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ARE WE UNDERESTIMATING THE GRADIENT IN PATIENTS WITH AORTIC STENOSIS AND ATRIAL FIBRILLATION: IT'S TIME TO CONSIDER VENTRICULAR PRELOAD

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FOR REFERENCES. Samual Hayman, Pantelis Diamantouros, Rodrigo Bagur, Michael Chu, Bob Kiaii, Bryan Dias, Patrick Teefy. My nedoozenivaem gradient davleniya u pazientov s aortal'nym stenozom i fibrillyaziey predserdiy: prishlo vremya izuchit' prednagruzku zheludochkov [Are we underestimating the gradient in patients with aortic stenosis and atrial fibrillation: it's time to consider ventricular preload]. *Neotlozhnaya kardiologiya i kardiovaskulyarnye riski* [Emergency cardiology and cardiovascular risks], 2018, vol. 2, no. 1, pp. 216–220.

Purpose: To understand the significance of variation in gradient beat-to-beat pressure gradients in patients with significant aortic stenosis and concomitant atrial fibrillation and determine its relationship to severity.

Methods: Assess the beat-to-beat variability of pressure gradients in patients significant aortic stenosis and concomitant atrial fibrillation from retrospective analysis of Doppler or catheter-based hemodynamic measurements and correlate with the preceding RR interval based on the corresponding electrocardiogram. Results: There is a direct correlation between the preceding RR interval and the mean pressure gradient in patients with significant aortic stenosis and concomitant atrial fibrillation. The variation seems to be more prominent in those with severe stenosis and preserved left ventricular function and may aid in classifying the degree of stenosis as severe in some with seemingly more moderate stenosis based on traditional averaging of consecutive beats.

Conclusions: Variation in pressure gradients beat-to-beat are important to consider in patients with aortic stenosis and concomitant atrial fibrillation and correlate with severity and contractile characteristics.

Background

Compared to those in sinus rhythm (SR), patients with atrial fibrillation (AF) in the setting of aortic stenosis (AS) have an elevated mortality risk whether managed medically or surgically [1]. When evaluating these patients, echocardiographic guidelines recommend averaging the peak velocities (V_{max}) and velocity-time intervals (VTI) over at least five beats [2]. Large patient series have adhered to these recommendations [1, 3]. However, stenotic office gradients are flow dependent. Variations in cardiac output, concomitant aortic or mitral valvular regurgitation or increased metabolic rate will all affect measured gradients for a given stenosis [2]. This is exemplified in the setting of low-flow low-gradient (LFLG) severe AS – dobutamine stress echocardiography will result in an increase in both stroke volume (SV) and mean gradient (ΔP_{mean}) [2, 4]. Likewise, in AF with a short RR interval, there is shortened ventricular relaxation and filling period, and a resulting smaller SV [3]. The ΔP_{mean} measured by echo is therefore dependent on heart rate and RR interval variability. This somewhat explains why patients in AF, compared to those in SR, will have lower peak velocities and gradients despite similar aortic valve areas (as assessed by the continuity equation) [5]. We sought to demonstrate the relationship between preceding RR interval and gradients (V_{max} and ΔP_{mean}) in AS with the hypothesis that the gradient that most accurately reflects the true stenosis is the one after the longest RR interval.

Acronyms: *AF – atrial fibrillation, AS – aortic stenosis, LFLG – low-flow low-gradient, SR – sinus rhythm, SV – stroke volume, VTI – velocity-time interval.*

Methods

We retrospectively identified patients with both AS and AF during their echocardiogram or invasive valve assessment. Patients were excluded if they were paced or if there were < 5 recorded continuous wave Doppler envelopes to re-analyze. Baseline characteristics and echocardiographic or invasive parameters were also recorded. Severe AS was defined as ΔP_{mean} > 40 mmHg. Pearson Correlation Coefficient was utilized to assess the relationship between preceding RR interval and gradients (Vmax and APmean).

Results

Twenty-one patients were reviewed for inclusion. Nineteen echocardiograms from 16 patients were reviewed for the analysis. Two studies were included from invasive catheterization data. Seven patients were excluded (insufficient data in five and permanent pacing in two). A total of 186 data points were measured. The final original assessment(averaging multiple beats) was severe (normal flow) AS in nine studies; LFLG severe AS in four; LFLG (paradoxical normal EF) severe AS in two; and moderate AS in six. There was a clear relationship between the RR interval and both the ΔP_{mean} (Figure 1) and Vmax. In the severe and moderate AS groups, R correlates ranged from 0.59–0.90 (APmean) and 0.31–0.94 (ΔP_{mean}), respectively. This was not as robust in the low-flow low-gradient group with R correlates ranging from 0.50–0.77 (ΔP_{mean}) possibly a result of the impaired ventricular systolic function. The overall mean R correlates were 0.71+0.15 (ΔP_{mean}) and 0.67+0.19 (V_{max}). Utilizing the maximum measured gradient, instead of the standard averaged gradient, the APmean increased by an average of 10.1 mmHg (range 2.1–30.4 mmHg) with two patients reclassifying from moderate to severe AS (including one LFLG).

