

activation, compromised fibrin polymerization and reduced whole blood thrombin generation capacity.<sup>2</sup>

We have undertaken additional experimental work in our laboratory to address the question of whether colloid-induced coagulopathy could possibly be reversed with the aid of rFVIIa by testing *ex vivo* two dose levels of rFVIIa and a buffer control for their possible influence on coagulopathy induced by various levels of haemodilution with HES 130/4. Without haemodilution, rFVIIa, at the two dose-levels tested, normalized the prolonged clotting time in experiments with saline and HES 130/0.4. However, following haemodilution with colloid to a level of 25% or more, rFVIIa does not appear to improve the diminished maximum coagulation velocity of whole blood clot formation (Fig. 1).

Recently, a randomized clinical trial on 300 trauma patients demonstrated that rFVIIa administered to bluntly traumatized patients significantly reduced the transfusion requirements as compared with placebo.<sup>3</sup> Trauma patients with shock often receive volume substitution initially with quite large amounts of plasma expanders to maintain sufficient blood pressure. In view of this, our new data contribute to understanding the limited effect on haemostasis if rFVIIa is administered after large volumes of colloid HES 130/0.4. The critical issue here is the lack of improvement of the velocity of clot formation. Our original paper<sup>1</sup> shows that addition of fibrinogen increases the velocity of clot formation. In view of this, severe bleeding occurring shortly after volume substitution with HES may be managed better with fibrinogen before rFVIIa.

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- 1 Fenger-Eriksen C, Heslop J, Anker-Møller E, Ingerslev J, Sørensen B. Thrombelastographic whole blood clot formation following *ex vivo* addition of plasma substitutes: improvements of the induced coagulopathy with fibrinogen concentrate. *Br J Anaesth* 2005; **94**: 324–9
- 2 Brummel-Ziedins K, Whelihan MF, Ziedins EG, Mann KG. Resuscitation fluid you choose may potentiate bleeding. *Blood* 2004; **11**: 104
- 3 Rossaint R, Boffard KD, Warren BL, et al. Decreased transfusion utilization using recombinant factor VIIa as an adjunct in trauma. *Intensive Care Med* 2004; **30**: S199

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### What does cerebral oximetry measure?

Editor—We feel that the recent paper by Yoshitani and colleagues<sup>1</sup> raises important issues. They demonstrated that, in patients undergoing elective hip arthroplasty, normovolaemic haemodilution caused no change in jugular bulb saturations ( $Sj_{O_2}$ ) but decreased cerebral saturations ( $Sc_{O_2}$ ) when measured with a cerebral oximeter (INVOS 4100S). Two explanations were offered for the unexpected disparity in readings. First, they postulated that subtle changes in regional  $Sc_{O_2}$  might not be revealed with the global measure provided by  $Sj_{O_2}$ . Second, they proposed that changes in near infrared path length induced by haemodilution could affect the  $Sc_{O_2}$  readings.

We feel the interpretation of the results deserves a more detailed appraisal. The INVOS 4100S gives a single readout for regional

cerebral oxygen saturations using an algorithm based upon the Beer–Lambert law. In this study, both subject groups showed no change in  $Sj_{O_2}$  but a decrease in  $Sc_{O_2}$ . The disparity in readings could be consistent with a systematic error. We suspect the algorithm incorporated within the INVOS 4100S may not take into account the fall in haemoglobin concentration. The fall in oxygenation index has actually been found to correlate with blood loss in healthy volunteers.<sup>2</sup>

Cerebral oximetry does not take into account changes in the relative proportions of blood in the arterial or venous part of a capillary bed. The proportion of arterial blood in the cerebral capillaries had been estimated at 28%.<sup>3</sup> Hypoxia can induce changes in the cerebral arterial to venous volume ratio<sup>4</sup> and it would not be unreasonable to assume that other factors may also affect the cerebral arterial to venous volume ratio. A change in the relative proportions of arterial and venous blood in the cerebral capillaries may alter cerebral oximetry readings without a ‘real’ effect on cerebral tissue oxygenation.

We have previously expressed concerns<sup>5</sup> about the interpretation of cerebral oximetry in a clinical setting, and Yoshitani’s paper has raised a most important issue concerning the effect of haemodilution upon the readings. A change in  $Sc_{O_2}$  could be attributable to many factors. In the clinical setting, changes in  $Sc_{O_2}$  should be interpreted with caution, particularly when there is significant blood loss.

