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Tunnelled central venous catheter-related bloodstream infection in Canadian blood stem cell transplant recipients: Associated costs

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ABSTRACT

Problem: Central catheter-related bloodstream infection (CRBSI) is associated with increased health care costs and patient morbidity. The purpose of the study was to estimate the direct inpatient charges of CRBSI in Canadian blood and marrow cell transplant recipients with a tunnelled central venous catheter (CVC).

Method: A case-controlled comparison of patient records from a single centre was completed. Records indicating CRBSI were paired for comparison to patient records not indicating CRBSI in the following domains: length of stay, laboratory tests, diagnostic tests, medications used, consultations to a specialty physician, catheter replacement costs, and length of stay in the intensive care unit.

Results: Cases stayed on average an extra 19.37 days in the hospital. Extra charges for diagnosing and treating CRBSI averaged \$4,739.95. The total estimated burden of CRBSI in Canadian blood and marrow transplant for the 2013 fiscal year was \$44,816.48 per incident. Infections also reduced the length of catheter use time by an average of 18.68 days.

Key words: catheter related bloodstream infection, cost, stem cell transplant

Controlling infection is a challenging endeavour in health care. Often, the sickest patients rely on medical technology for recovery. Cancer patients possess intrinsic risks for infection with compromised immune function being the most serious (Berek et al., 2012). A central venous catheter (CVC) is a commonly used device in blood stem cell transplant for delivering therapeutics and blood sampling (Scales, 2011). The device provides a direct portal to the bloodstream and, because of this, there is a potential for contamination. An infection with a catheter as the source of transmission into the body is defined by O'Grady et al. (2011) as a catheter-related bloodstream infection (CRBSI). Boersma and Schouten (2010) caution against expecting health care infection, as part of modern medicine. Infection control measures can be effective for ensuring safety with the use of medical devices including a CVC.

Certain hospital-acquired infections are avoidable with evidence-based prevention strategies that target extrinsic risk factors (Berek et al., 2012). Hand washing, for example, reduces transfer of microbes from one surface to another. Health care workers have an ethical responsibility to perform due diligence in preventing infection, which is especially threatening to immunocompromised patients. 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 health care provision. Scrutiny of hospital infection rates challenges administrators to ensure control measures are positively influencing outcomes as CRBSI is more widely associated with morbidity and treatment expense than patient deaths (O'Grady et al., 2011). It is useful to estimate CRBSI costs in the blood stem cell transplant population to determine the return on investments for preventing CRBSI. Currently, the costs of CRBSI in Canadian blood stem cell transplant recipients are unknown. The purpose of the study is to estimate inpatient direct medical care charges for CRBSI in Canadian blood stem cell transplant recipients with a cuffed tunnelled triple lumen subclavian CVC.

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REVIEW OF THE LITERATURE

CRBSI

The introduction of pathogenic organisms into the bloodstream may develop into a systemic infection. Determining that an infection is related to a catheter involves assessment and ruling out all other potential sources. Biofilm, which has an

affinity for surfaces, may colonize onto the inside or the outside of a catheter (Yasuhiko et al., 2012). Exterior surface colonies are associated to a CVC without the catheter being the source of entry. Placement, handling connections, or (rarely) infusions are all gateways for organisms to enter the bloodstream with central line use (O'Grady et al., 2011). The Infectious Diseases Society of America (IDSA) cites criteria for diagnosing CRBSI, which practice consultants differentiate from a central-line associated bloodstream infection (CLABSI) (O'Grady et al., 2011; Mermel et al., 2009). Comparative blood cultures are laboratory tests used for diagnosing CRBSI (Safdar, Fine, & Maki, 2005). Blood cultures that compare the differences in the growth time and overall quantity of organisms more accurately distinguish between organisms that are sourced in (and likely introduced from) a catheter (CRBSI) versus surface seeding or introduction from other portals (CLABSI).

