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Density of cerebrospinal fluid and intrathecal spread

To the Editor:

We read with interest the report by Lui *et al.*¹ and would like to make a few comments. In spinal anaesthesia, regardless of the density/baricity of the drug solution, the volume of the solution is always the most immediate factor affecting the extent of spread due to simple "bulk replacement" or area contact, the greater the volume, the more extensive is the spread. In clinical doses, dilution into much larger volumes will not produce the lower levels of block that smaller volumes may.^{2,3} However, when a non-isobaric solution is used, the baricity/position interaction becomes the main determinant of the direction and speed of intrathecal spread. Since non-isobaric solutions in small volumes are commonly used, that may explain why volume of injectate is not a determinant of block height in most clinical settings. Density is the weight in grams of 1 mL of a solution at a specified temperature while baricity is the density of the solution relative to that of CSF. Thus, baricity, not the density, of the solution affects the spread. Since the density of CSF varies, the baricity of any given solution will vary. However, except for tetracaine, which is available in lyophilised powder (niphanoïd) form, spinal anaesthetics are aqueous solutions. They are generally formulated with sodium chloride to be isotonic and thus nearly isobaric. In practice, adding glucose produces hyperbaric solutions, diluting with water makes hypobaric solutions, and using only CSF to dissolve lyophilised tetracaine achieves the best possible isobaric solution.

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REPLY:

Baricity is an important determinant of the distribution of spinal anaesthetic solutions as demonstrated in an in vitro study.¹ Hence, knowledge of the densities of the local anaesthetic solutions relative to the densities of the cerebrospinal fluid (CSF) in the surgical population is a necessary first step. Although saline is isotonic, it is not isobaric, but is by definition, hypobaric. Likewise, tetracaine in saline solution is also hypobaric.²

*Many other factors contribute to the final distribution which also depends on its dilution with CSF. Carpenter *et al.*⁴ demonstrated the correlation between lumbosacral CSF volume and sensory block height, concluding that the common diluent, namely CSF, is a major variable in determining local anaesthetic spread. In short, it is the dose of local anaesthetic, mixed with CSF (which has high interindividual variability in volume) that accounts for the variable block height observed in practice. There is little evidence to support volume of the solution as playing a major role in its distribution except for the situation where hypobaric solution is used to "float" the solution cephalad. In this instance, perhaps the phenomenon of "bulk replacement" that Drs. King and Wood alluded to might apply.*

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Temperature measurement during cardiac surgery

To the Editor:

We read with interest the paper by Robinson *et al.* that addresses the *best* site for temperature monitoring during cardiac surgery.¹ Although the authors succeeded in determining how various temperature sites compare with the still debatable 'gold standard' pulmonary artery (PA) site and concluded that oesophageal temperature is *most accurate*, this does not necessarily mean that it is the *most appropriate* temperature monitoring site during cardiac surgery. The true *best* site is determined by the balance of its precision and accuracy with its clinical utility. That is, does it accurately reflect the temperature in the organ system(s) of interest. For example, if one is interested in whole-body cooling and heating, then PA or oesophageal sites may well be appropriate. However, if one is interested in the cerebral thermal environment, particularly during rapid temperature fluxes (as during CPB), then an alternative site (tympanic or nasopharyngeal) may be better. Also, the authors mention their lack of nasopharyngeal monitoring due to the risk of epistaxis during systemic heparinization. We accept their concern but have used (and advocate) this site with no reported complications in many thousands of cases.

Finally, how one uses the temperature information to guide clinical management is equally, arguably more, important than the measurement itself. For example, the patient outlined in their Figure 1 had temperatures > 40°C during rewarming. Strategies such as slower rewarming, limiting inflow temperature, and accepting lower maximum temperatures seem prudent considering the indisputable data implicating hyperthermia in propagating cerebral ischemic injury.²

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REPLY:

We agree with Drs. Grocott and Newman that our study did not address the best site for monitoring temperature while the patient is on cardiopulmonary bypass (CPB). The reason for this is that our standard (pulmonary artery temperature) could not be used while the patient was on CPB and we chose not to select another site as an alternative standard. The temperature in the hypothalamus is more relevant than is the temperature of the rest of the body during CPB. Data is conflicting as to which site correlates best with hypothalamic temperature. Mariak found that readings from a probe on the tympanic membrane corresponded more closely to readings from the deep brain than did readings from the oesophagus, rectum, or skin.¹ However, Stone found that with rapidly induced hypothermia, nasopharyngeal, oesophageal, and pulmonary artery temperatures all tracked deep brain temperature better than did a tympanic probe.² It would be helpful to replicate these studies using an infrared tympanic thermometer rather than a tympanic probe.

Nasopharyngeal probes appear to be safe in the population we studied. However, there is conflicting data as to the accuracy of readings from this site.^{2,3} Grocott and Newman's own study suggests that nasopharyngeal probes may be slow to track rise in temperature using jugular venous bulb temperature as the standard.⁴ It would have been interesting had they compared other sites with the nasopharyngeal in this study.

We agree that avoidance of hyperthermia with rewarming during cardiac surgery is a worthy goal.

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