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Use of Cerebral Oximetry in Anemic Patient

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Abstract: Anemia increases the duration of hospital stay, costs, mortality, and morbidity. It is a serious health problem commonly seen in both perioperative and critical care patients. The primary purpose of blood is to transport oxygen to cells for the realization of energy-producing aerobic metabolism. Near-Infrared Spectroscopy (NIRS) technique is a non-invasive monitoring method that assesses average regional tissue oxygenation. The cerebral oximeter was placed bilaterally on the frontal cortex and measured near the transcutaneous membrane. It is believed that NIRS monitoring will be an effective key in resolving the dilemma of anemia and transfusion in patients by detecting tissue oxygenation disorders. Clinical studies are required for this. In this article, the connection between NIRS and anemia will be discussed. ©2024 NTMS.

Keywords: Cerebral Oximeter; Anemia; Tissue Oxygenation.

1. Introduction

Anemia is a common health problem encountered during the perioperative period. The World Health Organization has defined anemia as hemoglobin levels below 13 gr/dL in men and below 12 gr/dL in women. Anemia is a widespread health issue globally and is associated with mortality and morbidity [1]. According to the results of the World Health Organization's anemia prevalence studies, 48.8% of the world's population is anemic, and in Turkey, this rate is 25% [2]. Clinicians do not give the problem of anemia the same level of attention as other problems that increase mortality and morbidity to the same extent [2]. This is thought to be due to the existence of a simple solution such as blood transfusion. However, due to its complications and cost burden, the notion that blood transfusion is not entirely benign is increasingly being recognized. Knowing that both anemia and blood transfusion are factors that increase mortality and morbidity, it is believed that determining when to perform blood transfusion in the treatment of anemia during the perioperative period can prevent complications arising from these problems [3].

One of the most important factors ensuring adequate oxygenation of the tissues is the hemoglobin value. In anemia, there is a reduction in blood oxygen content and a disruption in tissue oxygenation. As a result, tissue hypoxia, organ failure, and death are observed [4]. There is a high incidence of anemia in surgical patients, most of which is treatable. Successful treatment of anemia in the preoperative period can prevent many blood transfusions. Anemia treatment should definitely be done before elective surgery. Ideally, anemia should be treated four weeks before elective surgery, as proceeding with surgery without treating anemia can lead to unnecessary blood transfusions.

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This is associated with mortality and morbidity. Therefore, especially in surgeries with a high risk of bleeding, anemia should be treated before proceeding with surgery [1,3].

Pulse oximetry is the most commonly used method for measuring oxygen levels in anesthesia practice. By attaching it to the distal extremities, the ratio of oxygenated hemoglobin to deoxygenated hemoglobin within the arterial system is measured. However, in individuals undergoing surgical procedures (such as open-heart surgery or hypotensive surgical applications) who experience cardiac arrest, measuring oxygen levels with a pulse oximeter on any extremity can lead to erroneous monitoring of oxygen levels within the cerebral vascular system. To evaluate cerebral tissue oxygenation and perfusion, cerebral oximetry has emerged as a specialized monitoring tool in anesthesia over the last two decades. There are two extensions of pulse oximetry: mixed venous blood oxygen saturation (SvO2) and cerebral oximetry. Evaluating SvO2 is challenging due to its dependence on factors like hemoglobin concentration, cardiac output, arterial oxygen saturation, and whole-body oxygen consumption. Therefore, cerebral oximetry has become more popular for assessing cerebral oxygenation. Cerebral oximetry employs non-invasive NIRS to monitor cerebral oxygenation. Its principle of operation is similar to that of conventional pulse oximetry, evaluating the ratio of oxygenated hemoglobin to deoxygenated hemoglobin. The self-adhesive emitters and sensor pads applied to the skin for cerebral oximetry measure light attenuation noninvasively at a predetermined distance from the NIRS emitter. It operates based on the detection of light emitted by the transmitter diode and detected by receiver diodes [5].

2. Discussion

The purpose of blood transfusion is to increase the oxygen-carrying capacity of the blood, correct hemostasis, increase oxygen delivery to tissues, and provide volume expansion to increase cardiac filling. Factors leading to unnecessary blood transfusion in anemia include lack of education, lack of knowledge, being the easiest option, quickly and easily correcting anemia, and lack of monitoring [6]. Parameters like hemoglobin, hematocrit, vital signs, and blood loss are insufficient in monitoring tissue oxygenation. Studies to date have used various parameters in monitoring tissue oxygenation [4]. These parameters are divided into global and regional parameters. Global parameters include venous oxygen saturation, central venoarterial carbon dioxide difference, arterial lactate level, lactate pyruvate ratio, and methemoglobin values. Regional parameters are gastric intramucosal pH, gastrointestinal tract tissue oxygenation, sublingual microcirculation, transcutaneous gas measurements, and NIRS [4,7].

Publications indicate that NIRS is associated with blood loss and can be used to detect early hypovolemia, decrease in total hemoglobin index, and critical hemoglobin value for blood transfusion. A NIRS device consists of a light source emitting light in the near-infrared range (650-1000 nm) at two or more wavelengths and a detector placed at a known distance from the source. NIRS devices contain diodes that generate specific wavelengths and photodiodes made of silicon that can measure the transmission/absorption ratio. NIRS is a technique that measures the amount of absorption undergone by chromophore molecules such as oxyhemoglobin and deoxyhemoglobin, myoglobin, etc., as near-infrared light passes through tissues. The absorption of near-infrared light by chromophores varies depending on whether they are oxygenated or deoxygenated [4,8].