Cost

Extended hospital stay is a common cost measure used to estimate fiscal implications of hospital infection. Fragile immune function, needed hospitalization, and CVC use heightens infection risks for blood stem cell transplant recipients. The cost of a CRBSI in blood stem cell transplant recipients with a tunnelled CVC has not been reported in the literature. It is unclear if CRBSI prolongs hospital stay in cell transplant in similar amounts of time as non-immunocompromised populations. Patient acuity in conjunction with infection potentially strains health care budgets to a greater extent in the blood stem cell transplant population. Hsu et al. (2013) note wide variations in health care cost estimates due to hospital reimbursement rates (profit versus non-profit) in multi-payer health care models. Variations in cost estimates may also be attributable to the differences in measures for each study. For example, some departments may include medication costs within the cost of hospital stay while others have separate pharmacy charges. Table 1 summarizes cost reports of a single incident of a bloodstream infection with varying estimates due to currency values, clinical population, and timing of the research. The Centers for Disease Control and Prevention (CDC) reported in 2005 that the cost of a single central line-associated infection exceeds \$25,000 U.S. without specifying differences in costs for CRBSI. In addition to the payment model, the majority of economic analyses displayed in Table 1 report findings from intensive care settings that may not be generalizable to the blood cell transplant population, as infection can influence immune reconstitution and recovery times (Tomblyn et al., 2009).

A basic tenet within modern microeconomic theory regards marginal value synonymously with the price of a commodity (Nicholson & Snyder, 2012). Cost factors in health care can be direct or indirect. Arguably, value in health care 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 and are beyond the scope of this study. Conceptualization of health care 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. Identifying direct medical charges for specific adverse outcomes can be useful in cost-benefit analysis and policy research.

Canadian cost factors

The Canadian health care insurance plan is a universal model designated by public authority and delivered on a non-profit basis (Health Canada, 2013). The government is the single payer for individual health insurance that covers all citizens. Health departments provide budgets to the federal and provincial/territorial governments, which then supply equal monies up front for the following year. Insured health benefits are defined and stipulated by health legislation. The Canada Health Act (1985) mandates 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. Billing is administered according to how departments are divided within a given institution. For example, individual care and associated meals, supplies, and equipment are typically billed together as a base cost for a 24-hour inpatient stay. Other benefits, such as medications or medical scans, are billed from respective pharmacy and diagnostic imaging departments. Fees for treating adverse events are absorbed within departmental operating budgets.

Observational research of past events puts cost containment into perspective by revealing the capital benefits of preventing adverse events. CRBSI (the independent variable of the study) leads to 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). Cultures indicating higher amounts of organisms or two-hour faster growth time within the catheter compared to the amounts of organisms or growth times in the bloodstream constituted a true CRBSI in this study.

The budget at the study centre for treating blood stem cell transplant recipients is funded by a single payer allocating funds to different departments. An initial lump sum is billed to the government for each blood stem cell transplant recipient (e.g., X amount of dollars including X amount of hospital days, cell collection and storage, etc.). Charges beyond the initial lump sum for transplant were determined based on the additional expenses billed to the government for diagnosing

and treating a CRBSI including extra days spent in the hospital. The dependent variable, charge, is operationally defined as the Canadian dollar value for allocated resources (including inpatient base costs per 24-hour day 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 diagnosing and treating a confirmed CRBSI.

Research questions

This study addressed the following questions. Among Canadian blood stem cell transplant recipients with a long-term cuffed tunnelled triple lumen subclavian CVC:

1. Is CRBSI associated with an extended hospital stay?
2. What are the average associated costs for only the diagnosis and treatment of a CRBSI?
3. What is the average total charge for a single CRBSI?

Table 1: Case control cost analyses of an incidence of central catheter bloodstream infection

Authors/Year	Country	Measures	Population	Extra Costs	*2014 CAD Equivalent
Orsi et al. (2002)	Italy	Extra costs for extended length of stay and infection treatment	ICU (surgical)	€16,356	\$23,279.74
Liu et al. (2002)	Taiwan	Extra cost for extended length of stay	Renal Dialysis	\$NT66,302	\$2,442.52
Rosenthal et al. (2003)	Argentina	Extra costs for extended length of stay, and antibiotics	ICU (medical/surgical and coronary)	\$4,888	\$655.59
Shannon et al. (2006)	United States	Extra costs for length of stay, antibiotics, laboratory/diagnostic tests, related procedures, non-nursing health care labo,r	ICU (medical and coronary)	\$26,839	\$30,702.58
Higuera et al. (2007)	Mexico	Extra care costs for extended length of stay and antibiotics	ICU	\$11,591	\$951.65
Tarricone et al. (2010)	Italy	Extra costs for extended length of stay, medications, supplies, lab tests, and care by an infection specialist	ICU (4 different specialty areas)	€9,154	\$13,028.52
Dal Forno et al. (2012)	Brazil	Difference in mean total cost of care including extra length of stay and resources until hospital discharge	ICU	\$89,886	\$40,073.68
Raschka et al. (2013)	Canada	Difference in mean length of stay	Inpatient (unspecified)	\$19,776	\$19,776
\$= Dollars; €= Euros; \$NT=New Taiwanese Dollars Cost=analyses of one single infection and/or associated costs of one infection CAD=Canadian dollars * http://www.xe.com/currencyconverter/					

