about 25% with pacing, but there was no indication of myocardial ischemia. The proper indications to institute pacing and the desired endpoints are subject to debate, but we have shown that, when desired, atrial esophageal pacing can be used in precisely controlling the heart rate in the setting of bradycardia and possible hypotension, which cannot be done by pharmacologic means.

Our study dealt only with atrial pacing, and all of our patients were in sinus rhythm. It should be emphasized that esophageal cardiac pacing cannot be used in patients with second or third degree heart block because of the inability to adequately and consistently pace the ventricle *via* the esophageal route.

In conclusion, we have shown body size does, but previous cardiac operative status does not, influence esophageal pacing current threshold. Increases in systemic blood pressure and cardiac output resulting from pacing were confirmed, and, therefore, we have defined better the effectiveness of the esophageal route of cardiac pacing.

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Thiopental for Phantom Limb Pain during Spinal Anesthesia

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Recurrences of phantom limb pain, occurring during a subsequent spinal anesthesia, have been described in several patients with previous lower limb amputations.[1–6] However, no therapy has been uniformly effective. We describe three cases where the pain was completely abolished by intravenous administration of subanesthetic doses of thiopental.

Case Reports

Case 1. A 68-yr-old, 43-kg woman with advanced tabetic arthropathy was scheduled for the right mid-thigh amputation. She had a history of severe pain by neural syphilis and had been taking analgesics herself for the past 30 yr. Two years previously she was admitted to our hospital, where morphine 30–40 mg daily, and other analgesics and tranquilizers had been administered. After a left mid-thigh amputation, performed 6 months previously, she had experienced severe phantom limb pain, but had been pain-free for 2 weeks prior to the second operation. Oral flunitrazepam 0.5 mg was given 90 min preoperatively. In the right lateral position, the spinal anesthesia was introduced with a 23-gauge needle at the L2–3 interspace using 14 mg tetracaine and 80 μg morphine in 2.8 ml of 10% glucose. Subsequently, the patient was put into the supine position. Five minutes later, she started to complain of phantom limb pain which was much more severe than that she had before. The sensory level to pin prick was at T6 bilaterally. Intravenous administration of 60 mg (1.4 mg/kg) thiopental immediately, though not completely, relieved the pain. Because of her restlessness, three doses of 5 mg diazepam were administered iv 5, 10, and 15 min after thiopental injection. Although the patient was still alert and somewhat restless, the pain completely disappeared and did not occur again. The operation was performed as arranged. The sensory level to pin prick was at T10 bilaterally at the end of the surgery.

Case 2. A 77-yr-old, 37-kg man with arterioscrelosis obliterans of lower extremities was scheduled for the right below-knee amputation. Two months previously, he underwent an amputation through the middle of the right foot, but experienced no pain thereafter. Oral flunitrazepam 0.5 mg was given 90 min preoperatively. In the right lateral position, the spinal anesthesia was introduced with a 25-gauge needle at the L3–4 interspace using 8 mg tetracaine and 2 mg phenylephrine in 1.6 ml of 10% glucose. He was kept in the same position for 15 min. The sensory level to pin prick was at L1, only in the right half of his body. Then he was turned into the supine position. Ten

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minutes later, he started to complain of severe phantom limb pain. The sensory level to pin prick was at T8 bilaterally. Intravenous administration of 38 mg (1.0 mg/kg) thiopental immediately relieved the pain, and no additional doses were necessary thereafter. The operation was performed as arranged.

Case 3. A 36-yr-old, 63-kg woman with myoma uteri was scheduled for hysterectomy. Sixteen years previously she had a right mid-thigh amputation for sarcoma. Since then, she suffered from severe phantom limb pain once a month at night. Oral flunitrazepam 1.0 mg was given 90 min preoperatively. In the right lateral position, the spinal anesthesia was introduced with a 25-gauge needle at the L3–4 interspace using 13 mg tetracaine, 3.3 mg phenylephrine, and 80 μg morphine in 2.6 ml of 10% glucose. Immediately after she was put into the supine position, she started to complain of phantom limb pain that was far more distressing than that she had experienced. The sensory level to pin prick was at T7 bilaterally. Intravenous administration of 25 mg (0.40 mg/kg) thiopental immediately relieved the pain. Five minutes later, the pain recurred, which she described as about half as severe as the first pain. Diazepam 5 mg iv did not relieve the pain. Intravenous administration of 50 mg (0.79 mg/kg) thiopental did relieve the pain without recurrence. The operation was performed as arranged. The sensory level to pin prick was at T7 bilaterally at the end of the surgery.

Discussions

Phantom limb pain may originate in the abnormal firing of the central nervous system.[7–9] This hypothesis is supported by the clinical findings that surgical sections of the pain pathway often fail to remove the pain permanently, and by the neurophysiological findings that, after denervation, neurons in the synaptic areas along the transmission routes of sensory projection systems produce abnormal firing.[7–9] Melzack and Loeser[8] named these hypersensitive neuron pool a "pattern generating mechanism." On the other hand, there exists a "central biasing mechanism" in the brainstem reticular formation, which exerts an inhibitory influence on the "pattern generating mechanism."[9]

Melzack[9] accounted for the phantom limb pain during spinal anesthesia as follows. The decrease of somatic inputs after anesthetic block lowers the level of inhibition exerted by the "central biasing mechanism," resulting in the increase of self-sustaining neural firing in the "pattern generating mechanism." In case 2, as the analgesic area spread cephalad and bilaterally, phantom limb pain occurred. Mihic and Pinkert[10] reported a case where the phantom limb pain occurred during continuous epidural anesthesia after the second local anesthetic administration, with the elevation of the analgesic level from T9 to T5. These cases indicate that phantom limb pain occurs with the extension of the sensory block area, in agreement with Melzack's theory.

