MEASUREMENT OF MIXED VENOUS OXYGEN SATURATION ($S\bar{v}O_2$) IN HIGH RISK CARDIAC SURGERY PATIENTS

Duc Hoang Doan, Hung Phu Cao.*, Luong Tan Nguyen.***

SUMMARY

Our study included 112 high risk patients undergoing cardiac surgery in our hospital. Their postoperative hemodynamic parameters were monitored in short intervals using a Swan-Ganz catheter. A ROC curve of $S\bar{v}O_2$ was plotted based on the collected data to evaluate its prognostic performance for patient early postoperative outcome and probability of dying within 30 days after surgery.

Results: The best cut-off $S\bar{v}O_2$ value for predicting post-operative complications related to heart failure and the probability of dying within 30 days after surgery in high risk cardiac sugery patients was 55% with a sensitivity of 91.18% and specificity of 31.82%. No death was reported in this study.

Conclusions: A $S\bar{v}O_2$value < 55% at the time of admission to ICU indicates poor prognosis for high-risk cardiac surgery patients and more aggressive treatment is required accordingly. This finding is consistent with the results from several studies on patients undergoing surgery for coronary artery disease.

I. INTRODUCTION

Mixed venous oxygen saturation ($S\bar{v}O_2$) is the percentage of oxygen bound to hemoglobin in the mixed blood from the venous system returning to the pulmonary artery. Therefore, $S\bar{v}O_2$is considered a hemodynamic parameter as it provides information about the status of the oxygen delivery system of the body (DO_2):

Oxygen delivery (DO_2) = Cardiac output (CO) x Oxygen saturation (Hb x SO_2)

Studies have shown that $S\bar{v}O_2$is a parameter that could be used to evaluate therapies aiming at improving the oxygen delivery capacity to the tissue to reduce post-operative complications. However, this is an invasive and expensive technique with potential risk of complications so there are still many controversaries regarding the most effective application of $S\bar{v}O_2$ - a critical topic.

In Vietnam, there have been some studies specifically investigate the use of Swan-Ganz catheter and central venous oxygen saturation ($ScvO_2$) in intensive care setting. However, to date, there is no study examining $S\bar{v}O_2$ in the field of cardiac surgery while there is a considerable need for these surgeries, both in quantity and complexity. Cardiac surgery patients usually have limited capacity in increasing cardiac output in response to exertion and therefore, require increased oxygen extraction to meet the increased demand in oxygen after surgery, which results in a decrease in $S\bar{v}O_2$. Therefore, a declined $S\bar{v}O_2$ is an early indication of hemodynamic dysfuction.

We conducted the study *"Measurement of mixed venous oxygen saturation$S\bar{v}O_2$in high-risk cardiac surgery patients"*with two objectives:

1. Investigate the variation of $S\bar{v}O_2$ values in high-risk patients undergoing cardiac surgery;

** Saigon Tam Tri Hospital*
*** Vinmec Central Park Hospital*
Scientific director: Duc Hoang Doan MD. PhD
Manuscript received: 01/02/2019 - Accepted for publication: 23/03/2020
Scientific reviewer: A/ Prof. Dang Ngoc Hung, PhD
Prof. Le Ngoc Thanh, PhD

2. Examine the correlation between $S\bar{v}O_2$ and other hemodynamic parameters in these patients.

II. STUDY SUBJECTS AND METHODS

2.1. Data collection timepoints

∗ *T_0timepoint:*when the patient is admitted to the operating theatre

∗ *T_2 timepoint:* 2hours after the patient is admitted to the intensive care unit (ICU)

