INTRAMUSCULAR SUCCINYLCHOLINE FOR ENDOTRACHEAL INTUBATION IN INFANTS AND CHILDREN[1]

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THE INDUCTION and intubation of an adult are seldom a problem, whereas the intubation of an infant or a child may be difficult, owing to the fact that, if not heavily premedicated, he may fight against the inhalation agent imposed upon him and make intravenous injection impossible, especially if the anaesthetist is working alone.

In a busy hospital, it is not so simple to postpone a relatively minor operation, such as tonsillectomy, hernia, or squint, solely because the child is not well premedicated, and is excited and crying. In such cases wrestling with the child usually results, especially if one tries to impose upon it the Vinethene-ether sequence which is still so popular in our hospitals or the more violent force of intubating a conscious baby with topical anaesthesia.

We have tried to simplify and shorten the induction period for intubation in the infant and child, and to make it easier for the anaesthetist and safer for the bad risk patient, by giving succinylcholine intramuscularly prior to the intubation.

In all cases succinylcholine was used in the form of Anectine (Burroughs Wellcome & Co.). The Anectine was always taken fresh from the refrigerator.

One hundred and fifty-five patients between three days and fourteen years of age have been intubated by this method. Operations performed were:

ENT, mainly tonsillectomies	63	Cardiac surgery	7
Hernias	21	Neurosurgery	6
Eye operations	13	Intra-abdominal	4
Circumcisions	11	Dental surgery	3
Plastic surgery	10	Others	8
Accidental injuries	9		

The action of the intramuscular Anectine was considered satisfactory if the patient was fully relaxed by the time of intubation done within three minutes after the injection of the relaxant Fully relaxed here means a complete flaccid paralysis of all striated muscles including the laryngeal muscles (the same as if the drug had been given intravenously)

Four variations of induction were used.

In the first, oxygen only was given before and after the injection and intubation in two cases of imminent death due to respiratory insufficiency resulting from severe convulsions. Patients dramatically improved.

In forty cases Anectine was given intramuscularly to the conscious patient, immediately followed by nitrous oxide–oxygen 6:3 by mask. The mask was lowered gradually to the patient's face, and the respiration assisted as it became shallow, and then controlled for a minute when it had ceased; then intubation

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was performed Controlled respiration with N_2O–O_2 was continued after the intubation until the patient's spontaneous respirations started (that is, when slight spontaneous movements of the diaphragm were noticed). From this point on, ether, trilene, Fluothane, or cyclopropane was added and gradually increased, and the respiration was assisted until clinically sufficient respiration was present—that is, when the tidal volume seemed to be satisfactory, and there were no signs of anoxia.

When Anectine was used in conscious patients, the following observations were made.

If the patient was crying prior to the injection, he lost his voice in 30 to 45 seconds after the injection, although the muscles of the extremities still seemed to be very strong, and the patient was able to lift his head for approximately ten seconds more Most of the patients became co-operative by the time they had lost their voices, as they were now able to listen to the voice of the anaesthetist, and started breathing as deeply as possible the anaesthetic mixture of N_2O or cyclopropane, which was flown over their faces When the patient was restless, and did not want to lie down, the injection was done with the child still in the nurse's arms, or sitting on the operating table When the head of the patient became too heavy, 45 seconds after the injection, he was placed horizontally, and gradually assisted, and then controlled respiration was started with the above mixture which seemed to render the patient unconscious within a minute

Although I do not think that this was the right way to apply this method, it still seems to be gentle in comparison with the Vinethene-ether sequence in the resisting patient or conscious intubation with topical anaesthesia Once the relaxant was given no force at all had to be applied by the anaesthetist.

In order to record the sensations of the patients a few older and co-operative children (one of 14 years) were induced by giving Anectine intramuscularly in the conscious state The following is an example

A very co-operative 10-year-old boy, weight 60 lb , underwent tonsillectomy. He was given 1 2 c c of 10 per cent Anectine intramuscularly After ten seconds the patient said that it did not hurt any more and it was less painful than the injection of the premedication (Demerol, Atropine), which was easily explained as the premedication was given subcutaneously. Then 20 seconds after the injection the patient said "I feel that am getting very tired and heavy" His voice was lost 30 seconds after the injection. His respiration became shallow 45 seconds after the injection, although the patient was still able to move his right hand if asked to do so Assisted respiration with N_2O–O_2 was started right away, and controlled respiration one and a half minutes after the injection, when there was a complete flaccid paralysis, and apnoea. Intubation was performed three minutes after the injection with very good relaxation Slight diaphragmatic movements appeared six minutes after the injection, which was considered as the commencement of spontaneous respiration Trilene was added to the N_2O–O_2 mixture, and gradually increased Recovery of the respiration, to the point where assisted respiration was considered no longer necessary, followed within the next nine minutes (that is, respiration was satisfactory 15 minutes after the intramuscular injection of Anectine). The operation was finished, and the patient was extubated, and was breathing well 23 minutes after the injection

