AN EVALUATION OF CATHETER RELATED INFECTIONS
IN CHILDREN WITH CANCER

By

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Approved by:

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Date: ______________________________________________
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ABSTRACT

Central Venous Catheters (CVCs) have revolutionized treatment protocol for patients with cancer. CVCs are inserted directly into large blood vessels, making administration of chemotherapy and blood products easy and effective. Unfortunately, the rate of CVC related infections is high, and consequences of infections in immunocompromised chemotherapy patients can be devastating. Thus, it is important to look at factors that are correlated with an increased risk of infection so that protocol can be enacted to reduce the infection rate. The purpose of this study was to describe factors that lead to an increased rate of infection, specifically in the pediatric oncology population.

A cross sectional descriptive design was used to evaluate infection rates and potential factors that might influence the occurrence of infections in 106 pediatric patients at the Arizona Health Sciences Center who had a central catheter and had been diagnosed with a malignancy or Langerhans cell histocytosis. A chart review was conducted to collect data on demographic and treatment related factors. Demographic data included gender, diagnosis, age at diagnosis, height and weight, type of catheter, provider placing the catheter (pediatric surgeons, interventional radiology, etc.) and total number of catheter days. For patients with positive cultures, data was collected on the number of catheter days at the time of positive culture, and the inpatient or outpatient status at the time the positive culture was identified. Data on the type of organism recovered, the treatment, and the ANC and platelet count at the time of positive culture was analyzed. Chi squared tests were conducted comparing patients with positive and
negative cultures with respect to the nature of the diagnosis, the type of catheter inserted, gender, BMI percentile, and placer of the catheter. T-tests were conducted comparing patients with positive and negative cultures with respect to age, BMI percentile, and catheter days.

Several significant findings emerged. Patients with hematologic tumors experienced infections more often than those with solid tumors (P<0.01) and patients with non-implanted catheters were more predisposed to infections than those with external catheters (P<0.05). We theorized that those with hematologic malignancies had a greater risk of infection due to the aggressive nature of treatment protocols, which was expected to increase the rate of neutropenia. Those patients with low neutrophil counts were also more susceptible to infection. Furthermore, our research suggested that patients with external catheters may have a higher risk of infection because the catheter was exposed at all times, and the exchange tube was not changed each time the catheter was accessed, which increased the potential for contaminants to accumulate along the tip. In this study, there was no statistically significant correlation of positive cultures with age, BMI percentile, and number of catheter days. As a result, this study should motivate subsequent investigations into the causes of CVC-related infections.
CHAPTER 1

Introduction

Central Venous Catheters (CVCs) are necessary for the treatment and supportive care of patients with cancer and other chronic diseases. Prior to the use of CVCs, peripheral intravenous lines were used to deliver chemotherapy drugs that are highly toxic and result in severe damage to patients’ subcutaneous tissue and peripheral veins. Subcutaneous tissue necrosis is often the result of repeated extravasal injection upon IV insertion. Repeated injections into these blood vessels also cause thrombophlebitis, which gradually destroys the lining of the peripheral veins (Hall, Cedermark, & Swedenborg, 1989). Over time, the availability of peripheral veins for intravenous treatment is problematic and delivery of chemotherapy medication is difficult.

Central venous catheters were used as early as the 1950s (Tan, Hong, Huang, & Lee, 2000), and soon became the standard of care for delivery of chemotherapy drugs. Central venous catheters are inserted into larger veins (either the jugular, subclavian, or femoral veins) because these veins are more resistant to drug toxicity and are better able to tolerate the chemotherapy treatment. Thus, central venous catheters optimize the delivery of chemotherapy. CVCs also allow for easy administration of antibiotics, blood products, and blood sampling. Unfortunately, the rate of CVC related infections is high, which can be devastating to immunocompromized cancer patients. (Henrikson & Axtell, 2000).

