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Relations between Mixed Venous Oxygen Saturation and Hemodynamic Variables in Patients Subjected to Abdominal Aortic Aneurysm Surgery and in Patients with Septic Shock

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ABSTRACT

In order to study if oxygen saturation in mixed venous blood (SvO_2) could be used as a marker for heart performance,oxygen delivery (DO_2) or consumption (VO_2) in critically ill patients 134 hemodynamic measurements were performed by a thermodilution pulmonary catheter in 23 patients after abdominal aortic aneurysm surgery.These data were compared to 200 measurements performed in 30 patients with septic shock.

When analysed on an individal basis SvO_2 was only closely related to DO_2 or VO_2 in a minority of the patients.Neither could SvO_2 be used as a reliable marker for heart rate,hemoglobin concentration,stroke volume or cardiac index.

On the other hand SvO_2 was found to be an excellent marker for oxygen extraction (OER) in both groups of patients (median $r=0.98.p<0.0001$).

In conclusion,the present study shows that SvO_2 could not be used as a reliable marker for the important hemodynamic variables CI,DO_2 or VO_2 in critically ill patients.However,SvO_2 was found to be an excellent marker for OER.

INTRODUCTION

During the last decade continuously measured oxygen saturation in mixed venous blood (SvO_2) has gained increasing popularity because it could be used as an early warning system of cardio-respiratory changes (3).In healthy man a change in SvO_2 is often associated with a corresponding change in cardiac output (CI) but in the critically ill patient the picture becomes more complex as SvO_2 is also related to several other variables such as the oxygen saturation in arterial blood (SaO_2), hemoglobin concentration (Hb),and the metabolic demand.Critically ill patients often show deviations in several of these variables and compensatory mechanisms are often impaired.

Furthermore,different intensive care patient groups show different cardio-respiratory patterns and measurements of SvO_2 might therefore be handled

differently in different patient groups.

It has been shown that CI,oxygen delivery(DO_2) and oxygen consumption (VO_2) are the most powerful predictors of survival in critically ill patients (7) and should therefore be carefully monitored.

The present study was undertaken in order to evaluate if SvO_2 could be used as a marker for CI,DO_2 or VO_2 in the clinical setting using hemodynamic measurements from two groups of patients; the postoperative patient subjected to major surgery (abdominal aortic aneurysms) and patients with septic shock.

MATERIAL AND METHODS

In this prospectively performed study 134 hemodynamic measurements from 23 patients operated for abdominal aortic aneurysms were collected in the postoperative period.All these patients with aortic aneurysms were subjected to scheduled surgery. During general surgery together with a thoracic epidural blockade the abdominal aortic aneurysm was replaced with a dacron graft.The epidural blockade was continued during the first 24 postoperative hours.

Two hundred hemodynamic measurements were also collected in 30 patients with septic shock.Septic shock was defined as occurrence of hyperthermia (>39° C), a positive blood culture or a known intraabdominal focus and a systolic blood pressure <90mm Hg.In most patients with septic shock leukocytosis,mental confusion and oliguria were also present.

In both the postoperative patients and in those with septic shock hemodynamic measurements were performed during the first 3 days of their stay in the intensive care unit.

The hemodynamic measurements were performed using a flow-directed thermodilution Swan-Ganz catheter placed in the pulmonary artery.Cardiac output was determined in triplicate and the mean value of the three recordings was used for further calculations.

Blood was drawn simultaneously from the pulmonary artery and a radial artery for analysis of mixed venous and arterial oxygen saturation in a blood gas analyzer (ABL4,Radiometer,Denmark).

Stroke volume (SVI),Oxygen extraction ratio (OER),DO_2 and VO_2 were calculated from standard formulas (1). CO was indexed for body surface area (BSA) and denoted cardiac index (CI). Also SVI, DO_2 and VO_2 were indexed for BSA.

All data were computerized.Pearsons' correlation coefficient was calculated on an individual basis.Two-tailed significance values were given.$p<0.05$ was regarded as significant.

RESULTS

Means and SD for studied variables are shown in table 1.

Table 1.Means and SD (in parenthesis) for studied blood variables and hemodynamic measurements in the different groups.

