Mixed venous oxygen saturation predicts short- and long-term outcome after coronary artery bypass grafting surgery: a retrospective cohort analysis

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Editor’s key points

- This large retrospective study analysed the association between \( SV_{O_2} \) and outcome after coronary artery bypass grafting (CABG) surgery.
- \( SV_{O_2} \) <60% on intensive care unit (ICU) admission was associated with worse short- and long-term outcome after CABG.
- This cut-off value of \( SV_{O_2} \) <60% is higher than previous reports.
- \( SV_{O_2} \) <60% on ICU admission increased attention and monitoring after CABG and could influence postoperative decision-making.

Background. Complications of an inadequate haemodynamic state are a leading cause of morbidity and mortality after cardiac surgery. Unfortunately, commonly used methods to assess haemodynamic status are not well documented with respect to outcome. The aim of this study was to investigate \( SV_{O_2} \) as a prognostic marker for short- and long-term outcome in a large unselected coronary artery bypass grafting (CABG) cohort and in subgroups with or without treatment for intraoperative heart failure.

Methods. Two thousand seven hundred and fifty-five consecutive CABG patients and subgroups comprising 344 patients with and 2411 patients without intraoperative heart failure, respectively, were investigated. \( SV_{O_2} \) was routinely measured on admission to the intensive care unit (ICU). The mean (so) follow-up was 10.2 (1.5) yr.

Results. The best cut-off for 30 day mortality related to heart failure based on receiver-operating characteristic analysis was \( SV_{O_2} \) 60.1%. Patients with \( SV_{O_2} \) <60% had higher 30 day mortality (5.4% vs 1.0%; \( P=0.0001 \)) and lower 5 yr survival (81.4% vs 90.5%; \( P=0.0001 \)). The incidences of perioperative myocardial infarction, renal failure, and stroke were also significantly higher, leading to a longer ICU stay. Similar prognostic information was obtained in the subgroups that were admitted to ICU with or without treatment for intraoperative heart failure. In patients admitted to ICU without treatment for intraoperative heart failure and \( SV_{O_2} \) ≥60%, 30 day mortality was 0.5% and 5 yr survival 92.1%.

Conclusions. \( SV_{O_2} \) <60% on admission to ICU was related to worse short- and long-term outcome after CABG, regardless of whether the patients were admitted to ICU with or without treatment for intraoperative heart failure.

Keywords: assessment, patient outcomes; coronary artery bypass grafting; patient monitoring; postoperative complications; survival rates

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Complications from postoperative heart failure are the leading cause of adverse outcomes after cardiac surgery\(^1\) and adequate monitoring of haemodynamic state in this setting is therefore essential. Unfortunately, commonly used methods to assess haemodynamic state are not well documented with regard to their association with outcome.\(^3\) \(^4\) Uncertainty regarding how to use haemodynamic data obtained for decision-making could partially explain reports of worse outcome or lack of benefit associated with the use of pulmonary artery catheters in critically ill patients and in cardiac surgery.\(^5\) \(^6\)

Heart failure, in physiological terms, reflects a cardiac output insufficient to meet systemic requirements.\(^7\) Evidence of such mismatch between supply and demand are low mixed venous oxygen saturation (\( SV_{O_2} \)) and inadequate organ function. In a small cohort of patients undergoing coronary artery bypass grafting (CABG), it has been shown that \( SV_{O_2} \) correlates with short-term outcome.\(^8\) These patients were managed according to a metabolic strategy whereby inotropic drugs were largely replaced by metabolic support.\(^8\) \(^9\) The cohort was highly selected, and therefore, these results may not be applicable to more general patients undergoing CABG. Furthermore, the additional value of \( SV_{O_2} \) measurements remains obscure given that many patients admitted to intensive care unit (ICU) already have treatment for known intraoperative heart failure.

Therefore, we wanted to test the hypothesis that \( SV_{O_2} \) has predictive value for short-term outcome in an unselected cohort of CABG patients. We also wanted to study the predictive value of \( SV_{O_2} \) in patients admitted to ICU with or without
intraoperative treatment for heart failure. As postoperative complications remain an important determinant of long-term outcome, we also wanted to study $SvO_2$ with regard to long-term survival.

