10:45

THE PROXIMAL FLOW CONVERGENCE METHOD FOR CALCULATING ORIFICE FLOW RATE REQUIRES CORRECTION FOR SURROUNDING LEAFLET GEOMETRY

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Recent studies have shown that the flow convergence region proximal to an orifice can be used to quantify flow rate Q by Doppler flow mapping. By continuity, Q = flow through a proximal isovelocity surface with a radius measured from the orifice to the first color alias. This method has been applied to orifices in flat surfaces assuming a hemispherical convergence region. Clinically, however, leaflet geometry may allow flow to converge over more or less than a hemisphere, as in LV dysfunction, mitral valve prolapse and mitral stenosis (fig. 2-4). For such cases, potential flow theory suggests that Q calculated for a hemisphere must be corrected by $\alpha/180^\circ$, where α is the inlet angle formed by the leaflets proximal to the orifice. Therefore, we tested the hypothesis that calculating orifice flow rate requires that inlet angle be taken into account. Steady flow (.8-4.5 l/min) was pumped through circular orifices between plates with geometries 1-4. The measured radius was maximized, and flow rate calculated with and without the inlet angle factor. **RESULTS:** Flow rates calculated assuming a hemispherical convergence region underestimated actual values by 37+5% for orifices 2-3 (270° inlet) and overestimated it by 95+7% for orifice 4 (90° inlet: p<.0002). Correcting for the inlet angle gave values within 3+6% of actual values (r=.98, SEE=.2 l/min by regression). **CONCLUSION:** Application of the proximal convergence method for flow through restrictive orifices must take into account the inlet angle determined by the surrounding leaflets.

11:00

FLOW CONVERGENCE CALCULATIONS OF FLOW RATE THROUGH NON OR MINIMALLY RESTRICTIVE ORIFICES: IN-VITRO STUDIES.

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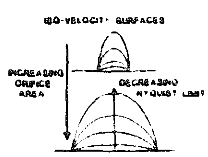
To test the flow convergence concept for calculating flow through non-restrictive or minimally restrictive orifices using color Doppler flow mapping (CDFM), we imaged steady flow (Toshiba SSH 160A) through normal prosthetic porcine AO valves of internal diameters from 15 to 24 mm and actual flow rates from 1.5 L/min to 9.7 L/min. Calculated flow rates using a hemispherical model for the flow convergence surface area correlated well with actual flow rates for the different NLs (r:0.80-0.90) and agreed well (slopes:0.92-1.3). Separately analyzing the individual variables of Nyquist limit (NL) and flow rate, a new surface area in the form of a hemi-ellipse was found to be more appropriate for explaining the systematic differences in predicted flow at differing NL variations. The transverse radius of the hemi-elliptical surface was observed to remain constant for constant orifice diameter and can be measured from one long-axis plane while the axial radius changes as NL and flow rate varies producing a family of isovelocity shells whose shape is dependent on flow rate and NL. We obtained better predictions for calculated flow rate using this new surface area (r:0.95-0.99, slopes: 0.95-1.05, intercepts:-1.1-0.5) for changing NLs. Our analyses and results shed insight into how NL and flow rate affect the proximal flow convergence surface area and provide a correction factor that can be used to correct for NL and flow rate variability.



11:15

INCREASED HEART RATE CAN CAUSE UNDERESTIMATION OF REGURGITANT JET SIZE BY COLOR DOPPLER FLOW MAPPING

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Recent studies have attempted to predict the severity of regurgitation from maximum jet area by color Doppler flow mapping (CFM), which correlates with flow rate for free jets at constant driving pressure and steady flow. In vivo, however, maximum jet area exists for only a limited time per beat, and the likelihood of recording it by CFM depends on its duration relative to the color frame sampling rate (FR). Increased heart rate (HR) could potentially diminish apparent jet size, particularly at slow FRs which may not visualize maximum jet area in all beats. We therefore addressed the hypothesis that, at a constant peak flow rate, increasing HR could decrease the maximum apparent jet size by CFM. We examined this in pulsatile flow, holding orifice size and peak flow rate constant and varying HR (70-180/min) and FR (3 rates) for jets of low and high momentum (MOM: 3-9 l/min and 2-5 m/sec). Maximum jet area was measured in 10 consecutive beats at each HR and FR, and averaged. **RESULTS:** 1) For the low-MOM jet, maximum color jet area (10-beat average) decreased progressively with increasing HR. As HR increased from 70 to 180, maximum jet area decreased 23% at the fastest FR and 43% at the slowest FR, with 13% beat-to-beat variability. Jet area decreased 12-20% at HRs as low as 90. Stepwise penetration of flow into the chamber could be seen in successive frames, with maximum areas of brief duration. 2) For the high-MOM jet, maximum jet area decreased by $\leq$ 9% from low to high HR at any FR. **CONCLUSION:** Increased HR can cause underestimation of apparent jet size by CFM for a given peak flow rate, particularly for jets with low momentum and delayed penetration into the receiving chamber. This may be relevant to acute severe regurgitation with increased HR. This effect can be reduced by increasing frame rate, and should be considered in relating jet size to the severity of regurgitation.

11:30

TRANSTHORACIC DOPPLER OF PROSTHETIC MITRAL REGURGITATION: THE UTILITY OF COLOR DOPPLER FLOW CONVERGENCE

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Prosthetic mitral valves (MVR) impede transthoracic echocardiographic (TTE) assessment of mitral regurgitation (MR) by left atrial (LA) shadowing. Color Doppler (CD) flow convergence (FC) for assessment of MVR MR during TTE has not been described. TTE of 60 MVR's (20 Carpentier Edward valves (CE), 18 caged-ball valves (CAGE), 22 St. Jude valves (SJ) were reviewed by two observers, blind to transesophageal echo (TEE) (performed on all pts within 1.1+/-2.2 days). With the LA covered during TTE retrospective review, FC on the LV side of the MVR was determined. TTE evidence of an intense MR signal on continuous wave (CW) Doppler and 3-4+ CD spatial mapping of the LA (LA-MR) were also sought. For the prediction of 3-4+ MR on TEE, the sensitivity/specificity of FC, CW, and LA-MR was:

	CE	CAGE	SJ	All Valves
FC	80/70	67/56	73/82	73/70
LA-MR	70/100	0/78	25/100	33/93
CW (+)	33/90	13/100	0/100	23/97

FC was more readily detected with CE and SJ valves than CAGE valves. FC was particularly useful when shadowing prevented CD imaging of the LA and the CW study was negative, with failure to place the CW cursor into the MR jet or FC. CD aliasing in the LV outflow (obscuring or mimicking FC) and technical limitations were the most common causes of error in the determination of FC.

CONCLUSION: FC by TTE is a more sensitive though less specific marker of (3-4+) MR on TEE than a strong CW signal of MR or 3-4+ spatial mapping of the LA on TTE. FC provides an alternate method to detect prosthetic MR.