Infection Control & Hospital Epidemiology (2024), **45**, 698–702
doi:10.1017/ice.2024.1

SHEA

Original Article

A comparative analysis of infection and complication rates between single- and double-lumen ports

Konrad M. Kozlowski BA, Hamed Jalaeian MD, Levi M. Travis BS and Joseph F. Zikria MD

Department of Interventional Radiology, University of Miami Miller School of Medicine, Miami, Florida

Abstract

Objective: Port-a-caths are implanted intravascular chest ports that enable venous access. With more port placements performed by interventional radiologists, it is important to discern differences in infection and complication rates between double- and single-lumen ports.

Methods: We retrospectively reviewed 1,385 port placements over 2 years at the University of Miami. Patients were grouped by single- or double-lumen ports. Data on duration of catheter stay, bloodstream infections, malfunctions, and other complications (fibrin sheath, thrombosis, catheter malposition) were collected. Multivariate Cox regression was performed to identify variables predicting port infection.

Results: The mean patient age was 58.8 years; the mean BMI was 26.9 kg/m^2; and 61.5% of these patients were female. Our search revealed 791 double-lumen ports (57.1%) and 594 single-lumen ports (42.9%). The median follow-up was 668 days (range, 2–1,297). Double-lumen ports were associated with significantly higher rates of bacteremia (2.78% vs 0.84%; $P = .02$), port malfunction (8.3% vs 2.0%; $P < .001$), fibrin sheath formation (2.2% vs 0.5%; $P < .02$), catheter tip malposition (1.0% vs 0; $P = .01$), and catheter-associated thrombosis (1.4% vs 0; $P = .003$). Multivariate Cox regression analysis, after adjusting for other variables, showed that double-lumen chest ports had 2.98 times (95% confidence interval, 1.12–7.94) the hazard rate of single-lumen ports for developing bloodstream infection ($P = .029$).

Conclusions: Double-lumen chest ports are associated with increased risk for bloodstream infection, malfunction, fibrin sheath formation, catheter tip malposition, and catheter-associated thrombosis. Interventional radiologists may consider placing single-lumen ports if clinically feasible; however, future studies are needed to determine clinical significance. The study limitations included the retrospective study design and the potential loss of patient follow-up.

(Received 31 May 2023; accepted 20 December 2023; electronically published 26 January 2024)

Port-a-caths (subcutaneous ports) are implanted devices that are widely used in oncology patients.[1,2] They allow for the administration of fluids, long-term chemotherapy, or blood draws via easy venous access.[3] Ports are widely utilized because they have lower rates of catheter-related infections than external catheters.[4,5] However, port-a-caths can also have significant complications, including local wound infections, bloodstream infections, fibrin sheath formation, catheter-associated venous thrombosis, and wound dehiscence.[6,7] Port-related infections are still the most common complication, occurring in 5.6%–13% of patients with a subcutaneous port (0.15–0.39 per 1,000 catheter days) and can precipitate port removal.[7–9] Infections and malfunctions related to ports can have significant impacts on patients, causing life-threatening complications, delaying their oncologic treatments, and prolonging hospital stays.[10–12]

Most ports are either single- or double-lumen ports, and the specific port selection depends on the patient's circumstance as well as on the preference of the oncologist and local institution protocols. Although double-lumen ports can facilitate the concurrent infusion of multiple chemotherapies, these ports are also larger and require a larger chest incision for placement. Furthermore, when considering the laterality of port placement, there are no clear guidelines as to whether placing right or left-sided ports causes fewer complications, and the literature shows conflicting results.[13–15]

Prior literature supports single-lumen central venous catheter (CVC) insertions to decrease the chance of CLABSI. However, data in the literature are lacking concerning indwelling port placement when analyzing the differences in complication rates between single and double-lumen ports. Therefore, we sought to determine the potential differences in infection and other complication rates between single- and double-lumen ports. We also investigated the complication rates of right- versus left-sided port placement.

Material and methods

Patient population

This retrospective study was conducted at the University of Miami Health System Hospitals and was approved by the local institutional review board. After completing a thorough search of hospital records, all adult patients (aged >18 years) who underwent port placement between March 2019 and March 2021 were identified.