There are many factors that contribute to central venous catheter related infections. A number of research studies have linked increased CVC infection rates to
factors such as patient age, immune status, and age related body size (Jonge, Polderman, & Gemke, 2005). Others have concluded that variables such as the type of catheter used (Flynn, Willis, Guar, & Shenep, 2003) (Allen, Holdsworth, Johnson, Chavez, Heideman, Overturf, et al., 2008), period of catheter insertion and patient age at time of catheter insertion (Abbas, Fryer, Paltiel, Felimban, Abdulmotalib, & Khattab, 2003) influence infection rates. Various other studies have also shown a link between central venous catheter related infections and thrombosis.

Significance to Nursing

Complications from central line infections include bacteremia, sepsis, and the possibility of death. Pediatric oncology patients are immunocompromized as a result of chemotherapy and other cancer treatments. As a result, their ability to fight infections is limited. Thus, it is imperative to study the causes and potential treatments of central venous catheter related infections in pediatric oncology patients.

Purpose of the Study

The purpose of our study was to describe factors that are associated with an increased risk of infection in pediatric oncology/hematology patients. We retrospectively and prospectively gathered data related to the cause of central venous catheter associated infections in pediatric oncology patients. Variables that were studied included patient age, gender, BMI, type of catheter used and type of cancer. Information was collected about the total number of catheter days and the provider who placed the catheter. For each patient with an infection, we collected data on immune status at the time of infection, platelet count, type of organism cultured, type of treatment, and inpatient or
outpatient status. Special attention was paid to the presence or absence of a thrombus.

Data gathered from the total number of infections and catheter days was used to
determine the rate of infection.

This study will contribute new knowledge related to minimizing complications
and infection rates among the pediatric patient population who receive treatment using
central venous catheters as a delivery system.

*Research Question:*

What variables contributed to increased rates of central venous catheter related infections
among the pediatric oncology population?

*Conceptual Framework:*

This thesis presented a review of relevant literature in the field of CVC infections
and a retrospective analysis of CVC infections on a sample population at the University
of Arizona Health Sciences Center. In order to evaluate potential risk factors for
infection, a literature review was conducted. Collecting risk factors, prophylactic
treatment options, and reactive treatment options, the following logical framework for
data collection was diagramed.
Figure 1. Conceptual Framework Model

Patient based factors included age, height and weight, BMI percentile, diagnosis, Absolute Neutrophil Count, platelet count, and inpatient or outpatient status. Catheter based factors included the type of catheter selected (internal vs. external) and the number of catheter days. Disease management and treatment based factors included the type of organism cultured and the treatment for positive blood cultures. The impact of these factors on the infection rate was analyzed.
CHAPTER 2
Review of Literature

*Catheter Related Infections and Thrombosis*

A number of research studies have shown a link between central venous catheters and thrombosis (or blood clots). It is now believed that the formation of a fibrin plug (an essential part of clot formation) facilitates the build up of bacteria along the tip of the central venous catheter (Abdelkefi A, & Torjman L, 2005). As a result, research has been conducted to determine whether the use of tissue plasminogen activator (an enzyme that dissolves clots) and heparin (another anticoagulant) along the catheter tip, either alone or in combination with antibiotics, can prevent CVC-related infections. However, studies on the impact of anticoagulants on CVC infections need to account for other factors that may influence infection rates.

*Other Risk Factors*

A study by Jong et al. (2005) indicated that certain patient demographics influenced a patient’s risk of infection. This literature study of pediatric oncology patients considered factors such as body size, age, and age-related immune status on the infection risk. The study found that there was a significant difference in factors relating to infection in both children and adult populations. In pediatric populations, body size, age, and age related immune status were factors that were closely linked to infections. Implanted catheters were typically used more often in the pediatric population than in the adult population, and site placement depended on factors such as patient age and the need for sedation and analgesia during the procedure. The authors of this study recommended
that, in contrast to adult protocol, a radiograph should always be made following CVC insertion in children to check the position of the catheter. They also recommend using full sterile barrier precautions during CVC insertion and strict protocol for catheter care. They further recommended that catheters be removed as soon as possible when no longer needed, but agreed that there was no need for elective CVC replacement on a routine basis. Although they found that the use of catheters impregnated with antibiotics may reduce the risk of infection, they indicated that more research is required on the subject.

