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CORRELATION BETWEEN PERIOPERATORY OXYGEN CENTRAL VENOUS SATURATION AND MORTALITY IN CARDIAC SURGERY: REVIEW OF SYSTEMATIC LITERATURE

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Abstract: Monitoring tissue oxygenation through central venous oxygen saturation is essential to ensure adequate perfusion. However, currently, the use of pulmonary artery catheters is discouraged in the literature, due to the fact that it is more complex, costly and invasive to the patient. Therefore, central venous oxygen saturation is commonly used in place of mixed venous oxygen saturation. This study aimed to present epidemiological data and information on the relationship between central venous oxygen saturation values below 70% and the rate of complications and mortality after cardiac surgery. The methodology was based on the search of national and international scientific articles using Pubmed as a database. Original articles indexed between 2010 and 2021 were included. The analyzed data showed that in patients undergoing elective cardiac surgery, in which central venous oxygen saturation levels < 70% perioperatively, intraoperatively and upon admission to the Intensive Care Unit, are associated with a higher risk of death. Following this same reasoning, studies have shown that in patients where fluid resuscitation was performed properly and following as a parameter values of central venous oxygen saturation greater than 70%, these patients had better postoperative recovery, reducing hospital expenses and length of stay. Therefore, it is concluded that low central venous oxygen saturation was frequently observed in patients during and after cardiac surgery and was related to higher rates of postoperative complications and higher mortality rates.
Keywords: Cardiac surgery, venous saturation, mortality.

INTRODUCTION

An estimated 234 million major surgeries are performed worldwide each year. Of these, high-risk surgical patients, such as cardiac

surgery, account for 15% of all procedures. However, they are responsible for more than 80% of deaths.1 A large portion of these deaths are due to postoperative complications. These complications, which are strongly related to the loss of balance between oxygen supply and demand.[1,2]

In addition, it can be stated that a continuous deficit in the ratio between oxygen supply (DO2) and oxygen consumption (VO2) reflects the donation in organs, and thus, death.[3] In this context, monitoring tissue oxygenation through central venous oxygen saturation (ScvO2) is essential to ensure adequate perfusion.[4]

Tissue oxygenation can be indirectly assessed by the oxygen extraction ratio, which is derived from the measurement of mixed venous saturation (SvO_2).[5] As ScvO2 is obtained by pulmonary artery catheterization, which is more costly and invasive to the patient, ScvO2 measured in the superior vena cava or right atrium has been suggested as a reliable substitute.[5,6]

In addition, the comparative simplicity of measuring ScvO2 makes this technique more attractive. With blood gas analysis technology available at most institutions, intermittent monitoring of ScvO2 can be performed on any patient with a central venous catheter.[7] Interest in measuring ScvO2 is not new, and several reports have explored the physiology and clinical significance of this parameter over the past 50 years.[8]

Furthermore, in patients undergoing cardiac surgery, ScvO2 has been shown to be higher than mean arterial pressure and heart rate as a qualitative warning sign of substantial hemodynamic deterioration.[9] Since, continuous intraoperative monitoring of ScvO2 allows early suspicion of occult bleeding, anemia, hypovolemia, increased metabolic needs or myocardial dysfunction. All conditions known to be harmful and that contribute to increased postoperative mortality.[9,10]

Consequently, the postoperative period of cardiac surgery deserves special attention, in which care and monitoring of its evolution in the ICU are essential. Since the use of cardiopulmonary bypass (CPB) associated with cardiopulmonary arrest has the potential to induce an exacerbated systemic inflammatory response, determining multiple organ dysfunctions.[10] For this reason, it is essential to know the physiological changes determined by surgical stress, so that homeostasis can be maintained during and after the procedure, determining satisfactory results with minimal morbidity and mortality.[11]

Because of this, beneficial effects of ScvO2 monitoring are reported during and after cardiac surgery.[12] The results of cardiac surgery are related to both preoperative risk factors and the proper management of homeostasis during and after the surgical procedure.[12,13] The main risk factors include: ventricular dysfunction (ejection fraction < 30%), left main coronary artery lesion, diabetes, renal failure, obesity, lung disease and old age. The literature has several methodologies and scores for risk assessment and outcome prediction, providing tools for the assessment of service quality and the development of continuous improvement strategies.[14]

Thus, aiming to seek tools to improve the outcomes of patients undergoing cardiac surgery. The present study aimed to present epidemiological data and information about ScvO2 values in the perioperative period and in the immediate postoperative period and to consider its correlation with mortality in patients undergoing cardiac surgery. Since, low ScvO2 when diagnosed early can be a strong predictor of progression to postoperative complications, which could be minimized with the pursuit of early goal-

directed therapy. Therefore, this knowledge aims to offer a better quality of life to the patient and a better basis for outlining the medical conduct.

