Assessment of the Sterility of Long-Term Cardiac Catheterization Using the Thermodilution Swan-Ganz Catheter*

Jack J. Applefeld, M.D.;** Tina E. Caruthers, R.N.;† Donna J. Reno, R.N.;‡ and Joseph M. Civetta, M.D.§

Fifty-seven patients requiring catheterization with a thermodilution Swan-Ganz catheter in the surgical intensive care unit were prospectively studied to determine the incidence and significance of positive pulmonary arterial blood cultures. Nonseptic (group 1) and septic (group 2) patients were identified, with subdivision of the groups into A and B classes contingent upon a negative or positive pulmonary arterial blood culture respectively. In the nonseptic group, there were no positive blood cultures, provided there was only one catheterization (Swan-Ganz), less than three repositionings of the catheter, and discontinuation of the catheterization within 72 hours after insertion. Although the septic group followed this pattern, 25 percent incidence of positive pulmonary arterial blood cultures was present within the 72-hour period. We believe that the thermodilution Swan-Ganz catheter is presently a valuable clinical tool and does not predispose the patient to an excessive infectious disease risk.

In 1970, Swan and associates1 reported the bedside use of a No. 5 French balloon-tipped cardiac catheter to measure the pulmonary arterial wedge pressure in the critically ill patient. This has facilitated the accurate intravenous administration of fluids to ensure an adequate left ventricular preload.2 The therapeutic importance and reliability of determination of cardiac output by thermodilution has been emphasized by Ganz et al3 and Weisel et al.4 Since cardiovascular monitoring may be required for prolonged periods, these central lines are frequently used in excess of 72 hours. The incidence of positive blood cultures from indwelling venous catheters had been studied;6 however, to date, no one has assessed the incidence of positive pulmonary artery blood cultures with prolonged thermodilution Swan-Ganz cardiac catheterization.

MATERIALS AND METHODS

All patients requiring insertion of a thermodilution Swan-Ganz catheter in the surgical intensive care unit at Jackson Memorial Hospital in Miami, Fla., between August 1976 and January 1977 were entered into this study. A record was prospectively maintained in the surgical intensive care unit, detailing the following: date of admission to the hospital; date of admission to the surgical intensive care unit; primary diagnosis; secondary diagnosis; dates and types of operations; anatomic site of initial and subsequent insertions of Swan-Ganz catheters; daily maximum temperature; white blood cell count in the morning; therapy with antipyretic agents; therapy with antibiotics; date and time of repositioning of the catheter; approximate number of daily pressure readings; type of tubing employed to monitor pressure; and number of determinations of cardiac output per day. Each patient had a daily culture of blood obtained in the morning through the pulmonary arterial lumen of the Swan-Ganz catheter and one other peripheral venipuncture. A separate prospective record was maintained detailing all cultured material (urine; sputum; wound). If a positive blood culture was reported, one of us (J.A. or J.M.) would determine its source and clinical significance.

Each Swan-Ganz catheter was introduced percutaneously through the internal jugular or subclavian vein after the area was appropriately prepared with solutions of acetone, povidone-iodine (Betadine), and alcohol. Once accurate pulmonary arterial and wedge tracings were verified, povidone-iodine (Betadine) ointment was placed over the site of insertion, and the distal 10 cm of catheter from the skin was gently coiled in a sterile 4 × 4-inch gauze. This was placed above the site of insertion, and a sterile occlusive dressing was secured. If a catheter needed to be repositioned, the dressing was removed, and the entire area was resterilized in the previously described fashion. The catheter would be advanced or withdrawn and appropriately redressed. Otherwise, the dressing of the catheter was changed once daily by the nursing personnel in the previously described fashion. Intravenous flushing solutions were changed every 24 hours; however, stopcock and high-pressure tubing were only changed when contaminated.

CHEST, 74: 4, OCTOBER, 1978

*Formerly Director, Surgical Intensive Care Unit. Presently Associate Professor of Surgery, Medicine, Anesthesiology, and Pathology, University of Miami School of Medicine, and Director, Surgical Intensive Care Unit.

