



# Cardiorespiratory fitness fails to predict short-term postoperative mortality in patients undergoing elective open surgery for abdominal aortic aneurysm

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## ABSTRACT

**INTRODUCTION** Preoperative cardiopulmonary exercise testing aids surgical risk stratification and is an established predictor of mid- to long-term survival in patients undergoing elective open abdominal aortic aneurysm repair. Whether cardiopulmonary exercise testing also predicts 30-day mortality in this population remains to be established.

**MATERIALS AND METHODS** Data for 109 patients (mean age 72 years) who underwent cardiopulmonary exercise testing to assess risk for surgical abdominal aortic aneurysm repair was analysed. Patients were classified according to cardiopulmonary fitness as fit (peak oxygen uptake  $\geq 15\text{ml O}_2\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ) or unfit (peak oxygen uptake less than  $15\text{ml O}_2\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ) and further stratified according to clamp position (infrarenal or suprarenal). Between-group postoperative outcomes were compared for in-hospital 30-day mortality, postoperative morbidity scale scores (day 5) and hospital length of stay.

**RESULTS** Seventy-nine patients underwent open surgery and 30 patients were treated conservatively. No deaths were recorded at 30 days post-surgery. Unfit patients with infrarenal clamping exhibited higher postoperative morbidity scale scores (64% vs 26%) and longer length of stay (four days) than fit patients ( $p < 0.05$ ). Conversely, with suprarenal clamping, postoperative morbidity scale scores were similar and length of stay longer (three days) in fit compared with unfit patients ( $p < 0.05$ ).

**DISCUSSION AND CONCLUSION** Preoperative fitness level defined by peak oxygen uptake failed to identify patients at risk of 30-day mortality when undergoing elective abdominal aortic aneurysm repair. Postoperative morbidity and length of stay in patients with suprarenal clamping was high independent of cardiopulmonary fitness. These findings suggest that cardiopulmonary exercise testing may be a useful predictor of complications following infrarenal rather than suprarenal clamping but may not be a good predictor of 30-day mortality.

## KEYWORDS

Cardiopulmonary fitness – Abdominal aortic aneurysm repair – Mortality – Morbidity – Prediction

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## Introduction

Over the past decade, advances in surgical technique and perioperative care have improved the clinical outcome of patients operated electively for abdominal aortic aneurysms (AAA).<sup>1,2</sup> The efforts to improve postoperative outcome in these patients increasingly reaches beyond the operating theatre and includes many factors, one of which is the increased use of preoperative cardiopulmonary exercise testing (CPET). This is a clinical risk assessment tool used to predict patient outcomes and support clinical

decision making to guide perioperative care.<sup>3,4</sup> CPET has thus gained popularity as part of the routine preoperative diagnostic assessment in the UK,<sup>5</sup> but substantial evidence from clinical studies to justify its use is scarce.<sup>4,6</sup>

The predictive value of cardiopulmonary fitness level according to CPET in relation to mid- and long-term survival in patients undergoing elective open surgical AAA repair is well established.<sup>7,8</sup> In terms of perioperative outcome, a 2012 study reported a more than five-fold higher 30-day mortality in unfit compared with fit patients

defined by the preoperative CPET in patients undergoing either open or endovascular AAA repair surgery.<sup>9</sup> An earlier study reporting data from 1996 to 1999 included patients undergoing open AAA repair and demonstrated a higher 30-day mortality in the unfit compared with the fit.<sup>10</sup> In a retrospective study, the use of CPET for preoperative risk assessment in AAA surgery was found to be associated with a lower 30-day mortality but hospital length of stay was around three days less than for historical controls who had not undergone CPET.<sup>11</sup> In this study, we investigated to what extent cardiopulmonary fitness, as evaluated by preoperative CPET, predicted 30-day mortality, morbidity and length of stay in patients undergoing present-day elective open AAA repair by a single surgeon in our institution.

## Materials and methods

The study was approved by the Cardiff and Vale University Health Board (15/AIC/6352). We retrospectively analysed data for 109 patients with AAA with a mean age of 72 years from a local anonymised database, of whom 79 underwent open surgical AAA repair performed by a single surgeon (IMW) and the remaining 30 were treated conservatively (ie no surgery performed given unacceptably high surgical risk decided by CPET, clinical risk factors, and surgeon/patient preferences).

CPET was performed on an electromagnetically braked cycle ergometer (Lode, Gronigen, Netherlands) and a Medgraphics Ultima metabolic cart (MedGraphics, Gloucester, UK) as previously described.<sup>12</sup> On this basis, each patient was classified as either fit (peak oxygen uptake,  $\dot{V}O_{2PEAK} \geq 15 \text{ ml O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ ) or unfit ( $\dot{V}O_{2PEAK} < 15 \text{ ml O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ ) according to current clinical guidelines.<sup>15</sup>

## Outcomes

Data from day 5 post-surgery were extracted from a local anonymised database. The data were used to assess complications using the postoperative morbidity scale,<sup>14</sup> an established nine-domain system previously validated in patients undergoing AAA repair.<sup>15</sup> A score between 0 and 9 was recorded. We defined the presence of clinically significant postoperative morbidity as a postoperative morbidity scale score  $\geq 1$ . Data were also collected from the same database for hospital length of stay and 30-day mortality.

## Statistics

Statistical analyses were conducted using IBM SPSS Statistics for Windows Version 26.0 and distribution normality was assessed by repeated Shapiro–Wilk *W* tests. We used the chi-square test for all frequency count comparisons (reported as mean and standard deviation). Because the length of stay data were not normally distributed, they were compared by Mann–Whitney *U* test (reported as median values with interquartile range). Significance for all two-tailed tests was established at a *p*-value less than 0.05.

