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Evaluation of retinal vessel caliber, choroidal thickness, and ocular perfusion pressure in patients with low cardiac ejection fraction

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ABSTRACT

Objectives: This study aims to investigate the retinal vessel caliber, choroidal thickness, and ocular perfusion pressure in patients with low cardiac output.

Patients and methods: Between June 2014 and June 2015, a total of 44 patients (34 males, 10 females; mean age 59.3±12.4 years) with low ejection fraction due to dilated cardiomyopathy and 44 healthy, age- and sex-matched individuals (34 males, 10 females; mean age 59.3±8.5 years) were included in this cross-sectional comparative study. All patients in the study group had an ejection fraction less than 40%. Retinal vascular caliber measurements were made using retinal photographs with fluorescein angiography, whereas subfoveal choroidal thickness and foveal thickness were measured using the spectral-domain optical coherence tomography. The ocular perfusion pressure was calculated according to a formula consisting of mean arterial blood pressure and intraocular pressure.

Results: There was no statistically significant difference between patients with low cardiac ejection fraction and healthy controls regarding the retinal vascular caliber, subfoveal choroidal thickness, foveal thickness, or ocular perfusion pressure (p>0.05). The mean intraocular pressure was 13.1±2.8 mmHg in the study group and 13.4±2.7 mmHg in the control group (p=0.59). Ejection fraction was not significantly associated with the retinal vascular caliber, subfoveal choroidal thickness, or ocular perfusion pressure (p>0.05).

Conclusion: Our findings suggest that reduced cardiac output does not significantly affect the retinal vessel caliber, choroidal thickness, or ocular perfusion pressure in clinical practice.

Keywords: Cardiac output, choroidal thickness, foveal thickness, heart failure, ocular perfusion pressure, retinal vessel caliber.

Being associated with progressive hemodynamic deterioration and thromboembolic risk,[1] chronic systolic heart failure is often caused by non-ischemic cardiomyopathy (non-ICMP).[2,3] Among researches addressing how heart failure affects the eyes,[4,5] one reported increased bulbar conjunctival vascular density in mild heart failure, whereas severe heart failure was shown to be characterized by decreased microvascular density.[4] Another study reported that chronic heart failure was associated with decreased choroidal thickness.[5]

In severe non-ICMP, the heart cannot pump blood well enough to meet the needs of tissue. Following heart failure, tissue hypoxia and peripheral edema, thus, usually develop,[1] along with peripheral vascular alterations such as arterial constriction and venous dilation.[1,4] By contrast, retinal-choroidal vessels may not be affected to as great an extent due to strong ocular hemodynamic and vascular protective mechanisms.

In the present study, we aimed to evaluate alterations in retinal-choroidal vascular and foveal thickness in patients with low cardiac ejection fraction (EF). Although ocular blood flow is primarily determined by perfusion pressure and vascular resistance, reduced

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cardiac output can also affect the ocular vascular structures.[4,5] We, therefore, hypothesized that several compensatory alterations may occur in the retinal vessels and choroidal thickness of patients with low cardiac EF due to chronic systolic heart failure.

PATIENTS AND METHODS

This cross-sectional and comparative study was conducted at Medicine Faculty of Pamukkale University, between June 2014 and June 2015. A total of 44 patients (34 males, 10 females; mean age 59.3±12.4 years) with low EF due to dilated cardiomyopathy and 44 healthy, age- and sex-matched individuals (34 males, 10 females; mean age 59.3±8.5 years) were included in the study. All participants were first evaluated by the cardiology and cardiovascular surgery department and later referred to our eye clinic.

A written informed consent was obtained from each patient. The study protocol was approved by the Medicine Faculty of Pamukkale University Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Study population

All patients in the study group were previously diagnosed with dilated cardiomyopathy with an EF ≤40%. Non-ICMP diagnosis was primarily based on echocardiography. No participant exhibited any ocular pathology other than low-grade age-related cataract or was taking ocular medication at the time of the study. Participants with any history of ocular surgery or heart transplantation, with ametropia of greater than two diopters spherical equivalent, or systemic disease such as diabetes mellitus and arterial hypertension which could affect the retinal-choroidal structures were excluded. Some of the patients in the study group were taking angiotensin-converting enzyme inhibitors or acetylsalicylic acid at the time of the study.

