Validation of the Edslab dual lumen oximetry catheter for continuous monitoring of jugular bulb oxygen saturation after severe head injury

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Summary

Continuous jugular bulb venous oximetry has been validated previously for periods of up to 12 h after calibration. We assessed a new Edslab venous oximetry catheter in 15 patients with brain injury in the intensive care unit. After insertion into the jugular bulb, the catheter was calibrated using a laboratory co-oximeter. Subsequent comparisons were made at varying intervals (range 20 min to 100 h); 78 paired samples were obtained during periods of stable recordings. Estimation of haemoglobin saturation by the methods correlated well ($r^2 = 0.97$, $P < 0.0001$). Mean difference ($d$) was small (0.28% (SD 2.35%)) and limits of agreement ($d$ ± (SD × 1.96)) were acceptable (−4.88% to 4.32%). There was no appreciable drift and there was negligible bias. This catheter did not suffer from problems of light intensity described with other systems, and it provided acceptable accuracy for clinical use for periods of up to and exceeding 24 h after calibration. (Br. J. Anaesth. 1996; 76: 744–746)

Key words

Continuous jugular bulb venous oximetry has developed into a valuable monitoring tool in the care of patients after head trauma. A cannulation technique and assessment of equipment accuracy have been described [1]. A limiting factor was that the apparatus was valid for periods of up to 12 h after in vivo calibration. This apparatus used a 40-cm flexible reflectance spectrophotometric catheter which had been designed for use within the umbilical artery in neonatal intensive care. The Edslab 4-French gauge catheter (Baxter Healthcare Corporation, Irvine, CA, USA), designed for venous oximetry, has been introduced recently.

This catheter offers several design advantages in that it has improved distance measurement markings and uses a firmer material which reduces flexing and kinking, but permits insertion without perforation of vessel walls. It is coated with an antimicrobial heparin coating and is also reportedly less subject to drift than catheters described previously.

We performed a prospective study in patients with severe head injury in the intensive care unit comparing in vivo measurements with samples aspirated from the jugular bulb measured in vitro with a Corning 270 laboratory co-oximeter (Ciba-Corning Diagnostics Ltd, Halstead, Essex, UK).

Methods

We evaluated the catheter in 15 patients with brain injury. Ethics Committee approval was obtained in advance for insertion and validation of jugular bulb catheters, without informed consent, in this group of patients.

Patients were referred to the Regional Neurosurgical Unit at the Western General Hospital, Edinburgh, from Edinburgh and Southeast Scotland. Eleven patients had suffered traumatic head injury and four had suffered a subarachnoid haemorrhage of World Federation of Neurological Surgeons grade 4 or 5. All subjects scored less than 8 on the Glasgow coma score on their last neurological examination, before muscle paralysis and artificial ventilation of their lungs for CT scan, any requisite surgery and insertion of an intraparenchymal intracranial pressure monitor. They were then transferred to the intensive therapy unit where they were sedated, paralysed and their lungs ventilated to mild hypocapnia ($P_aCO_2, 3.5–4$ kPa).

All treatment and care followed standard procedures agreed within our unit. Catheters were inserted using the Seldinger technique in a manner similar to cannulation techniques described previously. A compression test was performed to identify the dominant internal jugular vein and then the vein was entered percutaneously, lateral to the carotid artery at the level of the cricoid cartilage, directing the needle towards the external auditory meatus [1].

An important difference was that, rather than using a Vygon 14-gauge Leadercath cannula as an introducer (which is not haemostatic and must be withdrawn subsequently), the catheter was inserted using an 18-gauge Cook needle and a Daig 7-gauge Fast-Cath introducer, which has a Buorst–Tuohy...
haemostatic valve. The fibreoptic catheter was covered by a Baxter catheter contamination shield. The introducer is sutured to skin, remaining within the vein and, with the sheath, allows manipulation of the catheter after insertion to maintain accuracy, in a manner similar to that of pulmonary catheter insertion. This arrangement has not been reported previously for insertion into the internal jugular vein.

