Published in final edited form as:

Infect Control Hosp Epidemiol. 2012 August ; 33(8): 837–841. doi:10.1086/666739.

“What the Eyes Don’t See, the Heart Doesn’t Grieve Over”: Epidemiology and Risk Factors for Bloodstream Infections following Cardiac Catheterization

Kristen V. Dicks, MD¹, Russell Staheli, MPH², Deverick J. Anderson, MD, MPH^{3,6}, Becky A. Miller, MD⁴, W. Schuyler Jones, MD⁵, J. Kevin Harrison, MD⁵, Daniel J. Sexton, MD, FIDSA^{3,6}, Rebekah W. Moehring, MD³, and Luke F. Chen, MBBS, MPH, CIC, FRACP^{3,6}

¹Internal Medicine Residency Program, Department of Medicine, Duke University Medical Center, Durham, North Carolina

²Performance Services, Duke University Health System, Durham, North Carolina

³Program for Infection Prevention and Healthcare Epidemiology, Division of Infectious Diseases, Duke University Medical Center, Durham, North Carolina

⁴NorthShore University Health System, Evanston, Illinois

⁵Duke Heart Center, Durham, North Carolina

⁶Duke University Prevention Epicenter Program, Durham, North Carolina

Abstract

No standard definition exists for surveillance and characterization of the epidemiology of bloodstream infections (BSIs) after cardiac catheterization (CC) procedures. We proposed a novel case definition and determined the epidemiology and risk factors of BSIs after CC procedure using this new definition.

Bloodstream infections (BSIs) are devastating healthcare-associated infections that lead to substantial patient suffering and mortality. BSIs can occur following almost any invasive medical procedure, including cardiac catheterization (CC) procedures. As catheterization procedures have evolved to include longer procedural duration, use of prolonged indwelling catheters, and deployment of permanent implants, infection control in the catheterization laboratory takes on even greater importance. Few studies have specifically described the occurrence of BSIs after CC procedures,^{1–5} and there is no standard definition for surveillance of cardiac catheterization-associated BSIs (CC-BSIs). With more than a million CC procedures performed annually in American medical centers, an accurate and reliable surveillance definition is needed to study the epidemiology and risk factors for CC-BSIs. Thus, we aimed to (1) create and evaluate a surveillance definition for detecting CC-BSIs and (2) describe the epidemiology and risk factors of CC-BSIs by using this new definition.

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Address correspondence to Kristen V. Dicks, MD, Duke Medical Hospital, Medical Res Office, Room 8254DN, 2301 Erwin Road, Durham, NC 27710 (kristen.dicks@duke.edu).

Potential conflicts of interest. All authors report no potential conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

Presented in part: Interscience Conference of Antimicrobial Agents and Chemotherapy; Boston, Massachusetts; September 12–15, 2010 (Presentation K-991).

METHODS

We performed a retrospective case-cohort study of consecutive CC procedures among adults (18 years or older) at Duke University Medical Center, a 750-bed tertiary referral hospital. *International Classification of Diseases, Ninth Revision* (ICD-9) codes were used to identify diagnostic and interventional CC procedures performed from January 1, 2005, to December 31, 2009, and patient comorbidities (see appendix). Multiple CC procedures in a single patient were allowed in the study. Microbiology data of BSIs were collected and stored in the surveillance database of the Duke Program for Infection Prevention and Healthcare Epidemiology. Patients who had a central venous catheter placed during a 14-day time period prior to the CC procedure were excluded from the study.

All BSIs and skin contaminants were defined using standard surveillance criteria for laboratory-confirmed BSIs.⁶ A CC-BSI was defined as any BSI detected within 2 calendar days following CC. Postdischarge outcomes were not specifically assessed. Finally, if multiple BSIs occurred in a single patient, only the first episode was included in the analysis.

Incidence rates were calculated per 1,000 CC procedures. Patient demographics, comorbidity, and pathogen data were described as counts and proportions. We performed univariable and multivariable logistic regression with SAS (ver. 9.2) to determine independent predictors of CC-BSIs. Final parsimonious models were constructed with consideration to the clinical relevance of each factor and with backward selection; we retained variables in the model if their *P* values were .1 or less. Two-tailed *P* values of .05 or less were considered statistically significant.

RESULTS

A total of 28,250 CC procedures were performed during the 60-month study period; 1,781 (6.3%) patients had central venous catheters placed within 14 days of a CC procedure and were excluded from the analysis. The remaining 26,469 CC procedures were analyzed (an average of 441 CC procedures per month); 51% were inpatient procedures. The mean age of the study population was 60.3 years and 61.6% were male (see Table 1 for additional population characteristics).

In total, 60 CC-BSIs were detected (overall incidence of 2.3 CC-BSIs per 1,000 procedures). An average of 1 CC-BSI occurred per month during the study period. The most commonly isolated pathogens causing CC-BSIs were *Staphylococcus aureus* (21, 35%), coagulase-negative *Staphylococci* (14, 23%), and *Escherichia coli* (6, 10%). In total, 10 (16%) CC-BSIs were polymicrobial; 7 of 21 *S. aureus* isolates were methicillin-resistant.

