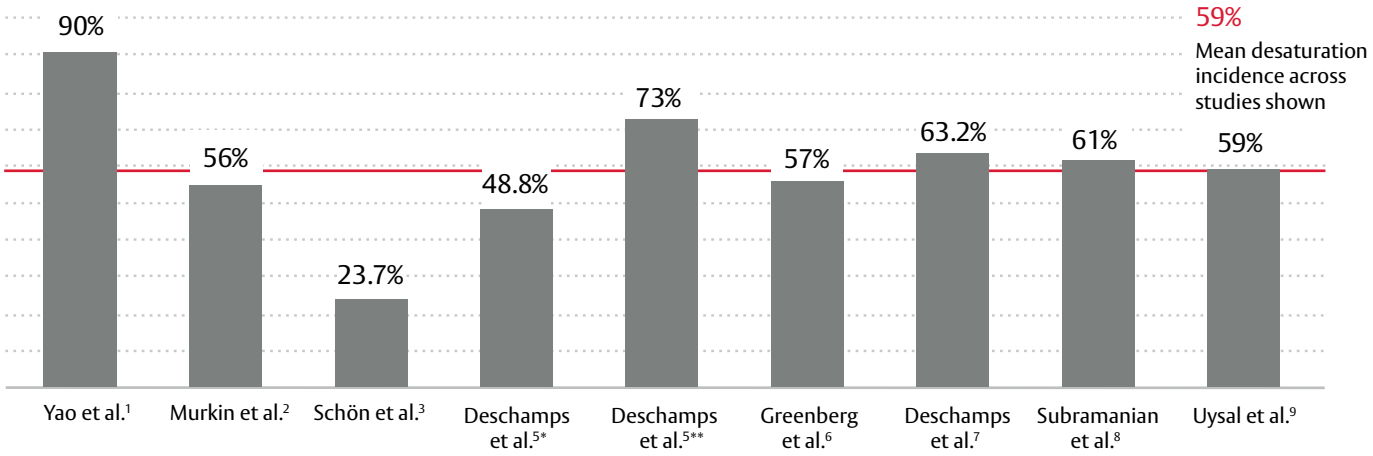
Cerebral Oximetry as Part of Brain Health in Cardiac Surgery

The cardiac surgical population has demonstrated a significant incidence of cerebral desaturation,[1-9] which has in turn been associated with a wide range of negative outcomes including increased morbidity and mortality,[2,10] postoperative neurocognitive disorders,[4,11] increased length of stay in both the ICU and hospital,[3,10,12] and increased incidence of stroke.[3] Evidence suggests that efforts to reduce the depth and duration of these desaturations can positively impact these outcomes.[2,6,7,9,13,14] Cerebral oximetry remains the only technology that monitors cerebral oxygenation noninvasively and continuously – allowing clinicians to detect problems and optimize perfusion before these negative outcomes and/or irreversible brain damage develop.[15]

Cerebral desaturations are common

Incidence
Research has consistently shown that cerebral desaturations occur during cardiac surgery across a variety of procedures and patient populations.

Patient incidence of desaturations during cardiac surgery

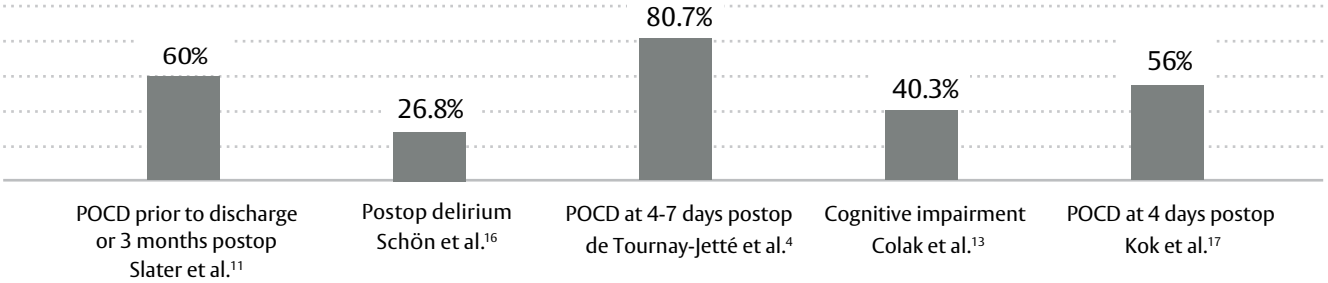


Note: Each publication has an independent definition of desaturation including absolute vs. relative change, duration of time, oximeter used, etc.
*Denotes incidence in prospective arm of publication
**Denotes incidence in randomized arm of publication

