SUCCINYLCHOLINE DRIP DURING CRANIOTOMY

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THE QUEST for an ideal anesthetic technique for neurosurgery has been long and tedious.[1-5] The need for the patient's cooperation during some types of intracranial surgery has complicated the search. Although local anesthesia would seem to be ideal for accomplishment of craniotomy with the patient awake, and has been used successfully in many cases since the time of de Martel,[6] it may be very exhausting for the patient. Children and some adults cannot tolerate it. There is great danger, moreover, of a generalized seizure or violent automatism following cortical stimulation. As such an occurrence may be hazardous for the patient, and difficult for the surgical team, an alternate technique was sought.

It has been known since 1909[7] that a craniotomy can be performed under general anesthesia, anesthesia then can be educed* and patients can cooperate during studies of cortical localization. Anesthesia can be re-induced for the surgical closing. Penfield and Pasquet recently reported their anesthetic technique in craniotomy for epilepsy.[5] Apparently, they rely in many cases on blind nasotracheal intubations carried out under the drapes. Since some anesthesiologists believe that the patient is safer either completely awake, or intubated and asleep, preferably the latter, new methods are still being sought. The cases here reported demonstrate that during a craniotomy the opening and closing of the operative wound can be done with the patient under general anesthesia. During studies of cortical localization, he can be awake and cooperative.

METHOD

Thirteen patients were administered a total of 16 anesthetics, all for intracranial neurosurgical procedures. The diagnoses were chronic brain syndrome (1 patient), dystonia musculorum deformans (1 patient), and temporal lobe epilepsy (11 patients). The patients varied in age from 15 to 45 years and in weight from 47 to 83 kg. (table 1).

The patient was prepared beforehand in the following manner: (1) He was told that he would awake during the operation and that he might or might not remember this afterward. He was reassured that during this period of wakefulness he would feel no pain or discomfort. (2) He was informed that there would be a tube in his "windpipe" and that this might feel strange, but that it would not be uncomfortable. He was warned that he would be unable to talk, and that he would be requested not to swallow or cough. (3) He was told that his breathing would be done for him by the anesthesiologist, and that if he felt short of breath, he was to signal this and the breathing would be immediately increased. He was asked to attempt neither to help nor to resist the control of his breathing. The signals consisted of an open hand indicating "yes" and a closed fist indicating "no." Most patients accepted this as a variation of Twenty Questions and cooperated well. (4) He was told that there would be an intravenous needle in one arm, that his arms would be restrained only enough to prevent him from reaching his head and that he would be free to move his extremities as much as he wished. These admonitions were believed to be important. The patient who feels that he has some control of the situation and is not completely restrained will exhibit much less anxiety and be more cooperative than he would be otherwise. (5) He was told that due to a drug to be administered to him (succinylcholine), he would be partially paralyzed and hence would feel somewhat weak, but that he *would* be able to move his extremities.

The first patient in this series received only scopolamine for premedication and was quite apprehensive. All of the others received a

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* Educe, the opposite of induce, previously used by K. H.[8]

TABLE 1

A Summary of Anesthetic Agents Used and Return of Spontaneous Respiration in 13 Patients for 16 Neurosurgical Procedures

Patient	Age in Years	Weight in kg.	Succinylcholine Total Dose (mg./kg.)	Other Anesthetic Agents Used	Return of Spontaneous Respirations in min. Before Termination of Anesthesia
1	15	70	8	F: N: D	50
2	29	58	32	T: N: D	−15*†
3a	42	54	23	T: N: D	0
3b	43	51	17	T: N: D: C	10
4	36	56	23	T: N: D	10
5a	21	70	14	T: N: D	5
5b	21	70	11	T: N: D	10
6a	14	47	9	T: N: D	15
6b	15	47	11	T: N: D	25
7	40	75	27	T: N: D	10
8	16	55	18	T: N: D: M	0
9	18	83	25	T: N: D	5†
10	45	57	19	T: N: D: C	30†
11	20	60	12	F: N: D	20†
12	20	79	18	F: N: D	55†
13	16	49	18	F: N: D	40†
Average:		61	18		17

The total dose of succinylcholine in mg./kg. includes from 60 to 80 mg. used for intubation. The fifth column lists the other agents used: F = 1,1,1,-Trifluoro-2,2-Bromochlorethane (Fluothane), T = thiopental, C = cyclopropane, M = meperidine, N = nitrous oxide, D = dibucaine. The sixth column gives the time in minutes, before the termination of anesthesia, when adequate spontaneous respirations occurred in each patient.

