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MINI-SYMPOSIUM: LUNG FUNCTION IN PRESCHOOL CHILDREN

The measurement of airways resistance using the interrupter technique (Rint)

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interrupter technique;
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Summary The interrupter technique (Rint) is a quick, easy and effort-independent way to obtain indirect measurements of airways resistance in the preschool child. Results may be obtained using a portable Rint machine or a whole-body plethysmograph. Normative data are available and recent studies have improved standardisation of the methodology. Despite this, between-occasion results can be variable, particularly in children with wheeze. This limits the usefulness of the test in the assessment of long-term interventions such as the administration of inhaled steroids. The most useful role for Rint, therefore, appears to be in the assessment of bronchodilator responsiveness where it is as sensitive as spirometry in separating children with reversible airways disease from healthy controls. This paper describes the physiology of the interrupter technique and the methodology needed to obtain reliable results. Normal ranges are provided. The clinical applicability, repeatability, strengths and limitations of the technique are also discussed.
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BACKGROUND

Although the measurement of airways resistance using the interrupter technique (Rint) was first described by Von Neergaard in 1927,[1] it is only in the last 10 years that portable, affordable equipment has facilitated its wider use as a research and clinical tool. As Rint is effort-independent, non-invasive and requires minimal subject co-operation, it is ideally placed for use in preschool children where traditional measurements of lung function may be unreliable or unachievable. Unfortunately, despite an increasing body of literature on its measurement and standardisation, the role of Rint in the clinical setting remains limited.

WHAT DOES RINT MEASURE?

Direct measurements of airways resistance (Raw) are traditionally obtained using whole-body plethysmography. Here, changes in alveolar pressure, caused by breathing, are recorded as pressure changes within the sealed plethysmograph (P_{alv}) and Raw is calculated from the ratio between the change in P_{alv} and the airflow at the mouth. In contrast, rather than measuring alveolar pressure itself, the interrupter technique is based on the assumption that during transient occlusion of the airway at the mouth, alveolar pressure will equilibrate rapidly with mouth pressure. Airways resistance (Rint) can then be calculated from the ratio of the mouth pressure (measured immediately after occlusion) to the airflow at the mouth (measured just prior to occlusion)[2] i.e.:

$$\text{Rint}\ (\text{kPa}\cdot\text{L}^{-1}\cdot\text{s}) = \frac{\text{Change in mouth pressure (kPa)}}{\text{Air flow at mouth}\ (\text{L}\cdot\text{s}^{-1})}$$

During a Rint measurement, a pressure–time curve [Pm(t) curve] is produced after airway occlusion (Fig. 1). This displays a sharp increase in mouth pressure immediately after the occlusion, followed by a series of high-frequency oscillations, followed by a smooth increase in pressure.[3–5] As an indirect measurement of airways resis-

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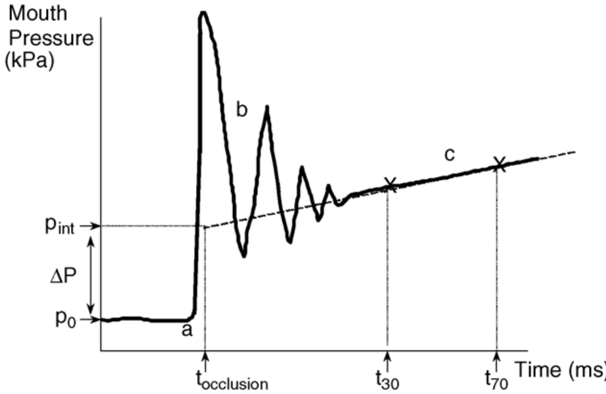

Figure 1 Optimal $P_{m(t)}$ curve showing back extrapolation $Rint_L$. An optimal $P_{m(t)}$ curve should display a sharp increase in pressure immediately following occlusion (a), a series of high frequency oscillations (b) and a smooth increase in pressure (c).[3,4,5] $Rint_L$ measurements are obtained by linear back extrapolation of two points from the curve 30 and 70 ms post-occlusion (t_{30} and t_{70}) to an arbitrary point 15 s post-occlusion at which total valve closure is thought to have occurred ($t_{occlusion}$). Mouth pressure measurements are taken pre-occlusion (P_0) and at time $t_{occlusion}$ (P_{int}). ΔPint is calculated from the difference between these two measurements. The ratio of this measurement to the expiratory flow at the mouth at the time of occlusion gives the Rint measurement.[5] Figure adapted from Phagoo et al.[5] and reproduced from Child et al.[6] with kind permission from the European Respiratory Journal.

Figure 2 Child performing MicroRint measurements.

tance, compared with plethysmographic measurements of Raw, Rint is influenced to a greater degree by the resistance of the lung parenchyma and chest wall, as well as of the airways themselves. The relative contributions from the airways, lungs and chest wall to the final measurement depend very much on how the Pm(t) curve is analysed. For example, values obtained by linear back extrapolation of the expiratory curve (Fig. 1) show the least baseline variability and the greatest sensitivity for detecting induced airway obstruction.[7] However, animal studies suggest that such measurements may be influenced to a greater extent by the resistive properties of the lung tissue, and therefore be a poorer reflection of true airways resistance than those taken from earlier points in the curve.[8]

HOW IS RINT MEASURED?

Rint measurements may be obtained using plethysmography or portable equipment such as the MicroRint machine (Micro Medical Ltd, Rochester, Kent, UK; Fig. 2). As with traditional Raw measurements, plethysmographic methods require expiration against a transiently closed valve in a body box and may be difficult or impossible for some young children. Portable devices also require valve closure, but have the advantage that children need not sit in a body box, nor be separated from their parents.

As with all measurements of airways resistance, Rint values are critically influenced by the compliance of the upper airways. Changes in upper airways compliance can be minimised, but not eliminated, by using standardised protocols in which the child is seated with their head extended and their cheeks supported from behind. The value of this cheek support has been questioned in one study.[9] As nasal resistance contributes significantly to total airways resistance, nose breathing should be avoided. This may be achieved using either a mask with integral mouthpiece or a mouthpiece and nose clip (Fig. 3). Both methods are equally successful and reproducible, but readings obtained using a facemask are significantly (7–10%) higher.[6]

Rint measurements taken throughout the respiratory cycle are surprising stable with expiratory readings averaging only 4% higher than inspiratory ones.[10] As airflow is significantly lower in expiration than in inspiration,[10] and as airways resistance is dependent on airflow, Rint measurements should be influenced to a greater extent by the child's breathing pattern than is seen in clinical practice. The reasons for this are not completely understood, but flow patterns within the airways, airway compliance and changes in glottic diameter are all likely to be important.[10]

All Rint measurements should be obtained during quiet tidal breathing. Curves that do not fulfil the standardised

Figure 3 Facemask and mouthpiece and nose-clip used to obtain MicroRint measurements.

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