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Cost-Effectiveness Analysis of Tunneled Central Venous Catheter Dressings in Canadian Blood Stem Cell Transplant

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COST-EFFECTIVENESS ANALYSIS OF TUNNELED CENTRAL VENOUS CATHETER DRESSINGS IN CANADIAN BLOOD STEM CELL TRANSPLANT

by

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COST-EFFECTIVENESS ANALYSIS OF TUNNELED CENTRAL VENOUS CATHETER DRESSINGS IN CANADIAN BLOOD STEM CELL TRANSPLANT

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Central venous catheters (CVC) are integral tools used in blood stem cell transplant with registered nurses responsible for maintenance and catheter care. However, CVC practice guidelines in the literature are inconsistent or absent. Gaps in the evidence generated several research questions regarding potential variability in CVC practice across Canada and the impact that variability may have on healthcare spending and patient outcomes. A survey revealed differences in CVC practice across Canada that coincide with discrepant and/or absent guidelines. Current cost-analyses within the blood stem cell transplant population were also absent in the literature. The cost of a single CRBSI was estimated using a case controlled comparison of records. The study quantified how costs can be contained through prevention efforts, and identified the importance of nursing research targeting infection control. One prevention area was tested in terms of infection

outcomes with tunneled catheters used by blood stem cell transplant recipients. The descriptive study compared three different nursing strategies for CVC exit site care in terms of CRBSI and cost. Results indicated each strategy poses similar CRBSI risks with significant differences in expense. Maximum value was attributed to transparent dressings followed by removing the dressing and lastly using a gauze dressing. The no dressing strategy was a more cost-effective alternative when a transparent dressing cannot be tolerated. Further analysis of the data generated in this project is ongoing with the intent to delineate other areas of nursing influence on CRBSI and identify further potential areas for cost containment.

Chapter One: Introduction

Mature cells in the human body *stem* or originate from a parent cell. The first cell in a lineage of cell chains that differentiate until maturity is often defined as a stem cell. There are many types of stem cells throughout the body that are the focus of transplant research. Hematopoietic or CD34 stem cells are sourced in the bone marrow and responsible for the production of several cell chains that eventually develop into the blood supply (Tomblyn et al., 2009). Certain hematological disorders interfere with normal blood and marrow functioning which may require a blood stem cell transplant. The basics of blood stem cell transplant are to eliminate abnormal cells and introduce a new source for healthy blood production. The source of stem cells used for transplant has given rise to different terms and medical acronyms. Transplanted stem cells may be given within a volume of bone marrow, otherwise known as a bone marrow transplant (BMT). Hematopoietic progenitor cell transplant (HPCT) uses isolated stem cells that are filtered from the bloodstream of the donor through a process known as apheresis. A cord transplant uses stem cells collected from a donated umbilical cord. BMT, HPCT, and cord transplant are all subcategories of the broader blood stem cell transplant (SCT) population.

Scientific progress, albeit beneficial, has increased hospital patient acuity outside of Intensive Care Units. Registered nursing care with acute populations often requires advanced competency training. Blood stem cell transplant nurses possess specialty knowledge for delivering treatments such as chemotherapy, blood products, and biologicals etc. These nurses must also develop skillful assessment abilities for monitoring critically ill patients, managing symptoms, and alleviating side effects of treatment. Complications faced by blood stem cell transplant recipients include weight loss, nausea, and graft versus host disease; however, infection predominates, occurring in over 60% of patients (Weissinger et al., 2011). Infection during acute transplant and beyond increases reliance on registered nursing care as several behaviors, actions, interventions, and facilitation of the multidisciplinary team are needed to address occurrence.

Central venous catheters (CVC) are an integral part of blood stem cell transplant nursing and a potential source of infection. Removing the dressing from the healed exit site of a tunneled CVC is a recent trend in the industry. In clinical practice, this author has observed the implementation of policy changes such as dressing removal with little explanation or provision of supporting evidence. Westbrook, Duffield, Li, and Creswick et al. (2011) point out that registered nurses work in such a high paced environment that they only spend around 37% of their time with patients. Majid et al. (2011) report that registered nurses in Singapore claim they are unable to keep up to date with current evidence due to heavy workloads. Findings suggest staff nurses entrust nurse leaders to expedite the dissemination of evidence that is incorporated at the bedside. Questionable policy changes may foster slow change or even initial non-adherence as was observed in

personal practice. Whether the dressing on a healed tunneled CVC exit site should be removed or maintained depends on the standpoint of the consulting panel. (Gillies, O'Rordan, Sheriff, & Rickard, 2011; Infusion Nurses Society, 2011; O'Grady et al., 2011; Olsin et al., 2004; Scales, 2010b; Seiler & Pember, 2012; Toshiyuki et al. 2012). Gaps in the evidence coupled with recent changes mandating dressing removal at the authors clinical practice site generated the research questions for this project.

Canada does not have universal practice standards for CVC nursing care. Initially, it was unclear if removing the dressing from a healed tunneled CVC exit site was becoming a baseline nationwide care strategy. Boersma and Schouten (2010) reported that care differences occur in elements of CVC care when there are unclear positions on the best course of action. It was hypothesized that CVC practice in blood stem cell transplant also differs across Canada which may result in excess healthcare spending and different outcomes. Subsequently, a descriptive survey of Canadian practice was planned and conducted in the summer of 2013 (Appendix A) following university institutional review board (IRB) approval (Appendix B). This initial survey, reported in Chapter Two, notes similar findings to Boersma and Schouten (2010) revealing differences in CVC practice across the nation that coincide with discrepant and/or absent CVC guidelines. Results of the study are currently in press according to the author guidelines in Appendix C, and publisher permission to include the manuscript in this portfolio was granted (Appendix D).

Following the initial survey study, it was unclear if CVC care differences pose the same risks for negative outcomes. Device-associated complications such as catheter-related bloodstream infection (CRBSI) are costly and avoidable. The literature did not

contain Canadian estimates of CRBSI costs beyond one study that only considered fees for extended length of hospital stay (Raschka, Dempster, & Bryce 2013). The unique needs of the blood stem cell transplant population and use of one specific type of CVC among 90% of centers surveyed in the first study directed research attention to the need to determine the cost of a single CRBSI alongside a planned study comparing negative outcomes among CVC dressing strategies. Understanding costs associated with the different dressing strategies was an integral first step to determining if one particular strategy was more effective in terms of preventing infection and the cost effectiveness associated with the various dressing strategies. University IRB and ethics board approval from the practice site (Appendix B) were secured for implementing a two-pronged study to examine costs associated with CRBSI and to determine the incidence of CRBSI among patients whose CVC sites were maintained using one of three dressing strategies.

The cost of a single CRBSI was estimated using a case controlled comparison of records and is reported in Chapter Three. Study results quantified CRBSI in Canadian dollars, thus informing how costs can be contained through prevention efforts and identifying the importance of nursing research targeting infection control. Concomitant examination of CRBSI with different exit site dressings was compared as planned. Asepsis theory guided variable selection (Duval, 2010). Tenets of the theory portray co-existence versus pathological relationships between hosts and micro-organisms that can be influenced by clinical actions. The descriptive study compared three different nursing strategies for CVC exit site care (transparent dressing, no dressing, or gauze dressing) in terms of CRBSI and fees for supplies. Results from this study are reported in Chapter Four.

Findings from this emerging program of research have the potential to influence blood stem cell transplant nursing practice in Canada and across the globe. These studies provide empirical data to help clinicians make informed and evidence-based practice decisions that may lead to improved patient outcomes and responsible fiscal practices.

Chapter Two: Central Line Practice in Canadian Blood and Marrow Transplant

Abstract and manuscript prepared for the Canadian Oncology Nursing Journal (in Press)

Abstract

More than 800 blood cell and bone marrow transplants are performed annually in Canada to treat fatal cancers and rare blood disorders. Central vascular access is fundamental in blood and marrow transplant nursing to facilitate chemotherapy and blood product infusions. A tunneled Central Venous Catheter (CVC) is the vascular access device-of-choice in the cell and marrow transplant population. Several practice guidelines direct nursing policy and procedure for CVC management and care. CVC insertion and removal guide- lines are increasingly relevant given the widening scope of advanced practice nursing. Unresolved issues are noted among the most heavily cited CVC practice recommendations accessible via the Centers for Disease Control and Prevention (CDC). A descriptive survey based on the CDC guidelines was conducted to identify potential variability in CVC strategies in Canadian blood and marrow transplant nursing. Survey results indicate nationwide differences in catheter site selection, educational strategies, dressing strategies, delegation of dressing changes, and volumes

of flushing and locking solutions used to manage catheter patency. Variability in practice coincides with gaps in the evidence identified in practice recommendations. Future studies comparing specific care approaches to device-associated complications are needed to resolve issues and strengthen practice guidelines.

Chapter Two: Central Line Practice in Canadian Blood and Marrow Transplant

Blood cell and/or bone marrow transplant is conducted for certain life-threatening diseases and blood cancers. Transplant involves obliterating the bone marrow followed by repopulation with donated cells. Tomblyn et al. (2009) explain that disease is both targeted and eradicated by proxy through destroying the system of origin. The curative aim of treatment is for transplanted donor cells to manufacture a new disease-free blood supply within the recipient. Procedurally, blood and bone marrow transplant is provided through intravenous infusions of chemotherapy, supportive medications, fluids, and transfusions of blood products including donor cells. A central venous catheter (CVC) is one type of vascular access device that was specially developed for complex medical care by enabling long term use, exchange of large fluid volumes, and delivery of medications caustic to peripheral veins (Scales, 2010). Patients describe a CVC as instrumental towards cure because it is the portal for delivering treatment (Møller & Adamsen, 2010).

CVC care and management, as well as patient education, are primarily the responsibility of registered nurses in Canada. Given that risks are associated with using medical devices patient safety is a central concern. Pneumothorax, infection, and thrombosis are examples of complications associated with CVC use (Kim et al., 2010; O'Grady et al., 2011). Infection

is of particular concern with the cell transplant population given their weakened immunity from disease and treatment (Tomblyn et al., 2009). Nursing policy and procedures routinely incorporate study findings that correlate CVC care strategies with minimized risks. However, at present, there remain gaps in the evidence to support nursing practice in this area. Boersma and Schouten (2010) found that actual CVC practices vary across Europe as a manifestation of discrepant and/or absent practice guidelines. It is not known what the adherence to guidelines regarding CVC care is across Canada.

Several jurisdictions provide clinical practice guidelines for CVC competency including insertion, routine care, maintenance, and removal (Appendix A). The recommendations by O'Grady et al. (2011) are the most frequently cited in North America given open access via the American Centers for Disease Control and Prevention (CDC) and collaboration with several expert panels. Unresolved issues noted by O'Grady et al. (2011) point out gaps in the evidence concerning CVC care and management worth future research attention. Specific issues in blood and marrow transplant nursing described in the report are that no evidence-based recommendations can be made for optimal site selection for the catheter, optimal dressing type, removing the dressing from a healed tunneled CVC site, or managing catheter patency. Periodic competency training is also encouraged with no clear stance on frequency. Policy makers and Registered Nurses are faced with distinguishing between conflicting recommendations and using practice-based approaches when

evidence is lacking. The purpose of this descriptive study was to examine adherence to recommended CVC guidelines within the Canadian blood and marrow transplant population and identify potential nationwide variability in care strategies to be tested in future research.

Method

The study was approved by the institutional review board at the University of Texas at Tyler. As no other instrument existed, a descriptive survey was created for the purposes of this study, based on infection prevention guidelines for intravascular catheters by O'Grady et al. (2011). The survey included 33 questions of inquiry in four areas related to the tunneled CVC commonly used in blood and marrow transplant: insertion, routine care, maintenance, and removal. Survey questions contained various response options: yes or no choices, multiple choice, and open-ended formats. The survey was electronically distributed to 25 centres within the 14 blood cell and bone marrow transplant programs across Canada. A purposive sample of advanced practice nurses, nurse educators, managers, and program coordinators in blood and marrow transplant was invited to voluntarily answer questions regarding the CVC policy at their centre. One response per centre was accepted. A draw for a $50 gift card was used as an incentive for participation.

Results and Interpretation

Thirteen respondents returned surveys and indicated provision of blood cell and/or bone marrow transplant at their centre (Appendix B). Three surveys were omitted from the analysis, as only the first two demographic

questions were answered, for a total response rate of 40% (*n*=10). Responses included in the analysis represent both inpatient and outpatient settings treating adult (70%) and pediatric (40%) patients, seven of eight provinces offering blood and marrow transplant, and approximately 67% of the Canadian blood and marrow transplant population (Canadian Blood and Marrow Transplant Group, 2013).