Corresponding author: Konrad Kozlowski; Email: konradkozlowski30@gmail.com

Cite this article: Kozlowski K. M., Jalaeian H., Travis L. M., Zikria J. F. A comparative analysis of infection and complication rates between single- and double-lumen ports. *Infect Control Hosp Epidemiol* 2024. 45: 698–702, doi: 10.1017/ice.2024.1

Measures investigated

We collected the following data: patient demographics (age, sex, and body mass index or BMI), underlying medical condition requiring chest port placement, functional status (Eastern Cooperative Oncology Group Performance Status or ECOG), duration of port catheter stay, port manufacturer, port lumen number, side of port insertion, port complications, and final event (infection, port malfunction, port removal, death, or loss of follow-up) by the study conclusion date (July 31, 2022).[16] The duration of the catheter stay (in days) was calculated as the time from port placement to the final event. Information regarding infections (bloodstream and port site) as well as port malfunctions was collected. Port-site infections included phlebitis and exit-site infections in patients who experienced erythema, warmth, and/or pain around the port site. Systemic infection, representative of bloodstream infection, was defined according to US Centers for Disease Control (CDC) guidelines.[2] Specifically, patients with an intravascular device had bacteremia or fungemia if positive blood cultures were obtained from a peripheral vein or if the patient had no apparent source for bloodstream infection but had clinical manifestations of infection. Malfunctions were further delineated as fibrin sheath formation, catheter extravasation, thrombosis around the port catheter vein, catheter malposition, hematoma, and wound dehiscence. Specific bacteria and fungi strains from positive blood cultures were collected, and any subsequent admissions were recorded.

Port placements

All ports were placed at the University of Miami Healthcare System by board-certified interventional radiologists or by trainees under their direct supervision. All patients received preoperative intravenous antibiotics prior to the procedure per local institution guidelines. The patient vessel was first determined to be patent with ultrasound, and the internal jugular vein was accessed under ultrasound guidance. A subcutaneous pocket was created in the right or left anterior chest wall, and a single or double-lumen port was placed (as determined by the referring medical oncologist). The catheter tip was positioned at the base of the superior edge of the crista terminalis (ie, the SVC/RA junction) under fluoroscopy guidance; the port was flushed and checked for patency; and the pocket was then closed with sutures, supported with dermabond. Chest radiograph was used to demonstrate adequate catheter position and the absence of pneumothorax. The referring oncology provider performed follow-up examinations.

Statistical analysis

The normality of the variables was checked visually using density plots and Q-Q plots and confirmed using the Shapiro-Wilk normality test. Continuous variables were examined as mean (standard deviation) or median (interquartile range or range) as appropriate. Comparisons between the groups at a single time point were performed with the unpaired *t* test or the Wilcoxon test for nonparametric data. Discrete variables were summarized as counts with percentages, which were compared across study groups using the Fisher exact test or the χ^2 test when appropriate. A survival analysis was performed on the length of catheter stay and infection was considered as the event. Other competing events (eg, death, loss to follow-up, and port removal for reasons other than infection) were considered right-censoring events. Notably, the data satisfied a proportional hazard model. Using automated software functions, a multivariate Cox regression model was fitted to identify the variables that are predictive of survival from infection episodes and to calculate the adjusted hazard ratios for other variables. All statistical analyses were performed using R version 4.3.2 software (R Foundation for Statistical Computing, Vienna, Austria), and 2-tailed P values $< .05$ were considered statistically significant.

Results

In total, 1,385 ports were placed between March 2019 and March 2021. Tables 1 and 2 demonstrate demographic variables of the study population and technical data related to chest ports placed for the study cohort. The mean patient age was 58.8 years; BMI was 26.9; and 61.5% of these patients were female. The median follow-up was 668 days (range, 2–1,297). Almost all patients (97.4%) were placed to facilitate chemotherapy for malignant tumors. In total, 791 ports (57.1%) had a double lumen and 594 (42.9%) had a single lumen. Overall, patients in this cohort had a bacteremia rate of 1.95%, a malfunction rate of 4.9%, a fibrin sheath rate of 1.44%, a catheter tip malposition rate of 0.58%, and a catheter-associated thrombosis rate of 0.79%. Table 3 demonstrates the most commonly cultured pathogens isolated from the bloodstream in patients with port infection.