Flynn et al. (2003) studied whether catheter design can influence the eradication of bacteremia or its recurrence. Patients at St. Jude Children’s Research Hospital with bacteremic episodes were included in this study. The data collection spanned from 1996-2001, with a total number of 172 cases. The authors found that catheter design did not influence short term eradication of bacteremia. However, the study did find that external central venous catheters were significantly associated with recurrence of this infection.

Abbas et al. (2003) looked for a possible correlation between the type of catheter inserted, the time of insertion and the age of the patient when diagnosed with acute lymphoblastic leukemia (ALL). Data was collected at the National Guard Hospital from 1996-1999. Factors such as age, timing of catheter insertion, treatment protocol, and the type of catheter insertion were closely examined. It was found that external catheters were more strongly associated with infection than totally implantable devices. Treatment protocol and patient age were significant only when the patient’s first line was being inserted. Timing of catheter insertion did not have a statistical impact on infection rates.

Allen et al. (2008) evaluated factors that may predispose children and young
adults to catheter related infections. All pediatric oncology patients with CVCs were included in the study. Special attention was paid to tumor and catheter type. Rates of infection were stratified by tumor histology and type of catheter design. Statistical comparisons were made using the Mantel-Haenzel statistic and the Cox proportional hazard model. Analysis of the data indicated that cancer patients using tunneled external catheters had the greatest risk of developing central venous catheter related infections.

Frantino et al. (2005) studied a number of factors that might correlate with an increased CVC complication rate. The study evaluated 418 central venous catheters inserted into 368 children from January 2000-May 2002. The study looked at risk factors such as type of malignancy and type of catheter used. The study concluded that those with hematological malignancies had significantly more complications than those with solid tumors (P<0.0001) and that single and double lumen broviac catheters (a type of external catheter) had a higher rate of infection than any other type of catheter studied.

Impact of Anticoagulants on CVC Infection

Studies by Abdelkefi and Torjman (2005), Pierce, Wade, and Mok (2000), and Long and Coulthard (2006) found that the use of heparin flushes significantly reduced infection and thrombosis rates in pediatric populations when compared to normal saline flushes.

Abdelkefi and Torjman (2005) evaluated the use of heparin flushes to eradicate fibrin sheath formation that is associated with central venous catheter related infections. The authors performed a randomized control trial to evaluate the use of heparin in 208 patients using non-tunneled catheters. The experimental group received heparin
prophylaxis. It was found that the use of heparin reduced the infection rate from 16.6% in the control group to 6.8% in the experimental group. The use of heparin was recommended for use with catheterization of patients with hemato-oncological disease.

Pierce et al. (2000) evaluated the impact of heparin bonding on central venous catheter-related infections and thrombosis. A double blind methodology was use to divide 209 critically ill children into two groups. One group received treatment with heparin bonding and one did not. The study found that heparin bonding in the CVAD significantly reduced the infection and occurrence of thrombosis. In addition, the proactive use of heparin bonding was found to be more cost-effective than the reactive treatment of infections and thrombosis.

Long and Coulthard (2006) evaluated the use of heparin-bonded central venous catheters on thrombosis and infection in both children and adults, using meta-analysis of earlier studies. Two studies (one conducted with children and the other with adults) were selected based on the research criteria, which included the use of randomized controls. Both studies concluded that heparin-bonded catheters significantly reduced infection and thrombosis rates.

