PARADOXICAL RESPONSE OF AORTIC REGURGITANT VELOCITY SLOPE AND PRESSURE HALF TIME TO CHANGES IN COMPLIANCE AND SYSTEMIC VASCULAR RESISTANCE

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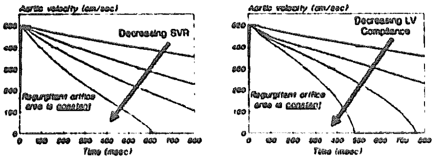
The slope and pressure half time ($T\frac{1}{2}$) of the Doppler derived flow velocity have been used to assess the severity of aortic regurgitation (AR). Computer simulation indicates, however, that these indices are dependent on systemic vascular resistance (SVR) and ventricular (C_V) and aortic (C_{Ao}) compliance (see figure).



To test this hypothesis, we constructed an in vitro analog of the aorta and left ventricle in which SVR, C_V, C_{Ao}, and aortic regurgitant orifice area(ROA) could be independently varied. Holding ROA and initial aortic pressure constant, we measured regurgitant fraction (RF), and AR Doppler slope and $T\frac{1}{2}$ in quadruplicate for 20 different combinations of SVR, C_V and C_{Ao}. RESULTS: AR $T\frac{1}{2}$ varied directly with SVR, C_V, and C_{Ao} (multivariate r=0.95), while slope varied inversely with each (multivariate r=0.93). Furthermore, when compared to RF, these indices varied opposite to their usual clinical interpretation: long $T\frac{1}{2}$ and a small slope predicted a higher RF (univariate r=0.61 and -0.56, respectively).
CONCLUSION: For a constant ROA, changes in SVR and compliance alter AR Doppler slope and $T\frac{1}{2}$ paradoxically.

A SIMPLIFIED METHOD TO DETERMINE REGURGITANT FRACTION BY DOPPLER IN PATIENTS WITH AORTIC REGURGITATION

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Available methods to quantify the severity of aortic regurgitation(AR) by echocardiography(DOP) remain limited. Therefore, we developed a simplified method to calculate regurgitant fraction(RF) from pulsed DOP recordings in pts with AR. The method is contingent upon the fact that, in normals, a constant relationship exists between the cross-sectional area of the LV outflow tract(Ao) and mitral annulus(MIT). To verify this concept, we measured flow velocity integral (FVI) by DOP from Ao and MIT in apical view in 50 normals: 32 male, 18 female, 21-58 years of age, mean 34. A close correlation r=0.95 was observed between FVI in Ao and MIT: MIT FVI=0.77 Ao FVI, or MIT FVI/Ao FVI =.77. In normals, mitral flow = aortic flow; therefore MIT (area x FVI) = Ao (area x FVI), or Ao area/MIT area = MIT FVI/Ao FVI. Since MIT FVI/Ao FVI equals .77, this figure represents a constant relationship between MIT and Ao cross-sectional areas. In AR, the RF = Ao flow - MIT flow/Ao flow, or 1 - MIT flow/Ao flow. Substituting 0.77 for the area component of flow, we obtain RF = 1-1/.77 x MIT FVI/Ao FVI, thereby enabling RF calculations solely from velocity measurements. To evaluate the accuracy of this equation we compared RF derived by catheterization to that from DOP in 10 pts ($\overline{age}$ 63) with isolated AR. RF by catheterization was calculated from angiographic and thermodilution stroke volume. A good correlation was observed between Doppler and cath RF, y=0.71x+13, r=0.88, p<.001. Thus, we present a simplified method of estimating RF from Doppler in pts with AR which requires only measurements of flow velocity integral from mitral annulus and LV outflow tract. This Doppler computation of RF correlates well with catheterization in pts with isolated AR.

PRESSURE RECOVERY - A CAUSE OF DISCREPANCY BETWEEN DOPPLER AND CATHETER GRADIENTS IN ST. JUDE VALVES

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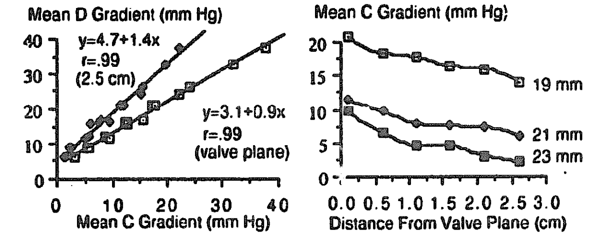
To examine the spatial relationship between CW-Doppler (D) and Catheter (C) gradients in St. Jude valves, three valve sizes (19-23mm) were studied in a pulsatile aortic flow model. Mean systolic flow rates were varied from 160 to 280 cc/sec. D gradients were calculated with the modified Bernoulli equation. C pressure gradients were measured with fluid filled catheters 2.5 cm proximal and 0 to 10 cm distal to the valve (pull back). D gradients correlated well to C gradients at 2.5 cm distance (r=.99, SEE=1.2 mm Hg) and at the valve plane (r=.99, SEE=.8 mm Hg), but D systematically overestimated C gradients at a distance from the valve. Significant decrease of C gradients was found within the first 2.5 cm distal to the valve (35%, 51%, and 87% for the 19, 21, and 23mm valve, respectively). Only a slight decrease was observed from 3 to 5 cm and no change from 6 to 10 cm.



Conclusion: D systematically overestimates C gradients measured at a distance from the valve, but corresponds to C measurements at the valve plane. These findings suggest localized gradients at the valve level, as well as pressure recovery as a cause of discrepancy between clinical D and C measurements.

THE ROLE OF DOPPLER ECHOCARDIOGRAPHY IN THE ASSESSMENT OF CARDIAC TAMPONADE: STUDIES USING A NEW CANINE MODEL.

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Reciprocal variations in left and right heart flow are known to occur with respiration in patients with cardiac tamponade (CT). To quantitate these variations and assess their relationship to hemodynamic changes a closed chest, spontaneously breathing canine model of CT was developed. Aortic (A) and pulmonic (P) flow velocity was measured by Doppler as saline was infused into the pericardial cavity causing pericardial pressure (PP) to increase in stages from baseline (mean = -4 mm Hg) to 0, 5 and 10 mm Hg. In 7 anaesthetized dogs this protocol was carried out as aortic pressure (AP), respiratory rate (RR), cardiac output (CO), peripheral pulsus paradoxus and maximal inspiratory change in peak A and P flow velocity was recorded.
RESULTS: (all units mm Hg unless otherwise indicated.)

PP	AP	RR/min	CO(l/min)	Pulsus	A(%)	P(%)
-4	139.8	12.2	3.08	4.0	-5.3	11
0	144.6	14.0	2.81	7.4	-13.7*	15
4.9	115.6	17.6	1.86*	15.3*	-22.6*!	58*!
9.4	67.4*	30.0*	0.57*	9.6	-31.9*!#	71*!

(* = p<0.05 vs baseline; ! = p<0.05 vs second stage; # = p<0.05 vs third stage)
CONCLUSIONS:
1) Respiratory variations in aortic and pulmonic flow velocity can be recorded by Doppler and increase in parallel with increasing pericardial pressure.
2) Although respiratory variation in peripheral blood pressure may return to baseline levels in severe cardiac tamponade, Doppler continues to detect significant respiratory variations in aortic and pulmonic flow.