Ocular examinations

One eye of each participant, chosen at random, was included. All participants received an ophthalmic examination involving the visual acuity assessment, biomicroscopic assessment, air-puff tonometry assessment, retinal examination, ocular perfusion pressure (OPP) calculation, and measurement with spectral-domain optical coherence tomography (SD-OCT, Spectralis, Heidelberg, Germany). The SD-OCT was used to measure the subfoveal choroidal thickness (SFCT) and macular thickness, while the SFCT was measured from the outer part of the hyper-reflective line corresponding to the retinal pigment epithelium to the inner surface of the sclera (Figure 1). The chorio-scleral interface was clearly visualized in all SD-OCT measurements. For macular analysis, only the thinnest foveal thickness was assessed.

Retinal vascular caliber measurements were made using colored retinal photographs with fluorescein angiography (VISUCAM 500, Carl Zeiss Meditec, Jena, Germany). The three largest retinal arterioles and venules passing through an area ranging from one-half to one-disc diameter from the optic disc margin were measured for retinal vascular caliber analysis using manual caliber tools provided by the

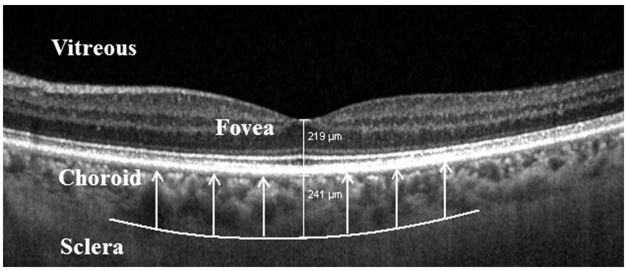

Figure 1. Macular enhanced depth optical coherence tomography screen of a patient in whom subfoveal choroidal thickness and foveal thickness measurements were performed.

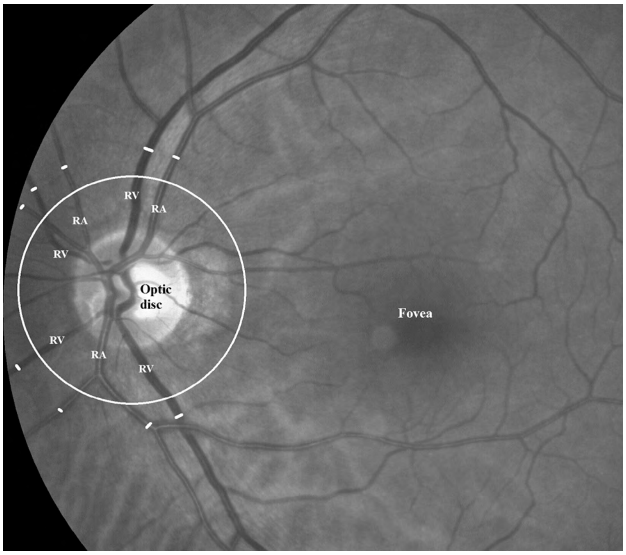

Figure 2. Retinal vessel caliber analysis method.

RA: Retinal arteriole; RV: Retinal venule.

Table 1
Baseline clinical characteristics of participants

	Low EF group	Control group	
	Mean±SD	Mean±SD	*p*
Visual acuity (logMAR)	0.03±0.06	0.03±0.07	0.68
Intraocular pressure (mmHg)	13.1±2.8	13.4±2.7	0.59
Foveal thickness (µm)	222.8±22.3	220.5±15.1	0.57

EF: Ejection fraction.

Table 2
Mean retinal vascular caliber and choroidal thickness measurements of participants

	Low EF group	Control group	
	Mean±SD	Mean±SD	*p*
Retinal arteriole caliber (µm)	93.0±8.7	93.7±6.8	0.69
Retinal venule caliber (µm)	139.0±15.7	134.4±14.6	0.16
Subfoveal choroidal thickness (µm)	270.6±112.4	280.4±83.6	0.65

EF: Ejection fraction.

fluorescein angiographic device software (Figure 2). The mean caliber values of the retinal vessels were calculated for each participant and recorded for analysis. The intraocular pressure (IOP) was measured with an air-puff tonometer (TonoRef II, Nidek Co. Ltd, Aichi, Japan) and the average of three measurements were recorded. Ocular examinations were performed in the afternoon to eliminate diurnal variation of the measurements. The mean arterial blood pressure was calculated as (2/3 × diastolic blood pressure) + (1/3 × systolic blood pressure), whereas the OPP was calculated as (2/3 × mean arterial blood pressure)-IOP.[6]

All blood pressure measurements were made by a trained nurse using a mercury sphygmomanometer and by monitoring the Korotkoff sounds, preferably on the upper arm. Before being measured for blood pressure, each participant remained seated for at least five minute and was freed of any restrictive clothing on the arms.