The third variation of the induction was used in ninety-nine patients—that is, in most of them. Here a concentrated mixture of cyclopropane–O_2 or N_2O–O_2 was

allowed to flow over the face of the patient as the mask was gradually lowered As soon as the patient was unconscious, usually two minutes after commencing the induction, Anectine was given intramuscularly, and N_2O–O_2 alone was given in all cases, with assisted and controlled respiration prior to intubation, so that relaxation at the time of intubation was entirely due to the Anectine injected.

The fourth variation was used for bad risk patients, and in cardiac surgery in fourteen patients The patients, of course, were well premedicated and calm or sleeping if not roused. Cyclopropane–O_2 was given by mask until the patient was unconscious; then Anectine was given intramuscularly and assisted and controlled respiration performed as necessary The vocal cords and trachea were sprayed with 4 per cent Xylocaine prior to the intubation. Cyclopropane–O_2 was continued after the intubation until intravenous infusions were installed or a venous cut-down performed During this type of induction, we did not notice any change in blood pressure and only a slight slowing of the pulse rate if the concentration of cyclopropane was increased After the installation of intravenous infusions, intravenous Anectine drip was started, and the patient was maintained on N_2O–O_2 anaesthesia during the operation

Amount and Concentration of Anectine

Anectine 2 per cent or 20 mg /c c

Dosage: *1·mg. per pound of body weight* This dosage was used in nineteen patients, aged two weeks to six years Nine of these were not completely relaxed within three minutes Although seven of them could be intubated with more or less difficulty, two were not sufficiently relaxed for intubation (that is, the results were not fully satisfactory in 50 per cent of the patients)

Dosage. *1¼ mg. per pound of body weight.* This dosage in thirty patients, aged two months to seven years resulted in 33 per cent of the patients being incompletely relaxed within three minutes after the injection, although it was possible to intubate all of them without an additional dose of relaxant.

Dosage: *1½ mg. per pound of body weight.* In twenty-seven patients, aged eight months to seven years, this dosage resulted in 30 per cent of the patients being incompletely relaxed, although intubation was possible in all cases

Dosage. *2 mg. per pound of body weight.* In twelve patients, aged three days to three years, this dosage resulted in complete flaccid paralysis in all patients within two minutes of the injection of the Anectine

Anectine 10 per cent or 100 mg per c c

Dosage. *1½ mg. per pound of body weight* was given intramuscularly in thirty-nine patients, aged eight months to fourteen years. Six patients, that is 17 per cent, were not fully relaxed and did not stop breathing completely although intubation was possible in all of them

Dosage: *2 mg. per pound of body weight* were given in twenty-eight patients, eight months to thirteen years old. All of these were fully relaxed, and intubated, within three minutes of the injection

Table I shows the amount of Anectine in milligrams per pound of body weight given in numbers of patients, in different age groups. In brackets the number of patients not fully relaxed at the time of intubation, that is, three minutes after the injection of Anectine.

TABLE I

Age	1 mg	1¼ mg	1½ mg (2%)	1½ mg (10%)	2 mg (2%)	2 mg (10%)	Total no of patents
Under 1 yr	6 (1)	3 (1)	4	2	8	2	27
1 yr.	2 (2)	5	3 (1)	3	1		17
2 yrs	1 (1)	1 (2)	4 (2)	4	2	2	20
3 yrs	1 (1)	5	3 (2)	11	1	7	31
4 yrs	(1)	4 (2)	1	3 (1)		4	16
5 yrs	(2)	1 (3)		5 (1)		5	17
6 yrs	(1)	1 (1)	2 (3)	4 (1)		3	16
7 yrs		(1)	1	1		2	5
8 and 9 yrs				(2)		1	3
10 yrs.						1	1
13 and 14 yrs				(1)		1	2
TOTAL	10 (9)	20 (10)	19 (8)	33 (6)	12	28	155

Table I indicates that smaller or younger children need less Anectine intramuscularly. They seem to have much faster absorption, and the level of succinylcholine in blood necessary for skeletal muscular paralysis is attained with smaller dosages.

