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Acute Radial Nerve Injury from Use of an Automatic Blood Pressure Monitor

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Intraoperative monitoring of arterial blood pressure using automatic equipment is standard practice in patients who do not require an arterial catheter. We report a rare complication of this usually benign monitoring technique.

CASE REPORT

A 20-yr-old parturient (primigravida) had a lumbar epidural catheter inserted for administration of analgesic drugs during labor complicated by mild cephalopelvic disproportion with relatively slow progression of the second stage. Fifteen milliliters of 1% lidocaine was injected *via* the epidural catheter during the first stage of labor. As delivery approached the patient was transferred to a delivery room and preparations were made for forceps delivery or cesarean section. A pulse oximeter was attached to a finger of the left hand, electrocardiographic electrodes were placed, and a standard sized adult blood pressure cuff connected to a Dinamap™ Model 1846 SX was affixed to the patient's upper right arm. The Dinamap was set to cycle automatically every 3 min; 10 ml of 1% lidocaine and 7 ml of 3% chloroprocaine were injected *via* the epidural catheter to provide analgesia. The patient grasped the hand holds on the table to aid bearing down attempts, vigorously straining and moving her arms. The obstetrician decided that vacuum extraction was required.

During the period of bearing down (approximately 1 h) the blood pressure cuff was observed to inflate repeatedly in response to an apparent inability of the Dinamap™ to determine the patient's blood pressure. The "844" alarm was displayed on several occasions on the front panel of the Dinamap™, and measurement of blood pressure was then manually initiated. The patient complained several times of discomfort from the cuff, and blood pressure measurement intervals were extended to 5 min, then to 8 min. No objects (*e.g.*, poles or bed attachments) were positioned near the patient's right arm that could have produced a nerve compression injury.

One day after delivery the patient complained of numbness over the dorsum of the right hand, wrist drop, and "pain from that cuff" over the lower lateral aspect of the upper right arm. Examination revealed 0/5 power of the wrist and finger extensor muscles, with reduced sensation in the radial aspect of the dorsum of the hand. The triceps and brachioradialis retained full power, as did the flexors of the wrist and hand. Acute radial nerve palsy was diagnosed. The wrist drop and numbness improved by the following day, and the patient was discharged home 3 days after delivery with an active wrist splint for support. Follow-up attempts have failed to locate the patient.

DISCUSSION

The portion of the radial nerve that was injured in this patient was probably that lying over the lateral aspect of the humerus in the lower one-third portion of the arm, where the nerve courses from the posterior compartment to the anterior compartment of the arm immediately superior to the lateral epicondyle.[1] The motor fibers to the triceps and brachioradialis leave the radial nerve more proximally, and the superficial branch (containing sensory fibers from the hand) leaves the nerve as it crosses the lateral epicondyle. The nerve then follows a superficial

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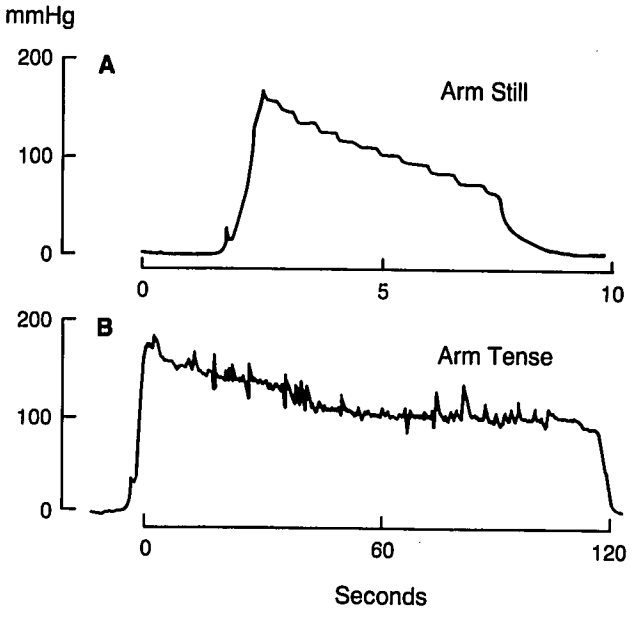

FIG. 1. Pressure tracings obtained from the blood pressure cuff during the inflation cycle of the Dinamap™ 1846 SX obtained with the arm at rest (*A*) and with the arm tense (*B*). Note that the maximum inflation time was 120 s. This resulted in the 844 Excess Determination Time alarm.

course. It was in this region that the distal edge of the pneumatic cuff was located and that the patient complained of residual pain on the day after delivery. Because this patient had thin arms (the patient weighed about 50 kg and was about 1.7 m tall), the radial nerve may have been relatively unprotected by subcutaneous fat.