## Results

Of the 79 patients who underwent open AAA repair, 45 (54%) were classified as fit and 36 (46%) unfit according to our CPET criteria. Of these patients, 53 (67%) underwent infrarenal clamping while 26 (33%) underwent suprarenal clamping during surgery.

Cardiopulmonary fitness according to clamp position and in conservatively treated patients (no surgery), as well as 30-day mortality, postoperative morbidity and length of stay are summarised in Table 1. The  $\dot{V}O_{2PEAK}$  of unfit patients who underwent surgery was identical to those treated conservatively. There were no deaths recorded in either group. In patients who underwent infrarenal clamping, postoperative morbidity was more prevalent in unfit than fit patients, with a correspondingly longer hospital stay. Conversely, postoperative morbidity was similar between fit and unfit patients who underwent suprarenal clamping and comparable to that observed in unfit patients who underwent infrarenal clamping. Surprisingly, hospital stay was longer (by three days) in fit compared with unfit patients who underwent suprarenal clamping.

## Discussion

The major finding in the present study is that CPET may be a useful predictor of complications following infrarenal rather than suprarenal clamping but may not be a good predictor of short-term mortality in patients undergoing elective open AAA repair.

We accept that our findings disagree with previous studies.<sup>9,11</sup> The notable advances in both the conservative and surgical treatment of AAA may contribute to the disparities observed. A more recent (2012) study demonstrated that patients with a  $\dot{V}O_{2PEAK}$  less than  $15 \text{ ml O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  were defined by increased 30-day mortality, but this study included patients undergoing a combination of endovascular and open AAA repair surgery who were older than the patients examined in the present study.<sup>9</sup> Thus, they may have presented with more comorbidities compounding postoperative complications especially in the less fit. In contrast and in direct agreement with our findings, a 2016 randomised trial found no effect of exercise-induced improvements in  $\dot{V}O_{2PEAK}$  on postoperative 30-day mortality albeit that postoperative cardiac, respiratory, renal complications and length of stay were reduced.<sup>16</sup> Indeed, no deaths occurred in our study, which may suggest that the notable advances in both conservative and surgical treatment have rendered patient cardiopulmonary fitness a less sensitive predictor of short-term postoperative mortality.<sup>1,2</sup> According to earlier studies, CPET-based cardiopulmonary fitness is more predictive of mid and long-term mortality in patients undergoing open AAA surgery,<sup>7,8</sup> but from our work, the acute physiological stress imposed by the surgical procedure may have a greater impact.

While preoperative CPET-based cardiopulmonary fitness levels failed to predict 30-day mortality, it was nonetheless

Table 1 Postoperative outcomes

Variable	Clamp position						Conservatively treated (n = 30)
	Infrarenal (n = 53)		p-value	Suprarenal (n = 26)		p-value	
	Fit (n = 31) <sup>a</sup>	Unfit (n = 22) <sup>a</sup>		Fit (n = 12) <sup>a</sup>	Unfit (n = 14) <sup>a</sup>		
Demographics:							
Sample size (n)	31	22	n/a	12	14	n/a	30
Age (years)	70 ± 7	74 ± 6	0.036	69 ± 6	72 ± 4	0.187	77 ± 5
$\dot{V}O_{2PEAK}$ (mL O <sub>2</sub> .kg <sup>-1</sup> .min <sup>-1</sup> ) <sup>b</sup>	18.4 ± 2.1	12.3 ± 2.2	< 0.001	17.4 ± 1.7	11.7 ± 1.9	< 0.001	12.7 ± 3.7
Mortality							
30-day mortality, n (%)	0 (0)	0 (0)	n/a	0 (0)	0 (0)	n/a	0 (0)
Morbidity:							
POMS score ≥ 1, n (%) <sup>c</sup>	8 (26)	14 (64)	0.008	8 (67)	7 (50)	0.391	n/a
Length of stay, median days (IQR)	8.0 (4.3)	12.0 (12.3)	0.010	10.5 (13.3)	7.5 (5.8)	0.041	n/a

<sup>a</sup> Cardiopulmonary fitness; fit patients exhibited peak oxygen uptake ( $\dot{V}O_{2PEAK}$ ) ≥ 15ml O<sub>2</sub>.kg<sup>-1</sup>.min<sup>-1</sup>, unfit patients < 15ml O<sub>2</sub>.kg<sup>-1</sup>.min<sup>-1</sup>.  
<sup>b</sup> Peak oxygen uptake values represent mean ± standard deviation.  
<sup>c</sup> Postoperative morbidity score (POMS) taken on day 5 post-surgery and reported binarily as having at least one recorded complication, or not. IQR, interquartile range; n/a, not applicable.

able to predict postoperative morbidity in patients who underwent infrarenal clamping for whom regular supervised preoperative exercise has previously been shown to confer vascular benefit.<sup>16</sup> However, this was not the case for those patients that underwent suprarenal clamping, who typically report higher postoperative morbidity given the renal ischaemia induced during the surgical procedure.<sup>17–19</sup> Length of stay was unexpectedly longer in those patients classified as fit, questioning the clinical predictive significance of CPET testing in this patient population.

## Conclusion

Our findings demonstrate that preoperative cardiopulmonary fitness levels failed to identify patients at risk of 30-day perioperative mortality following elective open AAA repair. Furthermore, fitter patients who underwent suprarenal clamping appeared to have longer length of hospital stay, showing a lack of correlation between cardiopulmonary fitness and clinical outcome. From a practical perspective, surgeons should not be discouraged from treating 'less fit' patients, as defined exclusively by a preoperative  $\dot{V}O_{2PEAK}$  less than 15ml O<sub>2</sub>.kg<sup>-1</sup>.min<sup>-1</sup>.

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