**Methods**

**Patients**

The University Hospital in Linköping is the only referral centre in the southeast region of Sweden, serving a population of ~1 million. All patients at this department undergoing isolated CABG between 1995 and 2000 were included in the study. During this period, a total of 2774 patients were operated on with isolated CABG. In this cohort, data on $SvO_2$ were lacking in 19 patients leaving 2755 patients to be followed in the study. Furthermore, these patients were divided into two subgroups of patients who did (n=344) or did not (n=2411) receive intraoperative treatment for heart failure before admission to ICU.

The study was performed according to the principles of the Helsinki Declaration of Human Rights and approved by the ethics committee for medical research at the Faculty of Health Sciences University Hospital of Linköping. Owing to the nature of the study, the ethics committee waived the need for written informed consent (2003-12-16; Dnr 03-596).

Patient characteristic and periprocedural data were registered prospectively in a computerized database and analysed retrospectively. All fields were defined in a data dictionary.

The cause of death within 30 days was analysed specifically from each patient chart and in most cases supported by autopsy. The cause of death was categorized as death related to heart failure or death due to other causes. Data on late mortality were retrieved from the Swedish Civil Registry. Eight patients emigrated during follow-up, four of them within 5 yr of surgery. The mean (s) follow-up was 10.2 (1.5) yr (range 0.9–12.7 yr).

**Clinical management**

After an overnight fast, and administration of their $\beta$-blocker medication, patients were premedicated with oxicone 4–10 mg and scopolamine 0.2–0.5 mg i.m. Anaesthesia was induced with thiopental 1–2 mg $kg^{-1}$ body weight and fentanyl 5–10 $\mu g$ $kg^{-1}$ body weight. Pancuronium bromide or vecuronium bromide was used for neuromuscular block. Anaesthesia was maintained with intermittent doses of fentanyl and isoflurane.

All patients underwent surgery using standard techniques with cardiopulmonary bypass (CPB) and aortic cross-clamping using cold crystalloid cardioplegia. $SvO_2$ was monitored on the venous line of the CPB circuit during and on weaning from CPB. Before weaning from CPB, an epidural catheter cut 5 cm from its tip (Perifix-Katheter, B. Braun Melssungen AG, Germany) was introduced by the surgeon through the outflow tract of the right ventricle 15 cm into the pulmonary artery for monitoring of pulmonary artery pressure and intermittent blood sampling. An epidural needle was used for puncture of the right ventricular wall and the abdominal wall. A 4-0 prolene purse string suture was gently tightened around the puncture site at the right ventricular outflow tract to minimize risk for bleeding at withdrawal, which usually was done the next morning before withdrawal of the chest tubes.

From this catheter, blood samples were drawn for the measurement of $SvO_2$, after weaning from CPB, on admission to ICU, the first postoperative morning and whenever other clinical variables raised questions about haemodynamic adequacy. Only $SvO_2$ measurements obtained on admission to ICU were routinely recorded in the computerized institutional database.

On the basis of previous experience, it was our practice to repeat sampling for $SvO_2$ in the ICU not only in patients with low $SvO_2$ but also in patients with a negative trend and whenever other clinical variables raised questions about haemodynamic adequacy. If benign causes such as hypovolaemia and shivering could be excluded, more serious conditions such as tamponade or myocardial pump failure were considered. In this respect, $SvO_2$ was used to identify patients who might benefit from echocardiography in the ICU and more meticulous haemodynamic monitoring. Pulmonary artery thermodilution catheters were used in 7.9% of the patients and mainly selected for patients with pronounced circulatory problems in need of pharmacological support.

**Definitions**

Definitions for variables presented in Table 1 are given in Supplementary material.

**Statistics**

A receiver-operating characteristic (ROC) analysis was carried out to calculate the area under the curve (AUC) and to evaluate prognostic performance of $SvO_2$ with regard to all-cause mortality, and mortality related to cardiac failure. The $\chi^2$ test or Fisher’s exact test was used when appropriate for comparison of dichotomous variables. Student’s t-test or the Mann–Whitney U-test was used when appropriate for comparison of continuous variables. The Kaplan–Meier estimator was used for the assessment of long-term survival. As the analyses were exploratory, no formal adjustment was made for multiple testing, but a more conservative $P$-value of <0.01 was required to be judged statistically significant. Results are given as percentages or mean (s).

Statistical analyses were performed using Statistica 8.0, StatSoft Inc., Tulsa, OK, USA, and SPSS 17.0 (SPSS Inc.).