Other anticoagulants have been evaluated for effectiveness as an alternative to heparin. Simon and Bode (2008) studied the effectiveness of the anticoagulant urokinase in reducing CVC-related infections. The authors analyzed treatments using meta-analysis of earlier studies. These earlier studies consisted primarily of case studies, with no systematically-randomized and controlled trials. The meta-analysis suggested a likely benefit to adding urokinase to long-term CVAD treatments, and the authors
recommended a controlled evaluation. The study suggested that the use of urokinase at a
dose of 5000 IU/ml (in the case of occlusion) or an infusion for 3 hours at 1000 IU/(Kg-hr) may be safe and effective.

**Hemophilia and Hemodialysis Studies**

Similar studies have been performed on hemophiliacs, a population of patients
that frequently use CVC’s. Dunn and Abshire (2008) performed a study on hemophilia patients that indicated the use of tissue plasminogen activator (TPA) was successful in reducing the frequency of CVC-related infections. The histories of all pediatric patients undergoing treatment in an initial study were reviewed. Three patients were eligible to be treated with recombinant tissue plasminogen activator every 2 weeks. The researchers collected information on age, severity of hemophilia, inhibitor titers, factor infusion schedules, dates of catheter placement and removal, types of catheters used, number of catheter infections, dose and scheduling of rTPA usage, and catheter imaging results. The rates of infections were compared to hemophilia patients who did not use rTPA. The authors contended that TPA was effective in reducing infection rates. However, a literature study by Ragini, Journecake, and Brambilla (2008) came to a different conclusion. These authors looked for correlations between central venous catheter-related infections and local thrombosis in children with hemophilia. Meta-analysis of the published thromboprophylaxis trials indicated that prophylactic treatment with rTPA did not prevent CDC infection. A literature review also suggested that thrombosis and infection rates do not occur simultaneously.

Onder and Chandar (2008) performed an evaluation on hemodialysis patients,
comparing the effects of treating already-infected patients with either TPA or heparin. For 10 months, 42 children on hemodialysis were observed for symptoms of CVC-related infections. Children with infections were treated with either an antibiotic lock with TPA, or an antibiotic lock with heparin. All children with CVC infections had symptoms that were resolved within 48 hours of treatment. Of the 18 children treated, 6 had recurrent infections. Children who were treated with the heparin antibiotic lock had a lower incidence of recurrent infection than those treated with TPA.

Combination Treatments

Henrickson and Axtell (2000) evaluated the effectiveness of three different catheter solutions in preventing central venous line infections. One hundred twenty-six pediatric oncology patients were divided into three groups using double blind methodology. One group received a heparin flush, another group received vancomycin and heparin, and the third group received vancomycin, heparin, and ciprofloxacin. Children receiving solutions that contained antibiotics and heparin showed significant reductions in gram positive and gram negative infections, as well as a lower number of occlusions, in comparison to the group that received heparin alone.
CHAPTER 3

Methods

After obtaining approval from the University of Arizona Human Subjects Protection Program, we retrospectively gathered data on patients aged 0-21 years who were treated by pediatric hematologists/oncologists at the University of Arizona Health Sciences Center. All of the patients had central catheters placed between January 1, 2007 - July 1, 2010 and had a diagnosis of a malignancy or Langerhans cell histiocytosis. We chose 2007 as the start date because prior to 2007 records were recorded on paper and were located off-site. Stem-cell transplant patients were censored at the time of transplant conditioning. Due to underlying immunosupression, patients with aplastic anemia or post-transplant lymphoproliferative disorder were excluded from the study.

The types of catheters placed were by physician discretion, considering factors such as diagnosis, age of the patient, and the need for multiple lumens to infuse medications. Peripheral inserted central catheters (PICC lines) and tunneled external catheters were flushed daily by caregivers or nursing staff. Access to all Port-a-caths was done using sterile techniques and catheters were flushed with heparin after each use. Dressings and needles were changed at least every 7 days. If the Port-a-caths were not in frequent use, they were flushed with heparin every 4 weeks to minimize the risk of developing thromboses.

A cohort of 106 patients from the database of newly diagnosed oncology patients met the above criteria. We gathered information on the diagnosis, age at diagnosis, gender, height and weight at diagnosis, type of catheter, total catheter days, and the
provider placing the catheter (pediatric surgeons vs. interventional radiology, etc.).

