CLINICAL NOTES

Complications Associated With Intermittent Pneumatic Compression

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ABSTRACT. Lachmann EA, Rook JL, Tunkel R, Nagler \V. Complications associated with intermittent pneumatic compression. Arch Phys Med Rehabil I992;73:482-5.

• The intermittent pneumatic compression device (1PCD) is prophylaxis for prevention of deep-venous thrombosis (DVT). This pneumatic leg sleeve has been used extensively in high-risk surgical patients, without complication. We describe two cases, one with peroneal neuropathy and the other with compartment syndrome, associated with IPCD use during surgery. Case I involves a patient with pancreatic cancer and weight loss who developed bilateral peroneal nerve palsies during surgery. Case 2 involves a patient with bladder cancer who developed lower leg compartment syndrome during prolonged surgery in the lithotomy position. These cases are unusual for several reasons. First, patients wearing IPCDs during surgery are at increased risk of neurovascular compression. Second, significant weight loss may predispose the peroneal nerve to injury from intermittent compression garments. Third, patients undergoing surgery in the lithotomy position are at risk of compartment syndrome. Therefore, physicians may wish to use another method of DVT prophylaxis in surgical patients with cancer or significant weight loss, or those who are undergoing procedures in the lithotomy position.

KEY M *ORDS: Compartment syndromes: Compression: Peroneal nerve: Postoperative complications*

Deep-venous thrombosis (DVT) and pulmonary embolism (PE) are causes of morbidity and mortality in hospitalized patients. Prophylaxis to prevent DVT formation include anticoagulation and physical methods such as the intermittent pneumatic compression device (IPCD). In high-risk surgical patients, the use of anticoagulants may be contraindicated: whereas, physical methods have been proven effective.[1",3]

The most common side effects of IPCD use are discomfort, warmth, and sweating beneath the vinyl leg sleeves.[4] Complications associated with a related pneumatic compression device, the sequential pneumatic compression device (SPCD), have been reported. These complications include peroneal nerve palsy and pressure necrosis of the thigh.[5-6] Neither of these complications lias been associated with IPCD use.

We describe the first reported cases of bilateral peroneal neuropathy and compartment syndrome associated with IPCD use during surgery. In the first case, a patient with cancer and significant weight loss developed peroneal nerve palsies postoperatively. Compression neuropathies due to weight loss alone are not uncommon, especially those involving the common peroneal nerve (CPN) at the fibular head.[7-8] Case 2 involves a patient with cancer who developed lower leg compartment syndrome after prolonged surgery in the lithotomy position. Patients undergoing surgery in the lithotomy position are at risk of limb compression and subsequent compartment syndrome.[9-10] Therefore, IPCDs should be used with caution in surgical patients with cancer, peripheral neuropathy, or weight loss or those undergoing procedures in the lithotomy position; other methods of DVT prophylaxis should be considered.

CASE REPORTS

Case I. A 65-year-old man with atherosclerotic heart disease and hypertension was admitted with a one-month history of anorexia, painless jaundice, 20-pound weight loss, and recently diagnosed non-insulin-dependent diabetes mellitus. Abdominal CT scan revealed a mass at the head of the pancreas. Preoperative physical examination revealed no clinical evidence of peripheral neuropathy. Surgical stockings and IPCDs were applied preoperatively for DVT prophylaxis. The patient underwent a subtotal pancreatectomy. with biopsy demonstrating poorly differentiated adenocarcinoma.

Postoperatively. the patient complained of numbness and weakness of both lower legs. On examination, distal pulses were present and the legs were warm with good capillary refill. Sensation was decreased over the anterolateral legs and dorsum of the feet. Motor testing revealed absence of ankle dorsiflexion and eversion. He ambulated with a bilateral steppage gait that improved with use of ankle-foot orthoses and a rolling walker.

Electrodiagnostic studies 14 days after surgery demonstrated bilateral peroneal neuropathies with slowed motor nerve conduc-

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Submitted for publication March 12. 1991. Accepted in revised form June II. 1991.

No commercial party having a direct or indirect interest in the subject matter of this article has conferred or will confer a benefit upon the authors or upon any organization with which the authors are associated.

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lion of the CPN across the fibular head. An EMG revealed denervation of the tibialis anterior, peroneus longus, and extensor hallucis longus, with the short head of the biceps femoris spared bilaterally. During the next three months, there was clinical evidence of partial resolution of the nerve injury with increased strength of ankle dorsiflexion (3/5), eversion, and great toe extension (2/5). He required a cane and bilateral posterior leaf-spring orthoses until his death three months later.

