Correlation between passive leg raising manoeuvre and fluid challenge in paediatric cardiac surgery patients by the use of impedance cardiography

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Fluid challenge in adults as well as paediatric population is a classical tool used to assess the volume status and is traditionally monitored using clinical variables such as heart rate, blood pressure and central venous pressure (when available). It has the advantage of rapidly improving the volume status of the patient but at the same time carries the risk for volume overload, especially in patients with cardiac decompensation. Use of a passive leg raising test as an alternative to fluid bolus has the advantage of simplicity, ease of performance and reversibility, especially when being performed in low body weight paediatric patients.

Predicting fluid responsiveness can be challenging, particularly in children. Even though it is often customary to include the basic haemodynamic variables to monitor a fluid challenge, the concomitant measurements in cardiac index changes after the passive leg raising manoeuvre in paediatric population can be helpful in predicting who might have an increase in cardiac index with subsequent fluid resuscitation [1].

To emphasize the variability of various techniques in predicting fluid responsiveness in critically ill children, a recent study compared oesophageal Doppler system, a pulse contour analysis algorithm system and respiratory variations in inferior vena cava diameter. Stroke volume index was measured by means of transthoracic echocardiography before and after fluid challenge to determine fluid responders. Predictability of fluid responsiveness was only found in Doppler peak velocity of blood flow in the descending aorta [2].

Numerous hemodynamic variables have been proposed as predictors of fluid responsiveness in paediatric population. A meta-analysis of 12 studies involving 501 fluid boluses in 438 paediatric patients (age range=1 day to 17.8 years) suggested that static variables based on heart rate, systolic arterial blood pressure, preload (central venous pressure and pulmonary artery occlusion pressure), thermodilution (global end diastolic volume index), ultrasound dilution (active circulating volume, central blood volume, total end diastolic volume, and total ejection fraction), echocardiography (left ventricular end diastolic area) and Doppler (stroke volume index and corrected flow time) did not predict fluid responsiveness in children. Respiratory variation in aortic blood flow peak velocity was the only variable shown to predict fluid responsiveness [3].

Coming to the method of cardiac output (CO) assessment in the current study, analysis of the literature suggests that the use of electrical impedance in paediatric population has evolved over the years. Even though the basic principle of applying a high-frequency, low-amplitude current to the thorax is similar, the newer version, referred to as electrical cardiometry (EC), is often confused with the traditional bioimpedance technology most commonly known as impedance cardiography.

Impedance cardiography methods rely on the assumption of periodical volumetric changes in the aorta to determine stroke volume and CO. In contrast, EC contributes the increase in conductivity to the change in the orientation of the red blood cells to determine the velocity of the blood flow and it derives the mean aortic blood velocity using a transformation [4].

Even though EC has been validated against the gold standard of the direct Fick method for measuring CO noninvasively in paediatric patients with congenital heart disease [5], a recent study comparing it with oesophageal Doppler suggests that it may not be clinically as effective as it is thought to be [6].

Use of EC for the assessment of CO in response to passive leg raising manoeuvre in the subset of paediatric cardiac surgical patients has been less frequently reported in the literature. There are studies that have reported its use in a similar group of patients.

A study comparing EC and transthoracic echo-Doppler in 24 neonates after arterial switch operation confirmed that EC was not inferior to transthoracic echo in postsurgery CO measurements [7].

Another study has demonstrated the equivalence of echocardiography and EC in paediatric population without congenital heart disease and a bit of underestimation in ventricular septal defect patients at induction of anaesthesia [8].

Further support to the use of EC comes from a recent publication [9] comparing impedance cardiography (electrical velocimetry) and transthoracic echocardiography for noninvasive CO monitoring in critically ill paediatric intensive care patients.

In my opinion, the current study provides a novel and simple technique for estimating fluid responsiveness in the subset of cardiac critical care patients, which is safe and reversible; however, patients who are actively bleeding, have circulatory overload, or have intrinsic myocardial dysfunction will have to be cautiously excluded. Even though there are studies that do not support the routine use of EC in the estimation of CO in paediatric patients, current evidence supports further use and assessment of this technique.

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Conflict of interest
There are no conflicts of interest.

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