

## The risk of infection related to radial vs femoral sites for arterial catheterization

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To evaluate risk factors for infections associated with indwelling arterial catheters, 186 catheters were randomly allocated for either femoral or radial insertion in 155 critically ill patients. Femoral catheters were easier to insert and it was easier to obtain blood specimens from them. Rates of local infection at the insertion sites and rates of positive catheter-tip cultures were similar for femoral and radial catheters. Evidence of local infection was not predictive of a positive catheter-tip culture. Percutaneously inserted femoral and radial artery catheters had a similarly low incidence of catheter-associated infections. There was only one catheter-related infection, and no cultured catheter was judged the cause of bacteremia. Routine prophylactic replacement of arterial catheter systems may be unnecessary in critical care units where rates of arterial catheter-associated infections are low.

The long-term indwelling arterial catheter is frequently used for hemodynamic monitoring and to obtain blood samples in critically ill patients. However, arterial catheter systems have been cited as a source of nosocomial infection.<sup>1-4</sup> To reduce the risk of life-threatening nosocomial septicemia from these devices, recommendations regarding their indications, use, and maintenance have been suggested.<sup>5-8</sup> Still, although the radial and femoral arteries are the most frequently selected sites for arterial catheterization, there are currently no guidelines that relate site selection to the prevention of catheter-associated infection. The advantages of the femoral artery for catheter placement include the ease of catheter placement, usefulness in obtaining blood specimens, and a low incidence of thromboembolism.<sup>9-11</sup> However, this site is frequently avoided because of the increased possibility of bacterial contamination from the perineal area.<sup>12</sup> To determine if the arterial puncture site influences the incidence of infectious complications associated with the use of ar-

terial catheters, we prospectively randomized the insertion of arterial catheters into either the radial or femoral artery.

### SUBJECTS AND METHODS

#### *Study Design*

From June 1981 to March 1982, all critically ill patients who were admitted to the LDS Hospital Shock and Trauma Unit and required an indwelling arterial catheter were considered for this study. Patients who lacked an available femoral and radial site were excluded. Suitable patients received by random allocation either a radial or a femoral artery catheter. The sample size of this study was based on a previously reported 35% difference in positive-culture rates between radial (15%) and femoral (50%) catheter tips.<sup>5</sup> Given this 35% difference, a sample size of approximately 70 catheters per group was required to detect a statistical difference at the 1% level with a 95% confidence level.

During this study, patients were assigned to femoral or radial groups according to the next-to-last digit of their computer-assigned patient number: even digits assigned the catheter to the radial site, and odd digits corresponded to femoral placement. The last digit of the computer-assigned patient number is a nonrandom number and, therefore, could not be used to randomly assign the sites of catheter placement. Any subsequent catheter insertions on the same patient were randomized by the next higher-order digit appearing anywhere in the patient's hospital number.

Specialized technicians inserted all radial artery catheters using a percutaneous technique.<sup>13</sup> A Teflon radial catheter (1-mm outside diameter, 0.45-mm lumen diameter) was inserted through an 18-gauge thin-wall needle and advanced 40 to 50 cm from the insertion site to the level of the axillary artery. House officers placed all femoral arterial catheters using the Seldinger technique.<sup>14</sup> A polyethylene femoral catheter (1.78-mm outside diameter, 1-mm lumen) was inserted percutaneously over a guidewire and advanced 20 to 25 cm from the insertion site to the level of the aortic bifurcation. All radial catheters were secured by tape and all femoral catheters were secured by suture and tape. A povidone-iodine ointment was applied to the site of insertion, and an elastic pressure dressing was used to control bleeding. Both radial and femoral artery cath-

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ters were then connected to identical transducer and continuous flush systems.<sup>13</sup> Component (catheters, flush solutions, tubing, flush devices, and transducers) changes were made only in the case of equipment dysfunction or to replenish the flush solution.

During daily dressing changes, specialized technicians inspected all catheter insertion sites for evidence of local infection characterized by redness, pus, or pain. Throughout the duration of arterial catheterization, records were made of patients' temperatures, peripheral white blood cell (WBC) counts, results of bacterial and fungal cultures and daily blood tests, antibiotic administration, and the volume and frequency of blood withdrawn daily through the catheter.

