Can Femoral Artery Pressure Monitoring Be Used Routinely in Cardiac Surgery?

Fadia Haddad, MD,* Carine Zeeni, MD,* Issam El Rassi, MD,† Alexandre Yazigi, MD,* Samia Madi-Jebara, MD,* Gemma Hayeck, MD,* Victor Jебara, MD,† and Patricia Yazbeck, MD*

Objective: The purpose of this study was to evaluate the safety of femoral arterial pressure monitoring in cardiac surgery.

Design: Prospective, observational study.

Setting: Cardiac surgery unit (CSU) in a university hospital.

Participants: Of a total of 2,350 consecutive patients scheduled for elective cardiac surgery with cardiopulmonary bypass, 2,264 patients with femoral artery pressure monitoring were included.

Interventions: A femoral arterial catheter was inserted percutaneously before the induction of anesthesia. The catheter was withdrawn 40 to 96 hours after surgery. It was replaced by a radial artery catheter in patients staying for more than 4 days in the CSU or in case of pulse loss or lower limb ischemia. The catheter was removed and sent for cultures whenever it showed local changes, discharge, or if sepsis was suspected.

Measurements and Main Results: Pain on insertion ranged from 0 to 20 mm on the 100-mm visual analog scale. Complications related to femoral artery cannulation were recorded. No cases of femoral artery thrombosis, lower extremity ischemia, or hematoma requiring surgery were noted. Small hematomas were observed in 3.3% of patients. The incidence of oozing was 2.1% after the insertion of the catheter and 4.9% after its removal. Three cases (0.13%) of serious bleeding occurred; 2 required surgery. Eight percent of catheter tips were sent for culture, and positive bacterial growth was recorded in 18.6% of them. Catheter-related bloodstream infection occurred in 0.5% of the total patient population included.

Conclusions: Femoral artery pressure monitoring was associated with a low complication rate and, therefore, it can be used routinely in cardiac surgery.

© 2008 Elsevier Inc. All rights reserved.

KEY WORDS: intensive care, arterial catheter, femoral artery catheter, arterial catheter complication, arterial pressure gradient, cardiac surgery, radial artery catheter

METHODS

Between January 2002 and June 2006, 2,350 patients were scheduled for elective cardiac surgery with CPB. Two thousand two hundred sixty-four patients were included in this prospective study. The exclusion criteria for femoral artery catheterization were severe atherosclerotic disease of the abdominal aorta, severe iliolumbar arterial stenoses, peripheral lower limb arterial disease diagnosed before surgery, the possible need of the femoral artery for arterial surgical cannulation or for insertion of an intra-aortic balloon, skin infection or ulceration of the site of puncture, and technical difficulties or failure to catheterize the femoral artery. In these excluded patients, radial or brachial arterial catheters were inserted; they were not considered as a failure group because the study design focused on the complications of successfully inserted femoral arterial catheters. In all patients included in the study, the management of invasive monitoring devices and anesthetic management were performed according to institutional protocols. This study was approved by the local institutional review board, and signed informed consent was obtained preoperatively from all patients. All relevant medical data were recorded by the senior anesthesiologists or the anesthesiology residents.

Before the induction of anesthesia, a 5F (16-G) polyurethane, noncoated arterial catheter (Plastimed, Seldicath, France: length: 11 cm for males, 8 cm for females) was inserted percutaneously in the femoral artery under local anesthesia and light sedation. Before puncture, explanation and psychological preparation were performed by the anesthesiologist and 1 to 2 mg of intravenous midazolam was administered with electrocardiographic monitoring, pulse oximetry, and supplemental oxygen. Insertion site preparation was conducted following the guidelines for the prevention of intravascular catheter-related infections of the Centers for Disease Control and Prevention (CDC). Good hand hygiene was achieved through the use of an antibacterial soap with adequate rinsing, followed by the use of sterile gloves. The skin was prepped with povidone iodine that was allowed to air dry before catheter insertion. Sterile drapes were applied around the groin to isolate the prepped area. The skin and subcutaneous tissues were infiltrated with 6 to 8 mL of 1% lidocaine, using a 22-G needle. The catheter was inserted using Seldinger’s technique and fixed to the skin. Arterial pressure catheters were transduced (Medex Medical Ltd, Haslingden, UK) and connected to a component monitoring system.
Patients were admitted to the authors' institution for cardiac surgery with CPB, including coronary artery bypass grafting, valvular heart replacement or repair, and congenital heart disease palliation or repair in adults. Using the exclusion criteria for femoral arterial catheterization cited earlier, 32 patients were directly excluded (1.3% of all cardiac surgical patients). Fifty-four of the remaining 2,318 patients (2.3%) were also excluded because of failure to puncture the femoral artery (16 patients) or because of catheterization failure (38 patients). In total, 2,264 patients (96.3%) were included in the study.

