Criterios pediátricos

The role of exercise testing in pediatric cardiology: indications and results

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Indications for exercise testing in pediatric cardiology differ considerably from indications in adult cardiology. In adult cardiology exercise testing is employed almost exclusively to detect ischemia. In pediatric cardiology the indications are more broad. Exercise testing is used to evaluate the effect of known diseases and the results of treatment of such diseases upon the cardiovascular and cardiorespiratory systems under the challenge of exercise, and also to confirm or rule out suspected but as yet unproven pathological conditions such as arrhythmias.

In 1997 the American College of Cardiology and the American Heart Association, the two bodies in the U.S. involved in the development of cardiovascular standards, established a task force to formulate guidelines for exercise testing in children [1]. Their recommendations are as follows:

CLASS I (Indicates conditions for which there is evidence or general agreement that the diagnostic procedure is useful and effective):

1. Evaluation of exercise capacity in children or adolescents with congenital heart disease, those who have had surgery for congenital heart disease, and children who have acquired valvular or myocardial disease.
2. Evaluation of the rare child with a description of anginal chest pain.
3. Assessment of the response of an artificial pacing system to exertion.
4. Evaluation of exercise-related symptoms in young athletes.

CLASS II (Indicates conditions for which there is conflicting evidence or divergence of opinion about the usefulness or efficacy of the diagnostic procedure. In Class IIA the weight of evidence or opinion is in favor of usefulness; in Class IIB the usefulness is less well established):

Class IIa

1. Evaluation of the adequacy of the response to medical, surgical, or radiofrequency ablation treatment for children with a tachyarrhythmia that was found during exercise testing before therapy.
2. As an adjunct in assessment of the severity of congenital or acquired valvular lesions, especially aortic valve stenosis.
3. Evaluation of the rhythm during exercise in patients with known or suspected exercise-induced arrhythmia.

Class IIb:

1. As a component of the evaluation of children or adolescents who have a family history of unexplained sudden death related to exercise in young persons.
2. Follow-up of cardiac abnormalities with possible late coronary involvement such as Kawasaki disease and systemic lupus erythematosus.
3. Assessment of ventricular rate response and development of ventricular arrhythmia in children and adolescents with congenital complete atrioventricular block.
4. Quantitation of the heart-rate response to exercise in children and adolescents treated with β-blockade.
5. Measurement of response of shortening or polongation of the corrected QT interval to exercise as an adjunct in the diagnosis of hereditary syndromes of prolongation of the QT interval.
6. Evaluation of blood pressure response and/or arm-to-leg gradient after repair of coarctation of the aorta.
7. Assessment of degree of desaturation with exercise in patients with relatively well-balanced or palliated cyanotic congenital cardiac defects.

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CLASS III (Indicates conditions for which there is evidence or general agreement that the diagnostic procedure is not useful and effective, and in some cases it may be harmful):

1. Screening before athletic participations by healthy children and adolescents.
2. Routine use of exercise testing for evaluating the usual nonanginal chest pain common in children and adolescents.
3. Evaluation of premature atrial and ventricular contractions in otherwise healthy children and adolescents.

This discussion will be restricted to the use of exercise testing for the evalution of the post-cardiac surgery child.

Maximal oxygen consumption (VO_2 max) is commonly used as an index of maximal effort, on the basis of the positive, direct relationship between work (exercise) performed and oxygen consumed.

The formula for VO_2 max is:

$$VO_2max = SV\ max \times HR\ max \times (CaO_2 - CVO_2)\ max.$$

(VO_2 max = maximal oxygen consumption; SV max = maximal stroke volume; HR max = maximal heart rate; $CaO_2 - CvO_2$ max = maximal arterial oxygen content-maximal venous oxygen content)

It can be easily visualized how various conditions can affect VO_2 max acting upon one or more of its components. Thus, SV max can be affected by stenotic and shunt lesions, cardiomyopathies, detraining, dehydration; HR max by iatrogenic or natural causes such as beta blockers and complete or high-degree heart block; CaO_2 max by anemia, hemoglobinopathies, right-to-left shunts, pulmonary diseases, kyphoscoliosis, morbid obesity; CVO_2 max by muscle dystrophy and atrophy, 2-3 DPG deficiency, cachexia.

