Science Letter

Effect of a novel viral filter on cardiopulmonary exercise testing during the COVID-19 pandemic

Cardiopulmonary exercise testing (CPET) before major surgery provides the best risk estimate of postoperative morbidity, mortality and consequent prognosis [1], yet is currently suspended because of the hazards associated with aerosol-generating physical exercise and potential infective transmission [2]. While some services have transitioned to secondary, less informative assessments of cardiopulmonary function [3], novel counter-measures are required if surgical outcomes are to be optimised. Moreover, the related effect size is such that by July 2020, COVID-19 disease was associated with an 81-fold increase in the number of patients (n = 83,000) waiting > 1 year for NHS treatment in England alone [4]. Despite the transmission-reducing potential of porous microbacterial/viral filters (BVF), concerns related to water vapour saturation and increased ventilatory resistance raise barriers to implementation [2]. The aim of our study was to investigate the effect of a novel BVF on cardiorespiratory parameters during CPET, in a randomised single-blind crossover study.

Following ethical approval as a service evaluation (Cardiff and Vale University Health Board), 12 healthy, male participants with a mean (SD) age of 45 (10) years completed two separate CPET tests (seven days apart), with BVF and without (true value) BVF, distal to the sampling line. Participants performed a standardised incremental cycling

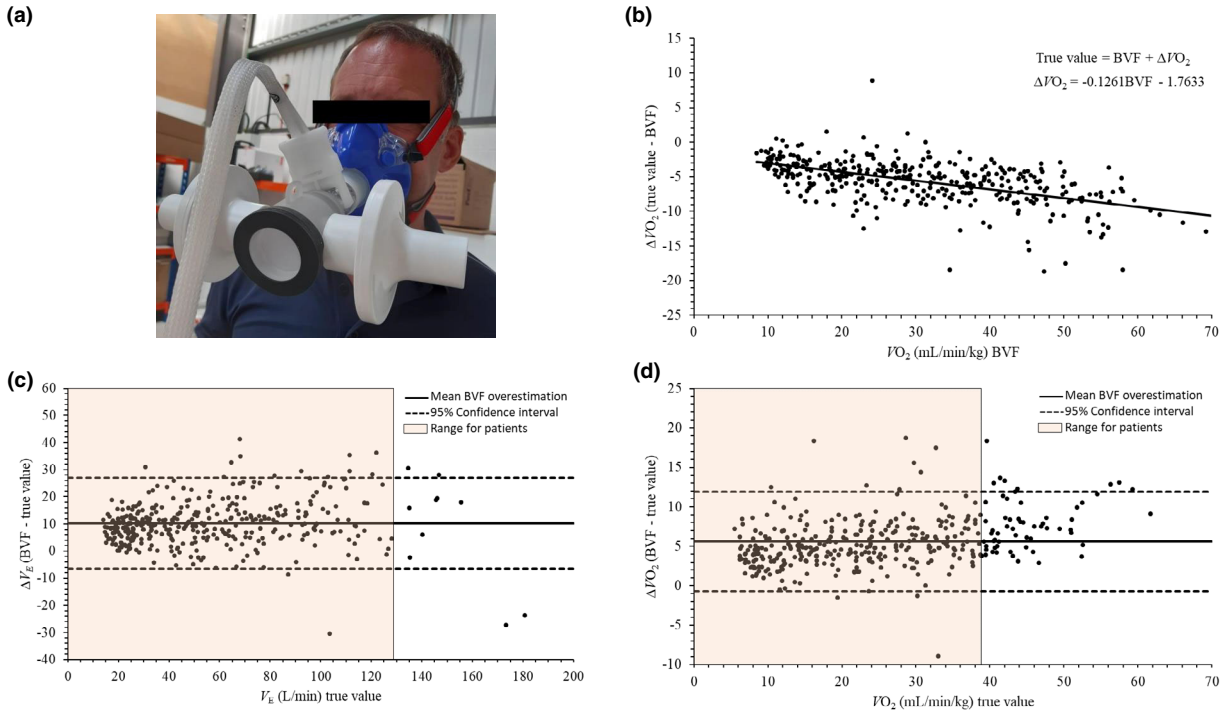

Figure 1 Dynamic changes in select cardiopulmonary metrics during cardiopulmonary exercise testing (CPET) with BVF and without (true value) a BVF. (a) specialist BVF; (b) provides the correction required when conducting CPET with a BVF. Modified Bland-Altman plots display the mean difference between BVF and true values for: (c) Pulmonary ventilation ($\dot{V}_E$), +10.2 $l.min^{-1}$ ($p < 0.001$) and (d) Oxygen uptake ($\dot{V}O_2$), +5.6 $ml.min^{-1}.kg^{-1}$ ($p < 0.001$). Data points represent the middle five of seven breaths subsequently averaged for each 10 W increment of power output. Reference ranges are from patients (n = 3168) who underwent CPET before major surgery; mean (SD) $\dot{V}_E$ 49.8 (17.9) $l.min^{-1}$ and $\dot{V}O_{2\,peak}$ 16.1 (5.0) $mlO_2.min^{-1}.kg^{-1}$.

test to volitional exhaustion with online breath-by-breath respiratory gas analysis (MedGraphics Ultima Series, Saint Paul, MN, USA) [5]. Modified Bland-Altman plots determined mean differences and course of bias. Interpretive implications for surgical risk stratification in a separate group of 618 patients who had previously undergone CPET before surgery for colorectal cancer were used for comparison.

A strong positive correlation was observed between the BVF and true value trials ($r^2 = 0.956$, $p < 0.001$). The BVF resulted in a systematic error and (mean) overestimation of pulmonary ventilation ($\dot{V}_E$, +10.2 $l.min^{-1}$, $p < 0.001$) and corresponding oxygen uptake ($\dot{V}O_2$, +5.6 $ml.min^{-1}.kg^{-1}$, $p < 0.001$) (Figure 1B–D, including corrective equation). Failure to account for these differences would have meant that 2.8 % of colorectal patients would have been misleadingly classified as being unfit (anaerobic threshold < 11 $mlO_2.kg^{-1}.min^{-1}$ [5]) compared with the authentic value of 53%.

Collectively, the findings indicate that CPET can be safely performed with a specialist BVF, minimising potential for transmission of aerosolised particles. The systematic overestimation driven by inflated measurement of gas flow across the mouthpiece pneumotach can be corrected for, allowing metrics of $\dot{V}O_2$ to be (re)calculated with accuracy and precision. These findings should help re-establish safe CPET services in the clinical setting to guide and refine physiological stage-directed patient care.

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