Femoral artery cannulation was technically easy in 2,104 patients (92.9%). Arterial puncture was difficult in 42 patients (1.9%), and its catheterization was difficult in 118 patients (5.2%). More than 1 puncture was necessary in 421 patients (18.6%). Most femoral arterial catheters (96.5%) were inserted by anesthesia residents and 3.5% by senior anesthesiologists. The senior anesthesiologist took over from the resident when the cannulation became difficult (ie, after 2 attempts at puncture or at catheterization).

Pain intensity, evaluated after insertion of the arterial catheter in the operating room, ranged from 0 to 20 mm on the 100-mm visual analog scale, with a mean pain intensity of 0.84 ± 0.88. Demographic and clinical characteristics are summarized in Table 1.

There were no cases of femoral artery thrombosis or ischemia of the lower limb, and no cases of hematoma requiring surgical intervention (Table 2). Small uncomplicated hematomas were observed in 76 patients (3.3%) during the insertion of the catheter, whereas withdrawal of the catheter did not result in any hematoma requiring intervention. Resorption of the hematomas was spontaneous without any complication or infection. Oozing was observed after the insertion of the catheter in the operating room in 48 patients (2.1%) and after its removal in the CSU in 112 patients (4.9%), requiring in all instances local manual compression for more than 10 minutes (range, 12.25 minutes). Three cases (0.13%) of serious bleeding occurred: 1 case in the operating room after insertion of the catheter, leading to its removal and manual compression, and 2 cases after catheter removal in the CSU, leading to surgical intervention for hemothrosis. There were no cases of pseudoaneurysms or arteriovenous fistulas in the present series. Surprisingly, and despite their large diameter (16-G), 24 femoral

### Table 1. Demographic and Clinical Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, range (y)</td>
<td>18-83</td>
</tr>
<tr>
<td>Age, mean ± SD (y)</td>
<td>54.3 ± 16.2</td>
</tr>
<tr>
<td>Sex, male/female (%)</td>
<td>58/42</td>
</tr>
<tr>
<td>Weight ± SD (Kg)</td>
<td>78.2 ± 25.6</td>
</tr>
<tr>
<td>Body surface area ± SD (m²)</td>
<td>1.8 ± 0.4</td>
</tr>
<tr>
<td>CPB time ± SD (min)</td>
<td>115.8 ± 38.5</td>
</tr>
<tr>
<td>Time of surgery ± SD (min)</td>
<td>245.2 ± 95.4</td>
</tr>
<tr>
<td>Length of catheter stay (h)</td>
<td>46.3 ± 6.4</td>
</tr>
</tbody>
</table>

Abbreviation: SD: standard deviation.

(Hellige SMU 612, Freiburg, Germany). Heparinized normal saline was used to maintain catheter patency. The site of insertion was dressed with a transparent, polyurethane dressing (3M Tegaderm; 3M Health Care, Neuss, Germany) permitting continuous visual inspection of the catheter site. If blood was oozing from the catheter insertion site, a sterile gauze dressing was used. The dressing was replaced every day and several times a day if needed.

