Evaluation of Driveline Infections in Diabetic Patients with Left Ventricular Assist Devices

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ABSTRACT

Objectives: Left ventricular assist devices (LVADs) are critical in advanced heart failure management, yet driveline infections remain a significant complication. This study aimed to evaluate the microbiological profile and clinical outcomes of driveline infections in diabetic and nondiabetic LVAD patients.

Methods: We conducted a retrospective analysis of 40 LVAD patients with driveline infections between January 2020 and December 2024. Microorganisms were categorized as gram-positive, gram-negative, or fungal agents, and their prevalence was compared between diabetic and nondiabetic groups. Clinical outcomes, including recurrence, bacteremia, and mortality, were analyzed.

Results: Gram-positive bacteria were the most commonly isolated microorganisms in both diabetic (53.2%) and nondiabetic (63.6%) groups, with no statistically significant difference (p=0.285). Staphylococcus aureus was more frequently isolated in nondiabetic patients (25% vs. 12.9%, p=0.110). Gram-negative bacteria and fungal agents were identified in 35.8% and 6.6% of cases, respectively, with similar distributions across groups. Mortality was primarily influenced by age (AOR: 0.879, 95% CI: 0.789-0.979, p=0.019), while other demographic and clinical factors showed no significant associations.

Conclusion: The microbiological profile of driveline infections in diabetic and nondiabetic LVAD patients is comparable, with minor differences in pathogen prevalence. Age was a significant independent risk factor for mortality, whereas diabetes did not contribute to differences in clinical outcomes. Larger, prospective studies are needed to validate these findings and optimize infection management strategies.

Keywords: Diabetes mellitus, driveline infections, heart failure, left ventricular assist device

Introduction

Heart failure is an increasingly prevalent health problem affecting approximately 26 million people worldwide.[1] Left ventricular assist devices (LVADs) have become an indispensable treatment option used to prolong life and improve quality of life in patients with advanced heart failure.[2,3] It can be used as bridge-to-transplantation or destination therapy in patients who cannot undergo heart transplantation.[4] However, complications after LVAD implantation constitute an important part of the treatment process. Among these complications, especially driveline infections pose a significant threat in terms of both morbidity and mortality in patients with LVADs.[5]

Driveline infections are infections that usually start at the site of device exit from the body and can lead to serious systemic infections such as bacteraemia and sepsis. Prevention and management of these infections is critical to improve survival in LVAD users.[6] However, the variety of infectious agents and the clinical course of these infections may vary depending on individual patient characteristics

and the device model used. Gram-positive microorganisms, especially Staphylococcus species, are among the most common infectious agents, but Gram-negative bacteria and fungal agents can also increase the severity of infection.[7]

On the other hand, diabetes mellitus (DM) is an important metabolic disorder that predisposes to infections due to its effects on the immune system. Complications of diabetes, such as hyperglycaemia, neuropathy and vascular damage, can lead to more frequent and more severe infections. [8] Although it is known that diabetes increases the risk of driveline infection, there are limited data in the literature in terms of the distribution and severity of infectious agents between diabetic and nondiabetic patients.[9] In this context, understanding the distribution of gram-positive, gram-negative and fungal infectious agents in different patient groups is important for the development of strategies for infection management.

In this study, we retrospectively analysed the clinical and demographic characteristics of patients with LVAD driveline infections, as well as the infectious agents seen in diabetic and nondiabetic patients. The aim is to evaluate the potential effects of diabetes on infectious agents and to shed light on the relationship between infection control and survival in these patients. It is thought that the results of the study will contribute to clinical practice, especially in infection management and prevention of complications.

Methods

Our study was conducted retrospectively between January 2020 and December 2024 in Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, in the Cardiovascular Surgery clinic, with patients who were hospitalised with a diagnosis of LVAD driveline infection or who were found to have driveline infection during hospitalisation. Demographic information such as age, height and weight of the patients were noted, body mass index (BMI) values were calculated for each patient, and those with a BMI of 30 kg/m^2 and above were included in the obesity group. The presence of diabetes mellitus (DM) as a comorbid disease was noted. During the evaluation of culture results, patients were divided into "diabetic" and "non-diabetic" groups and differences were evaluated. The etiology of heart failure was defined as "ischaemic" in patients with ischaemic coronary artery disease, and the remaining patients were included in the "non-ischaemic" group.

