

REVERSING CEREBRAL DESATURATION IN CORONARY ARTERY BYPASS GRAFT AND VALVE SURGERIES

With the INVOS™ cerebral/somatic oximeter

Prolonged cerebral desaturation during on-pump coronary artery bypass graft (CABG) and valve replacement surgeries has been linked to negative and costly postoperative patient outcomes. Examples include neurological deficit and prolonged hospital stay.^{1,2}

The American Society of Anesthesiology Brain Health Initiative states clinicians should seek tools to optimize cerebral perfusion to prevent perioperative neurocognitive disorders.³ The 2015 American Society of Anesthesiologists Practice Guidelines for Perioperative Blood Management reported that 91 percent to 95 percent of surveyed consultants and members agree with using additional monitoring modalities, including cerebral oximetry, for transfusion management.⁴ Additionally, the Japanese Society of Cardiovascular Anesthesiologists states that the proper use of NIRS technology is “indispensable” in monitoring and preventing cerebral injury during cardiac surgery.⁵

The American Society for Enhanced Recovery and Perioperative Quality Initiative provided recommendations for the use of perioperative cerebral oximetry, such as:⁶

- Using preoperative rSO₂ values to help identify patients who may be at increased risk of adverse outcomes
- Monitoring trends of perioperative rSO₂ values as they relate to the baseline, not absolute thresholds
- Using cerebral oximetry to guide interventions to manage changes in perfusion during cardiac surgery — and in turn reduce ICU length of stay

Cerebral oximetry-guided identification of cerebral desaturation coupled with an interventional algorithm targeting common causes of inadequate tissue oxygenation may decrease the burden of cerebral oxygen desaturation.^{7,8}

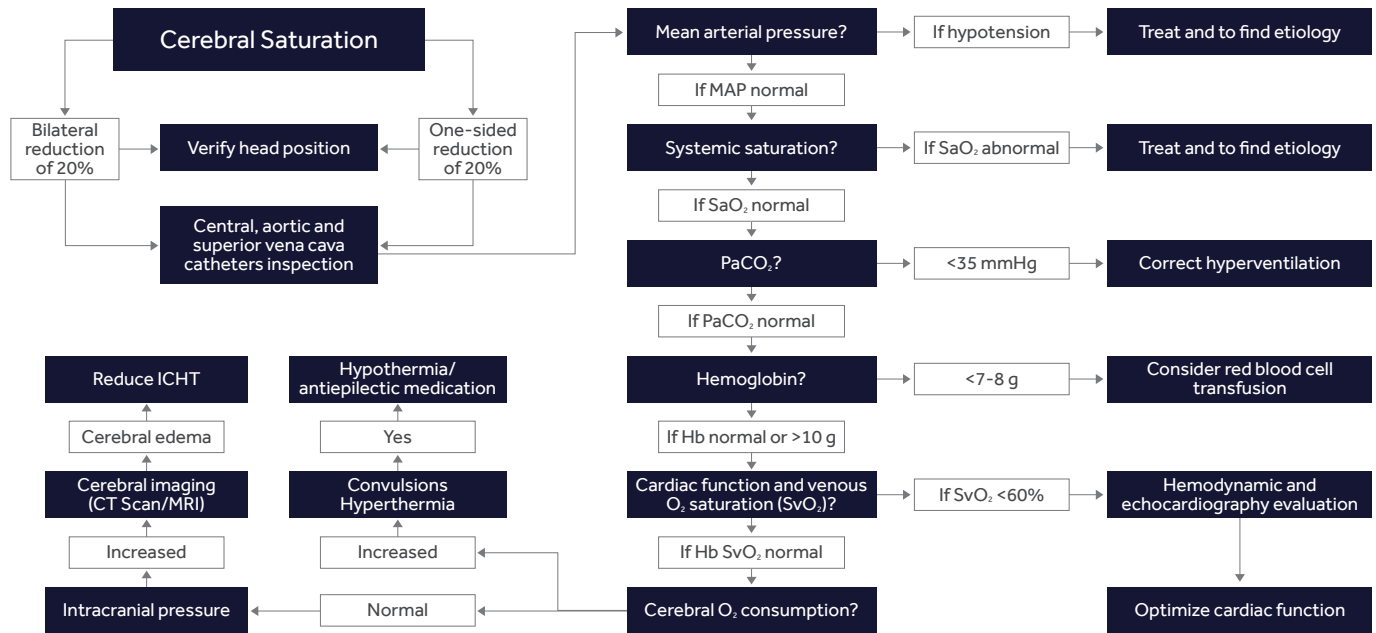
Peer-reviewed research, including publications outlined in this clinical evidence guide, have shown that monitoring and intervention improve postoperative outcomes, such as:

- Postoperative cognitive decline⁹
- ICU length of stay^{10,11}
- Major organ morbidity and mortality¹⁰⁻¹²

The Denault Algorithm

In 2007, Denault and Murkin, et al. published an interventional algorithm to assist clinicians in reversing cerebral desaturation events.^{10,13} Since its initial publication, the algorithm has been repeatedly demonstrated to be effective in high-risk surgical patients.^{7,8} The interventions in the algorithm target factors that regularly influence cerebral oxygen supply and demand such as:

- Perfusion pressure
- Cardiac output
- Arterial oxygen content
- Partial pressure of carbon dioxide (PaCO₂)
- Cerebral metabolic rate



Cerebral desaturation during CABG or valve surgery may require a variety of interventions for resolution

A multicenter pilot study assessing regional cerebral oxygen desaturation frequency during cardiopulmonary bypass and responsiveness to an intervention algorithm

SUBRAMANIAN B, NYMAN C, FRITOCK M, KLINGER RY, ET AL. (US)

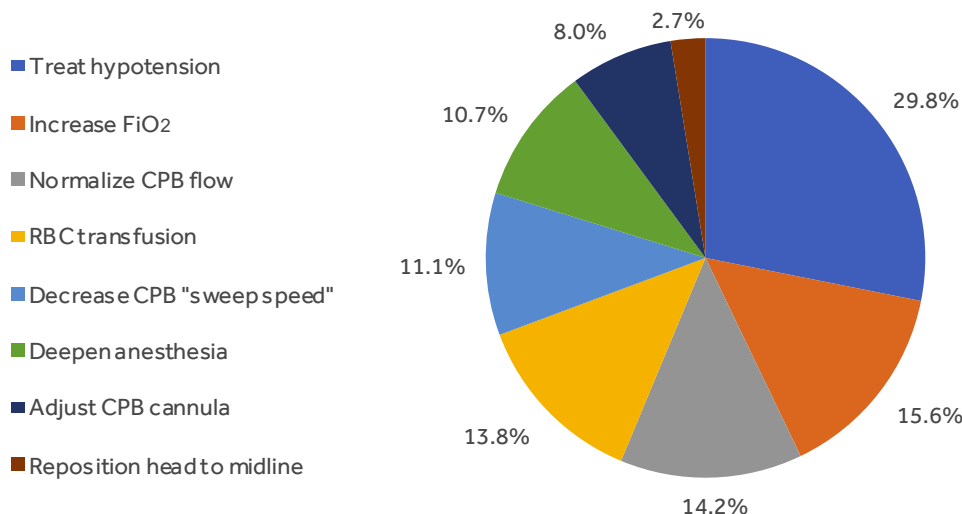


Figure: Interventions that corrected a total of 225 desaturation events (rSO₂ decrease of > 20% from baseline) among patients undergoing cardiac surgery on cardiopulmonary bypass

61%

Of patients experienced a cerebral desaturation event (CDE)

All but **18**

Of the patients had resolved CDEs with intervention

30%

Of events required > 3 interventions

Prospective multicenter cohort study of 235 adult patients undergoing coronary artery bypass graft and/or valvular surgery on cardiopulmonary bypass (CPB)

