THE USE OF SUCCINYLCHOLINE TO FACILITATE ENDOTRACHEAL INTUBATION • † ‡

L. JENNINGS HAMPTON, M.D., DAVID M. LITTLE, JR., M.D., AND EDWIN M. FULLER, M.D.

New Haven, Connecticut

Received for publication November 17, 1952

Endotracheal intubation has now become a maneuver of considerable importance in the clinical administration of anesthesia. Unwarranted and unjustified criticisms of the method have followed occasionally upon traumatic and otherwise improperly conducted endotracheal anesthesia; these criticisms are termed unwarranted and unjustified, because in such instances the fault lies not so much in the technic, as in the defections of those employing the technic. More specifically, such defections consist of failure to obtain those ideal conditions for the safe and proper performance of endotracheal intubation which are so essential to success. Three such conditions are necessary: first, the compliance of the patient must be assured; second, adequate relaxation of the muscles of the jaw and glottis must be attained, and third, control must be obtained over reflex activity attendant upon laryngoscopy and intubation itself. These three conditions may be fulfilled by a number of different approaches. On the one hand, cooperative patients may be intubated while awake, using nothing more than topical anesthesia applied to the pharynx, and at the other extreme, all three conditions may be satisfied by the employment of deep general anesthesia. A third approach has been the administration of a light general anesthetic, combined with a muscle relaxant and the application of topical anesthesia to the pharynx (1, 2). This technic has enjoyed an increasing popularity since its first utilization, which followed soon after Griffith’s classic, brilliant introduction of the first muscle relaxant, curare, into the clinical practice of anesthesiology (3). The shorter acting muscle relaxants, syncurine® and flaxedil®, have proved even more useful in this technic than curare itself (4–7). Nevertheless, it has become empirically evident that there is need for a muscle relaxant that would provide ideal conditions for intubation

• From the Department of Anesthesiology, Grace-New Haven Community Hospital, and the Section on Anesthesiology, Yale University School of Medicine, New Haven, Connecticut.


‡ The authors wish to express their thanks to Burroughs Wellcome & Company, Tuckahoe, N. Y., for generous supplies of the succinylcholine (available as “Anectine”) used in this study.
without leaving a trail of respiratory depression in its wake, particularly in those instances in which muscle relaxation is necessary and desirable only for that momentary period required for the actual performance of intubation. The introduction of succinylcholine (8–11), an ultra short-acting muscle relaxant which has a duration of activity of but two or three minutes following a full relaxant dose has provided the anesthesiologist with an almost ideal adjuvant for the facilitation of endotracheal intubation under such circumstances (12–19).

**Chemistry and Pharmacology**

Succinylcholine, or diacetylcholine, is simply two molecules of acetylecholine linked together at the alpha-methyl groups in such a way that 10 atoms are interposed between the two quaternary nitrogens, the optimal distance hypothesized as being necessary for neuromuscular blocking activity (20–23). The drug is an extremely

\[
\begin{align*}
\text{O} & \\
\text{CH}_3\cdot\text{C}^\cdot\text{O}\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{N}^\cdot\text{(CH}_2\text{H}_4\cdot\text{Cl}^-) \\
\text{CH}_3\cdot\text{C}^\cdot\text{O}\cdot\text{CH}_2\cdot\text{CH}_2\cdot\text{N}^\cdot\text{(CH}_2\text{H}_4\cdot\text{Cl}^-) \\
\text{O}
\end{align*}
\]

Succinylcholine (Diacetylcholine) Chloride

potent and rapidly effective blocking agent at the myoneural junction, its mode of action in this respect resembling that of decamethonium, in that it acts by depolarizing the motor end-plate membrane (8, 15, 24–26). For this reason, an antagonism exists between succinylcholine and those relaxants acting at the myoneural junction as do d-tubocurarine and flaxedil® (8, 9, 27). Furthermore, prostigmin and other anticholinesterase drugs not only cannot be employed successfully as antidotes to succinylcholine but will actually prolong the latter’s neuromuscular blockade (8, 24, 27), for although succinylcholine resembles decamethonium in its mode of action, it differs from that drug in apparently being hydrolyzed by cholinesterases, particularly the “pseudo”-cholinesterase of the plasma (8, 9), into the natural metabolites, succinyclic acid and choline. In individuals who have a low plasma titer of “pseudo”-cholinesterase, therefore, the action of succinylcholine might be expected to be prolonged (28). This is said to have been demonstrated clinically and has been offered as a possible explanation (15) for those instances of prolonged action which have been reported on a number of occasions (29–38). The drug has an extremely low toxicity, dogs maintained on artificial respiration
tolerating doses which were 450 times the paralyzing dose (11). Furthermore, such side effects as have been reported in the laboratory animal occurred only at tremendously high dosage levels (8, 11, 15, 25, 39), and such complications as histamine release and ganglionic blocking activity are reputedly not found in man when ordinary clinical doses are employed (40).

