The Axillary Vein: An Alternative Approach for Percutaneous Pulmonary Artery Catheterization*

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The axillary vein route was investigated prospectively for percutaneous pulmonary artery catheterization in 79 patients who underwent 83 attempts. Forty-nine of these patients were tracheostomized and under mechanical ventilation and eight had hemostasis disorders. Successful catheterization was achieved 74 times in the 79 patients. Pulmonary artery was reached within 6 ± 2.1 min after the catheter was set in place in the axillary vein. Less than 1 min was needed in 53 cases. Puncture of the axillary artery was noted in 11 patients without complication. No other significant complication was noted following the punctures. Mean duration of catheterizations was 3.6 ± 2 days. No septicemia was related to the catheterization procedure. One thrombosis of the axillary vein was noted. Catheterization of the pulmonary artery via the axillary vein is safe, simple and reliable and can represent an alternative method should the use of other routes be unsuccessful.

Catheterization of the pulmonary artery (PA) with a flow-directed, balloon-tipped catheter is a common procedure before anesthesia for patients with cardiac disease who undergo major surgery, or for patients under intensive care.1-3 Successful placement of the catheter requires reliable and safe entry into the intrathoracic circulation. The vessels usually selected include veins of the arm,4-6 external jugular veins (EJV),6,6 internal jugular veins (IJV),6,6,7-10 subclavian veins (SCV),6,11 and femoral veins.5,12 Some difficulties can arise with each of these routes. The arm veins are often in poor condition after several days of treatment in the intensive care unit (ICU). Catheterization of the PA via the femoral vein can be difficult without the help of fluoroscopic guidance,13 a technique which is not always available at patient's bedside in the ICU. Cannulation of the IJV or SCV is associated with a number of minor and some more serious complications including arterial puncture and pneumothorax.13,14 Entry into the intrathoracic circulation via the axillary vein (AV) is an alternative method.15-17 Clinical practice for several years supports the impression that PA catheterization via the axillary vein is safe, reliable and simple.18 In this study, the feasibility of PA catheterization using the axillary vein approach was investigated prospectively in unanesthetized patients and in patients under mechanical ventilation for treatment of adult respiratory distress syndrome (ARDS).

MATERIAL AND METHODS

Seventy-nine patients, 18 women and 61 men ranging in age from 18 to 75 years, were included in the study. They underwent 83 cannulations of the axillary vein and were carefully followed up in a prospective manner during a 17-month period. Informed consent was obtained from the 34 patients with angina who were scheduled for elective surgical procedures.

There were ten women and 24 men ranging in age from 42 to 75 years, mean age 62 ± 2 years (mean ± SEM). Twenty-seven of these patients underwent abdominal aortic aneurysmectomy. The other seven patients underwent hepatic resection for malignant tumors. All patients were catheterized in the operating room. Catheterization of the PA was also performed in 45 patients with ARDS. Eight women and 37 men ranging in age from 18 to 67 years, mean age 50 ± 3 years). For these sedated patients, informed consent was obtained from the family. All patients were tracheostomized and under controlled mechanical ventilation with positive end-expiratory pressure (PEEP) above 10 cmH2O. Ventilation with PEEP was used to treat hypoxemia following bacterial pneumonia in 23 patients, aspiration pneumonia in six, peritonitis in eight, fat embolism in five, and viral pneumonia in three. Eight patients had blood platelet counts below 70,000 mm3 and four patients below 20,000 mm3.

The axillary vein was cannulated following an original approach.18 The patient lay supine, the arm to be cannulated was abducted away from the patient side, and the hand placed behind the occiput. All catheters were set in place using sterile technique including masks, gowns, gloves and sterile draping. The axilla was shaved, cleansed with an iodine solution (Betadine) and towelled. The operator stood on the same side as the puncture site. The axillary artery was palpated and its course was noted (Fig 1). After a local anesthetic was injected into the skin and subcutaneous tissues, the axillary vein was cannulated initially with a 20-gauge, 51 mm (2 inch) needle. The needle was inserted high in the axilla at an angle of 30° to the skin parallel to the course of the artery, toward the chest wall and 1 cm medial to the artery (Fig 1). Puncture of the axillary vein was realized higher in the axilla than with Spracklen's method.19 After the needle was inserted into the vein, a 40-cm long, 0.64-mm (0.025 inch) diameter straight guide wire was threaded with subsequent 8.0-French dilator/sheath unit (Desilet, Vygon Laboratories) guided over the wire, and 7.0-French PA catheter (93A-1317 F, Edwards Laboratories) inserted into the sheath. Fluoroscopic guidance was never used in this study. Once the tip of the PA catheter was set in the superior vena cava, the balloon was inflated with 1.2 ml of air and

