Methods: The effect on visual assessment of stenosis severity of digital coronary angiograms was evaluated on a set of 100 image sequences using lossy (15:1) Joint Photographic Experts Group (JPEG) compression software. A panel of 3 angiographers reviewed 6200 frames from 10 clinical exams both with and without standard JPEG compression. Original and compressed versions of each sequence were viewed in random order by all panel members blinded to compression status. Images were viewed on the same display used for digital acquisition with the Philips Digital Cardiac Imaging (DCI) System. Panelists identified and graded severity of 99 stenoses in quartiles with >50% considered to be significant.

Results: There was no significant difference in the number of lesions identified with each modality. Overall agreement for severity of all lesions between compressed and non-compressed modalities was 0.60 and Kappa = 0.52. If lesions were dichotomized into "significant" (>50%) or "insignificant" (≤50%), agreement was 0.94 and Kappa = 0.88, suggesting that when disagreement occurred, it tended to be within one severity grade. These agreement statistics are consistent with previously reported intra-observer variability in the review of cine-coronary angiograms.

Conclusions: The significant reduction in digital storage and exchange requirements provided by lossy JPEG does not result in a decrease in diagnostic quality of digital coronary angiograms. Variability in visual assessment from original and compressed data formats is comparable to intra-observer variability from identical data formats. Therefore, JPEG compression does not result in loss of diagnostic information and is a valid means of reducing storage and exchange requirements of coronary angiograms.

994-95 Variability Sources in Quantitative Coronary Arteriography

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In a trial of progression/regression of coronary artery disease the results of quantitative coronary arteriography are affected by the following main factors:

(i) the frame selected for analysis (FRAME), according to the general agreement, that the lesion should be measured at enddiastole.

(ii) the frame rate (RATE), To obtain a truely enddiastolic image of a coronary lesion, a cine frame rate of 25 frames/sec is mandatory up to date. Newer digital equipped systems allow to use a frame rate of 12.5/sec, but there is concern, that one miss a truely representative enddiastolic image.

(iii) the measurement variance (MEAS) obtained from repeated measurements.

We analyzed the impact of these variability sources on the measurements in a study of 29 coronary lesions. The lesions were filmed at 25 and 12.5 frames/sec. The truely enddiastolic frame as well as the frame preceeding and following it was analyzed. Each frame was measured twice, using computer-assisted analysis of vessels. A nested multivariate analysis of variance was developed to quantify the effects of the independent variables RATE (12.5 instead of 25/sec), FRAME (enddiastole or a frame deviating from it) and MEAS (measuring the same frame twice) on the "outcome" in the sample the mean % diameter stenosis. The total variance in the sample by considering different stenosis (STEN; 15–75% diameter stenosis) was set to 100%.

Results: Multivariate analysis of variance shows the following influence of the various components on the size of % diameter stenosis:

	Independent variable			
	STEN	FRAME	RATE	MEAS
Coefficient of variation	23.67	9.23	4.38	5.70
% contribution to total variance	100	15.20	3.40	5.90

Conclusions: Frame selection is the major source of variability quantifying coronary lesions. Compared to the total variance the variance attributable to frame selection is nearly 3 times higher than the measurement variance and nearly 5 times higher than the rate attributable variance. Thus, one has to take great care of selecting appropriate frames and may use the lower frame rate (12.5/sec) to reduce radiation exposure and facilitate digital image archiving.

994-96 The Impact of the Vessel Position on the Accuracy of Vessel Measurement in Routine Quantitative Coronary Arteriography

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To convert computer-detected vessel dimensions in digitized angiograms from pixels into millimeters, the coronary catheter is commonly used as a calibration object. The absolute size of the vessel is then inferred from the ratio of the known to detected size of the catheter. However, the reliability of this inference is significantly affected by different angiographic magnifications of the vessel and catheter. The error in converting the vessel's size is dependent on the fractional positions of the catheter and vessel along their illuminating x-ray beams.

