

they used a different solution or that our patient had better arterial flow.

It is also worth noting that when stopcocks are used proximal to intravenous and intraarterial catheters, the tubing attached to the stopcock-catheter assembly should be separated and properly identified before injection of any drugs.

The intraarterial injection of 2.5% thiopental is usually followed by severe pain immediately after injection, and the skin may become pale, with subsequent hyperemia and possible cyanosis. Hyperesthesia, anesthesia, paresis,

paralysis, and gangrene may occur.<sup>2</sup> In contrast, the accidental intraarterial injection of 1% propofol solution caused no complications other than severe pain in our patient.

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73:184-186, 1990

## Increased Venous Hemoglobin Saturation during Percutaneous Right Internal Jugular Vein Cannulation in a Patient with a Mature Right Forearm Arteriovenous Hemodialysis Fistula

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Since the early description of the percutaneous cannulation of the internal jugular vein in the late 1960s by English *et al.*,<sup>1</sup> the internal jugular vein has become the central vein of choice among anesthesiologists because of its constant anatomy, accessibility intraoperatively, and lower incidence of associated pneumothorax.<sup>2,3</sup> However, this venous access has been associated with many acute<sup>2</sup> and long-term complications,<sup>4,‡</sup> the most frequent of which is inadvertent puncture of the carotid artery.<sup>5</sup> Severe morbidity and mortality rates have been reported as a result of accidental arterial puncture or cannulation.<sup>6,7</sup> Recommendations for ruling out arterial puncture during needle localization of the internal jugular vein include observation of blood flow and color, manometry, and blood gas analysis.<sup>5,8,§</sup> We present a case in which results

of all but one of the commonly employed methods of detecting an arterial puncture during internal jugular vein cannulation were equivocal.

#### CASE REPORT

A 52-yr-old, 57-kg man with a history of end-stage renal disease requiring hemodialysis and aortic insufficiency was referred for replacement of his aortic valve. Preoperative physical examination was significant for a mature arteriovenous fistula for hemodialysis on the right forearm. Hemoglobin was 9.4 g/dl, and an arterial blood gas obtained while the patient was breathing room air revealed pH 7.41, P<sub>CO<sub>2</sub></sub> 34 mmHg, and P<sub>O<sub>2</sub></sub> 106 mmHg. The patient was taken to the operating suite where electrocardiographic electrodes and pulse oximeter probe were applied. Arterial blood pressure was monitored from a left radial artery catheter. In preparation for inserting a pulmonary artery catheter, cannulation of the right internal jugular vein *via* the medial approach<sup>1</sup> was initiated while the patient breathed 100% oxygen *via* mask. Using the Seldinger technique an 18-G catheter was passed over a spring wire previously inserted through an 18-G thin-wall needle, and the wire was removed. In addition to the lack of pulsatile flow and bright color, manometry using an intravenous (iv) extension tubing demonstrated a 1.5 cm high column of dark non-pulsatile blood with respiratory variation. The extension tubing was replaced with the spring wire, and the 18-G catheter was removed.

For additional venous access, insertion of a second central venous catheter into the same jugular vein using the Seldinger technique was performed through a more caudal skin insertion. Manometry demonstrated sluggish blood return without respiratory variation, and blood aspirated through the catheter appeared brighter red than the blood obtained from the thin-wall needle during insertion of the guide wire. A blood gas analysis yielded pH 7.35, P<sub>CO<sub>2</sub></sub> 44 mmHg, P<sub>O<sub>2</sub></sub> 94 mmHg, and 96.7% calculated saturation. Simultaneously drawn blood from the indwelling radial artery catheter yielded pH 7.38, P<sub>CO<sub>2</sub></sub> 39 mmHg, P<sub>O<sub>2</sub></sub> 511 mmHg, and 99.9% saturation. Analysis of blood aspirated from the initial, more cephalad catheter site revealed pH 7.32, P<sub>CO<sub>2</sub></sub> 51 mmHg, P<sub>O<sub>2</sub></sub> 41 mmHg, and 70.9% saturation. After insertion of

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Received from the Department of Anesthesiology, Section of Cardiothoracic Anesthesia, Washington University School of Medicine, St. Louis, Missouri. Accepted for publication February 21, 1990.

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Key words: Anesthesia: cardiac. Anesthetic techniques: internal jugular vein cannulation. Arteriovenous fistula. Hemoglobin: saturation. Vein: internal jugular.

‡ Robinson R, Errett L: Arteriovenous fistula following percutaneous internal jugular vein cannulation: A report of carotid artery-to-internal jugular vein fistula. *Journal of Cardiothoracic Anesthesia* 2:488-491, 1988.

