Infection Prevention in Practice 2 (2020) 100050

Available online at www.sciencedirect.com

Infection Prevention in Practice

journal homepage: www.elsevier.com/locate/ipip

Venue of catheter insertion does not significantly impact the event of central line-associated bloodstream infection in patients with haematological diseases

Hiroaki Kitamura [a], Yasushi Kubota [a,b,*], Sho Komukai [c,1], Hisako Yoshida [c,2], Yukari Kaneko [d], Yukiko Mihara [d], Zenzo Nagasawa [e], Atsushi Kawaguchi [f], Yosuke Aoki [d], Shinya Kimura [a]

[a] Division of Hematology, Respiratory Medicine and Oncology, Department of Internal Medicine, Faculty of Medicine, Saga University, Saga, Japan
[b] Department of Transfusion Medicine, Saga University Hospital, Saga, Japan
[c] Clinical Research Center, Saga University Hospital, Saga, Japan
[d] Department of Infectious Disease and Hospital Epidemiology, Saga University Hospital, Saga, Japan
[e] Department of Medical Technology and Sciences, School of Health Sciences at Fukuoka, International University of Health and Welfare, Okawa, Japan
[f] Education and Research Center for Community Medicine, Faculty of Medicine, Saga University, Saga, Japan

ARTICLE INFO

Article history:
Received 15 November 2019
Accepted 24 February 2020
Available online 4 March 2020

Keywords:
Central venous catheter
Central line-associated bloodstream infection
Haematological malignancy
Leukaemia
Ward
Operating room

SUMMARY

Background: Central line-associated bloodstream infection (CLABSI) is a serious complication of central venous catheter (CVC) placement in patients with haematological diseases associated with neutropenia and immunosuppression. However, whether the venues where CVC are inserted influence CLABSI development remains unclear.

Methods: We investigated whether CVC insertion at venues with different standards of cleanliness altered the occurrence of CLABSI. We evaluated data from 279 patients (545 CVC insertions) with haematological diseases including age, sex, underlying disease, reason for insertion, insertion site, number of lumens, venue, dates of insertion and removal, complete blood counts, percentage of neutrophils and serum albumin concentrations at the time of CVC insertion.

Findings: Overall, 55 CLABSI events occurred during a period of 23,434 catheter days (2.35 per 1,000 catheter days). In total, 153 and 190 patients underwent 226 and 305 CVC insertions, respectively in a ward and in an operating room, respectively. Univariate analysis identified the operating room ($P = 0.017$), allogeneic haematopoietic stem cell transplantation ($P < 0.001$), triple lumen catheter ($P = 0.002$), haemoglobin ($P = 0.019$), white blood cell count ($P = 0.012$) and percentage of neutrophils ($P = 0.012$) as significant

* Corresponding author. Yasushi Kubota, MD, PhD, Division of Hematology, Respiratory Medicine and Oncology, Department of Internal Medicine, Faculty of Medicine, Saga University, 5-1-1 Nabeshima, Saga, 849-8501, Japan, Tel.: +81 952 34 2366; fax: +81 952 34 2017.
E-mail address: kubotay@cc.saga-u.ac.jp (Y. Kubota).
[1] Present address: Division of Biomedical Statistics, Department of Integrated Medicine, Graduate School of Medicine in Osaka University, Suita, Japan.
[2] Present address: Department of Medical Statistics, Osaka City University Graduate School of Medicine, Osaka, Japan.

https://doi.org/10.1016/j.infpip.2020.100050

factors for the development of CLABSI. However, multivariate analysis adjusted for age, reason for insertion, insertion site, number of lumens, haemoglobin, percentage of neutrophils and platelet counts found no significant differences between the venue where CVC were inserted and CLABSI development ($P = 0.158$).

Conclusion: The venue of CVC insertion is unlikely to influence CLABSI development in patients with haematological diseases.

Introduction

Central venous catheters (CVC) are often inserted into patients with haematological diseases to deliver intensive chemotherapy or haematopoietic stem cell transplants (HSCT). However, the procedures can be associated with serious complications [1,2], among which, central line-associated bloodstream infection (CLABSI) can be life-threatening for patients with neutropenia [3]. Therefore, CLABSI should be prevented.