The survey results reveal that variations in CVC practice coincide with discrepant and/or absent guidelines in the areas of competency training, insertion, routine care, maintenance, and removal. CVC practice is reported as the duty of physicians and nurses with overlapping responsibility for insertion, dressing changes, and removal. Forty per cent of centres indicated that CVC care is also delegated to patients, family members, and lay caregivers. Competency in CVC care requires learning skills, the rationale for device use, and how to avoid complications. Studies recommend targeted education to maintain vigilance with care and avoid human error (Faruqi et al., 2012; Rosenthal, 2009). All survey respondents reported that their centre has a policy in place to educate staff on insertion, routine care, and maintenance of a CVC. All centres that delegate routine care reported having a policy in place for educating patients, families, and lay caregivers. Sixty per cent of centres repeat CVC education annually while the remaining centres only rein- force policy changes. Different educational strategies coincide with the subjective recommendation by O'Grady et al. (2011) to periodically evaluate knowledge and concordance with recommended guidelines.

Insertion

Survey responses indicate CVC insertion is a physician responsibility in the majority of cases and adherence is fully observed in avoiding prophylactic antibiotics, avoiding femoral veins, and using tunneled or implanted catheters. Only one centre (10%) reported the use of antimicrobial impregnated cuffs which O'Grady et al. (2011) claim is only necessary with persistent infection in spite of prevention efforts. Instead, it is advised to employ multiple infection prevention strategies, known as bundling. CVC insertion bundling consists of: proper hand hygiene, using maximum barrier precautions (sterile gown, drape, gloves, equipment, and wearing a mask), using a >.5% chlorhexidine skin prep solution, choosing the appropriate site if known, and daily review of the necessity of the catheter with prompt removal when no longer essential (Faruqi et al., 2012; Moreau, 2009). Supervision for inexperienced practitioners and use of ultrasound guidance is also recommended to reduce the risk of insertion-related complications (Shekelle et al., 2013). In the survey results, adherence to bundling insertion strategies and use of ultrasound guidance was unknown by the responding nurses. Of note, the procedure is out of nursing practice scope in the majority of settings. The reported variation regarding insertion site selection coincides with the lack of evidence supporting subclavian over intra jugular sites, or one side of the body over the other (Ge et al., 2012). Awareness of insertion guidelines is increasingly important given advanced practice nurses are beginning to engage in line placement (10%).

Routine Care and Maintenance

There is general consensus in the literature that a newly inserted CVC is covered with a dressing, not submerged in water, and has an extra covering for showering. However, the optimal dressing material to use remains unclear (Gillies, O'Riordan, Sheriff, & Rickard, 2011). There is also consensus in the literature on the type of skin antiseptic to be used (>0.5% chlorhexidine or 70% alcohol, tincture of iodine, or iodophor for infants or allergies) and frequency of gauze or transparent dressing changes at 48 hours or after seven days respectively (Infusion Nurses Society, 2011; O'Grady et al., 2011; Scales, 2011). All centres surveyed reported full adherence to recommendations specific to gauze or transparent materials and use of barriers and aseptic techniques for line care. However, 20% reported no additional protection is used for showering. Non-adherence to the recommendation may be due to the waterproof capability of a transparent dressing, which is the most commonly used material (90%) to cover a CVC exit site. Case studies report the elimination of water-borne bloodstream infection when using a waterproof covering for hygiene, even when a dressing is used on a CVC exit site, as the strategy provides added protection against colonization of caps and connections from tap water (Baird et al., 2011; Toscano et al., 2009).

Another variation in practice across Canada coincides with the discrepancy in views about maintaining or removing the dressing from a healed tunneled exit site. The most recent Cochrane meta-analysis comparing dressing materials reported no study designed to draw comparisons with a "no dressing" group

(Gillies et al., 2011). Forty per cent of the centres surveyed in this study reported that healed tunnel sites are left open to air. The 2011 guidelines from the Infusion Nurses Society (INS) cite only one study supporting the no-dressing recommendation while the CDC remains irresolute on the issue.

Links between the inflammatory and coagulation response in the bloodstream interrelate infection and thrombosis (Levi, van der Poll, & Schultz, 2012). The correlation of cumulative infection and thrombotic risks in cancer patients with a CVC highlights the importance of prevention strategies (Hitz et al., 2012; Rowan et al., 2013). All centres reported CVC patency is maintained with normal saline flushing and heparin locking, though no centre used the same combinations or volumes. The INS (2011) defers maintenance decisions to instructions by product suppliers. Camp-Sorrell (2010) notes manufacturer recommendations continue to dictate care without providing current supportive evidence of product effectiveness versus complications. Varying volume and concentration types of locking solutions across Canada speak to the lack of guidance for preventing catheter occlusion which may, in turn, influence infection rates. Dibb et al. (2012) agree that maintaining the integrity of a CVC through the use of anti-coagulants and antimicrobial locking solutions may be a feasible approach to preserving central access while admitting more evidence is needed. All respondents in this study reported that attempts are made to salvage sluggish and/or occluded lines with anti-coagulants, and 60% indicated the use of anti-infective locking solutions are options for managing known infections. Practice guidelines for preventing infection do not speak to

thrombotic correlations, do not advise anticoagulant use for the purpose of preventing catheter-related bloodstream infection, and caution against use of anti-infective locking solutions unless repeat infections are problematic (O'Grady et al., 2011). Sodium citrate is one suggested multipurpose locking solution approved for use in Canada, though no centre in this survey reported use of the product (O'Grady et al., 2011).

Removal

Catheter-related infection, malfunction, or total occlusion may necessitate early line removal or replacement. Similar to insertion, CVC removal was reported in this study as primarily a physician responsibility with delegation to nurses in 20% of situations. Line removal is not recommended based on fever alone but is consistently advised for unnecessary catheters (INS, 2011; O'Grady et al., 2011; Tomblyn et al., 2009). Twenty per cent of the centres do not adhere to prompt removal however results may be limited to the subjective interpretation of necessity by the nurses surveyed.

Discussion

The results of a descriptive survey of Canadian CVC practice support similar findings in Denmark and the Netherlands by Boersma and Schouten (2010). When issues concerning CVC care remain unresolved in the literature, it poses clinical dilemmas for clinicians. Practice-based decisions often guide CVC care approaches when evidence is lacking or discrepant. Practice guidelines are not provided with the intent to replace clinical judgment rather they serve to narrow variability when there is convincing evidence supporting

certain care strategies over alternatives. Adherence to resolute guidelines depends on awareness of disseminated findings and time needed to incorporate findings into practice. Program accreditation is one option for ensuring minimum care standards within certain treatment areas. Regimented competency training may also ensure that diligence is maintained in practice. Care standards can only assist in mitigating risks when sufficient data are available. Gaps in the evidence may lead to different care approaches being adopted that may result in differences in clinical effectiveness. Strengthening evidence through research is still needed in several aspects of CVC practice.

The plethora of available central venous access devices and variation in patient requirements for care points to the need for population-centred inquiries. Camp-Sorell (2010) notes that best practice is often identified through measuring systematic practices against outcomes. Studies comparing different CVC care approaches to infection and thrombosis rates may provide pragmatic resolutions to existing practice discrepancies. Measuring overlapping constructs contributes to a bank of insufficient findings that are often excluded from meta-analysis (Ge et al., 2012). Examining specific vascular access devices within specific clinical populations should be considered for controlling construct validity. Variable practice and unresolved issues for recommendations point to the need for future dressing studies with tunneled CVCs, including comparisons to a "no-dressing" group. Mathers (2011) notes the absence of standard flushing protocols for central access across America, which coincides with these survey results of

Canadian practice. Empirical studies testing the effectiveness of particular flushing and locking solutions with specific devices in specific populations are needed for the development of practice guidelines.

Conclusion

Medical advances have allowed complex treatment for uncommon diseases. Central vascular access devices are commonplace in specialty areas treating acutely ill patients. Registered and Advanced Practice Nurses are in a position of positively influencing the incidence of complications with medical devices. Incongruent practice advice and gaps in evidence manifest in different care approaches worth research attention as variable practice may inadvertently propel disparate care. Results from the descriptive study of CVC practice across Canada indicate some centres do not fully adhere to all recommendations and that variable care approaches coincide with discrepant advice and gaps in evidence. Studies focusing on preventing catheter-related occlusions and infections have the potential to increase care quality. Incorporating the study of the cancer system capacity when investigating practice comparisons may, provide additional validation of nursing influence.

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Appendix A

Table1
Recommendations for CVC Practice

Location	Advisory	Access
Australia	Australian Society for Parenteral and Enteral Nutrition (AuSPEN)	www.healthinfonet.ecu.edu.au
	Center for Health Care Related Infection Surveillance and Prevention (CHRISP)	www.health.qld.gov.au/chrisp
	Australian Commission on Safety and Quality in Health Care, National Safety and Quality Health Service Standard	www.health.qld.gov.au
Canada	BC Cancer Agency	www.bccancer.bc.ca
	Canadian Patient Safety Institute (CPSI)	www.saferhealthcarenow.ca
	Public Health Agency of Canada: Canadian Nosocomial Infection Surveillance Program (CNISP)	www.phac-aspc.gc.ca
	Registered Nursing Association of Ontario (RNAO)	rnao.ca
Europe	European Center for Disease Prevention (ECDC)	ecdc.europa.eu
	European Society for Clinical Nutrition and Metabolism (ESPEN)	www.espen.org
Global	International Federation of Infection Control (IFIC)	www.theific.org
	World Health Organization	www.who.int/csr/resources/publications/drugresist/en/whocdscsreph200212.pdf
Japan	Ministry of Health, Labour, and Welfare	www.mhlw.go.jp/english/index.html

Appendix A (Continued)

New Zealand	Intravenous Nursing New Zealand (IVNNZ)	www.ivnnz.co.nz
United Kingdom	British Committee for Standards in Hematology (BCSH)	www.bcshguidelines.com
	National Institute for Clinical Excellence (NICE)	www.nice.org.uk
	Royal College of Nursing	www.rcn.org.uk
United States	American Society of Critical Care Anesthesiologists (SOCCA)	www.socca.org
	Center for Disease Control and Prevention (CDC)	www.cdc.gov
	Infectious Disease Society of America (IDSA)	www.idsociety.org/Index.aspx
	Infusion Nurses Society	www.ins1.org
	Society for Healthcare Epidemiology of America (SHEA)	www.shea-online.org

Appendix B

Table 2
Survey Responses

Adult inpatient	7 (70%)	Adult outpatient	3 (30%)
Pediatric inpatient	3 (30%)	Pediatric outpatient	1 (10%)
Transplant		Transplants per Year	
Blood Cell	62%	<50	30%
Bone Marrow	85%	51-100	30%
Cord	54%	>100	40%
Progenitor Stem Cell	85%		
Staff Education	100%	Patient Education	80%
Insertion			
Use of Prophylactic Antibiotics	0%	Use of Tunneled Line	80%
Insertion Bundle		Use of Antimicrobial Devices	
Yes	60%	Yes	10%
Unknown	40%	Unknown	50%
Under Ultrasound Guidance		Placement	
Always	30%	By a Physician	90%
Unknown	70%	By a Specialty Nurse	10%
Preferred Site		Preferred Number of Lumens	
Physician Choice	30%	Two	40%
No Preference	30%	Three	60%
Right Subclavian	20%		
Left Subclavian	10%		
Right Intra jugular	10%		
Routine Care and Maintenance			
Use Dressings	100%	Managing Patency	
Gauze (changed every 2 days	100%	Flushing with Normal Saline	100%
when used)		Heparin Locking	90%
Transparent (changed	90%	Locking with Normal Saline	10%
weekly	40%	Alteplase	100
when used)		(Suspect/Known Occlusion)	
None (after tunnel healing)			

Appendix B (Continued)

Dressings Changes Performed By	100%	Preventing Infection	
Registered Nurse	10%	Covering in Shower	80%
Licensed Practical Nurse	30%	2% Chlorhexidine Skin Prep	60%
Patient	50%	70% Alcohol Skin Prep	30%
Family/Lay Caregiver	20%	>.5% Chlorhexidine Skin Prep	10%
Specialty Nurse	10%	Antimicrobial Locking	60%
Physician		(known infection)	
Nursing Time for Dressing Change	60%		
15 minutes or less	40%		
15-30 minutes			
Removal			
Removal By		Replacement Indicated	
Physician	90%	Known Infection	100%
Specialty Nurse	10%	Known Occlusion	90%
Registered Nurse	10%	Malfunction	80%
Prompt Removal When no Longer Necessary	80%	Unresolved Complication	20%

Chapter Three: The Economic Burden of Catheter-Related Bloodstream Infection in Canadian Blood Stem Cell Transplant

Abstract

Catheter-related bloodstream infection (CRBSI) is associated with increased healthcare spending and patient morbidity. The purpose of this study was to estimate the direct inpatient charges for CRBSI in Canadian blood stem cell transplant recipients with a tunneled Central Venous Catheter (CVC). A case-controlled comparison of records indicating CRBSI and records not indicating CRBSI was used to quantify charges across the following domains: length of stay, laboratory tests, diagnostic tests, medications used, consults to a specialty physician, catheter replacement costs, and length of stay in the Intensive Care Unit. Infections reduced the length of catheter use time by an average of 13.51 days. Patients with CRBSI stayed on average an extra 19.81 days in the hospital, resulting in extra charges of $40,986 for base 24-hour stay. Extra fees for directly diagnosing and treating CRBSI averaged $4,683.90. Thus, the total estimated burden of CRBSI in Canadian blood stem cell transplant for the 2013 fiscal year was $45,670.79 per incident.