The incidence of anemia is 20-30% in non-cardiac surgery, 50% in cardiac surgery, and 90% in the postoperative period. Both morbidity and mortality have been found to be associated with anemia even in major non-cardiac surgeries [9,10]. Alexander Kulier and colleagues included 5065 patients undergoing coronary artery bypass graft surgery across 70 institutions worldwide and collected 7500 data points per patient. The research examined the effect of preoperative anemia on patients undergoing coronary artery bypass graft surgery. The relationship between preoperative in-hospital cardiac and non-cardiac morbidity and mortality was investigated in 4804 patients who did not receive preoperative blood transfusions. The likelihood of postoperative adverse events is higher in anemic patients undergoing heart surgery. The number of prior comorbidities has a significant impact on tolerance to perioperative anemia. Therefore, individual preoperative hemoglobin levels and the extent of accompanying risk factors should be considered in preoperative risk assessment and subsequent treatment plans such as blood transfusion [11].

Ülkü Sabuncu and Ayşegül Özgök reported in their letter to the editor titled "The Role of Cerebral Oxygen Saturation Monitoring in Detecting Regional Tissue Hypoxia" that NIRS could be useful in detecting tissue oxygenation. In their article, they considered that even when hemodynamic data of the patient is normal, tissue oxygen delivery could be reduced, and detecting this reduction could be effective in making transfusion decisions. They suggested that NIRS could be used as an additional routine monitoring method for transfusion [12].

Aritürk and colleagues investigated whether monitoring cerebral regional oxygen saturation (rSO2) via near-infrared spectroscopy (NIRS) is useful in assessing the effects of severe dilutional anemia on the brain during elective coronary arterial bypass graft (CABG) surgery. In the study, 15 patients had a hemoglobin level below 7 gr/dL and 15 patients had a hemoglobin level above 8 gr/dL. Both groups were monitored with standard monitoring as well as rSO2 monitoring. Initial NIRS values and values recorded during cardiopulmonary bypass were recorded for both groups. It was found that in patients with low hemoglobin values, changes in cerebral rSO2 were

within acceptable limits and consistent with blood lactate and blood gas analyses. It was thought that monitoring cerebral rSO2 with NIRS could be useful in evaluating the effects of severe dilutional anemia on the brain during CABG surgery [8].

In a study conducted on premature babies regarding brain tissue oxygen saturation and extraction before and after blood transfusion, it was examined whether pre-transfusion hemoglobin levels were related to rSO2 and fractional tissue oxygen extraction (FTOE), and the changes in these levels after blood transfusion were observed. As a result, it has been shown that cerebral tissue oxygen saturation significantly increased within the first 24 hours in premature babies receiving blood transfusions. However, FTOE was found to be low. It suggests that cerebral oxygenation may be at risk in premature babies when hemoglobin is below 9.7 g/dL [13]. The increase in hemoglobin values after blood transfusion has been shown to improve cerebral tissue oxygenation in other studies related to anemia and cerebral tissue oxygenation in preterm infants [14]. As a result of the conducted studies, it is thought that studies using NIRS in pediatric cases are promising.

The purpose of Liu and colleagues' study was to determine whether the decrease in hemoglobin during surgical operations for the correction of scoliosis in children affects cerebral oxygen saturation. There can be some issues with the surgical correction of scoliosis in childhood. Massive bleeding is one of these. A drop in hemoglobin levels following massive bleeding can disrupt cerebral perfusion, lead to hypoxia in brain tissue, and cause postoperative neurological problems. In this study, in addition to standard monitoring of heart rate, blood pressure, and oxygen saturation, monitoring intraoperative cerebral oxygen saturation provided useful information for ensuring the safety of surgery and anesthesia, and could also serve as a reference for fluid resuscitation and blood transfusion [15].

3. Conclusion

Near-Infrared Spectroscopy (NIRS) has been integrated into anesthesia practices, particularly in cardiovascular surgical cases, alongside standard monitoring (pulse, blood pressure, oxygen saturation, end-tidal carbon dioxide) and blood gas analysis. Research indicates that NIRS is beneficial in assessing tissue oxygenation. It has been noted that tissue oxygenation may be compromised even when hemodynamic parameters of the patient appear adequate, and NIRS can assist in deciding on transfusion in cases of anemia.

Recently, NIRS has been employed as an adjunct monitoring tool in neonatal intensive care units and other surgical settings. Neonatal ICU data includes 24-hour post-transfusion NIRS readings for anemic infants. However, there is insufficient information regarding the long-term outcomes and effects of transfusion monitored by NIRS in anemic patients. Therefore, anesthesiologists and surgeons should identify anemia in the preoperative period and closely monitor patients with preoperative anemia undergoing planned surgery.

Literature review suggests a lack of sufficient clinical evidence for the use of NIRS in anemic patients, indicating the need for supportive clinical studies to address this gap.

Limitations of the Study

None.

Acknowledgement

None.

Conflict of Interests

The authors have no conflicts of interest to declare.

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Author Contributions

HSK: Study conception, design, data collection and write the manuscript. SA: Data collection, HSK, SA: Analysis and interpretation of results, data collection. HSK, SA: Data collection. HSK: Study design, supervised the work, performed the analysis, contributed data and analysis tools. All authors read and approved the final version of the manuscript.

Ethical Approval

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Consent to participate

None.

Informed Statement

None.

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