**BACKGROUND**
Infected central venous catheters cause morbidity and mortality.

**OBJECTIVE**
To compare the risk for colonization of central venous catheters used for total parenteral nutrition with that of catheters used for other purposes.

**METHODS**
Retrospective review of prospectively acquired data on 260 patients with a stay in a surgical intensive care unit longer than 3 days. Single-lumen catheters used solely for total parenteral nutrition were inserted into the subclavian vein and cared for by a dedicated team. Catheters for other purposes were placed and cared for by other staff. Catheters were cultured if clinical findings suggested infection.

**RESULTS**
Of 854 central venous catheters, 61 (7%) were used for total parenteral nutrition. During 4712 catheter days of observation, 89 catheters of all types were colonized. Risk factors for colonization included duration of catheterization ($P < .001$), having 3 or more lumens (hazard ratio, 1.7; 95% CI, 1.1-2.6), pulmonary artery catheterization (hazard ratio, 1.7; 95% CI, 1.1-2.7), and placement in the internal jugular vein (hazard ratio, 1.6; 95% CI, 1.1-2.5). Catheters used for total parenteral nutrition (hazard ratio, 0.14; 95% CI, 0.04-0.57) and those in the subclavian vein (hazard ratio, 0.51; 95% CI, 0.3-0.8) were at lower risk of colonization. In a multivariate Cox model, the only significant factor was a 5-fold lower risk of infection for catheters used for total parenteral nutrition (hazard ratio, 0.19; 95% CI, 0.04-0.83).

**CONCLUSION**
Rates of colonization were lowest for catheters used solely for total parenteral nutrition, suggesting that a team approach improves patients' care. (American Journal of Critical Care. 2003;12:328-335)

The ability to provide complete energy requirements via total parenteral nutrition (TPN) is considered one of the greatest improvements in the care of surgical patients in the past century. Because the feeding formula for TPN is a hyperosmolar solution of dextrose and amino acids, delivery to the central venous circulation is required. Consequently, infection of central venous catheters used to deliver TPN solutions is an important short-term complication of this method of feeding. Several observational studies indicated that the risk for catheter-related infections is higher for central venous catheters used for TPN than for standard catheters. Quality improvement efforts to modify known risk factors for infection need to be evaluated to determine if the efforts lead to a decrease in the prevalence of catheter-related infectious complications in patients receiving TPN.

We undertook the study reported here to determine risk factors for infections associated with use of...
central venous catheters in a cohort of critically ill surgical patients with a prolonged stay in the intensive care unit (ICU). Because of their severity of illness and prolonged length of stay, these patients are at an increased risk for nosocomial infectious complications and often require TPN.9-11 At the Johns Hopkins Hospital, Baltimore, Md, a multidisciplinary nutrition team inserts and maintains central venous catheters used for TPN. Catheters used for any other indication are placed and cared for by other healthcare staff. We compared the risk of colonization and infection for TPN catheters placed and maintained by the nutrition team with the risk of colonization and infection for other central venous catheters placed and maintained by the ICU team.

Materials and Methods
Sample
Data were prospectively collected during a 1-year period, from January 7, 1998, to January 13, 1999, on a cohort of patients enrolled in an unrelated randomized clinical trial evaluating the efficacy of fluconazole for the prevention of fungal infections.10 We sought to identify a group of patients at highest risk for prolonged ICU stay and nosocomial infectious complications. To meet the inclusion criteria, patients must have had a projected ICU length of stay greater than 3 days. Intradermal parts of catheters were cultured when clinical findings suggested the possibility of infection. The protocol was approved by the Johns Hopkins Hospital Joint Committee on Clinical Investigation. Before enrollment in the study, each patient or the patient’s designated healthcare surrogate provided written informed consent.

Risk factors for catheter-related infections of the bloodstream include longer duration of catheterization, greater number of lumens, insertion in the internal jugular vein, and catheters used for TPN.

