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## Editorial

# Ultrasound and coarctation of the aorta

Initial reports of cross sectional echocardiography in the diagnosis of coarctation of the aorta were very promising,[1 2] with the technique allowing operation to be carried out without invasive investigation in many patients.[3] As experience grew, however, it became clear that high quality images of the aortic arch are not universally obtainable, that cross sectional echocardiography does not always provide an answer, and that occasionally it may even lead to false positive diagnosis of an aortic arch obstruction.[4] Doppler ultrasound was welcomed as a solution. Published studies were reassuring; calculation of the pressure drop across the site of coarctation by the modified Bernoulli equation was reported to reflect accurately both the blood pressure difference between the upper and lower limbs[5 6] and the invasively measured pressure gradient,[7–9] but again experience proved this approach to be too simplistic. Just as for other cardiovascular stenoses, gradients estimated by Doppler represent maximum instantaneous values rather than the traditionally used difference between peak systolic pressures on both sides of an obstruction. The differences between these two measurements may be considerable and clinically important.[10]

Disappointingly, even when these differences are taken into account, in some patients there is poor agreement between the coarctation gradients measured invasively and by Doppler.[11 12] Various factors are responsible for this. It can be difficult to align the Doppler beam with flow, complex flow dynamics in the aortic arch may invalidate some of the assumptions made in the calculation of pressure drop, and a tunnel like stenosis when present is a less suitable subject for Doppler calculations than a discrete obstruction.[13] Furthermore, it is now clear that severe obstruction of the aortic arch may be associated with normal or near normal aortic flow velocities depending on the state of the ductus arteriosus[12 14] or the presence of extensive collaterals.[15]

Use of the pressure gradient as an indicator of severity of valve stenosis has long been recognised as being fraught with problems, largely related to the dependence of gradient on blood flow. Similar confusion about the value of the pressure gradient in coarctation is understandable because this too is dependent on factors other than the degree of obstruction. Stroke volume, the presence of a ductus arteriosus, and the extent of the collateral supply to the descending aorta are all important factors. Thus many of the difficulties associated with the assessment of the severity of valve stenosis[16] are common to the assessment of coarctation and could be avoided, at least in theory, if the effective orifice area at the site of the coarctation could be estimated.

The concept of pressure decay (a square function of velocity decay) across an obstruction to flow as an indicator of effective orifice area has long been applied to fluid dynamics and was first applied in invasive cardiology to mitral stenosis,[17] later being adapted for use with Doppler ultrasound.[18] Disappointingly, like most single variables in heart disease, pressure decay across the mitral valve is affected by factors other than stenosis—such as ventricular compliance and aortic regurgitation.

Dr Carvalho and her colleagues (p 133) confirmed that the Doppler pressure drop alone cannot always be relied upon to predict the severity of coarctation of the aorta. They propose an additional measurement of diastolic flow velocity decay—the time to half peak diastolic velocity. This is defined as the time taken for flow velocity to fall from its peak value in diastole (measured at the end of the T wave of the electrocardiogram) to half this value. Prolonged flow deceleration in coarctation has long been recognised as diagnostically important[6 19–21] but little effort has been made to introduce a simple quantitative measurement of it, such as the time to half peak diastolic velocity. The combination of this measurement with peak systolic velocity considerably improved both the test sensitivity and the predictive value of a negative test compared with either measurement used alone in the patients studied.

There seems little doubt that pressure (or velocity) decay across the aortic arch in coarctation will also be affected by factors such as vascular resistance, the competence of the aortic valve, the presence of a ductus arteriosus, and the extent of collateral blood supply to the descending aorta. In the absence of these complicating factors, the combination of measurements of peak flow velocity and flow velocity decay is clearly useful. However, when complicating factors are present uncertainty will still arise, and then the best reference standard is still probably angiographic measurement of the aortic lumen as used by Carvalho *et al*. Even angiography may be difficult to interpret, however, because it is dependent on arbitrarily defined criteria of severity mainly relating to anatomical features. The importance of careful consideration of physiology as well as anatomy was emphasised by studies during exercise after operation for coarctation. Some alarming physiological changes may be seen with exercise even when there are no striking signs of residual or recurrent coarctation at rest.[22–25]

Non-invasive assessment of the severity of coarctation may be enhanced by measurement of velocity decay as well as peak flow velocity, but even the combination of these two measurements will not provide an answer in every patient. Further improvement in diagnosis is clearly desirable and it is hoped will prove possible with continued attempts to develop a combined anatomical and physiological approach that should involve exercising the patient.

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