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AUTHORS' RESPONSE

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RESPONSE TO:
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Dear Sir,

We are grateful for the correspondence by Harwood *et al* and appreciate the opportunity to put our findings into further clinical perspective.[1] The practical message that we wanted to convey was originally intended for the surgeon engaging with a busy clinical practice. The fact that our article has attracted attention from health and exercise scientists stands further testament to the complexities underlying systemic oxygen transport, highlighting the need to integrate multiple specialist disciplines to advance our understanding and better inform the care of patients with abdominal aortic aneurysms (AAA).

We accept their primary criticism and were pleased, if not indeed surprised, that our data collected prospectively in a busy clinical setting demonstrated no mortality at 30 days in those patients classified as 'unfit' according to our cardiopulmonary exercise testing (CPET) 'cut-off' metrics. Indeed, the current risk of death after elective open (infrarenal) AAA repair in the UK would have equated to approximately 3 deaths in the 79 patients examined. Given such a low event rate, it is clear from the outset that our study was not adequately 'powered' from a statistical perspective to detect differences in mortality though we take the opportunity herein to place further emphasis on what we originally intended to be our primary 'take-home' message. Incidentally, a total of ~2,292 patients would be required in order to detect a (fit vs. unfit) difference in mortality of 50% (ie from 4% to 2%) with 80% power at $p<0.05$ according to established statistical methods.[2]

Although many studies focus on 30-day postoperative mortality, the longer term outcome is far more important to patients, particularly elective AAA repair.[3] Patients are unlikely to commit themselves to major high-risk surgery based on results at 30 days postoperatively. Focusing postoperative mortality prediction on 30 days may be misleading with modern perioperative care.

In our study, the decision to proceed with surgery in 'unfit' patients was taken after careful consideration of our CPET data, albeit tempered with specialist clinical (anaesthetic and critical care) input and a full discussion with the patient given the 'potential' for increased morbidity as indicated by preoperative CPET. Our findings are clinically important in that some and possibly increasing numbers of surgical units may well have turned down these patients for surgical intervention, classifying them as inoperable and unfit for surgery. Furthermore, if these unfit patients return to hospital symptomatic from their AAA, they may well be denied surgical intervention.

The 'unfit' patients in our study survived surgery albeit with a higher postoperative morbidity and increased hospital length of stay. Yet importantly, they go on to enjoy a significantly prolonged length and quality of life. Rather than apologise for our findings, we argue that the 'unfit' patient should always be considered by experienced clinicians as to whether they proceed to surgery and the decisions of operability, should not solely be dictated by a 'single-point' estimate of cardiorespiratory fitness as defined by CPET metrics (more on this later). *Dura est manus cirurgi, sed sanans* (the hand of the surgeon is hard, but healing) with surgery considered by many as much of an art as it is informed by sound science. The diagnostic ability of CPET facilitates the optimisation of known/hidden comorbidities and the enhanced perioperative care of these patients.

Indeed, Harwood *et al*'s (finer) point highlighting the limitations imposed by generic dichotomous thresholds for $\dot{V}O_2$peak for fitness stratification is well made, although the best available, given the lack of available data at least in the AAA setting. As stated by Moran *et al*,[4] a $\dot{V}O_2$peak cut-off point of 15ml/kg/min was considered 'a good starting point' originally informed by the study of Hartley *et al*[5] and supported by others[6] including our own work in AAA patients.[7] Variations in thresholds clearly exist, confounded

by different surgical cohorts and perioperative care pathways, including access to critical care resources. Furthermore, we have previously recommended that clinicians should not consider cardiorespiratory fitness solely on the basis of single point estimates; 'cut-offs' should reflect a dynamic range given the inevitable 'noise' associated with natural (mostly biological) variation reflected by the mathematical construct defined by the critical difference.[8,9] Thus, rather than advocating specific binary threshold values, zones along a 'spectrum' of cardiorespiratory fitness will provide a much clearer lens through which we can view its impact on AAA patient outcome.

Finally, let us not dismiss the advantages offered by a single-centre study. Namely, all patients underwent identical pre- and postoperative protocols. Indeed, there is an argument that the standardisation of postoperative care on intensive care units/high dependency units is a much larger cog driving the patient survival wheel. Rather than a disadvantage, our results reflect patient outcomes without the inevitable variations that occur in multicentre studies with varying surgical experience and different healthcare systems. We thank Harwood *et al* for their comments but re-emphasise that CPET testing may discourage units from treating 'unfit' patients based on binary cut-offs and deny them the opportunity and benefits associated with surgical intervention.

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