MATERIALS AND METHODS

The methodology was based on the search of national and international scientific articles using Pubmed as a database. For the construction of the systematic literature review, original articles with experimental or observational design were included, using the following descriptors: "Correlation Between Perioperative Central Venous Oxygen Saturation and Mortality in Cardiac Surgery"; "Svco2 in Cardiac Surgery"; "Post Cardiac Surgery"; "Central Venous Oxygen Saturation"; "Goal Guided Perioperative Haemodynamic Therapy", using the "and" and "or" operators. From these descriptors, the following search phrases were created to assist in the search for data: "Correlation Between Perioperative Central Venous Oxygen Saturation and Mortality in Cardiac Surgery" OR "Post Cardiac Surgery" AND "Svco2 in Cardiac Surgery" OR "Central Venous Oxygen Saturation" OR "Goal Guided Perioperative Haemodynamic Therapy"; "Post Cardiac Surgery" OR "Central Venous Oxygen Saturation" AND "Svco2 in Cardiac Surgery" OR "Correlation Between Perioperative Central Venous Oxygen Saturation and Mortality in Cardiac Surgery" OR "Post Cardiac Surgery ".

With the first sentence, 2 articles were found, with the second 750 and with the third 780, totaling 1532 articles. After placing all filters, 1, 32 and 25 articles remained, respectively, totaling 58 articles.

The inclusion criteria used were: articles published between 2010 and 2021; full articles available for free; articles in English; clinical trials, randomized controlled trials and systematic literature reviews. The exclusion criteria were: duplicate articles and articles outside the topic addressed.

RESULTS

A total of 1532 articles were found in the researched database, of which 15 were selected for data extraction, with their synthesis and interpretation (Figure 1). The extracted information was separated into the following topics: author; year; goal; conclusion (Chart 1).

From the analyzed data, it is possible to see that the perioperative changes in ScvO 2 are related to the imbalance between oxygen consumption and supply. Similarly, reductions in ScvO 2 are common after major surgery, particularly cardiac surgery, and are associated with an increased rate of postoperative complications.

Furthermore, patients undergoing major surgery with low levels of ScvO 2 in the preoperative period evolved with a worse intra- and postoperative prognosis. Thus, this marker is important to stratify risk and suggest a therapeutic routine to be adopted preoperatively.

DISCUSSION

The successful use of central venous oxygen saturation (ScvO 2) as a hemodynamic goal in the management of early sepsis has sparked interest in the use of this parameter in surgical patients. [15]

Experimental studies have shown that changes in ScvO 2 closely reflect circulatory disturbances during periods of hypoxia, hemorrhage, and subsequent resuscitation. The fluctuations correlate well with mixed venous saturation (SvO 2) measurements, although the absolute values are different.[16] Observational studies have described changes in ScvO2 in several groups.[7,16] In particular, the prognostic significance of ScvO2 reductions below 65% has been demonstrated in trauma,

severe sepsis, myocardial infarction, and heart failure.[17]

Pearse *et al*. found that low ScvO2 trough values during the first eight hours post-operatively were associated with an increased risk of post-operative complications.[7] Their results come from a strictly protocolized single-center interventional study of goal-directed hemodynamic management in high-risk surgical patients.[20]

Currently, few parameters are used in clinical practice to assess tissue hypoxia, such as urinary output, acid-base differences and plasma lactate levels. However, these parameters show that hypoperfusion is already established and may be late parameters to guide the initiation of hemodynamic resuscitation.[21]

Rivers et al., demonstrated in one of his prospective randomized study in patients with severe sepsis and septic shock that, in addition to maintaining central venous pressure above 8-12 mm Hg, mean arterial pressure above 65 mm Hg, and urinary output above 0.5 mL / kg / h, maintaining an ScvO 2 above 70% resulted in an absolute 15% reduction in mortality. These findings refueled interest in measuring ScvO 2 in critically ill patients.[4,6,22]

