EDITORIAL

Blood Pressure Matters in Matters of the Heart

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I remember the very first time I was asked to perform an intraoperative transesophageal echocardiographic examination to assess for mitral regurgitation (MR). I was a senior fellow who had performed hundreds of studies, and I had been involved with some excellent mitral valve (MV) surgeons. So, when the request came from the operating room to assess for MR, I recall thinking that this would be a simple evaluation to help the surgeon determine the need for MV surgery at the time of bypass. Many years later, I most certainly have recall bias. (Recall bias is a systematic error that occurs when previous events or experiences are not accurately remembered or important details are omitted.)

Little did I know at that time that the assessment of MR should always occur before the intraoperative setting, during which hemodynamic status rarely reflects the nonoperative setting. Many years after this call to the operating room, I more clearly appreciate the significant impact of systolic blood pressure (SBP), heart rate, and volume status on the degree of MR. So, back then, as a fellow, seeing the transesophageal echocardiogram of the patient for the first time, having not reviewed the transthoracic echocardiogram that led to the request for MV surgery, I was not justified in my conclusion that "the MR grade is indeed mild" and did not warrant surgical repair or replacement. This conclusion was derived despite the markedly abnormal structural changes seen on the restricted posterior leaflet and the dilated left atrium in sinus rhythm. This conclusion was offered without my recommendation to raise the SBP to mimic the clinical, nonoperative, nonanesthetic setting. This conclusion was incorrect. This conclusion created an important opportunity for learning.

The patient underwent successful bypass surgery and had some degree of left ventricular (LV) systolic functional recovery, but the preoperative severe MR returned soon after the patient completed cardiac rehabilitation (with a return of the non-operating room hypertension). I have learned many physiologic concepts and how they relate to echocardiographic interpretations since that early career snafu. For one, I try never to report MR without including the blood pressure (BP) at the time of the study (a similar working decree is to never report transmitral gradients without including the heart rate). (Note that serial echocardiographic studies must take into consideration the clinical setting and variation in hemodynamic profile when reporting changes in two-dimensional and Doppler-determined leaks and gradients.)

As a young medical student, I was fascinated with the variability of cardiac murmurs and the influence of various physiologic maneuvers and body positioning. With simple instructions to patients, I was able to increase, decrease, lengthen, and shorten the sounds emanating from within their chests. These detectable changes provided me with the necessary information to categorize these sounds as MV prolapse, hypertrophic obstructive cardiomyopathy, or aortic stenosis. Continuing this concept and combining these various maneuvers with two-dimensional echocardiography and Doppler imaging, I was once again fascinated by the changes I could create during echocardiographic acquisition.

One of the simplest techniques that has clinical value is to have the patient perform a Valsalva maneuver during normal-appearing mitral inflow Doppler. During the Valsalva maneuver, a complex series of physiologic changes occur, but in the end, there is a transient reduction in LV preload. Therefore, a moderate grade II (aka pseudonormal) diastolic MV filling pattern will change, and a grade I pattern will be unmasked and readily distinguished. If a patient with heart failure with reduced ejection fraction has a restrictive MV filling pattern, the lack of change with a well-performed Valsalva maneuver signifies a very poor outcome (also known as a fixed restrictive pattern). A Valsalva maneuver during hypertrophic cardiomyopathy assessment for LV outflow tract obstruction is also clinically meaningful, as this will sometimes greatly increase the resting gradient. Having a patient stand quickly from a squatted position will mimic the Valsalva maneuver. (I admit that auscultation is relatively easy during this maneuver, but echocardiography and Doppler imaging are not.)

The opposite of the Valsalva maneuver is passive leg raising, which rapidly returns blood pooled in the legs back to the heart and increases LV filling. Isometric handgrip exercise or transient arterial occlusion (BP cuff inflation) will raise LV afterload and increase the murmur of MR and aortic regurgitation. Although I have not tested this during Doppler echocardiography, I would anticipate a similar effect on echocardiographic findings.

Another fun maneuver is Muller's maneuver, which is also the literal opposite of the Valsalva maneuver: forced inspiration against a closed glottis. Although rarely used in cardiology (some report that it may terminate supraventricular tachycardia), this maneuver is gaining some interest in helping assess patients with suspected obstructive sleep apnea.[1]

Isn't it interesting that we routinely perform echocardiography without much consideration of the clinical status and often report significant findings in the absence of knowing a patient's hemodynamic profile? Out of an abundance of simple curiosity, I performed real-time cardiovascular magnetic resonance imaging on a number of volunteers (otherwise known as fellows) during extreme physiologic maneuvers. I was struck by the structural impact to the interventricular chamber variation and ventricular septal contour configuration. Some of these volunteers could nearly flatten the septum as they moved from one extreme maneuver to the next. (This taught me to obsess on the importance of clarifying if patients' imaging findings occurred with "normal" respiration vs "exaggerated" respiration or "extreme" physiologic maneuvers.)

