operative and postoperative renal dysfunction may be reversible. In cases of patients who have C_{cr} of less than 25 ml/min and C_{H_2O} of more than −20 ml/hour, the cause of renal blood flow should be identified and corrected to prevent further deterioration of renal function. Fluid restriction and furosemide administration in anticipation of acute renal failure[7] may not be wise. A volume-loading technique[8] has been used not only to restore plasma volume, but to evaluate myocardial contractility in patients who have borderline heart failure. When aggressive fluid management is indicated for patients who have abnormal renal function, blood volume should be restored using a volume-loading technique. In management of patients who have both heart failure and renal dysfunction, dopamine, nitroprusside or diuretic may be used, depending on the individual patient's condition.

The reported incidence of nonoliguric renal failure has been less than 50 per cent.[1,3,10] We are unable to explain the high incidence of nonoliguric renal failure in this study. It has been reported that an adequate urinary output could be maintained with early administration of a potent diuretic,[11] aggressive fluid infusion,[10] and hypothermic treatment of the kidney.[12] Regardless, acute nonoliguric renal failure is known as a benign form of acute renal failure. Further study is needed to determine whether oliguria can be avoided in acute renal failure when renal dysfunction is detected early and treated.

There are pitfalls in measuring C_{cr} and C_{H_2O} from a single 24-hour urine sample. With more frequent determinations it may be possible to detect acute changes of renal dysfunction not detectable by a single determination from a 12–24-hour collection.

In conclusion, C_{H_2O} alone should not be used for the prediction of acute renal failure. It is suggested that impending renal failure can be recognized early by monitoring both C_{cr} and C_{H_2O} in the postoperative period. In management of patients who have a high risk of developing renal failure, C_{cr} and C_{H_2O} should be included for routine clinical monitoring.

References

1. Stott RB, Cameron JS, Ogg CS, et al: Why the persistently high mortality in acute renal failure? Lancet 2:75–78, 1972
2. Whelton A, Donadio JV: Post-traumatic acute renal failure in Vietnam. Bull Hopkins Hosp 124:95–105, 1969
3. Lordon RE, Burton JR: Post-traumatic renal failure in military personnel in Southeast Asia. Am J Med 53:137–147, 1972
4. Champion H, Sacco W, Long W, et al: Indications for early hemodialysis in multiple trauma. Lancet 1:1125–1128, 1974
5. Baek SM, Brown RS, Shoemaker WC: Early prediction of acute renal failure and recovery. Ann Surg 177:253–258, 1973
6. Baek SM, Makabali GG, Brown RS, et al: Free water clearance patterns as predictor and therapeutic guides in acute renal failure. Surgery 77:632–640, 1975
7. Landes RG, Lillehei RC, Lindsay WG, et al: Free water clearance and the early recognition of acute renal insufficiency after cardiopulmonary bypass. Ann Thorac Surg 22:41–43, 1976
8. Weil MH, Shubin H, Rosoff L: Fluid repletion in circulatory shock. JAMA 192:668–674, 1965
9. Bastron RD, Deutsch S: Anesthesia and the Kidney. New York, Grune and Stratton, 1976, pp 53–64
10. Anderson RJ, Linas SL, Berns AS, et al: Non-oliguric acute renal failure. N Engl J Med 296:1134–1138, 1977
11. Barry KG: Post-traumatic renal shutdown in humans. Milit Med 128:224–230, 1963
12. Baxter CR, Zedlitz WH, Shires GT: High output acute renal failure complicating traumatic injury. J Trauma 4:567–580, 1964

Anesthesiology
50:265–267, 1979

Does "Self-taming" with Succinylcholine Prevent Postoperative Myalgia?

Jay B. Brodsky, M.D.,* and John G. Brock-Utne, F.F.A.(S.A.)*

Muscle fasciculations associated with succinylcholine can be decreased or eliminated by administering a small dose (10 mg) of succinylcholine before giving the full paralyzing dose.[1] Does this "self-taming" technique prevent post-succinylcholine muscle pains?

* Assistant Professor of Anesthesia, Stanford University School of Medicine, Stanford, California 94305.

Accepted for publication July 23, 1978.

Address reprint requests to Dr. Brodsky: Department of Anesthesia, Stanford University School of Medicine, Stanford, California 94305.