If the concentrated Anectine (100 mg/c c.) was used, the relaxation was attained in a shorter period of time, as the absorption of the same amount of water carries more Anectine with it. It also seemed to be less painful if in a child of 50 lb. 1 c.c. of the concentrated Anectine was injected, instead of 5 c c. of the 2 per cent solution.

The following minimal dosages were found necessary in order to attain full relaxation in all patients in the following age groups: younger than twelve months—1½ mg./lb. of body weight of 2 per cent Anectine, one to three years—1½ mg/lb. of body weight of 10 per cent Anectine, four years and older—2 mg./lb. of body weight of 10 per cent Anectine. The question of how much succinylcholine could be safely given to a child is not yet decided. Our clinical experience shows that 10 mg./lb. of body weight can be given safely intravenously during an operation of one to two hours' duration. In this series a child nine months old, weighing 14 lb. received 30 mg./lb. of body weight of Anectine intravenously during repair of a diaphragmatic hernia which lasted two and a half hours. The infant started spontaneous respiration ten minutes after the interruption of the Anectine drip, but needed an additional 45 minutes for full recovery of respiration. It seems that 2 mg./lb. of body weight would be quite well inside the safety limits. The injection of Anectine intramuscularly did not cause any change in pulse rate or blood pressure But if the patient was very lightly anaesthetized, or when Anectine was given to a patient in a conscious state, there sometimes was a slowing of the heart during the intubation. In one patient there was an arrhythmia which lasted for ten minutes, until the anaes-

thesia was deepened. The arrhythmia, however, reappeared at the end of the operation one hour later. In most patients the intubation was combined with an increase in the pulse rate, and a slight increase in the blood pressure, unless the patient was heavily sedated, and induced with cyclopropane. The induction with cyclopropane, or N_2O, or Fluothane, prior to the intramuscular injection of Anectine, seems to contribute greatly to the comfort of the child. There were no differences in the time of the commencement and duration of relaxation, related to the state of consciousness at the moment of injection or intubation.

Average times before the commencement of spontaneous respiration after the intramuscular injection of Anectine, were 7½ minutes if 1 mg., 1¼ mg. or 1½ mg./lb of body weight were given (with variations in individual cases from 3 to 18 minutes). If 2 mg./lb of body weight were injected, the time was 10 minutes (with individual variations of 5–18 minutes), when the 2 per cent solution was used, and 11 minutes (with individual variations of 5 to 21 min.) if the 10 per cent solution was injected. This shows only 4 minutes difference in the time of appearance of spontaneous respiration in average values in 1 mg. of the 2 per cent and 2 mg. of the 10 per cent solution per pound of body weight are compared. The average times for return of adequate respiration after the injections were 11 minutes (with individual variations of 6–15 minutes) if 1 mg./lb. was given; 12 minutes (5–15 minutes) if 1¼ mg /lb of 2 per cent Anectine were given, 14½ minutes (10–25) if 1½ mg /lb of 2 per cent Anectine were given; 15 minutes (10–21) if 1½ mg /lb. of 10 per cent Anectine were given, 18 minutes (14–24) if 2 mg./lb of 2 per cent Anectine were given, 19 minutes (14–26) if 2 mg./lb. of 10 per cent Anectine were given

It is very seldom that there is an operation where the extubation takes place in less than 20 minutes, from the beginning of anaesthesia. So even for a minor operation, if the child has to be intubated, this seems to be a time-saving procedure

Possible Complications

It was obvious that even 2 mg./lb. of body weight of the 10 per cent Anectine solution did not cause any appreciable degree of relaxation if injected subcutaneously, therefore, a special technique for intramuscular injection was employed If the patient was lying on the table, the injection was performed by the anaesthetist on the frontal aspect of the thigh—perpendicular to the skin, down to the bone, and then the needle was withdrawn for ½ cm. This injection may be most comfortably performed by the anaesthetist who is holding the mask on the patient's face with his left hand In a sitting patient, the deltoid muscle or the buttock was used. For patients of one year and older a 1 c.c. syringe (tuberculine syringe) was used, in order to get exact amounts of the highly concentrated Anectine.

