Original Article

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Hemodialysis-Related Infections: A 4-Year Surveillance

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Abstract:

Objective: To analyze the results from the surveillance of hemodialysis-related infections.

Material and Methods: Data was prospectively gathered from outpatients attending a hemodialysis unit from April 2019 until March 2023. The National Healthcare Safety Network (NHSN) Dialysis Event Surveillance was used to identify three types of infection-related dialysis events. Event rates were calculated and stratified by vascular access type, standardized infection ratios for bloodstream infections (BSI), intravenous antimicrobial starts, and described pathogens identified among BSI.

Results: A total of 2,288 patient-month follow-ups were included. There were 79 infection-related dialysis events (24 BSI; 46 intravenous antimicrobial starts, nine pus, redness, or increased swelling at the vascular access site). The incidence of BSI per 100 patient-months was 1.05 (0.59 arteriovenous fistula, 0.83 arteriovenous graft, and 2.22 central venous catheter). Seventeen BSI were vascular access-related. Access-related BSI per 100 patient-months was 0.74 (0.39 arteriovenous fistula, 0.41 arteriovenous graft, and 1.85 central venous catheter). Intravenous antimicrobial starts per 100 patient-months was 2.01 (0.98 arteriovenous fistula, 2.62 arteriovenous graft, and 3.14 central venous catheter). Most events occurred in patients with a central venous catheter. When benchmarked with the 2014 NHSN, the standardized infection ratio of BSI, access-related BSI, and intravenous antimicrobial starts were 1.40, 1.26, and 0.55, respectively. The most serious outcome was BSI; resulting in 83.3% hospitalizations, 25% loss of vascular access, and 15.8% deaths.

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Conclusion: Surveillance of infection-related dialysis events is important for prevention. These events were highest among patients with a central venous catheter compared with other vascular access types.

Keywords: access, g-chart, Hemodialysis, infection, outbreak, surveillance, vascular

Introduction

End-stage kidney disease is the final stage of irreversible chronic kidney disease. Kidney function declines until it can no longer adequately meet the body's needs. Hemodialysis is a treatment for kidney failure that sends a patient's blood through a filter outside of the body. Hemodialysis accesses the bloodstream through a connection between an artery and a vein called vascular access. The three principal types of vascular access are arteriovenous fistula (AVF), arteriovenous graft (AVG), and central venous catheter (CVC).

An AVF is a surgical connection made to let blood flow from the artery directly into the vein. Although, AVG is similar to AVF, it uses synthetic materials to join the artery and vein. CVC is a specially designed, in-dwelling, transcutaneous conduit used to access the intravenous lumen, with two types available: tunneled and non-tunneled. Tunneled CVC involves creating a tunnel, then inserting and advancing the catheter into the great vessel; whereas, in non-tunneled CVC, the catheter is inserted directly from the skin into the vessel[1].

Frequent access to blood vessels, via vascular access, for blood collection and transfusion predisposes patients to infections. Infections are the most serious and life-threatening complication of vascular access, leading to significant morbidity, death, and compromised access. Thus, it is the second leading cause of death in patients undergoing hemodialysis[2]. With the continuous increase in the prevalence of patients undergoing hemodialysis, access-related infections have become a national burden; this infection rate is a significant indicator of the quality of care[3].

Our hospital has conducted systematic surveillance of infection-related dialysis events. among patients since 2019, and this is the first report. Therefore, it aimed to analyze the data on infections related to hemodialysis to better prevent and resolve such events.

Material and Methods

Setting

This study was conducted at a Kidney Therapy Center in southern Thailand. The center has 17 hemodialysis stations, which operate 6 days a week; from Monday through Saturday: from 8 AM to 9 PM. There are two shifts: morning (8 AM) and afternoon (4 PM).

Surveillance method

The National Healthcare Safety Network (NHSN) dialysis event surveillance protocol[1] was applied to outpatients undergoing hemodialysis in the Kidney Therapy Center. This was a 4-year study for all outpatients aged >17 years of age. During the study period, one of the investigators prospectively collected the number of outpatients admitted for hemodialysis on the first Monday and Tuesday of the month, using the denominators for infection-related dialysis events surveillance form. This count was then used to estimate the number of patient-months for which there was a risk of healthcare-associated infections. Throughout the month, all outpatients having received hemodialysis were monitored for three NHSN-defined dialysis events. All types of vascular access presented by the patient at the time of the event or a combination of events were reported.