Case 2. A 67-year-old man with recurrent transitional-cell carcinoma of the bladder was admitted for palliative treatment. Preoperative physical examination revealed no focal neurologic deficits and normal gait. Surgical stockings and IPCDs were applied preoperatively for DVT prophylaxis. The patient underwent radical cystectomy and ileal neobladder substitution, and he was in the lithotomy position for eight hours during the procedure.

Postoperatively. he complained of lower leg pain and paresthesias. Physical examination revealed a tight, swollen lower right leg. Distal pulses were present, as well as capillary refill. Sensation was decreased over the anterolateral leg and dorsum of the foot. Motor testing revealed calf pain with passive ankle dorsiflexion and plantar flexion, and weakness of active ankle dorsiflexion and great toe extension. Compartment pressures of the lower leg were as follows: anterior, 52mmHg: lateral, 58mmHg; superficial posterior, 55mmHg and deep posterior, SOmmHg.

Acute compartment syndrome was diagnosed. A four-compartment fasciotomy was performed, and multiple skin grafts were necessary to close the fasciotomy wound. The patient refused electrodiagnostic studies postoperatively. At discharge two weeks later, the patient had normal (5/5) dorsiflexion and great toe extension, as well as normal gait.

DISCUSSION

Pneumatic compression devices were developed during the 1970s as an alternative to anticoagulation for DVT prevention. Use of IPCDs reduces the incidence of DVT formation by 50% or more, and it is the prophylaxis of choice when low-dose heparin (LDH) is either contraindicated or ineffective.[11-13]

Surgical patients with malignancies require DVT prophylaxis because of high embolic risk. The high incidence of DVT formation may be due to coagulability properties of the malignancy or increase blood viscosity from dehydration.[4] One third of patients with pancreatic carcinomas develop venous thromboembolisms.[14] Use of IPCDs in cancer patients undergoing surgery may reduce postoperative DVT formation by 90%.[15]

An IPCD consists of a pair of double-walled, vinyl pneumatic sleeves, placed around the calves and connected to a compressor that inflates and deflates the garments (fig 1).

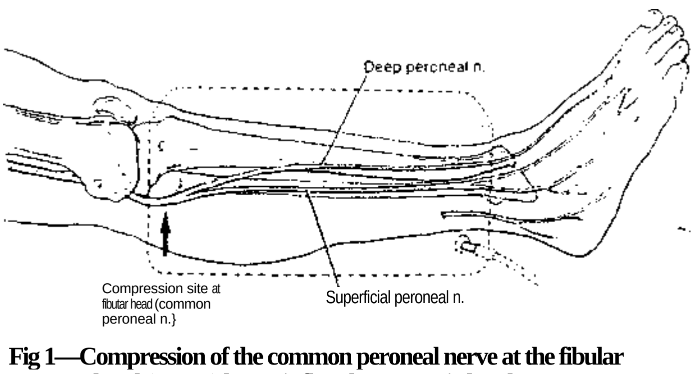

Fig 1—Compression of the common peroneal nerve at the fibular head (arrow) by an inflated pneumatic leg sleeve.

Compressions last 12 seconds per minute, with inflation pressure of 40mmHg. The leg sleeves (12 to 16 inches long) extend distally from the inferior border of the patella. They are applied preoperatively and are worn during surgery; they are removed once the patient begins walking.

This device compresses the lower leg, reproducing the action of the calf muscles in promoting venous return. Studies indicate that calf compression stimulates fibrinolysis, and this action contributes to preventing thrombus formation.[16-17] Contraindications to IPCD use include acute thrombophlebitis, suspected DVT, congestive heart failure, pulmonary edema, and leg ischemia due to peripheral vascular disease.

The etiology of the CPN palsy in the first case was multifactorial (ie, weight loss, paraneoplastic effects, nutritional and metabolic deficiencies, and intermittent pneumatic compression). Loss of tissue and fat around the CPN left it unprotected at the fibular head. Increased anterior compartment pressure from the intermittent compression device contributed to ischemia of the nerve.