Chapter Three: The Economic Burden of Catheter-Related Bloodstream Infection in Canadian Blood Stem Cell Transplant

Microbial resistance confronts efforts to control infection in healthcare. Coupled with patient acuity, infection further strains organizational budgets. Cancer patients possess intrinsic risks for infection with compromised immune function being the most serious (Bereket et al., 2012). A central venous catheter (CVC) is commonly used in cancer care for delivering therapeutics and blood sampling (Scales, 2011). The devices provide a direct portal to the bloodstream and because of this there is a potential for contamination. Boersma and Schouten (2010) caution against acquiescence of infection with healthcare technology. Infection control measures can be effective for ensuring safety with the use of medical devices including a CVC.

Patrick et al. (2013) found central line infection is grossly under-reported compared to the findings from the audits of medical records. This finding undermines ethical accountability in healthcare provision. Scrutiny of hospital infection rates challenges administrators to ensure control measures are positively influencing outcomes. Certain hospital-acquired infections are avoidable with evidence-based prevention strategies that target extrinsic risk factors (Bereket et al., 2012). Hand washing for example, reduces transfer of microbes from one surface to another. Due diligence in preventing infection alleviates morbidity and mortality risks that are especially threatening to cancer patients. Currently, the costs of catheter-related bloodstream infection (CRBSI) in blood stem cell transplant are unknown. The purpose of the study

was to estimate inpatient direct medical care charges for CRBSI in Canadian blood stem cell transplant recipients with a tunneled triple lumen subclavian CVC.

Review of the Literature

CRBSI

Catheter insertion, handling connections, or (rarely) infusions are all gateways for transmission of pathogens (O'Grady et al., 2011). Bacterial affinity for surfaces in the form of biofilm may also colonize onto catheter surfaces causing infections that are problematic to eradicate (Yasuhiko et al., 2012). Determining that an infection is related to a catheter involves assessment and ruling out all other potential sources. The Infectious Diseases Society of America (IDSA) cites criteria for diagnosing CRBSI, which practice consultants distinguish as different than a central-line associated bloodstream infection (CLABSI) (O'Grady et al., 2011; Mermel et al., 2009). Lab confirmation using comparative blood cultures with differences in growth time and overall quantity of organisms more accurately reflect if organisms are sourced in (and likely introduced from) a catheter (CRBSI) versus surface seeding or introduction from other portals (CLABSI).

Cost

The majority of cost analyses report findings from intensive care settings. The Centers for Disease Control and Prevention (CDC) reported in 2005 that the cost of a single CLABSI exceeds $25,000 United States Dollars. Hsu et al. (2013) note cost differences vary widely, depending on hospital reimbursement rates in multi-payer healthcare models. In addition to the payment model Table 3 summarizes costs reports of a single incident with varying estimates due to currency values, clinical population, and timing of the research.

Table 3
Case Control Cost Analyses of a Single Central Line Infection

Authors/ Year	Country	Cost	Population	Measures
Orsi, et al. (2002)	Italy	€16,356	ICU (surgical)	Extra charges for extended length of stay and infection treatment
Liu et al. (2002)	Taiwan	$NT66, 302	Renal Dialysis	Extra charges for extended length of stay
Rosenthal, et al. (2003)	Argentina	$4, 888	ICU (medical/surgical and coronary)	Extra charges for extended length of stay, and antibiotics
Shannon et al. (2006)	United States	$26, 839	ICU (medical and coronary)	Extra charges for length of stay, antibiotics, laboratory/diagnostic tests, related procedures, and non-nursing healthcare labor
Higuera et al. (2007)	Mexico City	$11,591	ICU	Extra charges for extended length of stay and antibiotics
Tarricone, et al. (2010)	Italy	€9,154	ICU (4 different specialty areas)	Extra charges for extended length of stay, medications, supplies, lab tests, and care by an infection specialist
Dal Forno et al. (2012)	Brazil	$89, 886	ICU	Difference in mean total cost of care including extra length of stay and resources until hospital discharge
Raschka, et al. (2013)	Canada	$19, 776	Inpatient (non-ICU)	Charges for extended length of stay

$= Dollars; €= Euros; $NT=New Taiwanese Dollars

A basic tenet within modern microeconomic theory regards value synonymously with the price of a commodity (Nicholson & Snyder, 2012). Cost factors in healthcare can be direct or indirect. Arguably, value in healthcare transcends consumerism given the inability to appraise both human lives and diverse costs associated with affliction. Indirect costs such as suffering, loss of life, or missed opportunities are difficult to quantify in terms of infection outcomes. Conceptualization of healthcare as a commodity

ensues as access and bottom lines inevitably converge. Direct medical costs are defined by Santerre and Neun (2010) as charges to the payer for tests, exams, treatment, and provision of care etc. Identifying direct medical charges for specific adverse outcomes can be useful in cost-benefit analysis and designing research.

Canadian Cost Factors

The Canadian healthcare insurance plan is a universal model designated by public authority and delivered on a non-profit basis (Health Canada, 2013). The *Canada Health Act* (1985) stipulates that hospital services include: accommodation and meals, services by all personnel employed within the institution, laboratory/radiology/diagnostic procedures and interpretation, drugs, supplies, and preparations, medical equipment and surgical supplies, full operative procedures and care for all services deemed medically necessary for maintaining health. Fees for treating adverse events are absorbed within departmental operating budgets. Observational research of past events puts cost containment into perspective by conveying the capital benefits of preventing adverse events. CRBSI (the independent variable of the study) incurs extra charges (dependent variable). Beyond prolonged hospital stays, care for CRBSI may include additional medications, laboratory tests, diagnostic tests, specialty consultation, and supplies (O'Grady et al., 2011; Tarricone, Torbica, Franzetti, & Rosenthal 2010). Quantifying how individual resources are being used to treat CRBSI allows for cost estimations within universal funding models that may influence administrative decisions.

For the purposes of this study CRBSI is operationally defined as a diagnosed bloodstream infection when no other source is apparent and confirmed by comparative or paired blood culture results with a time to positivity of 120 minutes or greater and/or

threefold difference in microbial load (Mermel et al., 2009). The dependent variable, charge, is operationally defined as the Canadian dollar value for allocated resources (including inpatient hospital bed and all associated inpatient care, medications, laboratory and diagnostic tests, supplies for line replacement, stay in the intensive care unit, and services of a specialty physician) required for treating a confirmed CRBSI.

Research Questions

The cost of a CRBSI in Canadian blood stem cell transplant recipients with a tunneled CVC has not been reported in the literature. This study addressed the following questions. Among Canadian blood stem cell transplant recipients with a long term tunneled triple lumen subclavian CVC:

1. Is CRBSI associated with an extended hospital stay?
2. What are the average extra charges for diagnosing and treating CRBSI?
3. What is the average total charge for a single CRBSI?

Methods

Design

Expedited institutional review board (IRB) approval for the study with a waiver of consent was granted from both academic and health care institutions. A retrospective case-control comparison analyzed healthcare spending between two groups. The case group included records with documented incidents of CRBSI. The comparison group included matched control records with no documented incidents of CRBSI.

Sample/Setting

The study sample consisted of medical records of blood stem cell transplant recipients with a tunneled triple lumen subclavian CVC, treated in a single adult

Canadian blood stem cell transplant program between 2008 and 2013. Inclusion criteria for both groups stipulated the use of a tunneled CVC, completion of transplant, and documented CVC removal, as well as a confirmed CRBSI for the case group. One additional criterion for records in the control group stipulated no documented incidence of CRBSI. Several exclusion criteria were applied to both groups in sample selection to eliminate potential cost influences. Records indicating simultaneous use of vascular or invasive catheters, more than one isolated CRBSI, tunnel infection, and multiple transplants, were excluded. Records indicating other line-associated complications (occlusion, thrombosis in the superior vena cava, and accidental displacement) were also excluded alongside records with no comparable control. Selection generated 133 pairs for a final sample size of 266.

Instruments

Data was coded into an electronic dataset designed specifically for the study as no existing instrument was identified. Clinical records and financial documents sourced the data yield. Base charges to the public payer for blood stem cell transplants, medical tests, hospital stays, intensive care stays, procedures, and specialty consult fees for the 2013 fiscal year were used to measure direct charges. Other monetary data for the 2013 fiscal year that were billed to the public payer were obtained through inpatient pharmacy inventory list that reports charges per dose of medications used and manufacturer contract pricing (confirmed by the manufacturer) for central venous catheters.

Procedure

All records were de-identified for any personal information in accordance with ethics regulations. Demographics, length of stay, and length of time each catheter was in

place were transcribed from electronic and hard copy records and recorded for both groups. All positive blood culture results were reviewed to confirm CRBSI according to pre-set study criteria and assigned to the case group. For case records, physician notes and medical orders were further catalogued for actual usage of resources specifically indicated for diagnosing and treating CRBSI. Charges were tallied by frequency of use according to set Canadian dollar values billed to the public payer for the 2013 fiscal year in the following domains: (1) length of stays, (2) laboratory tests, (3) diagnostic tests, (4) medications, (5) fees for insured procedures or consultations by a specialist physician, (6) replacement catheters, and (7) length of stays in the intensive care unit due to CRBSI. Additional supplies for delivering treatment (i.e. intravenous sets, infusion bags, cold packs etc.) were included as part of the daily hospital fees that are covered by the inpatient nursing unit budget.

Similar to other observational studies, case records were paired with controls to enhance comparability of groups. Control criteria were applied for matching each case record to a counterpart in age (+/- five years), gender, and type of transplant (autologous or allogeneic), diagnosis, type of stem cells, and treatment protocol. Controls were purposively selected for exact matches on four or more criteria. The Statistical Package for the Social Sciences (SPSS) Version 21 was used for data analysis (International Business Machines Corporation, 2010). The parameters for statistical significance were pre-set at α of .05 and β of .80. Non-parametric tests were used to analyze data in violation of assumptions for statistical tests.

Results

The final sample of 133 case-control pairs (n = 266) were subjected to 31,110 catheter days (*M* 117, *SD* = 87.63). Nineteen different treatment protocols were used for transplant conditioning. Sample characteristics are summarized in Table 4. Independent *t* tests show no significant differences in age or body mass index between groups. Although there were more males than females in the sample, the gender dispersion between groups was similar given non-significant Chi square results. Chi square tests also did not indicate group differences in diagnosis, type of transplanted cells, or treatment between case and control groups.

Table 4
Demographic Comparisons Between Case and Control Groups

Variable	Descriptive	Independent t			Chi Square		
	(*M*, *SD*, %)	*t*	*df*	*p*	χ^2	*df*	*p*
Age	*M* 50.56 ± 11.92	-.180	264	.858			
BMI	*M* 25.15 ± 5.54	-.717	264	.474			
Gender *Male* *Female*	 159 (59.8%) 107 (40.2%)				.141	1	.803
Diagnosis **Other* *Leukemia* *Lymphoma*	 70 (26.3%) 110 (41.4%) 186 (32.3%)				0	2	1
Cell *Allogeneic* *Autologous*	 150 (56.4%) 116 (43.6%)				0	1	1
Treatment					20.74	18	.255

*Other malignancy or blood disorder requiring blood or marrow cell transplant

Table 5 lists the numerous different organisms that were detected in the case group. Five cultures grew two different organisms, two cultures grew three different organisms, and one culture grew four different organisms. Seventy of the organisms

were classified as gram stain positive, 74 gram stain negative, and one gram stain was unknown. The most frequently occurring infections were *Staphylococcus* genus (n=42), *Escherichia Coli* (n=25), *Klebsiella* (n=17), and *Streptococcus* species (n=14).