On the other hand, de Jong and Cullen[11] considered that spinal anesthesia blocks the fast pain fibers at the dermatomal block level, reducing the fast fiber inhibition and increasing the passage of slow pains from the stump, which, *via* the sympathetic paraspinal pathways, enters the spinal cord several segments above the level of the fast fiber blockade.

However, whether pain from the extremities passes through the chain of sympathetic ganglia has not yet been proved experimentally nor clinically.[12] In our three cases and previously reported six cases of phantom limb pain during spinal anesthesia, the analgesic level was described when pain occurred.[1–5] For these nine cases, difference between the dorsal dermatomal level of the stump and the analgesic level of the spinal block is at least four segments. The dermatomal difference between the stump and the small fiber blockade level should be much greater, because, under spinal anesthesia, small fibers are blocked a few dermatomal segments cephalad to the large fiber blockade level. It is, therefore, unlikely that the slow impulses arising from the stump go cephalad along the paraspinal pathways and enter the spinal cord above the small fiber blockade level.

In 13 cases, including our three cases, of phantom limb pain induced by spinal anesthesia,[1–6] the drugs used for the treatment are thiopental (four cases), fentanyl with diazepam (two cases), morphine (three cases), and meperidine (two cases). No drugs are given in two cases. The effects of these drugs were as follows: 1) thiopental completely relieved the pain in four cases; 2) fentanyl and diazepam were partially effective in two cases; 3) morphine was partially effective in two cases, and not effective in one case; and 4) meperidine was partially effective in one case, and not effective in another case. Among those without therapies, one case suffered the pain until the spinal analgesia disappeared, and another case 12 h after analgesia wore off. Davis[3] reported a case where the phantom limb pain was relieved by 50 mg of iv thiopental administration. In conclusion, as much as 1 mg/kg of iv administered thiopental was extremely effective for treating the phantom limb pain induced by spinal anesthesia.

Deafferentation pain can be abolished by iv administered 50 mg thiopental.[7] Neuropharmacological studies suggest that subanesthetic doses of barbiturates diminish facilitation and enhance inhibition at synapses throughout the central nervous system.[13] Neurons affected by denervation hypersensitivity are unusually sensitive to barbiturates.[7] In the present cases, thiopental should have the inhibitory effects on the firing of the "pattern generating mechanism" activated by spinal anesthesia. Local anesthetic action of thiopental may not be significant since only one-fifth of the anesthetic dose was administered.[14]

Thiopental concentration in the brain tissue decreases to 10% of its peak level 30 min after a single iv injection, and patients awake within 15–30 min after administration.[14] In the present cases, although consciousness became clear 5–10 min after thiopental administration, and spinal anesthesia was still in effect, phantom limb pain did not recur. This may be due to the following reasons: 1) activated "pattern generating mechanism" was so sensitive to thiopental that it could be suppressed by extremely low

concentration of thiopental when the consciousness of the patients was clear; 2) both barbiturates and benzodiazepines, facilitate the GABA-ergic inhibition in the central nervous system,[13] and, therefore, benzodiazepines, administered pre- and/or intraoperatively, might have enhanced the effect of thiopental; 3) as Melzack suggested, patients had a higher pain threshold after the induction of phantom limb pain, because the increased output of the "pattern generating mechanism" could increase the descending inhibition;[9] and 4) phantom limb pain activated the sympathetic nervous system, which in turn enhanced the firing of the "pattern generating mechanism"[8] and reinforced the pain. Temporary effect of thiopental for the "pattern generating mechanism" abolished this vicious cycle.

As some authors have concluded, a history of lower limb amputation should be regarded as a contraindication to spinal anesthesia,[4,5] but one may have to choose spinal anesthesia for several practical reasons. When phantom limb pain occurs during spinal anesthesia, intravenous administration of subanesthetic dose of thiopental should be tried immediately.

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Spinal Anesthesia, Complete Heart Block, and the Precordial Chest Thump: An Unusual Complication and a Unique Resuscitation

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High spinal anesthesia (*i.e.*, above the fifth thoracic dermatome) has been associated with bradycardia and hypotension.[1] The presumed etiology of this phenomenon is a relative preponderance of vagal tone resulting from sympathetic blockade or, alternatively, from reflexes due to decreased atrial pressure (Bainbridge reflex). This is usually easily treated or prevented with vagolytic blockers such as atropine.

Although bradycardia and even asystole are well known complications of spinal anesthesia, third-degree heart block without ventricular escape has not been previously reported. We report a case during which complete heart block and ventricular asystole after a high bupivacaine spinal anesthetic was successfully treated by chest-thump induced pacing.

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Key words: Anesthetic technique: spinal. Complication: complete heart block. Heart: precordial thump.

Report of a Case

A 32-yr-old, 110-kg, 175-cm man was scheduled for repair of an uncomplicated ventral hernia. His past medical history, review of sys-