

SCIENTIFIC LETTER

Increased interbreath variability of gas exchange during exercise in children with cardiomyopathy

Tony Reybrouck, Steven Vangesselen, Luc Mertens, Marc Gewillig

Heart 2007;93:377–378. doi: 10.1136/hrt.2006.094508

During exercise testing in patients with chronic heart failure and severely depressed left ventricular function, an increased variability of gas exchange with a phenomenon of periodic breathing with an oscillatory pattern in oxygen uptake (VO_2) has been recognised.¹ Previous studies were performed in adult patients with chronic heart failure related to ischaemic heart disease. The aim of the present study was to analyse whether an increased interbreath variability for gas exchange with an oscillatory pattern could also be identified during exercise in children with cardiomyopathy. Moreover, we also analysed whether this new parameter correlates with cardiac function.

PATIENTS AND METHODS

In all, 49 patients were used for this analysis. Twenty patients were studied with dilated cardiomyopathy (DCMP; mean (SD) age 11.7 (3.7) years). At a regular outpatient visit the patients were clinically investigated, and underwent an echocardiographic and electrocardiographic examination. Myocardial function was assessed by determination of the fractional shortening on the echocardiogram. The patients were compared with 29 age-matched normal controls (NI) (10.7 (2.8) years).

Maximal exercise test was performed on a treadmill. Speed was set at 5.6 km/h, and the inclination was increased by 2% every minute until exhaustion. Gas exchange was measured breath-by-breath. During exercise, the interbreath variability for VO_2 was calculated as the mean value of all absolute differences between the VO_2 of all single breaths during 1 min, and the mean of all these breaths and was expressed as a percentage of the mean value for VO_2 during that minute.²

Exercise capacity was assessed by determination of the maximal VO_2 or symptom-limited VO_2 and was expressed as a percentage of the NI mean value.²

RESULTS

The left ventricular end diastolic diameter averaged 55.3 (9.3) mm in DCMP versus 41 (4.1) mm in NI ($p < 0.001$). The fractional shortening averaged 22.5 (7.4%) in DCMP versus 37.3 (4.2%) in NI ($p < 0.001$).

For submaximal exercise at 2% inclination, the variability for VO_2 amounted to 9.6 (5.4) for DCMP versus 7.1 (2.3%) for NI ($p = 0.006$) and at 4% inclination 8.6 (3.9) for DCMP versus 6.2 (2) for NI ($p = 0.006$).

In patients with DCMP an increased variability of VO_2 was found for four levels of exercise in half of the group, which exceeded the 95% confidence limit (CL) of NI (variability $> 8\%$). In these patients an oscillatory pattern in VO_2 could also be observed. For the total group (patients with DCMP and NI), at 2% inclination on the treadmill, significant negative correlations were found between the magnitude of the variability for the VO_2 and the VO_2 max ($r = -0.47$, $p = 0.05$) and the

fractional shortening ($r = -0.48$; $p = 0.05$) as an estimate of myocardial function.

Maximal oxygen uptake in DCMP averaged 79.8 (17.3%) of NI ($p < 0.005$, patients *v* NI).

DISCUSSION

This study shows a high-interbreath variability of VO_2 during graded exercise testing in patients with DCMP with a significantly increased variability of VO_2 in half of the patients. This increased variability with an oscillatory pattern for VO_2 correlates with a poor left ventricular function. In the present study, the prevalence of increased interbreath variability with an oscillatory pattern is higher than values reported in literature (10–20%).^{3,4} This may be explained by differences in methods such as duration of oscillations^{3,5} or comparing different time windows.⁴ In the present study, we defined an increased breath-by-breath variability as exceeding 8% (upper limit of 95% CL). In subjects with normal left ventricular function no oscillatory pattern of VO_2 was observed. A similar observation has been made in adult patients with DCMP and systolic dysfunction.¹ The underlying mechanism for an oscillatory pattern of VO_2 remains to be determined. Previous studies have shown that increased interbreath variability for VO_2 during exercise correlates with poor left ventricular function.⁵ Similarly, in the present study an increased interbreath variability of VO_2 was observed in the subjects with the lowest values for fractional shortening. Oscillatory changes of VO_2 during exercise correlate with an oscillatory pattern of pulmonary blood flow. In patients with reduced left ventricular function, Yajima³ showed during simultaneous breath-by-breath gas exchange measurements and beat-to-beat radionuclide recordings of ejection fraction oscillatory fluctuation for both parameters.