Immediately following a recorded positive blood culture, we extracted data on the type of organism cultured, treatment, ANC, platelet count, number of catheter days, and inpatient or outpatient status. All culture data and number of catheter days were censored on October 1, 2010 unless the patient began a stem cell transplant prior to that date. In such cases, data was censored at the time of transplant conditioning.

We also collected information on whether the patient had a thrombosis with the catheter 30 days prior to the positive blood culture. Inpatient and outpatient medical records provided information on any TPA administration done 30 days prior to the positive blood culture and radiology records indicated if any dye studies were performed for presumed thrombosis. Unfortunately, we discovered that documentation of TPA in the inpatient administration records was inconsistent. Although we did uncover 2 outpatient records that indicated TPA use, this would not allow for analysis of statistically significant data. The use of pharmacy records to prove TPA use in individual patients would have been helpful, but unfortunately current pharmacy databases do not allow for such a query. This is one limitation of a retrospective study.

Since the height and weight at diagnosis was recorded for each patient, we were able to calculate the BMI percentile for all patients over 2 years of age. We used weight in place of height percentiles for children less than 2 years of age. Those with percentiles under 5% were considered underweight, while those with percentiles greater than 90% were considered overweight.

We calculated the number of catheter days by examining data on line placement
to: a) the time of a positive culture, b) removal of the line (either due to persistent infection, line malfunction, or completion of therapy), c) patient death, d) time of stem cell transplant, or e) censoring of the data on October 1, 2010. The infection rate was calculated as the total number of catheter related infections/ the total number of catheter days x 1000. Infection rates were stratified by type of catheter, patient diagnosis, BMI percentile or weight/height for age percentile, age, and provider who placed the catheter using Chi squared analysis or T-tests.
CHAPTER 4

Results

Demographics

Our sample population of 106 patients consisted of 50 males and 56 females. The mean age was 107.4 months, ranging from 0-242 months. Forty-two patients had solid tumors (Table 1) and 64 had hematologic tumors (Table 2). There were a total of 124 lines placed. Eleven patients had their lines replaced at least once, and 2 patients had four lines. All but one of the lines was changed due to infection. University Medical Center pediatric surgeons placed 102 lines, Interventional Radiology placed 13 lines, the Pediatric Intensive Care Unit (PICU) team placed 5 lines, and 4 lines were placed outside of University Medical Center. Thirteen patients were below the 10th percentile, 40 were above the 80th percentile and 24 were above the 95th percentile for BMI.

A total of 36 male and 35 female patients had no positive cultures. Of these 71 patients, 34 had solid tumors and 37 had hematologic tumors. Fifty-four patients had implanted catheters and 17 had external catheters. Fifty-nine of the catheters were placed by pediatric surgeons and the remaining 12 were placed by Interventional Radiology (IR), the Pediatric Intensive Care Unit (PICU) or others. Twenty-three patients had a BMI greater than 85%, while 48 had a BMI less than 85%. The average age of those without positive blood cultures was 114.7 ± 73.8 months.

Twenty males and 15 females had positive blood cultures. Furthermore, 18 patients had 2 or more positive blood cultures. There were 72 cases of positive blood cultures over 42,501 catheter days, which represented an infection rate of 1.69/1000
catheter days. Of the 23 microorganisms identified in the positive blood cultures, 9 were gram positive, 3 were fungal, and 11 were gram negative cultures (Tables 3-5). The two most commonly cultured organisms were *Escherichia coli* and *coagulase negative staphylococcus*. Of the 35 patients with positive cultures, 8 patients had solid tumors and 27 had hematologic tumors. There were 85 internal catheters and 39 external catheters used. Forty-one catheters were placed by pediatric surgeons, 7 were placed by Interventional Radiology and 2 were placed by the Pediatric Intensive Care Unit. Thirteen patients had a BMI percentile over 85 and 22 had a normal BMI. The average age of those with positive cultures was 89.1 ± 76 months.
Table 1