Several interventions can be applied to reduce risk of CLABSI [4–7]. The Centres for Disease Control and Prevention (CDC) recommend maximum sterile barrier precautions (MSBP) during CVC insertion to prevent intravascular catheter-related infections; these include wearing a sterile cap, mask, gown, gloves and full body drape [8,9]. These recommendations were based on a prospective randomised trial, which found that MSBP reduce the risk of catheter-related infections in patients with solid or haematological tumours. One explanation for this finding was that MSBP prevent early contamination of catheters by skin-borne organisms during CVC insertion [10]. By contrast, subsequent studies [11,12] did not find that MSBP prevented catheter-related bloodstream infections, but the characteristics of the patients who participated in these studies differed from those in the study by Raad *et al.* [10]. Nevertheless, MSBP are always implemented during CVC insertion. Risk factors for CLABSI include underlying disease, the procedure used for CVC insertion, catheter insertion site, duration and reason for catheterisation [13]. A recent study showed that catheterisation of the subclavian vein was associated with a lower risk of bloodstream infection than that of jugular or femoral veins [14]. Catheters are associated with several inherent risks that might contribute to CLABSI, including cutaneous insertion (that can introduce skin-borne organisms), contamination of the catheter hub, lumen, or infusate and haematogenous colonization of CVC from distant infection [15]. However, few studies have examined whether the venue of CVC insertion affects the development of CLABSI [16,17]. Patients with haematological diseases, especially leukaemia, who undergo chemotherapy or HSCT are at high risk of infection due to neutropenia and immunosuppression. Thus, the relationship between the venue of CVC insertion and CLABSI development should be clarified. We retrospectively investigated whether differences in the cleanliness of venues during CVC insertion influence the development of CLABSI in patients with haematological diseases.

Methods

Study design, patients and data collection

This retrospective study included 279 patients with haematological diseases managed at Saga University Hospital between June 2009 and March 2017. Clinical data collected from medical records included age, sex, underlying disease, reason for CVC insertion, insertion site, number of CVC lumens, venue of insertion, dates of insertion and removal, complete blood counts, percentage of neutrophils and nutritional status (serum albumin concentrations) at the time of CVC insertion, CLABSI events, causative pathogens and death during CVC placement. The ward and treatment room were defined as ISO 14644-1 class 8, whereas the clean room, the intensive care unit (ICU) and operating room were defined as ISO 14644-1 class 7. Cleanliness is regularly assessed in the hospital to maintain consistent standards. The Institutional Review Board at Saga University Hospital approved the study (No. 2017-10-Expedited Review-01).

CVC insertion and dressing

Non-tunnelled CVC were inserted percutaneously using the Seldinger technique. Attending physicians selected the locations of CVC insertion, where physicians using aseptic technique (a cap, mask, sterile gown, sterile gloves and sterile drapes) inserted CV Legaforce® catheters (Terumo, Tokyo, Japan) into patients. Anaesthetists inserted CVC into patients on the operating room table. Skin was disinfected mainly with 10% povidone-iodine in alcohol until September 2012, and from October 2012 with 1% chlorhexidine gluconate in alcohol. After inserting a CVC, the implanted site was cleansed and usually maintained using IV3000® (Smith & Nephew, London, UK) and 10% povidone-iodine from the start of the study until September 2012, followed by Tegaderm™ chlorhexidine gluconate I.V. securement dressing (3M Corporation, St. Paul, MN, USA) with gel pads containing chlorhexidine and 1% chlorhexidine gluconate from October 2012 until the end of the study.

Definition of CLABSI

We defined CLABSI as a laboratory-confirmed bloodstream infection (LCBI) according to the CDC guidelines [18] as LCBI 1, in which a recognised pathogen cultured from one or more blood specimens was not related to infection at any other site, or as LCBI 2, in which fever (>38°C), chills or hypotension, signs, symptoms and positive laboratory results were not related to infection at any other site and a common skin contaminant was cultured from two or more blood specimens drawn on separate occasions. Patients who met at least one of these criteria were diagnosed with CLABSI. We also applied the criteria for mucosal barrier injury-laboratory confirmed bloodstream infection (MBI-LCBI) to the patients with CLABSI [19].