At the time of catheter removal, physicians were asked to indicate whether the catheter was discontinued because of catheter malfunction, excess bleeding at the insertion site, suspected catheter infection, patient improvement, patient death, or other reason. In this ICU, catheters are also removed when the patient continues to show evidence of sepsis despite appropriate treatment of identified infection, or when the source of sepsis is not identified.

#### Microbiologic Aspects

The arterial catheter was removed by specialized technicians and intensive care nurses. Before removal of the arterial catheter, the protective dressing was removed, the insertion site was cleaned with a sterile povidone-iodine scrub, and the site was wiped dry with a sterile gauze pad. The catheter was then removed aseptically.

The distal 2 to 3 cm of the catheter was cut off with sterile scissors or an 11 scalpel blade and placed into a sterile test tube containing 2.5 ml of tryptose-phosphate broth. In the laboratory, the arterial catheter tip was vortexed within the tryptose-phosphate broth. A 0.01-ml aliquot, obtained by a calibrated loop, was used to streak a blood agar plate for a quantitative culture. Ten ml of thioglycollate broth were then added to the tryptose-phosphate test tube containing the arterial catheter tip. The blood agar and the broth culture were incubated at 37°C and evaluated for bacterial and fungal growth during the next 7 days. All blood cultures were obtained by separate venipuncture when clinically indicated. All isolates were identified by standard bacteriologic methods.

#### Definitions

**Positive-catheter culture:** Any growth on the blood agar or in the broth

**Catheter-related infection** (all of the following):

1. Clinical features consistent with infection characterized by *either* of the following in any of the 3 days preceding the removal of the catheter:
  - a. temperature  $\geq 38.5^\circ\text{C}$
  - b. WBC  $\geq 12,500/\text{mm}^3$

2. No other apparent source of infection
3. Within 3 days after the catheter removal, resolution of the clinical features of infection characterized by *both* of the following:
  - a. highest daily temperature  $< 38.5^\circ\text{C}$
  - b. WBC  $< 12,500/\text{mm}^3$  or a 25% reduction of the WBC since catheter removal

**Catheter-induced bacteremia** (all of the following):

1. Species from catheter tip culture and from a separate blood culture obtained by venipuncture were identical
2. No other apparent source of bacteremia or fungemia
3. Clinical features consistent with infection characterized by *either* of the following:
  - a. temperature  $\geq 38.5^\circ\text{C}$
  - b. WBC  $\geq 12,500/\text{mm}^3$

#### STATISTICAL ANALYSIS

Data were analyzed using a two-tailed Student's *t*-test and contingency table analysis (Chi-square test with Yates correction) to determine statistical differences in measured variables.

#### RESULTS

We randomized 186 sites for either radial (97) or femoral (89) artery placement in 155 critically ill patients (Fig. 1). Clinical comparison between the randomized femoral and radial populations showed no significant difference in age distribution ( $54 \pm 19$  yr vs  $52 \pm 21$  yr, respectively), sex, or mortality rate (21% vs 22%, respectively). Most (148) patients were randomized for catheter insertion only once. Twelve patients were randomized for catheter insertion twice. Three patients were randomized for a catheter insertion a 3rd time, whereas 1 patient was randomized 5 times. Femoral catheter placement (88 of 89, 99%) was significantly more successful than radial artery insertion (82 of 97, 85%) ( $p < .002$ ). Catheter tips were obtained for culture from 73 femoral catheters and 68 radial catheters. The remaining 29 catheter tips (15 femoral and 14 radial) were not cultured, either because of contamination at time of removal or a failure to send the tip

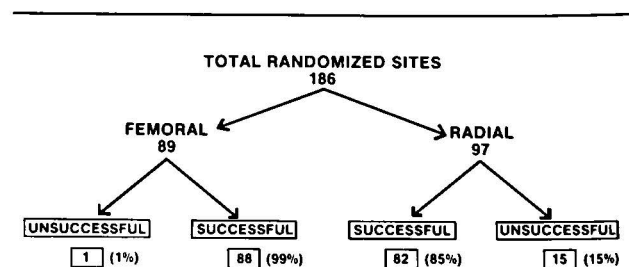


FIG. 1. Success of central artery catheter placement in patients randomized for femoral or radial site insertion. Numbers in parentheses denote the percent of successful or unsuccessful placements into the insertion site.

for culture. The clinical characteristics of the femoral vs radial groups from whom catheter tips were obtained showed no significant differences with respect to age distribution, sex, average duration of catheter placement, frequency of patient blood cultures, or the frequency of antibiotic use (Table 1). Although the total volume of blood obtained daily for laboratory tests was similar in both groups, the femoral catheter was used more frequently ( $p < .001$ ) to obtain a larger percentage ( $p < .001$ ) of the total blood volume than was the radial catheter. Evidence of local infection characterized by redness, pus, or pain was not significantly different between the femoral and radial catheter insertion sites (Table 2), nor was evidence of local infection predictive of positive catheter-tip cultures.