Catheters were inserted 15–20 cm, depending on patient size. Satisfactory catheter tip position was checked radiologically, ensuring that the tip was above the lower border of the first cervical vertebrae and was not kinking. This reduces extracranial contamination from the facial vein and reflectance errors. The catheter was connected to a Baxter Edwards Explorer System (Baxter Healthcare Corporation, Irvine, CA, USA) which contains an optical module and signal processor. The reading obtained was then calibrated against jugular venous samples analysed by a Corning 270 co-oximeter.

Subsequent comparisons were made at various intervals (mode 195 min; range 20 min to 100 h). If differences between catheter and co-oximeter values exceeded 5 %, the catheter was recalibrated. Samples were obtained slowly during periods of stable recordings (< 3 % oscillation).

Co-oximeter and catheter measurements were compared using linear regression and the method comparison technique recommended by Altman and Bland [2].

Results

Paired recordings (n = 78) were compared between 15 catheters and the co-oximeter using the difference in jugular saturation, the average difference and the SD of this difference to assess agreement between methods of measurement. These were also compared against time since the previous calibration, illustrating drift (fig. 1).

Forty-four samples were obtained at intervals of up to 24 h and 34 samples at intervals of 24–100 h. There was no appreciable drift, with accuracy being maintained, in some cases, to 3 or 4 days without recalibration.

There were only two points at which catheters required recalibration because they exceeded the 5 % agreement limits (errors of 7 % and 6 %, respectively). Estimation of haemoglobin saturation by the two methods correlated well ($r^2 = 0.97$, $P < 0.0001$) (fig. 2). Mean difference was small ($-0.28$ % (SD 2.35 %)) and limits of agreement (mean $-\text{(SD \times 1.96)}$) were acceptable clinically ($-4.88$ % to 4.32 %).

Individual catheter mean differences were all within the limits of agreement (fig. 3). There was negligible bias on a method comparison plot (fig. 4), with 95 % confidence intervals of bias ($d \pm (t \times \text{SEM})$) of 0.25 % to $-0.81$ %.

Mean change in haemoglobin concentration over the period of monitoring was 0.68 (range 0–4.8) g dl$^{-1}$. There was no relationship between changes in haemoglobin concentration and catheter/co-oximeter measurement differences.

Discussion

Continuous jugular venous oximetry has been criticized previously because of the high degree of drift and requirement for frequent recalibration [3]. We have noted significant errors even with 12-hourly calibration. This problem was aggravated by inability to rectify position after misplacement or slippage. The advantage of the previous Oximetrix 3 system was that it was a triple wavelength system providing two light intensity ratios with a theoretically superior accuracy. A large number of the readings are discarded however because of light intensity alarms and drift errors, which is not surprising, given the limited venous flow present.

Figure 1 Difference in haemoglobin saturation between the co-oximeter and catheter with time.

Figure 2 Co-oximeter vs catheter haemoglobin saturation readings.
The Edslab catheter is a dual wavelength system which relies on haemoglobin concentration or packed cell volume being entered during calibration. These values are unlikely to change dramatically from day to day in this patient population and the system appears to be tolerant of minor fluctuations with the benefit of a greatly reduced degree of drift and relative independence of light intensity in a poor flow environment.

The Edslab catheter provides acceptable degrees of accuracy for clinical use for periods up to and exceeding 24 h after in vivo calibration. We are unable to give a threshold of time over which readings are invalid or suspect. Theoretically, significant changes in packed cell volume may introduce error into the system and should probably necessitate recalibration; this process requires the current laboratory measured haemoglobin concentration or packed cell volume. The mean change in haemoglobin concentration per patient was small (0.68 g dl$^{-1}$). However, we have observed changes of up to 4 g dl$^{-1}$ in haemoglobin concentration between measurements without loss in accuracy. It is also true that this patient population, when resuscitated, usually maintain a stable packed cell volume.

Nevertheless, we would suggest that daily recalibration is an easy compromise and within the bounds of maintained accuracy. For two catheters there were only two comparisons made after the initial calibration. However, in both cases the time interval was greater than 24 h and on that basis the comparisons made indicated a satisfactory performance over time.

The identification of a suitable introducer allows manipulation of catheter position and maintenance of accurate readings. In conjunction they represent a significant improvement in the quality of clinical monitoring.

References