Table I
Surveillance of central line-associated bloodstream infection

Characteristics	No. of CVC insertions	Total of catheter days	No. of CLABSI events	CLABSI rate per 1,000 catheter days
Total	545	23,434	55	2.35
Reasons of CVC insertions				
Chemotherapy	328	14,963	32	2.14
Autologous HSCT	50	1,350	2	1.48
Allogeneic HSCT	59	3,413	16	4.69
Other	108	3,708	5	1.35
CVC insertion sites				
Internal jugular vein	490	21,504	50	2.33
Subclavian vein	32	1,537	4	2.60
Femoral vein	23	393	1	2.54
Number of lumens of CVC				
Single lumen	102	3,813	5	1.31
Double lumen	360	15,401	33	2.14
Triple lumen	83	4,220	17	4.03
Venue of CVC insertions				
Operating room	305	13,139	39	2.97
Ward	226	9,720	15	1.54
ICU	7	293	1	3.41
Clean room	4	139	0	0.00
Treatment room	3	143	0	0.00
Change of disinfectant and dressing				
June 2009—September 2012	193	7,497	20	2.67
October 2012—March 2017	352	15,937	35	2.20

CLABSI, central line-associated bloodstream infection; CVC, central venous catheter; HSCT, haematopoietic stem cell transplantation; ICU, intensive care unit.

Statistical analysis

The characteristics of the patients who underwent CVC insertion in the ward and in the operating room were compared. Categorical variables are expressed as numbers and proportions, and continuous variables are expressed as medians with interquartile range (IQR). Categorical and continuous variables were compared between groups using Chi-squared and Mann-Whitney *U* tests, respectively. Univariate and multivariate analyses of associations between CVC insertion venues and CLABSI events proceeded using generalized estimating equations (GEE) with a logit-link function, as well as unadjusted and adjusted odds ratios (OR) with 95% confidence intervals (CI). All CVC insertions were analysed in this manner. Correlations within patients were assessed using GEE because the analysed datasets might have included more than one value derived from the same individual. Multivariate analyses comprised three models. We estimated survival according to the amount of elapsed time between CVC insertion at various locations to CLABSI using Kaplan-Meier curves, which were subsequently and compared using log-rank tests. We estimated unadjusted and adjusted hazard ratios (HR) and 95% CI using a Cox proportional hazard model with gamma frailty (gamma frailty model), which was then used to adjust correlations within patients. Values with $P < 0.05$ were considered statistically significant. All data were statistically analysed using R version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Patient characteristics at baseline

The 279 patients underwent 545 CVC insertions for induction, consolidation and salvage chemotherapy, autologous or allogeneic HSCT, and because of difficulties with oral feeding and general deterioration. Acute myeloid leukaemia (38.2%) and non-Hodgkin lymphoma (39.6%) were the most prevalent underlying diseases. The major reason for CVC insertion was chemotherapy (60%). The internal jugular vein (90%) was the most frequent site of CVC insertion. The operating room (56.0%) and ward (41.5%) were the most common venues. In addition, CVC were inserted in an ICU (1.3%), and clean (0.7%) or treatment (0.6%) rooms. The median and mean durations of catheterisation were 35.0 and 42.3 days, respectively.

Frequency of CLABSI events

Table I summarises the overall CLABSI rate as well as the rates for each factor associated with CVC insertion. A total of 55 CLABSI occurred over 23,434 catheter days and the overall CLABSI rate was 2.35 per 1,000 catheter days. Among 55 CLABSI, 14 (25%) and 41 (75%) met the LCBI 1 and LCBI 2 criteria, respectively. Moreover, 1 (2%) and 2 (4%) met the MBI-LCBI 1 and MBI-LCBI 2 criteria, respectively.

Pathogens causing CLABSI

Pathogens isolated in patients with CLABSI are shown in Supplemental Table I. *Staphylococcus epidermidis* was the most common pathogen, followed by *S. aureus*, *Bacillus cereus* and *Corynebacterium striatum*.

Comparison of venues where patients underwent CVC insertion

Among 545 CVC insertions, 226 (42.6%) in 153 and 305 (57.4%) in 190 patients proceeded in wards and in the operating room, respectively. Table II shows inter-group comparisons. Among 54 CLABSI, significantly more occurred in the operating room than in the ward ($P = 0.030$). Age, reason for CVC insertion, CVC insertion site, CVC lumens and number of CVC insertions per year significantly differed between the groups. Haemoglobin values, WBC counts, percentage of neutrophils, absolute neutrophil counts and platelet counts were significantly lower, whereas albumin values were significantly higher when a CVC was inserted in the operating room.