∗ *T_8 timepoint:*8 hours after the patient is admitted to the ICU

∗ *T_{off} timepoint:*when the patient is hemodynamically stable

2.2 Diagram of intensive care based on $S\bar{v}O_2$

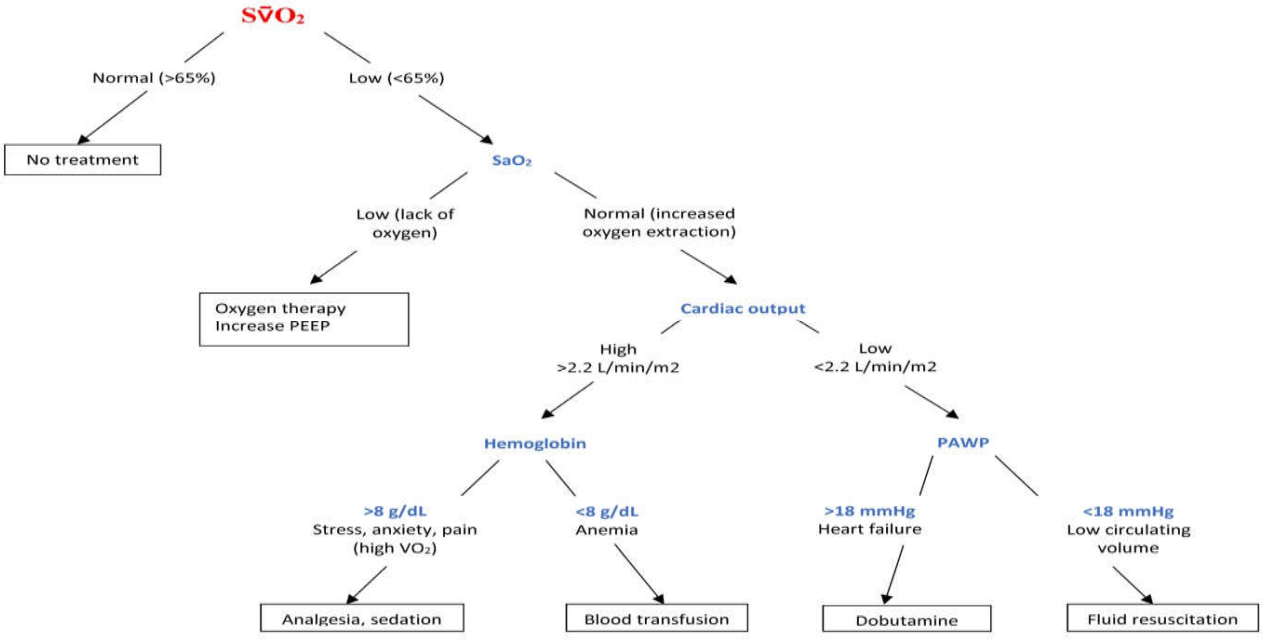


Figure 2.1. Diagram of intensive care based on $S\bar{v}O_2$

III. RESULTS

3.1. Characteristics of study cohort

∗ *Age and gender*

Table 3.1. Age and gender of study cohort

Age (years)	Gender				Total	
	Male		Female		n	%
	n	%	n	%		
< 60	38	86.4	58	85.3	96	85.7
≥ 60	6	13.6	10	14.7	16	14.3
Total	44	39.3	68	60.7	112	100

Comments: Most of patients were females and younger than 60 years old. The average age of study population was 46.69 ± 12.57 years old.

∗ *Preoperative risk factors*

Table 3.2. Preoperative risk factors

Preoperative risk factors	n	%
Preoperative heart failure (NYHA.III-IV)	91	81.3
Reduced EF < 50%	36	32.1
Pulmonary artery hypertension PAPS ≥ 55 mmHg	31	27.7
Recent myocardial infarction	4	3.6
Age ≥ 60 (years)	16	14.3

Comments: The majority of patients had NYHA.III-IV heart failure and a third of patients had reduced EF before surgery.

3.2. Variation of $S\bar{v}O_2$ values and cardiac index

∗ *Variation of $S\bar{v}O_2$ values*

Table 3.3. *$S\bar{v}O_2$ at different timepoints*

$S\bar{v}O_2$(%)	T_0	T_2	T_8	T_{off}
$S\bar{v}O_2 \geq 55\%$	112 (100%)	94 (83.9%)	56 (50.0%)	49 (43.8%)
$S\bar{v}O_2 < 55\%$	0 (0%)	18 (16.1%)	56 (50.0%)	63 (56.2%)
$S\bar{v}O_2$-TB	73.97±7.75	68.95±14.34	57.51±13.23	55.60±13.29
P	$p_{T0xT2} < 0.05$	$p_{T0xT8} < 0.05$	$p_{T0xToff} < 0.05$	$p_{T8xToff} > 0.05$

Comments: $S\bar{v}O_2$ values declined gradually from T_0 to T_{off} ($p < 0.05$).