Catheter Data
Patients were examined daily by the study personnel, and information concerning central venous catheters was obtained. None of the catheters used during the study period were coated with an antibiotic or impregnated with an antiseptic. Each catheter site was assigned a unique identifier, and the date of guidewire exchanges was recorded. Date of insertion, site of insertion (internal jugular vein, subclavian vein, groin), type of catheter (for dialysis, monitoring, TPN, administration of fluid or medication), and the number of lumens were recorded. Catheters were cultured if clinical findings indicated a possible infection. Catheters were removed entirely and cultured when a patient had local signs of infection, but catheters were exchanged over a guidewire according to protocol when an infection was suspected and not as a matter of routine. Suspected infection was defined as the presence of an intravascular catheter and persistent fever or increasing white blood cell count without another infectious source, a positive blood culture for a potential catheter-related pathogen without another source, or abnormalities at the insertion site that were suggestive of infection. Catheters were removed by using sterile technique, and the intradermal part of the catheter was sent to a central laboratory for processing via the semiquantitative roll plate technique.12

Quality Improvement Effort
TPN at the Johns Hopkins Hospital is managed by a comprehensive team approach, including a physician-manager, staff nurses, nutrition specialists, and resident physicians.12 This team is responsible for all aspects of parenteral nutrition, including inserting and maintaining the central venous catheters for the duration of TPN. The goal of this effort is to reduce the infection of these catheters by eliminating known risk factors.6-8,13-20 The guidelines are as follows:

- catheters are inserted by 1 resident physician who uses maximal barrier precautions,
- single-lumen catheters only are used,
- the catheters are inserted in the subclavian site,
- the insertion sites are checked daily,
• TPN solution only is delivered through the catheter (to minimize hub manipulation), and
• whenever a patient is transferred from another institution, blood samples are obtained through any indwelling catheters and are cultured; the cultures must be negative for pathogens before TPN therapy is started.

TPN nursing staff perform routine dressing changes. If infection is suspected, the catheter is changed over a guidewire, and the intradermal part of the catheter and samples of venous blood obtained via fresh venipuncture are sent for culture. Blood samples for culture are not obtained through indwelling central venous catheters. Central venous catheters are not routinely replaced.

All catheters used for reasons other than TPN are placed by surgical residents by using standard placement techniques; the residents are supervised by attending physicians. Location of placement and type of non-TPN catheters were selected on the basis of each patient’s needs and a risk-benefit analysis. After placement, the patients’ bedside nurses cared for these catheters.

Definitions of Infection
Colonization was defined as having more than 15 colony-forming units of a pathogenic organism on the intradermal part of the catheter, as indicated by the semiquantitative roll-plate technique. Catheter-related bloodstream infection (CRBSI) was defined as the combination of (1) the presence of more than 15 colony-forming units on the catheter and (2) isolation of the same organism via cultures of peripheral venous blood within the same 2 days. For coagulase-negative Staphylococcus, however, 2 blood cultures positive for this organism within 2 days were required for the diagnosis of CRBSI. For assessment of risk associated with the number of lumens, pulmonary artery catheters were assumed to have 4 lumens, and a cordis introducer catheter without a pulmonary artery catheters was assumed to have 2 lumens. For all other catheters, exposure was defined as the mean number of lumens per day. However, as stated previously, all TPN catheters had only 1 lumen.

Statistical Analysis
The catheter was used as the unit of analysis for the assessment of risk factors for CRBSI. In an initial analysis, univariate risk factors were assessed by using the $\chi^2$ test, Wilcoxon rank sum test, and simple logistic regression when appropriate. Univariate predictors were included in a multivariate analysis by using multiple logistic regression. The length of time a catheter remained in place was the strongest risk fac-

Table 1 Baseline characteristics of critically ill patients (N = 260) with and without catheters for total parenteral nutrition*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Catheter for total parenteral nutrition</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients (%)</td>
<td>Yes (54 [21])</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>24 (44)</td>
<td></td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>69 (16)</td>
<td>.003</td>
</tr>
<tr>
<td>Nonwhite</td>
<td>13 (24)</td>
<td></td>
</tr>
<tr>
<td>Gastrointestinal surgery</td>
<td>33 (61)</td>
<td>.03</td>
</tr>
<tr>
<td>Congestive heart failure (New York Heart Association class 3 or 4)</td>
<td>7 (13)</td>
<td>18 (9)</td>
</tr>
<tr>
<td>Score on Acute Physiologic and Chronic Health Evaluation III, mean (SD)</td>
<td>78 (24)</td>
<td>65 (21)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>11 (20)</td>
<td></td>
</tr>
<tr>
<td>History of malignant neoplasm</td>
<td>26 (48)</td>
<td>.002</td>
</tr>
<tr>
<td>Immunosuppressive drugs</td>
<td>11 (20)</td>
<td></td>
</tr>
<tr>
<td>Solid organ transplantation</td>
<td>2 (4)</td>
<td></td>
</tr>
<tr>
<td>Cirrhosis</td>
<td>10 (19)</td>
<td></td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>4 (7)</td>
<td></td>
</tr>
<tr>
<td>Dialysis-dependent renal failure</td>
<td>2 (4)</td>
<td></td>
</tr>
<tr>
<td>Positive for human immunodeficiency virus</td>
<td>0 (0)</td>
<td></td>
</tr>
</tbody>
</table>