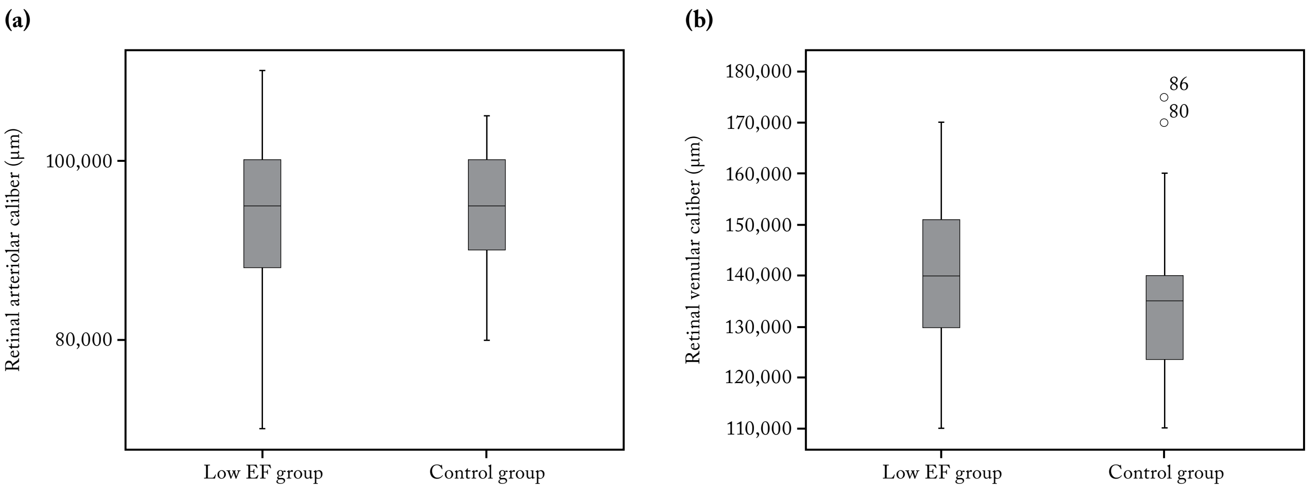

Figure 3. **(a)** The box plot graphics for retinal arteriolar caliber and **(b)** retinal venular caliber in low ejection fraction and control groups are shown.
EF: Ejection fraction.

Statistical analysis

A sample size of 44 for each group was estimated at the beginning of the study by taking the standard effect size 0.60, beta 0.20, and alpha 0.05. Statistical analysis was performed using the PASW version 17.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean±standard deviation (SD). An independent samples t-test was used to compare retinal vascular caliber, SFCT, foveal thickness, and IOP measurements between the study and control groups. The Pearson correlation analysis was used to examine the relationship among retinal vascular caliber, SFCT, OPP, and EF. A *p* value of <0.05 was considered statistically significant.

RESULTS

There were no statistically significant differences between the study and control groups in terms of the baseline characteristics and visual acuity, IOP, or foveal thickness. Table 1 shows clinical characteristics of the study and control groups.

Table 2 shows the retinal arteriole caliber (RAC), retinal venule caliber (RVC), and SFCT measurements of all participants. Although the mean RAC and SFCT values were lower and the RVC values were higher in the study group, there was no statistically significant difference compared to the control group. Figure 3 shows the box plots for RAC (Figure 3a) and RVC (Figure 3b) values in both groups.

Figure 4 is a scatter plot showing the correlation of EF and retinal-choroidal thickness parameters. As Figure 4a shows, as adjusted for age, there was no significant correlation between EF and RAC (r= -0.05, p=0.74). As shown in Figure 4b, there was no significant correlation between the EF and RVC (r=0.11, p=0.47). As adjusted for age, EF and SFCT were not correlated (r=0.07, p=0.66) (Figure 4c).