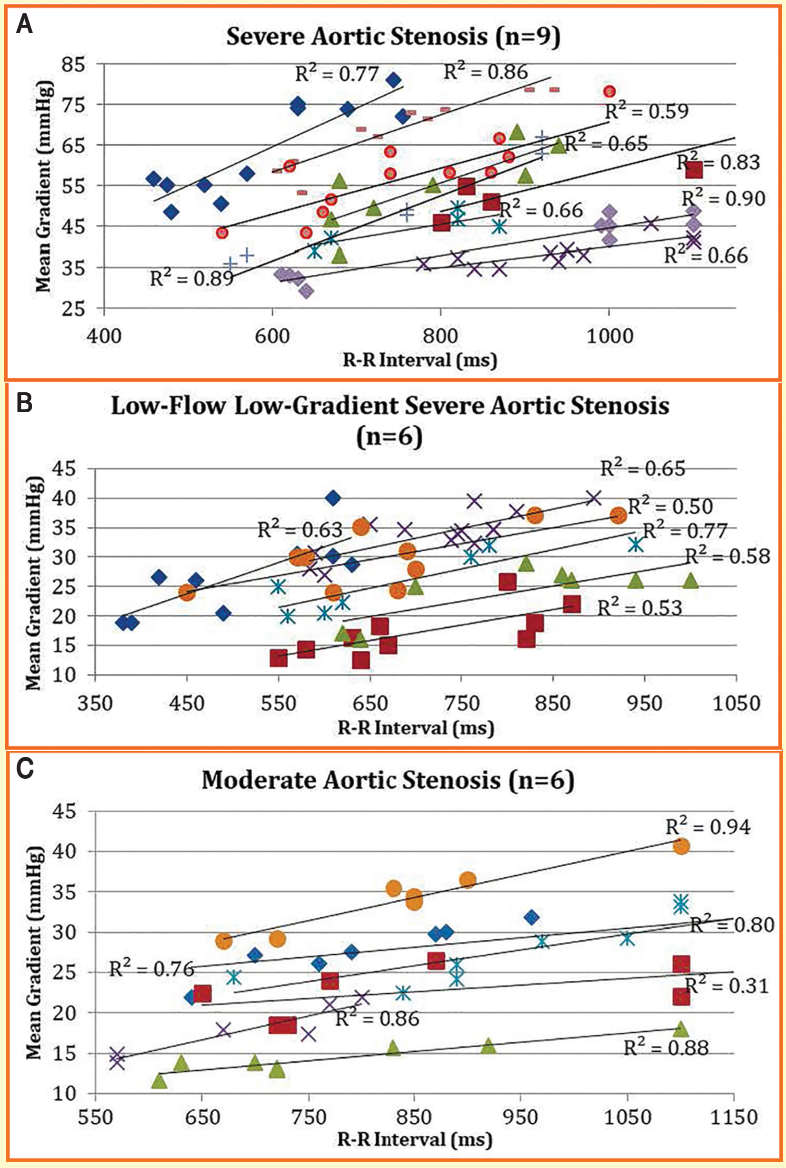

Figure 1. Ttrendline and R2 correlates comparing mean gradient to R-R interval in servere (A), LFLG servere (B), and moderate (C) aortic stenosis.

Discussion

Our study demonstrates the relationship between preceding RR interval and aortic gradient in the setting of concomitant AF and AS. When the RR interval is short there is decreased ventricular filling and a decreased SV resulting in a smaller gradient. In a number of our cases there was extensive variability in measured gradient depending on which cardiac cycle was included resulting in potential reclassification from moderate to severe stenosis. The relationship is not as robust in the LFLG subset. This may be as a result of not considering the pre-preceding RR interval, [3] the degree of mitral regurgitation and reduced contractile reserve. It also suggests that the slope of the RR interval and AP relationship is directly related to the left ventricular contractile reserve. In a similar vein, when differentiating 'true' versus 'pseudo' severe AS in a low-flow patient, other authors have suggested using the post-extrasystolic (therefore optimizing preload) gradient as a potential alternative to dobutamine [6, 7]. Similar to this or the use of dobutamine for LFLG aortic stenosis, the most appropriate measure of systolic gradient in AS with AF may occur with optimization of preload and SV (usually after the longest RR interval).

