Methods: Video and digital loops were presented in a random, blinded, side-by-side manner. The digital images were either uncompressed or JPEG compressed at a 10:1 or 20:1 ratio. 179 conference attendees participated (73 physicians (41%), 61 sonographers (34%) and 25% others) and compared 20 pairs of loops of grayscale images (5 different pathologies at 3 compressions, with 1 pair repeated). The pathologies used were: mitral valve vegetation (D1), posterior LV wall hypokinesis (D2), posterior mitral leaflet prolapse (D3), amyloidosis with Eustachian valve (D4), and mitral stenosis with spontaneous echo contrast (D5). Participants were asked to grade which image had better IQ and which had better DQ using a 5-point scale. Responses from only physicians and sonographers were used to assess DQ. *Results:* For all pathologies combined, the digital images have significantly better IQ and DQ (Wilcoxon Sign Rank (WSR), $p < 0.0001$ for each compression level). Similarly, for each individual pathology, the IQ is significantly better than the video at all levels of compression (WSR, $p < 0.0005$ for each compression and disease type). For DQ, all 5 pathologies tended to favor the digital images with D2–D4 teaching statistical significance. There is no significant differrence in IQ and DQ between uncompressed and compressed digital images—even at compression ratios of up to 20:1. (Friedman's test, IQ-p = 0.521, DQ-p = 0.252). *Conclusions:* Results from 179 observers indicate that diagnostic and image quality of JPEG compressed images (even at a 20:1 compression) are significantly better than video tape (the current standard). Furthermore, amongst the digital images there is no significant difference between uncompressed and 20:1 JPEG compressed images. Thus, archival of JPEG compressed digital images is superior to images stored on video tape.

970-3 Aortic Root Dilation in Marfan's Syndrome: Relationship to Outcome

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In order to examine the incidence of aortic (Ao) complications in Marfan's syndrome, and the relationship of the rate of Ao root dilation to outcome, 89 subjects with definite Marfan's syndrome (49 males, 40 females; mean age 27 ± 13 year) were followed for a mean of 5 (range 0–19) years. Endpoints examined were death, ascending Ao dissection and Ao root replacement. At follow-up, 71 patients were alive with no Ao complications, 6 patients died (4 from ascending and 2 from descending Ao dissection), and 12 patients survived Ao root replacement (3 for ascending dissection and 9 for ascending Ao aneurysm). Five year actuarial survival was 93%, and event free survival was 78%.

Patients receiving beta blocker therapy for greater than 1 year (n = 28, Group I) were compared with those who never received beta blockers or who took them for less than 1 year (n = 55, Group II). Actuarial survival at 5 years was 100% in Group I and 90% in Group II (p = 0.09), but event free survival was 73% in Group I and 85% in Group II (p = NS).

Serial echocardiographic measurements of the Ao root were made in 50 adults. Mean Ao root dimension was 40 ± 9 mm (range 25–83 mm) at entry and was 44 ± 10 mm (range 30–83 mm) at follow-up. Mean rate of change of Ao root dimension was 1 (range −3–18 mm/yr). A comparison of those with and without Ao complications (mean ± 1 SD) is shown below:

	No event (n = 39)	Event (n = 11)	p value
Enrollment age (yrs)	33 ± 9	37 ± 10	NS
Initial Ao sinus (mm)	38 ± 5	48 ± 15	0.02
Follow-up Ao sinus (mm)	42 ± 6	58 ± 19	<0.0001
Δ Ao dimension/year	0.5 ± 1	4 ± 7	0.003

The rate of change in Ao sinus ratio (observed/predicted), normalized for age and BSA, also was greater in those with (0.13 ± 0.24) vs those without (0.004 ± 0.03) an event (p = 0.006). There was no significant difference in the rate of change of aortic sinus ratio between beta-blocker Groups I and II (0.04 vs −0.005, p = NS).

Conclusions: Medium term survival was good in this Marfan's cohort, although there was a significant rate of aortic complications. Those with adverse outcomes had greater aortic dimensions, both at baseline and follow-up, as well as more rapid aortic root dilation.