We studied in 207 daily biplane angiograms the general magnitude of the measuring error, as well as its fractional parts with regard to the artery being studied (LAD n = =5, RCA n = 53, LCX n = 59) and the selected angiographic projection (RAO 30°, LAO 60°).

Results: The position difference between the vessel and catheter causes a measuring error of more than 5% in one third of the analyses. The resulting error in the vessel measurements (mean ± std) is:

	Angiographic projection:	
	RAO 30°	LAO 60°
lesion diameter error [mm]:	0.12 ± 0.05	0.12 ± 0.04
normal diameter error [mm]:	0.21 ± 0.07	0.21 ± 0.06

The measuring error for the LAD coronary artery is in LAO 60° projection 45%, for the RCA in RAO 30° projection 65% and for the LCX coronary artery in LAO 30° projection 22% lower, than in the opposite projections.

Conclusions: Since the position caused errors might be superimposed by detection errors, the total measuring error, using the coronary catheter for conversion to absolute vessel sizes, might increase markedly. Improvement of the measuring accuracy might be achieved by: (i) Selection of an angiographic projection with minimum displacement of the artery from the catheter, (ii) error balancing by empty/filled catheters. Catheterization laboratories equipped for biplane angiography should apply biplane angiographic correction procedures for position errors or use analytic calibration, which calculates the angiographic magnification of a vessel directly.

994-97 Quantitating Pulmonary Capillary Volume Using Digital Parametric Angiographic Analysis

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Assessment of the distal pulmonary vasculature in patients with pulmonary hypertension has been limited to *qualitative* description of pulmonary arteriograms. Digital parametric imaging, using contrast density and transit time, has been used to *quantitate* blood volume and flow in the coronary and renal vascular beds. This study was performed to determine whether digital parametric imaging can quantitate vascular volume in the distal pulmonary capillary bed with pulmonary flow intact.

Two digital angiograms of the pulmonary vasculature were acquired in 11 patients with varying degrees of pulmonary hypertension. A balloon flotation catheter was advanced distally into the pulmonary artery. The first angiogram (static image) was performed with blood flow occluded by inflation of the catheter balloon. Non-ionic contrast was then hand injected to completely fill the vasculature beyond the balloon occlusion. The second angiogram (flow image) was performed with the balloon deflated and blood flow preserved. A hand injection of a rapid bolus of contrast, 1–2 cc, was given. Digital subtraction image data were obtained at 15 frames/sec at end expiration for both angiograms. Contrast density measurements of the distal pulmonary vasculature were determined from the static images in various 2 × 2 mm areas using digital parametric imaging. The maximum density in these same areas was similarly determined from the flow images.

The correlation of the density measurements between the static and the flow images in 64 regions of interest was excellent (R = 0.92, regression slope = 0.98). This correlation was similar to that observed for repeated injections using the same technique (flow image) (R = 0.97, regression slope = 0.97).

Conclusion: Digital parametric measurements of pulmonary capillary volume obtained with blood flow preserved are the same as those obtained with flow occluded and the entire bed replaced by contrast. This method allows quantitation of pulmonary vascular volume and flow using a simple, single contrast injection in the distal pulmonary artery.

994-98 Patients' Radiation Risk During Diagnostic and Interventional Coronary Procedures

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Uncertainties in radiation risk estimates at low doses (<0.1 Gy) include the shape of the dose-response curve, use of a relative or absolute risk model, and the length of the latent cancer induction period. Coronary procedures are often repeated within short in many patients, but neither absorbed doses nor imparted energies are routinely measured. We used LiF thermoluminescence dosimeters in 15 consecutive diagnostic (D) and 15 PTCA (I) procedures, with stent implantation in 1 case, multivessel PTCA in 2, and PTCA of chronic occlusion in 2. A Philips Optimus 2000 DCI was used, with a standard

dose of 10 microR/f for an image intensifier format (IIF) of 23 cm. Fluoroscopy times (2.9 ± 1 min for D and 16 ± 6 min for I) number of cine runs (9 ± 2 for D and 17 ± 7 for I) and length of cine runs (5.3 ± 1.5 sec for D and 2.9 ± 2 sec for I) were representative of our standard procedures. A rate of 12.5 f/s was used for cine coronary imaging, with 25 f/s for left ventriculograms in 2 projections. IIF 18 and 13 cm were used for D and I, respectively. Patient absorbed doses (mGy) were [mean ± s.d.(range)]:

	Thyroid	R + L Thorax/2	Column	Gonads
D	0.6 ± 0.3	18 ± 27 (1.3–127)	21 ± 36	0.08 ± 0.05
I	2.0 ± 0.8	29 ± 50 (1.2–245)	26 ± 19	0.08 ± 0.02

Patient radiation exposure during D and I, despite dose-effective technique, is substantial, especially in areas (thorax) which cannot be shielded. It should be routinely measured since radiation risk may not be negligible when repeated procedures are performed. The risk/benefit ratio of repeated D and I must be weighed.

994-99 Can Late Saphenous Vein Graft Closure Be Predicted by Quantitative Angiographic Analysis Before the Clinical Event?

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Angiographic parameters predicting the likelihood of late occlusion of saphenous vein grafts (SVG) have been infrequently described. The Post-CABG Study, a 5-year trial aimed at reducing SVG closure in minimally symptomatic patients 1–11 years Post-CABG, offers a unique view into this event since this study requires an angiogram to document baseline graft patency. In this preliminary study we performed quantitative angiographic analysis (QAA Reiber) comparing the baseline Post-CABG study angiogram to an unscheduled "clinically driven" angiogram. Of 1253 enrolled patients with at least one patent SVG, 35 developed MI or unstable angina associated angiographically with a changed SVG lesion and either total or subtotal occlusion. Average patient age was 58 ± 2 (SEM)years; 97% were male. Years since SVG placement to baseline angiogram averaged 6.5 ± 0.4 (range 2–14). Time from the baseline to the unscheduled angiogram was 22 ± 2 mo (range 3–47). In 28 patients the involved graft was single and in 7 sequential. The SVG insertion segments involved the LCX in 17, RCA in 15 and LAD in 10.

Results: The initial lesion diameter at the site of the subsequent inciting lesion for all 35 patients averaged 2.58 ± 0.17 mm, or 29.5 ± 3.6% diam. stenosis. (This was defined as the most severe stenosis in any part of the graft in patients with subsequent total graft occlusion, and the exactly matched graft site in those with subtotal occlusion.) In 8 patients the baseline SVG was entirely normal. The initial lesion was >50% stenosis in only 4 patients. At the time of the clinical event, the lesion had progressed to 87 ± 2.6% diam stenosis (N = 35). In 16 patients the causal lesion was subtotal, while in 19 the SVG was totally occluded. The mean native vessel — responsible graft anastomotic diameter was 2.33 ± 0.12 mm.

Conclusion: QAA of SVG in asymptomatic patients may not predict subsequent graft closure associated with acute coronary syndromes. The initial site of the lesion is typically of mild-moderate severity, and only later exhibits rapid progression to occlusion.

994-100 Acute Neurological Complications of Cardiac Catheterization: Natural History and Risk Factors

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The development of an acute neurological deficit (ND) is a rare but dreaded complication of left heart catheterization. The natural history and predisposing risk factors for their development are not well known. We sought to determine the incidence, clinical outcome and variables associated with the development of ND from diagnostic left heart catheterization (LHC), angioplasty (PTCA) or valvuloplasty (V) in 6465 consecutive patients (pts) in the modern era. All cases of ND developing within 36 hours of LHC (n = 5245), PTCA (n = 1159) and V (n = 61) were collected prospectively. The clinical features and natural history of these events were studied and, using a case control method, each case was matched by month to 10, randomly chosen pts without ND, and the variables associated with developing ND were determined. Twenty-seven pts (0.4%) suffered a neurological deficit. The most common symptoms were: visual disturbances (n = 7; 26%), hemiparesis (n = 7; 26%), and facial droop (n = 7; 26%). Seizures occurred in 3 (11%), and one pt each developed dysequilibrium, transient global amnesia and transient unresponsiveness. Sixteen pts (59%) completely resolved at long-term follow-up with the majority (13/16) resolving within 24 hours. An additional 4 pts (15%) had minimal persistent deficits (diplopia, n = 2; homonymous hemianopsia, n = 2). Four pts (15%) had major deficits at follow-up (hemiparesis, n = 3; right upper extremity weakness, n = 1) and 3 pts (11%) died as a sequela. Clinical variables associated with ND and the odds ratio and confidence intervals:

Female Sex	3.2; (1.4, 7.4)*
Vascular Disease	3.1; (1.2, 8.0)**
≥2 Coronaries Diseased	3.0; (1.2, 7.4)**
Ejection Fraction	0.4; (0.2, 1.0)**
Left Ventricular Hypertrophy (LVH)	2.9; (1.2, 7.3)**

*p < 0.01, **p < 0.05

As a predictor of ND, female gender was independent of body surface area. Variables not associated with the development of ND included age, diabetes, hypertension, prior infarction or stroke, procedure performed, heparin dose and number of catheter exchanges.

We conclude that ND occurred in 0.4% of left heart procedures and 59% resolved completely. Females have a threefold greater risk than males, and this risk is independent of body surface area. Pts with vascular disease, extensive coronary disease, LVH aand poor ventricular function are at increased risk for a neurological complication of catheterization.

995 Factors Affecting Coronary Flow

Wednesday, March 22, 1995, 9:00 a.m.–11:00 a.m.
Ernest N. Morial Convention Center, Hall E
Presentation Hour: 10:00 a.m.–11:00 a.m.

995-16 Endothelial Dysfunction of Spasm-related Coronary Artery in Patients with Variant Angina

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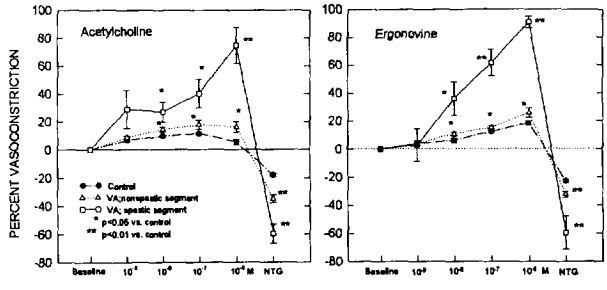
To investigate endothelial function in pts with variant angina(VA) with angiographically near normal coronary arteries, quantitative coronary angiographic study was done with continuous intracoronary infusion of incremental dose (from 10^{-9} to 10^{-6} M) of acetylcholine (Ach) and ergonovine (Erg). Changes in luminal diameter in spastic and nonspastic segments of spasm related artery of pts with VA (n = 28, mean age = 53) was compared to those of normal control pts (n = 21, mean age = 41). The results were as the following figures.



Data are expressed as mean ± SEM, NTG = nitroglycerine

Conclusions: The magnitude of vasoconstrictive response to Ach or Erg was greater at both spastic and nonspastic segments of spasm-related artery compared to control pts. The vasodilatatory response to NTG was also exaggerated in the spasm-related artery. These findings suggest that both basal and stimulated releases of EDRF may be decreased in the spasm related artery. This impaired endothelial function may also be related to the development of coronary spasm in pts with variant angina.

995-17 Are Intracoronary Doppler Flow Velocity Measurements Accurate for Assessment of Coronary Flow Reserve?

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Coronary flow reserve (CFR) measurements are useful for assessment of coronary stenoses and microvascular function in patients. Intracoronary Doppler probes are commonly used for CFR measurement, but changes in flow velocity reflect volumetric flow only if the conduit vessel size is constant. We hypothesized that potent resistance vessel dilators used for CFR measurement also produce conduit artery dilation that perturbs the relationship between coronary flow velocity and volumetric flow.