Heart Mate 2 or Heart Mate 3 model LVAD devices were used in the operation and appropriate postoperative wound care was performed in each patient. The diagnosis of driveline infection was made according to the criteria of the International Heart and Lung Transplant Consensus by evaluating purulent discharge, pain, tenderness, fever, laboratory data and culture results.[10] All patients were treated with appropriate wound care and intravenous antibiotherapy from the time of diagnosis. All microorganisms detected in consecutive cultures taken in the same hospitalisation and/or in blood or discharge cultures during repeated hospitalisations and the presence of bacteraemia were noted, and in addition to fungi, bacteria were classified according to gram staining. The number of re-hospitalisations of patients with recurrent infections was noted and mortality data of all patients were recorded.

This study was approved by the Education Planning and Coordination Committee of our hospital (EPKK number: E-28001928-604.01.01) and carried out according to the Declaration of Helsinki.

Statistical Methods

Statistical analysis was performed with SPSS v29.0 (SPSS Inc, Chicago, IL, USA). In descriptive statistics, continuous parametric variables were expressed as mean±standard deviation and nonparametric variables as median (min-max). Chi-square test and Fisher's exact test were used to analyse categorical variables among themselves. The Mann Whitney-u test was used for non-normally distributed variables, while the independent sample t test was used for normally distributed continuous variables. Hosmer-Lemeshow fit statistic was used to evaluate model fit in logistic regression analysis. Multivariate logistic regression analyses were expressed as odds ratio (OR) with 95% confidence interval (95% CI). A p value below 0.05 was accepted as a statistically significant difference.

Results

A total of 40 patients with LVAD driveline infection were analysed in our study.

The mean age of the patients was 55.3±8.06 years and 82.5% of the patients were male. The mean body mass index (BMI) was calculated as 28.9±4.7. Among the etiological causes, ischaemic causes were found in 52.5% and non-ischaemic causes in 47.5%. The device models used were equally distributed between HeartMate 2 and HeartMate 3.

Diabetes mellitus (DM) was found in 50%, obesity in 40%, and recurrent infection in 65% of the patients. The mean number of recurrences was 3.74 and the bacteraemia rate was 45%. The mortality rate was calculated as 60% during the study period and the mean interval between operation and mortality was 1357.9±772.8 days (Table 1).

In total, 106 microbiological culture results of 40 patients were evaluated; 58% (n=62) of these samples were from diabetic patients and 41.5% (n=44) from non-diabetic

Table 1. Demographic and clinical characteristics of patients with LVAD driveline infection

	n=40	%
Age, mean±SD	55.3±8.06	
Male gender	33	82.5
Boy, mean±SD	169.7±8.04	
Weight, mean±SD	83.2±14.2	
BMI, mean±SD	28.9±4.7	
Etiology		
Ischaemic	21	52.5
Non-ischaemic	19	47.5
Device model		
Heartmate 2	20	50
Heartmate 3	20	50
DM	20	50
Obesity	16	40
Recurrent infection	26	65
Mean number of recurrences, (min–max)	3.74 (1–21)	
Bacteraemia	18	45
Transplantation	2	5
Mortality	24	60
Time between operation and mortality	1357.9±772.8	

LVAD: Left ventricular assist devices; SD: Standard deviation; BMI: body mass index; DM: Diabetes Mellitus.

patients. No significant difference was found between the two groups in terms of microbial growth rates (Table 2).

Gram positive bacteria were the most common microorganism group in both groups with 53.2% (n=33) in the diabetic group and 63.6% (n=28) in the non-diabetic group (p=0.285). Staphylococcus species, especially non-aureus species, were frequently isolated in both groups and the difference between the groups was not significant (diabetic 24.2%, non-diabetic 29.5%; p=0.538). S. aureus was isolated 12.9% in the diabetic group and 25.0% in the non-diabetic group, but the difference was not statistically significant (p=0.110). Methicillin-resistant S. aureus (MRSA) was rare in both groups and was isolated in only three cases (2.8%) (p=1.000).

Gram negative bacteria were observed in 38.7% (n=24) of diabetic patients and 31.8% (n=14) of non-diabetic patients (p=0.466). Pseudomonas, Klebsiella and Achromobacter species were among the most frequently isolated gram negative bacteria. However, no statistically significant difference was found between the groups in terms of the distribution of these species (p>0.05 for all).