Results of catheter-tip cultures revealed no significant

TABLE 1. Clinical characteristics of study populations in which the randomized catheter placement was successful and catheter-tip cultures were obtained<sup>a</sup>

	Femoral	Radial	p-Value
No. of patients	73	68	NS <sup>b</sup>
Age	55.3 ± 19.3 yr	52.0 ± 21.3 yr	NS
Sex (M/F)	31/42	40/28	NS
Catheter duration in situ	4.7 ± 4.0 days	5.1 ± 4.8 days	NS
Volume of venous and arterial blood samples	68 ± 31 ml/day	70 ± 34 ml/day	NS
Volume of catheter blood withdrawn	68 ± 35 ml/day	17 ± 11 ml/day	<.001
No. of catheter blood samples	6.6 ± 3.0/day	4.4 ± 2.7/day	<.001
No. of blood cultures	2.6 ± 3.4/patient	2.8 ± 2.3/patient	NS
No. of patients receiving antibiotics	65/73 (89%)	61/68 (90%)	NS
Mortality rate	20/73 (27%)	15/68 (22%)	NS

<sup>a</sup> Data presented as mean ± s.d.

<sup>b</sup> NS = not significant at .05 level.

TABLE 2. Evidence of local infection at radial vs femoral insertion sites

Evidence of local infection	No. of sites		p-Value
	Femoral (N = 88)	Radial (N = 82)	
Redness	21	17	NS <sup>a</sup>
Pus	2	0	
Pain	2	2	NS
Any	22	17	NS

Evidence of local infection associated with positive catheter-tip cultures

	Positive catheter-tip cultures
Redness	11
Pus	1
Pain	2
Any	11

<sup>a</sup> NS = not significant at .05 level.

TABLE 3. Results of catheter-tip culture

	Total	Femoral	Radial	p-Value
No. of catheter-tip cultures	141	73	68	NS <sup>a</sup>
No. of positive blood agar cultures	4	2 (3%)	2 (3%)	NS
No. of positive broth-only cultures	34	18 (25%)	16 (24%)	NS

<sup>a</sup> NS = not significant at .05 level.

TABLE 4. Number of positive cultures and cultured organisms

Organism	Number of positive cultures			
	Blood agar (colonies/ml)		Broth-only	
	Femoral	Radial	Femoral	Radial
<i>Staphylococcus epidermidis</i>	1 (<1000)	1 (1-10,000)	8	9
<i>Pseudomonas</i>	1 (10-50,000) <sup>a</sup>		1	
<i>Klebsiella</i>		1 (>100,000)		
<i>Staphylococcus aureus</i>			1	2
Diphtheroids			2	3
<i>Acinetobacter</i>				1
<i>Micrococcus Serratia</i>			1	
<i>Escherichia coli</i>				1
<i>Enterococcus</i>			2	
<i>Candida</i>			2	

<sup>a</sup> Organism judged to be responsible for clinical infection.

TABLE 5. Reason catheter discontinued

	Femoral (N = 73)	Radial (N = 68)	p-Value
Suspected catheter infection	13 (18%)	4 (6%)	P = .06
Catheter malfunction	5 (7%)	11 (16%)	NS <sup>a</sup>
Excess bleeding at insertion site	1 (1%)	0	NS
Patient improved	34 (47%)	38 (56%)	NS
Patient died	20 (27%)	15 (22%)	NS

<sup>a</sup> NS = not significant at .05 level.

differences in the percentage of positive blood agar cultures or positive broth-only cultures in the femoral vs the radial group (Table 3). In only 1 of the 4 positive blood agar cultures was the cultured organism judged to be responsible for a clinical infection (Table 4). However, this organism (*Pseudomonas*) had been isolated from another source before placement of the catheter and, therefore, failed to qualify as a catheter-related infection or catheter-induced bacteremia. *Staphylococcus epidermidis* was the organism most frequently cultured from both the femoral and radial catheter tips, while a variety of organisms was identified in the remaining samples. Despite the high frequency of positive broth-only cultures in both groups, none of the positive broth-only cultures was judged to be responsible for a clinically important infection.