∗ *Cardiac index (CI)*

Table 3.4. CI values

CI (litre/minute/m^2)	T_0	T_2	T_8	T_{off}
CI < 2.2	100 (89.3%)	13 (11.6%)	15 (13.4%)	11 (9.8%)
CI = 2.2- 2.5	9 (8.0%)	10 (8.9%)	19 (17.0%)	18 (16.1%)
CI > 2.5	3 (2.7%)	89 (79.5%)	78 (69.6%)	83 (74.1%)
Mean CI	1.67±0.43	3.23±0.93	2.90±0.77	2.99±0.70
P	$p_{T0xT2} < 0.05$	$p_{T0xT8} < 0.05$	$p_{T0xToff} < 0.05$	$p_{T8xToff} > 0.05$

- Many patients had severe heart failure before surgery with CI < 2.2 litre/min/m^2. The percentage of patients had CI reduced after sugery but still within the normal range ($2.2 \leq CI \leq 2.5$ litre/min/m^2) was low.
- Almost all patients had improved CI after surgery (CI ≥ 2.5 litre/min/m^2). The variation of mean CI increased post-surgery ($p < 0.05$).

3.3. Results of hemodynamic treatment

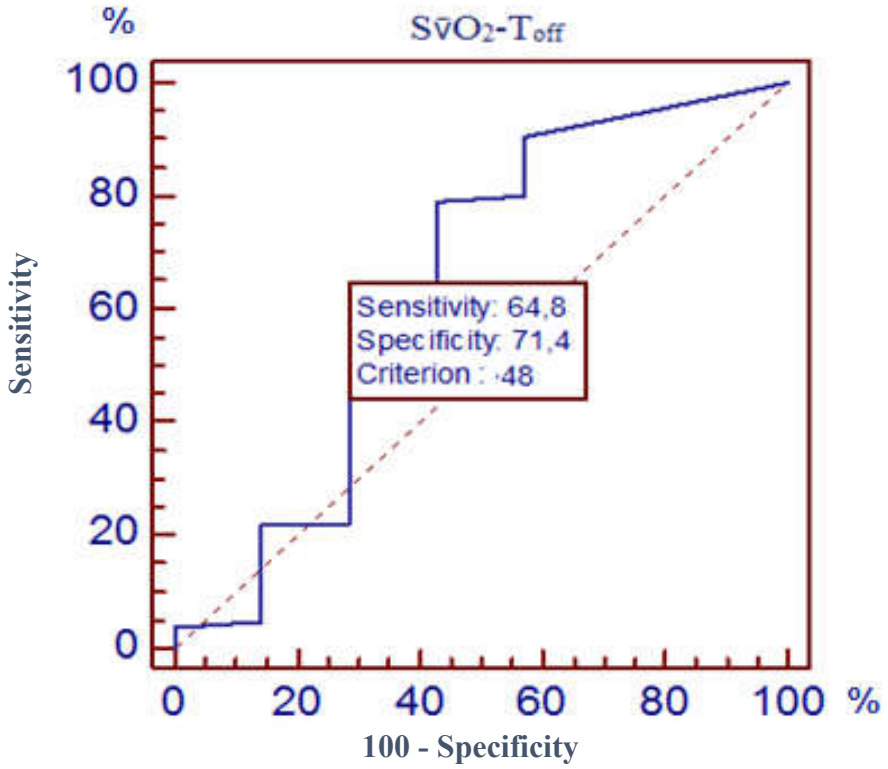
* *Ventilation duration*

Table 3.5. Ventilation duration

Ventilation time (mins)	Total	$S\bar{v}O_2 \geq 55\%$	$S\bar{v}O_2 < 55\%$	p
Mean (n=112)	22.56 ± 30.04	20.98±25.87	31.94±47.12	<0.05
Ventilation time≤48 hours	105 (93.8%)			<0.05
Ventilation time>48 hours	7 (6.2%)			

Comments: Most patients had ventilation time ≤ 48 hours; those with $S\bar{v}O_2 \geq 55\%$ had shorter ventilation time (p <0.05).