Impact of the venue of CVC insertion

We estimated the unadjusted OR (95% CI) in univariate analyses and found that the venue of CVC insertion was significantly associated with CLABSI events (Table III). Risk of CLABSI was higher when CVC were inserted in the operating room than in the ward (OR, 2.12; 95% CI, 1.14−3.94; $P = 0.017$). In addition, allogeneic HSCT, a triple lumen catheter, haemoglobin, WBC count and percentage of neutrophils were significantly associated with CLABSI. Age, sex, CVC insertion sites, absolute neutrophil count, platelet count, albumin and changes of disinfectants and dressings were not associated with CLABSI.

We adjusted for confounding factors using multivariate analyses with three models. Significantly associated variables in the univariate analysis were adjusted for either the venue of CVC insertion or CLABSI events in Model 1, which was the primary analysis [20]. The number of CLABSI events did not significantly differ between the ward and the operating room. Model 2 (complete model) was adjusted for all other variables. Model 3 (reduced model) was adjusted for variables determined using backward stepwise selection. Models 2 and 3 showed that the venue of CVC insertion was not significantly associated with the development of CLABSI ($P = 0.178$ and $P = 0.229$, respectively; Table IV). The number of CLABSI events did not significantly differ in a subgroup of patients with CVC inserted into the internal jugular vein (data not shown).

We also compared the amount of elapsed time between CVC insertion and diagnosis of CLABSI between the ward and the operating room. The incidence of CLABSI was higher among those inserted with a CVC in the operating room than the ward (Log-rank $P = 0.017$; Figure 1). The unadjusted model showed that CLABSI events occurred significantly earlier after CVC insertion in the operating room than the ward (HR, 2.13; 95% CI, 1.16−3.94; $P = 0.015$). However, CVC insertion in the operating room and the ward did not significantly differ between after adjustment by Model 1 (HR: 1.57, 95% CI: 0.82−3.00, $P = 0.174$; Table IV). Models 2 and 3 as shown in Table IV, were used in sensitivity analyses, which also did not find any significant differences (HR, 1.54; 95% CI, 0.80−2.97; $P = 0.197$ and HR, 1.56; 95% CI, 0.81−2.99; $P = 0.181$, respectively).

Discussion

Here, we investigated whether the development of CLABSI in patients with haematological diseases was associated with CVC insertion at venues with different standards of cleanliness. The results showed that the median duration of catheterisation was 35.0 days and that the rate of CLABSI was 2.35 per 1,000 catheter days. Although more CVC were inserted for HSCT in the operating room than in the ward, multivariate analysis showed that the venue of CVC insertion did not significantly affect CLABSI development.

Previous reports have described that patients with haematological malignancies are catheterised for a mean of 17.3−22.6 days [1,21,22], whereas the mean duration of catheterisation in the present study was 42.3 days, and included patients who received allogeneic HSCT. A non-tunnelled CVC was inserted during each period of chemotherapy or HSCT, then immediately removed depending on the recovery status of the patients. The removal of a CVC can occasionally be problematic when patients with haematological diseases have neutropenia or thrombocytopenia or have completed an intensive course of chemotherapy or HSCT and have difficulties with oral ingestion. Tunnelled CVC have not been inserted for long-term treatment in our department. They are inserted into patients with solid tumours in the operating room at our hospital. Therefore, our findings cannot be applied to tunnelled CVC insertion in haematological patients because this has not been validated in such patients.

The suggested rates of catheter-related bloodstream infections in patients with haematological diseases range from 5.6 − 16.3 per 1,000 catheter days [7,21−23]. Here, we found a CLABSI rate (including patients treated with HSCT) of 2.35 per 1,000 catheter days, which was lower than that in previous studies, despite prolonged catheterisation. One reason for this might have been meticulous daily management of the CVC implant port. The CLABSI rate was highest among patients who had undergone allogeneic HSCT, perhaps because of prolonged neutropenia and extreme immunosuppression. Placement of a CVC with multiple lumens significantly increases the CLABSI rate, according to Templeton *et al.* and Bicudo *et al.* [24,25]. Although multiple-lumen CVC are often inserted for chemotherapy or HSCT, it is best avoided wherever possible. Previous findings indicate that the major causative pathogens are coagulase-negative staphylococci, *S. aureus*, corynebacteria, enterococci, Gram-negative bacteria and *Candida* species [26]. Here, we identified Gram-positive cocci, Gram-positive bacilli and Gram-negative bacilli in 74%, 21% and 5% of patients, respectively.

