HYPERTENSION DURING ANESTHESIA IN PATIENTS WITH SPINAL CORD INJURIES *

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HYPERTENSION during the progress of surgical procedures and anesthesia is always of importance to the anesthesiologist. Its detection and correction are essential to maintain the normal physiologic status and to reduce morbidity of patients undergoing surgical intervention and anesthesia. The purpose of this communication is not to discuss hypertension, but to point out its occurrence in a special group of individuals who have injuries to their spinal cord.

The increase in number of patients surviving spinal cord injuries incurred in World War II has been attributed to antibiotics, improved techniques, and the studies made which have shed new light upon the changed physiology and pathology associated with these injuries together with the recommended procedures for restoration of functional balance (1). Under such a program, an increasing number of such patients may be found who need surgical intervention and require the services of anesthesiologists for diagnostic and therapeutic procedures.

It is known that, under favorable conditions, in cases of spinal cord injuries the portion of the spinal cord distal to the lesion not only recovers its reflex functions but becomes highly excitable. Such reflexes, although complicated and showing some adaptation, can be evoked from almost any portion of the paralyzed trunk, extremities and viscera. In some individuals, these reflexes can be produced with ease and result in an excessive and widespread reflex reaction adequately termed "mass reflex." Clinical occurrence of this mass reflex was first recorded in the classic papers of Head and Riddoch (2, 3). The syndrome may be manifested by excessive sweating, pilomotor erection, flushing of the face, severe headache, slowing of the pulse, increased blood pressure rising to precipitous heights, convulsions and loss of consciousness if the stimulus is continued. Although the trigger mechanism that sets off the diffuse sympathetic response most frequently was found to be distention of the bladder, cutaneous, proprioceptive or visceral stimuli may be followed by such outbursts of sympathetic overactivity.

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Hence, in individuals with intact isolated spinal cords completely divided from higher control, return of function assumes a form in which reflexes have lost, to a great extent, their local response, and the reaction is massive rather than specific. Furthermore, the receptive field from which the reflex can be evoked is enormously extended. Such mass reflexes constitute an excellent response to noxious stimuli in lower organisms, but are useless for discriminative action.

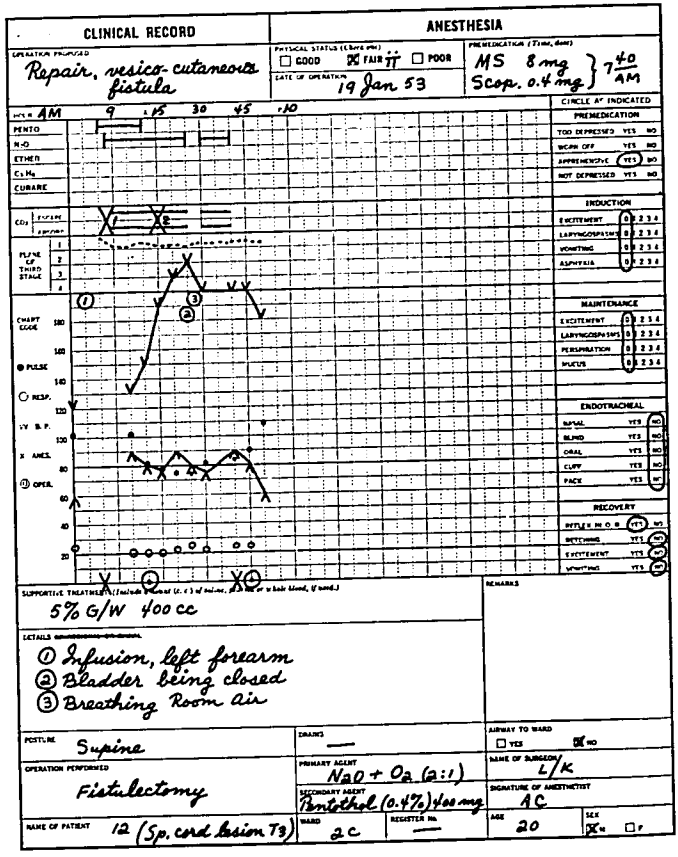

FIG. 1.