Table 5
Cultured Organisms in Cases of CRBSI

	One	Two	Three	Four	Total
Abiotrophia Defectiva	1				1
Acinetobacter	2				2
Acinetobacter Baumanni	1				1
Acinetobacter Hydrophillia	1				1
Bacillus Cereus	1				1
Brevibacterium	1				1
Candida Kreusei	1				1
Candida Paropsilosi	1				1
Citrobacter Freundii (complex)	1				1
Citrobacter Kosari	1				1
Clostridium Septicum		1			1
Coryneform	1				1
Diplococci	1				1
Escherichia Coli	22	2	1		25
Escherichia Cloacae	5	1			6
Enterobacter Aerugenosis	1				1
Enterococcus				1	1
Enterococcus Faecalis	2				2
Enterococcus (VRE)	1				1
Fusobacterium	1				1
Granulicatella		1			1
Haemophilus Influenza	1				1
Haemophilus Parainfluenza	1				1
Klebsiella Pneumoniae	16				16
Klebsiella Oxytoca	1				1
Leptotrichia Buccalis	1				1
Moraxella Catarrhalis	1				1
Pantoea Species	1				1
Pseudomonas	2	1			3
Pseudomonas Aerugenosa	2				2
Pseudomonas Oryzihabitans	1				1
Rhizobium Radiobacter	2	1			3
Roseomonas	1				1
Serratia Marcescens	1				1
Staphylococcus	2				2
Staphylococcus Aureus	7	2			9
Staphylococcus Capnocytophagia	1				1
Staphylococcus (CNS)	28				28
Staphylococcus Ludguenesis	2				2
Staphylococcus (MRSA)	1				1
Staphylococcus (MSSA)			1		1
Stenotrophomonas	2				2
Streptococcus	2				2
Streptococcus Group B	4		1		5
Streptococcus Group G	1				1
Streptococcus Mitis	6				6
Streptococcus Viridians	1				1

Control group records indicated 1,798 more catheter days than case group records with a mean difference of 13.51 days. Case records also indicated line replacement with a tunneled catheter on 22 occasions, a percutaneous intravenous central catheter (PICC) on 33 occasions, and an intra-jugular (IJ) catheter on seven occasions for a total requirement of 62 new lines (46.62%). Five records indicated ICU admission for infection. Eight cases and nine controls indicated demise with a CVC in situ.

The majority of the sample (n=253) exceeded the base allotment of hospital days for transplant with two records indicating discharge as estimated, eight discharges one day early, and three discharges two days early. Table 6 shows that inpatient length of stay ranged from 14-313 days. Mann Whitney U tests show there were significant differences in length of hospital stay (U = 6456, z = 3.664, p = <.001 r = .22) and subsequent costs of hospital stay (U = 6319, z = 4.027, p = <.001, r = .23) between groups, with longer stay and higher expenses associated with the case group. The case group stayed on average 19.81 days longer in the hospital than the control group.

Table 6
Catheter Days and Length of Stay in Case and Control Groups

	Median	Range	SD	Mean	Difference
Catheter Days					
Case	83	6-413	93.16	110.2	
Control	93	18-424	81.52	123.71	13.51 days
Total	92.5	6-424	87.63	116.95	
Length of Stay					
Case	53	15-313	54.48	71.89	
Control	39	14-269	52.08	52.08	19.81 days
Total	45.5	14-313	48.6	61.99	

Results of a Mann Whitney U test also revealed significant differences in total charges between groups (U = 5759, z = 4.96, p<.001, r = .30). The mean difference in

hospital stays of 19.81 days in the case group carried a price tag of $40, 986.89. Extra charges for treating infection ranged from $70.60 to1$198, 993.63 with a mean extra charges totaling $4, 683.90 (Median $708.5, *SD* $23, 803.51). The total estimated charges for a single infection considering fees for the mean extra length of stays and extra charges for actual resource usage were $45, 670.79.

Discussion

Results from the case control study of CRBSI in a single Canadian blood stem cell transplant centre reveal significant cost implications to both the program and the patient. Quality of life costs of CRBSI unmeasured by the current study deserve consideration. While the centre must absorb charges of $45,670.79 on average, the patient costs of discomfort with line replacement, time spent away from loved ones while in the hospital, and the symptom experiences of infection, to name a few, may be valued by individuals beyond monetary worth.

CRBSI in the case group is associated with shortened catheter life which coincides with practice guidelines that recommend line removal depending on the overall clinical picture and with certain organisms (Mermel, 2009). Studies comparing costs of salvaging lines versus replacement are needed to further inform practitioners in cost-effective decision making. Dibb et al. (2012) concur that removing a line on account of complications is not always necessary or possible as it may be needed for emergent rescue or may cause needless discomfort when simple treatments are possible. The tunneled catheters used in the sample population are designed for long term use (>90 days), and the mean length of use surpassed this time frame in both study groups (Joint Commission, 2012). Maintaining the integrity of the line without infection is possible as

several cases and controls retained a CVC for a year or longer. Care efforts should target prevention of infection over reactive management.

Although results indicate small effect size for the difference in length of stay between groups it was the most expensive charge. Intrinsic risk, namely compromised immunity, may explain part of the additional hospitalization required in blood stem cell transplant. However, in this study clear differences between groups make the case for inference that infection is also associated with prolonged stay in this population which coincides with past study findings (Dal Forno et al., 2012; Raschka, Dempster, & Bryce, 2013).

Effect size increased when considering total charges for diagnosing and treating infection. The need for intensive care support in five cases inflated the range of charges followed by medication use, and replacing the CVC. The wide variation in total charges also reflects the complexity of care required in the blood stem cell transplant population, the nature of different organisms, and difficulty in predicting individual care needs. Nearly all (95%) of the sample exceeded allotted hospital days included in the base price of transplant which suggests program funding is grossly underestimated.

The abundance of different organisms responsible for CRBSI in the sample may explain part of the wide variance in charges for treating CRBSI. *Staphylococcus* genus is the most widespread nosocomial pathogen within the study sample and globally (Bereket, 2012). Multi drug resistant gram negative organisms in the sample, such as *Acinetobacter Baumanni, Stenotrophomonas Maltophilia* and *Pseudomonas,* are known to have changing dynamics in cell function and the ability to resist current treatments (Bereket, 2012). This study did not show increased treatment costs with more resistant

gram stain negative types of organisms; rather, four of the five cases were admitted to the ICU with gram positive *Staphylococcus* genus organisms (none of which were identical) and one case of a fungal infection. Higher costs may be due to the onset of infection at a more vulnerable time in the treatment process. The nadir of chemotherapy conditioning, graft versus host disease, prolonged neutropenia, or relapse/graft failure that were not controlled for within this study beyond matching cases and controls; however, length of stays and extra charges were observed to be higher with related donor transplants, followed by unrelated donor transplants and lastly, self-donations. Cost analyses that distinguish infection outcomes and associated fees between allogeneic and autologous recipients are worth future research attention.

In addition to limitations noted in the discussion above, retrospective observations limit the ability to isolate causal relationships. Stringent matching criteria were implemented to offset validity threats by controlling group comparability. A second factor not considered in the study was that records were not audited beyond line replacement with non-tunneled catheters. Similar analyses with other catheter types have the potential to further inform practitioners on the best type of intravenous device to use post-transplant should tunneled CVC complications occur. Indirect costs to patients and the system, and associated cost for symptom management on an as needed basis were also not measured in this study; however, it is more likely that these considerations would inflate rather than reduce the overall estimate.

Summary

Curtailing hospital infection is not a new issue in healthcare. However, charges continue to inflate, outdating past cost-analyses. This study found that in 2013, CRBSI in

a Canadian blood stem cell transplant centre increased resource allocation, shortened central venous catheter life by an average of 13.51 days, extended hospital stays an average of 19.81 days, and incurred average charges of $45, 670.79 per incident. It is reasonable to expect similar results across Canadian blood stem cell transplant programs and with other bloodstream infections with the exception of fees incurred for CVC replacement. Costs may be lower in less acute areas and among populations that are not faced with immune system compromise.

The relatively small stem cell transplant population is a large contributor to healthcare spending. Reassessment of base funding in support of the program is needed alongside research targeting infection reduction. Nursing studies examining practice strategies aimed at reducing thrombo-infective complications with CVC care may be invaluable assets to cost containment. Findings from this study may be useful for estimating cost avoidance in research of clinical interventions that lead to a reduction in CRBSI and other device-associated bloodstream infections.

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Chapter Four: Analysis of Costs and Benefits of Tunneled Central Venous Catheter Dressings in Canadian Stem Cell Transplant Recipients

Abstract

Catheter-related bloodstream infection (CRBSI), an avoidable risk in cancer nursing, contributes to patient morbidity, and increases health care spending. The objective of the study was to evaluate the impact of three different nursing care strategies for tunneled central venous catheter (CVC) exit sites on infection outcomes and compare costs of each strategy. The study hypothesis proposed that CRBSI and charges for nursing care differ in Canadian blood and marrow cell transplant recipients with a tunneled CVC that use a transparent dressing, no dressing, or a gauze dressing. A sample of 432 records at a single centre compared CRBSI between dressing groups. A micro-costing approach was used to estimate dressing supply charges for an evaluation of the costs and benefits of each exit care strategy. Results of the study indicated no significant differences in CRBSI, number of organisms, gram stain of organisms, development of infections before or after tunnel healing, or onset of infection between the three dressing groups. In terms of supplies alone, transparent dressings were most economical, followed by no dressing and lastly, gauze. The no dressing strategy was the most cost-effective alternative to using a transparent dressing.

Chapter Four: Analysis of Costs and Benefits of Tunneled Central Venous Catheter Dressings in Canadian Stem Cell Transplant Recipients

Infection control, essential in minimizing healthcare costs, continues to challenge healthcare providers. Risk of infection is particularly concerning in blood stem cell transplant recipients given their weakened immune function and dependence on prolonged vascular access (Tomblyn et al., 2009). Nearly all blood stem cell transplant patients receive a tunneled central venous catheter (CVC) to facilitate life-saving treatment as it poses the lowest infection risk of all long term catheter choices (Faruqi et al. 2012; Scales, 2010a; Toscano et al., 2009). Catheter-related bloodstream infection (CRBSI) is typically associated with morbidity and expense rather than fatality (O'Grady et al., 2011). Blood stem cell transplant nurses are influential in preventing CRBSI as they manage and educate others on CVC care. Cost-benefit analysis considers how much and to what degree expected costs outweigh the total expected benefits (Santerre & Neun, 2010). Different care strategies do not posit equal expenditure. The effects and charges to the public payer for various exit site care strategies performed by registered nurses on infection outcomes are unknown in Canadian blood stem cell transplant.

A tunneled CVC features a cuff placed under the skin with the proximal end resting in the superior vena cava and a salient distal end (Scales, 2011). Immediate placement of a sterile dressing after CVC insertion secures the device until the cuff embeds into the surrounding tissue (tunnel healing), and protects the puncture sites (Macklin, 2010; Poole, 2010; Scales, 2011). Practice consultants such as the Infusion

Nurses Society (INS), claim a dressing on a healed CVC tunnel is unnecessary while others including the American Centers for Disease Control and Prevention (CDC) posit that they can make no recommendation on the issue (INS, 2011; Joint Commission, 2012; O'Grady et al., 2011; Scales, 2010b; Toscano et al., 2009).

Dressing options should meet patient needs and provide equal protection against infection risks. Evidence of the clinical effectiveness of CVC exit site care in regards to CRBSI is limited. The feasibility of certain nursing strategies must also be evaluated within the economic capacity of the financing system (Tarricone, Torbica, Franzetti, & Rosenthal, 2010). Canadian CRBSI cost estimates (for all central venous catheter types) exceed $19,000 per incident (Raschka, Dempster, & Bryce, 2013). A recent analysis by the author suggested CRBSI costs for Canadian blood stem cell transplant patients exceeded $45,000 per incident in 2013 (Keeler, in review). Carefully weighing cost-to-clinical benefit supports accountability in publicly funded healthcare. Expected fees associated with adverse events and nursing care may strongly influence practice decisions. The purpose of this study was to evaluate the impact on CRBSI and costs and benefits of nursing exit site care for Canadian blood stem cell transplant recipients with a long-term tunneled triple lumen subclavian CVC.