*Values are number (percentage) unless otherwise indicated. $\chi^2$ or t test. Blank cells indicate not significant.

Results
Characteristics of the Sample
A total of 260 critically ill patients in the surgical ICU were enrolled in the study. The median age of the patients was 65 years (interquartile range [IQR], 51-74) and the median score on the Acute Physiology and Chronic Health Evaluation III was 64 (IQR, 51-79). Approximately half of the patients had undergone some type of gastrointestinal surgery, and many patients had coexisting chronic diseases, including diabetes, malig-
nant neoplasms, and cirrhosis (Table 1). Patients receiving TPN were older than the other patients (mean, 69 years vs 61 years, \( P = .003 \)), and more had undergone gastrointestinal surgery (61% vs 42%, \( P = .03 \)), had a history of malignant neoplasm (48% vs 24%, \( P = .002 \)), and had a higher level of critical illness (mean score on the Acute Physiology and Chronic Health Evaluation III, 78 vs 64, \( P < .001 \)) (Table 1). Patients with and without TPN catheters were similar with respect to all other baseline characteristics.

Duration of catheter placement was the strongest risk factor for both colonization and catheter-related infection in the bloodstream.

Catheters used for TPN had a significantly lower level of colonization (1.6%) compared with catheters used for monitoring, administration of fluids or medication, or dialysis (12%-21%).

None of the catheters used for TPN led to a catheter-related infection of the bloodstream.

### Table 2 Characteristics of central venous catheters (N=854) in 260 critically ill surgical patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lumens</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>232 (27)</td>
</tr>
<tr>
<td>2</td>
<td>355 (42)</td>
</tr>
<tr>
<td>3</td>
<td>56 (7)</td>
</tr>
<tr>
<td>4 (pulmonary artery catheter)</td>
<td>211 (25)</td>
</tr>
<tr>
<td>Reason for insertion</td>
<td></td>
</tr>
<tr>
<td>Pulmonary artery catheter</td>
<td>211 (25)</td>
</tr>
<tr>
<td>Cordis introducer without pulmonary artery catheter</td>
<td>137 (16)</td>
</tr>
<tr>
<td>Total parenteral nutrition</td>
<td>61 (7)</td>
</tr>
<tr>
<td>Dialysis</td>
<td>47 (6)</td>
</tr>
<tr>
<td>Multipurpose (fluids/medication)</td>
<td>398 (47)</td>
</tr>
<tr>
<td>Site of catheter placement</td>
<td></td>
</tr>
<tr>
<td>Internal jugular vein</td>
<td>530 (62)</td>
</tr>
<tr>
<td>Subclavian vein</td>
<td>228 (27)</td>
</tr>
<tr>
<td>Femoral vein</td>
<td>91 (11)</td>
</tr>
</tbody>
</table>

Catheter Characteristics

In the 260 patients, 854 catheters were monitored during the patients’ ICU stay. The median length of time the catheters were in place was 3 days (IQR, 2-5), with a mean of 4.3 days (SD, 3.6 days). Of these 854 catheters, 61 (7%) were used for TPN (Table 2). The number of lumens, reason for placement, and anatomic site of placement of other central venous catheters are given in Table 2.

