) velocities (cm/s); left atrial size (LA, cm) and heart rate (HR). 13 pts of the study population had right heart catheter measurements of the pulmonary wedge pressure (PWP). Pts were assigned to two groups according to TMF: a restrictive (21

TUESDAY POSTER

pts) with E/A ≥ 2 and A ≤ 35, and a nonrestrictive (30 pts) with E/A < 2 or A > 35. Results (mean ± SD):

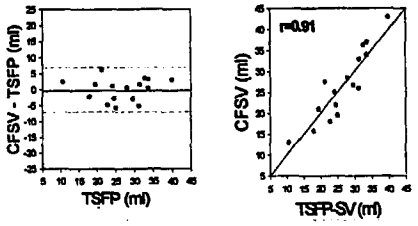
	S	D	Ar	LA
Restrictive:	28 ± 11	66 ± 13	12 ± 10	4.8 ± 0.4
Nonrestrictive:	51 ± 10	44 ± 10	24 ± 9	4.2 ± 0.6
p:	<0.01	<0.01	<0.01	<0.01

There was no relationship between PWP and Ar (r = 0.003, p = NS). However, an elevated PWP was associated a decreased S (r = – 0.70, P < 0.01) and an increased D (r = 0.76, p < 0.01). Thus, the Doppler echo findings in heart failure pts with a restrictive transmitral flow pattern suggest that both reduced LA compliance (i.e. decreased systolic atrial filling and high PWP) and reduced LA contraction (i.e. decreased forward and backward flow during atrial systole) contribute to abnormal left atrial transport function.

984-113 Stroke Volume From Computerized Analysis of Digital Color Flow Images: Comparison With Transonic Flow Probe

Jeffrey S. Soble, Thomas Stamos, Beomjin Kim, Alex Neumann, JoAnne Schmitt, Mark J. Harry, Niraj Sehgal, Gary L. Schaer, Tony Hursey, James Robergé, Richard H. Marcus. *Rush Medical College and Illinois Institute of Technology, Chicago, IL*

Validation studies of color flow stroke volume (CFSV), obtained by analysis of quantitative velocities within digital color flow (CF) images of the left ventricular outflow tract (LVOT), have shown a small systematic underestimation compared to the standard pulsed wave method in humans. We sought to compare CFSV to a more rigorous flow standard. CFSV using custom software designed for Hewlett-Packard digital CF images was compared to stroke volume measured simultaneously by an aortic Transonic flow probe (TSFP) in six open chested dogs. Digital CF images were acquired at frame rates of 35–45 MHz by epicardial imaging at baseline, after propranolol, and with pacing at 80 and 160 BPM, then redisplayed and analyzed off-line. After identifying the LVOT, the spatial distribution and magnitude of pixel velocities were determined automatically for each frame. Four pairs of semicircular concentric flow velocity rings were generated and CFSV was calculated from spatial and temporal integration of velocities throughout ejection. Hemiaxial symmetry was assumed. *Results:* Mean values for the CFSV and TSFP were 26.6 ± 8.4 and 26.7 ± 7.3 ml, respectively. The bias (average difference) was small (–0.1 ml) and the 95% confidence intervals narrow (+6.9 to –7.1 ml).

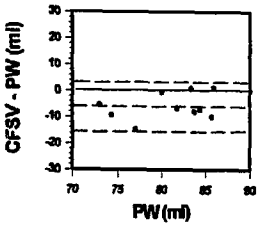


Conclusions: CFSV from computerized quantitative analysis of digital CF images is accurate compared to TSFP in this animal model. Discrepancies in humans may be related to a higher range of stroke volume or the quality of transthoracic images.