Review of the Literature

CRBSI

CRBSI can develop from systemic microbes adhering to the catheter surface or the introduction of organisms on insertion, manipulation, or infusion (O'Grady et al., 2011). A primary bloodstream infection is deemed a CRBSI when an alternate source cannot be determined in a patient with a CVC in place for 48 hours or longer (Chopra,

Krein, Olmsted, Safdar, & Saint, 2013). The most accurate diagnostic measure of CRBSI found by meta-analysis is paired blood cultures (Rodriguez et al., 2012). The measure compares a CVC blood sample to a peripheral sample from the same individual. Samples are grown in a media to detect and identify organisms. Positive CVC results with negative peripheral results are strongly indicative of a catheter source of infection. A difference in growth time-to-positivity between samples or three fold or greater microbial load in one sample also indicate the location of an infection (Mermel et al., 2009). Paired blood cultures distinguish CRBSI from disease and treatment-related symptoms that a CVC was designed to manage (Macklin, 2010; O'Grady et al, 2011; Tomblyn et al, 2009).

Dressing

Popular CVC dressings are made of cotton fiber (gauze) or polyurethane (transparent). A gauze dressing covers the exit site with or without securement. The adhesive on one side of a transparent dressing attaches directly to the catheter and surrounding skin. Dressings act as a barrier between the puncture site and the external environment. Microbes naturally collect in the first five layers of the stratus corneum, hair follicles, and sebaceous glands, and can re-colonize within 48 hours of disinfecting necessitating dressing changes (Macklin, 2010). Guidelines recommend changing a gauze dressing every two days and transparent dressing no more than once every seven days unless either is wet or soiled (O'Grady et al, 2011).

The most recent Cochrane review reports a wide range of increased CRBSI with the use of transparent dressings, even while considering research bias (Gillies, O'Riordan, Sheriff, & Rickard, 2011). Issues such as comparing different central line

types across different populations, lack of reporting effect size, lack of reporting missing data, and including overlapping variables are mentioned as result-limiting factors. None of the research in the meta-analysis compared dressing types to undressed sites. Preliminary studies report that dressings are predictors of CRBSI in renal and intensive care populations compared to a no dressing group (Seiler & Pember, 2012; Toshiyuki et al. 2012).

No Dressing

The debate for maintaining a dressing on a healed CVC tunnel began with a pilot study reporting no difference in line infections in a small sample of cancer patients without exit site dressings (Petrasino, Becker, & Christiansen, 1988). One random controlled trial by Olsin et al. (2004) revisited the issue. However, the small sample and early closure requires additional evidence to support practice recommendations based on study findings. This current state of the science contributes to questionable evidence guiding nursing care as approximately 40% of Canadian blood stem cell transplant centres reported in 2013 that their policy is to remove the dressing from a healed tunneled CVC site (Keeler, 2014).

Additional Care Strategies

Alternatives for preventing CRBSI can be found in the literature. Applying honey to the exit site has not been reported to significantly reduce CRBSI (Kwakman et al., 2012). More popular is trialing medical products and antiseptic solutions with varying reports of significance (O'Grady et al., 2011; Popovich, Hova, Hayes, Weinstein, & Hayden, 2010). Antibiotic ointment under the dressing in the blood stem cell transplant population is counterproductive as it is known to increase drug resistance and

colonization of fungi in immune compromised hosts (O'Grady et al., 2011; Tomblyn et al., 2009). Allergies, skin toxicities, and age younger than two months may render use of adhesive and antiseptic patch dressings inapplicable (Battistella, Bhola & Lok, 2011; Daniels & Frei, 2012; Tomblyn et al., 2009). Antimicrobial coated lines and impregnated cuffs are now available (Bard, 2012a; Bard, 2012b). Practice consultants only recommend use of these products if all other prevention efforts fail to decrease CRBSI incidence (O'Grady et al., 2011).

Theory

Duval (2010) summarizes the evolution of Lister's 19th century theory of asepsis that continues to guide clinical practice and research today. The theory outlines human and animal coexistence with microorganisms that may be innocuous or cause illness. Pathological transfer of microorganisms can be prevented by natural immunity, inoculation, interrupting the cycle of transmission, or decreasing microbial load. Application of the theory has evolved into common reference to the principles of asepsis that are modeled in Figure 1. Conformity to aseptic principles incorporates preventing exposure and/or any activities or techniques that aim to decrease or eliminate microbial presence. Examples include avoiding contact, inoculation, maintaining a dry environment, or using products and strategies for sanitization, disinfection, or sterilization (Lister, as cited by Beck, 1895; Macklin, 2010; Medeiros, dos Santos, Soares, Costa, & Lira, 2012; Pallo, 2012; Scales, 2011).

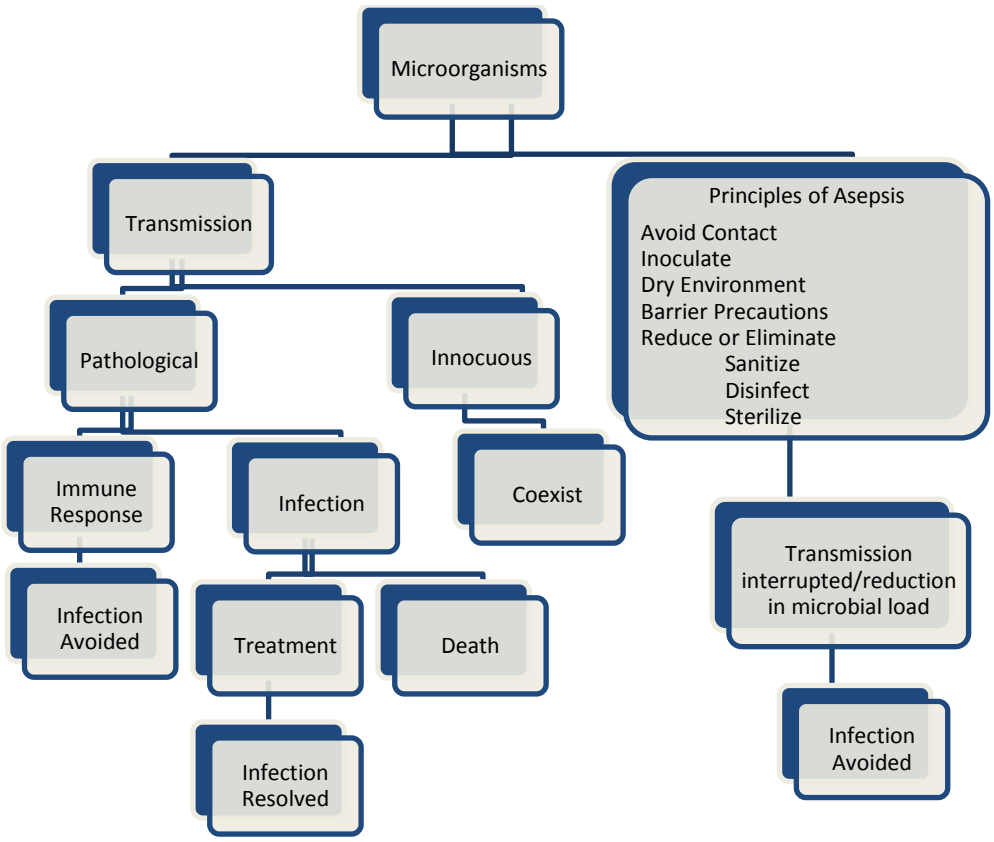

Figure 1. Model of Lister's Asepsis Theory

Judgment is required for applying aseptic principles in clinical care. For example, the aim of inoculation is exposure to certain organisms to stimulate an immune response should repeat exposure occur. Infection prevention strategies are multifaceted depending on clinical context and body of epidemiological knowledge. Avoiding infection requires conscious multidisciplinary efforts and actions at all stages of care and treatment in blood stem cell transplant.

Variable Selection

Study variables were selected after consideration of all other strategies incorporating aseptic principles with CVC access already in place at the study centre. The bundling strategy is used for catheter insertion. This strategy includes proper hand hygiene, using maximum barrier precautions (sterile gown, drape, gloves, equipment, and

wearing a mask), using a >0.5% chlorhexidine skin prep solution, choosing the appropriate site if known and a daily review of the necessity of the catheter with prompt removal when no longer essential (Faruqi et al., 2012; Moreau, 2009). In addition to the bundle strategy for insertion, all catheters are placed by a radiologist under ultrasound guidance.

Policy and nursing standard operating procedures at the study site mandate nearly all CDC recommendations for CVC practice and incorporate several principles of asepsis. Initial and yearly education for CVC competency is required in accordance with program accreditation standards. The support of both clinical nurse educators and experienced clinicians is available for staff skill certification and troubleshooting catheter-related complications. Prior to delegating the task, registered nurses assess patients' and lay caregivers' competency with exit site care by return demonstration. CVC access, infusions, and manipulations are performed via a needleless luer piggyback system with replacement of all infusion sets every 24 hours if the system is interrupted and every 72 hours if the system is uninterrupted. Sterile technique is mandated for dressing and cap changes with use of a sterile mask, gloves, and supplies, and 2% chlorhexidine skin antiseptic. Hand hygiene is routinely audited by the infection prevention and control department, and standard operating procedure mandates an alcohol scrub-the-hub for 15 seconds strategy for sterilizing connections prior to accessing infusion ports.

A policy change in 2011 incorporated removing the dressing from healed tunneled exit site and use of protective coverings over puncture sites and connections during showering. Prior to the current policy, transparent dressings were used when adhesive was tolerated; gauze dressings were used for individuals with skin sensitivities.

After the policy change all patients were instructed to remove the dressing after tunnel healing.

In spite of adherence to CDC guidelines and asepsis, CRBSI still occurs. According to the Institute for Healthcare Improvement (IHI), a CRBSI is criterion based infection diagnosed when no other source is apparent (2013). Confirmation that an infection is related to a CVC is obtained through comparative blood cultures. The Canadian Nosocomial Infection Surveillance Program (CNISP) criteria (2005) were used to operationally define CRBSI as the dependent variable for the study. The independent variable was the type of exit site care provided for a tunneled CVC at three levels: transparent dressing, no dressing after tunnel healing, or gauze dressing. The literature revealed a gap in the evidence regarding dressing maintenance after tunnel healing which generated the study hypothesis that there are differences in CRBSI and charges for exit site care strategies for Canadian blood stem cell transplant recipients with a long term tunneled triple lumen subclavian CVC that use a transparent dressing, no dressing, or gauze dressing.

Methods

Design

Following study approval by institutional and health board ethics committees, archived data from a single Canadian transplant centre was accessed. The posttest-only control group design was used to compare the dependent variable (CRBSI) after a specific treatment condition (type of dressing) among groups. A micro-costing approach was used to estimate the charges to the public payer for using a transparent dressing, no dressing, or gauze dressing, according to supplies and frequency of care.

Sample/Setting

The clinical records of adult blood and marrow cell transplant recipients from a single Canadian centre treated between 2008 and 2013 were reviewed. Documents noting completion of blood and/or marrow cell transplant and use of a long term tunneled cuffed triple lumen subclavian CVC were included in the sample. Records with absent documentation for line removal were excluded alongside records indicating catheters still in place. Additional exclusion criteria included known source of infection, multiple catheters at once, and non-adherence to standard policy and procedure for exit site care. All eligible records indicating dressing removal after tunnel healing were included in the sample. A purposive sample of records indicating the use of a gauze dressing or use of a transparent dressing were randomly selected until all three groups were equal in number. The transparent group (the largest group overall) was further stratified until overall gender dispersion was similar (N=432).

Instruments

Blood culture results were interpreted and confirmed using federal surveillance standards for reporting hospital acquired infections and practice recommendations from the Infectious Diseases Society of America (CNISP, 2005; Mermel et al., 2009). Electronic flow sheets and multidisciplinary progress notes were consulted to confirm individual dressing strategies. Nursing CVC policy and procedure and inventory price lists for supplies were used as measures for estimating weekly charges for each dressing strategy.