Use of IPCDs caused direct injury to the CPN. During inflation, the calf sleeve compresses the CPN at the fibular head, where approximately 4cm of the nerve is covered only by skin and superficial fascia and is susceptible to injury.[18,19] Loss of protective tissue over the fibular head due to weight loss also contributed to nerve injury.[20-24]

Pancreatic adenocarcinoma may contribute to the production of compression neuropathies through dramatic weight loss and production of humoral factors that affect peripheral nerves. Sensorimotor neuropathies have been associated with pancreatic adenocarcinomas.[25] These paraneoplastic effects, along with weight loss, render the CPN prone to compression injury.

In the second case, the etiology of compartment syndrome was multifactorial (ie, lithotomy position, prolonged surgery, and IPCD use). Prolonged surgery in the lithotomy position has infrequently been associated with the development of compartment syndrome.[9,10] A compartment syndrome occurs when the circulation and function of tissues within a closed space are compromised by increased pressure.[26] Muscles and nerves enclosed in these compartments are susceptible to injury by this condition. Acute compartment syndrome caused by a malfunctioning pneumatic-compression boot has been described.[27]

External envelopes, such as IPCDs, can hasten compartment syndrome by restricting the volume of the leg compartment, thus increasing intracompartmental pressures.[28] Direct local muscle pressure from the IPCDs can cause muscle necrosis and loss of capillary integrity. In the presence of an intact vascular supply, massive edema results.[29-30] Edema formation in closed compartmental spaces leads to increased compartmental pressures. A self-perpetuating edema-ischemia cycle results in myonecrosis and nerve injury in the compartment.

Compartment syndrome may occur during surgery in the lithotomy position; additional use of IPCDs during surgery increases the risk of compression injury. Experiments have shown that 90% of the external pressure developed by pneumatic garments is transmitted to the muscular compartments.[31] The IPCD produces 40mmHg of pressure for 12 seconds every minute; significant necrosis of intracom-

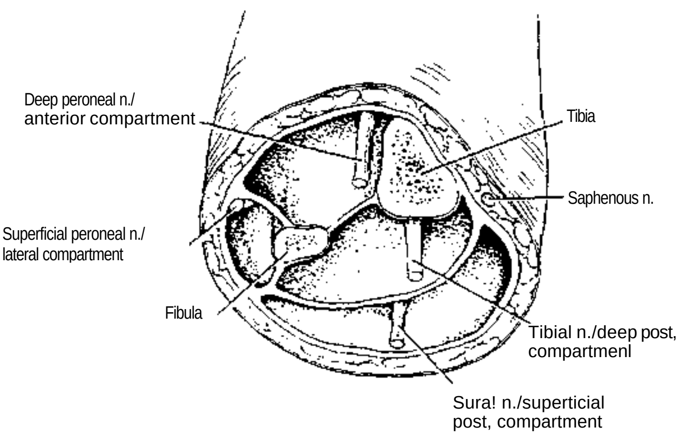

Fig 2—Cross-section of the middle and distal thirds of the leg, illustrating the four compartments and their respective nerves.

partmental muscle may be produced at a threshold of 30mmHg during eight hours.[32] Therefore, use of IPCDs during a prolonged surgical procedure in the lithotomy position predisposes patients to increased tissue pressures and compartment syndrome.

An acute compartment syndrome may occur in any one of the four compartments of the lower leg (fig 2), with the anterior compartment most commonly involved.[29] The CRN divides into the deep and superficial branches. The deep peroneal nerve courses from the lateral compartment to the anterior compartment. The superficial peroneal nerve courses along the anterior intramuscular septum in the lateral compartment. The deep posterior compartment contains the tibial nerve. The sural nerve travels in the fascia of the superficial posterior compartment. Elevated intracompartmental pressures may produce ischemia and sensory or motor deficits in the distribution of any of these nerves.

Methods other than conventional pneumatic compression devices should be used for DVT prophylaxis in surgical patients with cancer and weight loss; as in the first case. A CPN palsy can be avoided by using antithromboplastic agents such as LDH or dextran, or another physical method. Use of LDH carries the risk of bleeding and hematoma formation, and dextran has been associated with congestive heart failure, renal failure, and anaphylaxis.[4-33] Both methods carry significant risks for surgical patients. Physical methods are preferred and may include continuous passive motion (CPM) devices, range of motion (ROM) exercises for the knee and ankle, modified pneumatic compressive devices, surgical stockings, and electric stimulation of the calf.