We are unaware of previous reports of an injury to the radial nerve caused by a blood pressure cuff, although three cases of apparent ulnar nerve injury secondary to automatically cycled blood pressure cuffs were reported by Sy.[2] Most cases of acute radial nerve injury occurring intraoperatively are due to malposition of the arm on the operating table, with consequent stretching or compression of nerves. Subsequent ischemia of the vasa nervorum damages the nerve.[3]

To separate the probable causes in this case, we tested the Dinamap™ (Model 1846 SX Operation Manual; Critikon, Inc. Tampa, Florida) to determine whether any of its operating characteristics could have contributed to the nerve injury. First, we confirmed that the Dinamap™ was correctly calibrated and responded (as per specifications) by deflation when subjected to a pressure of 350 mmHg. We then tested whether the Dinamap™ correctly followed its inflation–deflation cycling algorithm under varying conditions of arm movement by continuously recording the pressure during the automatic determination mode (3-min intervals) in a standard adult sized blood pressure cuff applied to the upper left arm of a normotensive volunteer. The volunteer's resting blood pressure when sitting was 120/70 mmHg as determined *via* a standard mercury manometer and auscultation technique. With no arm movement, the volunteer's blood pressure at rest as determined by the Dinamap™ was 126/72 mmHg (fig. 1*A*).

Flexion and extension of the elbow at variable rates consistently sounded the Dinamap™ alarms, signifying excess cuff inflation times. These alarms included the "855" excess inflation time at any one pressure alarm, which sounded after 60 s of cuff inflation, and the "833" alarm, which sounds after an initial inflation time exceeding 40 s. When the volunteer grasped a fixed structure and alternately pulled and pushed while keeping the arm tensed (thereby simulating as closely as possible the type of movement artifact likely to have been present during labor), the "844" alarm sounded after 120 s (fig. 1*B*), indicating an excess determination time, usually caused by excessive patient movement and or an erratic pulse rate. Therefore, movement artifact can prolong inflation time at a given pressure, introducing the potential for nerve injury.

Nerve ischemia was not likely the principle cause of the patient's injury. With repeated failures to sense oscillations, the maximum time the Dinamap™ spends in any one determination cycle is 120 s, and the maximum inflation pressure reached is 250 mmHg. The maximum systolic pressure recorded during labor in this patient was 150 mmHg, making it unlikely that cuff inflation pressures of 250 mmHg were experienced. The total time during the delivery period in which the blood pressure cuff was used did not exceed 1 h.

Forty-five to 60 min of compression of 250 mmHg directly over a nerve are required to reversibly block nerve conduction in the segment directly beneath the nerve. Nerve conduction is slowed, but not completely blocked, in the nerve segment distal to the tourniquet, even after 3 h of compression at 250 mmHg.[4]

Mechanical forces are more likely to be the principal causes of nerve injury in this case. Differential pressures may be generated at the edge of the cuff and result in intussusception of the myelin sheath. This type of injury, proposed by Ochoa and Noordenbos,[5] has been verified by electron microscopy and may result in reversible deterioration of nerve conduction independent of the effects due to ischemia. We surmise that positioning the inflatable cuff close to the elbow exaggerated the mechanical effects of flexion and extension at the joint. The difficulty in obtaining blood pressures during active arm movements in this patient further increased the potential for injury to the radial nerve by necessitating more frequent determination attempts. This type of injury is not seen during

surgical procedures (*e.g.*, hand surgery), in which a pneumatic cuff is used and the arm is ischemic, because the elbow is immobile and there are no additional mechanical forces present. It seems likely, therefore, that our patient's injury was caused primarily by mechanical damage to the nerve.

In summary, we have described a case of radial nerve injury associated with the use of an automatically cycled blood pressure machine. This rare injury may have resulted from the mechanical effects of differential pressure exerted at the distal edge of the inflatable cuff. Locating the cuff higher on the arm, away from the elbow joint and the most superficial portion of the radial nerve, may prevent this type of injury. Caution should also be exercised in using automatically cycled blood pressure monitors on actively moving subjects because movement artifacts will result in longer inflation sequences and repeat cycles to obtain blood pressure measurements.

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