

INCIDENCE AND PREVENTION OF MUSCLE PAIN FOLLOWING THE ADMINISTRATION OF SUCCINYLCHOLINE

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MUSCLE pain has often been observed following the intravenous use of succinylcholine.¹⁻⁷ This muscle pain is similar to muscular aching following strenuous exercise. The pain usually starts the day after succinylcholine administration and persists for one or more days. It is more often noted following minor operative procedures where it may outweigh and outlast the pain of the operation and may be a source of great distress to the patient. Churchill-Davidson⁶ found the pain to be more frequent in ambulatory than in bed patients.

The exact etiology of this pain is somewhat obscure. It has been suggested that it may be related to the muscle fasciculation often seen with succinylcholine administration. Hegarty² proposed that the pain might be reduced by injecting succinylcholine slowly to minimize fasciculation but failed to reduce the incidence or severity of muscle pain. Moreover, when administered rapidly, no correlation could be made between muscle pain and succinylcholine-induced fasciculation.

It was Churchill-Davidson's¹ impression that gallamine triethiodide, when administered prior to the succinylcholine, both reduced the fasciculation and the postanesthetic muscle pain. He did not substantiate his impression. Morris,³ in 1957, did show that *d*-tubocurarine, administered prior to a single dose of succinylcholine reduced both fasciculation and postanesthetic muscle pain. The rationale of using nondepolarizing relaxants to prevent muscle pain lies in the antagonism exhibited by nondepolarizing relaxants against depolarizing relaxants. Foldes⁸ notes that during anesthesia larger doses of depolarizing relaxants are necessary to produce muscular relaxation if given after a nondepolarizing relaxant.

The purpose of this study was to extend the previous work on the relation of succinylcholine to muscle pain. In particular, a practical

method was sought for using succinylcholine in short operative procedures without the side effect of muscle pain. During the course of the study, it was also believed necessary to evaluate the effect of *d*-tubocurarine on succinylcholine-induced paralysis.

METHOD

In the first part of the study, all drugs were administered intravenously to men between the ages of 18 and 80 years (average 50 years). These patients were undergoing short genito-urinary operations and were anesthetized with thiopental and nitrous oxide. One hundred and thirteen patients were divided into four groups, each group being given one of the following:

1. Succinylcholine—50 mg. injected rapidly.
2. Succinylcholine—0.2 per cent solution by slow infusion to complete respiratory paralysis avoiding visible muscle fasciculation.
3. *d*-Tubocurarine—3 mg. followed four minutes later by succinylcholine—50 mg. injected rapidly.
4. *d*-Tubocurarine—3 mg. followed four minutes later by succinylcholine—0.2 per cent solution by slow infusion for at least 15 minutes. Each patient was given enough succinylcholine to paralyze him completely both at the beginning and end of the 15 minute period.

In the two techniques using succinylcholine as a slow intravenous infusion, the dosage ranged from 80 to 800 mg. and averaged 220 mg. If fasciculation occurred it was graded as mild, moderate or severe, depending on the number of muscle groups involved and the degree of skin rippling observed.

Patients who developed pain on the first postoperative day were observed daily until it disappeared. Pain was recorded as mild, moderate or severe, depending on the number of muscle groups involved and the duration of the pain.

In the second part of the study, the influence of *d*-tubocurarine on succinylcholine induced paralysis was studied in seven patients undergoing herniorrhaphies with thiopental-nitrous

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oxide anesthesia. During maintenance, each patient was given 20 mg. of succinylcholine intravenously. The onset and duration of apnea were timed. Eleven minutes later (the effect of the initial succinylcholine having worn off), the patient was given 3 mg. of *d*-tubocurarine intravenously followed in four minutes by a second dose of 20 mg. succinylcholine.

RESULTS

Fasciculation was grossly visible only within the group which received a rapid single dose of succinylcholine without *d*-tubocurarine. Pain, when it occurred following succinylcholine administration, most frequently involved the muscles of the pectoral girdle and neck. Only in the cases with moderate to severe pain did it extend to other muscle groups. There was no correlation between occurrence or extent of fasciculation and later development or degree of muscle pain. The pain occurred at all ages without sparing young or old.

As shown in table 1, when used in a single 50-mg. dose without *d*-tubocurarine, succinylcholine produced pain in 40 per cent of 25 patients. *d*-Tubocurarine administered prior to the single dose of succinylcholine completely prevented muscle pain ($P < 0.01$). The slow infusion of dilute succinylcholine significantly reduced the incidence of muscle pain (from 40 to 14 per cent). However, when the slow infusion was preceded by *d*-tubocurarine, there was no further reduction in muscle pain. Therefore, the two groups (3a and b) receiving succinylcholine as a slow infusion were combined. Of the 68 patients so treated (3a and b) 16 per cent developed pain ($P < 0.05$). When pain did occur, its severity did not appear to differ from group to group.

