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Severe Laryngospasm Without Intravenous Access – A Case Report and Literature Review of the Non-Intravenous Routes of Administration of Suxamethonium

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ABSTRACT

Severe laryngospasm may occur during inhalational induction of paediatric patients. Effective and rapid treatment of this complication is extremely important to prevent severe hypoxia. The treatment of choice is intravenous suxamethonium if muscle relaxation is desired. However, in the absence of intravenous access, alternate routes of administration have to be considered. The rapidity and the effectiveness in treating laryngospasm by these non-intravenous routes are important to the outcome of the patient. Though the intramuscular route may be relatively slower in onset time (time taken to reach maximum effect of paralysis) compared with the intravenous route, clinical experience so far indicates satisfactory result in the treatment of laryngospasm. Current evidences indicate that the intraosseous route is probably superior to the intramuscular route and comparable to the intravenous route in terms of onset time.

Keywords: suxamethonium, laryngospasm, intramuscular, intraosseous

INTRODUCTION

It is common practice to induce anaesthesia in the paediatric patient by the inhalational route followed by intravenous cannulation. During induction, laryngospasm is not uncommonly encountered but is often easily aborted by maintenance of a patent upper airway, deepening of anaesthesia with assisted ventilation and application of continuous positive airway pressure. Rarely, laryngospasm becomes severe and necessitates paralysis of the glottis, in order to achieve adequate ventilation. Intravenous suxamethonium remains the treatment of choice in this situation. However, if intravenous access has not been established or cannot be established under emergent circumstances, suxamethonium may be given by an alternative route. We report a day surgery case who presented with this clinical problem.

CASE REPORT

A 2-year-old child was scheduled for elective herniotomy. Pre-operative assessment of the slightly obese child (body weight, 17 kg) revealed no previous medical problems or upper respiratory tract infection. Anaesthesia was induced with inhalation of 2% halothane in 70% nitrous oxide and 30% oxygen mixture. He was monitored with continuous electrocardiography, non-invasive blood pressure monitoring and pulse oximetry. When the child appeared adequately anaesthetised, intravenous cannulation was attempted on the dorsum of the left hand. After repeated failed attempts in all the limbs, the head was turned to the left and the right external jugular vein was selected for intravenous access. Upon puncture of the skin, crowing noise was heard at once followed by paradoxical breathing. Attempted bag and mask ventilation proved almost impossible despite attempts to improve patency of the upper airway and assist ventilation with 100% oxygen and increased concentration of halothane. Oxygen saturation started to decrease and a decision was made to give intramuscular suxamethonium 50 mg (3 mg/kg) at the right deltoid muscle. About 30 to 45 seconds later, ventilation improved and oxygen saturation increased from 85% back to 99%. Laryngoscopy and oral endotracheal intubation were performed when the child was adequately anaesthetised. Anaesthesia was maintained with nitrous oxide, oxygen and halothane mixture and ilioinguinal nerve block was given with 5 mLs 0.25% bupivacaine. Our patient was mechanically ventilated until there was evidence of spontaneous respiration. He was on assisted ventilation till he was able to breathe adequately. The surgery lasted 30 minutes. At the end of the operation, he was extubated "deep". The child was well postoperatively.

DISCUSSION

Intravenous suxamethonium is very effective in treating severe laryngospasm. However, an acute situation may arise whereby severe laryngospasm develops before intravenous access is achieved. In such a situation, an alternative route of administering suxamethonium that will lead to expeditious and effective relief of laryngospasm is

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extremely important to the favourable outcome of the patient. As it is not a common practice to use suxamethonium by the non-intravenous routes among anaesthetists, knowledge regarding these other modes of administration may be lacking.

Intramuscular suxamethonium has been recommended in the doses ranging from 1.5 to 3 mg/kg[1-5]. Liu et al studied the dose response relationship of intramuscular suxamethonium in children. At 2 mg/kg and 3 mg/kg of intramuscular suxamethonium, some patients still demonstrated very little twitch depression (less than 10%) of the adductor pollicis. However, at 4 mg/kg intramuscular suxamethonium, all patients achieved significant twitch depression (more than 80%). Thus he recommended at least 4 mg/kg of suxamethonium given intramuscularly in order to ensure adequate muscle relaxation[6]. The dose response relationship of intramuscular suxamethonium was also studied in the adult patients. It showed that at least 3 – 4 mg/kg of intramuscular suxamethonium was needed to achieve complete neuromuscular blockade[7].

The main drawback with this route of administration is the slow onset time (defined as the time taken to achieve maximal twitch depression) compared to the intravenous route. At 4 mg/kg of intramuscular suxamethonium, the onset time (the mean maximum depression of the first twitch of the train-of-four was 89.7 ± 5.0%) is about 4 minutes[8]. The slow onset time may be a concern especially if airway control has to be established rapidly to prevent severe hypoxia. However, clinical experience with the use of intramuscular suxamethonium in children has been that airway control after laryngospasm is achieved in less time than the time to maximum depression[6]. This indicates that the onset time to effective relief of laryngospasm is shorter than the onset time to maximal twitch depression measured at the thumb. This is further substantiated by the finding that a very small dose of suxamethonium 0.1 mg/kg intravenously has been effective in treating laryngospasm visualised by direct laryngoscopy[9]. Since suxamethonium is broken down rapidly by plasma cholinesterase, much of a very small dose would have been hydrolysed before it reached the intrinsic muscles of the larynx. One can only surmise that the laryngeal muscles are very sensitive to the effects of suxamethonium. Donati et al has reported a method to measure the train-of-four of the adductor muscles of the larynx[10]. The endotracheal tube cuff is positioned between the vocal cords under direct vision. The adductors of the larynx are stimulated by electrical impulses delivered to the recurrent laryngeal nerve by surface electrode placed at the thyroid notch. The contraction of the adductors press on the cuff and increases the pressure within. This is measured by an air-filled transducer joined to the connector of the pilot ballon. With this method, the effects of vecuronium on the adductors of the larynx and the thumb have been studied[11]. So far, no such study has been conducted with suxamethonium. The dose response relationship of intramuscular suxamethonium can be more relevantly measured at the adductors of the larynx rather than at the thumb.