Event definitions and key terms

Infection-related dialysis events: Three types of events were reported: positive blood culture; intravenous (IV) antimicrobial start; pus, redness, or increased swelling at the vascular access site. The following measures were also generated: bloodstream infections (BSI), access-related bloodstream infections (ARBSI), and exit site infections.

A positive blood culture was recorded if the blood specimen was collected in the outpatient setting or within 1 calendar day after hospital admission (i.e., on the day of or the day after admission to the hospital). There must have been 21 or more days between positive blood cultures for these to be reported as separate events. For each positive blood culture, the suspected source was indicated as (1) vascular access, (2) another site, (3) contamination, or (4) uncertain. All positive blood cultures were defined as BSI, regardless of the suspected source. ARBSI was defined as a BSI, with the suspected source reported as vascular access or uncertain.

IV antimicrobial start was any outpatient initiation of IV antibiotics or antifungal drugs in a patient who had not received antimicrobials in the previous 21 days. IV antimicrobials may have been continued in inpatient antimicrobial treatment. Exit site infections were also reported when the patient had evidence of one or more symptoms of pus, redness, or increased swelling at the vascular access site. There must have been 21 or more days between the onset of the first and second episodes for these to be reported as separate events.

Data processing and statistical analysis

Data were entered into a Microsoft Excel® (Microsoft Corp., Washington, USA) spreadsheet for editing, consolidation, analysis, and reporting purposes. Data are described in terms of arithmetic mean, geometric mean, and percentage; with a corresponding 95% confidence interval (CI)[4], based on the type of data dispersion. Patient-months were defined as the total number of months for which patients visited the Kidney Therapy Center. The proportion of vascular access types was analyzed by dividing the patient-months with vascular access by the total number of patient-months. For each event type, the numerator was the total count of events, and the denominator was the total number of patient-months reported. Rates were expressed as events per 100 patient-months, and the corresponding 95% CI was based on Poisson's statistics.

To compare incidence rates (BSI, ARBSI, and IV antimicrobial start) to those reported by the NHSN in 2014[5], the standardized infection ratio (SIR) with a corresponding 95% CI was used. The SIR is a summary measure used to track healthcare-associated infections at a national level over time; it was calculated by dividing the actual number of events reported by the number that would be predicted[6], given the standard by NHSN 2014. In other words, an SIR >1.0 indicated that more events were observed than predicted; conversely, an SIR <1.0 indicated fewer events being observed than predicted[5]. The calculation of 95% CI of SIR was based on Poisson statistics[4].

The *g*-chart was used to identify any abnormal variation in the incidence of BSI. The control limits of the *g*-chart were calculated based on geometric distribution. It was used to count the number of events between rarely occurring errors or nonconforming incidents[7-10].

The frequency of causative pathogens was reported in terms of percentage, and the cluster of outbreaks was illustrated with an epidemic curve, a tool to analyze the time of an outbreak. During the outbreak the incidence rate was not constant; therefore, the attack rate (number of cases) was used instead of the incidence rate[11].

Ethics in research

The study protocol was approved by the Human Research Ethics Committee of the Faculty of Medicine, Prince of Songkla University (REC. 66-123-15-8). Because of the observational nature of the study, written informed consent was not required.

Results

Sample description and outcome

This study included 2,288 patient-months (196 patients), monitored from; April 1, 2019, and March 31, 2023. The prevalence of hemodialysis for different vascular access types was as follows: AVF, 44.6%; AVG, 31.7%; and CVC, 23.6%. Overall, 79 Infection-related dialysis events were reported (32 patients); including 24 (30.4%) BSIs, 46 (58.2%) IV antimicrobial starts, and nine (11.4%) exit site infections. Among BSIs, 17 (70.8%) were ARBSIs. The incidence of BSI, ARBSI, IV antimicrobial start and exit site infections per 100 patient-months were 1.05, 0.74, 2.01, and 0.39, respectively. In addition, a higher incidence of infection-related dialysis events of all types occurred in patients with CVC than otherwise. (Table 1). The rate of events was then compared to that of NHSN 2014 in the form of SIR. The incidences of events and SIRs stratified by event types are illustrated with a forest plot in Figure 1.