The trial sought to determine the incidence of cerebral desaturation events (CDE), how often clinicians can accurately detect them, and the effectiveness of an intervention protocol to reverse cerebral desaturations. CABG comprised 54.9 percent of the study population, alone or in combination with other valve procedures. CDEs were defined as a drop of rSO₂ more than 20 percent from the baseline value as measured by INVOS™ monitoring technology. **In the findings:**

- Clinicians identified all patients that desaturated but only identified 89.5 percent total desaturation events recorded by the NIRS monitor
- Of 340 total cerebral desaturation events, 115 resolved spontaneously
- Cerebral desaturation was resolved via the interventional algorithm in 92 percent of the remaining 225 events
- The number of interventions required to address cerebral desaturation were:
 - 1 intervention: 32 percent
 - 2 interventions: 26 percent
 - 3 interventions: 12 percent
 - >3 interventions: 30 percent

Cerebral oximetry-guided intervention during CABG surgery may reduce postoperative cognitive decline

Influence of intraoperative cerebral oximetry monitoring on neurocognitive function after coronary artery bypass surgery: a randomized, prospective study

COLAK Z, BOROJEVIC M, BOGOVIC A, ET AL. (Croatia)

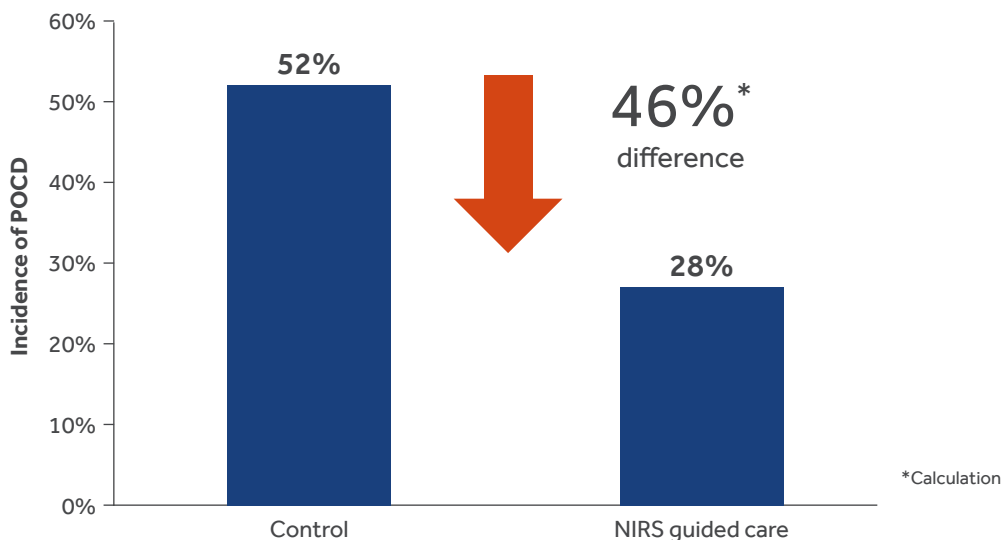


Figure: Incidence of cognitive decline among 200 coronary artery bypass graft (CABG) patients randomized to receive either care guided by cerebral oximetry partnered with an interventional algorithm or standard practice ($P=0.002$)

Patients undergoing CABG surgery on cardiopulmonary bypass (CPB):

40.3%

Overall incidence of POCD

12x

Higher odds of POCD among those who had prolonged desaturation

79%

Decreased odds of POCD with INVOS™ monitoring

Single center, prospective, double-blinded, randomized control trial of 200 patients undergoing coronary artery bypass graft surgery (CABG) on cardiopulmonary bypass (CPB)