**Results**

**Patient characteristics**

The mean (s) age in the whole unselected cohort was 65 (9) yr; 22% were female. The average Higgins score was 2.3 (2.5). Overall 30 day mortality was 1.9% and 5 yr survival 88.9%. The mean (s) $SvO_2$ on arrival to ICU was 66.3 (7.0%). The distribution of $SvO_2$ values is given in % intervals in Supplementary Figure S1, with the majority in the range...
between 60% and 75%. Figure 1 displays 30 day mortality related to these $SvO_2$ intervals.

There were no complications recorded that were related to catheterization of the pulmonary artery.

The best cut-off for 30 day mortality related to heart failure based on ROC analysis was $SvO_2$ $\geq 60\%$ with an AUC of 0.74, a sensitivity of 59.3%, and a specificity of 82.4% (Fig. 2). The negative predictive value was 99.5%.

On the basis of the ROC analysis, the patients were divided into two groups with higher ($\geq 60\%$) and lower ($< 60\%$) $SvO_2$. Two thousand three hundred and nine patients (84%) had $SvO_2 \geq 60\%$ and 446 patients (16%) had $SvO_2 < 60\%$.

Patients with $SvO_2 < 60\%$ had significantly higher Higgins’ score, higher age, higher proportion of female gender, diabetes, hypertension, recent myocardial infarction, and poor left ventricular function (Table 1).

### Short-term outcome

Thirty day mortality was 1.0% ($n=24$) in patients with $SvO_2 \geq 60\%$ and 5.4% ($n=24$) in patients with $SvO_2 < 60\%$ ($P<0.0001$), yielding a relative risk of 5.2 (95% confidence interval $3.0–9.0$) for the patients with $SvO_2 < 60\%$ compared with those with $SvO_2 \geq 60\%$ ($P<0.0001$).

Thirty day mortality related to heart failure was 0.6% ($n=13$) in patients with $SvO_2 \geq 60\%$ and 3.1% ($n=14$) in patients with $SvO_2 < 60\%$ ($P<0.0001$), yielding a relative risk of 5.6 (95% confidence interval $2.6–11.8$) for the patients with $SvO_2 < 60\%$ compared with those with $SvO_2 \geq 60\%$ ($P<0.0001$).

Postoperative morbidity was also significantly higher in patients with $SvO_2 < 60\%$ including higher incidence of perioperative myocardial infarction, renal failure, stroke, and re-operation for bleeding. ICU stay and ventilator treatment was prolonged in patients with $SvO_2 < 60\%$. Patients with $SvO_2 < 60\%$ received inotropic drugs more frequently both intraoperatively and in the ICU.

### Long-term follow-up

Five yr survival was 90.5% ($SvO_2 \geq 60\%$) and 81.4% ($SvO_2 < 60\%$), respectively ($P<0.0001$).

Survival up to 12 yr related to different levels of $SvO_2$ according to Kaplan–Meier is presented in Figure 3.

### Subgroup analyses

#### Patients without intraoperative treatment for heart failure

From the total cohort of 2755 patients, 2411 were admitted to ICU without treatment for heart failure intraoperatively. In this subgroup, the mean age was 65 (9.4) y and 21% were female. The mean ($\bar{s}$) $SvO_2$ on arrival to ICU was 66.5 (6.8%). The average Higgins score was 1.9 (2.1). Overall 30 day mortality was 0.9% and 5 yr survival 91.0%.

