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Appraisal

Clinimetrics: Indirect calorimetry

Summary

Description: Indirect calorimetry is a technology that measures energy expenditure by quantifying oxygen consumption (VO_2) and carbon dioxide production (VCO_2). It is considered to be the gold standard device for measuring resting energy expenditure in the clinical setting.[1] There are several indirect calorimetry systems, with the most well-known being the total collection system (eg, Douglas bag) and the modern open circuit system, which are currently used (eg, Deltatrac II, Quark RMR).[1,2] Open circuit systems range from desktop devices with facemasks or mouthpieces/nose clips in spontaneously breathing patients to arrangements that include a canopy or ventilated hood.[3,4] The reliability and validity vary between indirect calorimetry systems and configurations. All of this needs to be carefully considered along with the purpose of use prior to purchasing devices, as costs vary between AUD10 000 to 60 000 per unit.

Psychometric properties between systems and configurations: The Douglas bag total collection system is considered to be the most accurate and reference standard for the measurement of gas exchange, but is seldomly used due to limitations in the size of the collection bag, expensive analyser equipment and need for technical expertise.[1,2] There are several modern open circuit devices that have inbuilt mixing chambers and gas analysers available in Australia. The Deltatrac II, which is no longer produced, was considered to be the most accurate open circuit system due to its precision with the Douglas bag.[2] Validation studies between currently available open circuit systems and reference methods should be considered prior to purchasing or using devices.

The range of available open circuit system configurations ensures that indirect calorimetry measurements can be completed in spontaneously breathing or ventilated patients[1] across the healthcare continuum (acute, subacute and rehabilitation settings). Canopy and ventilated hood configurations provide the most accurate measure of energy expenditure, as they are less likely to interfere with breathing patterns and gas measurement readings, and should be considered for clinical and research purposes.[3] Facemask or mouthpiece/nose clip configurations provide useful information on physical activity-related changes in energy expenditure, but unfamiliarity and constriction can interfere with the stability of gas exchange measurement.[3,4]

Psychometric properties when completing measurements: Specialised training is required for the accurate use and interpretation of indirect calorimetry measurements. Several elements can be assessed to confirm test reliability. The respiratory quotient, a ratio of VCO_2 produced to VO_2 consumed, provides an indication of unreliable tests when readings are outside the normal physiological range of 0.67 to 1.3.[1,5] The stability of measurements can also be assessed by determining if a test reaches a 'steady state', commonly defined as a variation in VO_2 and VCO_2 of $< 10\%$ for five consecutive minutes.[5,6] A steady state period is considered to reflect total daily energy expenditure and has been shown to provide reliable measurements of total daily energy expenditure.[5,6] For measurements that do not reach a steady state, a 30-minute or longer indirect calorimetry measurement is generally considered a valid and reliable measure of energy expenditure in most populations.[6] Therefore, test duration varies and is heavily influenced by test stability.

Commentary

Indirect calorimetry is currently underutilised in clinical and research settings and is not widely recommended for use outside of the intensive care unit. This is due to many factors, including cost, lack of expertise, technical limitations in certain populations (eg, patients with high ventilatory needs), requirement for specialised training, need for completion under stringent conditions and lack of definitive evidence on the benefit of use.[1,2,5] Predictive equations, which estimate energy expenditure using a mathematical equation and are quick and easy to apply at the bedside, remain the most common method used in standard care.[7] Nonetheless, accuracy issues surrounding the use of predictive equations are well documented, with the use of these equations resulting in clinically significant underestimation and overestimation of energy expenditure in several populations.[7–9]

Despite the limitations raised, with appropriate training and knowledge of the appropriate application, indirect calorimetry provides a reliable measure of energy expenditure.[1] This tool has the potential to be used more in both clinical and research settings to enhance understanding of resting energy expenditure and inform nutrition delivery.[1] Indirect calorimetry can also be used to provide information on active energy expenditure, including the impact of increased physiotherapy on metabolism. Although it is acknowledged that increases in physical activity increase energy expenditure, clinicians often do not adjust for this in practice.[10] The use of indirect calorimetry to guide nutrition therapy, coupled with repeat physiotherapy, presents a unique research opportunity to determine if this combination may assist in preserving muscle mass during hospitalisation and the associated impact on functional recovery.

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