In agreement with the above, in another study Rivers et al. used ScvO2 with a value of 70% as a goal for goal-directed hemodynamic therapy (GDT) in patients who presented to the hospital with severe sepsis and septic shock.[4,23] They demonstrated that it may be possible to achieve substantial reductions in mortality without the need for complex or invasive cardiac output monitoring technology. The success of the work by Rivers et al. and several perioperative GDT trials indicate that the use of ScvO 2 as a hemodynamic target may be equally valuable in surgical patients.[4,22,23]

Therefore, considering that the multiple logistic regression analysis model confirmed that ScvO2 < 70% after anesthetic induction is an independent risk factor associated with mortality, it is noteworthy that patients with initial intraoperative values below 70% need attention for improve tissue perfusion.[14,25]

Thus, the optimization of blood volume, cardiac output and/or hemoglobin must be considered. This recommendation is based on Fick's equation, since ScvO2 is a passive variable determined by arterial oxygen saturation, hemoglobin, cardiac output, and oxygen consumption.[5,26]

Furthermore, the study by Pearse et al. demonstrated in their results the evidence of the association between ScvO 2 and postoperative complications in a purely observational and multicenter environment. In addition, intraoperatively, a significant difference in ScvO 2 between patients who developed and those who did not develop complications can be seen.[7,27]

The essential finding of the aforementioned study is the occurrence of considerable fluctuations in ScvO 2 after major general surgery, with prognostic significance. Multivariate analysis identified the lowest ScvO 2 value, lowest CI value and P-POSSUM score as independent predictors of complications. This observation supports the conjecture that it is possible that disturbances in ScvO 2, IC and DO 2 I may indicate the presence of occult tissue hypoperfusion before disturbances in other parameters.[7,28]

Perioperative hemodynamic improvement has contributed to reductions in morbidity and mortality in patients undergoing major surgery, such as cardiac surgery. The results demonstrate that volume expansion by saline solution can establish a maximum venous oxygen saturation in the surgical patient.[29]

The data confirm that unfavorable outcomes after high-risk surgeries represent a global problem.[4,5] Even in patients who survive hospitalization, complications remain an important determinant of short survival

time.[5,30] Therefore, it is essential to seek tools that improve the evolution of patients undergoing major surgeries.[30]

CONCLUSION

Therefore, it is concluded that low ScvO 2 was frequently observed in patients during and after cardiac surgery and ScvO 2 values < 70% were related to higher rates of postoperative complications and higher mortality rate. Therefore, it was demonstrated that ScvO 2 can be considered an early parameter to identify worse evolution in surgical patients.

These follow-ups encourage studies to adopt ScvO 2 as the therapeutic goal of objective-directed fluid therapy in high-risk surgical patients. Based on these data, and in agreement with other studies,13 preoperative ScvO 2 levels must be above 70% to 75% and levels below 70% must be avoided.

Despite the promising results of this work, the routine perioperative use of goal-guided fluid therapy guided by Scv O 2 cannot be recommended until a large randomized trial has confirmed the value of this approach. Thus, the aim is to update professionals and students in the area and the current bibliography.