Among the 24 BSIs in 19 patients, the total number of BSIs was greater than the number of patients. Twenty-two BSIs required hospitalization, and six required vascular access replacement. The overall in-hospital mortality was three in 19 patients that had BSI (15.8%). One patient, after five episodes of BSI, died in the hospital (Table 2).

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Table 1 Incidence and percentage of the distribution of dialysis events by type of vascular access

Type and access	Person-months	Percentage	Event	Incidence	95% CI
All BSI					
AVF	1,021	44.6	6	0.59	0.22 – 1.28
AVG	726	31.7	6	0.83	0.30 – 1.80
CVC	541	23.6	12	2.22	1.15 – 3.87
Total	2,288	100.0	24	1.05	0.67 – 1.56
ARBSI					
AVF	1,021	44.6	4	0.39	0.11 – 1.00
AVG	726	31.7	3	0.41	0.09 – 1.21
CVC	541	23.6	10	1.85	0.89 – 3.40
Total	2,288	100.0	17	0.74	0.43 – 1.19
Intravenous antimicrobial start					
AVF	1,021	44.6	10	0.98	0.47 – 1.80
AVG	726	31.7	19	2.62	1.58 – 4.09
CVC	541	23.6	17	3.14	1.83 – 5.03
Total	2,288	100.0	46	2.01	1.47 – 2.68
Exit site infection					
AVF	1,021	44.6	2	0.20	0.02 – 0.71
AVG	726	31.7	–	–	–
CVC	541	23.6	7	1.22	0.45 – 2.67
Total	2,288	100.0	9	0.39	0.18 – 0.75
Total	2,288	100.0	79	3.45	2.73 – 4.30

Incidence=person-month incidence; 95% CI=Negative binomial statistics, AVF=arteriovenous fistula, AVG=arteriovenous graft, CVC=central venous catheter, BSI=bloodstream infections, ARBSI=access-related bloodstream infections

three in 19 patients that had BSI (15.8%): one patient, after five episodes of BSI, died in the hospital (Table 2).

A geometric statistical process control chart was constructed to identify any abnormal variation in the incidence of BSI (Figure 2). On average, the interval between events was >32 days. There were two points below lower warning limit (LWL), between events 11 and 12 and events 14 and 15, which meant that an abnormality had occurred.

Epidemiology and distribution of the 24 BSIs by pathogen type were observed. During the 2nd-3rd trimester of 2021, and the 1st trimester of 2022, a cluster (five cases) of *R. pickettii* during the same period was encountered (Figure 3).

Of these 24 pathogens, the most frequent were *Ralstonia pickettii* and *Staphylococcus aureus*, both occurring 7 times, followed by *Escherichia coli*; observed 3 times. *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, and *Candida albicans* were detected once, and other Gram-positive pathogens accounted for 4 cases. None of the *S. aureus* isolates were methicillin-resistant. The pathogens are listed in Table 3.

Table 2 Clinical outcome of patients with BSI by vascular access type

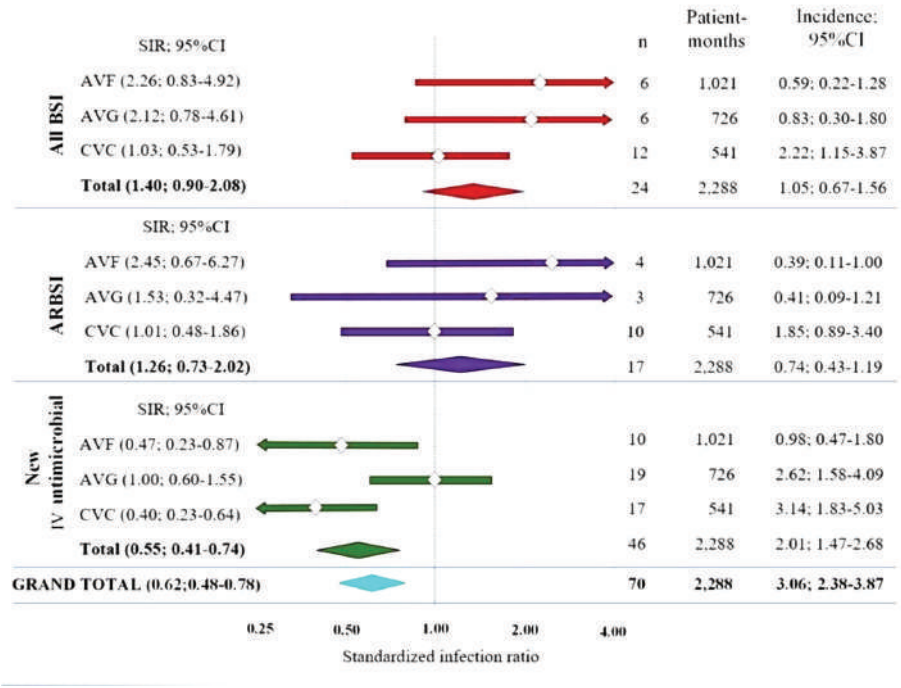
Patients = 19	Hospitalization	Loss of vascular access	Death
All BSI (N=24)			
AVF (n=6)	6	-	-
AVG (n=6)	6	1	1
CVC (n=12)	10	5	2
Total	**22**	**6**	**3**