Edwards

Desaturations can cause harm

Patient incidence of certain neurological outcomes for cardiac surgery patients



Importantly, poor neurocognitive outcomes related to coronary artery bypass grafting (CABG) and valve surgeries utilizing cardio pulmonary bypass (CPB) remain an issue despite declining mortality rates for those procedures.[15]

Impact of cerebral desaturations among cardiac surgical patients

Neurological

Intraoperative desaturations were linked to the following neurological outcomes:

- **7.69 X** increased risk of developing postoperative cognitive dysfunction (POCD) within one week following surgery[4]
- **3.32 X** increased risk of developing POCD within three months following surgery[4]
- **2.22 X** POCD within three months following surgery[10]
- **30-day** increase in mortality risk with mean pre-bypass rSO_2 under 63%[18]

Length of Stay

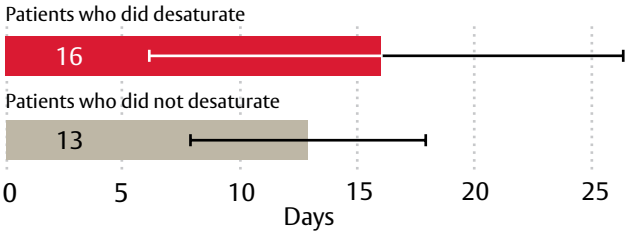
Results from Schön et al.[3]

$SctO_2 < 50\%$ = **3-day** increase in median length of hospital stay†

†Other studies may vary in LOS.

Results from Hong et al.[12]

Length of Stay (days) for patients with or without desaturations.[12]



Patients with greater duration of low $SctO_2$ and showing greater integrals of low $SctO_2$ over time for the $SctO_2$ threshold values of 65% and 60% were significantly more likely to have longer LOS in the ICU.

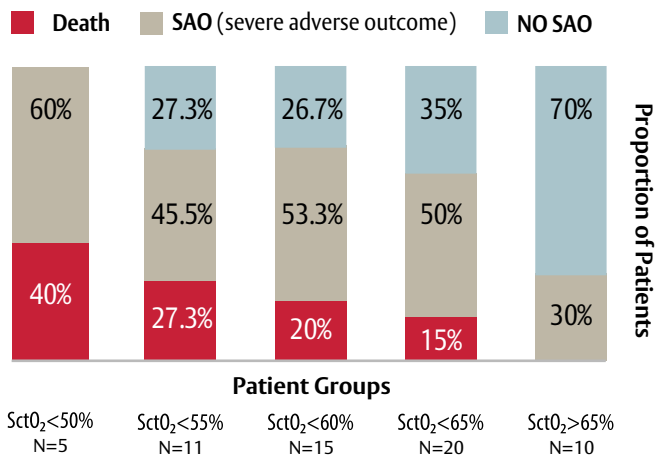
MOMM

Major organ morbidity and mortality (MOMM) has been demonstrated to be associated with:

- **Lower baseline saturations**[2]
- **Significantly profound desaturations**[2,10]
- **More prolonged desaturations**[2]
- **Higher cerebral desaturation load**[1]

Fischer et al. data[10] shows the relationship between **lower cerebral saturations, severe adverse outcomes,** and even **death.**

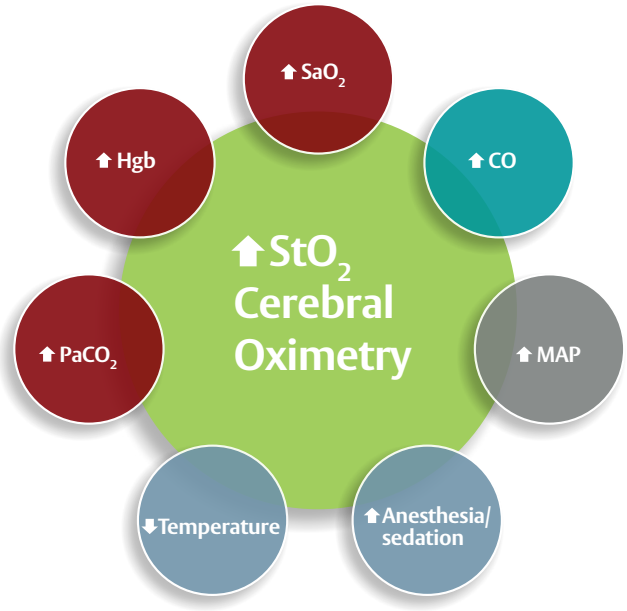
Fischer 2011: Time under threshold and negative outcomes



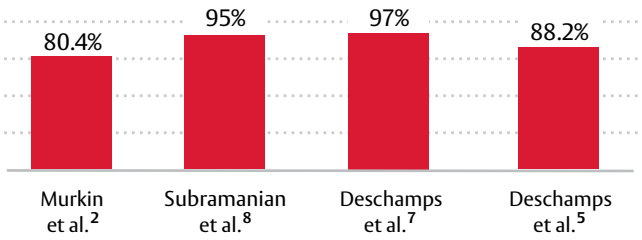
Aortic arch surgery patients with at least 10 minutes spent below a given $SctO_2$ threshold.