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**Table 1** Perioperative characteristics in all patients with $SvO_2 \geq 60\%$ and $SvO_2 < 60\%$. Data presented as mean ($\bar{s}$) or %. BMI, body mass index; CVI, cerebrovascular injury; COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction; CPB, cardiopulmonary bypass; GIK, glucose–insulin–potassium; ICU, intensive care unit; IABP, intra-aortic balloon pump; LVAD, left ventricular assist device; MOF, multiorgan failure. *$P<0.01$ was taken as statistically significant to reflect the multiple endpoints and exploratory nature of the analyses.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>$SvO_2 \geq 60%$</th>
<th>$SvO_2 &lt; 60%$</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>65 (9)</td>
<td>68 (9)</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Female gender</td>
<td>20.0%</td>
<td>31.4%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>BMI (kg m$^{-2}$)</td>
<td>26.7 (3.7)</td>
<td>26.9 (3.6)</td>
<td>0.35</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>18.5%</td>
<td>24.7%</td>
<td>0.003*</td>
</tr>
<tr>
<td>Hypertension</td>
<td>39.3%</td>
<td>46.4%</td>
<td>0.005*</td>
</tr>
<tr>
<td>Preoperative CVI</td>
<td>6.2%</td>
<td>8.3%</td>
<td>0.10</td>
</tr>
<tr>
<td>COPD</td>
<td>5.9%</td>
<td>4.1%</td>
<td>0.13</td>
</tr>
<tr>
<td>NYHA class III/IV</td>
<td>76.4%</td>
<td>80.6%</td>
<td>0.06</td>
</tr>
<tr>
<td>Myocardial infarction &lt;1 week</td>
<td>4.8%</td>
<td>9.4%</td>
<td>0.002*</td>
</tr>
<tr>
<td>LVEF $\leq 0.30$</td>
<td>4.4%</td>
<td>10.4%</td>
<td>0.0002*</td>
</tr>
<tr>
<td>Higgins’ score</td>
<td>2.1 (2.4)</td>
<td>3.2 (3.0)</td>
<td>$&lt;0.0001$</td>
</tr>
<tr>
<td>Urgent surgery</td>
<td>45.8%</td>
<td>52.5%</td>
<td>0.01</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>4.7%</td>
<td>10.6%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Redo procedure</td>
<td>2.7%</td>
<td>6.7%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>46.7%</td>
<td>57.7%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Aortic cross-clamp time (min)</td>
<td>43 (18)</td>
<td>48 (20)</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>80 (28)</td>
<td>94 (38)</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Number of peripheral anastomoses</td>
<td>3.6 (1.2)</td>
<td>3.8 (1.1)</td>
<td>0.0008*</td>
</tr>
<tr>
<td>Left internal mammary artery graft</td>
<td>94.5%</td>
<td>93.9%</td>
<td>0.67</td>
</tr>
<tr>
<td>Inotropic drugs started intraoperatively</td>
<td>4.1%</td>
<td>7.2%</td>
<td>0.005*</td>
</tr>
<tr>
<td>GIK started intraoperatively</td>
<td>9.0%</td>
<td>15.9%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Inotropic drugs, GIK, or both started intraoperatively</td>
<td>11.3%</td>
<td>18.4%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Inotropic drugs started in ICU</td>
<td>5.6%</td>
<td>18.6%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Mechanical assist (IABP/LVAD)</td>
<td>1.1%</td>
<td>4.9%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>$SvO_2$ ICU (%)</td>
<td>68.5 (5.0)</td>
<td>55.0 (4.3)</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Reoperation for bleeding $&lt; 24$ h</td>
<td>2.5%</td>
<td>5.6%</td>
<td>0.0005*</td>
</tr>
<tr>
<td>Perioperative stroke</td>
<td>1.4%</td>
<td>3.4%</td>
<td>0.004*</td>
</tr>
<tr>
<td>Perioperative myocardial infarction</td>
<td>5.0%</td>
<td>13.0%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Renal failure</td>
<td>1.9%</td>
<td>5.3%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Postoperative dialysis</td>
<td>0.3%</td>
<td>0.9%</td>
<td>0.04</td>
</tr>
<tr>
<td>MOF</td>
<td>0.5%</td>
<td>1.1%</td>
<td>0.14</td>
</tr>
<tr>
<td>Time in ICU (days)</td>
<td>1.5 (2.0)</td>
<td>2.3 (3.2)</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Time on ventilator (h)</td>
<td>13 (40)</td>
<td>27 (67)</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Mortality 30 days (total)</td>
<td>1.0%</td>
<td>5.4%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>Mortality 30 days (heart failure)</td>
<td>0.6%</td>
<td>3.1%</td>
<td>$&lt;0.0001$*</td>
</tr>
<tr>
<td>5 yr survival</td>
<td>90.5%</td>
<td>81.4%</td>
<td>$&lt;0.0001$*</td>
</tr>
</tbody>
</table>
Two thousand and forty-nine patients (85%) had $SvO_2 \geq 60\%$ and 362 patients (15%) had $SvO_2 < 60\%$. Patients with $SvO_2 < 60\%$ had significantly higher Higgins’ score, higher age, higher proportion of females, diabetes, hypertension, recent myocardial infarction, and poor left ventricular function (Supplementary Table S1).

