Curare Monitoring in the Ventilated Infant

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Summary

This paper reviews the indications for:
1. Neuromuscular blockade during ventilation in paediatric intensive care,
2. the expected benefits
3. the classical administration schemes.

It is the authors' wish to propose a method of evaluating the depth of the block in order to ensure smooth relaxation for prolonged periods.

Introduction

Neuromuscular blockade in long term mechanical ventilation in infants and children has been advocated for some time by different authors.

In the paediatric intensive care unit, there are indications for neuromuscular blockade in medically as well as surgically indicated ventilatory support.

Whatever the indications, when a decision is taken to paralyse a child, it must be kept in mind that such action will suppress most visible reactions from the child, including reactions to pain and discomfort.

Adequate analgesia and sedation is thus mandatory when muscle relaxants are administered as well as prophylactic antacid therapy via a nasogastric tube or intravenously.

Indications for neuromuscular blockade should be correctly delineated.

1. MEDICAL INDICATIONS

Some paediatric intensivists make use of muscle relaxants whenever ventilation becomes difficult for whatever reason: for example when the child "struggles" with the ventilator. The authors do not favour this attitude but prefer to treat the cause of the problem through correct sedation or analgesia, improving ventilation conditions or emptying the bladder. A more generally accepted reason for curarisation is when good gas exchange can only be obtained by increasing positive pressure.

In those conditions, the suppression of resistance due to muscle tone can lower the pressure needed for adequate ventilation, reducing the risks of lung dysplasia and of pneumothorax due to excessive positive pressures.

Finally, certain pathologic conditions due to some degree of muscle tension demand mechanical ventilation as is the case in tetanus infection.

In these conditions, where the aims is to reduce ventilatory pressure the benefits of muscle relaxants are self explanatory.

2. SURGICAL INDICATIONS

After closure of a diaphragmatic hernia, transpulmonary pressure must be maintained as low as possible to avoid rupture of the hypogastic lung.

Primary suture of the oesophagus in the oesophageal atresia is not uncommonly performed under tension. Any rise in the intrathoracic pressure can be damaging for the suture line.

After closure of a parietal defect of the abdominal wall, gastrochisis or exomphalos, whether complete or with a temporary silastic bag containing part of the gut, any muscle activity will counteract the relaxation of the abdominal wall and interfere with healing.

Muscle relaxants are very useful in all those conditions. When surgical conditions requires neuromuscular blockade, its depth should be strictly maintained at a near surgical level i.e. 20 to 25% of twitch height.

This level should then be as stable as possible. Sudden coughing as well as other manifestations of partial reversal should never occur.

DOSAGE AND CONTROL

In most cases, administration of muscle relaxants in the ICU follows one of two schemes: either a fixed dose, administered when ventilation of the child is difficult to achieve – the "on demand" method, or a fixed dose repeated at fixed intervals – the "by the clock method."
More recently, with the introduction of shorter acting non-depolarizing muscle relaxants, a third method has been developed: continuous infusion technique with either Vecuronium\textsuperscript{(3)} or Atracurium\textsuperscript{(4)}.

The first two schemes have serious drawbacks.
The "on demand" administration based on sheer observation of the infant leads to irregular and somewhat erratic levels of curarisation. The numerous factors involved in the genesis of pressure rise makes it unrealistic to regulate relaxant administration by following the airway pressure. This measurement can only be used to decide on the moment of weaning from the drug. The good stability can be achieved with the "by the clock method", but the dosage is based on average needs for the age and weight. Individual sensitivity can lead to either inadequate or excessive blockade.

The probability of excessive block is increased when very sick babies whose renal and hepatic function are impaired. Excessive block is especially inconvenient when the patient is ready to be weaned from IPPV or when it is important to assess cerebral status.

To maintain a stable level of curarisation and obtain a rapid recovery from neuromuscular blockade, continuous infusion of the new shorter acting curares has been tested in the ICU.\textsuperscript{(3,4)} Atracurium infusions would be the most suitable in severely ill patients with impaired renal or hepatic functions.

However, Laudanosine, Atracurium's main metabolite, is excreted through the kidney, and since high doses produce seizures in animals,\textsuperscript{(5)} caution is still required in infants with immature kidney or children with impaired renal function, until long term studies are completed.

To avoid inadequate curarisation, a more accurate monitoring of the neuromuscular blockade is advocated during muscle relaxation for mechanical ventilation in paediatric intensive care. Two methods of monitoring the end plate are commonly used in theatre anaesthetic practice: isometric contraction measurement using the pressure transducer and the stimulated electromyographic measurements. The latter is certainly more suitable in childhood due to the difficulty of adapting the pressure transducer to a small thumb. Whatever the technique, two measurements are possible: one is the twitch height (T.H.) or ratio of the muscle responses to a supramaximal single twitch at a definite time and before curarisation or ratio of the fourth to the first responses of the muscle to a train of 4 stimulations at a frequency of 2 Hertz.

This second measurement presents the advantage to be independent of any precurarisation measurement and can thus be performed at any time, more over it will not vary with alterations of the electrodes impedance. Whatever the technique used, continuous recording is mandatory. In the case of a long or medium term ventilated infant, continuous measurement as well as pre-administration measurement can be unpractical. It should be remembered that after a T4 stimulation a visible response to the first twitch corresponds to about 10\% of T.H. recovery, to the first 2 corresponds about 20\%, to three 25\% and to all four 40\%. Observation of the responses is thus a way of monitoring the depth of paralysis suitable in most clinical situations. In our ICU, calculation of dosage administered with this simple monitoring in comparison with a fixed interval scheme "by the clock method" has shown an economy of about 25\% in circulatory stable infants.

A T.H. of about 20\% should be maintained for adequate relaxation.

**PRACTICAL HINTS**

Assessment of adequate curarisation can be performed with a simple and compact stimulator that can be installed after the first dose of relaxant has been given and all resuscitative measures have been taken. Two electrodes are glued to the forearm on the course of the ulnar nerve. A T4 stimulation is then performed every 15 minutes until 1 or 2 contractions are elicited in the fifth finger. Stimulations are then performed every 5 minutes and a dose of relaxant is administered when the third contraction appears. Measurements can then be suspended for half an hour. The rate of measurements and the dosage is subsequently easily adapted.

The stability of the blockade is excellent and overdosage becomes practically impossible.

**Bibliography**