Methods

Forty adult patients, ASA classes 1–3, undergoing major surgical procedures were randomly divided into two groups. Premedication with a narcotic and an anticholinergic drug was essentially the same for all patients. In both groups, following preoxygenation, anesthesia was induced by a slow injection of thiopental, 4 mg/kg, iv, followed by succinylcholine, 1.5 mg/kg, iv, to facilitate endotracheal intubation. Patients in Group I received the entire amount of

TABLE 1. Muscle Fasciculations after Succinylcholine

	Number of Patients with Degree of Fasciculation*				Total Number of Patients
	0	+1	+2	+3	
Group I Bolus	0	4	6	10	20
Group II "Self-taming" dose	15	1	2	2	20
Second dose	10	2	5	3	
Significance of difference†	$P < 0.05$	NS	NS	NS	

* Degrees of fasciculations: 0 = none visible; +1 = fine facial and/or fingertip; +2 = minimal trunk and extremities; +3 = vigorous trunk and extremities.

† Chi-square analysis of Groups I and II. NS = not statistically significant.

succinylcholine as a single bolus injection. Those in Group II were given succinylcholine in two doses, an initial 10 mg ("self-taming" dose) followed 60 sec later by the remainder. Endotracheal intubation was performed 60 sec following the paralyzing dose of succinylcholine.

The occurrence and severity of muscle fasciculations were recorded.[2] Each patient was visited on the first and second postoperative days by an anesthesiologist who did not know in which group the patient belonged. The interviewer asked a series of standard questions,[3] the third of which was, "Do you have any pain or weakness in your muscles?" When the answer was yes, the location, duration, and degree of pain were recorded. The time interval between operation and patient ambulation was also noted.

Data were analyzed by the chi-square method, with $P < 0.05$ considered significant.

RESULTS

There was no significant difference with respect to age, body weight, anesthetic technique, patient position, or length or type of operation performed between the two groups. Male and female patients were evenly distributed in the two groups. Relaxation for endotracheal intubation was adequate in all patients. Muscle fasciculations were observed in all patients in Group I following the injection of succinylcholine. Five patients in Group II manifested fasciculations after the "self-taming" dose of succinylcholine, and ten patients in this group showed fasciculations after the larger, second dose of the drug. Only one patient in Group II who showed fasciculations with the "self-taming" dose experienced additional fasciculations with the subsequent dose. Six patients in Group II had no visible fasciculation after either dose ($P < 0.05$). Ten patients in Group I had vigorous (+3) fasciculations, while five in Group 2 had +3 fasciculations (NS) (table 1). Significant cardiac arrhythmia was not observed in any patient studied.

Five patients in Group I and five patients in Group II had postoperative myalgias (table 2).

DISCUSSION

Pretreatment with a small amount of nondepolarizing muscle relaxant prior to giving succinylcholine is an effective means of preventing muscle fasciculations.[2,4–6] This technique may not provide for optimal intubation conditions since there is an antagonistic

TABLE 2. Patients with Postoperative Myalgias

	Age (Years), Sex	Length of Operation (Min)	Degree of Fasciculation*			Severity and Site of Myalgia†	Interval to Postoperative Ambulation (Hours)
			Bolus	Self-taming Dose	Second Dose		
Group I (bolus succinylcholine)							
Patient 1	60, M	140	+3	—	—	+2, shoulder and back	24
Patient 2	52, M	150	+3	—	—	+2, neck	18
Patient 3	24, M	150	+3	—	—	+1, flank pain	20
Patient 4	67, F	190	+1	—	—	+1, shoulder	8
Patient 5	31, F	390	+3	—	—	+1, neck	26
Group II ("self-taming" succinylcholine)							
Patient 6	21, F	95	—	0	+2	+2, "ache all over"	6
Patient 7	35, F	120	—	0	0	+1, neck	8
Patient 8	65, M	175	—	+3	0	+1, shoulder	24
Patient 9	63, M	185	—	0	+3	+1, shoulder	18
Patient 10	56, F	460	—	0	+2	+1, neck	>48

* Degrees of fasciculation: 0 = none visible; +1 = fine facial and/or fingertip; +2 = minimal trunk and extremities; +3 = vigorous trunk and extremities.