We predicted that the rate of CLABSI development after CVC insertion would be lower in the operating room than in the ward because of a difference in air cleanliness. Inter-group comparisons showed that CVC for HSCT were inserted mostly in the operating room, and that WBC and absolute neutrophil counts were significantly lower in the operating room than in the ward. The main reason for CVC insertion in the operating room for myelosuppressed patients who were to undergo HSCT is physician preference based on the perception of a higher standard of

Table II
Baseline characteristics of patients with CVC inserted in a ward or operating room

Variables	Ward group, n=226	Operating room group, n=305	*P* value
Median age, years (IQR)	63 (53–70)	59 (49–66)	0.003
Male, n (%)	136 (60.2)	176 (57.7)	0.629
Underlying diseases, n (%)			0.101
Acute myeloid leukaemia	78 (34.5)	124 (40.7)	
Acute lymphoblastic leukaemia	18 (8.0)	34 (11.1)	
Mixed-phenotype acute leukaemia	2 (0.9)	2 (0.7)	
Acute undifferentiated leukaemia	1 (0.4)	1 (0.3)	
Chronic myelogenous leukaemia	2 (0.9)	2 (0.7)	
Chronic lymphocytic leukaemia	0 (0.0)	1 (0.3)	
Myelodysplastic syndrome	5 (2.2)	4 (1.3)	
Hodgkin's lymphoma	2 (0.9)	3 (1.0)	
Non-Hodgkin's lymphoma	109 (48.2)	105 (34.4)	
Multiple myeloma/Plasmacytoma/Amyloidosis	8 (3.5)	25 (8.2)	
Benign haematological disease	1 (0.4)	4 (1.3)	
Reasons for CVC insertions, n (%)			<0.001
Chemotherapy	163 (72.1)	163 (53.4)	
Autologous HSCT	6 (2.7)	44 (14.4)	
Allogeneic HSCT	4 (1.8)	52 (17.0)	
Other	53 (23.5)	46 (15.1)	
CVC insertion sites, n (%)			<0.001
Internal jugular vein	194 (85.8)	284 (93.1)	
Subclavian vein	12 (5.3)	19 (6.2)	
Femoral vein	20 (8.8)	2 (0.7)	
Number of lumens of CVC, n (%)			<0.001
Single lumen	45 (19.9)	57 (18.7)	
Double lumen	166 (73.5)	189 (62.0)	
Triple lumen	15 (6.6)	59 (19.3)	
Median Hb, g/dL (IQR)	9.8 (8.2–11.7)	9.3 (7.5–10.8)	0.001
Median WBC count,/μL (IQR)	4,800 (3,125–7,075)	4,000 (2,500–6,400)	0.035
Median percentage of neutrophils, % (IQR)	62.3 (44.9–75.8)	58.4 (36.8–71.4)	0.022
Median absolute neutrophil count,/μL (IQR)	2,827 (1,463–4,605)	2,158 (1,222–3,770)	0.014
Absolute neutrophil count <1,000/μL, n (%)	45 (19.9)	65 (21.3)	0.775
Median platelet count,/μL (IQR)	145,000 (62,250–24,075)	123,000 (35,000–203,000)	0.001
Median albumin, g/dL (IQR)	3.4 (2.8–3.9)	3.5 (2.8–4.0)	0.033
Year, n (%)			<0.001
2009	8 (3.5)	29 (9.5)	
2010	16 (7.1)	27 (8.9)	
2011	32 (14.2)	34 (11.1)	
2012	32 (14.2)	25 (8.2)	
2013	15 (6.6)	43 (14.1)	
2014	9 (4.0)	67 (22.0)	
2015	52 (23.0)	45 (14.8)	
2016	46 (20.4)	33 (10.8)	
2017	16 (7.1)	2 (0.7)	
Change of disinfectant and dressing, n (%)			1.000
June 2009–September 2012	80 (35.4)	109 (35.7)	
October 2012–March 2017	146 (64.6)	196 (64.3)	
Median duration of catheterisation, days (IQR)	34 (21–62)	35 (21–57)	0.953
CLABSI event, n (%)	15 (6.6)	39 (12.8)	0.030
Death during CVC placement, n (%)	30 (13.3)	46 (15.1)	0.644