984-114 Accuracy of Computerized Quantitative Analysis of Digital Color Flow Doppler Images for Stroke Volume Determination

Jeffrey S. Soble, Thomas Stamos, Beomjin Kim, Alex Neumann, James H. Stein, Dae H. Kim, Joseph E. Parillo, James Robergé, Richard H. Marcus. *Rush Medical College/Illinois Institute of Technology, Chicago, IL*

Computer analysis of the quantitative velocity information within digital color flow images of the left ventricular outflow tract (LVOT) may provide easier and faster access to flow quantitation than current methods. Color flow stroke volume (CFSV) was obtained in 10 patients using custom software designed for Hewlett-Packard digital color flow images. CFSV was compared with stroke volume from pulsed wave (PW) Doppler and LVOT cross sectional area. Digital color flow data were acquired in the apical long-axis view at frame rates of 35–45 MHz, redisplayed and analyzed off-line. After identifying the LVOT, the spatial distribution and magnitude of pixel velocities were determined automatically for each frame. Four pairs of semicircular concentric flow velocity rings were generated, and CFSV was calculated from spatial and temporal integration of velocities throughout ejection. Hemiaxial symmetry was assumed. *Results:* Mean values for the CFSV and PW techniques were 74.9 ± 7.5 and 80.9 ± 4.4 ml, respectively. CFSV systematically underestimated PW but the bias *(average difference)* was small (–7.6%, p = 0.004) and the 95% confidence limits of agreement between the two methods were narrow (–19.8% to +4.5%).

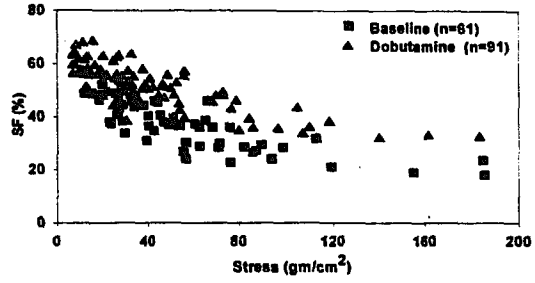


Conclusions: CFSV from computerized quantitative analysis of digital images is feasible, with slight underestimation of stroke volume compared with standard PW Doppler. Further study is needed to identify whether this small systematic difference arises from velocimetric, spatial or temporal components of the color flow data or CFSV algorithm.

984-115 In Vivo Determination of Left Ventricular Stress-Shortening Relations in Mice Using Echocardiography

Zia U. Khan, Corinn Dahm, Richard A. Walsh, Brian D. Hoit. *Univ. of Cincinnati, Cincinnati, OH*

Although targeted alterations of the mouse genome are used increasingly to identify the mechanisms underlying cardiac function, the methods used to study the phenotypic expression of these alterations *in vivo* are limited. In order to derive a noninvasive, load-independent measure of LV contractility in mice, we cannulated the femoral artery and performed 2-D directed M-mode echo studies (9 MHz, Interspec – ATL CX 200) in 16 anesthetized FVB/N mice (31.3 ± 2.6 gm). Loading conditions were altered by intraarterial methoxamine (3–12 μg/g), and LV shortening fraction (SF) was determined at several steady states both before and after myocardial contractility was altered by intraperitoneal dobutamine (4 μg/gm). The slopes of the pooled LV systolic meridional stress-shortening relation were inverse and linear both before (r = 0.80, slope = 0.2 %/g/cm^2, intercept = 50%, SEE = 1.3%) and after dobutamine (r = 0.78, slope = 0.2%/g/cm^2, intercept = 59%, SEE = 0.9%, both p < 0.0001):



At matched low (28 ± 8 g/cm^2) and high (61 ± 19 g/cm^2) levels of LV stress, SF was significantly greater after dobutamine than before (55 ± 5 vs. 44 ± 5% and 45 ± 7 vs. 35 ± 8%, respectively; both p < 0.05). We conclude: 1) inverse stress-shortening relations can be assessed noninvasively in mice; 2) these relations are sensitive to alterations in inotropic state, independent of loading conditions.

985 Advances in Doppler Echocardiography

Tuesday, March 26, 1996, 3:00 p.m.–5:00 p.m.
Orange County Convention Center, Hall E
Presentation Hour: 3:00 p.m.–4:00 p.m.

985-101 Incremental Information Provided by Three-Dimensional Echocardiography in the Delineation of Vegetations, Perforations and Abscesses in Patients With Endocarditis

Tsui-Lieh Hsu, Shuenn-Jinn Ho, Alain Delabays, Lissa Sugeng, Giuseppina Magni, Stefano De Castro, Gerald Marx, Ravi Kasliwal, Ajay Kanojia, Naresh Trehan, Natesa Pandian. *VA General Hospital, Taipei; Tufts-New England Medical Center, Boston, Mass.*

To explore whether 3-D echocardiography (3DE) provides added information