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The Axillary Vein Approach for Pulmonary Artery Catheterization (Martin et al)
pushed while the vascular pressure and the ECG were carefully monitored.\textsuperscript{15} Once the wedge pressure was obtained, the balloon was deflated. Before the PA catheter was secured to the skin with a suture, the arm was stretched out and put at an angle of 30\(^\circ\) with the thorax. The pressure tracing was then carefully observed. If wedge pressure appeared with an inflation volume of less than 1 ml, the balloon was deflated and the catheter withdrawn centrally. With this technique we ensured that the catheter tip was located as centrally as possible. Daily chest x-ray films were reviewed to check the position of the catheter tip.

During placement of the PA catheters, careful monitoring of the oscilloscope tracing was completed for signs of myocardial ischemia (angina or depression of ST-segment on the ECG of 1 mm or greater), premature ventricular contractions (PVCs), runs of ventricular tachycardia (three or more successive PVCs) or any other arrhythmia. Following catheter placement, puncture sites were cleansed with Betadine solution; then a sterile gauze impregnated with Betadine was applied to the site. Finally, the catheter and sterile gauze were covered with a sterile occlusive dressing. An adhesive, transparent, semipermeable film was used (Op-Site, Smith and Nephew, Inc.). The 10-cm segment of catheter extending from the puncture site was coiled within the dressing. Sterile dressing changes were carried out every day, using the same technique. Stopcocks and tubing were changed daily, using sterile technique. These procedures were eventually performed several times a day if dressings were soiled or unstuck. Patients were visited every day and puncture sites were inspected for hematoma and evidence of infection (redness, swelling, heat). Cultures of the catheters were obtained only when catheter-related infection, and catheter-related bacteremia were suspected, or when puncture sites became infected. Catheter-related infection was defined as follows: temperatures $\geq 38.5\textdegree C$, white blood cell count $\geq 12,500$/mm$^3$, no other apparent source of infection. Catheter related bacteremia was defined as follows: species from catheter tip culture and from separate blood culture obtained by venipuncture identical, no other source of bacteremia, temperature $\geq 38.5\textdegree C$, white blood cell count $\geq 12,500$/mm$^3$. In all patients, blood cultures were obtained when body temperature was $\geq 38.5\textdegree C$. Body temperature was checked every four hours. The catheters were aseptically removed by intensive care nurses. The insertion site was cleaned with an iodine solution and the distal 3 cm of the catheter cut off with a scalpel blade. In the laboratory, catheter segment was transferred from a transport tube (Culturette, Marion Corp) onto the surface of blood agar plates. Growth of 15 or more colonies on a semiquan-

titative plate was regarded as positive, indicating catheter infection. In the other patients, when no catheter-related infection or bacteremia were suspected, the cultures of catheter tip were not obtained.

**RESULTS**

Axillary vein catheterization for placement of a PA catheter was attempted 83 times in the 79 patients. A total of 74 catheterizations were successful (89.2 percent). The right axillary vein was utilized 36 times and the left axillary vein 47 times. In six cases (7.2 percent), the operator failed to catheterize either axillary vein and in three cases (3.6 percent) the guide wire could not be successfully introduced into the vein. Therefore, of the 74 cases in whom the PA catheter could be introduced into the axillary vein, 74 (100 percent) underwent successful PA catheterization. This required less than three punctures in 53 cases (64 percent). The time necessary to perform the cannulations was 13 ± 2 min (range: 25 sec to 45 min). The time required to reach PA was 6 ± 2.1 min after the tip of the catheter was inserted into the vein. In 53 cases (64 percent) the PA was reached within 1 min or less. The entire PA catheterization procedure was 18 ± 3 min in the 74 cases; in whom PA was catheterized successfully. In five cases (6 percent) ventricular extrasystoles were observed, but none of the patients exhibited ventricular tachycardia. No patient experienced angina or ECG changes. Arterial punctures occurred 11 times (13 percent) and large hematomas were always avoided by prolonged pressure (3 min or more) very easily achieved because of the superficial position of the axillary artery. No other complication was noted. The catheters were in place for 2.1 ± 1.5 days in patients undergoing surgery and for 4.6 ± 1.5 days in patients with ARDS. No septicemia or bacteremia was related to the PA catheterization. In the ARDS group, five cases of catheter-related infection were suspected.
Catheters were withdrawn and cultures of the tips showed *Staphylococcus aureus* in three cases, *Proteus mirabilis* in one case, and *Pseudomonas maltophilia* in one case. Blood cultures obtained from these patients did not grow any organism. One thrombosis (1.2 percent) of the axillary and subclavian vein was clinically diagnosed and successfully treated with heparin. No late neurologic sequel and no damage of the axillary plexus were noted.