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Editor—We wish to thank Pattinson and colleagues for their comments on our recent article and are pleased to take this opportunity to reply. We demonstrated that there was a discrepancy between  $Sj_{O_2}$  and  $Sc_{O_2}$  values during normovolaemic haemodilution<sup>1</sup> and two possible explanations were offered (as above). Pattinson and colleagues<sup>5</sup> have suggested that our results deserve a more detailed appraisal and that various factors may have an effect on  $Sc_{O_2}$  values. Validation of near infrared spectroscopy measurements has not been established.

In our study, we demonstrated that there was a significant correlation between haemoglobin concentrations and  $Sc_{O_2}$  values. The results indicated haemoglobin concentration had a significant effect on  $Sc_{O_2}$  values. Kurth and Uher<sup>6</sup> suggested that there was a significant negative correlation between haemoglobin concentrations and optical path length in an experimental model. We believe that optical path length had a strong effect on  $Sc_{O_2}$  values. As suggested above, the algorithm incorporated in the INVOS 4100S might not take into account the fall in haemoglobin concentration. The algorithm is not open for scrutiny (Somanetics, Troy, MI, USA). If a modified Beer–Lambert law, in which optical path length should be constant, was incorporated in INVOS 4100S, prolongation of optical path length would cause enhancement of changes in  $Sc_{O_2}$ . Therefore, if optical path length became longer with haemodilution, there would be an overestimation of changes in  $Sc_{O_2}$ .

Previous studies have demonstrated that various factors, such as haemoglobin concentrations, extracranial blood flow and changes in cerebral arterial to venous blood volume ratio had an effect on near infrared spectroscopy measurements.<sup>7–9</sup> However, it was difficult to evaluate the degree of effects of such factors on  $Sc_{O_2}$  values. We have only investigated the effect of haemoglobin concentration

on  $Sc_{O_2}$  values. However, we need to evaluate the degree of effects of other factors on  $Sc_{O_2}$  in the near future.

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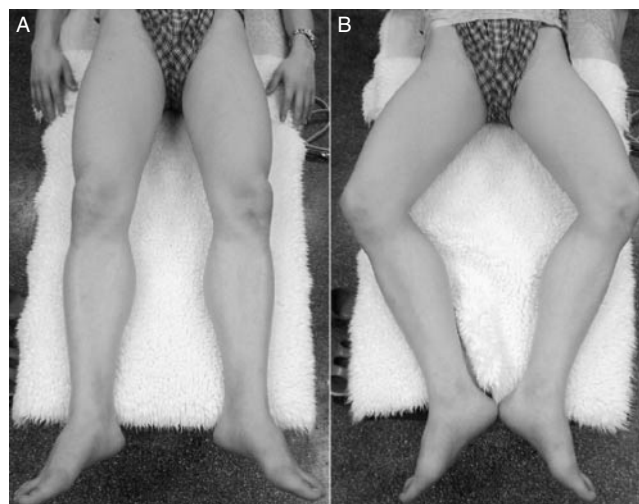
- 1 Yoshitani K, Kawaguchi M, Iwata M, et al. Comparison of changes in jugular venous bulb oxygen saturation and cerebral oxygen saturation during variations of haemoglobin concentration under propofol and sevoflurane anaesthesia. *Br J Anaesth* 2005; **94**: 341–6
- 2 Torella F, Cowley R, Thornilley MS, McCollum CN. Monitoring blood loss with near infrared spectroscopy. *Comp Biochem Physiol A Mol Integr Physiol* 2002; **132**: 199–203
- 3 McCormick PW, Stewart MG, Goetting MG, Balakrishnan G. Regional cerebrovascular oxygen saturation measured by optical spectroscopy in humans. *Stroke* 1991; **22**: 596–602
- 4 Wolff CB, Imray CHE. Partitioning of arterial and venous volumes in the brain under hypoxic conditions. *Adv Exp Med Biol* 2003; **540**: 19–23
- 5 Pattinson K, Clutton-Brock T, Imray C. Validity of near-infrared cerebral spectroscopy. *Anaesthesia* 2004; **59**: 507–8
- 6 Kurth CD, Uher B. Cerebral hemoglobin and optical pathlength influence near-infrared spectroscopy measurement of cerebral oxygen saturation. *Anesth Analg* 1997; **84**: 1297–305
- 7 Kishi K, Kawaguchi M, Yoshitani K, et al. Influence of patient variables and sensor location on regional cerebral oxygen saturation measured by INVOS 4100 near-infrared spectrophotometers. *J Neurosurg Anesthesiol* 2003; **15**: 302–6
- 8 Germon TJ, Young AE, Manara AR, Nelson RJ. Extracerebral absorption of near infrared light influences the detection of increased cerebral oxygenation monitored by near infrared spectroscopy. *J Neurol Neurosurg Psychiatry* 1995; **58**: 477–9
- 9 Watzman HM, Kurth CD, Montenegro LM, Rome J, Steven JM, Nicolson SC. Arterial and venous contributions to near-infrared cerebral oximetry. *Anesthesiology* 2000; **93**: 947–53