Study limitations

Our study has a number of limitations. Firstly, it is retrospective which has inherent bias. Secondly, we review a relatively small sample size, which makes assessment of outcomes, which we did not do, of little value. Thirdly, we do not directly measure other factors that affect flow in the setting of AS and AF such as the pre-preceding RR interval, concomitant aortic or mitral insufficiency and a full assessment (no only ejection fraction) of left ventricular contractility and function (diastolic function, longitudinal strain). However, these would incrementally reduce the practical applicability in a busy echo lab. Lastly, we do not measure the post-extrasystolic gradient which may further optimize preload and stoke volume, however this data was not available as our current practice is to avoid measurements port ectopy and they were not saved.

Conclusions

There is a relationship between the RR interval and measured gradient in the setting of AS and AF. Assessing the gradient may be most accurate during optimal ventricular preload and stroke volume, which is usually after the longest RR interval. Rather than averaging gradients and velocities, the highest recorded values may more accurately reflect the degree of stenosis. A larger study with simultaneous measurements of left ventricular outflow tract (V_1) and maximal orifice velocities (V_{max}) are necessary to further explore this relationship.

Conflict of Interest: *There are no conflicts of interest to declare.*

References

[1] Bronzetti G., Brighenti M., Mariucci E., Fabi M., Lanari M., Bonvicini M., Gargiulo G., Pession A. Upside-down position for the out of hospital management of children with supraventricular tachycardia. *Int J. Cardiol*, 2018, vol. 1, no. 252, pp. 106–109. doi: 10.1016/j.ijcard.2017.10.120.

[2] Li X.M., Ge H.Y., Shi L., Liu X.Q., Guo B.J., Li M.T., Jiang H., Zheng X.C., Li A.J., Zhang Y.Y. Multicenter investigation of the correlation between supraventricular tachycardia and tachycardia-induced cardiomyopathy in children. *Zhonghua Er Ke Za Zhi*, 2017, vol. 2, no. 55(9), pp. 668–671. doi: 10.3760/cma.j.issn.0578–1310.2017.09.009.

[3] Labombarda F., Hamilton R., Shohoudi A., Aboulhosn J., Broberg C.S., Chaix M.A., Cohen S., Cook S., Dore A., Fernandes S.M., Fournier A., Kay J., Macle L., Mondésert B., Mongeon F.P., Opotowsky A.R., Proietti A., Rivard L., Ting J., Thibault B., Zaidi A., Khairy P. Increasing Prevalence of Atrial Fibrillation and Permanent Atrial Arrhythmias in Congenital Heart Disease. *J. Am Coll Cardiol*, 2017, vol. 70, no. 7, pp. 857–865. doi: 10.1016/j.jacc.2017.06.034.

[4] Bassareo P.P., Fanos V., Pala M., Antonucci L., Neroni P., Antonucci R., Mercuro G. Supraventricular tachycardia during the first year of life: is subclinical inflammation the trigger? *J. Matern Fetal Neonatal Med*, 2018, vol. 31, no. 1, pp.53–58. doi: 10.1080/14767058.2016.1275545.

[5] Yıldırım I., Özer S., Karagöz T., Sahin M., Özkutlu S., Alehan D., Çeliker A. Clinical and electrophysiological evaluation of pediatric Wolff-Parkinson-White patients. *Anatol J. Cardiol*, 2015, vol. 15, no. 6, pp. 485–490. doi: 10.5152/akd.2014.5462.

[6] Brembilla-Perrot B., Olivier A., Villemin T., Manenti V., Vincent J., Moulin–Zinsch A., Lethor J.P., Tisserant A., Marcon F., Jean Marc S. Follow-up of children or teenagers with paroxysmal supraventricular tachycardia, but without pre-excitation syndrome. *Arch Cardiovasc Dis*, 2017, vol. 110, no. 11, pp. 599–606. doi: 10.1016/j.acvd.2017.01.013.

[7] Ge H., Li X., Zhang Y., Liu H., Jiang H. Clinical course and treatment of ectopic atrial tachycardia in 144 children. *Zhonghua Er Ke Za Zhi*, 2015, vol. 53, no. 3, pp. 214–219.

[8] Backhoff D., Klehs S., Müller M.J., Schneider H., Kriebel T., Paul T., Krause U. Radiofrequency Catheter Ablation of Accessory Atrioventricular Pathways in Infants and Toddlers ≤ 15 kg. *Pediatr Cardiol*, 2016, vol. 37, no. 5, pp. 892–898. doi: 10.1007/s00246–016–1365–z.

[9] Paul T., Bertram H., Bökenkamp R., Hausdorf G. Supraventricular tachycardia in infants, children and adolescents: diagnosis, and pharmacological and interventional therapy. *Paediatr Drugs*, 2000, vol. 2, no. 3, pp. 171–181.

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