Pulse checks distal to the catheter were performed once daily and more frequently if any symptoms of vascular insufficiency appeared in the lower limb. When the pulse was not palpable, pulsed Doppler ultrasound was used for detecting ischemia. The arterial catheter was usually withdrawn 40 to 48 hours after surgery and before discharge of the patient from the cardiac surgery unit (CSU). The catheter tip was not sent for bacteriology if it was removed before 48 hours. However, at any time, in case of a serous or purulent discharge, local cutaneous changes, or overt or suspected sepsis of any origin, swabs were taken from the puncture site, and the catheter was systematically removed, sent for cultures, and replaced by a radial arterial catheter. The femoral arterial catheter was also systematically replaced by a radial arterial catheter in all patients staying for more than 4 days in the CSU or earlier in case of pulse loss or with any clinical sign of lower-limb ischemia. In these circumstances, the catheter tip was also sent for culture. After removal of the femoral arterial catheter, sustained external manual compression was performed by a registered nurse for at least 10 minutes to prevent hemorrhage and consequent hematoma. If bleeding persisted, more compression was applied. The catheterized extremity was immobilized for 30 minutes, and its use was discouraged for 1 hour.

Demographic data including age, sex, weight, body surface area, CPB time, surgical time, and length of catheter use were collected. The timing of the arterial catheter replacement was noted. Complications related to femoral arterial catheterization included the following: oozing requiring more than 10 minutes of compression, bleeding, hematoma (either self-contained or requiring surgical intervention), lower limb ischemia leading to thrombectomy or invasive vascular surgery, and infection. Infection related to the catheter included local skin changes; discharge; and positive growth of the same organism from the bloodstream, the puncture site, or the catheter tip.

The arterial cannulation was considered to be technically easy when the successful arterial puncture and/or catheterization required only 1 or 2 attempts. Puncture and catheterization were difficult when they required more than 2 attempts. Pain intensity was assessed by using a 100-mm visual analog scale after insertion of the arterial catheter in the operating room.

No statistical analysis was performed. Continuous variables were reported as means and standard deviations, and categoric variables were reported as percentages.

### RESULTS

During the 54 months selected for data analysis, 2,350 patients were admitted to the authors’ institution for cardiac

### Table 2. Complications of Femoral Arterial Catheter in the CSU

<table>
<thead>
<tr>
<th>Complications</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral artery thrombosis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ischemia of lower limb</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arteriovenous fistula</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hematoma requiring surgical intervention</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Small uncomplicated hematoma</td>
<td>76</td>
<td>3.3</td>
</tr>
<tr>
<td>Serious bleeding requiring manual compression only</td>
<td>1</td>
<td>0.04</td>
</tr>
<tr>
<td>Serious bleeding requiring surgical intervention</td>
<td>2</td>
<td>0.08</td>
</tr>
<tr>
<td>Oozing after insertion of the catheter</td>
<td>48</td>
<td>2.1</td>
</tr>
<tr>
<td>Oozing after removal of the catheter</td>
<td>112</td>
<td>4.9</td>
</tr>
<tr>
<td>Waveform distortion or difficulty to aspirate blood sample</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Catheter-related blood stream infection</td>
<td>12</td>
<td>0.5</td>
</tr>
</tbody>
</table>
arterial catheters (1%) were changed for either radial or contralateral femoral arterial catheters 1 hour to 4 days after their insertion because of waveform distortion or difficulty to aspirate blood samples.

In total, 182 catheter tips (8%) were sent for culture; catheter-related infection was defined according to CDC criteria. Positive bacterial growth was recorded in 34 of 182 (18.6%). Only 12 patients with a positive catheter tip culture had a positive blood culture for the same microorganism; hence, of the 2,264 patients, 12 (0.5%) had an infected femoral arterial catheter probably responsible for their sepsis. Ten of those 12 (83.3%) had the same catheter for more than 48 hours.