Male sex, cardiac impairment, and renal impairment were significant predictors of BSI on univariable analysis (Table 2). Only renal impairment remained a statistically significant predictor of CC-BSI on multivariable logistic regression (adjusted odds ratio, 4.25; 95% confidence interval, 2.36–7.63).

DISCUSSION

We proposed and used a definition of CC-BSI to determine an incidence of BSIs following CC procedures (2.3 per 1,000 procedures or approximately 1 per month). The incidence rate from the current study was similar to previous studies (2–6 per 1,000 procedures);^{1–5} however, different definitions for CC-BSI were used in these studies.

Our definition for CC-BSI used the “2 calendar days” rule to temporally and epidemiologically connect a BSI with a CC procedure. Two calendar days is a commonly used time frame in infection control to establish an epidemiological association between a healthcare-associated infection and a potential inciting event. Additionally, a prior analysis showed the vast majority (90%) of positive blood cultures within 7 days of the CC procedure occurred within 2 calendar days. Moreover, positive blood cultures detected at least 2 calendar days after a CC procedure were frequently skin contaminants, were rarely associated with clinical sepsis, and few actually required specific therapy.

Data on pathogens and risk factors for CC-BSI could inform appropriate antimicrobial use and prevention of CC-BSI. For example, at least one-third of the *S. aureus* isolates were resistant to methicillin, suggesting that empirical therapy for suspected CC-BSI should include vancomycin. Renal impairment was found to be a significant predictor for CC-BSI; however, another possible explanation for this finding is renal impairment is associated with more severe symptoms of a BSI, thus resulting in blood cultures being performed. Considering the above, subsequent studies should directly examine renal impairment with regards to risk for CC-BSI and evaluate the role for prophylactic antibiotics among patients with renal impairment who are undergoing CC procedures.

This pilot study had several limitations. For example, there was no specific follow-up for BSIs in the outpatient setting, primary and secondary BSIs were not specifically differentiated, and we did not adjust for effects from concurrent antibiotic use. Furthermore, true BSIs may be underestimated with ICD-9 administrative billing codes⁷ and with the “2 calendar day” time frame in our definition. Despite these limitations, we believe the definition of CC-BSI is easy to use, uses readily available billing data, and provides an important method to perform surveillance and even outbreak investigations of CC procedures. The surveillance data obtained from applying this definition could inform and improve infection control practices within catheterization laboratories.

The strengths of our study include a large cohort of consecutive patients and our methods for CC-BSI detection, which is based on NHSN definitions for laboratory-confirmed BSIs. Excluding patients with central lines allowed us to reduce confounding factors from the data set; however, the decision may erroneously exclude episodes of bacteremia that are due to a CC procedure, rather than the central venous catheter.

This definition we proposed and used in this pilot study may be used to calculate incidence rate of CC-BSIs. Additionally, amount of time or number of procedures between CC-BSI events may be used to detect clustering and to trigger investigation of potential outbreaks. Although our definition of CC-BSI needs to be evaluated by other investigators in other medical settings, and additional refinements may be necessary, we believe that this definition is a useful framework to further examine the epidemiology of CC-BSI. Also, our definition may allow other medical centers to assess and monitor their local rates and to use these rates to detect outbreaks and monitor the efficacy of their prevention programs. Finally, the definition of CC-BSIs establishes a good basis to study the incidence of clinical sepsis following CC procedures and to perform other studies of risk factor and intervention. A standard definition for BSIs following catheterization procedures is long overdue. Our proposed definition, once validated, can be the standardized approach to finally shed light on the true epidemiology of bloodstream infections following cardiac catheterization procedures and provide a platform for subsequent surveillance and research.

Acknowledgments

We thank the Division of Infectious Diseases and the Department of Medicine at Duke University Medical Center, and the Duke Infection Control Outreach Network (DICON) for assistance with this study.

Financial support. This work was supported by the Division of Infectious Diseases at Duke University Medical Center. D.J.A. was supported by the Robert Wood Johnson Foundation Physician Faculty Scholar's Program and a K23 grant from NIAID (1K23AI095357-01).