**Solid Tumors**

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desmoplastic Small Round Cell Tumor</td>
<td>1</td>
<td>2.38</td>
</tr>
<tr>
<td>Ewing’s Sarcoma</td>
<td>5</td>
<td>11.90</td>
</tr>
<tr>
<td>Germ Cell Tumor</td>
<td>2</td>
<td>4.76</td>
</tr>
<tr>
<td>Glioblastoma</td>
<td>1</td>
<td>2.38</td>
</tr>
<tr>
<td>Hepatoblastoma</td>
<td>2</td>
<td>4.76</td>
</tr>
<tr>
<td>Hepatocellular Carcinoma</td>
<td>2</td>
<td>4.76</td>
</tr>
<tr>
<td>Meduloblastoma</td>
<td>2</td>
<td>4.76</td>
</tr>
<tr>
<td>Neuoblastoma</td>
<td>2</td>
<td>4.76</td>
</tr>
<tr>
<td>Osteocarcoma</td>
<td>3</td>
<td>7.14</td>
</tr>
<tr>
<td>Pontine Glioma</td>
<td>4</td>
<td>9.52</td>
</tr>
<tr>
<td>Retinoblastoma</td>
<td>3</td>
<td>7.14</td>
</tr>
<tr>
<td>Rhabdomyosarcoma</td>
<td>5</td>
<td>11.90</td>
</tr>
<tr>
<td>Supratentorial Primitive Neuroectodermal Tumor</td>
<td>2</td>
<td>4.76</td>
</tr>
<tr>
<td>Wilm’s Tumor</td>
<td>8</td>
<td>19.04</td>
</tr>
</tbody>
</table>
### Table 2

*Hematologic Tumors*

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Lymphoblastic Leukemia</td>
<td>35</td>
<td>54.68</td>
</tr>
<tr>
<td>Acute Myeloid Leukemia</td>
<td>4</td>
<td>6.25</td>
</tr>
<tr>
<td>Biphenotypic Leukemia</td>
<td>1</td>
<td>1.56</td>
</tr>
<tr>
<td>Burkitt’s Lymphoma</td>
<td>4</td>
<td>6.25</td>
</tr>
<tr>
<td>Hodgkin’s Lymphoma</td>
<td>13</td>
<td>20.31</td>
</tr>
<tr>
<td>Langerhans Cell Histocytosis</td>
<td>3</td>
<td>4.68</td>
</tr>
<tr>
<td>Non Hodgkin’s Lymphoma</td>
<td>4</td>
<td>6.25</td>
</tr>
<tr>
<td>Type</td>
<td>Frequency</td>
<td>%</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----------</td>
<td>-----</td>
</tr>
<tr>
<td>Bacillus species</td>
<td>4</td>
<td>9.75</td>
</tr>
<tr>
<td>Coagulase negative staphylococcus</td>
<td>14</td>
<td>34.14</td>
</tr>
<tr>
<td>Enterococcus faecalis</td>
<td>5</td>
<td>12.21</td>
</tr>
<tr>
<td>Leuconostoc</td>
<td>1</td>
<td>2.44</td>
</tr>
<tr>
<td>Micrococcus species</td>
<td>3</td>
<td>7.32</td>
</tr>
<tr>
<td>Norcardia</td>
<td>1</td>
<td>2.44</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>4</td>
<td>9.75</td>
</tr>
<tr>
<td>Streptococcus pneumonia</td>
<td>1</td>
<td>2.44</td>
</tr>
<tr>
<td>Streptococcus viridans</td>
<td>8</td>
<td>19.51</td>
</tr>
</tbody>
</table>
Table 4

*Fungal Cultures*

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candida dubliniesis</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Candida parapsilosis</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>Candida tropicalis</td>
<td>1</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 5