Table 4 shows the data comparison of patients with double-lumen chest ports with those with single-lumen devices. Double-lumen ports were associated with a significantly higher rate of bacteremia (2.78% vs 0.84%; $P = .02$), port malfunction (8.3% vs 2.0%; $P < .001$), fibrin sheath formation (2.2% vs 0.5%; $P < .02$), catheter tip malposition (1.0% vs 0; $P = .01$), and catheter-associated venous thrombosis (1.4% vs 0; $P = .003$).

Most ports were placed on the right side of the chest: 1,123 (81.1%) versus 262 (18.9%) (Table 5). Patients with left-sided ports were more likely to have a single-lumen chest port (50.4% versus 41.1%; $P = .008$), were more likely to be female sex (79.8% vs 57.3%; $P < .001$), and had a higher risk of complications such as port malfunction (9.5% vs 4.7%; $P = .004$) or port catheter malposition (1.5% vs 0.4%; $P = .05$).

In the survival analysis, the hazard risk of port infection was significantly higher in double-lumen ports compared to single-lumen chest ports (Likelihood ratio test statistic, 7.32; $P = .007$) (Fig. 1). Using an automated forward step function, a multivariate proportional hazard Cox regression model was built for an adjusted test to predict survival from an infection event, according to the Akaike information criterion (AIC) procedure. We investigated the following variables included in the model: double (vs single) lumen, port brand, underlying neoplastic (or nonneoplastic) condition requiring port placement, side of the port placement, BMI, age, sex, and ECOG functional status of the patient at the time of chest port placement. The main effect variables that remained significant in the final Cox regression model included double (vs single) lumen, sex, age, and body mass index (likelihood ratio test statistic of the Cox regression model, 13.29; $P = .004$). Table 6 lists the hazard ratios, 95% confidence intervals, and the associated local test P values. There was no significant interaction between the main effect variables. After adjusting for other variables, having a double-lumen chest port had a 2.98 times hazard rate of a single-lumen port (95% confidence interval, 1.12–7.94; $P = .029$) for developing infection.

https://doi.org/10.1017/ice.2024.1 Published online by Cambridge University Press

Table 1. Patient Demographics and Port Variables

Variable	Total
Age, mean y (±SD)	58.8 (±4.0)
BMI, Mean kg/m^2 (±SD)	26.9 (±5.7)
Sex, no. (%)	
Female	852 (61.5)
Male	533 (38.5)
Catheter duration, median d (IQR)	668 (489–919)
No. of port lumens, no. (%)	
Single lumen	594 (42.9)
Double lumen	791 (57.1)
Side of port placement, no. (%)	
Right	1,123 (81.1)
Left	262 (18.9)

Note. SD, standard deviation; IQR, interquartile range.

Table 2. Underlying Medical Condition Requiring Port Placement

Medical Condition	No. (%)
Breast cancer	334 (24.1)
Colorectal cancer	172 (12.4)
Pancreatic or ampullary cancer	120 (8.7)
Non-Hodgkin's lymphoma	120 (8.7)
Lung cancer	120 (8.7)
Head and neck cancer	53 (3.8)
Ovarian tumor	47 (3.4)
Bladder or ureter cancer	43 (3.1)
Nonmalignant condition[a]	36 (2.6)
Hodgkin's lymphoma	33 (2.4)
Gastric cancer	29 (2.1)
Prostate cancer	28 (2.0)
Endometrial cancer	28 (2.0)
Leukemia	21 (1.5)
Multiple myeloma	20 (1.4)
Esophageal cancer	20 (1.4)
Cholangiocarcinoma	16 (1.2)
Soft tissue sarcoma	15 (1.1)
Anorectal cancer	14 (1)
Cervical cancer	12 (0.9)
Bone primary tumor	11 (0.8)
Leiomyosarcoma	10 (0.7)
Other[b]	83 (6.0)

[a]Nonmalignant conditions included sickle cell disease, ALS, and cystic fibrosis.
[b]Others include brain tumor (n=5), liver primary tumor (n=8), aplastic anemia (n=1), neuroendocrine tumor (n=3), gall bladder cancer (n=6), renal tumor (n=7), germ-cell tumor (n=1), appendiceal cancer (n=6), Kaposi sarcoma (n=2), skin cancer (n=8), adrenal malignant tumor (n=3), angiosarcoma (n=3), liposarcoma (n=3), peritoneal tumors (n=6), uterine cancer (n=9), vulvar cancer (n=1), myelodysplastic syndrome (n=4), testicular cancer (n=3), and thymic tumor (n=4).