Guttman and Whitteridge (4) studied the vascular changes that occur during distention of the bladder in paraplegic patients. In patients in whom the lesions were above the second lumbar segment, distention of the bladder was followed by constriction of blood vessels of the toes. When the lesions were situated at or below the sixth thoracic segment, vasoconstriction of the toes was accompanied by vasodilatation in the fingers and a slight rise in arterial blood pressure. When the lesions were located at or above the fifth thoracic segment, vasoconstriction of the toes was accompanied by vasoconstriction of the fingers, a marked rise in arterial blood pressure and slowing of the pulse. In this group of patients who had vasoconstriction of the fingers, a rise in arterial blood pressure could not be prevented, whereas in patients with vasodilatation of the fingers, the blood pressure level could be maintained within narrow limits. It was found that vasoconstriction not limited to skin was the basic reflex response in all patients with transections above the second lumbar segment in whom distention of the bladder occurred.

Thompson and Witham (5) pointed out the clinical significance of paroxysmal hypertension in cases in which the lesions were high in the spinal cord in that hemostasis during surgical procedures may tax the ingenuity of the surgeon and postoperative cerebrovascular accidents may be provoked by this mechanism.

It soon became apparent that hypertension occurred quite frequently in these patients during general anesthesia. A typical anesthesia graph is illustrated in figure 1. Since it was shown that in patients who had lesions lower in the spinal cord there were still areas in the upper extremities and splanchnic region under vasomotor control which could provide compensatory vasodilatation, and that hypertension did not occur, patients with paraplegia were divided into two groups. Group I consisted of patients who had complete lesions at the fifth thoracic segment or above and group II consisted of patients with complete lesions at the sixth thoracic segment or below.

In group I there were 27 patients who had undergone surgical manipulation and general anesthesia fifty-four times. The average age of the patients in this group was 27.8 years. All these patients had histories of mass reflex activity, including paroxysmal hypertension. General anesthesia was suggested for these patients for the following reasons: (1) reflex spasms and movements were annoying to surgeons, (2) problems could be discussed openly during the operation, (3) functional studies during anesthesia were facilitated, and (4) a number of patients requested that they be put to sleep. Table 1 lists the incidence of rise of systolic pressure of 50 mm. of mercury or more during general anesthesia in this group.

A rise of systolic pressure of 50 mm. of mercury was arbitrarily selected as being significant and to eliminate minor fluctuations in blood pressure from other causes. Respirations were assisted in these cases

to prevent excess carbon dioxide. Twenty-three patients, or 42.5 per cent, showed this degree of hypertension. The highest systolic increase was 160 mm. of mercury in one individual. Concomitant with a rise in blood pressure, a fall in pulse rate usually occurred which