**TECHNICS**

Succinylcholine has been employed to facilitate endotracheal intubation by two distinct techniques. In the first, either a 1 or 2 per cent concentration of the drug has been utilized as a single intravenous injection. After premedication and the induction of anesthesia to first plane of third stage with either pentothal or cyclopropane, a dose of 10 to 50 mg. (average 30 mg.) of succinylcholine has been injected. Apnea has ensued within twenty to ninety seconds (average thirty seconds), and has lasted from one-half to six minutes (average two minutes). With the onset of apnea, the patient has been hyperventilated and then intubated. It has seemed desirable to accomplish apnea to obviate the necessity for haste and trauma, and to prevent "bucking" at the time of the introduction of the endotracheal catheter.

In the second technic, an intravenous infusion of a dilute, 0.1 per cent concentration of succinylcholine in 5 per cent glucose and water has been employed. Following premedication and the induction of pentothal-nitrous oxide anesthesia, the succinylcholine infusion has been started and continued until complete apnea supervened. This has usually occurred subsequent to the administration of 15 to 90 mg. of the drug, and the patient has then been hyperventilated and intubated. However, the total amount of the drug injected is of little real importance with this technic, since the patient is used as an indicator in the titration of the succinylcholine, and the clinical effects obtained serve as a test dose which indicates the exact dosage necessary to produce either apnea or any lesser degree of muscular relaxation in a given patient. When uninterrupted neuromuscular blockade has been desirable throughout intra-abdominal surgical intervention, the infusion has been continued after the completion of intubation, but at a slower rate. Under such circumstances, spontaneous respiratory activity usually returned within thirty to 180 seconds when the rate of the infusion has been slowed from 8 mg. per minute to 2.5 mg. per minute. Inhalational anesthesia has then been established in full, and the infusion rate regulated throughout operation to provide variable and graded degrees of muscular relaxation according to the surgical requirements of the moment. In those instances in which a prompt return to full muscular and respiratory activity has been desired upon completion of the intubation, the infusion has been discontinued and maintenance general anesthesia has been achieved. This may appear to be a cumbersome method for the
accomplishment of but a few moments of relaxation but, as previously indicated, the infusion technic has the great advantage of serving as a test dose, and of providing a quantitatively exact end-point determination of the necessary dosage for the adequate performance of intubation.

**Results**

Succinylcholine has been employed to facilitate endotracheal intubation on 724 occasions. The drug’s rapid and profound relaxing effects upon both the muscles of the jaw and the glottic structures produce ideal conditions for the performance of laryngoscopic manipulations and yet, due to its very brief action of two to three minutes following a full relaxant dose, complete muscular activity and spontaneous respirations return within seconds or minutes. This is an advantage of real importance when the need for muscular relaxation is temporary, encompassing merely the period required for the actual performance of intubation.

**TABLE I**

**Comparative Action of Various Muscle Relaxants to Facilitate Endotracheal Intubation**

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
<th>Group IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocal Cords</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Intubation</td>
<td>Open</td>
<td>Open</td>
<td>Active</td>
<td>Unsuccessful</td>
</tr>
<tr>
<td></td>
<td>Very easy</td>
<td>Easy</td>
<td>Difficult</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nil</td>
<td>Slight, settles</td>
<td>Considerable,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>rapidly</td>
<td>long-lasting</td>
<td></td>
</tr>
<tr>
<td>Cough after Intubation</td>
<td>27.9%</td>
<td>52.2%</td>
<td>16.2%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Flaxedil® (Doughty (5))</td>
<td>22.8%</td>
<td>42.1%</td>
<td>24.6%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Syncurine® (Doughty (5))</td>
<td>81.8%</td>
<td>13.4%</td>
<td>1.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Succinylcholine (present series)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Certain other advantages besides that of brevity of action have become apparent during the course of this series, and serve to recommend further the use of succinylcholine to facilitate intubation. Thus, not only do such muscle relaxants as d-tubocurarine, syncurine® and flaxedil® possess the disadvantage of long activity but they also produce ideal conditions for intubation with less consistency than does succinylcholine (table 1). Doughty (5) studied the effects of both syncurine® and flaxedil® in combination with pentothal-nitrous oxide anesthesia for the facilitation of endotracheal intubation, comparing in particular the state of the vocal cords, the ease of intubation and the occurrence of cough following intubation. The results were divided into four numerical groups, according to whether intubation was considered “very easy,” “easy,” “difficult” or “unsuccessful.” Over 300 of the 724 intubations facilitated by succinylcholine in this series have been analyzed in detail on this basis, and the results
suggest the drug's evident superiority over both of the other muscle relaxants employed for this technique: 81.8 per cent of the intubations for which succinylcholine was employed were classified in Group I, or "very easy" intubations, as compared to only 27.9 per cent when flaxedil® was used and 22.8 per cent when syncurine® was the muscle relaxant. Furthermore, succinylcholine's supremacy over the other two drugs may be seen in all the various groups of this classification. It would appear to be the muscle relaxant of choice to produce the ideal conditions necessary for safe and proper endotracheal intubation.