Microbiology and Colonization

Of the 854 catheters, 418 (49%) were sent for culture, and 136 (52%) of the 260 patients had at least 1 catheter cultured during the observation period. The median number of catheter cultures obtained was 2 per patient (IQR, 1-4; range, 1-26). A total of 89 (10%) of the catheters in 54 patients (21%) were colonized with more than 15 colony-forming units of a pathogenic organism. Thus, 21% (89/418) of the catheters cultured because of clinical findings suggestive of infection were colonized. The 89 colonized catheters yielded 120 microbiological isolates. Colonization was monomicrobial in 73% of catheters and polymicrobial in 27%. The isolates were gram-positive bacteria in 80%, gram-negative bacteria in 15%, and yeast in 5% (Table 3). Only 1 (2%) of the TPN catheters became colonized during the 1-year study period. In contrast,

### Table 3 Microbiological isolates (N=120) for colonized catheters

<table>
<thead>
<tr>
<th>Isolate</th>
<th>No. (%) with &gt;15 colony-forming units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram-positive bacteria</td>
<td>96 (80)</td>
</tr>
<tr>
<td>Staphylococcus epidermidis</td>
<td>59</td>
</tr>
<tr>
<td>Corynebacterium species</td>
<td>11</td>
</tr>
<tr>
<td>Methicillin-resistant Staphylococcus aureus</td>
<td>8</td>
</tr>
<tr>
<td>Vancomycin-resistant Staphylococcus aureus</td>
<td>7</td>
</tr>
<tr>
<td>Enterococcus faecalis</td>
<td>6</td>
</tr>
<tr>
<td>S aureus</td>
<td>2</td>
</tr>
<tr>
<td>Other Enterococcus species</td>
<td>2</td>
</tr>
<tr>
<td>Streptococcus viridans</td>
<td>1</td>
</tr>
<tr>
<td>Gram-negative bacteria</td>
<td>18 (15)</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>9</td>
</tr>
<tr>
<td>Enterobacter species</td>
<td>3</td>
</tr>
<tr>
<td>Proteus species</td>
<td>2</td>
</tr>
<tr>
<td>Acinetobacter species</td>
<td>2</td>
</tr>
<tr>
<td>Serratia species</td>
<td>1</td>
</tr>
<tr>
<td>Citrobacter species</td>
<td>1</td>
</tr>
<tr>
<td>Yeast</td>
<td>6 (5)</td>
</tr>
<tr>
<td>Candida albicans</td>
<td>5</td>
</tr>
<tr>
<td>Candida parapsilosis</td>
<td>1</td>
</tr>
</tbody>
</table>

Downloaded from http://ajcc.aacnjournals.org/ by AACN on November 2, 2017
49 multifunctional catheters (12%), 10 dialysis catheters (21%), and 25 pulmonary artery catheters (12%) were colonized (Table 4). The total days of catheter observation was 4712. During that time, 17 episodes of CRBSI occurred in 9 patients. The overall incidence of CRBSI was 3.6 (95% CI, 2.1-5.8) episodes per 1000 catheter days. None of the catheters used for TPN led to the development of CRBSI.

### Risk Factors for Colonization

Colonized catheters were in place for a median of 5 days (IQR, 3-8 days) versus 3 days (IQR, 2-5 days) for catheters that had no growth (P<.001). Because of the interaction between the length of time the catheter was in place and colonization, we used time-to-event (ie, time to colonization) methods for the remaining analyses. Univariate risk factors for catheter colonization included having a catheter with 3 or more lumens (hazard ratio [HR], 1.7; 95% CI, 1.1-2.6), having a catheter in the pulmonary artery (HR, 1.7; 95% CI, 1.1-2.7), and having a catheter in the internal jugular vein (HR, 1.6; 95% CI, 1.1-2.5). The risk for colonization was lower for catheters dedicated to TPN (HR, 0.14; 95% CI, 0.04-0.57) and for those in the subclavian vein (HR, 0.51; 95% CI, 0.3-0.8) than for other types of catheters (Table 5). The Kaplan-Meier plots show the increased risk of colonization for catheters with 3 or more lumens compared with those with fewer than 3 lumens (Figure 1), the effect of position of the catheters (Figure 2), and the differences between TPN catheters and all other catheters (Figure 3).

In the multivariate Cox model, the only significant variable was reduction of colonization for catheters used for TPN (Table 5). Catheters used for TPN were independently associated with a 5-fold reduction in the risk of colonization (HR, 0.19; 95% CI, 0.04-0.83). None of the other univariate factors had an incremental independent effect on the risk of colonization. Randomization to fluconazole or placebo had no effect on the outcome of catheter colonization or CRBSI.