* Patient in whom adequate spontaneous respirations were delayed (see text).

† Jefferson Ventilator used.

barbiturate (usually pentobarbital) two hours prior to anesthesia, an analgesic (usually meperidine) and anticholinergic agent (usually scopolamine) one hour prior to anesthesia.

A plastic "needle" † was inserted in a vein of the forearm. It was securely taped in such a manner that the patient could move his arm with very little danger of dislodging the intravenous catheter. Cocaine in a concentration of 10.0 per cent was sprayed into the larynx and trachea. The soft plastic endotracheal catheter was well lubricated with lidocaine ointment, 4.0 per cent. In spite of this, it was found two hours later that complete anesthesia of the trachea was not maintained. The administration of succinylcholine by means of a slow drip intravenously and hyperventilation were necessary to prevent coughing and "bucking" on the endotracheal tube.

† Rochester Products Company, Rochester, Minnesota.

For all patients, anesthesia was induced with thiopental or Fluothane (1,1,1,trifluoro-2,2-bromochlorothane). All were intubated following the administration of succinylcholine and anesthesia was maintained with nitrous oxide and oxygen administered in a semiclosed system with flows ranging from 4 to 7 liters per minute. Local infiltration of the scalp with dibucaine hydrochloride (nupercaine) was accomplished by the surgeon (M. B.). Little additional analgesia was needed and little, if any, of the thiopental or Fluothane was administered after induction. A solution of succinylcholine (2 mg./cc. of succinylcholine in glucose, 5.0 per cent in water) was administered after induction. This infusion was maintained at as slow a rate as possible, using an accurate flow meter ‡ (fig. 1). The flow was increased when the patient moved or resisted adequate ventilation. After experience

‡ "Clinical Flowrator," Fischer & Porter Co., Hatboro, Pennsylvania.