	Postoperative	Septic shock
SvO_2 (%)	64 (9.0)	64 (7.3)
Hemoglobin (g/L)	108 (13)	98 (13)
Heart rate (beats/min)	93 (18)	106 (20)
SaO_2 (%)	95 (3.0)	93 (4.1)
CI (l/min/BSA)	3.4 (0.8)	4.8 (1.8)
SVI (ml/BSA)	37 (11)	47 (18)
DO_2 (ml/min/BSA)	494 (122)	601 (245)
VO_2 (ml/min/BSA)	157 (41)	187 (70)
OER (%)	33 (0.09)	32 (32)

A wide spread of correlation coefficients was seen when SvO_2 was related to the other hemodynamic variables in each individual.When the medians for the r-values for each of the relationships were calculated only the relationship between SvO_2 and OER was found to be close (see table 2 and fig.1 for details).

DISCUSSION

In the present study SvO_2 was not satisfactorily related to any of the important variables CI,DO_2 or VO_2 in any of the groups of patients.

Aortic aneurysm patients may show elevated serum lactate levels postoperatively (2) as a sign of an insufficient VO_2 in relation to the metabolic demand.A compensatory rise in heart performance might be limited in this group of patients because of the high prevalence of ischemic heart disease associated with abdominal aortic aneurysms.

Taken together these circumstances may distort the use of SvO_2 as a reliable indicator of CI,DO_2 or VO_2 after aortic aneurysm surgery.

In patients with septic shock both myocardial depression (8) and an impaired

Table 2.Median for individual values of Pearson´s correlation coefficient in each group when SvO_2 was related to different blood variables and hemodynamic measurements.

	Postoperative	Septic shock
Heart rate	0.46	0.59
Hemoglobin	0.40	0.50
SaO_2	0.55	0.71
SVI	0.49	0.59
DO_2	0.50	0.58
VO_2	0.56	0.71
CI	0.44	0.43
OER	0.98	0.98

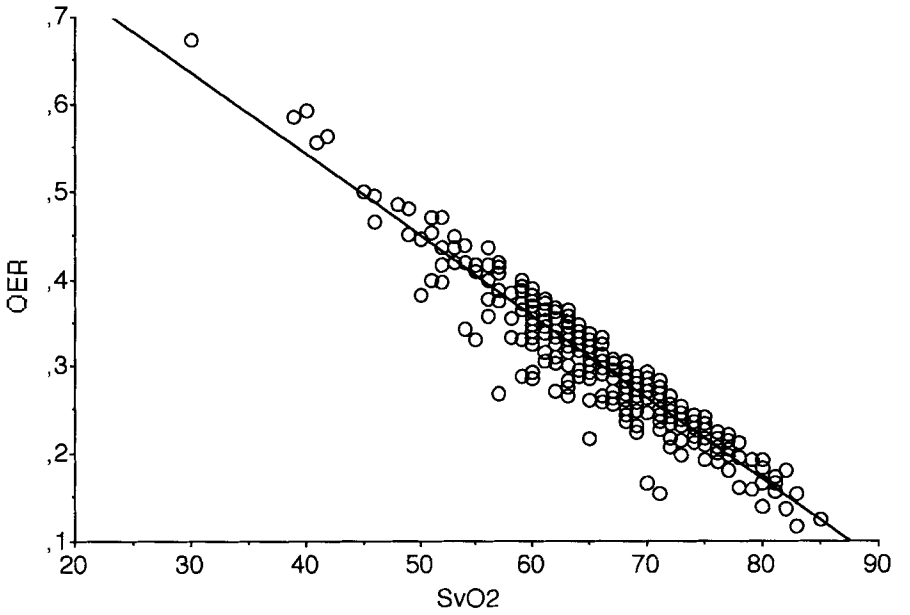

Figure 1.Relationship beween SvO_2 and OER (r=0.98,p<0.0001).

oxygen utilization in the periphery (4) have been reported .Furthermore,the metabolic demand often exceeds the VO_2 in these patients.All these factors might distort the relations between SvO_2 and the different hemodynamic variables in patients with septic shock.

As shown in previous studies (5,6) an excellent correlation between SvO_2 and OER was found in all groups of patients.OER was defined as the ratio of VO_2 to DO_2,which could be simplified as the ratio between SaO_2 -SvO_2 and SaO_2. Thus, SvO_2 in this manner should be related to 1- SvO_2/SaO_2 and as SaO_2 with modern ventilatory treatment in almost all cases could be kept > 90% the correlation coefficient between SvO_2 and OER would be close to 1.0.

In conclusion,the present study shows that SvO_2 could not be used as a reliable marker for the important hemodynamic variables CI,DO_2 or VO_2 in critically ill patients.However,SvO_2 was found to be an excellent marker for OER in all groups of patients.

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