### Discussion

Our findings indicate a dramatic decrease in the risk of colonization of central venous catheters used for TPN when the catheters are single-lumen, single-purpose catheters placed into the subclavian vein and maintained by a multidisciplinary team. Colonization of catheters dedicated to TPN was 5-fold less than colonization of catheters used for other reasons. This dramatic reduction in infectious complications is attributable to a quality improvement effort focused on minimizing known risk factors for infections associated with use of central venous catheters. Specifically, the catheters have only a single lumen, are inserted in the subclavian vein, are used solely for TPN (to minimize hub contamination), and are checked daily. Previous research indicated that decreasing catheter colonization would subsequently decrease the rate of CRBSI. These findings have important health policy implications, both specifically, for the maintenance of TPN catheters, and generally, for future design and implementation of quality improvement efforts.

Several previous studies indicated that the risk for infection is higher for catheters used for TPN than for other catheters, highlighting the remarkable reduction of infection in our study. In a large, prospective observational study at several ICUs, Richet et al found that the rate of catheter colonization was much higher for catheters used for parenteral nutrition than for catheters not used for nutrition (28% vs 17%, P<.05). In a univariate analysis of patients from ICUs at multiple hospitals, Moro et al similarly found that the rate of catheter-related infection was higher for TPN catheters than for other catheters (13.9% vs 7.7%, P=.03). Use for TPN was also associated with catheter hub contamination, which had a dramatic independent association with infection in the multivariate risk factor profile.

Many authors have described additional risk factors for infection associated with the use of central venous catheters. Yeung et al randomized patients receiving TPN to receive either single- or triple-lumen catheters. A dramatic reduction in infection rates.
occurred when single-lumen catheters were used. Consistent with the results of our study, Moro et al found that the duration of catheterization was associated with an increased risk of infection. A 4-fold increase in infection occurred between days 7 to 14 and a 5-fold increase after 14 days. Additional risk factors included being on a surgery or coronary care service (vs medical service) and skin and hub colonization. Raad et al also reported that duration of catheterization was an important risk factor for catheter-related infection. In a prospective multicenter study, Richet et al found that duration of catheterization, use of a semipermeable dressing, and use of the internal jugular vein were all independent risk factors for CRBSI. In a previous retrospective study from our institution, the single most important risk factor for infection associated with use of central venous catheters was placement of the catheter in the internal jugular vein. In summary, the consistent risk factors seem to include longer duration of catheterization, increasing number of lumens, insertion in the internal jugular vein, and use for TPN. Skin and hub colonization represent the pathogenesis of catheter colonization and CRBSI rather than true clinical risk factors.

Few studies on potential risk factors for catheter-related infection were specific to critically ill surgical patients. The sample in our study was a well-defined population of patients who required a long duration of central venous access. Compared with the patients in previous studies, our patients may have a unique risk factor profile. Furthermore, in many of the previous studies, the duration of central venous catheterization was not considered. In contrast to us, none of the previous investigators used a time-to-event analysis, which is necessary to correct for different types of catheters remaining in place for different amounts of time. For example, patients who require triple-lumen catheters need multiple antibiotics, intravenous fluids, other medications, and, potentially, pharmacological agents for hemodynamic support. In contrast, patients who need only a single pharmacological agent or, perhaps, have poor peripheral venous access, will have a single-lumen catheter. Among these 2 groups of patients, the risk for infection may be higher in the first group for reasons other than use of a triple-lumen catheter. The number of lumens, along with other catheter characteristics, may in some instances be a simple proxy for severity of illness. Therefore, in studies of risk factors associated with catheter-related infections, the investigators should use time-to-event methods and should make adjustments for differences in severity of illness by using an appropriate physiological risk-adjustment tool.