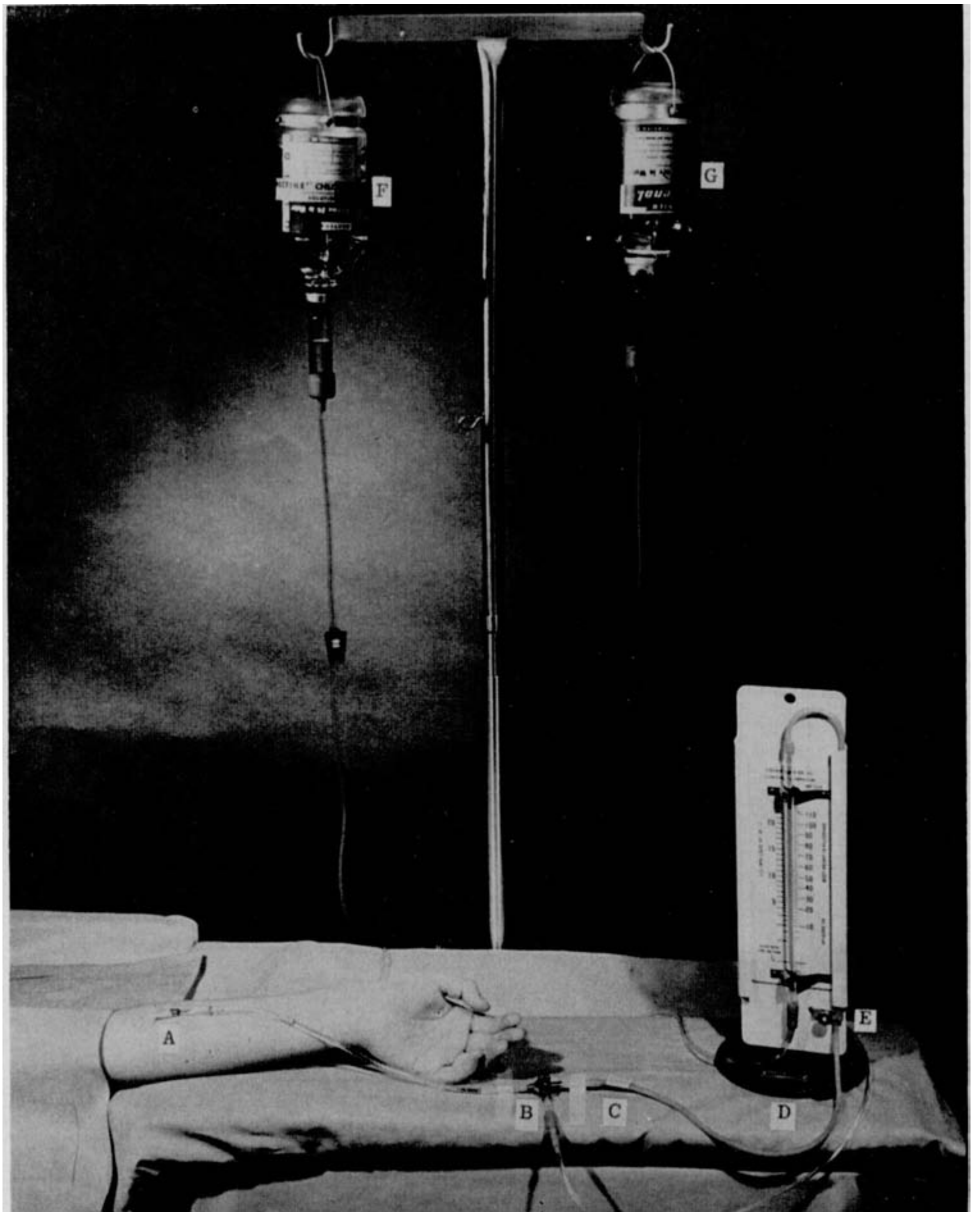

FIG. 1. Flowmeter assembled to measure the flowrate of succinylcholine. A, plastic needle; B, a 3-way stopcock; C, red tape on the tube delivering succinylcholine; D, flowmeter with its calibrated scale; E, knurled knob for accurately regulating flow; F, the succinylcholine solution (marked with red tape); G, dextrose 5.0 per cent in water.

with the first 2 patients, it became apparent that it was difficult to maintain a patient on assisted respirations and still have: (1) adequate ventilation, (2) a quiet patient, and (3) a quiet, nonbulging brain. For these reasons, patients subsequently were maintained on controlled respirations until the critical part of the operation was completed. Respiration was assisted manually in ten instances and a Jefferson § ventilator was employed in six instances.

Approximately fifteen minutes before the

§ Jefferson Ventilator, Air-Shields, Inc., Hatboro, Pennsylvania.

neurosurgeon was ready to begin his electrocortical recordings, stimulations, and questions, eduction of anesthesia was started. The administration of nitrous oxide was discontinued, and the patient was given oxygen. Administration of succinylcholine was continued at a rate adjusted to produce a quiet patient with generalized paresis and a subjective sensation of weakness, but not immobility.

When the patient indicated that he was fully awake by giving correct "yes" and "no" responses and by correctly identifying objects placed in his hand such as pens, paper clips, keys or combs, the neurosurgeon was notified and the localization procedure was begun. When the neurosurgeon had finished, anesthesia was reinduced, and for the remainder of the operation it was continued as it would have been for any other intracranial procedure. Occasionally the neurosurgeon wished to do cortical extirpations and then record electrocorticograms from the remaining brain tissue or restimulate this tissue for motor responses or epileptic aura. If the time necessary for extirpation was short, the patient was kept awake since this procedure is not painful. If, however, the period of extirpation was expected to be lengthy, anesthesia was reinduced with nitrous oxide and oxygen. Hyperventilation was maintained. Anesthesia was educed when further electrical testing was necessary.