Table 3. Bloodstream Pathogens After Port Infection

Pathogen	No. (%)
Staphylococcus aureus	12 (46.15)
Enterococcus faecalis	6 (23.08)
Escherichia coli	3 (11.54)
Candida albicans	2 (7.69)
S. epidermidis	1 (3.85)
Pseudomonas aeruginosa	1 (3.85)
S. warneri	1 (3.85)

Table 4. Single Variable Analysis: Comparison of Single- and Double-Lumen Ports

Variable	Single Lumen, No. (%)[a]	Double Lumen, No. (%)[a]	*P* Value
Total	594 (42.9)	791 (57.1)	
Age, mean y (±SD)	58.4 (±14.1)	59.1 (±14.0)	.30
Body mass index, mean kg/m^2 (±SD)	27.1 (±5.9)	26.7 (±5.6)	.25
ECOG performance status, median (IQR)	1 (1–2)	2 (1–2)	.02*
Catheter duration, median d (IQR)	643.5 (487.5–878.75)	690.0 (490.5–935.0)	.06
Common reasons for port insertion			<.001*
Breast cancer	219 (51.9)	115 (25.9)	
Colorectal cancer	44 (10.4)	128 (28.8)	
Pancreatic or ampullary cancer	33 (7.8)	87 (19.6)	
Non-Hodgkin's lymphoma	63 (14.9)	57(12.8)	
Lung cancer	63 (14.9)	57 (12.8)	
Port manufacturer			<.001*
Bard	580 (97.6)	397 (50.3)	
Angiodynamics	5 (0.8)	381 (48.2)	
Navilyst/Namic	0	5 (0.6)	
Unknown	9 (1.5)	7 (0.9)	
Complications, no. (%)			
Bacteremia	5 (0.84)	22 (2.78)	.02*
Malfunctions	12 (2.0)	66 (8.3)	<.001*
Fibrin sheath	13 (1.16)	7 (2.67)	.08
Catheter tip malposition	0	8 (1.0)	.01*
Catheter-associated thrombosis	0	11 (1.4)	.003*
Extravasation	0	1 (0.1)	1
Wound dehiscence	2 (0.3)	3 (0.4)	1
Wound infection	3 (0.5)	7 (0.9)	.53

Note. SD, standard deviation; IQR, interquartile range; ECOG, Eastern Cooperative Oncology Group (ECOG) performance status.
[a]Units unless otherwise specified.
*Statistically significant.

https://doi.org/10.1017/ice.2024.1 Published online by Cambridge University Press

Table 5. Single Variable Analysis: Comparison of Right- Versus Left-Sided Ports

Variable	Right, No. (%)[a]	Left, No. (%)[a]	*P* Value
Total ports placed	1,123 (81.1)	262 (18.9)	
No. of lumen			.008*
Single lumen	462 (41.1)	132 (50.4)	
Double lumen	661 (58.9)	130 (49.6)	
Sex			<.001*
Male	480 (42.7)	53(20.2)	
Female	643 (57.3)	209 (79.8)	
Port complication			
Bacteremia	21(1.9)	6 (2.3)	.85
Malfunctions	53 (4.7)	25(9.5)	.004*
Fibrin sheath	13(16.2)	7(3.8)	.08
Malposition	4 (0.4)	4 (1.5)	.05*
Catheter-associated thrombosis	7 (0.6)	4 (1.5)	.14
Wound dehiscence	4 (0.4)	1 (0.4)	1
Wound infection	9 (0.8)	1 (0.4)	.70
Hematoma	4 (0.4)	2 (0.8)	.312

[a]Units unless otherwise specified.
*Statistically significant.

Table 6. Cox Regression Model Demonstrating Hazard Ratios of Main Effect Variables Associated with the Risk of Port Infection

Variable	Hazard Ratio	95% CI	*P* Value
Double lumen (vs single lumen)	2.98	1.12–7.94	.029*
Body mass index	1.08	0.86–1.00	.05*
Female (vs male)	0.53	0.24–1.14	.10
Age	0.98	0.96–1.00	.10

Note. Likelihood ratio test statistic, 13.29. $P = .004$.
*Statistically significant.