Procedure

Study data was de-identified and converted to an electronic data set. Analysis was performed using the Statistical Package for the Social Sciences (SPSS) Version 21 (International Business Machines Corporation, 2012). An inventory list indicating prices for supplies that were billed to the public payer by the inpatient blood stem cell transplant nursing unit was accessed. Charges for all supplies listed in the nursing policy and procedure document and unit standard operating procedures were tallied according to dressing strategy: for example, gloves, chlorhexidine swab sticks, dressing type, shower covers etc. Weekly costs were determined according to policy with transparent dressings changed after seven days, daily care after showering for the no dressing group, and gauze dressings changed after 48 hours. Individual dressing costs were estimated by multiplying the weekly cost of the dressing strategy used by the number of weeks the catheter was in place. Individual costs were adjusted for use of securement devices (once a week) and initial care post insertion (mean cost for the no dressing groups until tunnel healing set at day 14). Parameters for statistical significance were set at α at .05 and β at .80. The analysis of variance test was used to compare differences in CRBSI between groups. Kruskall-Wallis tests were used to analyze data in violation of assumptions for parametric statistics, and the Chi square test was used to analyze categorical data.

Results

The final sample represented 46,496 catheter days (*M* 107.63, *SD* 74.86) for 432 recipients of allogeneic (46.53%), autologous (53.01%), and syngeneic (.46%) blood and/or marrow cell transplant. Overall, Table 7 shows there were similar numbers of males and females in the entire sample; however, dressing dispersion by gender was not

equal. Analysis of variance tests were non-significant when comparing groups according to age F (2) = .489, p = .614, and body mass index F (2) = 2.849, p = .059. Chi square results also showed no significant differences in general diagnosis between groups, χ^2 (4) = 5.884, p = .208.

Table 7
Study Sample Characteristics and Catheter History

	Transparent Dressing	No Dressing	Gauze Dressing	Total (N=432)
Male	42	93	78	213
Female	102	51	66	219
Age	49.65±13.34	51.15±12.95	50.19±12.79	50.33±13.01
BMI	24.51±5.11	25.54±4.8	25.92±5.58	25.32±5.19
Leukemia	53 (36.8%)	40 (27.78%)	53 (36.8%)	146 (32.4%)
Lymphoma	46 (31.94%)	48 (33.33%)	52 (36.11%)	146 (33.8%)
Other	45 (31.25%)	56 (38.89%)	39 (27.08%)	140 (33.8%)
Allogeneic	72 (50%)	55 (38.2%)	74 (51.4%)	201 (46.5%)
Autologous	72 (50%)	88 (61.1%)	69 (47.9%)	229 (53%)
Syngeneic	0	1 (.7%)	1 (.7%)	2 (.5%)
Catheter Days	16966	14116	15414	46496
M, SD	117.82±70.54	98.03±62.79	107.04±88.17	107.63±74.86
Infections	52	43	52	147
Incidence	12.04%	9.95%	12.04%	34%
*Prevalence	3.06	3.04	3.37	3.16

Other= disease or malignancy treated with blood stem cell transplant
*Prevalence = number of infections per 1000 catheter days

All records indicated treatment with a conditioning chemotherapy protocol followed by a blood stem cell transplant. Of the 432 patients, 129 individuals developed 147 separate CRBSIs (113 people with one infection, 14 people with two infections, and two people with three infections). Multiple infections that met the criteria for being a new infection were included in the analysis for a total incidence of 34% and prevalence rate of 3.16 infections per 1000 catheter days. CVC replacement due to infection was required in 70 cases (16.2%) and one record indicated demise was suspected from a CRBSI.

The lowest incidence rate for the no dressing group and highest prevalence rate for the gauze dressing group indicated on Table 7 reveal there are slight differences in infection outcomes according to dressing group. Comparative statistical tests in Table 8, however, show that the differences between infection groups are non-significant.

Table 8
Infection Among Dressing Groups

	Analysis of Variance				Kruskall-Wallis		Chi Square	
	F	*df*	*p*	ω	*H*	*p*	χ^2	*p*
CRBSI	.375	(2,429)	.555	.05				
Number of Organisms	.700	(2,429)	.497	.06				
Gram + Organisms	1.104	(2,429)	.333	.07				
Gram - Organisms	.396	(2,429)	.673	.04				
Onset of First Infection	1.779	(2,429)	.17	.09				
Onset of Second Infection	.285	(2,429)	.752	.04				
Onset of Third Infection					2	1		
Stage of Tunnel Healing							6.558	.34

Analysis of variance results indicate there were no significant differences in the number of infections, number of organisms, gram stain of organisms, or onset of infection among groups. According to Field (2009) ω calculations more accurately estimates effect size beyond the sample population because average variance is considered rather than using numerator sum of squares of the model over denominator total sum of squares. The ω values in Table 8 indicate that the average variance explained by the analysis of variance

tests are minute, coinciding with non-significant findings of difference between groups. There were also no significant differences in the number of infections before tunnel healing (day 14), or after tunnel healing (day 15 and beyond) among groups as indicated by the non-significant results of the χ^2 test.

Although overall effects of type of dressing on CRBSI are small, between group comparisons in Table 9 reveal odds ratios (OR) and relative risks (RR) were higher in the gauze and transparent groups than the no dressing group, with gauze and transparent dressings resulting in equal risk. OR was determined by dividing the odds of developing an infection in one group by the odds of developing infection in a different group. Similarly, RR was determined by dividing the percentage of infection in one group by the percentage of infection in a different group. The odds of developing an infection in the gauze group were .58 times higher than the no dressing group. The odds of developing and infection in the transparent group were also higher than the no dressing group by .25. Relative risks for each group comparison show narrower differences between each dressing group with a .21% higher risk when a gauze dressing versus no dressing is used, and a .17 % higher risk of infection when a transparent dressing is used instead of no dressing.

The abnormally distributed cost variables were analyzed with non-parametric equivalent tests, namely the Chi square test for multiple group comparisons, and the Mann Whitney U test was used in substitute of a parametric *t* test. There were significant differences in costs of each care strategy, $\chi^2 = 2.75.68$ (df2), $p < .001$. Mann Whitney U tests show gauze dressings (*M* $2059.7, *SD* 1660.81) cost more than no dressing (*M*

$712.31, *SD* 501.312), and no dressing costs more than using a transparent dressing (*M* $445.8, *SD* 682.32).

Table 9
CRBSI Risk and Cost Differences Between Dressing Strategies

	CRBSI		Cost			
	Odds Ratio	Relative Risk	Mann Whitney			
	OR	RR	U	*z*	*p*	*r*
GD vs. ND	1.33	1.21	3784	9.32	<.001	.55
GD vs. TD	1	1	1787	12.14	<.001	.72
ND vs.TD	.75	.83	5381	7.06	<.001	.42

GD=gauze dressing, ND=no dressing, TD=transparent dressing

Discussion

Results from this study comparing the incidence of CRBSI among blood stem cell transplant recipients whose tunneled catheter sites were managed with either gauze, transparent, or no dressing suggest that the type of CVC exit site dressing is not associated with infection in this population. However, supply charges for the different dressing strategies were significantly different, with gauze dressings incurring the highest costs to maintain ($ 59.10/week), followed by no dressings ($55.89/week), and lastly, transparent dressings ($23.71/week). The overall costs and benefits of each strategy require clinical judgment and consideration of negative outcomes, charges, and non-monetary costs.

Study results indicate bloodstream contamination at the tunnel site is unlikely when the site is kept dry beneath dressings or by dressing removal. Initial dressings prevent exposure to host bodily fluids and catheter slippage until the tunnel site has healed. O'Grady et al. (2011) suggest moisture catalyzes microbial tunnel migration and increases surface colonization thereby advising to protect access sites from unsterile

precipitation. Recommendations are based on case-reports of water borne infections likely introduced via unprotected connections. Covering all sites and connections during showering may be more influential on CRBSI reduction than the type of dressing.

It is further advised to use careful judgment with dressing maintenance for a prolonged period of time (O'Grady et al., 2011). Clinical judgment is also needed for dressing removal. Daily skin antisepsis, shower covers and using securement devices are recommended strategies that incur charges. Medical products designed for these purposes may not be feasible in low income countries or may be intentionally overused in for-profit areas. All patients should receive equal quality and commission of essential health care. Affordable options such as using cellophane and waterproof tape may be viable solutions to overcoming the expense of using brand name medical products without reducing care quality. In addition, like dressings, some patients may not tolerate adhesive shower coverings and securement devices. Topical skin barriers and/or hydrocolloid dressings in conjunction with adhesive should be used with discretion over removing the dressing entirely.

It appears the recent trend to remove the dressing from a healed tunneled exit site is not only a safe strategy it is also a cost-effective alternative to using a gauze dressing in terms of supply charges. In accordance with asepsis theory, the embedded cuff suffices as a barrier while removing the dressing maintains a dry environment. Daily skin cleansing with the no dressing strategy also ensures more frequent attempts to reduce microbial load around the exit site. However, daily skin antisepsis after showering as opposed to cleansing once per week incurs fees for supplies that exceed the more

traditional approach of using a transparent dressing. Options at the bedside should consider additional potential factors that inflate expenses when treatment is lengthy.

A recent survey of Canadian CVC practice in blood stem cell transplant reports registered nurses spend up to 30 minutes for a single dressing change with average time of 15 minutes (Keeler, 2014). A review of collective agreements for nursing wages in Canada in 2013 (Table 10), reveals that the national average hourly wage for a level I registered nurse (excluding the Territories and Quebec) is $35.28. The gauze dressing strategy incurs more than double the expense of a transparent dressing when considering nursing wages that do not need to be factored into the costs of the no dressing strategy. Removing the dressing from a healed tunneled CVC site can reduce time constraints on registered nurses that perform dressing change procedures and educate others so the task can be delegated.

Table 10
Average Canadian 2013 Registered Nursing Wages

Increment	BC	AB	SK	MB	ON	NB	NS	PEI	NFLD
1	30.79	35.00	34.94	31.02	30.17	29.86	32.84	29.57	30.77
2	31.96	36.34	36.59	32.10	30.91	31.87	33.82	30.77	31.98
3	33.16	37.69	37.43	33.19	31.12	33.05	34.91	32.16	33.28
4	34.33	39.04	38.28	34.32	32.65	34.42	36.13	33.53	34.88
5	35.52	40.39	39.19	35.428	34.2	35.76	37.39	34.91	36.46
6	36.71	41.72	40.09	36.572	36.12	36.80	38.69	36.03	38.10
7	37.90	43.08	41.45	-	38.06	37.88	-	-	-
8	39.02	44.35	42.81	-	40.01	-	-	-	-
9	40.42	45.93	44.08	-	42.85	-	-	-	-
Average	31.04	40.39	39.43	33.77	35.94	34.23	35.63	32.82	34.25
National Average									35.28

*Excluding QC and the Territories
* For level I registered nurses excluding education/shift/weekend/long-service differentials, or retrospective lump sum payments

Patient context may be the most important factor in determining the type of CVC exit site care required. Typically, individuals with allergies to adhesive employ the use of a gauze dressing. Dressing removal may also serve as a more comfortable option to other individuals by eliminating pruritus and decreasing excoriation from repeat adhesive removal. Findings from this study suggest that resorting to no dressing is a more cost-effective approach than using gauze. Dressing removal may also relieve care burden on patients and lay caregivers by simplifying the amount of education needed and minimizing the number of tasks required for self-care. Cost savings should be balanced with patient preference and provider experience when implementing nursing policy.

It was noted that adherence to the policy of removing the dressing was not rapidly incorporated at the study site. Clinical documentation indicated some patients were anxious and/or uncomfortable leaving the exit site open to air. Non-adherence to removing the dressing after the policy change could have result-limiting effects. Individuals who refused the no-dressing strategy were eligible to be included in the

sample. It is unclear if individual choice increases vigilance with infection prevention; however, results do not indicate significant infection reduction in groups that used dressings.

Conclusion

The decision to dress and maintain a CVC dressing is the responsibility of clinicians who employ best practices based on empirical evidence, clinical expertise, and patient preference. Differences in nursing care strategies are not necessarily disparities. Rather the various care approaches may represent conscious efforts of nurses applying theoretical and practice-based experience at the bedside. The study empirically supports each dressing strategy in terms of infection risk while weighing in on certain costs and benefits. Overall, this study supports the traditional use of transparent dressings on a tunneled CVC in the blood stem cell transplant population unless circumstances dictate intolerance. The no dressing strategy is the recommended alternative to a transparent dressing as it is a safe and more cost-effective approach than using gauze dressings. Further cost containment can be achieved with the no dressing strategy by reducing time constraints on nurses and patients that are difficult to quantify in monetary measures.