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 health care spending at a single centre 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 or known infections prior to transplant. Prior power analysis indicated at least a five-year span of records was required based on the average number of patients treated at the centre, to ensure a large enough sample size for statistical analysis.

Sample/setting

The study sample consisted of medical records of blood stem cell transplant recipients with a cuffed tunnelled triple lumen subclavian CVC, transplanted at a single adult Canadian blood stem cell transplant program between 2008 and 2013. Records indicated all CVCs were placed by a physician in the radiology department of a single centre using the same standard operating procedures for CVC placement. Inclusion criteria for both groups stipulated the use of a cuffed tunnelled 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 additional exclusion criteria were applied to both groups in sample selection to eliminate potential cost influences and control for as many variables as possible that could potentially influence lengths of stay. Records indicating bloodstream infection within 48 hours of line insertion (6), a known exposure to potential contamination of the line for example a cap disconnection (8), and non-adherence to the study centre CVC policy (12) were excluded. Records indicating simultaneous use of vascular or invasive catheters (29), more than one isolated CRBSI (25), multiple transplants (15), and tunnel infection (7) were excluded. Records indicating other line-associated complications [occlusion (24), thrombosis in the superior vena cava (14), and accidental displacement (24)] were also excluded alongside records without comparable matches (193). The sample was not further stratified for post-transplant complications such as graft versus host disease or prolonged neutropenia. It was possible to match 131 patients with a confirmed CRBSI with 131 comparable control patients without infections (Figure 1) out of a total of 690 recipients. This matching process led to a final sample size of 262.

Instruments

Data were transcribed and coded into an electronic dataset on site at the study centre. 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 consultation fees for the 2013 fiscal year (the only current available price list at the time of data collection) were used to measure direct charges. Other monetary data for the 2013 fiscal year that were billed to the public payer were obtained through an 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, completed medical orders, and documentation of medications given 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 for each 24-hour increment of inpatient hospital stay.

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

Figure 1. Record selection process

(peripheral blood stem cells, cord blood stem cells, bone marrow, etc.), and treatment protocol (conditioning regimen). 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, 2012). The parameters for statistical significance were pre-set at α of .05. Since these variables are not normally distributed, non-parametric tests were used for statistical tests of differences.

RESULTS

The final sample of 131 case-control pairs ($N=262$) was subjected to 30,121 catheter days ($M=114.97$, $SD=84.42$). Nineteen different treatment regimens were used for transplant conditioning. The average age was 50.4 years old. Males made up 59.8% of the sample and females 40.2%. Patients with malignant diseases, for example myeloma, made up 26.5% of the diagnoses in the sample; 41.3% had leukemia, and 32.2% had lymphoma. Of the patients 56.4% received allogeneic stem cells and 43.6% received autologous stem cells.

The purpose of matching was to ensure that other factors (such as age, gender, type of transplant, etc.) did not cause confounding effects. To be sure that our groups matched each

other well, we needed to determine if there were any significant differences in these potentially confounding factors between the two groups. Tests for possible differences in these variables across the infection and no infection groups are shown in Table 2. None of the continuous variables displayed met statistical assumptions for normal patterns of distribution requiring the use of non-parametric tests. Since age and BMI are continuous variables, Mann-Whitney U tests were used to compare groups. The tests show no significant differences in age or body mass index between groups. Since gender, diagnosis group, cell type, and treatment type are categorical variables, contingency table Pearson chi-square tests were used for comparing cases and controls. Although there were more males than females in the sample, the gender dispersion between groups was similar, as confirmed by non-significant Chi square results. Pearson Chi square tests also did not indicate group differences in diagnosis, type of transplanted cells, or treatment between case and control groups.