*Gram Negative Cultures*

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capnocytophagia species</td>
<td>2</td>
<td>7.43</td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>10</td>
<td>37.04</td>
</tr>
<tr>
<td>Haemophilus influenza</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Klebsiella oxytoca</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Moraxella catarrhalis</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Neisseria elongata</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Neisseria sicca</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Proteus vulgaris</td>
<td>1</td>
<td>3.70</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>7</td>
<td>25.93</td>
</tr>
</tbody>
</table>
Data Analysis

Chi squared tests were conducted comparing patients with positive and negative cultures with respect to the nature of the diagnosis, the type of catheter inserted, gender, BMI percentile, and placer of the catheter. T-tests were conducted comparing patients with positive and negative cultures with respect to age, BMI percentile, and catheter days.

Significant Findings

Our finding showed that those with hematologic tumors had more infections than those with solid tumors, $X^2(1, N=106) = 8.21, p< 0.01$ (see Table 6). Furthermore, those with non-implanted catheters were more predisposed to infections, $X^2(1, N=106) = 4.34, p<0.05$ (Table 7).

Table 6

Summary of Cultures by Solid Tumors vs. Hematologic Tumors

<table>
<thead>
<tr>
<th></th>
<th>Positive Cultures</th>
<th>Negative Cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Tumors</td>
<td>8</td>
<td>37</td>
</tr>
<tr>
<td>Hematologic Tumors</td>
<td>27</td>
<td>34</td>
</tr>
</tbody>
</table>

$X^2(1, N=106) = 8.21, p< 0.01$
Summary of Cultures by Implanted vs. Non Implanted Catheters

<table>
<thead>
<tr>
<th></th>
<th>Positive Cultures</th>
<th>Negative Cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implanted Catheters</td>
<td>31</td>
<td>54</td>
</tr>
<tr>
<td>Non Implanted Catheters</td>
<td>22</td>
<td>17</td>
</tr>
</tbody>
</table>

$X^2(1, N=124) = 4.34, p<0.05$

Other Findings

Using Chi squared analysis, we found no significant difference when comparing positive and negative cultures with gender $X^2(1, N=106) = 0.39, p=0.53$, BMI percentile $X^2(1, N=106) = 0.236, p=0.63$, or places of catheter lines $X^2(1, N=124) = 0.08, p=0.77$.

The t-test was used to compare positive and negative cultures using non-categorical factors (such as age). We found no statistically significant difference between positive (M=92, SD=75), and negative cultures (M=114.7, SD=71), through the t-test with age, $t(106) = 1.4685$. Similarly, we found no statistical significance between positive (M=61.6, SD=35.5) and negative cultures (M=60.2, SD=32), through the t-test with BMI percentile, $t(106) = 0.8491$. Additionally, we found no statistical significance between positive (M=337.52, SD=321.32) and negative cultures (M=344.78, SD=283.73), through the t-test with the number of catheter days, $t(124) = 1.4685$. 

CHAPTER 5
Discussion

A key finding of this study was that external catheters are associated with a higher incidence of infections. This is consistent with previous findings in Flynn et al. (2003), Abbas et al. (2003), and Allen et al. (2008). External catheters pass through the derma, which may offer a pathway toward increased infection. To combat this, standard protocols require a sterile patch (Biopatch™) and a clear cover (Tegaderm ™), but there is always some possibility of infection even with these measures. External catheters may be subject to trauma at the insertion site, since part of the catheter is exposed at all times, and the catheter may be pulled by patient movement, visitors, or even hospital staff. Also, the external tube is not changed each time the catheter is accessed, and it is possible that contaminants accumulate on the tip. In contrast, implanted catheters (such as the Port-a-Cath™) have no external components when not being used to administer medication. Insertion protocols used with the implanted catheters require the use of sterile procedures, and the attachment is by penetration of the sub-dermal catheter membrane by a needle.