TABLE 1

RISE OF SYSTOLIC BLOOD PRESSURE (50 MM. OR MORE) IN GROUP I

Case	Location of Lesion	Anesthetic Agents	Operation	Systolic Increase, mm.	Diastolic Increase, mm.	Pulse
1	C_6	Pentothal, cyclopropane-ether	Obturator nerve section	50	24	−10
4	C_7	Pentothal-nitrous oxide	Cystolithotomy	74	42	−10
4	C_7	Pentothal-nitrous oxide	Pudendal neurectomy	60	48	−30
4	C_7	Pentothal, cyclopropane-ether	Fistulectomy (urethral)	70	34	−20
5	C_8	Pentothal-nitrous oxide	Laminectomy, anterior and posterior rhizotomies, $S_1 - S_5$	100	90	−12
5	C_8	Cyclopropane	Laminectomy and rhizotomy (operation canceled)	110	60	−24
9	C_6	Cyclopropane-ether	Tenodesis, left hand	60	40	−18
9	C_6	Local procaine and intravenous barbiturate	Bilateral rhizotomies, $S_1 - S_5$	60	40	0
9	C_6	Nitrous oxide	Suprapubic cystotomy	50	10	− 8
10	C_6	Pentothal-nitrous oxide	Obturator neurectomy	52	42	−10
10	C_6	Cyclopropane, pentothal-nitrous oxide	Rhizotomies, thoracic	50	30	−20
12	T_3	Pentothal-nitrous oxide	Fistulectomy (vesico-cutaneous)	100	30	−26
12	T_3	Trilene®-nitrous oxide	Litholapaxy	160	50	−24
13	T_3	Pentothal-nitrous oxide	Obturator neurectomy	52	60	0
15	C_6	Pentothal-nitrous oxide	Bilateral pudendal neurectomy	90	32	−20
15	C_6	Pentothal-nitrous oxide, cyclopropane-ether	Anterior and posterior rhizotomies, $T_9 - T_{11}$	110	80	−20
36	C_6	Pentothal-nitrous oxide	Cystoscopy	90	60	−20
17	C_7	Cyclopropane-ether	Tendon transplants, right arm	50	20	0
20	C_6	Pentothal-nitrous oxide	Obturator neurectomy	50	40	−30
20	C_6	Pentothal-nitrous oxide	Anterior and posterior rhizotomies, $T_{11} - L_2$	60	40	−10
24	C_6	Cyclopropane-ether, pentothal-nitrous oxide	Laminectomy and rhizotomy, $S_1 - S_5$	50	50	−10
24	C_6	Cyclopropane-ether, pentothal-nitrous oxide	Rhizotomy, $T_{12} - L_5$	50	50	+20
35	T_4	Pentothal-nitrous oxide	Laminectomy, anterior and posterior rhizotomy, $T_{12} - S_5$	60	40	−20

probably was part of a depressor reflex through the aortic and carotid sinus nerves, initiated by the hypertension. Hypertension did not occur consistently in the same patients. This was accounted for by the type of stimulus applied. A strong stimulus caused a more vigor-

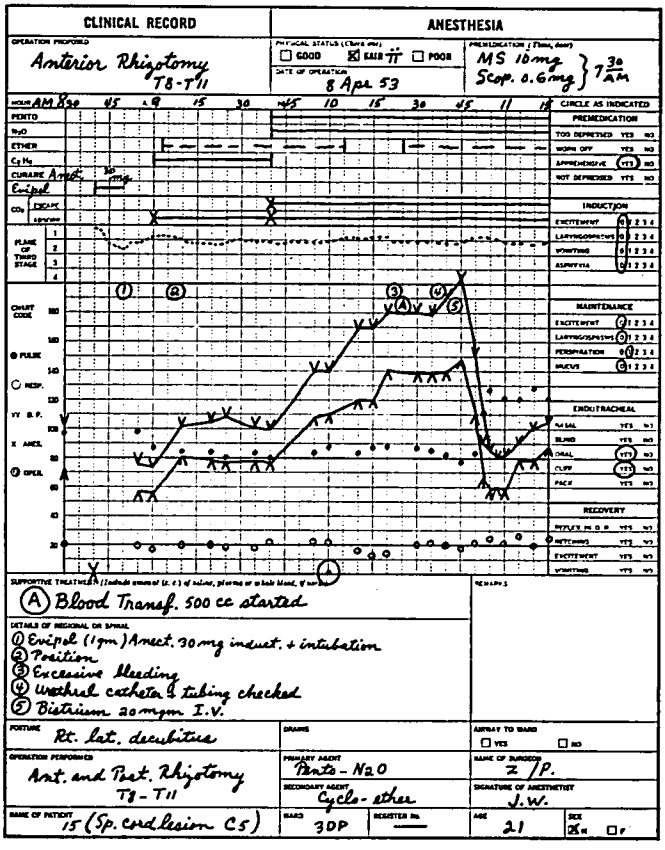

FIG. 2.

ous reaction than a weak one. A subminimal stimulus, when repeated several times in quick succession, evoked a reflex reaction (3). Depth of anesthesia undoubtedly played some part in incidence and degree of reflex response.