Data are shown as n (%) or as medians with IQR. CLABSI, central line-associated bloodstream infection; CVC, central venous catheter; Hb, haemoglobin; HSCT, haematopoietic stem cell transplantation; IQR, interquartile range; WBC, white blood cells.

cleanliness. Univariate analysis revealed that more CLABSI events occurred after insertion in the operating room than in the ward. However, the difference did not reach significance in multivariate analyses. Whether venues of CVC insertion increase risk for CLABSI is controversial. One retrospective study found that an operating room was more significantly associated with the development of central line infections than a surgical ICU [16], whereas a prospective observational study

Table III
Univariate analysis of clinical and laboratory variables associated with CLABSI in patients inserted with a CVC in a ward or operating room

Variables	OR (95% CI)	*P* value
Venue of CVC insertions		
Ward	Reference	
Operating room	2.12 (1.14–3.94)	0.017
Age (10 y.o.)	0.98 (0.84–1.13)	0.764
Sex		
Female	Reference	
Male	1.61 (0.88–2.94)	0.121
Reasons of CVC insertions		
Chemotherapy	Reference	
Autologous HSCT	0.38 (0.09–1.63)	0.191
Allogeneic HSCT	3.63 (1.83–7.19)	<0.001
Other	0.37 (0.13–1.09)	0.071
CVC insertion sites		
Internal jugular vein	Reference	
Subclavian vein	1.39 (0.49–3.92)	0.534
Femoral vein	0.41 (0.05–3.22)	0.395
Number of lumens of CVC		
Single lumen	Reference	
Double lumen	2.03 (0.78–5.31)	0.149
Triple lumen	5.31 (1.84–15.30)	0.002
Hb (g/dl)	0.87 (0.78–0.98)	0.019
WBC count (1,000/μL)	1.01 (1.00–1.02)	0.012
Percentage of neutrophils (%)	0.99 (0.98–1.00)	0.012
Absolute neutrophil count (/μL)	1.00 (1.00–1.00)	0.339
Absolute neutrophil count (/μL)		
≥1,000	Reference	
<1,000	0.98 (0.50–1.95)	0.964
Platelet count (10,000/μL)	1.00 (0.97–1.02)	0.705
Albumin (0.1 g/dL)	1.01 (0.98–1.05)	0.387
Change of disinfectant and dressing		
June 2009–September 2012	Reference	
October 2012–March 2017	1.03 (0.57–1.84)	0.934

CI, confidence interval, CLABSI, central line-associated bloodstream infection; CVC, central venous catheter; Hb, haemoglobin; HSCT, haematopoietic stem cell transplantation; OR, odds ratio; WBC, white blood cells; y.o., years old.

Table IV
Multivariate analysis of venues where CVC insertion was associated with CLABSI events

Model	Variables	OR (95% CI)	*P* value
Model 1	Venue of CVC insertions		
	Ward	Reference	
	Operating room	1.69 (0.82–3.48)	0.158
Model 2	Venue of CVC insertions		
	Ward	Reference	
	Operating room	1.62 (0.80–3.41)	0.178
Model 3	Venue of CVC insertions		
	Ward	Reference	
	Operating room	1.57 (0.75–3.26)	0.229

Model 1: Adjusted for age, reason for CVC insertion, CVC insertion site, number of CVC lumens, haemoglobin, percentage of neutrophils and platelets.
Model 2: Adjusted for variables included in Model 1 and sex, white blood cell count, absolute neutrophil count, absolute neutrophil count < 1,000/μL, albumin, and change of disinfectant and dressing.
Model 3: Adjusted for variables included in Model 1 and sex, white blood cell count and absolute neutrophil count < 1,000/μL.
CLABSI, central line-associated bloodstream infection; CVC, central venous catheter; CI, confidence interval.

