time after injury), spontaneous, and pathologic (following abscess, tumor, etc).

Most early reported cases were related to trauma.[2] In recent years, congenital cervical pulmonary hernias in children and young adults have been described.[3,4] They may be associated with other congenital defects and, when present, any Valsalva maneuver will increase the herniation. When they are asymptomatic, no treatment is necessary. Supraclavicular herniation of the lung in the emphysematous adult patient is not uncommon.[5] Symptomatic pulmonary hernias may require operative repair, and Munnel[6] has described a variety of techniques that have been used.

A rare and unexpected case of cervical herniation of the lung has been presented. This abnormality should be kept in mind in the differential diagnosis of a mass in the neck, especially in association with positive pressure on the airway or the Valsalva maneuver.

References

1. Morel-Lavellee A: Hernies du poumon. Bull Soc Chir Paris 1:75, 1845–1847
2. Montgomery JG, Lutz H: Hernia of the lung. Ann Surg 82:220–231, 1925
3. Catalona WJ, Crowder WL, Chretien PB: Occurrence of hernia of Morgagni with filial cervical lung hernia: A hereditary defect of the cervical mesenchyme? Chest 62:340–347, 1972
4. Stearman MD, Majd M, Lopresti JM: Congenital cervical herniation of the lung. Med Ann DC 40:759–760, 1971
5. Fenichel NM, Epstein BS: Pulmonary apical herniations. Arch Intern Med 96:747–751, 1955
6. Munnel ER: Herniation of the lung. Ann Thorac Surg 5:204–212, 1968

A Safe Surface Electrode for Peripheral-nerve Stimulation

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In 1974, Lippmann and Fields reported burns at the site of skin contact with metal ball electrodes used in conjunction with a peripheral nerve stimulator.[1] As a result of that report, the manufacturer of the most widely available such stimulator now advocates that only subcutaneously inserted needle electrodes be used with this unit.[2] The manufacturer specifically discourages the use of any surface electrode.

Bruner[3] and Gray[4] quickly expressed reservations as to the necessity for such a severe restriction on the use of this unit. We also believe that this injunction against skin electrodes is unwarranted if care is taken in preparation of the skin and a suitable electrode is selected. We examined this hypothesis in 100 adult patients undergoing surgical procedures in which the use of muscle relaxants and a nerve stimulator was deemed advantageous.

Materials and Methods

The NDM long-term monitoring electrode† was used as the skin electrode in all patients. This is a disposable pre-gelled silver/silver chloride electrode with an adhesive foam pad backing. The connecting lead wires between electrode and peripheral nerve stimulator (mushroom snap connector to male banana plug) were also obtained from NDM Corporation.‡

In studies of the first 50 patients, a Wellcome peripheral nerve stimulator was selected, because it is widely distributed and it was the unit mentioned by Lippmann and Fields. Since the Wellcome peripheral nerve stimulator is no longer being manufactured,

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† NDM Corporation, P.O. Box 1408, Dayton, Ohio. Catalog #01-1010.

‡ Catalog #03-2542.

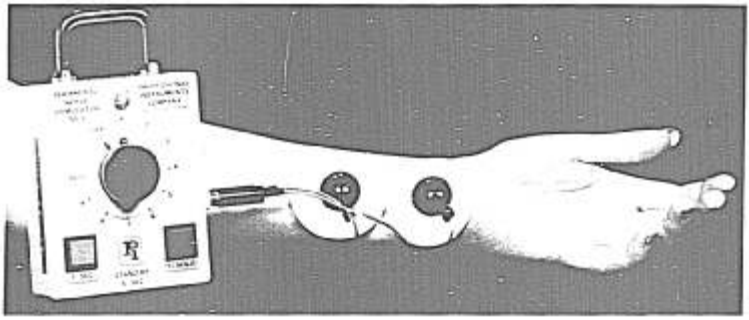

FIG. 1. NS-2 nerve stimulator with lead wires and disposable surface electrode.

we employed a similar and newly available nerve stimulator§ in studies of an additional 50 patients.

Electrodes were applied either close together over the ulnar aspect of the distal third of the forearm (fig. 1) or with one electrode so situated and the other over the ipsilateral olecranon notch. The underlying skin was "prepared" by rubbing with a dry gauze pad until the skin was slightly erythematous. All patients received at least ten tetanic stimuli of 3-second duration at maximum voltage output during the operative procedure. The skin at the electrode site was examined for irritation at the termination of the procedure, before discharge from the recovery room, and, if evidence of erythema was evident at that time, 24 hours later.

RESULTS

In none of the 100 patients studied was any burn encountered. Slight reddening at the site of gel application was quite common immediately following removal of the electrode. Similar erythematous reactions are frequently seen at the site of insertion of needle electrodes as well. Upon discharge from the recovery room, however, these had all faded completely. Four patients did have skin irritation at the site of the foam adhesive the following day.

§ NS-2 Peripheral Nerve Stimulator, Professional Instruments Company, P.O. Box 38245, Houston, Texas.