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Chapter Five: Summary

Registered nursing is a theoretically based science that involves application of experience, skills, and evidence-based interventions. Nurses are not as interchangeable between practice settings as their historic counterparts. Specialty areas require competencies that were once viewed as advanced practice. The evolution of healthcare has pushed nursing research to examine specific gaps in evidence within specific populations and specific circumstances. This research approach not only assists in controlling construct validity; it also fine tunes nursing science and confirms theoretical standpoints for care strategies that have not been empirically tested.

Blood and marrow cell transplant nursing is a unique practice specialty with its own nursing subculture. Nurses in this area have first-hand familiarity with common morbidities associated with cancer treatment. Leung et al. (2012), report that bone marrow transplant nurses in Canada undergo immense stress when they know their patients are suffering. The interpersonal element of care gives rise to leadership and advocacy at the bedside that can be critical to patient well-being. When nursing practice changes are imposed with little support, the professionals expected to deliver care may question quality measures. In turn, administrators may be faced with lack of adherence to policy. Légaré et al. (2010) also point out the importance of shared decision-making that maintains the patient as the centre focus and incorporates family and significant others. The model includes the client as a key stakeholder in inter-professional collaboration and

mitigates barriers to the most appropriate plan of care for an individual. It is essential that policy decisions include input from frontline personnel and be communicated with credible evidence to achieve a buy in for change; especially when the ramifications for practice are life threatening and expensive. Building organizational rapport may also indirectly influence bedside rapport and patient satisfaction with care recommendations.

The general topic addressed by this research project involved clinical changes to CVC care practice with blood and marrow cell transplant recipients. Guiding evidence to support these actions was conflicting and/or absent in the literature. It was first established through a descriptive survey that CVC practice differs across Canada; however, the individual needs of each patient were considered to be a primary consideration when selecting an exit site care strategy for a tunneled CVC. Other discrepancies such as different competency training approaches and flushing protocols are worth future nursing research attention. Blanketing strategies across the entire blood stem cell transplant population undermines the flexibility and judgment of unique circumstances in registered nursing. Differences in care do not constitute disparity; rather, they provide options that require expertise for selection.

Awareness of the cost implications for nursing care strategies may assist the organization in capital planning. The study estimating the cost of CRBSI in blood and marrow cell transplant recipients with a tunneled triple lumen subclavian CVC was conducted with the intent to highlight the importance of infection prevention. Findings revealed significant healthcare expenses in the presence of CRBSI within the blood stem cell transplant population which are higher than infection costs in other clinical areas. Budgets should not dictate clinical decisions that favor administrative goals over patient

outcomes. Abuse of this knowledge has the potential to violate the trust of both consumers and clinicians alike. Insights into the costs of negative outcomes should be used for targeting prevention strategies that maintain patient-focused quality care. In turn, solutions can serve multifaceted purposes that meet the goals of all parties involved in the healthcare system.

The third study compared the no-dressing strategy that was the subject of a practice change initiated at a large transplant center in Canada to two other dressing alternatives for patients with tunneled catheters who received blood stem cell transplant. Findings were able to substantiate all three care approaches in terms of infection risks. Results fill the gap in the evidence for recommending removing the dressing from a healed tunneled CVC exit site. Analysis of the costs and benefits of each strategy may further inform practice decisions at bedside and administrative levels. Nursing care of the exit site did not positively influence infection outcomes provided all other current guidelines are followed. Additional research investigation of other areas of nursing influence may further elucidate unknown sources of CRBSI.

Findings from all three studies have the potential to influence stem cell nursing practice in Canada and across the globe. Further analysis of the large data set generated in this project is planned to delineate other areas of nursing influence on long-term tunneled triple lumen subclavian CVC-related complications. Specific attention will be given to other complications noted in data collection such as occlusion and thrombosis in the superior vena cava, accidental line removal, and tunnel infection. A more comprehensive analysis of specific organisms and gram staining will also be considered. Future research efforts will continue to focus on generating evidence to support practice

decisions for care of patients receiving stem cell transplants for hematologic disorders and malignancies.

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Appendix A

Survey

Cover Letter

Dear Participant

Due to your experience, you have been selected to participate in a research study on central venous catheter practice in Canadian cell transplant. Your perspective will help inform health policy and future research. This study is being conducted by a Canadian doctoral candidate studying at the University of Texas at Tyler.

A link to an attached survey is provided at the end of this document. Participation assumes your consent. You will receive an e-mail reminder of the survey if you are unable to participate at this time. Results of your survey will be compared to other Canadian transplant centres. The information you provide will be summarized and reported within a nursing doctoral dissertation and potentially a peer reviewed academic journal.

You are free to ask questions or discuss participation at any time. You are also free to withdraw at any time without prejudice. Participants will be entered to win a random draw for a $50 Tim Horton's gift card. For information or questions feel free to contact Melanie Keeler at (403) 890-9249 or mkeeler@patriots.uttyler.edu

This study has been approved by the Institutional Review Board at the University of Texas at Tyler.

Appendix A (Continued)

Survey Questions

Demographic Questions

1. In what Canadian Province or territory is your centre located?

   YT NT NU BC AB SK MB ON QC NB NS NL PEI

2. Does your centre provide any of the following transplants (check all that apply)

   blood cell
   bone marrow
   cord
   hematopoietic progenitor stem cell

3. What is the estimated number of transplant patients treated at your centre each year?

   50 or less 50 to 100 more than 100

4. Is your centre considered

   A) Adult
   B) Pediatric
   C) Both

Content Questions

The following section concerns central line education

5. Does your centre have a policy in place to educate clinicians about central lines?

Insertion	Yes	No
Routine Care	Yes	No
Maintenance	Yes	No

Appendix A (Continued)

6. Does your centre have a policy in place to educate patients, family, or lay caregivers about central lines?

   Routine Care Yes No
   Maintenance Yes No

7. How often is education on central line care reinforced at your centre for example, recertification, lunch and learn, or training modules?

   Never Yearly Other_____

The following section concerns the insertion of central lines at your centre

8. Who is responsible for inserting central lines (excluding PICCS) at your centre?

   Radiologist/Radiology Resident
   Physician/Resident Physician
   Anesthesiologist
   Specialty Nurse
   Other (specify)_____

9. Where are non-emergent central lines inserted at your centre?

   Bedside
   Radiology department
   Operating room
   Angio suite
   Other (specify)_____

10. Select the barrier precautions used at your centre for central line insertion? (Check all that apply)

    Hand washing
    Sterile field/drape/gown
    Aseptic technique
    Antiseptic skin preparation
    Mask
    Sterile glove
    Clean glove

Appendix A (Continued)

11. What type of antiseptic solution is used for central line insertion at your centre?

    Unknown
    0.5% chlorhexidine
    2% chlorhexidine
    Tincture of Iodine
    Iodophor
    70% Alcohol
    Other (specify)_____

12. What type of central line is preferred and/or most commonly used for cell transplant recipients at your centre?

    Tunneled
    Non-tunneled
    Port/IVAD
    IJ
    Femoral
    PICC
    Other (specify)_____

13. Does your centre use ultrasound guidance for central line insertion (excluding PICC)?

    Always When possible Never Unknown

14. How many lumens do the majority of central lines have in cell transplant recipients at your centre?

    1
    2
    3
    More than 3

Appendix A (Continued)

15. Does your centre use central lines impregnated with antimicrobial agents?

    Yes Line
    Yes cuff and line
    No
    Unknown

16. Do cell transplant recipients at your centre receive prophylactic antibiotics prior to line insertion?

    Yes
    No
    Unknown

17. Is there a preferred insertion site for central line catheters in cell transplant recipients at your centre?

    Physician preference
    No
    Right subclavian
    Left subclavian
    Right IJ
    Left IJ
    Right Port/IVAD
    Left Port/IVAD
    Double lumen Port/IVAD
    Right Femoral
    Left Femoral
    Right PICC
    Left PICC

The following section concerns central line maintenance at your centre

18. What solution is used with central line catheters (excluding PICCS) at your centre?

    Not applicable
    Flushing solution_____ Volume (mL)_____
    Locking solution_____ Volume (mL)_____

Appendix A (Continued)

19. Does your centre instill any of the following solutions into the lumen of an infected central line or when a central line infection is suspected? (check all that apply)

    No
    Sodium citrate
    Ethyl Alcohol
    Vancomycin
    Gentamyacin
    Other (specify)_____

20. Does your centre use any solutions with occluded or suspected central line occlusion?

    No
    High dose heparin (5000u/mL or >)
    Alteplase/Tpa
    Other (specify)_____

The following section concerns central line care at your centre

21. What type of dressing is applied to a central line at your centre immediately after insertion?

    Pressure
    Gauze
    Gauze and transparent
    Mepore/Premapore
    Other (specify)_____

22. At what point after insertion is the initial dressing changed for a central venous catheter (excluding PICC)?

    24 hours or earlier if soiled
    48 hours
    1 week
    Other (specify)_____

Appendix A (Continued)

23. What type of dressing is most commonly applied to a central line when the initial dressing is removed?

    Gauze (with or without disc)
    Semi-transparent film such as tegaderm
    Mepore/Primapore
    Biopatch or chlorhexidine sponge
    Other (specify)___

24. How often is a non-soiled central line dressing changed at your centre?

    Daily
    Every 48 hours
    Weekly
    No more than once every 7 days
    Other (specify)_____

25. What is the average amount of time spent by you or a staff member for one central line dressing change?

    <15 minutes 15-30 minutes 30-45 minutes 45 minutes or more

26. Does your centre maintain a dressing on a healed tunneled central line exit site?

    Yes No

27. Who performs central line dressing changes at your centre? (check all that apply)

    Physician
    Nurse Practitioner/Clinical Nurse Specialist
    Registered Nurse
    Licensed Practical Nurse
    Patient
    Family Member
    Lay caregiver
    Other (specify)_____

Appendix A (Continued)

28. What barriers/ precautions are used at your centre for central line dressings by staff at your centre? (check all that apply)

    Mask
    Sterile gown
    Sterile gloves
    Clean gloves
    Sterile drape
    0.5% chlorhexidine
    2% chlorhexidine
    Iodaphor
    Tincture of iodine
    70% alcohol
    Alcohol swabs
    Normal saline
    Other (specify)_____

29. At your centre, do cell transplant recipients with central lines use additional barriers or coverings such as aquaguard while showering?

    No
    Yes at all times and with all dressing types
    For gauze dressings only
    For healed tunneled lines open to air only
    Other (specify)

30. How often is exit site skin care performed on central lines that do NOT have a dressing?

    Not applicable
    Daily
    More than once a day
    Only after showering
    Other (specify)

Appendix A (Continued)

The following section deals with central line removal at your centre

31. Who is responsible for removing central lines (excluding PICC) at your centre?

    Anesthesiologist
    Physician/Resident physician
    Advanced practice nurse
    Registered Nurse
    Anyone trained in the procedure
    Other (specify)_____

32. Are central lines in cell transplant recipients promptly removed at your centre when no longer essential?

    Yes No

33. Under what circumstances would a cell transplant recipient have a central line replaced at your centre? (check all that apply)

    Suspect infection
    Known infection
    Suspect occlusion/thrombus
    Known occlusion/thrombus
    Malfunction
    Other (specify)_____

Thank you for your time and participation. If you wish to be informed of the survey results please provide your contact information and preferred method of communication. This information will be stored in confidence and securely destroyed after results have been shared with you.

Appendix B

Institutional Review Board Approvals

The University of Texas at Tyler
Institutional Review Board

October 10, 2013

Dear Ms Keeler,

Your request to conduct the study: *Cost-benefit Analysis of Tunneled Central Venous Catheter Dressings in Canadian Stem Cell Transplant Recipients* IRB #F2013-17 has been approved by The University of Texas at Tyler Institutional Review Board under expedited review. This approval includes a waiver of written informed consent, and is conditional on approval by the Alberta Cancer Research Ethics Committee. In addition, please ensure that any research assistants are knowledgeable about research ethics and confidentiality, and any co-investigators have completed human protection training within the past three years, and have forwarded their certificates to the IRB office (G. Duke).

Please review the UT Tyler IRB Principal Investigator Responsibilities, and acknowledge your understanding of these responsibilities and the following through return of this email to the IRB Chair within one week after receipt of this approval letter:

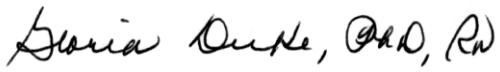
- This approval is for one year, as of the date of the approval letter
- Request for Continuing Review must be completed for projects extending past one year
- Prompt reporting to the UT Tyler IRB of any proposed changes to this research activity
- **Prompt reporting to the UT Tyler IRB and academic department administration will be done of any unanticipated problems involving risks to subjects or others**
- Suspension or termination of approval may be done if there is evidence of any serious or continuing noncompliance with Federal Regulations or any aberrations in original proposal.

