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dP/dt and Isovolumic Pressure Decline

I read with great interest the thoughtful article by Paulus et al.¹ I take issue, however, with their use of dP/dt (20/60) as an index of nonexponentiality of isovolumic pressure decline, as suggested by Kumada et al.² For a pure monoexponential pressure decline,³

$$P = P_0 e^{(-t/T)} + P_B$$

$$dP/dt = -1/T [P_0 e^{(-t/T)}]$$

Thus

$$dP/dt (20/60) = e^{(-20/T)} / e^{(-60/T)} \\ = e^{(40/T)}$$

dP/dt (20/60) is greater for smaller values of T. Thus, it is affected by T itself independent of nonexponentiality of pressure decline.

Inspection of the data of Paulus et al bears out this inverse relation between T and dP/dt (20/60). The group mean values of their four measurements of T were 47, 53, 42, and 73 msec. For exponential pressure decline, the corresponding values for dP/dt (20/60) predicted by the last equation above are 2.4, 2.1, 2.6, and 1.7, respectively. The actual values of dP/dt (20/60) reported by the authors are 2.8, 2.8, 2.7, and 1.7. Because the fall in dP/dt (20/60) to 1.7 on nitroprusside after balloon aortic valvuloplasty could be predicted from the associated increase in T to 73 msec itself, the conclusion that it demonstrates nonexponentiality of isovolumic pressure decline is not justified.

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Reply

Inversion of the negative dP/dt upstroke pattern from convex upward to convex downward was first reported by Kumada et al¹ during the initial stages of brief coronary occlusion. Such inversion implies a deviation of isovolumic left ventricular (LV) pressure decline from a monoexponential decay.¹ The same investigators subsequently reported this phenomenon in patients with coronary artery disease and proposed the dP/dt (20/60) ratio as an index for the morphology of the negative dP/dt upstroke pattern.² In their

study, a deviation from a monoexponential decay was accompanied by a lower dP/dt (20/60) ratio.

Dr. Fifer points out nicely that for a monoexponential decay, the dP/dt (20/60) ratio is also affected by a prolongation of T and therefore provides no unique measure of the morphology of the negative dP/dt upstroke pattern. Assessment of the morphology of the negative dP/dt upstroke pattern should consist of a comparison between the measured value of the dP/dt (20/60) ratio and the value predicted by the corresponding T assuming a monoexponential pressure decline ($=e^{(40/T)}$). When the measured value is significantly different from the predicted one, the conclusion of deviation from a monoexponential pressure decline seems justified.

After sequential balloon aortic valvuloplasty with arterial vasodilation,³ a significant prolongation of T was observed for the entire study group, but a bimodal negative dP/dt waveform and a convex downward negative dP/dt upstroke pattern was observed in only 10 of the 14 patients. As shown by Dr. Fifer, the mean dP/dt (20/60) ratio for the entire study group was equal to the predicted one (1.7), but 11 of the 14 individual dP/dt (20/60) ratios were lower than their predicted counterparts. For these patients, in whom a convex downward negative dP/dt upstroke pattern was observed after sequential balloon aortic valvuloplasty-arterial vasodilation, the mean measured dP/dt (20/60) ratio (1.5 ± 0.4) was significantly lower than the mean predicted dP/dt (20/60) ratio (1.7 ± 0.2 ; $p < 0.05$). Hence, comparison of measured dP/dt (20/60) ratio to predicted dP/dt (20/60) ratio failed to show a significant deviation from monoexponential LV pressure decay for the entire study group but revealed a significant change in the patient subgroup, in whom an actual inversion of the negative dP/dt upstroke pattern had occurred after sequential balloon aortic valvuloplasty-arterial vasodilation.

We agree with Dr. Fifer that the dP/dt (20/60) ratio is affected not only by the morphology of the negative dP/dt upstroke pattern but also by T itself. This dependence on T should be accounted for in future studies by comparing actually measured dP/dt (20/60) ratios to dP/dt (20/60) ratios predicted from corresponding T values and the $e^{(40/T)}$ formula. Moreover, deviation from a monoexponential LV pressure decay should be deduced not only from a dP/dt (20/60) ratio but also from a phase-plane plot⁴ of LV pressure decay (dP/dt versus P plot; Figure 4 in Reference 3). Such phase-plane plots offer the advantage of comparing isovolumic relaxation rates at similar isovolumic relaxation pressures irrespective of the presence or absence of a monoexponential LV pressure decay.

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