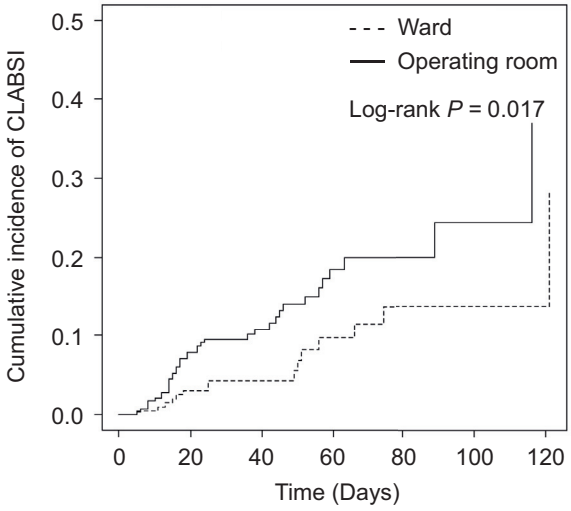

Figure 1. Kaplan-Meier curves for cumulative incidence of CLABSI in ward and operating room groups.

found higher infection rates when CVC were inserted in an ICU than in an operating theatre or ward (9.4% vs. 1.4% and 2.8%) [17]. Our results together with these findings suggest that the cleanliness of venues might not contribute to the development of CLABSI despite the different backgrounds of the patients in the present and previous studies.

The design of this retrospective chart review had some inherent limitations. The attending physicians selected the venues for CVC insertion. Some preferred what they perceived to be a "cleaner" venue (namely, the operating room). This might have introduced bias with respect to the patients. Therefore, we compared the effects of insertion venues using multivariate analysis. Furthermore, CLABSI was diagnosed as LCBI according to CDC guidelines. Blood cultures were categorised as positive, negative or contaminated using an automated microbial detection system (BacT/Alert 3D®) rather than by semiquantitative or quantitative methods.

In conclusion, the present study found a lower rate of CLABSI than that reported previously, and that the location during CVC insertion might not affect the development of CLABSI.

Author contribution

Hiroaki Kitamura: Conceptualization, Methodology, Investigation, Validation, Writing - Original Draft, Writing - Review & Editing.

Yasushi Kubota: Conceptualization, Methodology, Investigation, Validation, Writing - Original Draft, Writing - Review & Editing.

Sho Komukai: Methodology, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing.

Hisako Yoshida: Methodology, Validation, Formal analysis, Writing - Review & Editing.
Yukari Kaneko: Resources, Writing - Review & Editing.
Yukiko Mihara: Resources, Writing - Review & Editing.
Zenzo Nagasawa: Resources, Writing - Review & Editing.
Atsushi Kawaguchi: Validation, Writing - Review & Editing.
Yosuke Aoki: Methodology, Validation, Writing - Review & Editing.
Shinya Kimura: Supervision, Writing - Review & Editing.

Funding

This work was supported in part by grants from the JSPS KAKENHI (16K09851 to Y.K.) and the Japan Leukemia Research Fund (Y.K.).

Ethics considerations

This study proceeded under the approval of the Institutional Review Board at Saga University Hospital. Written informed consent was waived due to the nature of the study.

Conflict of interest

The authors have no conflicts of interest to declare.

Authorship statement

All authors meet the ICMJE authorship criteria.

Acknowledgements

We are grateful to the hospital physicians and staff involved in the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.infpip.2020.100050.

