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ing, along with the other factors described above, might contribute to the interindividual variability in the response to similar blood propofol concentrations.

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Were They Subdural Injections?

To the Editor:—The recent report by Chadwick *et al.*¹ of suspected subdural local anesthetic and morphine administration raises two issues.

First, the suspicion of subdural injection during three intended epidural anesthetics was raised by the development of extensive sensory block, but were these extraordinarily extensive? All three patients were significantly obese (body mass index of 38–61 kg/m², at the extreme of the range for a comparable group of pregnant patients²), which is known to increase the extent of blockade,² as does pregnancy.³ In two cases, the catheters were identified as entering at the L3–4 and L1–2 interspaces. The other insertion level was not confirmed, and although L2–3 was intended, the actual level is often higher than determined by palpation in obese subjects.⁴ Upper lumbar epidural injection is another cause of high blockade.⁵ There is great variability in extent of blockade from epidural anesthesia, which is only loosely dose related.^{6,7} As observed by Bromage,⁸ that some epidural blocks should extend to above T2 using these doses is expected. The sensory levels achieved in the three reported cases (using 13–16 ml 2% lidocaine with epinephrine, a potent solution) are not exceptional for epidural administration.

Second, the central topic of the report was the effect of subdurally placed drugs, but was the subdural passage of the injected solution really "radiologically confirmed?" Although no radiologist was credited in the report, we assume that the traditional criteria of thin layering of contrast and lock of passage through the intervertebral foramina were used. We are unaware of any investigation confirming the ability to distinguish epidural from subdural contrast injection on a plain radiograph, for instance using computed tomography for more definitive imaging. The cases reported by Chadwick *et al.* used small volume contrast injections (4–7 ml) in obese patients who have diminished epidural compliance, making thin layering also likely in the case of epidural injection. Water-soluble contrast, as was used, has a low viscosity and spreads thinly. Other epidural injections that have showed thick layering have typically required injectate volumes of 15–20 ml.⁹ The epidural injectate volume necessary to outline

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nerve root sleeves is 8–14 ml.¹⁰ Finally, passage out the foramina ("extravasation") was observed in one of the reported cases of Chadwick *et al.*

In our neuroradiology division, we are unable to reliably discern epidural from subdural contrast injection during plain radiograph myelography and prefer to state only that the injection was "extra-arachnoid." This also may be prudent in the anesthesia literature.

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In Reply:—We thank Hogan and Mark for their interest in our recent case report. They raise the questions of whether (1) the extent of blocks were really unexpected especially given that these were obese pregnant patients, and (2) whether it is really possible to identify subdural injections with small volumes (4–7 ml) of water-soluble contrast media using plain film radiographs.

Although every anesthesiologist is taught the effect of weight (and pregnancy) on local anesthetic volume requirements, we have not been impressed by this relationship in everyday clinical practice. One of us (HSC), with more than 12 yr clinical experience providing obstetric anesthesia, has observed that although epidural dose requirements may, in obese patients, be more variable, most such patients require similar volumes of local anesthetic compared to non-obese parturients to achieve high thoracic blocks and satisfactory anesthesia for cesarean section. Lubenow *et al.* have proposed clinical criteria for identifying subdural injections.¹ The patients we reported all met the criteria suggested by these authors for identifying subdural injections. Although it may not be possible to distinguish between extreme spread of an epidural anesthetic and subdural injection of local anesthetic on purely clinical grounds, the patients we presented were all unusual enough to prompt us to ask for a radiographic study. Two of our patients had T2–3 level blocks with 13 ml of local anesthetic solution; one patient had a C2 sensory level and complete motor block of the upper extremities. In our experience, this is most exceptional following lumbar epidural administration of 13 ml 2% lidocaine.

Hogan and Mark point out that volumes of 8–20 ml of contrast material have been recommended to adequately outline epidural nerve root sleeves. Indeed, prior to magnetic resonance imaging, this was common practice for *diagnostic* epidurography.^{2–4} To completely outline multiple nerve root sleeves, it is necessary to completely fill the anterior epidural space, which requires a larger volume of injectate than is necessary to merely confirm needle placement. In recent reports in which patients were studied to confirm epidural catheter placement, much smaller volumes (1–5 ml) of contrast material were recommended and considered adequate for documentation of catheter placement.^{5,6} This fits well with our injected volumes of 4 and 7 ml. Despite the small volumes of contrast, all three patients showed good filling of the subdural space over an area of 5–7 vertebral levels. In case 3, which showed extravasation at the nerve root sleeves of T12, it appears that some of the contrast layered within the epidural space but with contrast clearly layering in the anterior subdural space as well. Unlike injections of small volumes into the posterior epidural space, subdural injections of even small volumes of contrast media readily layer in the anterior aspect of the theca, as was demonstrated in case 3.

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We take exception to the statement that one cannot reliably discern epidural injection from subdural contrast injection with plain radiographic films, especially when these are taken under appropriate conditions with fluoroscopic control of the injection and filming. We perform many epidurograms at our institution, usually for confirmation of epidural catheter placement in patients with severe chronic pain conditions. Our experience in confirming epidural *versus* subdural or extraspinal placement of the catheter has been very good. We believe that it is inadequate merely to state that the injection is "extra-arachnoid" and believe that the distinction is important for proper anesthetic management and patient safety. If equivocal findings are present, then the patient should be studied using cross-sectional computed tomographic imaging.

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