§ McGoon MD, Benedetto PW, Green BM: Complications of percutaneous central venous catheterization: A report of two cases and review of the literature. *Johns Hopkins Medical Journal* 145:1-6, 1979.

an 8.5-Fr sheath-dilator unit over one wire, a pulmonary artery catheter was easily floated to wedge position; a 6-in., 14-G catheter was inserted over the second wire. The proximal part of the pulmonary artery catheter and the 14-G catheter both revealed a normal central venous pressure waveform when transduced. A postoperative chest x-ray revealed the tip of the pulmonary artery catheter in the right pulmonary artery and the 14-G catheter at the junction of the superior vena cava and the right atrium.

## DISCUSSION

Percutaneous cannulation of the internal jugular vein is common practice in the management of critically ill patients and of surgical patients undergoing open heart procedures. Although it is generally regarded as a safe procedure, a complication rate of 2–13% has been reported.<sup>9–11</sup> By far the most common complication is inadvertent puncture of the carotid artery with a resultant hematoma.<sup>3</sup> Simple compression has been reported to provide adequate hemostasis.<sup>11,12</sup> However, systemic heparinization prior to cardiopulmonary bypass can result in serious complications.<sup>7</sup> No mortality has been attributed to a carotid artery puncture from a 21-G seeker needle; fatalities have been reported when a sheath-dilator was inserted into the carotid artery.<sup>5,6</sup> The importance of confirming a venous puncture *versus* an accidental arterial puncture prior to cannulation with a large bore catheter or a sheath-dilator cannot be overemphasized. Jobses *et al.*<sup>5</sup> suggested guidelines for detecting arterial puncture, which included blood flow and color criteria and transducing the pressure within the catheter. In our patient with a peripheral arteriovenous fistula for hemodialysis, the placement of the cephalad cannula was thought to be venous on the basis of dark appearing blood, which was nonpulsatile and had a low manometry reading in the iv extension tubing. However, insertion of the second cannula caudad raised a suspicion of an arterial puncture when blood return was constant, with a color appearing brighter red than venous blood. Manometry was not helpful because of sluggish siphoning. When accidental arterial catheterization is suspected, verification by observing the pressure and waveform tracings may result in correct identification.<sup>5</sup> However, in the case of a kinked catheter or a catheter with the tip adjacent to the vessel wall, the pressure and waveform data may be difficult to interpret. Due to the sluggish blood flow attained with iv tubing manometry, we elected not to connect a pressure transducer. Blood aspirated from the more caudad of our two catheters had a  $P_{O_2}$  of 94 mmHg (96.7% saturation), whereas that from the more cephalad catheter had a  $P_{O_2}$  of 41 mmHg (70.9% saturation), suggesting a possible arterial puncture; the hemoglobin saturation of the right internal jugular vein has been reported to range from 42% to 72%<sup>13</sup> with only minimal increases in the jugular venous oxygen content when breathing 85–100% oxy-

gen.<sup>14</sup> The most plausible explanation would be that the tip of the caudad catheter sampled partially arterialized blood in the superior vena cava from the peripheral arteriovenous fistula returning *via* the right brachiocephalic vein. Blood flow across a mature hemodialysis arteriovenous fistula may contribute up to 28% of the resting cardiac output.<sup>15</sup> The diagnosis of a peripheral arteriovenous fistula can be made by noting a higher  $Sv_{O_2}$  in the involved limb than that of the contralateral limb.<sup>16</sup> The  $P_{O_2}$  of 41 mmHg (70.9% saturation) from the first cephalad catheter may be accounted for by the more proximal position of the catheter tip in the right internal jugular vein, proximal to the junction of the right brachiocephalic vein. Only after comparing the  $P_{O_2}$  of the blood from the caudad catheter with that from the radial artery did we feel secure in believing the catheter was indeed in the central venous system.

In summary, this case demonstrates that percutaneous internal jugular vein cannulation in a patient with a peripheral arteriovenous fistula for hemodialysis cannot be verified by simple assessment of color or by  $P_{O_2}$  determination of the blood without simultaneous comparison of the blood with an arterial sample. Comparison of blood gases may also be a useful method to confirm cannulation in situations in which pressure and waveform data are inconclusive or unavailable. It may be assumed that any condition involving a central (*e.g.*, atrial septal defect) or peripheral (*e.g.*, hemodialysis fistula, sepsis, or Paget's disease) arteriovenous shunt may render routine methods of verification inaccurate or difficult to interpret.

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Anesthesiology  
73:186-188, 1990

## 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.<sup>1</sup> 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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Received from the Department of Anesthesia, University of California, San Francisco, and San Francisco General Hospital. Accepted for publication February 26, 1990.

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Key words: Complications: nerve palsy. Monitoring: noninvasive blood pressure monitors.