Certain other pertinent observations have been made during the use of succinylcholine in the described manner. Early in the course of the administration of the drug, massive fasciculations have occurred in approximately 21 per cent of the cases. These fibrillations are similar but more intense than those noted with decamethonium, and like the latter, presumably represent depolarization of the motor end-plate membrane. They may appear startling to the uninitiated, but they have not proved to be deleterious in any way. Salivation has constituted the only other side effect of importance observed during the administration of the drug; this has usually occurred during very light general anesthesia or during emergence from anesthesia, but it has never been of such a quantitative proportion as to be excessively troublesome and it has never been accompanied by bronchorrhea.

Succinylcholine has been employed in combination with a variety of general anesthetic agents following intubation, in those instances in which a continuous infusion has been maintained for muscular relaxation throughout intra-abdominal operation, without the clinically observable occurrence of synergism. On occasion, however, the drug has appeared to be antagonistic to ether which, on pharmacologic grounds, is not unreasonable.

Effects that are believed to represent central respiratory depression have been noted on four occasions. These cases have been characterized by persistent apnea that has coincided with evidences of peripheral muscular activity in other muscle groups; winking, swallowing, and even purposeful movements of the arms have been noted in the course of apneas that have been far too prolonged to be mere breath holding. Granted that many factors are involved in the production of apnea during anesthesia, it is obvious, nevertheless, that these cases are quite different from the prolonged apneas that have been reported frequently by clinicians which are said to be due to abnormally low levels of plasma "pseudo"-cholinesterase.

**Discussion**

A relaxed jaw and open, unreactive vocal cords may be achieved in certain phlegmatic and cooperative patients with the use of nothing more than a local anesthetic agent applied topically to the pharynx,
but in the average patient this approach to the problem is greeted with little enthusiasm. Ideal conditions for intubation may be provided also by deep, plane 3 anesthesia with such powerful agents as ether or cyclopropane, but only at the cost of at least some physiologic derangement; in those instances in which the only real need for relaxation is for the accomplishment of intubation, as in head and neck surgery, this cost seems a bit too high. The use of pentothal-nitrous oxide anesthesia in combination with a muscle relaxant has proved to be a thoroughly adequate solution to the problem. Excellent conditions for intubation result, but the metabolic disorders attendant upon deep general anesthesia are avoided.

Of the muscle relaxants presently available, succinylcholine appears to be by far the most satisfactory for this purpose. It provides those ideal conditions, a fully relaxed jaw and wide open, unreactive cords, that are so necessary for safe intubation without trauma and yet the extremely rapid recovery from a full relaxant dose allows the prompt return of spontaneous respiratory activity and normal respiratory exchange. For this reason, prolonged artificial respiration following intubation, which may be mandatory when other relaxants are employed, is seldom necessary after the use of succinylcholine. Furthermore, the very brief operation, for which, nevertheless, endotracheal anesthesia is required, can be performed in this manner without danger that the operation may be terminated while the effects of the muscle relaxant linger on. Finally, not only can intubation be accomplished easily, rapidly and safely, but the patient tolerates the endotracheal catheter without prolonged "bucking" and coughing. These undesirable reactions can also be avoided when other muscle relaxants are used, but usually only if either very large doses of relaxant are employed, or the dose of pentothal is very great.

Conclusions

The prompt and complete paralysis produced by succinylcholine, followed as it is by rapid recovery, renders this muscle relaxant an ideal adjuvant to facilitate endotracheal intubation. It would be wrong, however, to leave the impression that succinylcholine is the panacea that will solve all the problems of endotracheal intubation. The drug is no substitute for carefully applied skill in the art of anesthesia. More than that, it is a potent substance; its use in the hands of the unknowing and unwary may undoubtedly prove dangerous, and its use in the hands of the uncaring will almost certainly be disastrous. The need for continuous supervision of the patient's ventilation and the use of assisted or controlled respirations when necessary, cannot be emphasized too strongly. Succinylcholine is a valuable drug but its usefulness is dependent upon the thought, skill, studied application, and experience of the anesthesiologist.
Summary

Succinylcholine, or diacetylcholine, is an extremely potent muscle relaxant, producing myoneural blockade by a depolarization of the muscle end-plate membrane. This blocking action is of brief duration, presumably because of rapid hydrolysis of the drug by the "pseudo"-cholinesterase of the plasma into naturally occurring metabolites, succinyllic acid and choline.

Succinylcholine has been employed in combination with light general anesthesia to facilitate endotracheal intubation on 724 occasions.

Succinylcholine provides ideal conditions for intubation, including a fully relaxed jaw and wide open, unreactive vocal cords in most instances. The extremely rapid recovery from a full relaxant dose allows the prompt return of spontaneous respiratory activity and normal respiratory exchange.

REFERENCES


AMERICAN COLLEGE OF ANESTHESIOLOGISTS

The written examinations of the American College of Anesthesiologists will be held in various locations on August 15, 1953.