Figure 3.1. Receiver operating curve (ROC) of prognostic performance of $S\bar{v}O_2$in predicting ventilation time



Comments: The cut-off $S\bar{v}O_2$= 48%could predict the ventilation time with a sensitivity of 64.76% (95% CI= 54.8 – 73.8%) and a specificity of 71.43% (95% CI= 29.0 – 96.3%).The area under the ROC: AUC = 0.652

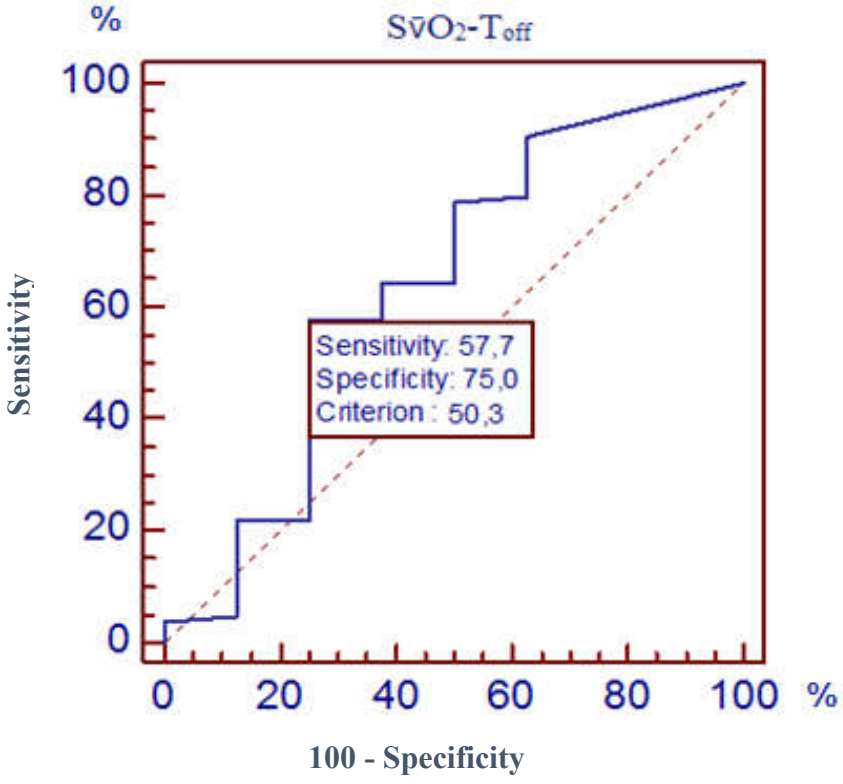
**Length of stay at the ICU*

Table 3.6. Length of stay at the ICU

Length of stay at the ICU	Total	$S\bar{v}O_2 \geq 55\%$	$S\bar{v}O_2 < 55\%$	p
Mean (n=112)	51.16 ± 35.13	48.78±30.31	63.61±53.26	<0.05
≤ 72 hours	104 (92.9%)			< 0.05
>72 hours	9 (7.1%)			

Comments: Most patients stayed at the ICU≤ 72 hours. Those with $S\bar{v}O_2 \geq 55\%$ had shorter length of stay at the ICU (p <0.05).

Figure 3.2. ROC of the length of stay at the ICU



Comments: The cut-off $S\bar{v}O_2$ = 50.3%could predict the length of stay at the ICU with a sensitivity of 57.69%(95% CI= 47.6 – 67.3%) and a specificity of 75.00%(95% CI= 34.9 – 96.8%). Area under the ROC: AUC = 0.642.