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RESULTS

Fifty-seven consecutive patients undergoing catheterization were prospectively studied. Their ages ranged from 20 to 72 years, and the indications for catheterization were either (1) elective or emergency surgery requiring cardiovascular monitoring or (2) profound respiratory failure. These patients were divided into two major groups. Group 1 (33 patients) was composed of those individuals who had elective surgical procedures in whom cardiovascular monitoring was indicated. Group 2 (24 patients) comprised those patients who had an easily identifiable source of sepsis prior to catheterization (ie, perforated viscus, multiple intra-abdominal abscesses, or infection of the urinary tract). Each group was further subdivided on the basis of the presence or absence of a positive culture of blood obtained from the pulmonary arterial lumens of the catheter. Subdivision 1A (30 patients) consisted of those individuals with consistently negative cultures of pulmonary arterial blood, while subdivision 1B (three patients) comprised those patients with positive cultures of pulmonary arterial blood (Table 1).

Group 2 had a more even distribution of patients, with 13 patients having no positive cultures of pulmonary arterial blood (group 2A) and with 11 patients having positive cultures of pulmonary arterial blood (group 2B). In order to determine whether a statistical significance existed between groups 1 and 2, a $\chi^2$ analysis was performed, yielding $P = 0.01$ (Table 1).

The mean duration of catheterization in group 1A was 2.4 days, whereas group 1B had a mean of 8.3 days. The septic patients had approximately the same results, with group 2A having a mean duration of catheterization equalling 2.3 days and group 2B having a mean equalling 5.8 days. Regarding repositioning of the catheter, the nonseptic group 1A had a mean of 1.9 repositionings per patient, whereas group 1B had a mean of 6.67 repositionings per patient. The septic patients likewise had a mean of 2.23 repositionings per patient in group 2A, while group 2B had a mean of 4.27 repositionings per patient (Table 1). Finally, in group 1A, there was a mean of 1.1 catheterization per patient, whereas group 1B has a mean of 2.3 catheterizations per patient. Group 2A meanwhile had a mean of one catheterization per patient, while group 2B had a mean of 1.5 catheterizations per patient. These data are presented in Table 1, with the appropriate standard deviations.

Table 2 compares the organisms cultured from the pulmonary arterial blood with a culture of simultaneously obtained peripheral blood. In group 1A, these organisms were also cultured from endotracheal tubes and a Foley catheter. Group 2, on the other hand, had the identified organism cultured from both the pulmonary arterial blood and documented anatomic focus of infection.

### Table 1—Summary of Catheterization Data

<table>
<thead>
<tr>
<th>Group</th>
<th>Nonseptic (1)</th>
<th>Septic (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary artery blood culture*</td>
<td>Negative (A)</td>
<td>Positive (B)</td>
</tr>
<tr>
<td>Mean No. of catheterization**</td>
<td>2.40±1.19</td>
<td>8.33±5.13</td>
</tr>
<tr>
<td>Mean No. of repositionings†</td>
<td>1.98±1.05</td>
<td>6.69±7.23</td>
</tr>
<tr>
<td>Mean No. of catheter insertions‡</td>
<td>1.10±0.31</td>
<td>2.33±1.53</td>
</tr>
</tbody>
</table>

* $\chi^2 = 10.12$  P<0.01  
** t=5.63  P<0.01  t=2.87  P<0.05  
† t=3.72  P<0.01  t=2.24  P<0.05  
‡ t=4.18  P<0.01  t=2.17  P<0.01  

Group 1A and 2A had negative cultures of pulmonary arterial blood; groups 1B and 2B had positive cultures of pulmonary arterial blood. Values are means ± SD.