**Short-term outcome**

Thirty day mortality was 0.5% ($n=10$) in patients with $SvO_2 \geq 60\%$ and 3.2% ($n=12$) in patients with $SvO_2 < 60\%$ ($P<0.0001$), yielding a relative risk of 6.8 (95% confidence interval 3.0–15.6%) for the patients with $SvO_2 < 60\%$ compared with those with $SvO_2 \geq 60\%$ ($P<0.0001$).

Thirty day mortality related to heart failure was 0.1% ($n=3$) in patients with $SvO_2 \geq 60\%$ and 1.4% ($n=5$) in patients with $SvO_2 < 60\%$ ($P=0.0002$), yielding a relative risk of 9.5 (95% confidence interval 2.3–39.4) for the patients with $SvO_2 < 60\%$ compared with those with $SvO_2 \geq 60\%$ ($P=0.002$).

Thirty day mortality related to $SvO_2$ interval is given in Supplementary Figure S2.

Postoperative morbidity was also significantly higher in patients with $SvO_2 < 60\%$ including higher incidence of perioperative myocardial infarction, renal failure, and reoperation for bleeding. ICU stay and ventilator treatment were prolonged in patients with $SvO_2 < 60\%$ (Supplementary Table S1).

**Long-term follow-up**

Five yr survival was 92.1% ($SvO_2 \geq 60\%$) and 84.5% ($SvO_2 < 60\%$), respectively ($P<0.0001$).

**Patients with intraoperative treatment for heart failure**

From the total cohort of 2755 patients, 344 patients were admitted to ICU with treatment for intraoperative heart failure. These patients were treated with either inotropic support, glucose–insulin–potassium, or both. In this subgroup, the mean age was 67 (9) yr and 28% were female. $SvO_2$ on arrival to ICU averaged 64.9 (8.3%). The average Higgins score was 4.7 (3.5). Overall 30 day mortality was
7.6% (n=26), yielding a relative risk of 8.3 (95% confidence interval 4.7–14.4%) for these patients compared with those admitted to ICU without intraoperative treatment for heart failure (P≤0.0001). Five year survival was 74.1%.

Two hundred and sixty patients (76%) had $S_vO_2 \geq 60\%$ and 84 patients (24%) had $S_vO_2 < 60\%$. Preoperative characteristics are given in Supplementary Table S2.

**Short-term outcome**

Thirty day mortality was 5.4% (n=14) in patients with $S_vO_2 \geq 60\%$ and 14.3% (n=12) in patients with $S_vO_2 < 60\%$ (P=0.007), yielding a relative risk of 2.7 (95% confidence interval 1.3–5.5%) for the patients with $S_vO_2 < 60\%$ compared with those with $S_vO_2 \geq 60\%$ (P=0.009).

Thirty day mortality related to heart failure was 3.8% (n=10) in patients with $S_vO_2 \geq 60\%$ and 10.7% (n=9) in patients with $S_vO_2 < 60\%$ (P=0.02), yielding a relative risk of 2.8 (95% confidence interval 1.2–6.6%) for the patients with $S_vO_2 < 60\%$ compared with those with $S_vO_2 \geq 60\%$ (P=0.02).

Thirty day mortality related to $S_vO_2$ interval is presented in Supplementary Figure S2.

Postoperative morbidity was also significantly higher in patients with $S_vO_2 < 60\%$ with a higher incidence of perioperative myocardial infarction and stroke. ICU stay and ventilator treatment was prolonged in patients with $S_vO_2 < 60\%$.

**Long-term follow-up**

Five yr survival was 77.7% ($S_vO_2 \geq 60\%$) and 63.1% ($S_vO_2 < 60\%$), respectively (P=0.008).

**Discussion**

The major finding of this study was that $S_vO_2 < 60\%$ on admission to ICU in a large unselected cohort of CABG patients was associated with worse short- and long-term outcome.