Each patient was questioned when awake, about four hours postanesthesia, and the following day, in order to ascertain whether he remembered the localization procedure. In an attempt to determine the level of consciousness and presence or absence of amnesia in these patients, 5 arbitrary classifications were made:

(1) The patient was awake, moved, and would respond to commands by movement. (2) The same as 1, plus the ability to give correct "yes" and "no" responses on command. (3) The same as 2, plus the ability to identify objects or show other signs of cerebration. (4) The same as 3, plus a subjective memory of the awake period postoperatively. (5) The same as 4, plus objective proof that the patient could remember what happened during the awake period. In order to do this, the patient was given objects to identify, such as pens, paper clips, keys or combs, without being told beforehand that this would be done at all. Postoperatively, if the patient volunteered the information that this was done and correctly named some of the objects or could quote verbatim any of the conversation used during the awake period, he was placed in category 5.

Results

The average total duration of anesthesia was five hours. The largest dose of thiopental used was 825 mg. for a six and a half hour anesthesia. Such a dose was not considered excessive. The average total dose of succinylcholine was 18 mg./kg. body weight (table 1). All patients, therefore, were maintained in light planes of anesthesia except for the awake period.

In spite of the large doses of succinylcholine given, all patients, except one, were breathing spontaneously with adequate ventilation at the termination of anesthesia (table 1). One patient (no. 2) had received 1,880 mg. of succinylcholine (32 mg./kg.) and 825 mg. of thiopental over a six and a half hour period. She was breathing spontaneously five minutes before the end of the procedure, but her tidal air was considered minimally adequate and her respirations were assisted for fifteen minutes after the termination of anesthesia, by which time her tidal volume had returned to normal.

The amount of succinylcholine that was necessary to maintain the desired level of paresis during the awake period is shown in table 2. The average maintenance dose was 0.14 mg./minute/kg. of an 0.2 per cent solution of succinylcholine. The average time that the patients were awake was seventy-two minutes. It may be noted from table 2 that 3 patients came under awake classification 5. One patient considered this awake period as a "dream," although he could correctly remember the events as they occurred. To the others, this awake period was a reality, although they said that at times they felt very sleepy. In these patients, the subjective time was much shorter than the objective time. For example, patient 2, who was awake for sixty-three minutes, remembered it as being about fifteen minutes. In those patients who were

TABLE 2

DOSAGE OF SUCCINYLCHOLINE TO MAINTAIN A PATIENT QUIETLY AWAKE

Patient	Age in Years	Weight in kg.	Succinylcholine Maintenance Dose (mg./min./kg.)	Total Period Awake, Minutes	Awake Classification
1	15	70	0.20	65	2
2	29	58	0.21	63 (28 + 35)	5
3a	42	54	0.22	75	4
3b	43	51	0.12	75	4
4	36	56	0.11	79 (27 + 52)	2
5a	21	70	0.14	40 (20 + 10 + 10)	1
5b	21	70	0.16	80	1
6a	14	47	0.17	40	5
6b	15	47	0.13	70	5
7	40	75	0.21	72 (52 + 20)	3
8	16	55	0.04	60	5
9	18	83	0.14	175	4
10	45	57	0.14	85 (65 + 20)	1
11	20	60	0.10	70	2
12	20	79	0.13	60 (40 + 20)	4
13	16	49	0.08	50 (30 + 15 + 5)	4
Average:		61	0.14	72	

The figures in parentheses indicate when a patient was awakened more than once. In the sixth column, patients are classified according to the level of consciousness and the presence or absence of amnesia (see text).

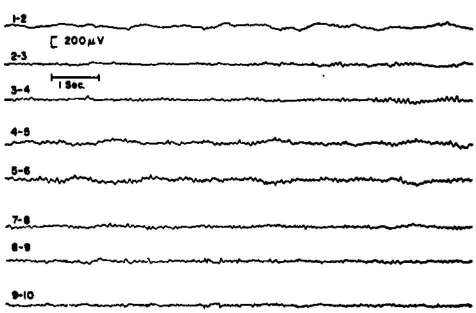

FIG. 2. Awake electrocorticogram in patient 1. This seemed to be a normal record. The numbers indicate different combinations of 10 cortical electrodes.

