stitial fluid, which is held in a gel state under normal conditions, will swell 30 to 50 per cent with the addition of liquid, after which any further increase in fluid volume is not absorbed by the gel and is highly mobile.[7] The fluid is free to flow downward in the tissue influenced by the pull of gravity. The higher the specific gravity, the greater the pull.

Summary

Chloroprocaine, 0.5 per cent, with physiologic saline solution, has a specific gravity of 1.007 and a osmolarity of 283 mOsm/l, which increase to a specific gravity of 1.025 and an osmolarity of 542 mOsm/l when chloroprocaine is prepared in dextrose, 5 per cent. Chloroprocaine, 2.7 per cent, shows similar increases in specific gravity and osmolarity with dextrose 5 per cent. The highest sensory anesthesia level attained in pregnant patients following epidural injection of 10 ml of each of these solutions was determined. Chloroprocaine in dextrose, 5 per cent, produced a significant lowering of the highest sensory anesthesia level attained, compared with solutions to which dextrose was not added.

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Leg Lift and Maximum Inspiratory Force, Clinical Signs of Neuromuscular Blockade Reversal in Neonates and Infants

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Clinical signs of adequate neuromuscular blockade reversal in adults are based on voluntary actions (head raising, grip strength) that often are not applicable to the neonate and infant. Reflex leg lift has been used for more than ten years in the evaluation of neurologic development in neonates and infants.[1] We propose that leg lift might also serve as a criterion of adequate neuromuscular blockade reversal in this age group. Values of maximum inspiratory force (MIF), an established test for identification of adequate neuromuscular block reversal in adults, have not been reported for healthy infants, and were determined in this study. Reflex leg lift was then correlated with MIF measured before and after anesthesia and reversal of neuromuscular blockade. Correlation of reflex leg lift with train-of-four stimuli was found to be impractical in awake neonates and infants because they would not maintain a resting (relaxed) thenar muscle tension for 2 sec at the time they reflexly raised their legs, or for any two-second period soon thereafter.

Methods

This study was approved by the Committee for Protection of Human Subjects. We determined MIF according to the method of Westcott and Bendixen,[2] except that airway occlusion was maintained for only 15 sec.[3] A 16-gauge tapered catheter, inserted into a 90-degree elbow connector, was connected by high-pressure tubing to a Hewlett Packard 1280C pressure transducer, and the negative inspiratory effort recorded. The transducer and recorder were calibrated, in centimeters of water, against a Wallace and Tierman Penwalt Series 6150 Portable Pneumatic Calibrator.

The patients were divided into two study groups. Group I consisted of 20 infants (aged 1 day to 12 weeks) who were premedicated with only atropine

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(40 μg/kg). After awake endotracheal intubation, they were anesthetized with halothane and air. Control measurements of MIF were obtained after the awake endotracheal intubation but prior to pancuronium administration. Group II consisted of 30 infants (aged 7–36 weeks) studied in a similar manner but without awake endotracheal intubation or preparalysis MIF determinations. This group was premedicated with atropine (20 μg/kg) and, for infants more than 24 weeks of age, pentobarbital (4 mg/kg, im). They were anesthetized with nitrous oxide and fentanyl or halothane.

At the end of the surgical procedure, but at least 20 min after the last dose of pancuronium had been given, neuromuscular blockade was reversed in both groups by the intravenous administration of atropine, 20 μg/kg, and neostigmine, 70 μg/kg. Reversal occurred in Group I at a mean (±SE) of 62.9 (±7.4) min and in Group II, 55.2 (±4.2) min after the last dose of pancuronium. We repeated MIF measurements as soon as the patient raised both legs off the operating table.

Results

Control MIFs in neonates (Group I) averaged -70.9 ± 4.5 cm H_2O (range -38 to -100 cm H_2O). After reversal of neuromuscular blockade, the mean MIF accompanying leg lift was -58.6 ± 4.1 cm H_2O (range -22 to -90 cm H_2O). Postreversal MIFs averaged 12.2 ± 4.5 cm H_2O (range $+44$ to -50 cm H_2O) less than control MIFs, with 15 per cent of patients having the same MIF as control.

Postreversal MIFs in older infants (Group II) averaged -76.1 ± 3.2 cm H_2O. No patient in this study needed reintubation of the trachea or showed any evidence of airway obstruction or respiratory insufficiency after extubation of the trachea.

Discussion

We have been unable to find any report of a clinical sign for adequate neuromuscular blockade reversal in neonates and infants. Westcott and Bendixen[2] reported that a MIF of -20 cm H_2O indicated adequate ventilatory reserve for endotracheal extubation in adults. The present study indicated that a MIF of at least -32 cm H_2O corresponds with leg lift, which is associated with apparent adequate ventilatory reserve for tracheal extubation. We, therefore, regard leg lift as a reliable clinical sign of adequate reversal of neuromuscular blockade in neonates and infants. Our MIF data in unanesthetized neonates agree with the findings of Karlberg *et al.*,[4] who found that normal neonates generate extrathoracic pressures of -16 to -70 cm H_2O during the first few breaths after birth, and with data obtained in infants before extubation.[5]

Postreversal MIF values can approach control values, but also may be substantially less negative in some neonates and infants who appear to have adequate airway and ventilatory function. These lower MIF values may be a sign of subclinical residual neuromuscular blockade or residual nervous system depression due to anesthesia. However, we still conclude that leg lift is a good sign of adequate reversal of neuromuscular blockade, since it is associated with a MIF of at least -32 cm H_2O.

Addendum

Since submission of this report, three studies of MIF in neonates and infants recovering from respiratory failure have been published.[6,7,8]

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