Increased interbreath variability with oscillatory changes of VO_2 may significantly influence the determination of the maximal value for VO_2 . With modern gas analysis equipment data are often reported with a time window of 10–15 s. Therefore, if a patient has an increased interbreath variability of VO_2 with a periodic oscillatory breathing, the peak of this value may exceed the true VO_2 max. The overestimation will depend upon the size of the oscillation and can amount up to 5 ml O_2 /min/kg or up to 35% of the average VO_2 .⁴ This can be equal to the effect of some interventions—for example, physical training, pharmacological treatment; such difference can therefore be important for managing patients during a work up for heart transplantation. To obviate these problems, a time interval of 60 s or minimally 30 s should be recommended.

Abbreviation: DCMP, dilated cardiomyopathy

Authors' affiliations

Tony Reybrouck, Department of Cardiac Rehabilitation, University Hospital Gasthuisberg, Leuven, Belgium

Steven Vangesselen, Department of Rehabilitation Sciences, University of Leuven (K U Leuven), Leuven, Belgium

Luc Mertens, Marc Gewillig, Department of Paediatric Cardiology, University Hospital Gasthuisberg, Leuven, Belgium

Competing interests: None declared.

Correspondence to: Professor T Reybrouck, Department of Cardiovascular Rehabilitation, University Hospital Gasthuisberg, Herestraat, 3000 Leuven, Belgium; tony.reybrouck@uz.kuleuven.ac.be

Accepted 29 August 2006

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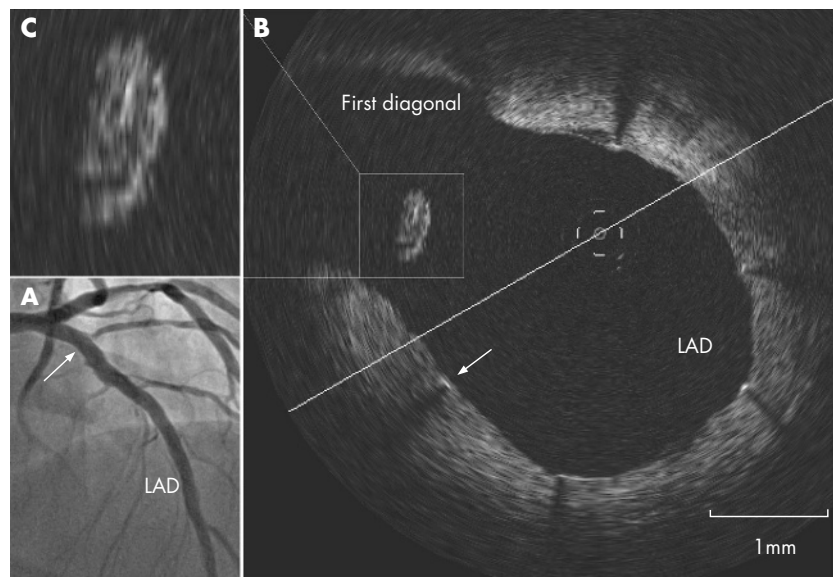
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IMAGES IN CARDIOLOGY

doi: 10.1136/hrt.2006.091876

Do unapposed stent struts endothelialise? In vivo demonstration with optical coherence tomography

Although drug-eluting stents have dramatically reduced restenosis rates after percutaneous coronary intervention, concerns remain with regard to the potential risk of stent thrombosis. For bifurcation lesions, a stent thrombosis rate up to 3.6% has been reported, and incomplete stent apposition has been proposed as a possible mechanism. We report the case of a 52-year-old man with diabetes and three-vessel disease. Initially, three overlapping sirolimus-eluting stents (Cypher, Cordis) were deployed to the left anterior descending artery. No further kissing post-dilatation was performed because of TIMI-3 flow in the diagonal branches. Angiography at 4 months of follow-up showed widely patent stents with TIMI-3 flow to both diagonals (panel A). Optical coherence tomography (LightLab Imaging Inc, Westford, Massachusetts, USA) at the bifurcation of the left anterior descending artery to the first diagonal (arrow) showed good stent apposition, with minimal (<0.07 mm) intimal layer (panel B, arrow) on almost all struts. One strut was protruding into the lumen at the origin of the diagonal branch circumferentially covered by a thick tissue layer (0.25 mm, panel C) extending to its connection with the vessel wall proximally and distally. On the basis of tissue density and uniform growth on the free strut with minimal growth on other apposed struts, the case strongly suggests that this tissue consists of thrombus, likely fully organised and endothelialised. These findings lead to two thoughts on stent thrombosis in the presence



of malapposed drug-eluting stents. Firstly, unapposed struts can nestle thrombus triggering stent occlusion and secondly, the process can be self-limiting, eventually allowing growth of tissue on the stent strut and possibly promoting its complete endothelialisation.

J Tanigawa
P Barlis
C Di Mario
c.dimario@rbht.nhs.uk

JT is a recipient of a research grant from Goodman-LightLab imaging, Japan.