If too small a dosage of Anectine is given, the child will be partially paralysed and difficult to intubate The cords may be very weak and let the tube pass easily, yet the masseter muscle may still be in spasm If the spasm is overcome by pushing the chin downward, intubation may be easy, as the child is not capable of closing its mouth, once the laryngoscope is inserted, although he is capable

of moving his arms and legs, and may extubate himself when intubated. An additional dose of Anectine intramuscularly will relax the child within a minute, without interfering appreciably with the return of respiration. If insufficient Anectine is given, the child may resist the controlled respiration, and become anoxic.

If Anectine is given in a conscious child, the mask should not be applied immediately to the face, and assisted respiration should not be started before the relaxation starts, otherwise serious breath-holding, and laryngospasm ensue, which may last for approximately one minute. During that time the child may become very cyanotic as its increased muscular activity greatly increases the metabolism. If the anaesthetist now tries to push O_2 forcefully, he merely fills up the stomach Therefore, the mask should be lowered gradually, and N_2O–O_2 or another non-irritating gas allowed to flow freely on to the patient's face. The mask should be applied only when assisted respiration must be started, which is obvious from the shallow diaphragmatic respiration of the patient. This occurs approximately 30 to 45 seconds after the injection of Anectine Assisted and controlled respiration should be carried out very gently, if not, the stomach will be filled up with gas

During the period of apnoea the depth of anaesthesia should be gradually increased, especially if ether has to be given during the operation. When the patient starts his spontaneous respirations, he may emerge from the relaxation in four to five minutes That time may be too short to get him deep enough to tolerate the ether vapour. Struggling and breath-holding result, which may cause anoxia, or dangerous cardiac reflexes, if the concentration of the ether vapour is suddenly increased.

If during the period of apnoea the patient is deeply anaesthetized, he will not start spontaneous respiration unless the anaesthesia is lightened

However easy the induction and intubation are made, this method is not for the beginner in anaesthesia, as with this method a good judgment of the depth of anaesthesia, as well as an estimation of respiration, is essential Secondly, the assisted and controlled respiration in a baby needs an experienced hand For an experienced anaesthetist it seems to be, however, a method which simplifies the induction and contributes to the safety of the grave risk patient

Summary

In a series of 155 infants and children, relaxation for endotracheal intubation during the period of induction of anaesthesia was attained by giving succinylcholine in the form of Anectine intramuscularly

In forty conscious patients the intramuscular Anectine was given first, followed by induction with some anaesthetic mixture by mask, but most patients were rendered unconscious before the injection, which was mainly with cyclopropane.

If the appropriate dosage of Anectine was given, all the patients were fully relaxed within two to three minutes after the intramuscular injection, and could be easily intubated.

This kind of induction was found to be especially useful in grave risk patients and cardiac surgery.

The 10 per cent solution of Anectine containing 100 mg./c.c. was used in most patients. It was found to be more effective than the 2 per cent solution, containing 20 mg./c.c.

The intramuscular doses of Anectine necessary for intubation were: 1½ mg./lb of body weight in children three years old and younger, 2 mg./lb. of body weight in children four years and older.

The full recovery of respiration ensued within 25 minutes of the intramuscular injection.

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RÉSUMÉ

Nous rapportons une série de 155 bébés et enfants chez lesquels le relâchement pour l'intubation orotrachéale, durant le période d'induction, fut obtenu au moyen de succinylcholine (Anectine) intramusculaire. Quarante de ces patients reçurent leur Anectine intramusculaire à l'état de conscience, suivie par une induction au masque, mais dans la majorité des cas, les patients furent rendus inconscients avant l'injection, dans la plupart des cas, au cyclopropane. Avec une dose adéquate d'Anectine, tous ces patients étaient complètement relachés deux ou trois minutes après l'injection et l'intubation était très facile. Cette méthode d'induction fut particulièrement appréciée chez les mauvais risques et dans les cas de chirurgie cardiaque.

La solution d'Anectine à 10%, contenant 100 mg. au cc., fut utilisée dans la plupart des cas, et trouvé plus efficace que la solution à 2% (20 mg./1 cc.).

La dose d'Anectine intramusculaire nécessaire pour une intubation facile était de 1½ mg./1 lb. chez les enfants jusqu'à trois ans, et de 2 mg./1 lb. à compter de quatre ans.

La respiration était redevenue complètement normale au bout de 25 minutes ou moins.