References

[1] van Rooden CJ, Rosendaal FR, Barge RM, van Oostayen JA, van der Meer FJ, Meinders AE, et al. Central venous catheter related thrombosis in haematology patients and prediction of risk by screening with Doppler-ultrasound. Br J Haematol 2003;123(3):507—12.
[2] Penack O, Rempf P, Eisenblatter M, Stroux A, Wagner J, Thiel E, et al. Bloodstream infections in neutropenic patients: early detection of pathogens and directed antimicrobial therapy due to surveillance blood cultures. Ann Oncol 2007;18(11):1870—4.
[3] Conn JR, Catchpoole EM, Runnegar N, Mapp SJ, Markey KA. Low rates of antibiotic resistance and infectious mortality in a cohort of high-risk hematology patients: A single center, retrospective analysis of blood stream infection. PLoS One 2017;12(5): e0178059.
[4] Park SW, Ko S, An HS, Bang JH, Chung WY. Implementation of central line-associated bloodstream infection prevention bundles in a surgical intensive care unit using peer tutoring. Antimicrob Resist Infect Control 2017;6:103.
[5] Pronovost P, Needham D, Berenholtz S, Sinopoli D, Chu H, Cosgrove S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med 2006;355(26): 2725—32.
[6] Lorente L. What is new for the prevention of catheter-related bloodstream infections? Ann Transl Med 2016;4(6):119.
[7] Schalk E, Hanus L, Farber J, Fischer T, Heidel FH. Prediction of central venous catheter-related bloodstream infections (CRBSIs) in patients with haematologic malignancies using a modified Infection Probability Score (mIPS). Ann Hematol 2015;94(9): 1451—6.
[8] O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 2011;52(9): e162—93.
[9] O'Grady NP, Alexander M, Dellinger EP, Gerberding JL, Heard SO, Maki DG, et al. Guidelines for the prevention of intravascular catheter-related infections. Am J Infect Control 2002;30(8): 476—89.
[10] Raad II, Hohn DC, Gilbreath BJ, Suleiman N, Hill LA, Bruso PA, et al. Prevention of central venous catheter-related infections by using maximal sterile barrier precautions during insertion. Infect Control Hosp Epidemiol 1994;15(4 Pt 1):231—8.
[11] Ishikawa Y, Kiyama T, Haga Y, Ishikawa M, Takeuchi H, Kimura O, et al. Maximal sterile barrier precautions do not reduce catheter-related bloodstream infections in general surgery units: a multi-institutional randomized controlled trial. Ann Surg 2010;251(4):620—3.
[12] Haga Y, Miyanari N, Takahashi T, Koike S, Kobayashi R, Mizusawa H, et al. Risk factors for catheter-related bloodstream infections in adult hospitalized patients - multicenter cohort study. Scand J Infect Dis 2013;45(10):773—9.
[13] Gahlot R, Nigam C, Kumar V, Yadav G, Anupurba S. Catheter--related bloodstream infections. Int J Crit Illn Inj Sci 2014;4(2): 162—7.
[14] Parienti JJ, Mongardon N, Megarbane B, Mira JP, Kalfon P, Gros A, et al. Intravascular Complications of Central Venous Catheterization by Insertion Site. N Engl J Med 2015;373(13):1220—9.
[15] Crnich CJ, Maki DG. The promise of novel technology for the prevention of intravascular device-related bloodstream infection. I. Pathogenesis and short-term devices. Clin Infect Dis 2002;34(9):1232—42.
[16] Charalambous C, Swoboda SM, Dick J, Perl T, Lipsett PA. Risk factors and clinical impact of central line infections in the surgical intensive care unit. Arch Surg 1998;133(11):1241—6.
[17] Tan CC, Zanariah Y, Lim KI, Balan S. Central venous catheter-related blood stream infections: incidence and an analysis of risk factors. Med J Malaysia 2007;62(5):370—4.
[18] Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36(5):309—32.
[19] Central Line—Associated Bloodstream Infection (CLABSI) Event. National Healthcare Safety Network website. https://www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABScurrent.pdf. [Accessed 6 January 2020].
[20] VanderWeele TJ, Shpitser I. A new criterion for confounder selection. Biometrics 2011;67(4):1406—13.
[21] Worth LJ, Seymour JF, Slavin MA. Infective and thrombotic complications of central venous catheters in patients with hematological malignancy: prospective evaluation of nontunneled devices. Support Care Cancer 2009;17(7):811—8.
[22] Dix CH, Yeung DT, Rule ML, Ma DD. Essential, but at what risk? A prospective study on central venous access in patients with haematological malignancies. Intern Med J 2012;42(8):901—6.
[23] Luft D, Schmoor C, Wilson C, Widmer AF, Bertz H, Frei R, et al. Central venous catheter-associated bloodstream infection and colonisation of insertion site and catheter tip. What are the rates and risk factors in haematology patients? Ann Hematol 2010; 89(12):1265—75.

[24] Templeton A, Schlegel M, Fleisch F, Rettenmund G, Schobi B, Henz S, et al. Multilumen central venous catheters increase risk for catheter-related bloodstream infection: prospective surveillance study. Infection 2008;36(4):322—7.

[25] Bicudo D, Batista R, Furtado GH, Sola A, Medeiros EA. Risk factors for catheter-related bloodstream infection: a prospective multicenter study in Brazilian intensive care units. Braz J Infect Dis 2011;15(4):328—31.

[26] Wolf HH, Leithauser M, Maschmeyer G, Salwender H, Klein U, Chaberny I, et al. Central venous catheter-related infections in hematology and oncology : guidelines of the Infectious Diseases Working Party (AGIHO) of the German Society of Hematology and Oncology (DGHO). Ann Hematol 2008;87(11):863—76.