Desaturations may be reversed

Interventions
While these correlations paint a bleak picture, research has also shown that these desaturations can be detected utilizing cerebral oximetry and reversed or corrected through routine interventions to reduce the cerebral desaturation load during surgery.

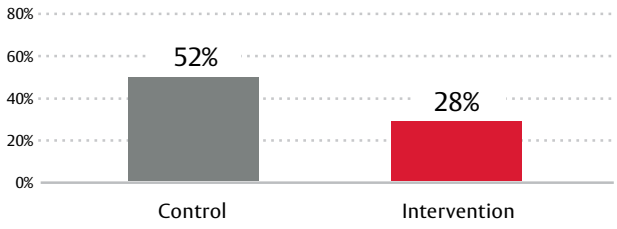


Success of Interventions to Reverse Desaturations

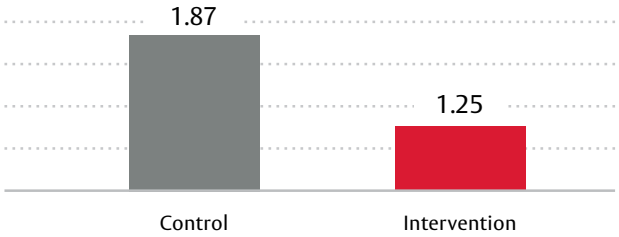


Reversing desaturations can improve outcomes

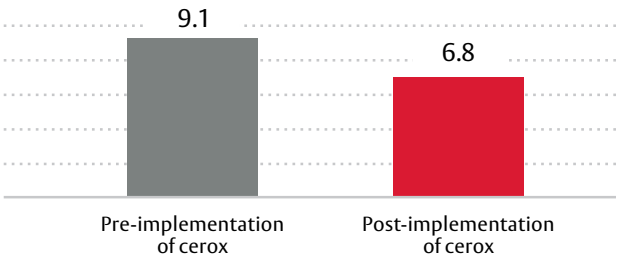
Incidence of Cognitive Decline[13]



ICU Length of Stay (days)[2]



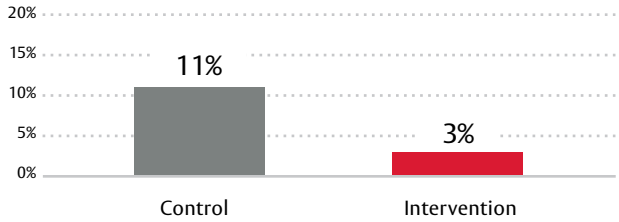
Hospital Length of Stay (days)[14]*



2.3 day reduction for NYHA Class I recipients of CABG/Valve surgery despite overall sicker population

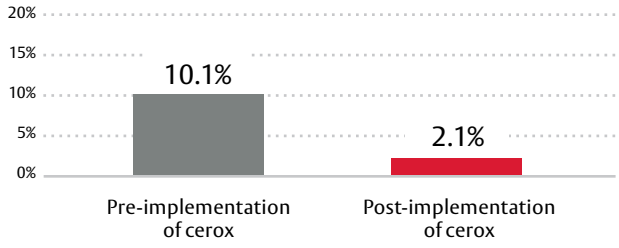
*NYHA class I

MOMM[2]



Intervention = **73%** reduction in MOMM

Prolonged Mechanical Ventilation Needed[14]



For NYHA Class I recipients of CABG/Valve surgery despite overall sicker population

Summary

"Diffuse hypoperfusion of the brain can be avoided only by very careful planning; if something goes wrong, the only hope is early detection and immediate restoration of adequate perfusion before irreversible brain damage develops. For this purpose, sensitive, real-time monitoring of brain ischemia during such surgical procedures is needed. At the present time, cerebral oximetry can fulfill this role as the only feasible technology that monitors cerebral hypoxia and/or cerebral ischemia noninvasively and continuously." –Fischer et al.[15]