The goal of the trial was to decrease the incidence of postoperative cognitive dysfunction (POCD) with the use of continuous cerebral oxygenation monitoring (INVOS™ monitoring technology) and an interventional protocol. Patients either received standard monitoring or INVOS™ monitoring with interventions occurring if the patient desaturated below 80 percent of baseline or below an rSO_2 value of 50 percent for more than a minute. Neurocognitive testing occurred preoperatively and seven days postoperatively. **In the findings:**

- Patients randomized to monitoring and intervention had a lower rate of POCD 7 days after surgery (28% vs. 52%; $P=0.002$)
- Those with prolonged desaturation had a 12x higher odds of cognitive decline
- Intraoperative NIRS monitoring was associated with a lower odds of POCD

Cerebral oximetry guided intervention during CABG surgery may reduce ICU length of stay and major morbidity and mortality

Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study

MURKIN JM, ADAMS SJ, NOVICK RJ, ET AL. (Canada)

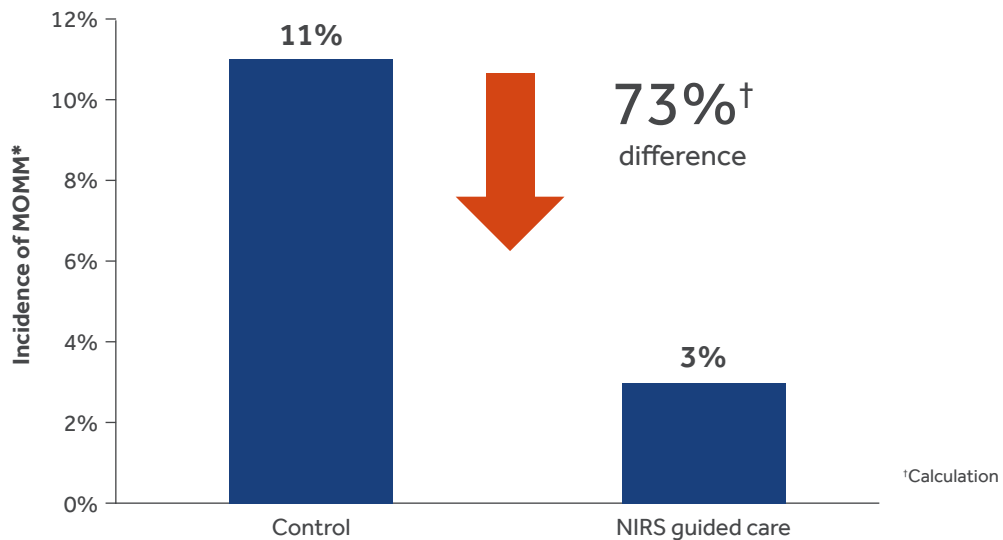


Figure: Incidence of major organ morbidity and mortality among 200 patients undergoing coronary artery bypass graft surgery on CPB ($P < 0.05$)

*MOMM is a composite endpoint of outcomes including death, prolonged ventilation, stroke, myocardial infarction, and return for re-exploration.

In patients undergoing on-pump CABG receiving NIRS-guided care:

14 hours

Less time spent
in the ICU



Zero

Patients experienced
prolonged desaturation

Single center, prospective, randomized control trial of 200 adult patients undergoing coronary artery bypass graft (CABG) surgery on cardiopulmonary bypass (CPB)

The trial investigated the effect of intraoperative NIRS monitoring and interventional protocols to correct desaturation on the incidence of postoperative complications. Patients either received standard monitoring or INVOS™ monitoring with interventions occurring if the patient desaturated below 75 percent of baseline for more than 15 seconds. **In the findings:**

- Monitoring and intervention was associated with:
 - Lower rate of 30-day MOMM (3% vs. 11%; $P = 0.048$)
 - Shorter ICU length of stay (1.25 vs. 1.87 days; $P = 0.029$)
 - Lower incidence of prolonged desaturation (0% vs. 6%; $P = 0.014$)
- There was a significant inverse correlation ($r^2 = 0.29$; $P < 0.05$) between mean intraoperative rSO_2 and hospital length of stay in patients requiring hospitalization ≥ 10 days
- The Murkin, et al., 2011 follow up post hoc analysis on the diabetic cohort of patients within this sample found that NIRS monitoring and intervention was associated with lower incidences of complications, ICU and overall hospital stays.