Attempts were made to hasten the onset of intramuscular suxamethonium. Increasing the concentration of suxamethonium from 2% to 5% did not demonstrate any improvement[8]. Injection into more than one muscle site was expected to be more effective, however, this was not demonstrated by injection into two deltoids when compared to one deltoid[6]. Onset time after injection into the tongue was shown to be intermediate between the intravenous route and the intramuscular route[12]. Digital massage of the tongue after injection significantly improved the onset[13]. However, the onset time of the intramuscular route cannot equal that of the intravenous route.

There are some concerns regarding the intramuscular injection of suxamethonium. As the dose of suxamethonium given is higher, the type of block is likely to be phase 2 block. As such, the duration of block may be a concern if the surgery is short. However, clinical studies so far have not shown the recovery to be unduly prolonged[6,8]. Cardiac arrthymia is thought to be higher due to the larger dose. Contrary to expectation, the incidence is documented to be much lower in intramuscular injections to conventional sites (eg. deltoid and quadricep femoris)[14] compared with intravenous injection. However, injection into the tongue (which is a muscle) is surprisingly associated with a higher incidence of cardiac arrthymia and is comparable to the intravenous route[6,12]. Because of the low incidence of bradycardia, it has been recommended that concomitant injection of atropine is unnecessary[15]. An unusual association has been reported between intramuscular suxamethonium and frank pulmonary oedema[16]. In three infants, the only evidence was the close temporal relationship between the administration of intramuscular suxamethonium and the development of the complication. The cause is unknown.

Suxamethonium has also been administered via the intraosseous route. Experiments in sheep comparing the onset time of suxamethonium after intravenous, intraosseous and intramuscular injections demonstrate that onset following the intraosseous route is comparable to the intravenous route and superior to the intramuscular route[17]. Subsequent to that, anecdotal reports show that intraosseous suxamethonium (1 mg/kg) resulted in adequate intubating conditions within 45 seconds[18]. Experimental evidences indicate that intraosseous injection behave very much like intravenous injection. Congo red dye injected into the rabbit tibia can be found in the right ventricle within 10 seconds[19]. Similar blood levels of atropine were achieved when administered intravenously or intraosseously[20]. It has also been shown that fluid injected into the marrow cavity rapidly flows, via the emissary veins, into the general circulation.

This technique is suitable for use in children up to 6 years of age, after which the bones become too hard, although cannulae have recently been developed which are suitable for adults[21]. The most common sites used for the insertion of the intraosseous cannulae are the anterior surface of the tibia, 2 – 3 cm below the tibial tuberosity, the tibia 3 cm above the medial malleolus or the femur 3 cm above the lateral condyle. The proximal tibia is the preferred site. After skin preparation and using an aseptic technique, the bone is held firmly between the thumb and the index finger, and the needle is inserted through the skin onto the bone. It should then be directed away from the epiphyseal plate and the joint surface at an angle of 60° and 90° to the bone surface and screwed into the bone. As the cortex is penetrated there is loss of resistence and the needle is held firmly in place by bone. Aspiration of bone marrow can be used to confirm correct placement but the aspirate may block the needle. The needle is then ready to use. Removal involves screwing the needle out of the bone, application of pressure until the bleeding stops and then a sterile dressing is applied. Drugs should be washed through with a bolus of fluid.

Intraosseous injection can be achieved with any 20-G to 13-G needle with a stylet. Currently, there are commercially available intraosseous needles (eg. Sussmare-Rysynski Intraosseous Needle. Cook Critical Care) with a guard to prevent insertion of the needle too far and threaded to help prevent leakage around the needle and more secure fixation. Although the technique appears simple, successful intraosseous injection still requires practices which will be unlikely during routine anaesthetic practice. However, one possibility of acquiring competence is to perform several marrow aspirations under supervision by haematologists. This is also very important to reduce unnecessary delay during the crisis.

There are potential complications associated with intraosseous injection. Osteomyelitis is a rare complication and generally occurs if the needle is left in place for 24 hours or more. Although pulmonary emboli resulting from dislodging fat and marrow may be a complication, so far there is no such report. The commonest problem is the failure to locate the marrow cavity; it results from either penetrating the opposite cortex of the bone or failure to penetrate the bone at all. Technical failure has been reported as high as 20%[21]. Damage to the epiphyseal plate occurs if the needle is inserted too close to the joints.

CONCLUSION

Administration of suxamethonium by the intramuscular route is useful in the management of severe laryngospasm. Review of the literature suggests that the intraosseous, although technically more difficult results in an onset time that is comparable to the intravenous route. The anaesthetists should keep in mind these techniques and appropriate doses for intramuscular and intraosseous routes when confronted with an acute situation of severe laryngospasm before intravenous access is achieved.

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