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Major article

The additional costs of catheter-related bloodstream infections in intensive care units

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Purpose: The additional costs of health care-associated infections vary depending on the reimbursement systems of different countries. We estimated the additional costs of central venous catheter-related bloodstream infections (CVC-CRBSI) in Japan, which has a universal health insurance system covering all citizens.

Methods: We conducted a retrospective matched case-control study. Twenty-two patients with CVC-CRBSI were identified among 2,148 patients treated between October 2011 and May 2014 in the intensive care unit of Tokyo Medical University Hospital (1,015 beds). Twenty-two matched controls were selected on the basis of 5 criteria. The drug and medical material costs and technical fees incurred from the date of catheter insertion until hospital discharge were examined using a fee-for-service system. The additional costs of CVC-CRBSI were calculated as the difference between the costs of cases and controls. The contribution of antimicrobial drugs and the causative microorganism to the additional drug costs were also assessed.

Results: The additional costs of CVC-CRBSI were estimated at $57,090 per case. Antimicrobial agents comprised only about 10% of the additional drug costs. The additional costs of *Candida* infection were almost twice those of CVC-CRBSI caused by other microorganisms.

Conclusions: The additional costs of CVC-CRBSI in Japan were estimated at $57,090 per case.

The total number of cases of health care-associated infection (HAI) in the United States is reported to have reached 1.7 million.[1] In addition to the morbidity and mortality caused by HAIs, they also substantially increase the costs of care: Each case is reported to incur additional costs of $535 to $184,800.[2] A large proportion of HAIs, ranging from 20%-70%, are thought to be preventable.[3]

The precise medical costs of HAIs vary according to the characteristics of the medical insurance and reimbursement systems of each country. Consequently, many reports about medical costs are not generalizable, especially to Japan, which has a universal health care insurance system covering all citizens. Although the additional medical costs of surgical site infection (SSI) have already been reported from Japan,[4] the costs of other HAIs have not been reported. The costs of catheter-related bloodstream infections (CRBSI) are particularly high, meaning that the greatest cost savings can be achieved by introducing strategies to prevent them.[3] We examined the economic and clinical effects of CRBSI in Japan, focusing particularly on the additional health care costs incurred as a result of central venous catheter bloodstream-related infections (CVC-CRBSI), which have not yet been reported from a country with a universal health care system.

MATERIALS AND METHODS

Design and setting

We undertook a retrospective case–control study at a single medical center using a matching method to measure additional health care costs. Patients diagnosed with CVC-CRBSI were selected from 2,148 patients admitted to the mixed medical/surgical intensive care unit (ICU) of our tertiary medical facility, Tokyo

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Medical University Hospital (Tokyo, Japan) (1,015 beds), between October 2011 and May 2014.

Case definition

The diagnosis of CVC-CRBSI was made when the same microorganism grew from a culture of the catheter tip and in at least 1 percutaneous blood culture.[5] We excluded those with concurrent or second sources of infection.

Data collection

We identified control patients without CVC-CRBSI matched for the following 5 variables: sex, age, history of surgery during the index admission, specialty of supervising physician, and whether the underlying disease was benign or malignant. Controls (CVC-noBSI) were defined as patients with indwelling CVCs but in whom there was no evidence of CRBSI. The medical costs from the day of catheter insertion to the day of discharge were recorded for each case, in accordance with a fee-for-service system set by the Ministry of Health, Labour, and Welfare in Japan, based on drug costs, medical material costs, and technical fees. Drug cost was defined as the cost of medications; that is, injectable drugs, including antibiotic agents; blood products; topical drugs; contrast agents; and others. Medical material cost was defined as the cost of the medical consumables and equipment used in each medical intervention; for example, catheters, sutures, oxygen, and radiograph film. The technical fee was defined as the cost of staff, surgery, imaging tests, admission, and administration. As an example of cost estimation, the cost of a chest radiograph includes the cost of image acquisition, the radiography film, and reporting (the technical fee in this case is the sum of the costs of image acquisition and reporting). The currency exchange rate used was US$1 to ¥100. The additional health care costs incurred as a result of CVC-CRBSI were calculated from the difference between the mean costs of all CVC-CRBSI cases and the CVC-noBSI control cases. We also identified the additional costs of antimicrobial drugs and other drugs used in the treatment of CVC-CRBSI. Antimicrobial drugs were defined as antibacterial or antifungal agents. Additional costs were also analyzed for each of the following causative organisms: methicillin-resistant *Staphylococcus aureus* (MRSA), gram-positive organisms other than MRSA, gram-negative rods, and *Candida* sp. The additional cost of infection caused by each causative organism was calculated as the difference between the mean cost of CVC-CRBSI due to each organism and the mean cost of the CVC-noBSI control cases.