Our study has several limitations. First, we compared central catheters used for TPN with catheters used for other reasons; we did not have a concurrent or historical control group. The ideal study method would be to randomize consecutive patients and all of their catheters to be either cared for or not cared for by using the protocol for the team approach to quality improvement. This method would allow optimal control of potential confounding variables. Because our current policy mandates having a dedicated service for TPN catheters only, randomizing patients to a protocol would be logistically difficult because patients receiving TPN solutions could be inherently different from patients who did not receive TPN solutions. In addition, many patients in the control group might benefit from the intervention because of a heightened awareness of infection prevention measures during the study period, otherwise known as the “Hawthorne effect.” Using historical or nonconcurrent controls is also fraught with difficulty, because many potentially unmeasured aspects of care can change over time and confound the results. Furthermore, the prospective acquisition of data for this

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Univariate analysis, hazard ratio (95% CI)</th>
<th>Multivariate analysis, hazard ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased risk of colonization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catheters used for total parenteral nutrition</td>
<td>0.19 (0.04 to 0.83)</td>
<td></td>
</tr>
<tr>
<td>Catheters in the subclavian vein</td>
<td>0.51 (0.3-0.8)</td>
<td>NS</td>
</tr>
<tr>
<td>Increased risk of colonization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catheters with ≥3 lumens</td>
<td>1.7 (1.1-2.6)</td>
<td>NS</td>
</tr>
<tr>
<td>Pulmonary artery catheters</td>
<td>1.7 (1.1-2.7)</td>
<td>NS</td>
</tr>
<tr>
<td>Catheters in the internal jugular vein</td>
<td>1.6 (1.1-2.5)</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS indicates not significant in the multivariate Cox proportional hazards model.
study was very detailed, and the study was designed to examine risk factors for infections associated with use of central venous catheters in a cross-sectional approach. Any data obtained before implementation of the quality improvement initiative would be much less rigorously collected and therefore less accurate.

Finally, recent evidence indicates that catheters coated with antibiotic or impregnated with antiseptic are both efficacious and cost-effective for the prevention of CRBSI. None of the catheters used in our study were coated with antibiotic or impregnated with antiseptic. However, because only 1 catheter used for TPN was colonized and no episodes of CRBSI occurred, most likely using such catheters would result in only a small incremental improvement for our already low-risk population. Despite these limitations, the magnitude of the decrease in infection (almost the entire elimination of infection during 1 year) was remarkable, especially because of the strength of the data linking TPN to an increased risk for catheter-related infection.

In conclusion, colonization of central venous catheters was dramatically lower for catheters used for TPN than for catheters used for other purposes. We attribute this finding to a quality improvement effort focused on modifying known risk factors for catheter-related infection. Specifically, TPN catheters at the Johns Hopkins Hospital are inserted and maintained by a multidisciplinary team. The catheters are single-lumen, are placed in the subclavian position, and are used solely for TPN (to minimize hub manipulation and contamination). After this practice was implemented, the incidence of catheter-related infection in high-risk surgical ICU patients was 5-fold lower for TPN catheters than for other catheters. We recommend that other institutions focus on reducing the rates of nosocomial infection by implementing quality improvement efforts that include modification of known risk factors.

Although previous studies have repeatedly shown that catheters used for TPN are at higher risk for infection than are catheters inserted for other purposes, this study, using a single-lumen catheter, a subclavian insertion site, and a dedicated TPN team for catheter insertion and management, yielded a 5-fold reduction in colonization of catheters used for TPN.
Figure 3 Kaplan-Meier plot of the time to colonization for catheters used for total parenteral nutrition only or for other purposes.

Commentary by Mary Jo Grap (see shaded boxes).

REFERENCES
Risk of Colonization of Central Venous Catheters: Catheters for Total Parenteral Nutrition Vs Other Catheters
Justin B. Dimick, Sandra Swoboda, Mark A. Talamini, Robert K. Pelz, Craig W. Hendrix and Pamela A. Lipsett

Am J Crit Care 2003;12 328-335
Copyright © 2003 by the American Association of Critical-Care Nurses
Published online http://ajcc.aacnjournals.org/

Personal use only. For copyright permission information:
http://ajcc.aacnjournals.org/cgi/external_ref?link_type=PERMISSIONDIRECT

Subscription Information
http://ajcc.aacnjournals.org/subscriptions/

Information for authors
http://ajcc.aacnjournals.org/misc/ifora.xhtml

Submit a manuscript
http://www.editorialmanager.com/ajcc

Email alerts
http://ajcc.aacnjournals.org/subscriptions/etoc.xhtml