Catheter malfunction occurred more frequently in radial (16%) than in femoral (7%) artery catheters, but this difference was not significant (Table 5). Although physicians removed more catheters from the femoral

TABLE 6. Clinically suspected catheter infection and positive catheter-tip cultures associated with femoral vs radial sites

	Femoral	Radial
No. of suspected catheter infections	13	4
No. of positive catheter-tip cultures	3 (23%)	1 (25%)
<i>S. epidermidis</i>	1 (broth only)	1 (broth only)
<i>Pseudomonas</i>	1 (10–50,000 colonies/ml)	
<i>Serratia marcescens</i>	1 (broth only)	

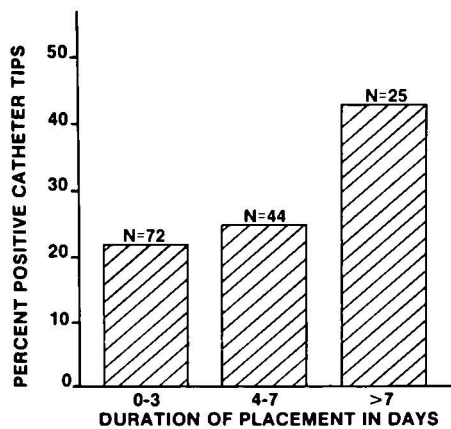


FIG. 2. Days catheter in place versus percent positive-culture catheter tips. N denotes the number of cultures.

artery than from the radial artery because of suspected infection, the frequencies of culture-positive catheter tips in the two groups were not different (Table 6). Duration of catheterization was not related to the frequency of positive catheter-tip cultures until after 7 days, when the frequency of positive cultures increased (Fig. 2).

Of the 141 patients with cultured catheters, 35 patients died and were therefore unable to be clinically evaluated for evidence of a catheter-related infection. In the remaining 106 patients, follow-up during the 3 days after catheter removal revealed only one clinically evident catheter-related infection, associated with a femoral catheter. However, the catheter tip from this patient showed no growth on blood agar or in broth. None of the 141 cultured catheters met the criteria for catheter-induced bacteremia.

#### DISCUSSION

Indwelling femoral artery catheters are becoming increasingly important in the hemodynamic monitoring of critically ill patients. In 1981 approximately 400 femoral artery catheters were used at the LDS Hospital. Nonetheless, data pertinent to long-term indwelling femoral artery catheters are limited.<sup>9,10,15</sup>

The increased use of femoral artery catheters is in part due to their ease of insertion with the Seldinger

technique,<sup>14</sup> especially in critically ill patients whose peripheral vasoconstriction makes the passage of a central radial artery catheter more difficult. The assignment of house officers to place all femoral catheters and of specialized technicians to place all radial catheters does not appear to affect the success of arterial catheter placement. In fact, the use of highly skilled technicians for the placement of radial catheters avoided even higher failure rates that could be expected from the monthly training of new house officers attempting to learn this more difficult procedure.

The ratio of the catheter's outside diameter to the diameter of the arterial lumen is directly related to the risk of vascular occlusion and thrombosis.<sup>16,17</sup> Even though the femoral catheter has larger inside and outside diameters, it has a smaller ratio than the radial catheter and, thus, a lower risk of occlusive complications. The larger lumen of the femoral catheter allows more blood to be withdrawn without occlusion. In our study, despite the significantly higher frequency and volume of blood specimens withdrawn through femoral catheters, the frequency of catheter malfunction was equal in radial and femoral groups.

Despite these advantages, femoral artery catheter placement continues to be avoided because of the possibly increased risk of contamination and infection due to the proximity of the perineal region.<sup>12</sup> Our study confirms this bias since more femoral artery catheters than radial artery catheters were removed because of suspected infection ( $p < .06$ ). However, this concern appears to be unjustified since we found very small and statistically insignificant differences between rates of femoral and radial catheter colonization, catheter-related infection, and catheter-induced bacteremia.