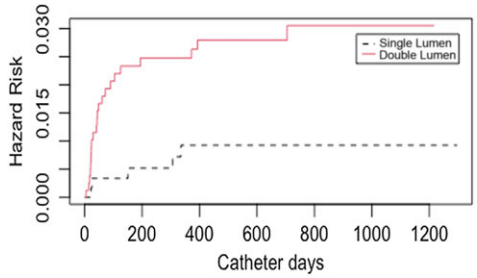

Figure 1. Cumulative hazard risk of infection in double- versus single-lumen chest ports (likelihood ratio test statistic, 7.32; $P = .007$).

Discussion

Port placement is a common procedure used for intravenous therapy, mostly in oncology patients. This study was performed to compare safety and complication rates among single- and double-lumen ports. At our institution, double-lumen ports are more commonly placed than single-lumen ports. The oncologists' rationale for the decision to place double-lumen ports is to facilitate 2 intravenous chemotherapies simultaneously and to have a second lumen available if the initial lumen malfunctions.

Most of the association between catheter-related bloodstream infections and the number of catheter lumens in the literature has been from studies focusing on tunneled CVCs rather than implantable chest ports. For example, in a meta-analysis of 7 high-quality studies, usage of multilumen CVCs was associated with a higher chance of catheter-related bloodstream infections (OR, 1.30; 95% CI, 0.50–3.41) compared to single-lumen CVCs, but the rates of catheter colonization were not significantly different.[17] In another meta-analysis of 17 studies, multilumen CVCs were found to be an individual risk factor for CLABSI.[18]

However, our results have demonstrated that double-lumen indwelling chest ports have 2.98 times the hazard rate of single-lumen ports for developing infection, after adjusting for other variables. These results echoed the CDC recommendation (category IB) of implanting devices with the least number of lumens because the risk of infection could be potentially higher due to a greater number of entries.[19] Furthermore, in this study, double-lumen chest ports were associated with a higher chance of port malfunction, fibrin sheath formation, catheter tip malposition, and catheter-associated venous thrombosis. This may be because double-lumen chest ports have a larger port reservoir than single-lumen ports; hence, the skin incision and surgical pocket created must be larger, which likely accounts for the higher early postoperative infection rates. The double-lumen ports used at the institution measure ~4 cm in long-axis diameter, as opposed to the largest single-lumen port, which measures 3 cm in long-axis diameter. The double-lumen port catheters used at the institution typically have a diameter range of 9.5–11.4 French, as opposed to the single-lumen ports, which have a maximum diameter of 8 French. The larger size of these devices may make it more difficult to position correctly in the chest during the port placement surgery. This size difference in the double-lumen port reservoirs or catheters may also account for relatively higher rates of wound dehiscence, port-site infections, or hematoma in the immediate postoperative period, although these outcome rates were not statistically different in this study.

Among a subset analysis of the ports evaluated during this study, no statistically significant difference was observed in the bacteremia rates between ports placed on the right or left side of the chest (1.9% vs 2.3%; $P = .85$). However, left-sided ports had significantly higher rates of catheter tip malposition (1.5% vs 0.4%) and demonstrated a trend for possible higher rates of fibrin sheath formation (2.7% vs 1.2%). These findings may be attributed to the longer catheter course required from a left-sided jugular venous approach to the right atrium of the heart. The right brachiocephalic vein has a shorter and more vertical course compared to the left brachiocephalic vein, which has a slightly more undulating "s" shape.

This study had several limitations. The study design was retrospective, and the study was conducted at a single center. In addition, although this study had a relatively large sample size, the inherent low incidence rate of some complications after chest port placement may have affected statistical power in some of the subgroup comparisons. Another limitation of this study may be the differences in technique among individual operators in port placements. Although all ports were placed utilizing the internal jugular venous access technique under ultrasonography and fluoroscopy guidance, technical differences in the incision, port pocket creation, and suturing methods were not evaluated in this study. Future prospective studies will be helpful in further establishing the causes of infections and complications in ports.

Double-lumen chest ports were associated with a higher chance of infection, malfunction, fibrin sheath formation, catheter tip

https://doi.org/10.1017/ice.2024.1 Published online by Cambridge University Press

malposition, or catheter-associated venous thrombosis. Implanting devices with the least number of lumens should be considered if feasible, especially for oncology patients who may be immunosuppressed and predisposed to infection. We hope that our findings will help direct the placement of port-a-caths by oncologists and their interventional radiology colleagues and will contribute to the reduction of port complications.