In the early postoperative period after cardiac surgery, the heart is in a vulnerable state recovering from ischaemia. Inotropic agents should be used judiciously particularly after CABG since these drugs can aggravate the consequences of ischaemia and it has been demonstrated that ischaemia and evolving myocardial infarction account for a large proportion of patients with postoperative heart failure.4 10 12 In this situation, a goal-orientated strategy of $S_vO_2$ levels might lead to an overuse of inotropic support and increased cardiac workload, which could be harmful to the heart. On the other hand, a more conservative approach with acceptance of lower $S_vO_2$ might lead to inadequate systemic perfusion jeopardizing perfusion of vital organs. On the basis of this reasoning, it would be desirable with appropriate guidelines to assess the adequacy of circulation in individual patients. In the absence of studies providing generally accepted criteria for institution of inotropic treatment, observational data such as ours may provide some guidance. The high negative predictive value found in our study suggests that it may be reasonably safe to withhold inotropic treatment if $S_vO_2$ exceeds 60% if other clinical, haemodynamic, and laboratory data do not suggest otherwise.
Although used for the assessment of haemodynamic state and even for goal-directed therapy, there are few data in the literature regarding adequate $\text{SvO}_2$ values during the first postoperative hours after cardiac surgery.\textsuperscript{14} In a highly selected small cohort of patients treated according to a metabolic strategy, there was markedly increased morbidity and mortality if patients $\text{SvO}_2$ on admission to ICU after CABG was below 55%.\textsuperscript{8} In a relatively small cohort of patients undergoing surgery for aortic stenosis, ROC analysis suggested a cut-off $\text{SvO}_2$ of 53.7%.\textsuperscript{15} The present study is considerably larger and includes all patients undergoing CABG in southeast Sweden during a 5 yr period. Basically, our results confirm the previous observations but suggest that the level of $\text{SvO}_2$ that should lead to increased attention after CABG is $\sim 60\%$ rather than 55%.

Outcome after cardiac surgery is to a large extent determined by the preoperative status of the patient. However, the outcome is also influenced by events during surgery and anaesthesia and the patient’s prognosis on arrival at ICU may differ markedly from the preoperative evaluation. Early re-evaluation on admission to ICU is desirable for a proactive management plan, identification of patients who may benefit from further diagnostic and therapeutic measures, and estimation of the need for ICU resources and for better prediction of the prognosis for individual patients.\textsuperscript{16} Our results suggest that $\text{SvO}_2$ data can be used not only to identify patients in need of more meticulous surveillance but also those who can be passed on according to fast-track protocols. With the simple and inexpensive method to measure $\text{SvO}_2$ used in our practice, $\text{SvO}_2$ data can be safely obtained in virtually all patients, despite a restrictive use of pulmonary artery thermodilution catheters. It remains to be documented if information of similar value can be obtained by sampling from central venous catheters.\textsuperscript{17,18}

It can be argued that in most patients, a poor haemodynamic state is evident on admission to ICU without $\text{SvO}_2$ measurements. In this study, we found that $\text{SvO}_2$ provided information of prognostic value even in patients admitted to ICU without known heart failure. Thus, patients with $\text{SvO}_2$ below 60% had significantly higher postoperative mortality and morbidity. On the other hand, if patients were admitted to ICU without intraoperative treatment for heart failure and $\text{SvO}_2 \geq 60\%$, the risk of death within 30 days related to heart failure was 0.1%. Furthermore, these patients comprising approximately three-quarters of the CABG cohort had a 92.1% 5 yr survival.

In patients operated for aortic stenosis, $\text{SvO}_2$ below 55% was associated not only with increased postoperative mortality but also markedly impaired long-term survival.\textsuperscript{15} The present study confirms the long-term prognostic value of $\text{SvO}_2$ on admission to ICU. In addition to a significantly reduced long-term survival in the subgroup with $\text{SvO}_2$ below 60%, we found a relationship between different levels of $\text{SvO}_2$ on admission to ICU and long-term survival (Fig. 3). This implies that $\text{SvO}_2$ on admission to ICU reflects the haemodynamic state adequately taking into account preoperative risk factors for heart failure, intraoperative events leading to heart failure, and recovery occurring before admission to ICU.

The limitations of this study are its retrospective nature and that only $\text{SvO}_2$ data obtained on admission to ICU were available in our database. The latter prevented interpretations regarding therapeutic interventions to increase $\text{SvO}_2$. The data come from a cohort undergoing CABG more than 10 yr ago, although this did provide the opportunity to study long-term outcome. Furthermore, the fundamentals of circulatory physiology have remained unchanged during this time, although shifts in patient profile and clinical management have occurred.

In conclusion, we found that in a large unselected cohort of CABG patients, the measurement of $\text{SvO}_2$ on admission to ICU estimates a haemodynamic state that predicts short- and long-term outcome after CABG. This association remained valid regardless of whether patients were admitted to ICU with or without treatment for intraoperative heart failure.

**Supplementary material**

Supplementary material is available at *British Journal of Anaesthesia* online.

**Conflict of interest**

None declared.

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