Appendix B (Continued)

- Any change in proposal procedures must be promptly reported to the IRB prior to implementing any changes except when necessary to eliminate apparent immediate hazards to the subject.

Best of luck in your research, and do not hesitate to contact me if you need any further assistance.

Sincerely,



Gloria Duke, PhD, RN
Chair, UT Tyler IRB

Appendix B (Continued)

[redacted]

30 October 2013

[redacted]

Dear [redacted]

Re: 26162: Cost-benefit Analysis of Tunneled Central Venous Catheter Dressings in Canadian Stem Cell Transplant Recipients

Thank you for submitting the proposal for the above named study. On behalf of the [redacted] I have reviewed the following documents as of 18 October 2013:

- Application for Research of Minimal Risk dated 11 October (received 16 October 2013)
- The University of Texas at Tyler Institutional Review Board Approval Letter and Application dated 10 October 2013

Thank you also for your submission dated 25 October 2013 in response to correspondence dated 21 October 2013, together with the following:

- Application for Research of Minimal Risk dated 25 October (received 25 October 2013)

As of 28 October 2013, the following documents have been approved:

- Application for Research of Minimal Risk dated 25 October (received 25 October 2013)

Appendix B (Continued)

Please note that this approval is based on the following conditions:

if there are any other changes to the protocol during the year, a letter describing the chang[redacted] be forwarded to the

- an Annual Renewal form must be submitted two months prior to the deadline date of **18 October 2014 (one year from the date of initial review)** containing the information as per our annual renewal form;
- a Final Report must be submitted at the termination of the project.

The deliberations of the [redacted] include all elements described in Section 50 of the Health Information Act, and this study was found to be in compliance with all the applicable requirements of the Act. Access to personal identifiable health information was requested in th[redacted] application, however upon review, the [redacted] has waived consent as it was demonstrated to be impractical, unreasonable or not feasible to obtain.

The [redacted] complies with the following guidelines and regulations:

[redacted]

- Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans;
- Health Information Act which has been proclaimed on April 25, [redacted]
- Health Canada, as defined in C.05 (Part C Division 5) (1024 - Clinical Trials) of the Food And Drug Regulations -Amendment and the Therapeutic Products Directorate Guidelines /ICH Harmonized Tripartite Guidelines - Good Clinical Practice: Consolidate Guidelines;
- National Institutes of Health - Code of Federal Regulations (USA); and
- Our institution has been approved by the Office for Human Research Protections in the United States.

Membe[redacted] who are named as investigators or co/sub-investigators in research studies do not participate in discussion related to, nor vote on, such studies when they are presented to the [redacted]

Appendix B (Continued)

Please accept the Committee's best wishes for success in your research. Sincerely,

[redacted]
Associate Chair, [redacted]

[redacted]

[redacted]

Appendix B (Continued)

The University of Texas at Tyler
Institutional Review Board

October 10, 2013

Dear Ms Keeler,

Your request to conduct the study: *Cost-benefit Analysis of Tunneled Central Venous Catheter Dressings in Canadian Stem Cell Transplant Recipients* IRB #F2013-17 has been approved by The University of Texas at Tyler Institutional Review Board under expedited review. This approval includes a waiver of written informed consent, and is conditional on approval by the [redacted] Research Ethics Committee. In addition, please ensure that any research assistants are knowledgeable about research ethics and confidentiality, and any co-investigators have completed human protection training within the past three years, and have forwarded their certificates to the IRB office (G. Duke).

Please review the UT Tyler IRB Principal Investigator Responsibilities, and acknowledge your understanding of these responsibilities and the following through return of this email to the IRB Chair within one week after receipt of this approval letter:

- This approval is for one year, as of the date of the approval letter
- Request for Continuing Review must be completed for projects extending past one year
- Prompt reporting to the UT Tyler IRB of any proposed changes to this research activity
- **Prompt reporting to the UT Tyler IRB and academic department administration will be done of any unanticipated problems involving risks to subjects or others**

Appendix B (Continued)

- Suspension or termination of approval may be done if there is evidence of any serious or continuing noncompliance with Federal Regulations or any aberrations in original proposal.
- Any change in proposal procedures must be promptly reported to the IRB prior to implementing any changes except when necessary to eliminate apparent immediate hazards to the subject.

Best of luck in your research, and do not hesitate to contact me if you need any further assistance.

Sincerely,

Gloria Duke, PhD, RN

Gloria Duke, PhD, RN
Chair, UT Tyler IR

Appendix C

Canadian Oncology Nursing Journal Guidelines for Authors

Guidelines for Authors

Introduction
The Canadian Oncology Nursing Journal (CONJ) welcomes original articles, research papers, letters to the editor, media reviews, professional ads, and stories of interest to nurses who provide care to patients with cancer and their families.

Policy
All correspondence and manuscripts must be forwarded to the editor-in-chief. The editor-in-chief or delegated associate editors will assume responsibility for obtaining confidential peer review. Normally, the process of peer review takes approximately three months. If published, manuscripts become the property of CONJ. The journal will have exclusive rights to the manuscript and to its reproduction. Manuscripts may not be under consideration by any other journal.

Copyright
When submitting a manuscript, include a statement of ownership and assignment of copyright as follows: "I hereby declare that I am the sole proprietor of all rights to my original article entitled…, and I assign all rights to CANO/ACIO for publication in the Canadian Oncology Nursing Journal." Please date and sign. ALL authors must sign this statement. Please submit this statement in a WORD document by electronic mail to the editor in chief, CONJ.

Authors must obtain written permission for use of previously published materials included in the manuscript. This includes extensive quotations (greater than 500 words), tables, figures, charts, graphs, etc. Written permission for all copyright materials must be included with the manuscript.

Manuscript Content
1. Style
Manuscripts must be typewritten or word processed in times roman or courier typeface using a 12 points font. Copy must be clear and legible. Uniform margins of

at least 1 inch, and double spacing are required. Number pages consecutively in upper right-hand corner, beginning with title page. Identify each page with the first two or three words from the title inserted above the pagination. Use one side of the paper only. The required style is that recommended by the American Psychological Association (APA). (2001). Publication manual (5th ed.). Washington, DC: Author.

2. Length

The preferred length is 6 to 16 double-spaced pages including tables, figures, and references.

3. Title page

The title page must include the title of the article, the name(s) of the author(s) as meant to appear in the publication, and, if possible, an e-mail address where the main or contact author may be reached. If more than one author, the order must be that desired in the publication. Accuracy is essential to ensure accuracy in publication. Include the author(s) credentials, position, place of employment, correct mailing address, telephone and facsimile numbers. Indicate preferred author and address for correspondence.

1. Abstract

Include an abstract of 100-120 words. This abstract should summarize the article and highlight the main points of interest for the reader. It must be double-spaced and on a separate page.

2. References

References must be double-spaced, in alphabetical order, complete, and accurate. References should start on a separate page and must be cited in the text.

3. Tables

Tables are numbered consecutively in the order in which they are first mentioned in the text. Double-space and begin each table on a separate page. Tables should complement, not duplicate text.

4. Figures

All figures must be copyrighted and documented. They must be submitted on separate pages and should not duplicate text. Number consecutively in the order in which they are first mentioned in the text. Figures must be clear, easy to interpret, and in black and white only for reproduction.

Appendix C (Continued)

5. On acceptance for publication

Manuscripts accepted for publication are subject to copyediting. Electronic copies should be on the Windows operating system and rich text format is preferred.

Correspondence
A letter of query to the editor-in-chief regarding suitability of a proposed manuscript is suggested, but not required. Forward the original complete manuscript in a WORD document by electronic mail to the editor-in-chief. Include your e-mail address and other contact addresses with your manuscript for acknowledgement of receipt of your manuscript.

Non-refereed material
The journal also invites brief submissions of less than 500 words that highlight clinical practice tips, new program developments, research in progress, or reviews of articles, books, and videotapes. These submissions are published at the discretion of the editor-in-chief. Queries are unnecessary.

Language
Articles will be published in the language of submission with a summary in the other official language (French or English). Selected articles will be translated in total. The Canadian Oncology Nursing Journal is officially a bilingual publication.

Heather Porter, RN, Ph.D. hbporter@rogers.com Editor-in-Chief
Canadian Oncology Nursing Journal (CONJ) 14-54 Blue Springs Drive
Waterloo, ON N2J 4M4 Tel: (519) 886-8590
Fax: (519) 886-9329

Appendix D

Permission Letter

2/17/2014

Melanie Keeler
1047 Maggie Street, SE Calgary, AB
T2G4L8 Canadian Oncology Nursing
Journal
375 West 5th Avenue, Suite 201, Vancouver BC, V5Y 1J6

Dear Dr. M. Fitch:

I am preparing my dissertation at The University of Texas at Tyler, with plans to co1nplete my degree on May 9, 2014. We use a multi-paper format for our dissertation portfolio, which includes papers we have written and/or published.

The article Central Line Practice in Canadian Blood and Marrow Cell Transplant, of which I am first author, is scheduled to appear in your Canadian Oncology Nursing Journal, reports an essential part of my dissertation research. I would like permission to reprint the article as a chapter in my dissertation portfolio. As per your preference, I can either include a pdf of the published article or a word document of the submitted article with reference to the journal.

Following the final dissertation defense, our dissertation portfolios are submitted to our institutional repository and access may be restricted to those currently employed or enrolled at The University of Texas at Tyler. The copyright for the article named above remains with the Canadian Oncology Nursing Journal. Submission to our institutional repository will in no way restrict republication of the material in any other form by you or by others authorized by you

Appendix D (Continued)

If you have any questions, please contact me at mkeeler@patriots.uttyler.edu or my dissertation chair, Dr. B. Haas at bhaas@uttyler.edu. Thank you for your assistance,

X

Melanie Keeler
RN, PhD candidate at the University of Texas

I hereby give permission for the use as requested above:

x

Marg Fitch
Editor In Chief CONJ

Biosketch

BIOGRAPHICAL SKETCH			
Keeler, Melanie Erin		POSITION TITLE RN MN	
eRA COMMONS USER NAME (credential, e.g., agency login) keelerme			
EDUCATION/TRAINING			
INSTITUTION AND LOCATION	DEGREE	MM/YY	FIELD OF STUDY
The University of Calgary	BN	06/2002	Nursing
The University of Southern Queensland	MN	04/2009	Nursing
The University of Texas at Tyler	PhD	candidate	Nursing

A. Personal Statement

The goal of the proposed research was to investigate Canadian blood and marrow cell transplant nursing practice with central venous catheters in terms of cost. Specifically, we measured differences in catheter-related bloodstream infection across six-year period in a cohort of adult blood and marrow transplant recipients with long-term tunneled triple lumen subclavian central venous catheters that used different types of dressings (transparent, no dressing, or gauze). Concomitant analysis of the cost of infection and cost of each dressing strategy was conducted. My clinical background in hem-oncology nursing and post-graduate coursework in nursing and research enabled me to successfully carry out the study.

Biosketch (Continued)

B. Positions and Honors

Positions and Employment

2001-Present (per diem). RN. Hematology/Oncology/ HPC Transplant. [redacted]
2009-Present. Adjunct Clinical Nursing Instructor. [redacted]
2009-2010. Adjunct Nursing Instructor in Context Based Learning. Red Deer College, Red Deer, AB
2004. Registered Nurse. Pediatric Oncology, Alberta Children's Hospital, Calgary, AB
2003-2004. Travel Nurse. Oncology. Alta Bates Medical Center, Berkeley CA
2003. Travel Nurse. Hematology/Oncology. Stanford Medical Center, Palo Alto CA

Other Experience and Professional Memberships

Canadian Association of Nurses in Oncology
Canadian Blood and Marrow Transplant Group
Canadian Nurses Association
Phi Kappa Phi Honors Society

Honors

May, 2013 [redacted] TD Insurance Meloche Monnex Scholarship
May, 2012 [redacted] Registered Nurses Educational Trust: Board of Directors Scholarship
August, 2011 [redacted] Registered Nurses Educational Trust: Doctoral Studies Funding
August, 2009 [redacted] Registered Nurses Educational Trust: Masters Studies Funding

C. Peer-reviewed Publications

Keeler, M.E. (2014). Central line practice in Canadian blood and marrow cell transplant. *Canadian Oncology Nursing Journal*, (inPress)