Goal-directed hemodynamic therapy, including cerebral oximetry, during CABG surgery may impact postoperative outcomes

A multidisciplinary perioperative strategy for attaining “more physiologic” cardiac surgery

ANASTASIADIS K, ANTONITSIS P, DELIOPOULOS A, ET AL. (Greece)

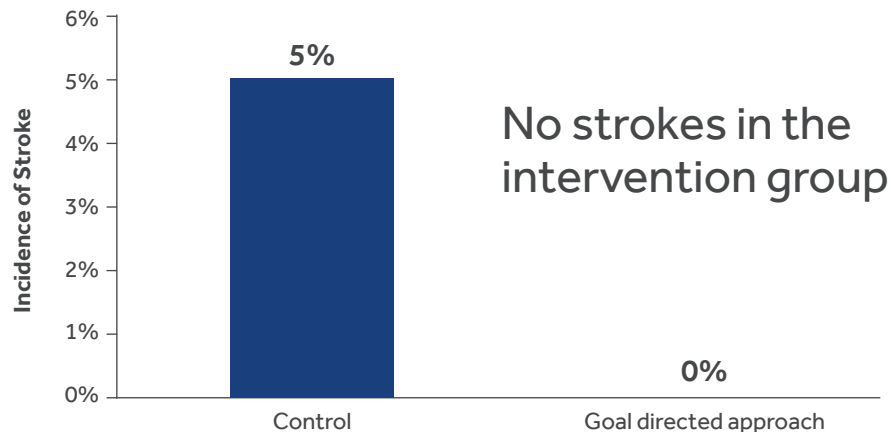


Figure: Incidence of stroke among 120 patients undergoing on pump cardiac surgery receiving goal-directed hemodynamic therapy, which included cerebral oximetry ($P < 0.05$)

Patients undergoing cardiac surgery on cardiopulmonary bypass (CPB) subjected to goal-directed hemodynamic therapy with cerebral oximetry:

60%

Fewer patients developed stage 2 or 3 acute kidney injury



1/3

Fewer RBC units used

Single center, retrospective analysis of 120 patients undergoing cardiac surgery on cardiopulmonary bypass before and after implementing a “more physiologic” goal-directed anesthetic approach

The analysis sought to determine if goal directed intraoperative monitoring and intervention decreased the incidence of postoperative complications in cardiac surgery patients. CABG comprised 48.3 percent of the study population alone or in combination with other valve and/or aortic procedures.

Patients in the control group received routine anesthetic strategy. Patients in the intervention group received a goal-directed strategy using cardiac index, SvO₂ (mixed venous saturation), DO₂i (oxygen delivery), DO₂i/ VCO₂i (oxygen delivery indexed to carbon dioxide production ratio), and rSO₂ (using the INVOS™ monitor), in addition to using minimally invasive extracorporeal circulation.

If patients' rSO₂ dropped more than 20 percent from the baseline value, physicians implemented a protocol to reverse desaturation.

In the findings:

- The goal-directed monitoring and intervention group:
 - Experienced fewer strokes (0% vs. 5%, $P < 0.05$)
 - Demonstrated less acute kidney injury (AKI stage 2 and 3; 3.3% vs. 8.3%, $P < 0.05$)
 - Required fewer RBC units intraoperatively (1 vs. 1.5 units, $P < 0.05$)
- A strategy to continually monitor perfusion and immediately take action to maintain optimal perfusion throughout the perioperative period protects end-organ function and improves patient outcomes after cardiac surgery

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The INVOS™ monitoring system should not be used as the sole basis for diagnosis or therapy and is intended only as an adjunct in patient assessment.

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