970-4 Echocardiographic and Doppler Study of Patients with Heat Stroke and Heat Exhaustion

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Three groups of patients exposed to heat during pilgrimage season (29th May–2nd June 1993) were studied. Outdoor temperatures exceeded 45°C. Standard 2D-Echocardiographic views and Doppler recordings of mitral and tricuspid inflows, aortic, subclavian and hepatic venous flows were obtained with computed assessment of chamber volumes, diameters and cardiac output. The 1st Group (G1) consisted of 35 patients admitted with clinical picture of heat stroke to the cooling units and were studied acutely during cooling. Fifty three % were females and forty seven % males. They had a mean age of 58 ± 11 years and mean B.S.A. of 1.9 ± 0.2 m^2. The mean rectal temperature for this group was 41.7 ± 0.9°C. The 2nd Group (G2) consisted of 27 patients admitted with diagnosis of heat exhaustion, 85% were males and 15% females. Mean age was 47 ± 15 years and mean B.S.A. 1.8 ± 0.2 m^2. The mean rectal temperature was 38.7 ± 1.3°C. The 3rd Group (G3) consisted of 31 control patients exposed to heat but without the above diagnoses. Eighty four % were males and 16% females with mean age of 38 ± 15 years and mean B.S.A. OF 1.7 ± 0.1%m^2, mean rectal temperature was 37.1 ± 0.6°C.

Findings: Cardiac output in G1 (8.2 l/min), was significantly higher than in G2 (6.4 l/min) (P = 0.002). Both significantly higher than in G3 (4.9 l/min) (P = 0.0000 and P = 0.0005 respectively). Left ventricular end systolic volumes were smaller in G1 (25.4 ml) compared to G2 (33.8 ml) P = 0.04 and G3 (52 ml) P < 0.0001. Mean heart rate (HR) and systolic blond pressure (BP) were 119 ± 24/min and 76 ± 25 mmHg for G1 97 ± 16/min and 102 ± 18 mmHg for G2 73 ± 11/min and 92 ± 16 mmHg for G3.

We conclude that haemodynamic changes in severe heat exposure reflect a hyperdynamic circulation in most of the patients with vasodilation of relative hypovolemia more pronounced in patients with heat stroke compared to heat exhaustion patients.

970-5 Echocardiographic Assessment of Left Ventricular Contractility During Prolonged Head-up Tilt in Patients with Neurally Mediated Syncope

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The cause of head-up tilt (HUT) induced syncope is thought to be an inappropriate Bezold-Jarisch reflex resulting in a paradoxical chronotropic and/or vasomotor response to sympathetic stimulation after HUT induced decrease in left ventricular volume. If this was uniformly true, left ventricular hypercontractility should always precede HUT induced syncope. To test this hypothesis, we analyzed fractional left ventricular shortening (FS) throughout prolonged head-up tilt in 10 patients with HUT induced syncope and in a control group of 10 healthy volunteers without HUT induced syncope by two-dimensional echocardiography. HUT was performed at 60° for 45 min with foot plate support ("Westminster-Protocol"). No provocative maneuvers such as Isoprel infusion or carotid sinus massage were used. Hypercontractility in pts with HUT induced syncope was considered to be present if FS increased more than 20% during tilt compared to FS measured in the supine position.

Results: Hypercontractility during HUT was not observed in any of the 10 healthy volunteers without neurally mediated syncope (FS in the supine position was 34 ± 3% and did not change significantly during HUT). Hypercontractility preceded syncope in 5 of 10 pts with HUT induced syncope (FS supine: 31.6 ± 3%; FS shortly before syncope: 39.6 ± 4%, $p < 0.05$). In the remaining 5 patients with HUT induced syncope FS did not increase shortly before syncope (FS supine: 33.2 ± 3.4%; FS shortly before HUT induced syncope: 32.6 ± 1.7%, p = NS.).

Conclusions: Presence and absence of left ventricular hypercontractility before HUT induced syncope in 50% of our study patients suggest that the Bezold Jarisch reflex is not the only mechanism of neurally mediated syncope.

970-6 In Vivo Studies of Aortic Stenosis: Role of Inertial and Viscous Forces in Doppler/Catheter Discrepancies

Edward G. Cape, Lilliam M. Valdes-Cruz, Isumi Yamada, Michael D. VanAuker, Michael Jones. *University of Pittsburgh, PA; NHLBI-LAMS, Bethesda, MD*