### Table 2—Bacteriologic Data from Group 1B (No Prior Sepsis) and Group 2B (Prior Sepsis)

<table>
<thead>
<tr>
<th>Group and Consecutive Days with Swan-Ganz Catheter</th>
<th>Organism Cultured from Pulmonary Arterial Blood</th>
<th>Other Source of Identical Organism</th>
<th>Culture of Peripheral Blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1B</td>
<td>Enterobacter cloacae; Serratia marcescens</td>
<td>Endotracheal tube</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Pseudomonas aeruginosa</td>
<td>Endotracheal tube</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Escherichia coli</td>
<td>Foley catheter</td>
<td>Negative</td>
</tr>
<tr>
<td>Group 2B</td>
<td>Escherichia coli</td>
<td>Wound in thigh</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Escherichia coli</td>
<td>Acute peritonitis</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Group-D streptococcus</td>
<td>Peripheral amputation</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Acinetobacter; Serratia marcescens</td>
<td>Empyema</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Coagulase-positive staphylococcus</td>
<td>Renal transplant wound</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Klebsiella pneumoniae</td>
<td>Perforated colon</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Candida albicans</td>
<td>Perforated jejunum</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Coagulase-positive staphylococcus</td>
<td>Superficial abscess in skin</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Enterococcus</td>
<td>Pyleonephritis</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Klebsiella pneumoniae</td>
<td>Perforated colon</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>Escherichia coli</td>
<td>Perforated colon</td>
<td>Negative</td>
</tr>
</tbody>
</table>

378 APPLEFELD ET AL

CHEST, 74: 4, OCTOBER, 1978
Discussion

In 1947, two years after the introduction of plastic catheters for intravenous therapy by Meyers, Neuhofer and Selye reported six cases of sepsis secondary to cannulation of the leg. Moncreiff detailed four cases of septic thrombophlebitis with a fatal outcome and described an association between the incidence of complications and the duration of cannulation in 1958. This encouraged Crane to advise against catheterization via the leg, while recommending removal of a catheter after 48 hours of use. By 48 hours, 8 percent of central lines (excluding lines for hyperalimentation) may have positive blood cultures.

As presently employed, the thermodilution Swan-Ganz catheter would seem to have an inordinately high risk of becoming colonized. It is subjected to multiple uses through central venous pressure and pulmonary arterial lumens, including measurements of pressure, aspiration of blood for routine chemical and central mixed venous blood gas analysis and frequent injections of cold solutions for thermodilution cardiac output determinations. For those individuals who underwent elective catheterization, there were no positive pulmonary arterial blood cultures, provided the catheterization was discontinued within 72 hours. There was a 50 percent incidence of positive pulmonary arterial blood cultures if the catheterization was continued, however. The source of organisms in this group is probably from the flora of the skin, which harbors Staphylococcus epidermidis, S. aureus, Klebsiella pneumoniae, Enterobacter cloacae and Serratia marcescens in acutely ill hospitalized patients. These organisms gain entrance to the tip of the catheter at the time of insertion or possibly migrate along the interface between the fibrinous tract and tissue. It is well documented that other areas (i.e., tracheostomy or Foley catheter) serve as an “organism bank” to see the loosely organized colt of fibrin at the tip of the catheter.

In those patients who had an easily identifiable source of infection prior to the catheterization, 25 percent (six patients) had a positive pulmonary arterial blood culture within the first 72 hours of use. All catheters remaining longer than 72 hours had a positive pulmonary arterial blood culture. The organism grown from the pulmonary arterial lumen was the same as that cultured from the peripheral location. This has been well documented with central venous catheterization. Various studies have tried to differentiate contamination, colonization, and infection of central lines. The pathophysiologic consequences of a culture-positive tip of a catheter has yet to be understood. Patients with positive culture tips have been shown to have a positive nitroblue tetrazolium test, which suggests a leukocytic response to these organisms even in the absence of documented bacteremia. Others have shown that patients can develop overt septic shock from infected central lines.

When interpreting the consequences of repositioning a Swan-Ganz catheter, it is evident that in excess of three repositionings per individual catheterization may predispose the nonseptic patient to a positive catheter blood culture. In the septic group the information is more difficult to interpret, as some of the catheters became colonized without being repositioned. This observation is obviously in need of future investigation.

The number of recatheterizations also is a critical issue. Does the increased incidence of positive blood cultures reflect the greater number of catheter insertions or the fact that those patients requiring more than one catheterization represent a sicker population more prone to infection?

In conclusion, the subclavian Swan-Ganz catheterization for prolonged use does not appear to expose the patient to an inordinately high infectious disease risk. Each catheter requires sterile insertion, less than three repositionings, and only 72 hours of use if the incidence of positive pulmonary arterial blood cultures is to be minimized. The necessity for recatheterization needs to be weighed against the risk of a potentially “colonized” central line remaining in place.

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Assessment of Sterility of Long-Term Cardiac Catheterization

CHEST, 74: 4, OCTOBER, 1978
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