The rate of fungal growth was 8.1% in diabetics and 4.5% in non-diabetics. All fungal microorganisms isolated were Candida species and there was no significant difference between the groups (p=0.697). In conclusion, no significant difference was found between diabetic and non-diabetic groups in terms of microbial growth and isolated

microorganism species. In addition, no statistical significance was observed in recurrence rates, bacteraemia or mortality rates between diabetic and non-diabetic groups.

The factors associated with mortality were first analysed by univariate logistic regression analysis, and then mortality risk ratios were determined by multivariate logistic regression analysis (Table 3). Gender, DM, obesity, device model and etiology of heart failure had no significant effect on mortality (p>0.05). However, age was found to be an independent risk factor for mortality (AOR: 0.879, 95% CI: 0.789–0.979, p=0.019). The mean age of the mortality group was younger than the non-mortality group (53.0±7.07; 58.8±8.40, respectively). The association of the presence of recurrent infection with mortality was marginally significant (AOR: 0.199, 95% CI: 0.033–1.201, p=0.078). Gram positive and negative microorganisms or fungal infections had no significant effect on mortality (p>0.05). The regression model showed an overall good fit (χ^2=9.21, df=8, p=0.324).

Discussion

In this study, the microbiological profile of driveline infections in diabetic and non-diabetic patients using LVADs was examined, and their effects on mortality were evaluated together with other clinical features. When the general demographic characteristics of the patients were analysed, it was observed that they were predominantly male, middle-aged, and half of them were diabetic. Recurrence in driveline infections is a problem for many centres. In our study, a 65% recurrent infection rate was observed, and rates up to 71.4% were reported in the study of Tin et al.[11] Although our results are largely compatible with the findings in the literature, there are some important differences, especially in terms of the distribution of microorganism species.

Gram positive microorganisms were found to be the most common infectious agent in both patient groups in our study. Gram positive growth was observed in 53.2% of diabetic patients and 63.6% of non-diabetic patients. In the literature, there are also large-scale studies in which gram-positive pathogens predominate in LVAD infections.[5,12,13] For example, a study by Nienaber et al.[5] reported that more than 60% of LVAD infections were caused by Staphylococcus species. However, in our study, all Staphylococcus species accounted for 47.1% of the total isolates. The fact that S. aureus was isolated more frequently in non-diabetic patients suggests that the immune response may be activated differently in this group. However, this difference did not reach statistical significance (p=0.110). Although Corynebacterium, one of the other important gram-positive agents, is not emphasised as a causative agent in other studies, it was isolated with a rate of 8.5% in our study, and an isolation rate of up to 19% was reported in a cohort in Singapore.[14]

Table 2. Grouping of microorganisms grown in cultures in driveline infections and differences between diabetic and non-diabetic groups

Microorganism	Diabetic patient cultures n=62 (58%)		Non-diabetic patient cultures n=44 (41.5%)		Total n=106 (100%)		p
	n	%	n	%	n	%	
Gram +	33	53.2	28	63.6	61	57.5	0.285
Enterococcus	2	3.2	0	0	2	1.9	0.510
Staphylococcus							
Non-aereus	15	24.2	13	29.5	28	26.4	0.538
S. aereus	8	12.9	11	25.0	19	17.9	0.110
MRSA	2	3.2	1	2.3	3	2.8	1.000
Corynebacterium	6	9.7	3	6.8	9	8.5	0.732
Gram -	24	38.7	14	31.8	38	35.8	0.466
Pseudomonas	6	9.7	4	9.1	10	9.4	1.000
Klebsiella	5	8.1	2	4.5	7	6.6	0.697
Achromobacter	2	3.2	3	6.8	5	4.7	0.647
Stenotrophomonas	3	4.8	1	2.3	4	3.8	0.640
Acinetobacter	3	4.8	0	0	3	2.8	0.265
Other	5	8.1	4	9.1	9	8.5	1.000
Fungal	5	8.1	2	4.5	7	6.6	0.697
Candida	5	8.1	2	4.5	7	6.6	0.697
	Diabetic patients n=20 (%)		Non-diabetic patients n=20 (%)				
Recurrent infection	13	65	13	65	26	65	1.000
Bacteraemia	11	55	7	35	18	45	0.204
Mortality	12	60	12	60	24	60	1.000

MRSA: Methicillin-resistant Staphylococcus aureus.