Another major finding was that patients with hematologic malignancies had higher rates of infection than other groups. Treatment of hematologic malignancy tends to be aggressive, which can result in neutropenia. Low neutrophil counts increase susceptibility to infection. The combination treatments evaluated by Hendrickson et al., combined with proper sterile procedure, may provide a reduced risk of infection for these immunocompromised patients. Hendrickson’s evaluation showed decreased infection rates by catheter flushing with both heparin and vancomycin, or a combination of
heparin, vancomycin, and ciprofloxacin.

The two most commonly cultured organisms found in this study were *Escherichia coli* and *coagulase negative staphylococcus*. Staph is commonly found on the skin (a component of normal flora that does not typically make healthy people ill). This could perhaps indicate that those with CVC-related staph infections are most likely neutropenic. Similarly, *E. coli* is also found on the skin. The high occurrence of *E. coli* infections may be due to poor hand hygiene and inadequate or improper use of sterile technique.

*Findings Related to Literature*

Several studies have shown the link between external catheters and higher rates of infection. Flynn et al. (2003) studied whether catheter design can influence the eradication of bacteremia or its recurrence. The authors found that catheter design did not influence short term eradication of bacteremia. However, external catheters were significantly associated with recurrence of bacteremia. Abbas et. al (2003) found that external catheters were associated with higher infection rates. Other factors were significant only when the patient’s first line was being inserted. Allen et al. (2008) found higher infection risk for cancer patients with tunneled external catheters as compared to implanted catheters. The higher infection rates associated with external catheters were consistent with our findings.

Our findings on overall infection rate (1.69 per 1000 catheter days) was also closely related to studies done of a similar sample population. The study conducted by Allen et al. (2008) included a sample size of 139 pediatric oncology patients with either internal or external CVCs. The infection rate of their sample was 1.6 per 1000 catheter days. Allen et al. (2008) also found that the two most commonly cultured organisms
were Escherichia coli and coagulase negative staphylococcus. These finding were consistent with our results.

At least one study has shown that patients with liquid tumors are more predisposed to CVC-related infection. Frantino et al. (2005) found that patients with hematological malignancy had higher complication rates than those with solid tumors. This is also consistent with our findings.

Limitations

This study was a retrospective analysis of existing patient data collected at one facility over a specific time range. It is possible that other facilities have different patient and disease mixes, protocols, and standards, and so a similar study at a different facility could yield different results. This is a characteristic limitation of many retrospective studies. Specific evaluation of different treatment methods is best performed with controlled studies.

Another limitation in the study pertains to the dataset itself. The data collected for Absolute Neutrophil Count (ANC) was not suitable for either Chi-squared or t-test analysis, since there was no data in this subset with negative cultures. Subsequent studies should include this parameter for all patients.

Implications for Nursing Practice

This study, when combined with analysis of the literature, suggested a possible approach to reducing infection rates for the most immunocompromized patients or chemotherapy patients likely to become immunocompromised due to treatment (such as patients with hematologic malignancies). A combination of heparin/antibiotic flushing
with the use of implanted catheters would appear to have potential benefit and merits further investigation. Individual treatment plans, however, are made on a case-by case basis by the attending physician. For individual staff nurses, adherence to sterile protocols and awareness of possible infection mechanisms is imperative.

Another implication for nursing practice is that more attention needs to be paid to the frequency of port access and control over the access. For example, in the case of pediatric patients, do parents access the ports in some cases, and if so, is this practice associated with increased infection?

**Future Recommendations**

For nursing and other medical researchers, it would be of great value to continue investigations into CVC-related infection. Both mechanistic and protocol-based studies are merited. Data collection for this study was through chart audits. It may be advantageous in future studies to follow patients longitudinally to gain a deeper understanding of factors related to infection risk. The discovery of a relatively high incidence of *E. coli* in this study suggests possible problems with sterile protocol. A longitudinal study could possibly reveal information about who is accessing the ports, and the relationship between port access frequency and infection rate. Although difficult to realize, the use of double-blind, controlled studies is highly recommended.
References