Acknowledgments.

Financial support. No financial support was provided relevant to this article.

Competing interests. All authors report no conflicts of interest relevant to this article.

References

1. Biffi R, de Braud F, Orsi F, *et al.* Totally implantable central venous access ports for long-term chemotherapy. A prospective study analyzing complications and costs of 333 devices with a minimum follow-up of 180 days. *Ann Oncol* 1998;9:767–773.
2. Tippit D, Siegel E, Ochoa D, *et al.* Upper-extremity deep vein thrombosis in patients with breast cancer with chest versus arm central venous port catheters. *Breast Cancer (Auckl)* 2018;12:1178223418771909.
3. Strum S, McDermed J, Korn A, Joseph C. Improved methods for venous access: the port-a-cath, a totally implanted catheter system. *J Clin Oncol* 1986;4:596–603.
4. Pegues D, Axelrod P, McClarren C, *et al.* Comparison of infections in Hickman and implanted port catheters in adult solid-tumor patients. *J Surg Oncol* 1992;49:156–162.
5. Groeger JS, Lucas AB, Thaler HT, *et al.* Infectious morbidity associated with long-term use of venous access devices in patients with cancer. *Ann Intern Med* 1993;119:1168–1174.
6. Fischer L, Knebel P, Schröder S, *et al.* Reasons for explantation of totally implantable access ports: a multivariate analysis of 385 consecutive patients. *Ann Surg Oncol* 2008;15:1124–1129.
7. Narducci F, Jean-Laurent M, Boulanger L, *et al.* Totally implantable venous access port systems and risk factors for complications: a one-year prospective study in a cancer centre. *Eur J Surg Oncol* 2011;37:913–918.
8. Zerati AE, Figueredo TR, de Moraes RD, *et al.* Risk factors for infectious and noninfectious complications of totally implantable venous catheters in cancer patients. *J Vasc Surg Venous Lymphat Disord* 2016;4:200–205.
9. Lebeaux D, Larroque B, Gellen-Dautremer J, *et al.* Clinical outcome after a totally implantable venous access port-related infection in cancer patients: a prospective study and review of the literature. *Medicine (Baltimore)* 2012;91:309–318.
10. Penel N, Neu JC, Clisant S, Hoppe H, Devos P, Yazdanpanah Y. Risk factors for early catheter-related infections in cancer patients. *Cancer* 2007;110:1586–1592.
11. Raad I, Hanna H, Maki D. Intravascular catheter-related infections: advances in diagnosis, prevention, and management. *Lancet Infect Dis* 2007;7:645–657.
12. Veenstra DL, Saint S, Sullivan SD. Cost-effectiveness of antiseptic-impregnated central venous catheters for the prevention of catheter-related bloodstream infection. *JAMA* 1999;282:554–5560.
13. Ignatov A, Hoffman O, Smith B, *et al.* An 11-year retrospective study of totally implanted central venous access ports: complications and patient satisfaction. *Eur J Surg Oncol* 2009;35:241–246.
14. Tsai YF, Ku YH, Chen SW, Huang WT, Lu CC, Tsao CJ. Right- and left-subclavian vein port-a-cath systems: comparison of complications. *Eur Surg Res* 2012;49:66–72.
15. Lin WY, Lin CP, Hsu CH, *et al.* Right or left? Side selection for a totally implantable vascular access device: a randomised observational study. *Br J Cancer* 2017;117:932–937.
16. Sok M, Zavrl M, Greif B, *et al.* Objective assessment of WHO/ECOG performance status. *Support Care Cancer* 2019;27:3793–3798.
17. Dezfulian C, Lavelle J, Nallamothu BK, Kaufman SR, Saint S. Rates of infection for single-lumen versus multilumen central venous catheters: a meta-analysis. *Crit Care Med* 2003;31:2385–2390.
18. Lafuente Cabrero E, Terradas Robledo R, *et al.* Risk factors of catheter-associated bloodstream infection: systematic review and meta-analysis. *PLoS One* 2023;18:e0282290.
19. O'Grady NP, Alexander M, Burns LA, *et al.* Guidelines for the prevention of intravascular catheter-related infections. *Clin Infect Dis* 2011;52:e162–e193.

https://doi.org/10.1017/ice.2024.1 Published online by Cambridge University Press