Three-dimensional echocardiography and left bundle branch block: prime time in cardiology

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Three-dimensional echocardiography – a promise made, a promise kept

Shortly after the introduction of ultrasound to image the heart, echocardiography became the most important noninvasive diagnostic tool in cardiology. The development from M-mode to two-dimensional imaging was fast and its implementation as the most frequently used technique in daily cardiology practice was made possible by Dutch pioneers in the field such as Klaas Bom, Jos Roelandt and Cees Visser. Also, more than 30 years of structured postgraduate education in echocardiography has already been provided in the Netherlands.

However, although a promise for decades, three-dimensional (3D) echocardiography could not enter daily clinical care until recently because of complex acquisition and lengthy data analysis.¹ This is one of the reasons that, in the meantime, 3D imaging with other modalities could evolve, such as magnetic resonance and computer tomographic imaging, and made the cardiologist aware of the great benefits of the additional dimension. Especially the combination of 3D anatomical and functional imaging with MRI in combination with late gadolinium-enhanced imaging is expanding its role in diagnosis and prognosis in cardiovascular diseases.² Finally with real time 3D and advanced post-processing tools, echocardiography is back in the arena. The main advantages of echo are the widespread bedside availability, relatively low cost compared with MRI, no radiation burden compared with multislice CT and it is also usable in patients with ICD and pacemakers.³

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Left bundle branch block unraveled

Left bundle branch block (LBBB) is a rather common conduction disturbance, however seen with dismay by many cardiologists because of diagnostic difficulties in ischaemic syndromes, electrocardiographic exercise testing, in scintigraphic studies and so on. Recently van Dijk and colleagues reviewed the new insights on LBBB gained with novel imaging modalities in this journal.⁴ Besides new diagnostic and (patho)physiological insights, the turning point was the possibility to restore this altered electrical activation with potential benefits for our patients. We would like to highlight some important aspects of LBBB in this respect.

Many epidemiological studies have shown that LBBB is a harbinger of underlying heart disease and in itself portends an increased risk of cardiovascular disease.⁴ It has a particularly strong association with heart failure in which its prevalence increases up to 25%.⁴ Epicardial pacing of the left ventricle, in particular by pacing the right ventricular (RV) apex, is another common source of abnormal ventricular activation in clinical practice. It shares with LBBB most of its electrical and mechanical consequences and its negative impact on ventricular function, morbidity and mortality has now been firmly established.⁵

Indeed, the abnormal sequence of ventricular electrical activation induced by LBBB and RV pacing has been shown to impair ventricular function even in the otherwise normal heart and to instigate or aggravate a number of (mal)adaptive processes typically associated with ventricular failure.⁶ The central pathophysiological mechanism by which abnormal electrical activation impairs mechanical performance and by which it may initiate or accelerate remodelling can be summarised as dyscoordination of contraction. This dyscoordination encompasses regional differences in timing, duration and amplitudes of contraction.⁶ When the differences are large enough, part of the contractile energy of early contracting segments will be dissipated into abnormal stretching of remote areas during early systole and vice versa at end systole, representing a net decrease in contractile efficiency.^{6,7} The decreased global LV pump function will activate neurohormonal

response mechanisms in an attempt to maintain normal cardiac output, favouring ventricular dilatation and remodelling. The abnormal distribution of contraction also results in regional differences in wall stress and stretch, primary determinants of energy consumption and important stimuli for a number of molecular, electrical and structural responses.^{6,8,9}

An integrated approach to imaging of contractile asynchrony

Patricia Bakker and colleagues from Utrecht, the Netherlands were the first to apply biventricular pacing in the failing human heart with LBBB.¹⁰ Since then, what has become known as cardiac resynchronisation therapy (CRT) has been shown to be an effective and lifesaving therapy in a subset of patients with end-stage heart failure and LBBB.¹¹ Prognostic outcome in CRT is best predicted by a decrease in LV end-systolic volume, which in turn is best predicted by mechanical asynchrony.¹² The recognition of the crucial role of mechanical rather than electrical asynchrony has been the impetus to expand the research on CRT to its application in earlier stages of heart failure (preventive therapy) and in a number of cardiac conditions in which asynchronous contractions are common denominators of ventricular dysfunction, for example systolic heart failure with a narrow QRS and diastolic heart failure. Simultaneously, this insight has intensified the quest for better noninvasive imaging modalities and indices of contractile asynchrony. While the jury is still out on whether global or regional parameters of asynchrony are most desirable, it follows from the pathophysiological principles that an imaging modality that yields information on mechanical asynchrony, both in terms of spatial and temporal contraction differences as well as on their global impact, is likely preferable.¹³

Real time 3D echocardiography is, therefore, a promising new tool in the management and follow-up of the patient with heart failure and potential asynchrony. By expressing regional and global volume changes, it represents an intuitively attractive way of expressing the asynchrony of the heart as a pump.¹⁴ More data are awaited to determine the value of 3D-derived asynchrony parameters but meanwhile, the data presented by Brunekreeft and coworkers in this issue of the Netherlands Heart Journal again confirm the impact of asynchronous contractions on left

ventricular function.¹ More importantly, they highlight that with the current software, real-time 3D echocardiographic assessment of left ventricular volumes and function has evolved towards a robust, time efficient and overall feasible technique, also in the nonacademic practice.¹ ■

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