Statistical analysis

The χ^2 test was used for univariate analysis. The Student *t* test was used to analyze continuous variables. All statistical analyses were performed using SPSS (version 20; IBM-SPSS Inc, Armonk, NY).

RESULTS

During the study period, 22 patients with CVC-CRBSI met the study inclusion criteria, and 22 CVC-noBSI matched controls were identified. We considered matching 2 controls for each patient with CVC-CRBSI, but there were too few eligible patients with CVC-noBSI. The demographic and clinical characteristics of both groups are shown in Table 1. There were no statistically significant differences between the groups in terms of any of the criteria used for matching. In addition, there were no significant differences in the proportion undergoing emergent surgery or death outcomes ($P = .3$ for both).

Table 1
Demographic and clinical characteristics of patients with central venous catheter-related bloodstream infections (CVC-CRBSI) and controls

	CVC-CRBSI (n = 22)	Control (n = 22)	*P* value
Age, y	64.0 ± 17.7	63.7 ± 18.2	1.0
Female sex	7 (31.8)	7 (31.8)	1.0
Operation	20 (90.9)	20 (90.9)	1.0
Emergency operation	8 (36.4)	5 (22.7)	.3
Treatment department			
Vascular surgery	6	7	
Digestive surgery	6	6	
Others*	10	9	
Underlying disease			
Malignant disease	10 (45.5)	10 (45.5)	1.0
Death outcome	8 (36.4)	5 (22.7)	.3

NOTE. Values are presented as mean ± standard deviation, n, or n (%) patients.
*Others included otorhinolaryngology, gynecology, urology, respiratory surgery, pediatrics, plastic surgery, and cardiovascular disease.

Table 2
Medical costs (in US$) for each case of central venous catheter-related bloodstream infection (CVC-CRBSI) cases

Case	Drug costs (anti-infective agents)	Medical material costs	Technical fees	Total costs
1	17,230 (5,520)	1,442	113,237	131,908
2	28,258 (3,110)	1,645	82,726	112,628
3	13,155 (96)	8,032	62,550	83,737
4	41,108 (13,717)	1,173	106,720	149,002
5	168,333 (1,050)	12,535	70,896	251,765
6	14,851 (7,509)	2,984	115,412	133,247
7	29,651 (1,595)	13,014	61,642	104,308
8	2,368 (430)	268	9,661	12,297
9	21,688 (1,340)	11,395	59,402	92,485
10	10,645 (1,007)	614	20,126	31,385
11	199,960 (4,134)	763	48,167	68,926
12	9,169 (1,217)	735	74,857	84,760
13	1,563 (1,089)	277	8,327	10,168
14	6,480 (198)	5,420	38,930	50,830
15	7,941 (1,014)	547	43,050	51,538
16	76,872 (11,321)	4,253	39,031	120,157
17	195,324 (3,153)	14,143	93,335	302,802
18	88,397 (4,469)	9,763	124,443	222,603
19	24,357 (7,491)	404	43,364	68,125
20	14,307 (2,987)	158	21,419	35,883
21	38,387 (3,054)	5,381	27,455	71,223
22	27,763 (5,156)	1,785	60,152	89,701
Mean	38,993 (3,666)	4,397	60,223	103,613

NOTE. Cases 1-3=methicillin-resistant *Staphylococcus aureus*, cases 4-7=gram-positive microorganisms other than methicillin-resistant *Staphylococcus aureus*, cases 8-15=gram-negative rod infections, cases 16-20=*Candida* sp, and cases 21 and 22=others.

The detailed findings for total medical costs, drug costs, medical material costs, and technical fees for cases of CVC-CRBSI and controls are shown in Tables 2 and 3. Mean medical costs, individual drug costs, medical material costs, and technical fees are presented in Table 4. The difference between mean drug costs, mean medical materials costs, and mean technical fees between cases of CVC-CRBSI and controls was $30,529, $461, and $26,100, respectively. The mean additional cost per single case of CVC-CRBSI, obtained by estimating the difference between the mean total medical costs of CVC-CRBSI cases and controls, was $57,090.

The greatest additional costs of CVC-CRBSI were incurred in those with *Candida* infection ($103,260), followed by gram-positive microorganisms ($98,950), MRSA ($62,601), and gram-negative microorganisms ($3,644). The additional costs of *Candida* CVC-CRBSI infections were almost twice the cost of CVC-CRBSIs caused by other microorganisms (Table 5).