Glossary

CABG: Coronary Artery Bypass Grafting

CDE: Cerebral Desaturation Event

CDL: Cerebral Desaturation Load *(measurement of duration and depth of cerebral saturations under a threshold)*

Cerebral Desaturation: Decrease in cerebral saturations below a certain value or relative threshold

CPB: Cardio Pulmonary Bypass

LOS: Length of Stay

MOMM: Major Organ Morbidity and Mortality

NYHA: New York Heart Association

OR: Operating Room

POCD: Postoperative Cognitive Dysfunction

References

1. Yao FSF, et al. Cerebral oxygen desaturation is associated with early postoperative neuropsychological dysfunction in patients undergoing cardiac surgery. *J Cardiothorac Vasc Anesth.* 2004;18:552-8.
2. Murkin JM, et al. Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study. *Anesth Analg.* 2007;104:51-8.
3. Schön J, et al. Cerebral oxygen saturation monitoring in on-pump cardiac surgery – A 1 year experience. *Appl Cardiopulm Pathophysiol.* 2009;13: 243-252.
4. de Tournay-Jetté, et al. The relationship between cerebral oxygen saturation changes and postoperative cognitive dysfunction in elderly patients after coronary artery bypass graft surgery. *Cardiothorac Vasc Anesth.* 2011;25:95-104.
5. Deschamps A, et al. Reversal of decreases in cerebral saturation in high-risk cardiac surgery. *J Cardiothorac Vasc Anesth.* 2013;27:1260-6.
6. Greenberg SB, et al. Cerebral desaturation events in the intensive care unit following cardiac surgery. *J Crit Care.* 2013;28:270-276
7. Deschamps A, et al. Cerebral oximetry monitoring to maintain normal cerebral oxygen saturation during high-risk cardiac surgery: a randomized controlled feasibility trial. *Anesthesiology.* 2016;124:826-36.
8. Subramanian B, et al. A multicenter pilot study assessing regional cerebral oxygen desaturation frequency during cardiopulmonary bypass and responsiveness to an intervention algorithm. *Anesth Analg.* 2016;122:1786-93.
9. Uysal S, et al. Optimizing cerebral oxygenation in cardiac surgery: A randomized controlled trial examining neurocognitive and perioperative outcomes. *J Thorac Cardiovasc Surg.* 2020;159:943-953.
10. Fischer GW, et al. Noninvasive cerebral oxygenation may predict outcome in patients undergoing aortic arch surgery. *J Thorac Cardiovasc Surg.* 2011;141:815-21.
11. Slater JP, et al. Cerebral oxygen desaturation predicts cognitive decline and longer hospital stay after cardiac surgery. *Ann Thorac Surg.* 2009;87:36-45.
12. Hong SW, et al. Prediction of cognitive dysfunction and patients' outcome following valvular heart surgery and the role of cerebral oximetry. *Eur J Cardiothorac Surg.* 2008;33:560-5.
13. Colak Z, et al. Influence of intraoperative cerebral oximetry monitoring on neurocognitive function after coronary artery bypass surgery: a randomized, prospective study. *Eur J Cardiothorac Surg.* 2015;47:447-54.
14. Goldman S, et al. Optimizing intraoperative cerebral oxygen delivery using noninvasive cerebral oximetry decreases the incidence of stroke for cardiac surgical patients. *Heart Surg Forum.* 2004;7:E376-81.
15. Fischer GW, et al. Recent advances in application of cerebral oximetry in adult cardiovascular surgery. *Semin Cardiothorac Vasc Anesth.* 2008;12:60-9.
16. Schön J, et al. Preoperative regional cerebral oxygen saturation is a predictor of postoperative delirium in on pump cardiac surgery patients: a prospective observational trial. *Crit Care.* 2011;15:R218.
17. Kok WF, et al. A pilot study of cerebral tissue oxygenation and postoperative cognitive dysfunction among patients undergoing coronary artery bypass grafting randomised to surgery with or without cardiopulmonary bypass. *Anaesthesia.* 2014;69:613-22.
18. Stannard B, et al. Regional cerebral oximetry is consistent across self-reported racial groups and predicts 30-day mortality in cardiac surgery: a retrospective analysis. *J Clin Monit Comput.* 2021;35:413-421.

Edwards, Edwards Lifesciences and the stylized E logo are trademarks of Edwards Lifesciences Corporation or its affiliates. All other trademarks are the property of their respective owners.

© 2022 Edwards Lifesciences Corporation. All rights reserved. PP--EU-3602 v1.0

Edwards Lifesciences • Route de L'Etraz 70, 1260 Nyon, Switzerland • edwards.com

Edwards