In previous studies *in vitro* we have used a Reynolds number approach to analyze second order effects on pressure recovery distal to stenosis. It was shown that two fundamentally different effects, viscous losses and turbulent dissipation, can control the basic overestimation due to pressure recovery at both ends of the Reynolds number scale. Having quantified this effect in vitro, this study attempted to reconcile Doppler and catheter gradients across aortic stenosis *in vivo*. *Methods:* In 4 sheep with surgically created aortic stenosis, 30 hemodynamic states were studied (4–11 per sheep) using Millar transducers in the LV and Aorta (peak PG ranged 3–150 mmHg). A Vingmed 775 interfaced to a computer was used to measure CW velocities simultaneously with catheter recordings. *Results:* Instantaneous Doppler peak gradient correlated with catheter instantaneous gradient throughout the range of baseline and stenotic conditions (r = 0.973, SEE= 8.7 mmHg), but Doppler overestimated cath gradient (up to 70%) for all stenotic valve conditions by an average of 17%. Plotting overestimation versus Reynolds number revealed a second order profile of the shape derived in vitro. Correction of Doppler gradients using this parabolic factor reduced average overestimation from 17% to 1.5%. *Conclusions:* Overestimation due to pressure recovery is basic to aortic stenosis, but this overestimation can be partially canceled by two apparently unrelated effects: viscous effects and turbulent

dissipation. The former is deleted from the simplified Bernoulli equation, but more importantly, the latter is not characterized by *any* form of the Bernoulli equation. A Reynolds number based approach characterizes the relative importance of these effects and could lead to reconciliation of Doppler and catheter gradients in the clinical setting.

970-7 In Vivo Comparison of Simultaneous Doppler and Hemodynamic Transvalvular Pressure Gradients Across Bileaflet Mechanical Valves in the Mitral Position

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Continuous wave Doppler (CW) is routinely used clinically to measure pressure gradients across bileaflet mechanical mitral valves; however discrepancies with catheter (CATH) gradients have been recognized. Recently it has been hypothesized that inertial and viscous forces, which are partially affected by valve size and orifice geometry, may control pressure recovery and thus play a role in these discrepancies. Therefore, in this study we examined the accuracy of CW derived pressure gradients us a function of valve size and orifice position in an attempt to determine the clinical utility of this technique. In 10 sheep with chronically implanted (anatomic orientation) St. Jude mitral valves (23, 25, 27 mm), 76 hemodynamic states (3 to 14 per sheep) were studied using Millar® catheters in the LA and LV. Peak gradient (PG) range = 2.0–23.0 mmHg; mean gradient (MG) range = 1.9–18.7 mmHg. Simultaneously, a Vingmed 775 with a port for transfer of digital data was used to obtain CW velocities across the three valve orifices: central (C), LV septal (S), and LV free wall (FW). Regression analysis for the 25 mm valve, for which the largest number of studies was available (n = 40), showed CW PG and MG correlated with CATH (PG: $y = 1.28x - 0.16$, $r = 0.89$, SEE = 2.9; MG: $y = 1.05x + 0.03$, $r = 0.88$, SEE = 2.1) but with consistent overestimation. In addition, considerable CW scatter was seen in the moderate range of CATH gradients. Analysis of the 25 mm valve orifices revealed the following % overestimation:

PG (S)	PG (C)	PG (FW)	MG (S)	MG (C)	MG (FW)
27%	32%	19%	4%	8%	0%

The 23 mm (n = 21) valves demonstrated significantly greater overestimation than either the 25 or 27 mm (n = 15) valves for both PG ($p < 0.02$) and MG ($p < 0.05$). *Conclusions:* There is good correlation of CW derived and CATH measured pressure gradients across bileaflet mechanical mitral valves. For a given CATH gradient, the CW derived pressure gradients vary for different valve sizes and their individual orifices. CW overestimated CATH gradients particularly in the smallest valve tested. For all valve sizes and individual orifice CW scatter was noted particularly in the mid range of gradients tested. Therefore, simplified Bernoulli calculations using CW velocities from any specific valve/orifice, although useful, are limited as accurate clinical predictors of CATH gradients.

971 Quantitative Assessment of Perfusion

Tuesday, March 21, 1995, 3:00 p.m.–5:00 p.m.
Ernest N. Morial Convention Center, Hall E
Presentation Hour: 4:00 p.m.–5:00 p.m.

971-54 A Non-invasive Method of Visually Assessing Renal Perfusion Using a Newly Developed Intravenous Ultrasound Contrast

Thomas R. Porter, Feng Xie, Karen L. Kilzer. *University of Nebraska Medical Center, Omaha, Nebraska*

Present methods of quantifying renal artery blood flow (RABF) in renovascular disease require either radionuclide techniques or invasive delivery of radiographic or ultrasound contrast. Perfluoropropane is a gas routinely used for intraocular injections which, when sonicated with dextrose albumin (PESDA), produces microbubbles with prolonged survival in blood. We hypothesized, therefore, that this prolonged ultrasound contrast effect could be utilized to non-invasively evaluate RABF and perfusion. Accordingly, we gave intravenous injections (IVI) of PESDA (0.06 cc/kg) to seven dogs while imaging with an external 4.5 MHz linear array transducer. RABF was monitored using a Transonic Doppler probe placed around the renal artery. Contrast two-dimensional enhancement was quantified off-line. Both echo and color Doppler enhancement were also qualitatively graded as 0 = no enhancement, 1+ = mild, 2+ = marked enhancement.