BSI=bloodstream infections, AVF=arteriovenous fistula, AVG=arteriovenous graft, CVC=central venous catheter

Table 3 Percentage and frequency of pathogen by vascular access type

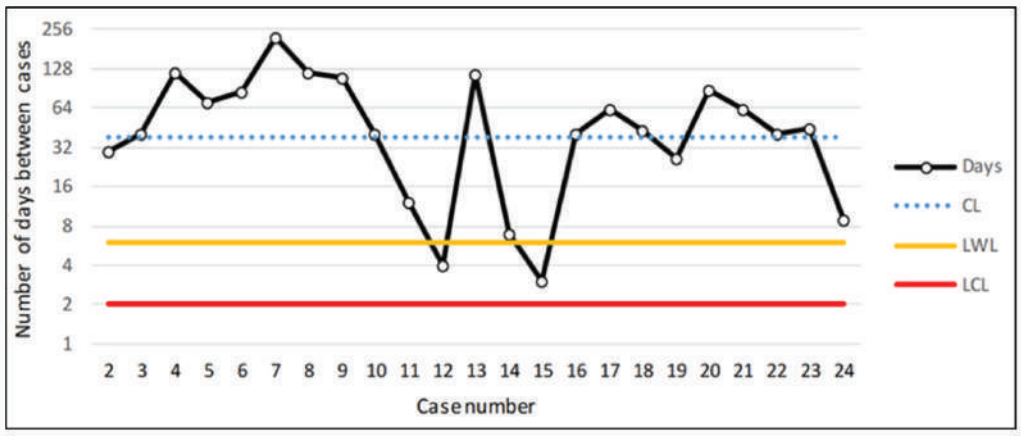
Pathogen	Vascular access type			Total
	AVF	AVG	CVC	
Ralstonia pickettii	3	3	1	7(29%)
Staphylococcus aureus			7	7(29%)
Escherichia coli	1	1	1	3(13%)
Pseudomonas aeruginosa	1			1(4%)
Klebsiella pneumoniae		1		1(4%)
Candida albican		1		1(4%)
Other gram positive	1		3	4(17%)
Total	**6**	**6**	**12**	**24(100%)**

AVF=arteriovenous fistula, AVG=arteriovenous graft, CVC=central venous catheter



SIR=standardized infection ratio, 95% CI=95% confidence interval, N=number, BSI=bloodstream infections, ARBSI=access-related bloodstream infections, New IV=new intravenous antimicrobial start, AVF=arteriovenous fistula, AVG=arteriovenous graft, CVC=central venous catheter

Figure 1 Forest plot of standardized infection ratios of dialysis-related events, stratified by vascular access types. The person-time incidences, with corresponding 95% confidence intervals, are also presented



CL=control limit, LWL=lower warning limit, LCL=lower control limit

Figure 2 g-Chart plot between the cases with bloodstream infections and the interval between cases

