Mixed venous oxygen saturation does not adequately predict cerebral perfusion during pediatric cardiopulmonary bypass

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As survival continues to improve in surgery for congenital heart disease, surgeons have been able to focus, not only on patient survival, but also on quality of life. To optimize quality of life, we must ensure optimal postoperative neurologic function. Mixed venous oxygen saturation (MVO₂) is widely used as a measure of adequacy of whole-body perfusion on cardiopulmonary bypass even though MVO₂ correlates poorly with cerebral saturation in adults.¹ These data did not indicate whether MVO₂ monitoring predicts the adequacy of cerebral perfusion in children.

Methods

At Kosair Children's Hospital, after obtaining institutional review board approval, we studied 15 patients undergoing cardiopulmonary bypass (aged 3 days to 16 years, from 1997-1998). The lesions repaired included tetralogy of Fallot (n = 4), ventricular septal defects (n = 4), atrial septal defects (n = 2), transposition of the great arteries (n = 1), atrioventricular septal defect (n = 1), pulmonary stenosis (n = 1), conduit change (n = 1), and subaortic stenosis (n = 2). Patients were instrumented with jugular venous bulb catheters.² Under a variety of temperatures, hematocrit values, and times on bypass, cerebral venous oxygen saturations were intermittently sampled³ prospectively and retrospectively correlated with systemic MVO₂ measured in the venous return to the pump. MVO₂ was continuously measured online. Regression analysis was used to calculate a correlation coefficient. Confidence intervals are $\pm 95\%$. A mixed model analysis of variance was used to determine whether time was statistically significant.

Figure 1

Results

There was no significant correlation between systemic MVO₂ and jugular venous oxygen saturation (Figure 1). An MVO₂ above 75% was misleadingly associated with jugular venous oxygen saturations as low as 37%. The correlation coefficient (r^2 value) was 0.33 and the relationship was not statistically significant (Figure 1). Time on bypass, hematocrit value, and temperature exerted no statistically significant effects on the relationship.

Discussion

Many centers monitor MVO₂ as a measure of adequacy of perfusion on cardiopulmonary bypass. Our data show that MVO₂ does not reliably correlate with adequacy of cerebral perfusion in children undergoing cardiopulmonary bypass. Without specific cerebral monitoring, potentially correctable cerebral malperfusion may be undetected until permanent neurologic deficits result. At Kosair Children's Hospital, we routinely use a noninvasive approach to neurologic monitoring during pediatric cardiac surgery. Our approach includes (1) continuous transcranial Doppler assessment of middle cerebral arterial velocity, (2) continuous neon infrared transcranial oxygen saturations, and continuous electroencephalographic monitoring in selected leads. The jugular venous bulb catheters in this study are not part of our usual routine but were placed under experimental protocol to validate and calibrate the developing technology permitting transcranial monitoring of oxygen saturation (INVOS 5100, Somanetics Corp, Troy, Mich). Anecdotally, we are surprised at how often innocent surgical maneuvers drastically diminish cerebral blood flow. Inadvertent pressure on the carotid arteries, suboptimal cannula position, systemic vasodilation, and inadvertent introduction of air into the systemic circulation are rapidly detected as malperfusion or embolic phenomena and, generally, are easily corrected. Without this feed-

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back, these situations might go uncorrected for the entire case, potentially resulting in prolonged malperfusion with the associated neurologic risks.

In the current era of excellent survival in surgery for congenital heart disease, excellent neurologic function is paramount. In the future, if we are able to show that intraoperative cerebral monitoring improves neurologic outcome, then the current standard of care can be improved.

References

1. Croughwell ND, White WD, Smith LR, Davis RD, Glower DD Jr, Reves JG, et al. Jugular bulb saturation and mixed venous saturation during cardiopulmonary bypass. *J Card Surg.* 1995;10:503-8.
2. Schell RM, Cole DJ. Cerebral monitoring: jugular venous oximetry. *Anesth Analg.* 2000;90:559-66.
3. Matta BF, Lam AM. The rate of blood withdrawal affects the accuracy of jugular venous bulb. *Anesthesiology.* 1997;86:806-8.