We found that supramaximal stimulation was reliably obtained when one electrode was placed over the olecranon notch, the other over the ulnar nerve at the wrist. Response to tetanic stimuli with the surface electrodes so placed was compatible with what we have come to expect with needle electrodes. With both electrodes placed at the wrist, control responses seemed to be more variable.

DISCUSSION

While needle electrodes work well for peripheral nerve stimulation, they have certain inherent disadvantages for use in routine clinical practice. Because insertion is uncomfortable for the awake patient, electrode application is usually delayed until after anesthesia has been induced, and often until after an initial dose of relaxant has been given. Finally, whenever an invasive technique is used, there is the possibility of infection, broken needles, or intraneural placement.

We agree with Lippman and Fields that metal plate or ball electrodes may be dangerous. When an electrolyte gel is not used, skin impedance remains high and when, in addition, skin contact is poor, current density at the site of application can be excessive.

However, we have found the use of disposable ECG electrodes very satisfactory for peripheral nerve stimulation. Control twitch and tetanic responses were good and skin reactions were minimal aside from occasional sensitivity to the adhesive on the pad. We

would caution, however, that if an ECG electrode other than the one tested is used, an initial period of close observation may be warranted.

With the use of disposable pregelled surface electrodes, we have found the study of neuromuscular function during anesthesia to be as safe, simple and convenient as routine ECG monitoring.

References

1. Lippmann M, Fields WA: Burns of the skin caused by a peripheral nerve stimulator. ANESTHESIOLOGY 40:82–84, 1974
2. Wellcome Peripheral Nerve Stimulator Instruction Manual
3. Bruner JMR: Questions and Answers section. Anesth Analg (Cleve) 54:297, 1975
4. Gray JA: Nerve stimulators and burns. ANESTHESIOLOGY 42:231–232, 1975

Tachyphylaxis to Sodium Nitroprusside

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Rapidly developing tolerance to the hypotensive effects of ganglionic blocking agents, when administered repeatedly and at short intervals, is well known.[1] Similar pharmacologic behavior (*i.e.*, acute tolerance) has not been reported to occur with sodium nitroprusside.[2,3] However, cases in which initial high doses of sodium nitroprusside were needed have been reported.[4] Even though the pharmacologic mechanisms of tachyphylaxis to sodium nitroprusside are not clear, the following case report describes the development of acute progressive tolerance to the administration of sodium nitroprusside.

Report of a Case

A 41-year-old Caucasian woman who had Legg-Perthes disease was scheduled for left total hip replacement. Medical, surgical, and anesthetic history was unremarkable. The patient weighed 82 kg and was normotensive. According to cardiology and anesthesiology consultation, the patient was in good general health (ASA Physical Status I). The general laboratory work-up was within normal limits.

The patient was premedicated with morphine sulfate, 8 mg, and secobarbital, 100 mg, im. In the operating room, after iv administration of atropine, 0.6 mg, the heart rate was 80 beats/min and blood pressure 120/80 torr. Induction and maintenance of general endotracheal anesthesia with sodium thiopental, 300 mg, iv, 70 per cent nitrous oxide, 30 per cent oxygen, morphine sulfate, 20 mg, iv, and *d*-tubocurarine, 48 mg, iv, were uneventful. Controlled ventilation via an Air-Shields respirator was adjusted to maintain arterial P_{CO_2} 30–35 torr. Esophageal heart sounds, lead II electrocardiogram, direct radial arterial pressure, arterial blood gases and hourly urinary output were monitored.

After the fascia lata was incised, sodium nitroprusside (0.005 per cent solution in 5 per cent dextrose in water) was infused iv via microdrip to achieve controlled hypotension.[5] Response to the drug was prompt, and systemic arterial blood pressure was easily maintained at 90/60 torr for approximately 30 minutes with 300 μg/min sodium nitroprusside. During the following 30 minutes the heart rate increased from 80 to 100 beats/min and the dose of sodium nitroprusside had to be increased to 500 μg/min to maintain systolic pressure around 90 torr. At this stage the pupils were constricted. Even though there was no sign of "light" anesthesia, morphine sulfate, 10 mg, and thiopental, 600 mg, iv, were administered in incremental doses, with no appreciable effect on heart rate or on the sodium nitroprusside dosage. The systolic blood pressure kept rising, necessitating a further increase in nitroprusside dosage (fig. 1). At this time we decided to use a fresh, more concentrated solution of nitroprusside (0.01 per cent in 5 per cent dextrose in water). During the next 45 minutes the nitroprusside dose had to be progressively increased to 1,200 μg/min (approximately 15 μg/kg/min). Arterial blood-gas analysis at the peak of tolerance to nitroprusside showed *p*H 7.35, P_{CO_2} 35 torr, and P_{O_2} 100 torr. The hypotensive technique was abandoned and samples of blood and urine were obtained for catecholamine and renin activity estimation. The remainder of the operative procedure was completed with blood pressures ranging from 180/100 to 160/90 torr and heart rates from 110 to 100 beats/min. Total anesthesia time was 4 hours, 15

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