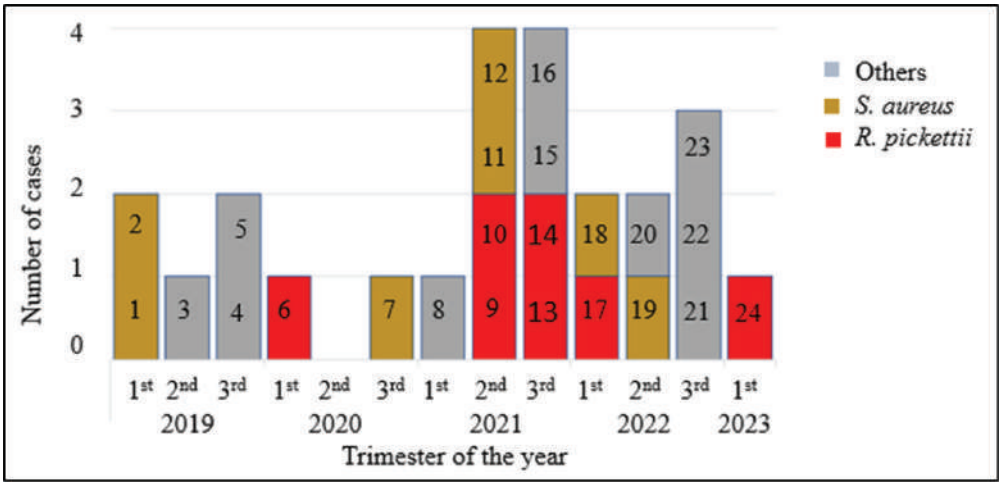


Figure 3 Epidemic curve of bloodstream infections by pathogen and trimester of the year

Discussion

Active surveillance programs to monitor and track vascular access infections among outpatients undergoing hemodialysis are recommended by the NHSN[1] and The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative[2]. Several studies have demonstrated that an infection surveillance program can assist in identifying infection-related dialysis events, and result in timely interventions to monitor and control infections[3,12,13]. In 2019, the Kidney Therapy Center of Songklanagarind Hospital initiated hemodialysis vascular-related infection events. Consequently, the 4-year surveillance data was analyzed to evaluate the quality of infection complication prevention through benchmarking with the NHSN.

A total of 79 infection-related dialysis events were reported in this study, with the overall incidence rate being 3.45 per 100 patient-months; the incidence rate was higher than in other countries; which was 1.4-3.1 per 100 patient-months[13-15]. In addition, the death rate was 9.4% (3/32), also higher than in other countries[13,15]. Previously, no relevant studies have been conducted in Thailand. This study's analysis revealed that AVF was the most prevalent vascular access type, which complied with The Fistula First Breakthrough Initiative goal in 2005 (40%), but not with the goal in 2009 (66%)[16]. The next mission will be to meet the 2009 goal. Although the prevalence of AVF was the highest, the incidence of BSI, ARBSI, and IV antimicrobial start was the lowest. This contrasted with CVC, which had the lowest prevalence but the highest incidence of all events. This was comparable to other studies[13-15] and the NHSN[5].

In this study, the overall SIR of infection-related dialysis events was 0.62 (95% CI=0.48-0.78); however, when separated into BSI and ARBSI, it was found that these were higher than the NHSN[5]. This may reflect the use of infection control measures in our facility. Additionally, this is related to the founding of clusters of *R. pickettii*. On the other hand, when IV antimicrobial start was compared, the SIR was significantly lower than the NHSN[5] (SIR=0.55; 95% CI=0.41-0.74). This indicates the conservation of antimicrobial use within the hospital.

A control chart is a key tool in statistical process control charts. Used for tracking and improving ongoing processes, the g-chart is based on geometry. The distribution is designed to track rare events; such as the

discovery of an outbreak: as in this study. The outbreak was detected by the drop-down in the number of the date intervals between cases with BSI (Figure 2). The pathogen responsible for the outbreak was *R. pickettii* (Figure 3). *R. pickettii*, is a very rare pathogen; however, was frequently found in this study. In the normal dialysis process within our facility, various waters from the systems involved in dialysis are tested every 3 months. During the time that *R. pickettii* was found, it was also found that the water system was contaminated with this *R. pickettii*. After the source of the outbreak was identified and controlled, the outbreak declined. However, other studies have also found that the hemodialysis system was identified as a source of *R. pickettii* infections[17,18].

Moreover, it was found that *S. aureus* was the most common pathogen for CVC infection. This finding is consistent with many other studies[5,14,15], however *S. aureus* in this study was non-resistant to methicillin.