Another index utilized to evaluate exercise capacity is the ventilatory anaerobic threshold, which measures submaximal effort. However, in pediatric exercise a true VO_2 max or ventilatory anaerobic threshold may not be obtainable. Thus, for clinical evaluation "Endurance Time" – the length of time an individual is capable to tolerate the effort of exercise – is generally substituted for the other indices to measure exercise capacity.

Cumming et al [2] using the Bruce protocol found a high correlation between maximal VO_2 and endurance time, and significant negative correlations between heart rates for stage 2 and 3 of the Bruce test and endurance times. However, if endurance time is used to measure the exercise capacity of a child, this individual needs to be evaluated using normal standards from a comparable population. Ideally each exercise laboratory should obtain its own normal standard pool for age and sex [3].

Exercise is the least used among the tests in the current cardiological diagnostic armamentarium, on the premise that a child under the watchful eye of its parents and school personnel can be accurately categorized concerning its tolerance for effort without the need of a formal test. Studies conducted by Rogers et al [4] in Belgium and by Musewe et al [5] in Canada in asymptomatic children after successful repair of tetralogy of Fallot and transposition of the great arteries should put this notion to rest for good.

In the investigation conducted by Rogers et al [4] parental evaluation of their child's activity level resulted in 41 of 69 children being misclassified as performing at above average or average levels. In fact when tested their performance resulted to be below normal range. This study clearly indicates how inadequate are subjective estimates of exercise capacity.

Musewe et al [5] measured the exercise capacity of 17 asymptomatic children 10 years after atrial repair of transposition of the great arteries. While at 50% of maximum workload they performed within normal range, at maximal exercise their endurance time, maximal work capacity, heart rate, and VO_2 max were significantly lower than those of matched controls ($p < 0.001$ - < 0.01). Similar results were obtained by other investigators in children operated for correction of tetralogy of Fallot [6] and closure of secundum atrial septal defects [7]. The message of these studies is that normal daily activities require submaximal energy expenditure; accordingly, children after successful cardiac surgery remain asymptomatic. Thus exercise testing is particularly useful for the child who wants to engage in competitive sports. Postoperative patients with Fontan type of repair have a more severe reduction of their exercise capacity [8]. However, recent studies indicate that younger age at surgery may improve effort tolerance [9].

In related investigations exercise capacity was noted to be influenced by age at surgery in patients after total correction of tetralogy of Fallot [10] and in patients with cardiac transplant [11]. However, the latter investigation was conducted in a small number of children and requires confirmation.

In contrast to these reassuring data, Mocellin & Gildein [12] cast some doubts on the ability of post-cardiac surgery children to cope with the activities they engage in with their peers. These investigators compared VO_2 max, oxygen uptake adjustment at onset of high-intensity exercise and maximal blood lactates of 35 children after correction of various cardiac lesions with those of 10 healthy prepubertal boys. All three indices were abnormal in the postoperative children. The authors conclude that these children are less fit not only for endurance performance but also for short-lasting, high-intensity exercise. The authors' recommendation is that these children would benefit from the economy of motion in order to lower the metabolic cost. Unfortunately, in the US at present there are no organized programs for postoperative rehabilitation in pediatric cardiology. However, the recently introduced microsurgical techniques and catheter interventions, together with the deployment of neonatal and fetal correction of many congenital cardiac defects should be a harbinger of a new era where the myocardial damage produced by the altered hemodynamics and the stress of cardio-pulmonary bypass is reduced to a minimum. When these children will come to age for exercise testing their exercise capacity will be hopefully normal.

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