3.4. Post cardiac surgery complications

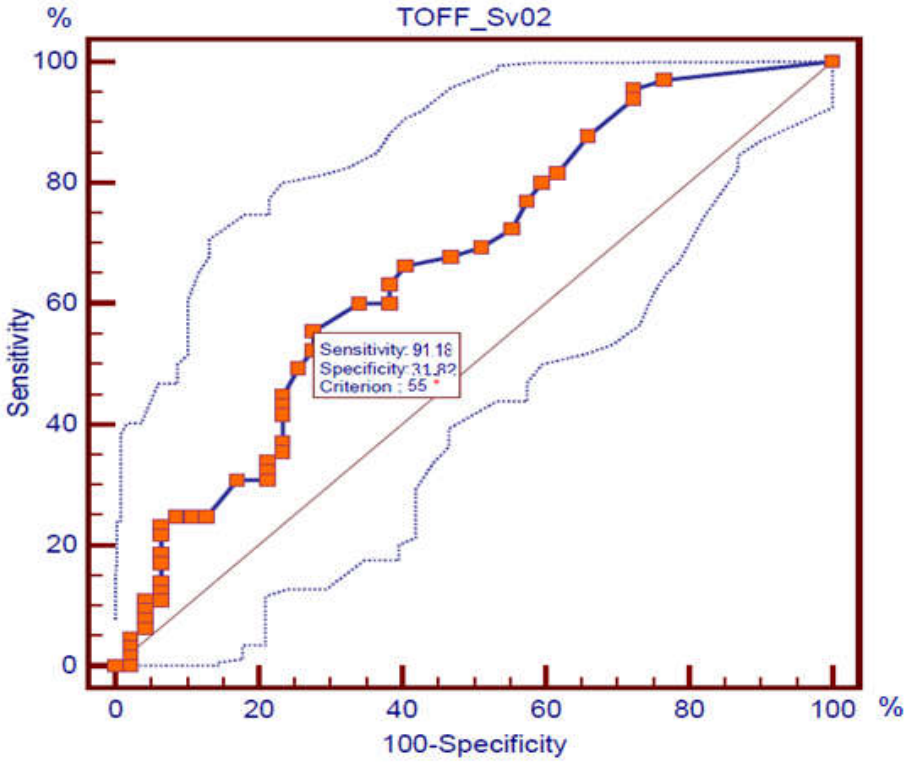
* *Post cardiac surgery complications*

Table 3.7. Post cardiac surgery complications

Postoperative complications	n	Percentage %
Bleeding	6	5.4
Renal failure	1	0.9
Low cardiac output syndrome	3	2.7
Multi-organ failure	2	1.8
Pneumonia	1	0.9
No complications	99	88.4
Death	0	0
Total	112	100

Comments: Few patients had bleeding complications; low cardiac output syndrome; one patient suffered from renal failure and three patients experienced multi-organfailure with full recovery and no postoperative death was recorded.

3.5. ROC of prognostic performance of $S\bar{v}O_2$in predicting hemodynamic outcomes



Comments:

- The hemodynamic goals of treatment include: heart rate ≤ 90 lần / phút; central venous pressure ≤ 14 mmHg; mean arterial blood pressure = 60 - 100 mmHg; pulmonary artery wedge pressure ≤ 18 mmHg; CI ≥ 2,2 litre/min/m^2; ventilation time ≤ 48 hours; length of stay at the ICU ≤ 72 hours; no low cardiac output syndrome; no renal failure; no multi-organ failure; no death.

- The cut-off $S\bar{v}O_2$ = 55%has good predictive value with a sensitivity of 91.18% (95% CI= 81.8-96.7%) and a specificity of31.82% (95% CI= 18.6-47.6%); area under the ROC: AUC = 0.640

IV. CONCLUSIONS

1. The variation of$S\bar{v}O_2$values in high-risk patients undergoing cardiac surgery

- Most of the study subjects had valvular heart disease (94.6%). The main risk factors before surgery were severe heart failure (NYHA III-IV, 81.3%), reduced EF (EF < 50%, 32.1%) and pulmonary artery hypertension (PAPS ≥ 55 mmHg, 27.7%).

- The variation of $S\bar{v}O_2$declined after surgery (from 73.97±7.75%to 55.60±13.29%;p < 0.05), while CI was improved (increased from 1.67±0.43 litre/minute/$m^2$to 2.99±0.70 litre/min/m^2; p< 0.05).

- The cut-off value of$S\bar{v}O_2$ ≥ 55% measured at the time the patient was admitted at the ICU (T_2) is an early indication of good early prognosis after cardiac surgery (sensitivityof 91.18%and specificity of 31.82%).

2. The correlation of $S\bar{v}O_2$ with other hemodynamic parameters: Hemodynamic intensive care using $S\bar{v}O_2$as an indicator was associated with improved early outcomes (91.1% of patients had CI increased ≥ 15% after fluid resuscitation, 96% had increased CI after the use of cardiac inotropes; p < 0.05); reduced ventilation time (93.8% patients on ventilation ≤ 48 hours; p < 0.05), shortened length of stay at the ICU (92.9 % stayed at the ICU ≤ 72 hours; p < 0.05), improved postoperative complications and mortality.