In the seven patients in whom the effect of *d*-tubocurarine on succinylcholine was studied, 20 mg. of succinylcholine produced fasciculation and apnea without exception. The average duration of apnea was 90 seconds. However, when succinylcholine was preceded by 3 mg. of *d*-tubocurarine, only two of the seven patients became apneic, and in these two the duration of apnea was less than that produced by succinylcholine alone (30 and 60 seconds). The five patients who did not become apneic with the addition of *d*-tubocurarine did have markedly depressed respirations.

TABLE 1
MUSCLE PAIN FOLLOWING VARIOUS TECHNIQUES OF
SUCCINYLCHOLINE ADMINISTRATION

Muscle Relaxants	Total Patients	Patients Developing Muscle Pain	
		Number	Per Cent
1. Succinylcholine—50 mg. single injection	25	10	40
2. Succinylcholine—50 mg. single injection, preceded by 3 mg. <i>d</i> -Tubocurarine	20	0	0*
3A. Succinylcholine—0.2% solution by slow infusion	35	5	14
3B. Succinylcholine—0.2% solution by slow infusion preceded by 3 mg. <i>d</i> -Tubocurarine	33	6	18
	68	11	16**

* $P < 0.01$.
** $P < 0.05$.

DISCUSSION

The mechanism by which succinylcholine produces muscle pain postoperatively long after its paralytic effects have disappeared is unknown. Clinical observations would lead one to implicate as a causative factor the muscle fasciculations so frequently seen after succinylcholine administration. Mayrhofer⁷ proposed that succinylcholine releases potassium and possibly lactic acid and that the muscle pain is related to this process. He also stated that fibrillatory movements of the muscles are important for subsequent pain but did not prove this.

Our study confirms the findings of Morris³ that no simple correlation exists between the severity of muscle fasciculations and the development of postoperative muscle pain. The findings of others^{1, 3, 7} that prior administration of small amounts of *d*-tubocurarine could prevent muscle pains following succinylcholine administration was confirmed in this investigation. However, it was unexpected that *d*-tubocurarine would show this protective effect against a single, rapidly-injected paralyzing dose but not against a slow infusion of diluted succinylcholine. As a possible explanation it may be suggested that the duration of the succinylcholine infusion (15 to 20 minutes) outlasted the protective activity of the small amount of *d*-tubocurarine administered. It is plausible that a higher blood concentration was attained following the rapid injection of

50 mg. of succinylcholine than at any time during the slow infusion of the 0.2 per cent solution. This may explain why only 14 per cent of patients exposed to the slow infusion developed pain as against 40 per cent following the single injection.

Since apnea was produced in both groups of patients, but the incidence of pain was significantly different, it would appear that the occurrence of apnea and of muscle pain, though not invariably associated, are both functions of the concentration of succinylcholine reaching the receptors of the muscle fibers as well as of individual susceptibility. Our observation that 3 mg. of *d*-tubocurarine appreciably decreased the paralytic effect of 20 mg. succinylcholine in the patients undergoing herniorrhaphy strengthens the hypothesis that the protective activity of *d*-tubocurarine in relation to muscle pain is based on its ability to block the depolarization of the muscle fibers by succinylcholine. It may therefore be permissible to postulate that *d*-tubocurarine administered a short time before succinylcholine prevents muscle pain by a mechanism which is equivalent to an injection of a smaller amount of succinylcholine without prior *d*-tubocurarine. Further experimentation would prove or disprove this point.

If the foregoing assumptions are correct the results of this study would indicate that any measure reducing the concentration of succinylcholine reaching and effectively acting on the muscle receptors would also decrease the incidence of postoperative muscle pain. Two such measures, *i.e.* prior administration of *d*-tubocurarine and slow infusion of a dilute solution of succinylcholine, have been found effective and clinically applicable in this investigation.

SUMMARY

In a control group, the incidence of muscle pain following a single injection of succinylcholine was 40 per cent. The prior injection of *d*-tubocurarine completely prevented this pain.

Infusing a dilute solution of succinylcholine slowly, reduced the incidence of muscle pain to 14 per cent. *d*-Tubocurarine was not effective in reducing further this 14 per cent incidence of pain.

The avoidance of muscle pain by the use of *d*-tubocurarine was achieved only with a clinically noticeable decrease in the effect of a single dose of succinylcholine. It is reasoned that *d*-tubocurarine protects from muscle pain by preventing a portion of the injected succinylcholine from depolarizing the muscle fibers.

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