This study has some limitations. First, it was unable to track the outcomes of all patients undergoing hemodialysis. Second, some patients may have received treatment at other hospitals.

Conclusion

Our experience in infection-related dialysis events surveillance showed the ability to detect an outbreak early, and facilitate the implementation of measures to prevent further outbreaks. The surveillance results can also be used to evaluate the implementation of these measures and improve the surveillance system.

Conflict of interest

There are no potential conflicts of interest to declare.

References

1. Centers for Disease Control and Prevention: Dialysis Event Protocol. [homepage on the Internet]. Atlanta: Centers for Disease Control and Prevention; 2023 [cited 2023 Oct 29] Available from http://www.cdc.gov/nhsn/PDFs/pscManual/8pscDialysisEventcurrent.pdf.
2. Ikizler TA, Burrowes JD, Byham-Gray LD, Campbell KL, Carrero JJ, Chan W, et al. KDOQI Clinical practice guideline for nutrition in CKD: 2020 update. Am J Kidney Dis 2020;76:S1-7.
3. Schwanke AA, Danski MTR, Pontes L, Kusma SZ, Lind J. Central venous catheter for hemodialysis: incidence of infection and risk factors. Rev Bras Enferm 2018;71:1115-21.
4. Breslow NE, Day NE. Rate and Rate Standardization. In: Heseltine E. editor. STATISTICAL METHODS IN CANCER RESEARCH. New York: Oxford University Press; 1987; p.48-79.
5. Nguyen DB, Shugart A, Lines C, Shah AB, Edwards J, Pollock D, et al. National Healthcare Safety Network (NHSN) dialysis event surveillance report for 2014. Clin J Am Soc Nephrol 2017;12:1139-46.
6. The NHSN Standardized Infection Ratio (SIR). Centers for Disease Control and Prevention. [homepage on the Internet] Atlanta: The NHSN; 2022 [cited 2023 Nov 2] Available from https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/nhsn-sir-guide.pdf.
7. Zhang M, Peng Y, Schuh N, Megahed FM, Woodall WH. Geometric charts with estimated control limits. Qual Reliab Eng Int 2013;29:209-23.
8. Morton AP, Whitby M, McLaws ML, Dobson A, McElwain ML, Looke D, et al. The application of statistical process control charts to the detection and monitoring of hospital-acquired infections. J Qual Clin Pract 2001;21:112-7.
9. Benneyan JC. Number-between g-type statistical quality control charts for monitoring adverse events. Health Care Manag Sci 2001;4: 305-18.
10. Benneyan JC. Performance of number-between g-type statistical control charts for monitoring adverse events. Health Care Manag Sci 2001;4:319-36.
11. Outbreak Toolkit [homepage on the Internet]. Canada: Outbreak Toolkit- Enteric Outbreak Investigations, [cited 2023 Nov 4]. Available from: https://outbreaktools.ca/background/epidemic-curves/
12. Gork I, Gross I, Cohen MJ, Schwartz C, Moses AE, Elhalel MD, et al. Access-related infections in two haemodialysis units: results of a nine-year intervention and surveillance program. Antimicrob Resist Infect Control 2019;8:105.

13. Zhang H, Li L, Jia H, Liu Y, Wen J, Wu A, et al. Surveillance of dialysis events: one-year experience at 33 outpatient hemodialysis centers in China. Sci Rep 2017;7:1-7.
14. Abdelfattah RR, Jumaah S, Korbi L, Qahtani T. Three years' experience of dialysis event surveillance. Am J Infect Control 2019;47:793-7.
15. Hasanoglu I, Guner R, Sahin S, Karadag FY, Parmaksiz E, Atalay HV, et al. Surveillance of hemodialysis related infections: a prospective multicenter study. Sci Rep 2022;12:222-40.
16. Lee T. Fistula First Initiative: Historical impact on vascular access practice patterns and influence on future vascular access care. Cardiovasc Eng Technol 2017;8:244-54.
17. Tejera D, Limongi G, Bertullo M, Cancela M. *Ralstonia pickettii* bacteremia in hemodialysis patients: a report of two cases. Rev Bras Ter Intensiva 2016;28:195-8.
18. Strateva T, Kostyanev T, Setchanova L. *Ralstonia pickettii* sepsis in a hemodialysis patient from Bulgaria. Braz J Infect Dis 2012;16:400-1.