In our study, transducers, catheters, and other disposables were not frequently changed as per the CDC recommendations.<sup>8</sup> Our procedure contrasts to recent CDC recommendations to replace flush solutions every 24 h, to replace tubing, continuous flush device, and transducer domes every 48 h, and to replace arterial cannulas every 4 days.<sup>8</sup> Yet, we found the incidence of catheter-related infection or bacteremia from these devices was low. This contrasts with recent studies which have reported higher incidences of infection from catheter systems.<sup>5,6</sup> A previously suspected reason for the differences between various reports was that of culture techniques. Recently, the "roll technique", in which the culture is inoculated by rolling the catheter tip on the surface of an agar plate, has been described as a means of distinguishing vascular inserts with a high risk of infection from those with a low risk.<sup>5,18</sup> However, culture techniques do not explain the differences in infectious complication rates observed in our study as compared to previous studies. Our study used a well-established technique for assessing infections occurring from indwelling intravascular catheters.<sup>19</sup> This technique al-

lowed cultures to be assessed in both a specific and sensitive manner. Although the broth culture cannot distinguish infection from contamination of vascular inserts, its sensitivity is well established. None of the organisms cultured only in broth was judged to be responsible for a clinical infection. A recent study using the roll technique for culturing arterial catheters also found a low incidence of catheter-associated infections.<sup>20</sup>

Another recent report suggests that the discrepancy in observed catheter infection rates may be attributable to the method in which the arterial catheter's flush system is set up.<sup>21</sup> Our study suggests another explanation for differences in reported catheter-associated infections. All of our catheters as well as those of other studies were inserted percutaneously,<sup>13,20,21</sup> while Band and Maki's original study included catheters which were inserted both percutaneously and by cutdown.<sup>5</sup> Arterial catheters inserted by cutdown have much higher infectious complication rates.<sup>5</sup> Band and Maki reported a 4% rate (5 of 107) of catheter-induced septicemia.<sup>5</sup> However, if catheters placed by surgical cutdown (12 of 107) are excluded from data analysis, their rate of catheter-induced septicemia is approximately 2% (2 of 95), which is not statistically different from the results found in our study. Apparently, percutaneously inserted catheters have similarly low infection rates that are independent of the flush system.

We used longer radial catheters than those used in many critical care units. Despite this difference, we found a low incidence of catheter-associated infections. There is no published study relating catheter length to catheter-associated infections.

*S. epidermidis* is an important cause of nosocomial septicemia,<sup>22</sup> and it was the most frequently cultured organism in our study. However, since we had no cases of catheter-associated bacteremia, our study confirms other reports in which *S. epidermidis* cultured from catheter tips was associated with a very low risk of septicemia and morbidity.<sup>20</sup>

#### CONCLUSIONS

Our incidence of catheter-associated infection was very low despite the fact that CDC recommendations for catheter-system changes (replacing the flush solutions every 24 h; replacing tubing, continuous flush devices and transducer domes every 48 h; and replacing arterial cannulas every 4 days<sup>8</sup>) were not performed. Had CDC recommendations been followed, the number of required catheter insertions would have increased 52% and the cost associated with using these devices would have increased 70%. At our institution where nearly 2000 arterial catheters are inserted each year, the additional costs for such routine catheter-system changes would be approximately \$130,000 per year. Our study suggests that frequent prophylactic changing

of the catheter system may not be required, if these systems are changed when clinically indicated. This avoids not only unnecessary expense but possible additional hemorrhagic, infectious, and thrombogenic risks. Nonetheless, CDC recommendations should be seriously considered in the context of each institution's experience with catheter-associated infections and should be further evaluated with prospective studies.

#### SUMMARY

Femoral and radial artery catheters inserted by our protocol had a low incidence of catheter-associated infections. The incidence of local infection was similar for both femoral and radial catheter insertion sites. Local infection was not predictive of positive catheter-tip cultures. Physicians were unable to reliably predict which catheters removed because of suspected infection would have positive catheter-tip cultures. For the critically ill patient, the femoral artery site is preferred because of such factors as success of insertion and ease of obtaining blood specimens. Routine prophylactic arterial catheter-system changes may be unnecessary in ICUs that have low rates of catheter-associated infection.

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