† Severities of myalgia: 0 = none; +1 = transient; +2 = numerous sites and/or very severe in single site; +3 = incapacitating.

interaction between the nondepolarizing agent and succinylcholine.[1,2,6] Muscle relaxation may be inadequate and the onset of block delayed. Our study confirms the work of Baraka, who has shown that "self-taming" with succinylcholine will decrease the incidence of muscle fasciculations while producing excellent relaxation for endotracheal intubation.[1] Twenty-five per cent of patients in Group II showed fasciculations after the initial 10 mg of succinylcholine. Baraka observed a 20 per cent incidence of fasciculations after an identical "self-taming" dose of succinylcholine.[1] Using a paralyzing dose of succinylcholine, 1 mg/kg, he found fasciculations in another 20 per cent of his patients. Our second dose of succinylcholine was larger (1.5 mg/kg less the 10 mg "self-taming" dose), which may explain the higher incidence (50 per cent) of patients in our study who showed fasciculations in response to the second dose of succinylcholine. We arbitrarily chose a 1.5 mg/kg dose of succinylcholine. Waters and Mapleson showed that the amounts of succinylcholine used in Baraka's study and used by us for this study did not cause a statistically significant change in the incidence of postoperative muscle pains, and that a decrease in muscle pains can actually be achieved by using still larger doses of succinylcholine.[7]

We found no relationship between the presence and degree of fasciculations following administration of succinylcholine and the occurrence of postoperative myalgia. Six patients in Group I and three patients in Group II had vigorous (+3) fasciculations and did not experience postoperative myalgia, whereas one patient in Group I had minimal (+1) fasciculations and had postoperative muscle pains. One patient in Group II had no visible fasciculation with either of the two doses of succinylcholine she received, yet experienced postoperative muscle pain. Previous studies have also failed to correlate the occurrence of post-succinylcholine myalgias with fasciculations.[4,5,8–10] Waters and Mapleson believe that more severe muscle aches follow mild fasciculations, whereas vigorous generalized fasciculations are protective against myalgia.[7]

Post-succinylcholine myalgias occur more frequently in patients who ambulate soon after operation.[3,4,8] Although approximately 50 per cent of the patients in our study walked within 24 hours after receiving succinylcholine, none was physically active, and all were receiving narcotic drugs for postoperative incisional pain. Post-succinylcholine myalgia is a true clinical entity.[3,4,11] It most frequently affects the neck, shoulder, pectoral and upper abdominal muscles and is similar to muscle soreness that follows unaccustomed exercise. However, muscle aches may occur postoperatively even when succinylcholine has not been used, and it is impossible to differentiate succinylcholine-induced myalgia from muscle soreness due to other causes.

In a previous study, use of a 5-mg "self-taming" dose of succinylcholine followed by an unspecified paralyzing dose of the drug led to an increased incidence of postoperative muscle pains.[12] We found that although the incidence and degree of fasciculations from succinylcholine can be decreased by pretreatment with a 10-mg dose of the drug, this "self-taming" technique offers no advantage in decreasing the occurrence or severity of postoperative myalgia.

References

1. Baraka A: Self-taming of succinylcholine-induced fasciculations. Anesthesiology 46:292–293, 1977
2. Cullen DJ: The effect of pretreatment with nondepolarizing muscle relaxants on the neuromuscular blocking action of succinylcholine. Anesthesiology 35:572–578, 1971
3. Churchill-Davidson HC: Suxamethonium (succinylcholine) chloride and muscle pains. Br Med J 1:74–75, 1954
4. Morris DDB, Dunn CH: Suxamethonium chloride administration and postoperative muscle pain. Br Med J 1:383–384, 1957
5. Lamoreaux LF, Urbach KF: Incidence and prevention of muscle pain following the administration of succinylcholine. Anesthesiology 21:394–396, 1960
6. Bryson THL, Ormston TOG: Muscle pains following the use of suxamethonium in caesarean section. Br J Anaesth 34:476–480, 1962
7. Waters DJ, Mapleson WW: Suxamethonium pains: Hypothesis and observation. Anaesthesia 26:127–141, 1971
8. Hegarty P: Postoperative muscle pains. Br J Anaesth 28: 209–212, 1956
9. Prince-White F: Suxamethonium and post-operative muscle pains. Br Med J 1:761, 1957
10. Stoelting RK, Peterson C: Adverse effects of increased succinylcholine dose following *d*-tubocurarine pretreatment. Anesth Analg (Cleve) 54:282–288, 1975
11. Bourne JG, Collier HOJ, Somers GF: Succinylcholine (succinoylcholine) muscle-relaxant of short action. Lancet 1: 1225–1229, 1952
12. Burtles R, Tunstall ME: Suxamethonium chloride and muscle pains. Br J Anaesth 33:24–28, 1961