A total of 144 different organisms were reported in the case group. Five cultures grew two different organisms, two cultures grew three different organisms, and one culture grew four different organisms. Sixty-nine of the organisms were classified as gram stain positive, 74 gram stain negative, and

Table 2: Demographic characteristics and statistical tests of differences between case and control groups

Variable	Descriptive			Case vs. Control					
	Total (N=262)	Case (n= 131)	Control (n= 131)	Mann-Whitney U			Pearson Chi Square		
	(M, SD, %)	(M, SD, %)	(M, SD, %)	U	z	p (2-sided)	χ^2	df	p (2-sided)
Age	M 50.50 $\pm$ 11.93	M 50.56 $\pm$ 12.09	M 50.23 $\pm$ 11.80	8343.5	-.387	.699			
BMI	M 25.12 $\pm$ 5.51	M 25.35 $\pm$ 5.76	M 24.89 $\pm$ 5.25	8202.0	-.617	.531			
Gender									
Male	158 (60.3%)	80 (61.1%)	78 (59.5%)				.064	1	.0801
Female	104 (39.7%)	51 (38.9%)	53 (40.5%)						
Diagnosis									
*Other	70 (26.7%)	35 (26.7%)							
Leuk	108 (41.2%)	54 (41.2%)							
Lymph	84 (32.2%)	42 (32.1%)					0.000	2	1.000
Transplant									
Allo	149 (56.4%)	74 (56.5%)	75 (57.3%)						
Auto	115 (43.6%)	57 (43.5%)	56 (42.7%)				.016	1	.901
Treatment							19.3	18	.375

*Other malignancy or blood disorder requiring blood or marrow cell transplant
Leuk=Leukemia, Lymph=Lymphoma, Allo=Allogeneic, Auto=Autologous

Table 3: Catheter days and length of stays in case and control groups					
	Median	Range	SD	Mean	Difference
Catheter Days					
Case	82	6–413	86.1	105.63	18.68 days
Control	98	18–424	81.97	124.31	
Total	91.5	6–424	84.42	114.97	
Length of Stay					
Case	53	15–313	53.52	71.06	19.37 days
Control	39	14–269	39.40	51.69	
Total	45.5	14–313	47.90	61.38	

one gram stain was unknown. The most frequently occurring infections were *Staphylococcus* genus ($n=43$), *Escherichia Coli* ($n=24$), *Klebsiella* ($n=17$), and *Streptococcus* species ($n=15$).

Five records indicated ICU admission for infection. Seven case and nine control records indicated death with a CVC in situ. Table 3 shows summary statistics on catheter days and length of stays of the case and control groups. Control group records indicated more catheter days than case group records with a mean difference of 18.68 days (124.31 days for the control group versus 105.63 days for the case group). Case records also indicated line replacement with a tunnelled catheter on 24 occasions for patients (21 people had one replacement, and one person had three replacements), a peripherally inserted central catheter (PICC) on 33 occasions, and an intra-jugular (IJ) catheter on seven occasions for a total of 64 new lines and line replacement rate of 48.85% in the case group.

Table 3 shows that inpatient length of stays ranged from 14 to 313 days. A Mann-Whitney U test (Table 4) shows there were significant differences between groups in length of hospital stay ($U=6,369$, $z=-3.607$, $p<.001$, $r=.22$) with longer stays associated with the case group. The cost of hospital stays only considered fees for inpatient hospital days beyond the number of days allotted within the base charges for transplant. The Mann-Whitney U test also showed the costs of hospital stay were significantly higher in the case group ($U=6,140$, $z=-3.98$, $p<.001$, $r=.25$).

The case group stayed on average 18.68 days longer in the hospital than the control group. The base charges for a 24-hour inpatient stay on the blood and stem cell transplant unit at the study centre for the year 2013, was \$2,069.00. The mean difference in hospital stays of 19.37 days between the case group and the control group, carried a price tag of \$40,076.53. Limiting extra charges to those for treating infection ranged from \$70.60 to \$199,064.00 with mean extra charges totalling \$4,739.95 (median \$708.50, SD \$23,981.46). The mean total estimated charges for a single infection considering fees for the mean extra length of stays and extra charges for actual resource usage were \$44,816.48.