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ANNEX

Author	Year	Goal	Conclusion
Donizetti et al.[1]	2016	Evaluate the clinical efficacy of Objective-Guided Therapy in hemodynamics to reduce morbidity and mortality in surgical patients. Establish a guideline for hemodynamic monitoring and fluid resuscitation in high-risk patients.	It was recommended that hemodynamic parameters be used as an integral part of the protocols. The presence of fluid responsiveness is not an indication for fluid administration; the final decision to administer fluids must be supported by the apparent need for hemodynamic improvement, the presence of fluid responsiveness, and the absence of associated risks.
Miranda et al.[5]	2020	Monitor perioperative central venous oxygen saturation and assess its correlation with mortality in cardiac surgery.	Early intraoperative central venous oxygen saturation values lower than 70% indicated a higher risk of death in patients undergoing cardiac surgery. There was a perioperative reduction of it, with high levels in the intraoperative period and lower levels in the postoperative period.
Gutierrez et al.[9]	2020	Examine the physiological basis for the use of central and mixed venous oxygen saturations to determine systemic extraction rate, oxygen consumption, and tissue oxygenation.	The ideal variable monitored in the ICU must meet each of the following parameters: (1) easy to measure; (2) easy to interpret; (3) amenable to treatment; and (4) measured non-invasively. Pulse oximetry is the ultimate monitoring device that meets all of these criteria. Monitoring of central venous oxygen saturations, on the other hand, falls far short of this expectation.
Hartog et al. [10]	2014	Early detection and rapid treatment of tissue hypoxia from venous oxygen saturation.	The use of central hemodynamic monitoring and venous oxygen saturation did not improve long-term survival when compared to clinical assessment of circulation adequacy.
Shaw et al. [11]	2018	Analyze the US multicenter retrospective electronic health records database to identify associations between the use of pulmonary artery catheters in adult cardiac surgery and effects on clinical outcomes.	The use of pulmonary artery catheters during cardiac surgery in adults is associated with decreased length of stay, reduced cardiopulmonary morbidity, and increased infectious morbidity, but no increase in 30-day hospital mortality. This suggests an overall potential benefit associated with pulmonary artery catheter-based monitoring in this population.
Laine et al. [12]	2013	To determine whether isolated central venous oxygen saturation generates an increase or decrease in lactato na admissão em uma UTI e associa-se a um aumento da morbidade e do tempo de permanência após cirurgia cardíaca.	Low central venous oxygen saturation isolated with normal lactate or moderately lactate high with normal central venous oxygen saturation on admission to the ICU after cardiac surgery was not associated with increased morbidity or length of stay.
Gasparovic et al. [13]	2014	Avaliar a relação entre as saturações venosa central e venosa mista no período pós-operatório imediato.	A acurácia diagnóstica da saturação venosa central para estimar a venosa mista é proporcional ao desempenho cardíaco. Correlacionou-se com a necessidade de suporte inotrópico, maior escore de risco operatório, idade, nível de lactato e duração da circulação extracorpórea.

Balzer et al. [18]	2015	To determine the impact of central venous saturation measured in the ICU on admission after cardiac surgery.	Patients with high central venous saturation were particularly affected by unfavorable outcomes.
Beest et al. [23]	2011	The use of venous oxygen saturations seems especially useful in the early stages of illness or injury. It is still unclear whether venous oxygen saturations must be measured continuously.	The use of venous oxygen saturations seems especially useful in the early stages of illness or injury. It remains unclear whether venous oxygen saturations must be measured continuously.
Futier et al. [28]	2010	Identify persistent low flow after preload optimization has been achieved by fluid loading during high-risk surgery.	Central venous saturation reflects important changes in O 2 supply in relation to O 2 requirements during the perioperative period. Central venous-arterial carbon dioxide <5 mmHg can serve as a complementary target to central venous oxygen saturation during objective-directed fluid therapy to identify persistent inadequacy of circulatory response in the face of metabolic needs when thecentral venous oxygen saturation ≥71% is achieved.
Suehiro et al. [32]	2014	To determine whether increases in the discrepancy between central and mixed venous saturation during surgery in cardiac surgery patients can predict postoperative complications.	The discrepancy between central and mixed venous saturation during cardiac surgery is an independent risk factor for postoperative complications, such as prolonged ICU stay and ventilation time.
Shanmukhappa et al.[33]	2020	Relate central venous saturation to meet tissue metabolic demands.	Venous oxygen saturation levels must be used in conjunction with other hemodynamic parameters. However, there is still a lot to be understood about the translation of the information provided by him into therapeutic protocols for beneficial results.
Lobo et al. [34]	2013	An important goal is to prevent an imbalance between oxygen supply and oxygen consumption in order to prevent the development of multiple organ dysfunction.	In the ICU, additional therapy titrated to increase central venous saturation or the venous-arterial carbon dioxide difference and to decrease serum lactate concentrations may be necessary to restore adequate systemic oxygenation.
Júnior et al. [35]	2010	Assess the low central venous oxygen saturation that indicates an imbalance between the supply and consumption of cellular oxygen and, consequently, a worse prognosis for critically ill patients.	Intraoperative central venous oxygen saturation levels are higher than pre- and postoperative levels. However, low preoperative central venous oxygen saturation determines a worse prognosis.
Holm et al. [36]	2010	To analyze the operating characteristics of the central venous oxygen saturation receptor in relation to postoperative heart failure-related mortality and mortality	Central venous oxygen saturation on admission to the ICU after aortic stenosis surgery demonstrated excellent sensitivity and specificity for postoperative mortality related to heart failure andimportant for all-cause mortality, with excellent negative predictive value.