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### Does external leg rotation facilitate femoral venipuncture?

Editor—Although the femoral vein (FV) is often used for central venous access, it carries a potential risk of femoral artery (FA) puncture. This complication is usually benign, but massive retroperitoneal haemorrhage,<sup>1</sup> femoral nerve palsy<sup>2</sup> and arterio-venous fistula<sup>3</sup> have been reported. To avoid this complication, patient position is extremely important but the advantages of external leg rotation have not been reported. We have measured the anatomical relationships of FA and FV with the leg in external rotation or extension.

After ethical committee approval and written informed consent, 19 healthy male volunteers (mean age, height and weight 35.4 yr, 172.3 cm and 68.5 kg, respectively) were placed supine in a Fowler position with about 15° elevation, allowing dilation of the FV. The positions are shown in Figure 1A and B. Right femoral vessels were examined using an SSA-260A ultrasonograph (Toshiba, Tokyo, Japan) and a PLF-703NT 7.5-MHz linear probe (Toshiba, Tokyo, Japan) at 0, 2 and 4 cm below the inguinal ligament (IL). Ultrasonographic images of the cross-sections of femoral vessels were obtained under minimum pressure between the probe and skin. FA–FV overlap, depth of FV from the surface,



**Fig 1** (A) Leg extension (EX) represents the posture maintaining functional leg position. (B) External leg rotation (ER) represents the posture with external rotation of the coxofemoral joint while keeping the coxofemoral and femorotibial joints slightly flexed.

and FV transverse and antero-posterior diameters were determined and compared. Wilcoxon single-rank testing was used for statistical analysis, with  $P < 0.05$  considered statistically significant.

External rotation significantly decreased FA–FV overlap and FV depth at all levels and the transverse diameter of FV was significantly decreased at 0 and 2 cm below, but not at 4 cm below the IL compared with extension. With external rotation, the antero-posterior diameter of the FV was significantly decreased only at the level of the IL.

Our study demonstrates the anatomy of the femoral vessels of the right groin to 4 cm below the IL. In both positions, FA–FV overlap and FV depth were minimal up to 2 cm below the IL. Below that, the FV runs more laterally and deeper, overlapping with the FA, and at 4 cm the FV lies just posterior to the FA and is completely hidden by the FA on anterior-view ultrasonography. The distal part of the FV runs laterally to the FA. This anatomy, with the FV crossing below the FA distal to the groin, is well described. Hughes performed *in vivo* ultrasonography in humans and described similar results to ours.<sup>4</sup> Thus, our results appear to confirm that the optimal needle insertion site for safe femoral venipuncture is up to 2 cm below the IL.<sup>5</sup> Our results also demonstrated that FA–FV overlap is decreased in external rotation, which also has the effects of decreasing FV depth and increasing transverse and antero-posterior FV diameters; not only facilitating cannulation of FV, but also decreasing the risk of accidental FA puncture. External rotation of the thigh decreases lateral pressure against the femoral vessels by lateral shift of the ilio-lumbar and quadriceps muscles, and decreases muscle tension in these muscles.

Since Duffy introduced femoral vein catheterization,<sup>5</sup> clinicians recommended external rotation for safe and reliable femoral venipuncture, presumably based on clinical experience. Our ultrasonographic study, in a small way, appears to support this view.

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