Table 4: Differences in hospital stays and costs of hospital stays

	Mann-Whitney			
	<i>U</i>	<i>z</i>	<i>p</i>	<i>r</i>
Length of Stays	6,369	-3.607	<.001	.22
Length of Stays Cost	6,140	-3.98	<.001	.25

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 \$44,816.48 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 charges.

The difference in length of stays between groups was the most expensive domain measured followed by intensive care charges for five cases. Clear differences in length of stays between groups make the case for inference that infection is also associated with prolonged hospitalization in this population, which coincides with past study findings (Dal Forno et al., 2012; Rosenthal et al., 2003; Tarricone et al., 2010). Findings of this study indicate CRBSI charges in blood stem cell transplant are more than twice the amount of other Canadian inpatient reports (Raschka, Dempster, & Bryce 2013). Part of the variation in CRBSI charges in this study is attributable to intensive care needs for a fraction of cases. Intrinsic risk, namely compromised immunity, may explain prolonged recovery in hospital for CRBSI and potential need for costly

intensive care support amidst an anticipated lengthy time in hospital for blood stem cell transplant.

The wide variation in extra charges ($SD = \$23,981.46$) for individual cases 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. The mean extra charges totalling \$4,739.95 for the case group included intensive care costs for five cases. The majority of extra expenses in the extra charges category were due to medication use. The abundance of different organisms responsible for CRBSI in the sample may explain part of the variance in charges for treating CRBSI. Charges for treating infection with different medications varied due to the type of organism and treatment with patented versus generic drugs, and the use of more expensive medications with patient allergies to first-line treatment. *Staphylococcus* genus is the most widespread nosocomial pathogen within the study sample and globally (Bereket, 2012). Multi-drug resistant gram-negative organisms identified in the sample records, such as *Acinetobacter Baumannii*, *Stenotrophomonas Maltophilia* and *Pseudomonas*, are known to have changing dynamics in cell function and the ability to resist current treatments (Bereket, 2012). Higher drug costs in some cases may also 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 were not controlled for within this study beyond matching cases and controls. Cost analyses that distinguish infection outcomes and associated fees between allogeneic and autologous recipients or specific organisms are worth future research attention.

In this study, CRBSI in the case group is associated with shortened catheter life, which coincides with the recommendation for line removal depending on the overall clinical picture and with certain organisms (Mermel, 2009). The consequence of an infection reducing catheter use time on average by 18.98 days is unfortunate, as the tunnelled line is the best catheter option in the blood cell transplant population. Lack of vascular access at critical points in the blood cell transplant process increases patient vulnerability. The CVC itself may be essential to time-sensitive treatment with vesicant drugs and/or apheresis that cannot be delivered via some of the alternate catheter types. 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 because 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 tunnelled catheters used in the sample population are designed for long-term use (>90 days), and the mean length of use surpassed this timeframe 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. Further investigation into points of contamination such as the exit site and access ports for flushing/medicating are worth future research efforts.

Specifically focusing on modifications to care that aim to reduce the incidence and/or prevalence of CRBSI can potentially reduce the cost burden to both patients and providers. This study did not include CRBSI attributable to breaks in asepsis with line insertion. All cases of CRBSI were the result of contamination; likely by human error. Preventing infection is an essential and realistic goal for health care providers working with CVC's. Reducing the frequency of accessing ports to by necessity only, and providing regimented continuing education for line care to staff and patients has the potential to positively influence infection outcomes in this population.

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-tunnelled catheters. For example, fees for relapsed infections or care tracing back to the use of the initial tunnelled CVC infection were not accounted for as extra charges. 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 tunnelled 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

Curtailling hospital infection is not a new issue in health care. However, charges continue to inflate, outdating past cost reports of central catheter infection. This study found that, in 2013, CRBSI in a Canadian blood stem cell transplant centre extended hospital stays an average of 19.37 days, increased resource allocation by \$4,739.95, shortened central venous catheter life by an average of 18.68 days, and incurred additional average charges of \$44,816.48 per incident. It is reasonable to expect similar results across Canadian blood stem cell transplant programs that are funded by the same single payer. Costs may be lower in less acute areas and among populations that are not faced with immune system compromise. Coupled with patient acuity, infection further strains organizational budgets. The relatively small stem cell transplant population is a large contributor to healthcare spending. Nursing studies examining practice strategies aimed at reducing 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.

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