**DISCUSSION**

Placement of a PA catheter requires entry into the intrathoracic circulation. The central vessels can be reached percutaneously from several sites. Catheterization of the deeper venous route (IJV or SCV) is associated with serious complications such as arterial puncture, pneumomediastinum or accidental entry of the PA catheter into the mediastinum. An approach via the antecubital vein is safer, but catheterization of this vein is often impossible in patients after several days of hospitalization, especially in the ICU. Puncture of the EJV is also simple and safe, but the vein is not present in all patients. Catheterization of the AV can be an alternative method.

In this study, PA catheterization was achieved in 89.2 percent of attempts. This success rate is lower than with the IVJ which is the vessel most often selected for entry into the intrathoracic circulation. Cannulation of the AV is proposed as an alternative route for PA catheterization and must be compared with other alternative routes. The 89.2 percent success rate of AV compared favorably with the 77 percent success rate reported for EJV by Schwartz et al., with 48 percent of the patients catheterized after two or less cannulation attempts. This 89.2 percent success rate of AV also compared favorably with the 75 percent reported for PA catheterization with the antecubital vein. The time of catheter insertion via the AV seems acceptable. Cannulation of the AV is performed within a few minutes and needs less than three cannulation attempts in 64 percent. In a few cases, more time was needed for AV cannulation. This was related in most cases to procedures performed by residents during their first year of training. As with other vein routes, procedures performed with more skilled and experienced operators are considerably more rapid. Malposition of the arm can lead to some difficulties in AV cannulation. Should this occur, it is of great importance to place the hand correctly behind the occiput before a new puncture is attempted. There are no controlled studies to compare the time required to achieve the entire procedure of PA catheterization via AV and other routes. However, this time averages 15 min using IJV and 21 min using basilic vein. In this study, the time needed was 18 ± 3 min, which is acceptable. Arterial puncture occurred at a similar frequency as during IJV puncture.

No complication was noted following these arterial punctures. They were all easily treated with finger pressure enhanced by the superficial position of the artery. No pneumomediastinum followed the PA catheterization. The risk of neurologic sequel after puncture of the nerves of the arm or forearm seems more theoretic than real. No complication of that kind was noted. This is confirmed by Spracklen et al and by a study based on over 300 cannulations over several years.

A low incidence of ventricular dysrhythmias was observed in this study (6 percent). Frequency of this complication is highly variable, ranging from 72 percent to 10 percent. In our study, cardiac monitoring was done using oscilloscope tracing and not paper recording. Should the latter technique be used, the incidence of dysrhythmias could have been higher. In six cases, chest x-rays obtained daily allowed diagnosis of spontaneous inward migration of the catheter which was withdrawn to a proper position. No kinking in the AV was noted. One thrombosis of the AV was diagnosed. In this study, only clinical signs were used to investigate this complication and we cannot exclude that routine use of phlebography might have shown a greater incidence of thrombosis of the AV.

Catheter-related sepsis can cause serious nosocomial infections. No case of catheter-induced bactemia was noted in our patients (all of them had blood cultures drawn when body temperature was ≥38.5°C). Catheter-related infection was suspected in five cases (6 percent). Resolution of the infection was obtained in all cases after catheter removal. Catheter tip cultures were not obtained in all the patients, but only when clinical features were consistent with local or general catheter-related sepsis. For this reason, we cannot exclude that positive-catheter cultures (growth on the blood agar), without local or general infection, might have been present in some of our patients. This incidence of catheter-related sepsis was comparable in a previous study of more than 300 AV cannulations where septicemia occurred in 2.7 percent of the patients. These patients were at risk of catheter-related infection since most of them were tracheostomized and average duration of catheterization was 18.6 days.

As a practical point, the administration of medications through a distal vein in the catheterized arm should be discouraged. This study does not provide controlled data about this point, but venous stagnation might occur following AV cannulation and cause elevated drug concentrations and tissue slough.

It is concluded that PA catheterization is performed easily, reliably and relatively free from complications via the AV. This technique represents an alternative method of PA catheterization which may have merit in certain patients in case of inability to use the other sites.
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