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APPENDIX

INTERNATIONAL CLASSIFICATION OF DISEASES, NINTH REVISION (ICD-9)

CODES IDENTIFYING CARDIAC CATHETERIZATION PROCEDURES: 00.24, 37.21–37.23, 88.55–88.57, 00.55, 36.06, 36.07, 00.66, 35.96, 36.04, 36.09, 36.91, 37.26

ICD-9 Code	Diagnosis
Diabetes mellitus	
249.0	Secondary diabetes mellitus without mention of complication
249.1	Secondary diabetes mellitus with ketoacidosis
249.2	Secondary diabetes mellitus with hyperosmolarity
249.3	Secondary diabetes mellitus with other coma
249.4	Secondary diabetes mellitus with renal manifestations
249.5	Secondary diabetes mellitus with ophthalmic manifestations
249.6	Secondary diabetes mellitus with neurological manifestations
249.7	Secondary diabetes mellitus with peripheral circulatory disorders
249.8	Secondary diabetes mellitus with other specified manifestations
249.9	Secondary diabetes mellitus with unspecified complication
250.0	Diabetes mellitus without mention of complication
250.1	Diabetes mellitus with ketoacidosis
250.2	Diabetes mellitus with hyperosmolarity

ICD-9 Code	Diagnosis
250.3	Diabetes mellitus with other coma
250.4	Diabetes mellitus with renal manifestations
250.5	Diabetes mellitus with ophthalmic manifestations
250.6	Diabetes mellitus with neurological manifestations
250.7	Diabetes mellitus with peripheral circulatory disorders
250.8	Diabetes mellitus with other specified manifestations
250.9	Diabetes mellitus with unspecified complication
648	Diabetes mellitus complicating pregnancy
Asthma	
493.0	Extrinsic asthma
493.1	Intrinsic asthma
493.2	Chronic obstructive asthma
493.8	Other forms of asthma
493.82	Cough variant asthma
493.9	Asthma, unspecified
Renal impairment	
585.1	Chronic kidney disease, stage I
585.2	Chronic kidney disease, stage II
585.3	Chronic kidney disease, stage III
585.4	Chronic kidney disease, stage IV
585.5	Chronic kidney disease, stage V
585.6	End stage renal disease
585.9	Chronic kidney disease, unspecified
586	Renal failure, unspecified
Cardiac failure	
428.0	Congestive heart failure, unspecified
428.1	Left heart failure
428.2	Systolic heart failure
428.3	Diastolic heart failure
428.4	Combined systolic and diastolic heart failure
428.9	Heart failure, unspecified
398.91	Rheumatic heart failure (congestive)
Smoking	
305.1	Tobacco use disorder
989.84	Tobacco
Urinary incontinence	
788.30	Urinary incontinence, unspecified
788.31	Urge incontinence
788.32	Stress incontinence, males
788.33	Mixed incontinence, female/male
788.34	Incontinence without sensory awareness
788.35	Postvoid dribbling

ICD-9 Code	Diagnosis
788.36	Nocturnal enuresis
788.37	Continuous leakage
788.38	Overflow incontinence
788.39	Other urinary incontinence
788.91	Functional urinary incontinence
625.6	Stress incontinence, female
788.32	Stress incontinence, male
Obesity	
278.00	Obesity, unspecified
278.01	Morbid obesity
278.02	Overweight
Immunosuppressed state	
042	Human immunodeficiency virus disease
079.53	Human immunodeficiency virus, type 2
279.00–279.09	Deficiencies of humoral immunity
279.10–279.13, 279.19	Deficiency of cell-mediated immunity
279.2	Combined immunity deficiency
279.3	Unspecified immunity deficiency
279.4	Autoimmune disease, not elsewhere classified
279.5	Graft versus host disease
279.8	Other specified disorders involving the immune system
279.9	Unspecified disorder of immune mechanism
795.71	Nonspecific serologic evidence of human immunodeficiency virus

TABLE 1**Characteristics of Study Participants**

Characteristic	Study participants
Mean age, years (95% CI)	60.3 (60.1–60.5)
Male sex	16,313 (61.6)
White	18,662 (70.5)
Obesity	3,219 (12.2)
Cardiac failure	7,539 (28.5)
Renal impairment	3,570 (13.5)
Smoking	3,368 (12.7)
Asthma	1,313 (5.0)
Incontinence	464 (1.8)
Immunocompromised	261 (1.0)

NOTE. The study characteristics were identified through ICD-9 coding. Data are no. (%) of participants, unless otherwise noted. CI, confidence interval.

Univariable and Multivariable Analysis of Factors Associated with Development of Bloodstream Infections following Cardiac Catheterization Procedures

TABLE 2

Characteristic	Cases (165)	Controls (53,819)	P	Adjusted OR	P
Male sex	46 (76.67)	16,267 (61.60)	.02	1.81 (0.99–3.31)	.06
White	42 (70.00)	18,620 (70.51)	.89	...	...
Obesity	9 (15.00)	3,210 (12.15)	.43	...	...
Cardiac failure	27 (45.00)	7,512 (28.44)	<.01	1.19 (0.67–2.13)	.56
Renal impairment	25 (41.67)	3,545 (13.42)	<.01	4.25 (2.36–7.63)	<.01
Smoking	12 (20.00)	3,356 (12.71)	.12	...	...
Asthma ^a	4 (6.67)	1,309 (4.96)	.54	...	...

NOTE. Data are no. (%) of participants, unless otherwise noted. OR, odds ratio.

^aNo immunocompromised patients or incontinent patients had CC-BSIs.