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Non-invasive measurements of energy expenditure and respiratory quotient in children on extracorporeal membrane oxygenation by respiratory mass spectrometry

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Objective. Extracorporeal membrane oxygenation (ECMO) provides temporary life-saving support for pediatric patients with severe cardiac failure, but causes metabolic disturbances and altered nutritional requirements. However, few studies have addressed the optimal energy supply to meet demand of these children largely due to technical difficulties with their invasive nature. We have adapted respiratory mass spectrometry to continuously measure O₂ consumption and CO₂ production across the ECMO oxygenator. This study aimed to assess energy expenditure (EE) and respiratory quotient (RQ) in children on ECMO.

Methods. Five children (age 0.3-36 months, median 20) were studied in day 1 to 6 on ECMO. EE and RQ were measured in sequential fashion at the child's native lungs and ECMO oxygenator using respiratory mass spectrometry. Measurements were collected at 4-hr intervals, with the means in 24 hours representing the values of each day. Each child's caloric and protein intakes were recorded for each day.

Results. In ECMO day 1-6, there was a small but significant increase in EE from 40 to 46 kcal/kg/d ($p=0.03$). In comparison, the caloric intake significantly increased by twice as much as the increase in EE from 30 to 61 kcal/kg/day ($p=0.017$). As a result, RQ significantly increased from 0.6 to 1.0 ($p<0.0001$). Protein intake significantly increased during ECMO day 1-6 from 0.5 to 1.5g/kg/day ($p=0.04$).

Conclusions. Respiratory mass spectrometry provides a unique, safe and precise technique to measure EE and RQ in patients on ECMO. Without this knowledge, both underfeeding and overfeeding would occur. Clinical nutritional treatment should be guided by directly measured energy and protein demands in this special group of critically ill children.