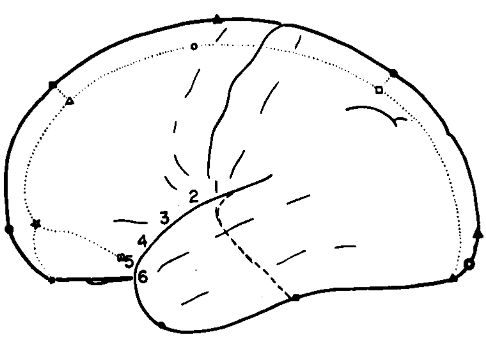

FIG. 3. Placement of 6 of the cortical electrodes on the left temporal lobe of patient 3 (fig. 4). The other 4 electrodes were placed medially and do not show in this view.

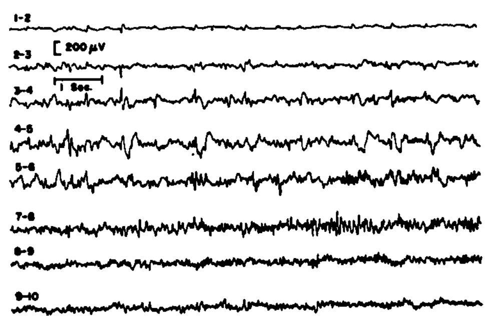

FIG. 4. Electrocorticogram of patient 3. The numbers indicate the combinations of electrodes used (fig. 3). This is an abnormal record due to epileptic activity.

awakened more than once, the second eduction seemed much more difficult than the first, and sometimes the patient did not remember the second awake period at all.

Satisfactory electrocorticograms were obtained on all of these patients (figs. 2, 3 and 4) and stimulation with motor response, which was indicated in 6 patients (2, 3b, 4, 6b, 10 and 13), was done satisfactorily in spite of the paresis due to the infusion of succinylcholine. Sensory phenomena, including auras, were also elicited by stimulation in these patients and communicated to the anesthesiologist by means of hand signals.

Discussion

Despite the fact that some patients in this series were uncooperative before operation, studies of cortical localization were successful in every instance. Electrocorticograms were obtained from all patients. Cortical stimulation to elicit motor responses and sensory phenomena, including auras, was successfully accomplished when indicated. Anderson and Funk [9] previously reported successful elimination of artifacts due to movement in electroencephalography by means of succinylcholine administered to produce muscular paralysis. The more cooperative of the patients in the present series were able to indicate answers, by means of hand signals, to complex questions concerning subjective sensations related to cortical stimulation.

The total amount of succinylcholine was minimized by using an accurate flow meter and carefully titrating the flow rate against degrees of paresis. No severe ventilatory depression occurred postoperatively; one patient seemed to have a minimally adequate tidal exchange, for which the respiration was assisted for fifteen minutes after anesthesia was discontinued.

Several patients reported experiencing dyspnea during the period awake, although to the anesthesiologist their controlled minute volumes seemed greater than normal. For this reason, most of the patients were markedly hyperventilated. This presented an additional problem, since hyperventilation was related to a tendency to sleep, probably due to alkalotic narcosis. Careful adjustment of the respiratory minute volume seemed necessary to maintain wakefulness without dyspnea. No difference was found between those patients who were manually ventilated and those for whom a Jefferson ventilator was employed.

While reducing the hazard to the patient, this technique has the disadvantage that the patient cannot talk. Therefore, patients whose speech center may be involved receive only local anesthesia.

Summary

A technique is reported for use in neurosurgical procedures that provides for the voluntary cooperation of the patient and complete control by the anesthesiologist. The technique was used 16 times in 13 patients. Patients were maintained under general anesthesia for the craniotomy and the closing, but were allowed to awake for studies of cortical localization during the operation.

Electrocorticograms were obtained from all patients. Cortical stimulation was carried out successfully when indicated. The dose of succinylcholine averaged 0.14 mg./minute/kg. of body weight.

Although all the patients were cooperative during the period of wakefulness, some had complete amnesia of the event while others had a clear memory of it.

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