DISCUSSION

In cardiac surgery, a significant pressure gradient between the femoral and radial arteries occurs early during CPB and may persist up to 60 minutes after its completion. The monitoring of the arterial pressure may show a falsely low arterial blood pressure, which may lead to inappropriate hemodynamic management with the use of vasoconstrictor drugs. A large number of studies have confirmed the reliability of the femoral artery for monitoring of the arterial pressure during and after CPB. Forearm vascular resistance variations have been described for the existing femoral-to-radial pressure gradient by several authors, but the true mechanism remains unclear; many other factors may contribute to the occurrence of the pressure gradient, such as marked arterial-venous shunting in the hand, or some local thermoregulatory mechanism. A similar femoral-to-radial pressure gradient has also been observed in different situations such as hypothermic circulatory arrest or in critically ill surgical patients requiring high doses of vasoconstricting agents.

Sites other than the radial artery have been used for monitoring the arterial pressure in cardiac surgery including subclavian, axillary, femoral, and brachial arteries. Several studies found that subclavian, axillary, and brachial artery pressure monitoring were more accurate and reliable than monitoring the radial artery pressure.

This is the first prospective observational study evaluating the safety of femoral arterial pressure monitoring in patients undergoing cardiac surgery with CPB. The authors found only one retrospective study evaluating the incidence of radial artery infections after cardiac surgery. In the authors’ institution, radial arterial pressure monitoring had been the routine since 1993 for the 500 annual cardiac surgical patients. In 2002, the authors elected to switch to the routine use of femoral arterial pressure monitoring, unless there were specific contraindications to femoral artery catheterization. This decision was triggered by a literature review and the authors’ earlier prospective study confirming the presence of a significant systolic and mean gradients between the femoral and radial arteries during CPB.

The accuracy of the arterial waveform and blood pressure are not the only factors taken into account when choosing a cannulation and monitoring site. In the authors’ experience, femoral artery catheterization using Seldinger’s technique is easy and yields a cannulation success rate of 96.5% when the catheters are inserted by anesthesia residents. These findings concur with those of Frezza and Mezghebe and Thomas et al who concluded that femoral artery cannulation is by far the easiest technique, especially in older patients with calcified arteries or in unstable patients in shock.

Arterial monitoring catheters can cause various complications that depend mostly on the caliber of the catheter and its site of insertion. Minor or major bleeding can occur during the insertion or after the removal of the arterial catheter. In a study conducted in different ICUs using mainly radial and femoral arterial pressure monitoring, Frezza and Mezghebe found an oozing incidence of 1.5% in the medical ICU and 2.3% in surgical ones. In the authors’ study, oozing occurred in 5.4% of the patients; this higher incidence could be attributed to the heavily anticoagulated patients before surgery and during and after extracorporeal circulation. However, anticoagulation did not increase the incidence of serious bleeding, which occurred in 0.13% of the authors’ patients compared with 1.7% in Soderstrom et al’s study. Similarly, rates of hematoma formation did not seem to increase with anticoagulation; the authors’ previous study yielded an incidence of 3.3% compared with 3.7% for patients monitored continuously with femoral and axillary artery catheters. Hematomas have been reported in 0.2% and 0.3%, respectively, in medical and surgical ICU units. Furthermore, Soderstrom et al and Frezza and Mezghebe showed in their respective studies that the cannulation site, femoral or radial, did not influence the incidence of bleeding.

Other potentially serious vascular complications include partial or total thrombosis of the cannulated artery. These thromboses are closely linked to the diameter of the catheter, the diameter of the vessel, and the duration of cannulation. Martin et al reported a total occlusion in 19% of catheterized radial arteries, with partial occlusion reaching up to 76% when the catheter stayed in the artery for a mean of 13.3 ± 4 days. These radial artery thromboses were diagnosed by ultrasound and were clinically asymptomatic because of the presence of heavy collateral blood flow. However, ischemic changes may be noted; a series by Bedford showed a thrombosis rate of 38% for radial artery cannulation, with associated ischemic changes in 3.8% of the cases. Ischemia was completely reversible after removal of the catheter. In the largest study of radial artery catheters, Slogoff et al concluded that thrombosis risk was more than 25%, but the risk of severe ischemic complications was very low. Although tissue loss is rare with the use of the radial artery, it has been reported in the literature. A study of 157 brachial artery catheters revealed an immediate radial artery pulse loss in 39% of the cases, constituting the most frequent complication of brachial arterial catheters because of the absence of collateral blood flow. Other serious complications included lesions of the median nerve.