I know that the sonographers reading this are fully aware of the impact the patient has on inferior vena cava (IVC) variation and,

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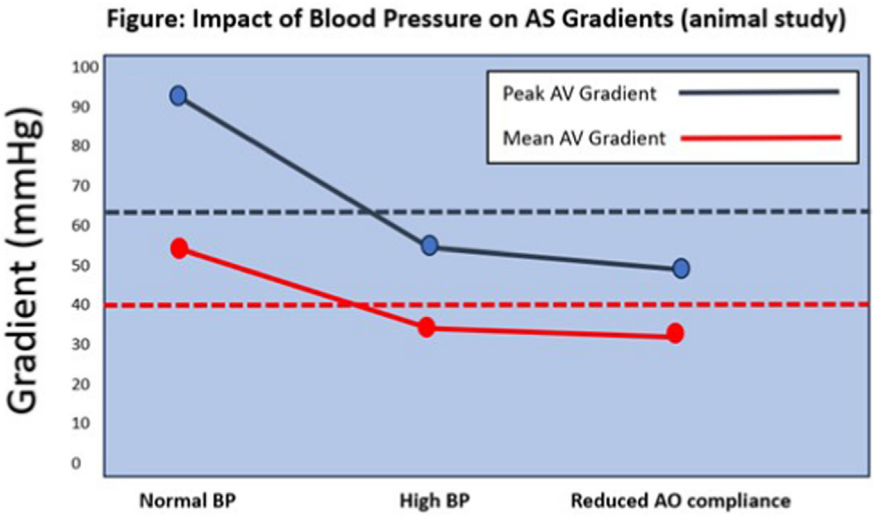

Figure 1 In a controlled large animal study of severe AS, the peak *(solid blue line)* and mean *(solid red line)* aortic valve gradients, measured in a normotensive setting, fall into the nonsevere range *(dotted lines)* in the setting of concomitant hypertension or normal BP with reduced systemic arterial (aortic) compliance. (Modified from Figures 2A and 2B in Coté *et al*,[2] in compliance with CC BY-NC 4.0 license.) *AO*, Aortic; *AV*, aortic valve.

subsequently, on our final interpretation of the estimated right atrial pressure. When asked to "sniff," some patients take pride in their ability and consider it a challenge, and when they do so, the IVC wholly disappears during subcostal imaging. Other patients, not so much. Their "sniff" is not worthy of any rewards, and the IVC appears unchanged during echocardiography. From these two examples, is it really any wonder that IVC variation is not a very accurate marker of the estimated right atrial pressure?

High SBP, which frequently coexists with aortic stenosis, may result in a reduced transvalvular velocity and estimated gradient, leading to an underestimation of the severity of the stenosis. In a controlled animal study of critical and severe aortic stenosis, the mean gradient and maximal velocity were demonstrated to fall into the nonsevere range in the setting of hypertension or reduced aortic compliance with normal BP (Figure 1).[2]

Although the normal LV ejection fraction response during exercise stress echocardiography is to increase by >5% to 10% with normal coronary arteries, this normal increased response may be blunted or attenuated in the setting of a marked hypertensive SBP response and may contribute to a false-positive interpretation. In nearly every published report on stress echocardiography, the list of causes for a false-positive interpretation includes reader bias (basal inferior wall), abnormal septal motion (left bundle branch block or postoperative translation), cardiomyopathies, and a hypertensive BP response to stress.

In this issue of *CASE*, there are many excellent examples of common and uncommon findings on echocardiography to expand your clinical knowledge and increase the value of cardiac ultrasound. Bhuiya *et al*. report on a patient with a relatively classic clinical presentation of vasculitis despite a subsequent unexpected diagnosis of infective endocarditis, reminding us of this important medical masquerade. In another unusual presentation, Maidman *et al*. reported on a young man with scleroderma who developed a fatal, rapidly progressive cardiomyopathy. Hasnie *et al*. collected multimodal images from two patients with ventricular fibromas. Their report follows the patients through surgery, includes pathologic images, and discusses the value of partial resection. In a beautiful example of the potential congenital abnormalities that may be found when evaluating a patient with a murmur, Binder *et al*. include high-quality transthoracic and transesophageal echocardiographic images of a patient with cor triatriatum dexter. It seems as if every issue includes an important report that readers should keep on hand in their echocardiography laboratories. Maidman *et al*. include just such a case series, which provides us an important review of the various cysts that may be seen around the heart during echocardiography. The authors include a table of the imaging characteristics of some of the most common paracardiac cysts to help us differentiate these masses. Goh *et al*. describe a patient with an LV apical aneurysm and walk us through their multimodality imaging approach, which resulted in the diagnosis of an underlying idiopathic etiology. They offer correlative imaging, including electrocardiography, transthoracic echocardiography, nuclear single-photon emission computed tomography, two-dimensional and 3D cardiac computed tomography, and cardiac magnetic resonance, offering a unique glimpse into the varied tissue characteristics and patterns that may be seen. In another recurring theme, nearly every issue includes something I have never seen before, and this issue doesn't let me down. In one of the more unusual locations to detect a cardiac mass, Ibrahim *et al*. report on a patient with a spontaneous coronary sinus thrombosis that you simply must see for yourself.

This editorial serves as a reminder to all *CASE* readers to maintain a healthy respect for the hemodynamic setting at the time of echocardiographic acquisition. Sonographers should record the most recently obtained BP or, preferably, remeasure BP if this was not concurrent. Physicians should annotate the BP directly on the image loop when evaluating MR during transesophageal echocardiography. Reporting

the clinical setting is paramount when comparing serial studies. Watch for a future editorial on the importance of the heart rate.

And remember, every echocardiogram you see today has a teaching point, and every teaching point is a potential new *CASE* report.

REFERENCES

1. Schwartz RN, Payne RJ, Forest VI, Hier MP, Fanous A, Vallée-Gravel C. The relationship between upper airway collapse and the severity of obstructive sleep apnea syndrome: a chart review. J Otolaryngol Head Neck Surg 2015;44:32. https://doi.org/10.1186/s40463-015-0086-2.
2. Côté N, Simard L, Zenses AS, Tastet L, Shen M, Clisson M, et al. Impact of vascular hemodynamics on aortic stenosis evaluation: new insights into the pathophysiology of normal flow-small aortic valve area-low gradient pattern. J Am Heart Assoc 2017;6:e006276. https://doi.org/10.1161/-JAHA.117.006276.

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