Modification of IPCDs and SPCDs, ie, leaving the fibular head exposed so as not to inflate over it, is the most viable alternative (fig 3). These modified devices may become the prophylaxis of choice in patients with weight loss and cancer and in the general population, since the CPN cannot be directly injured from compression. However, the effectiveness of modified pneumatic compression devices for DVT prophylaxis has yet to be proven.

Surgical or thromboembolism-deterrent stockings are free of side effects and are effective for DVT prophylaxis.[34] Electric stimulation of the calf has been shown to be less effective. However, unaltered pneumatic compression devices are superior to these two methods in preventing DVT formation.'-'[03]

In the second case, acute compartment syndrome may have been prevented by following certain precautions when positioning the patient in the lithotomy position. The hips should not be flexed more than 60° with the horizontal. Forced adduction or abduction of the foot and stretching of hip adductor muscles should be avoided. Generous soft padding should be placed against bony prominences, especially around the knees and ankles, since the CPN, saphenous nerve, and tibial nerve may also be injured in this position. Hyperextension of the hips should be avoided. Personnel in the operating room should avoid leaning objects of any kind on the patient's extremities.[35,36]

The safe maximal time for patients in the lithotomy position is unknown, but compartment syndrome has been reported after 6 1/2 hours in this position.[9-10] When IPCDs are used for DVT prophylaxis, modification of surgical positioning is a viable alternative. A leg suspension system may be used during prolonged procedures in the lithotomy position. This prevents unnecessary pressure on any portion of the lower extremity. The legs may be placed on skis and abducted. Avoidance of the lithotomy position altogether may be recommended for prolonged surgery to avoid lower extremity complications.[9]

If surgery is to be performed in the lithotomy position using standard leg holders, other physical methods of DVT prophylaxis may be considered. This include CPM devices, surgical or thromboembolism-deterrent stockings, and electric stimulation of the calf. Postoperative use of IPCDs may be resumed, since this method has been proven superior for DVT prophylaxis.'

COiNCLUSION

Intermittent pneumatic compression devices are the prophylaxis of choice for DVT prevention in patients undergo-

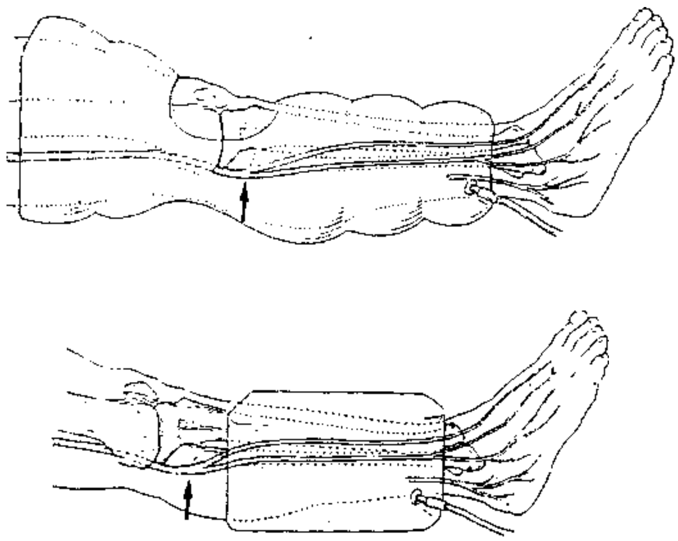

Fig 3—(upper) modified sequential pneumatic leg sleeve without compression over the fibular head (arrow); (lower) modified intermittent pneumatic leg sleeve, with uncovered fibular head (arrow).

ing high-risk surgery, including neurosurgery, orthopedic surgery, and thoracic, abdominal or pelvic surgery for malignancy. However, physicians may wish to use other methods of DVT prophylaxis in certain surgical patients. Patients with malignancy and weight loss are at risk of CRN palsy with IPCD use. Patients undergoing prolonged surgery in the lithotomy position may develop compartment syndrome with the use of pneumatic leg sleeves. In these cases, alternative methods of DVT prophylaxis are necessary. Physical methods such as modified pneumatic compression and CPM devices, passive ROM exercises, surgical stockings, and electric stimulation of the calf are viable alternatives. Careful positioning of the patient during surgery may avoid nerve compression and increased intracompartmen-tal pressures. Alternative surgical positioning may be necessary.

Acknowledgment: Our thanks, go to Ms. Pauline Thomas, medical illustrator. Comell University Medical College, for her illustrations.

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