Figure 2 is part of an anesthetic record and illustrates a case of severe hypertension during operation. The indwelling Foley catheter and tubing were examined to determine whether bladder distention

was the source of stimulus; they were patent and urine emptied freely into a bottle. Bleeding was continuous and so profuse that cancellation of the operation was considered. A dose of hexamethonium bromide (20 mg.) was given intravenously at this point and an immediate fall occurred in arterial blood pressure, from 210 mm. to 80 mm. systolic and from 140 mm. to 60 mm. diastolic. Operation was continued uneventfully except that one additional dose of hexamethonium bromide was given to control hypertension. Recovery was uneventful.

Tetraethylammonium chloride was also found to be effective in blocking the reflex and in controlling sympathetic activity (5).

In group II there were 35 patients who had undergone general anesthesia fifty-one times. The average age of these patients was 27.5 years. Only 2 patients showed a marked rise in systolic pressure, the highest being 50 mm. of mercury. The two groups can readily be compared in table 2. Attention has been called to the fact that occasionally vasoconstriction and hypertension may emanate from cord segments

TABLE II

COMPARISON OF GROUPS I AND II

	Group I (Lesion T_5 or Above)	Group II (Lesion T_6 or Below)
Number of patients	27	35
General anesthesia	54	51
Systolic rise, 50 mm. or more	23 (42.5%)	2 (3.9%)
Slowing of pulse with hypertension	19 (82.6%)	1 (50%)

with lesions situated lower than the fifth thoracic segment, that is, the sixth and seventh thoracic segments (6).

Spinal anesthesia was used thirteen times in patients who had lesions at or above the fifth thoracic segment (Group I). It was used primarily during cystography and cystometry. It soon became evident that spinal block was advantageous and, when feasible, this method was used in surgical procedures below the umbilicus. The following is a report on cystography and cystometry performed before and after spinal anesthesia: The patient was a paraplegic (lesion at the sixth cervical segment) who showed considerable spasms of the bladder, lower extremities and abdominal muscles. During the course of these spasms, he underwent severe headaches with rise in blood pressure, sweating and occasionally nausea and vomiting. He was placed upon the table and cystometrograms were made. While undergoing this procedure, he had violent headaches with considerable sweating and the formation of cutis anserina. He was then removed to the x-ray table where cystography was done, using sodium iodide in the bladder. Following these two procedures, a spinal anesthetic was injected between the third and fourth lumbar vertebrae and cystography and cysto-

metrography were repeated. Sweating, headache or cutis anserina did not occur. In addition, the bladder capacity increased almost 100 per cent and the patient was completely relieved from his former spastic state.

In all 13 patients who had spinal anesthesia, no instance of hypertension or headache occurred from reflex activity. Although spinal anesthesia prevented the reflex effects, preliminary studies were made with bilateral paravertebral sympathetic procaine blocks which were found to be insufficient to stop the reflex (5).

SUMMARY AND CONCLUSIONS

Reflex response of autonomic mechanisms as alarm symptoms of abnormal visceral activity in the paralyzed part of the body may occur during general anesthesia in paraplegics.

In 54 patients with lesions at or above the fifth thoracic segment, the incidence of increase in systolic pressure of 50 mm. or more during general anesthesia was 42.5 per cent. The highest increase was 160 mm. of mercury.

Removal of the stimulus is the ideal method of treatment, but this procedure may be impossible since the trigger mechanism may not be readily apparent.

The reflex may be controlled with autonomic ganglion blocking drugs, such as hexamethonium or tetraethylammonium chloride.

Spinal anesthesia also is effective in preventing the reflex and affords these patients relief and a sense of well-being during surgical procedures on the lower part of the abdomen or the extremities.

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