Table 3. The effect of epidemiological and clinical characteristics on mortality

	Risk ratios			
	CR (95% CI)	p	AOR* (95% CI)	p
Gender	0.200 (0.022–1.851)	0.156		
Age	0.901 (0.819–0.991)	**0.032**	0.879 (0.789–979)	**0.019**
DM	1.000 (0.282–3.544)	0.295	–	
Obesity	0.500 (0.137–1.828)	0.295	–	
Etiology				
Ischaemic	1.000		–	
Non-ischemic	0.346 (0.238–3.004)	0.796	–	
Device model				
HeartMate 2	1.000		–	
HeartMate 3	0.429 (0.117–1.568)	0.201	–	
Reproduction				
Gram+	1.000		–	
Gram–	2.667 (0.237–30.066)	0.427	–	
Gram + and –	0.667 (0.153–2.903)	0.589	–	
Fungal	1.333 (0.183–9.725)	0.777	–	
Recurrent infection	0.467 (0.116–1.878)	0.283	0.199 (0.033–1.201)	0.078
Bacteraemia	2.600 (0.689–9.806)	0.158	3.884 (0.773–19.513)	0.100

*² χ=9.21; df = 8; p<0.324; log likelihood = 42.933; Cox and Snell = 0.239; R2 Nagelkerke=0.323. CR: Crude ratio; CI: Confidence interval; AOR: Adjusted odds ratio; DM: Diabetes mellitus.

Gram-negative microorganisms were found at a rate of 38.7% in the diabetic group and 31.8% in the non-diabetic group, totalling 35.8% in our study. These results partially differ from the studies in the literature, which reported that gram-negative bacteria were isolated at lower rates. Nienaber et al.[5] reported gram-negative microorganisms with a rate of 27.5%, while Kamat et al.[13] reported a rate of 41.5%. Pseudomonas was the leading gram-negative agent with 9.4%. Although gram-negative bacteria generally cause more invasive infections, the effect of these microorganisms on mortality was not found to be significant in our study (p>0.05).

Fungal infections, especially Candida species, have been identified as an important risk factor for mortality, although they are less common in LVAD infections.[15] The frequency of fungal infection up to 35% was mentioned in the study by Gordon et al.[16] In our study, Candida species were isolated at similar rates in both groups (8.1% vs. 4.5%) and no significant difference was found between the groups (p=0.697). It was detected in 6.6% of all cultures, and the low frequency of fungal infections may have limited the statistical power.

The fact that no difference was observed in the distribution of microorganisms, recurrence rates, septicaemia and mortality between the diabetic and non-diabetic groups, which was the main objective of the study, may be related to the limitation of the sample size of the study, but it is also thought that it may be a guide for not choosing different preferences in the choice of prophylactic antibiotherapy in the presence of diabetes. However, this hypothesis should be confirmed with prospective studies with a higher number of patients.

In terms of mortality analysis, our results are consistent with the risk factors reported in the literature. Especially younger age was found to be an independent risk factor for mortality (AOR: 0.879, 95% CI: 0.789–0.979, p=0.019). Younger age was also found to be a risk factor in the studies by Pavlovic et al.[17] and O'Horo et al.[18]. However, high BMI or obesity, which were identified as risk factors in these studies, were not statistically significant in our study. Pienta et al.,[19] on the other hand, did not find a significant increase in risk for variables such as diabetes and BMI, as in our study, but they stated malnutrition and hypoalbuminemia as a risk factor. Due to the retrospective design of our study, these data could not be included in the results.

In conclusion, although LVAD devices have revolutionised the treatment of severe heart failure, the most common driveline infections remain a serious complication with high recurrence rates. Still, issues such as empirical or targeted antibiotherapy, exit site topical treatments or device replacement/transplantation decision still leave clinicians in a difficult situation.[20]

Our study shows that infection profiles are similar in diabetic and non-diabetic patients, but some differences in the prevalence of certain microorganism species may exist between the groups. Compared with existing studies in the literature, our findings provide an important contribution to better understand the pathophysiology of LVAD infections and to improve strategies for the management of these infections. However, these findings need to be confirmed with larger patient groups and prospectively designed studies.

Conclusion

This study compared the microbiological profiles of driveline infections and their effects on mortality in diabetic and non-diabetic patients using LVADs. Gram-positive bacteria were the most frequently isolated infectious agents in both groups. There was no significant difference in the distribution of infectious agents, recurrence rates and mortality between diabetic and non-diabetic patients. However, age was found to be an independent risk factor for mortality.

The study findings suggest that there is no need for different strategies for diabetic and non-diabetic patients in the management and prophylaxis of infections. However, prospective studies with larger sample groups are necessary to confirm these results.

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