Following all 36 (100%) IVI of PESDA, there was 2+ contrast ultrasound enhancement of the renal cortex. A linear correlation existed between Doppler renal artery flow and peak renal cortex videointensity following IV PESDA ($r = 0.65$, $p < 0.001$). Color Doppler signals were also enhanced following IV PESDA, and resulted in excellent visualization of the main renal artery as well as segmental and lobar arteries. When renal artery stenosis was induced to decrease RABF to less than 10% of baseline, the segmental and lobar arteries were not visualized with color Doppler following IV PESDA, and peak renal cortex videointensity was reduced from 26 ± 10 to 15 ± 8 units ($p < 0.05$). These data demonstrate that renal artery and cortical blood flow abnormalities can be detected using intravenous PESDA. This ultrasound contrast agent could be a new non-invasive method to detect renal artery stenosis or abnormal renal perfusion.

971-55 Can Regional Myocardial Tissue Blood Flow be Measured in Terms of ml/min/g Using Contrast Echocardiography?

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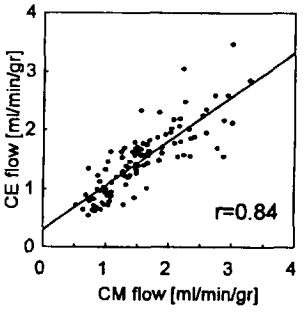
Absolute quantification of regional myocardial tissue blood flow (RMBF) based on contrast echocardiography has not yet been achieved. The aim of this study was to validate of our recently proposed algorithm for the quantification of RMBF and examine its reproducibility. This approach evaluates RMBF as the intravascular volume fraction (ratio of the areas under myocardial time intensity curve and a curve obtained from a reference region of interest) divided by mean transit time (obtained using deconvolution of impulse response). Experiments were carried out using an isolated rabbit heart model (N = 8), wherein coronary blood flow was controlled by varying perfusion pressure. Factors confounding in-vivo experimentation, such as cardiac translation and limited image quality, were eliminated in this setup. Aortic root injections of FS069, a new stable contrast solution (MBI, 1:200 in saline, filtered using a 8 μm-pore filter) and colored microspheres, used as the "gold" standard for reference, were performed at different levels of coronary flow. During contrast injections, end-diastolic images of the heart and an extracardiac reference chamber were acquired using a 7.5 MHz transducer and digitized on-line and processed using the above algorithm. Contrast echocardiographic measurements of RMBF highly correlated with microsphere flow (figure). Bland-Altman analysis revealed an insignificant bias of 0.07 ml/min/gr, with 95% limits of agreement at 0.69 ml/min/g. Using this algorithm, repeated evaluations of RMBF were highly reproducible ($r = 0.92$). In summary, the use of this new algorithm in conjunction with stable contrast agents, such as FS069, allows accurate and reproducible quantification of RMBF.



971-56 Myocardial Contrast Echocardiography can be Used to Assess Dynamic Changes in Microvascular Function In-Vivo

Suad Ismail, William Spotnitz, Ananda Jayaweera, Norman Goodman, Danny Skyba, Sanjiv Kaul. *University of Virginia, Charlottesville, VA*

The transit rate of sonicated albumin microbubbles (Albunex®, mean size = 4.3 μ) has been shown to correlate with that of radiolabelled red blood cells in the blood perfused beating heart. We have previously demonstrated that the transit rate of these microbubbles is decreased during hyperthermia-induced microvascular injury. In this study, we hypothesized that microbubble transit rate could be used as a marker of reversible endothelial injury during myocardial contrast echocardiography (MCE).

We produced endothelial injury by inducing different degrees of myocardial hypoxia. This was accomplished by perfusing an arrested heart with either arterial blood, venous blood, or blood diluted to different degrees with a crystalloid cardioplegia solution. The flow rate into the cross-clamped aorta was held constant in each dog (mean = 170 ml), as was the perfusate temperature (mean = 27°C). Perfusate hematocrit varied from 0–27%, while perfusate pO_2 ranged from 15–600 mmHg. MCE was performed by injecting 2 ml of a 1:1 dilution of Albunex® into the perfusate line and im-

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