tion of free morphine in serum and cerebrospinal fluid (c.s.f) was at this time 62 nmol litre⁻¹ and 10.9 nmol litre⁻¹ respectively, measured by a radioimmunoassay technique (Abuscreen).

Concentrations in serum and in c.s.f. present considerable interindividual variations some hours after extradural morphine injections (Jørgensen, Andersen and Enquist, 1981; Weddel and Ritter, 1981). The concentrations of morphine in our patient were within the limits of variations and had probably been larger before the concentrations had been determined, as maximum values for both probably will be reached earlier than 4 h after the injection (Magora et al., 1980; Weddel and Ritter, 1981; Möller et al., 1982).

Tolerance is probably developed in long-term treatment with extradural morphine, so that even large doses of morphine can be tolerated without adverse side-effects. However, extradural morphine administration by unskilled persons might prove hazardous.

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**NITROUS OXIDE IN OXYGEN AND TRACHEAL TUBE CUFF VOLUMES**

Sir,—In this very interesting article, Mehta (1981) demonstrates that the increase of cuff pressure because of nitrous oxide diffusion is a phenomenon that has to be considered even during brief anaesthesia. He showed that the volume in low pressure-cuffs had almost doubled after 3 h. These results correspond with our own investigations when we found the main increase in cuff pressure to be during the first hours of anaesthesia (Brandt, Pokar and Renz, 1980; Brandt, Beck et al., 1981).

It seems to be important to make some remarks on the following point: Dr Mehta cites Stanley (1975), who asserted that there was a smaller increase in cuff volume and cuff pressure in vivo than in vitro. He explained this by the smaller diffusion area in vivo. In our own studies, pressure and volume were increased in vivo almost doubled after 3 h. These results correspond with our own observations during the first hours of anaesthesia (Brandt, Pokar and Renz, 1980; Brandt, Beck et al., 1981).

Therefore we questioned the theory of Stanley that only the distal portion of the cuff, that is, the portion not in contact with the tracheal wall, should be the area of diffusion. Our experience indicates that, in vivo, the contact area with the tracheal wall is a diffusion area also. This theory can be proved by analysing the cuff pressure curve during operations with extracorporeal circulation (ECC). An example is shown in figure 1.

**Fig. 1.** The pressure in a high volume—low pressure tracheal tube cuff during an operation with extracorporeal circulation (Rusch Super Safety Cuff, 8.0 mm i.d., $F_{N2O} = 0.66$). A = after intubation, cuff pressure 24 mm Hg; B = onset of bypass, cuff pressure 98 mm Hg; C = beginning of rewarming the patient, D = termination of ECC, cuff pressure 44 mm Hg; E = end of anaesthesia, cuff pressure 90 mm Hg.

Immediately after intubation (A) the cuff pressure was 24 mm Hg. Until the onset of ECC (B) it increased to 98 mm Hg within 95 mm. During the whole time of ECC the pressure decreased discontinuously by 54 mm Hg (D—end of ECC). This pressure reduction occurred in spite of continuing the tracheal ventilation during ECC with 1 litre min⁻¹ of the same anaesthetic gas mixture as before ECC ($F_{N2O} = 0.66$). This ensured that partial pressure relations of the gases were kept constant at the distal cuff area. Nevertheless, the cuff pressure decreased. This pressure decrease during ECC can only occur if nitrous oxide diffuses out of the cuff through the contact area with the tracheal wall additionally. Partial pressure relations changed in this area only: the tracheal tissue becomes free of nitrous oxide during ECC. After termination of ECC (D) the conditions become the same as before ECC. Cuff pressure increases again to nearly the same value of 90 mm Hg until the end of anaesthesia (E).

Therefore, in our opinion, the whole cuff wall constitutes a diffusion area for nitrous oxide in vivo (Brandt, Gumrukci et al., 1981). Moreover, as the size of the contact area is about 10 times the cuff area not in contact with the tracheal wall, the main part of diffusion takes place from tracheal tissue through the contact area into the tracheal cuff, and vice versa.

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