The large diameter and high blood flow of the femoral artery seem to protect it from these complications. In the authors’ experience, as well as that of Soderstrom et al, there were no thrombotic complications in catheterized femoral arteries. However, in Gurman and Kriemerman’s study with 50 cannulated femoral arteries in critically ill patients, one was complicated by a clinically significant mural thrombus. Lazarides et al studied iatrogenic femoral arterial injuries and concluded that the most common cause was catheterization for coronary or vascular angiography; these iatrogenic injuries resulted in
false aneurysm formation in the femoral artery and in arterial thrombosis in the brachial artery. These complications may be explained by the large diameter of the indwelling catheter.

Infectious complications remain the authors’ main concern. Catheters can be contaminated or may cause bacteremia or sepsis. Martin et al. reported 16% contamination and 2.9% infection in radial artery catheters used for more than 4 days. Radial and femoral arteries in medical and surgical ICU units were found to be infected in 0.4% to 0.7% of patients. 

In a comparative study of radial versus femoral arterial catheters inserted for more than 3 days, Soderstrom et al. reported an infection rate of 2.8% in radial arterial catheters and no infection in femoral arterial catheters. However, comparing femoral and radial arterial catheters, other studies found similar infection rates in both sites. In their study published in 2004, Lorente et al. found no differences between femoral and radial artery catheters concerning catheter-related local infection (CRLI) or blood stream infection (CRBSI) (incidence: 1.6% v. 0.4% and 0.1% v. 0.1%, respectively). In contrast, this same Spanish team conducted a much larger study on infection related to different arterial catheter sites and concluded that femoral artery catheterization was associated with significantly higher incidences of both CRLI and CRBSI compared with radial artery cannulation (number of infection per 1,000 catheter days: 3.02 v. 0.75 and 1.92 v. 0.25, respectively; odds ratio: 1.5 and 1.9, respectively). These results could be partly explained by the differences in local flora density between the sites. However, the most recent guidelines of the CDC do not provide any recommendations concerning a preferred arterial catheter insertion site and do not recommend the routine replacement of a radial arterial catheter to prevent infection.

The authors’ low CRBSI rate of 0.5% is probably because of the selected noninfected patients undergoing “clean” cardiac surgery. The early removal of the catheters and the well-trained staff probably contributed to these results. Similarly, in a retrospective study on radial artery infection after cardiac surgery, El-Hamamsy et al. found an incidence of 0.2% for CRLI and 0.15% for CRBSI. Puri et al. showed that gravely ill patients tend to present more catheter-related complications.

Despite the already established reliability of the femoral arterial pressure compared with the radial artery pressure during and after CPB and despite the safety of femoral arterial cannulation, the femoral artery is not yet commonly monitored in cardiac surgery. This could be related to some events that the authors did not experience. Percutaneous arterial femoral cannulation can be considered as a painful and psychologically traumatic technique in an awake patient. In the present study, 96.5% of the femoral arterial catheters were inserted by residents, and pain ranged from 0 to 20 mm on the 100-mm visual analog scale, confirming the efficacy of the authors’ multimodal analgesia protocol during puncture of the femoral artery in blunting the pain response. The present patients usually experienced little or no discomfort and remained fully cooperative.

This study has 2 limitations. First, the authors did not have a control group for comparative purposes; complications were reported only from femoral arterial catheters in cardiac surgery, without comparison between femoral and other sites used for arterial pressure monitoring. Second, the present results were compared with those in the literature that include patients from medical, surgical, and cardiac ICU units, with wide variations in patients, conditions, and management protocols. Based on the present results, the authors are currently designing a larger, controlled study, necessary to better elucidate the safety of femoral arterial catheters in the CSU.

In conclusion, the low complication rate for femoral artery catheterization and the reliability of the femoral artery pressure readings during and after CPB encourage the authors to continue to use it routinely for arterial pressure monitoring. The authors think that femoral artery pressure monitoring can be used in cardiac surgery when no vascular contraindications exist.

REFERENCES