In the study group, the mean systolic blood pressure was 118.6±19.9 mmHg, the mean diastolic blood pressure was 74.3±13.8 mmHg, and the mean OPP was 46.2±10.7 mmHg. There was no statistically significant correlations with OPP and EF (r=0.24, p=0.11), RAC (r= -0.12, p=0.45), RVC (r= -0.05, p=0.74), and SFCT (r= -0.06, p=0.72). Since the RAC, RVC, and SFCT examinations were performed by a single investigator, intra-observer correlation was assessed and the values of RAC (r=0.98, p<0.001), RVC (r=0.98, p<0.001), and SFCT (r=0.99, p<0.001) were found to be high.

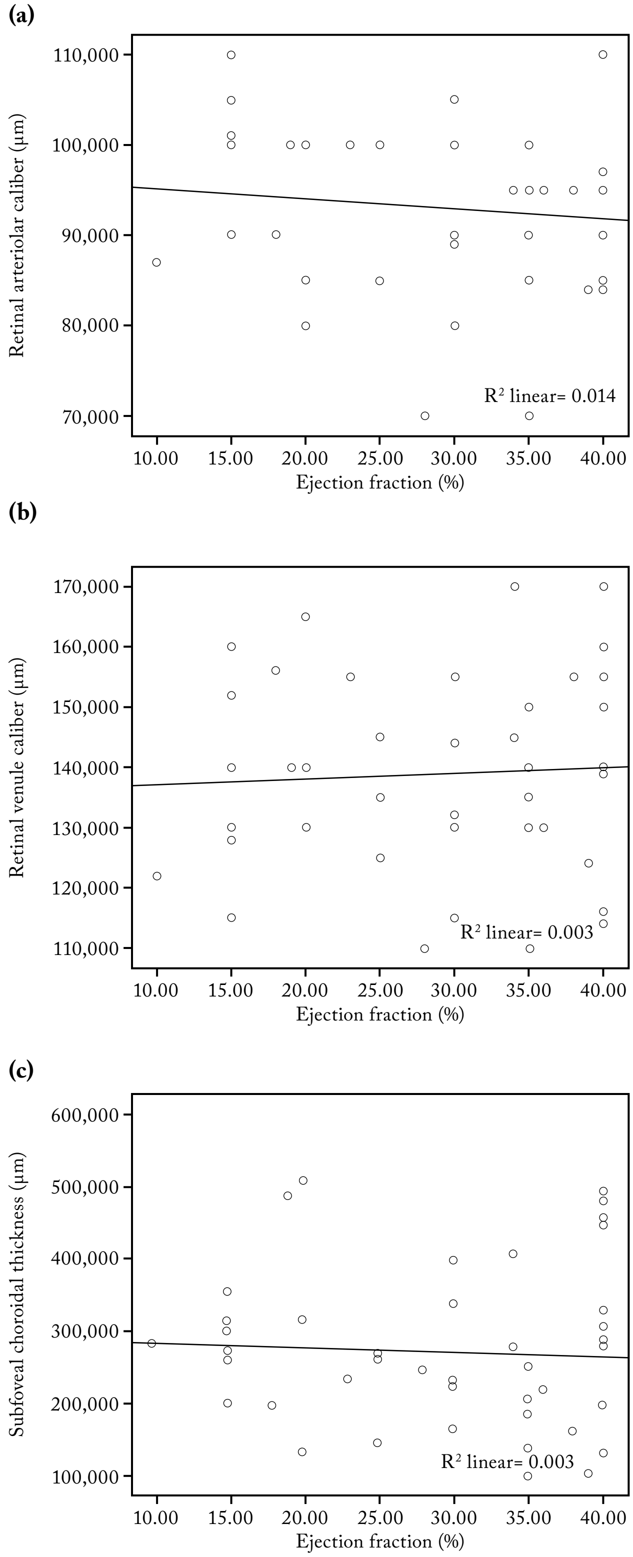

Figure 4. The scatter plot graphics showing **(a)** correlations of ejection fraction (cardiac output) with retinal arteriole caliber, **(b)** retinal venule caliber and **(c)** subfoveal choroidal thickness.

DISCUSSION

In this study, we investigated the retinal vessel caliber, choroidal thickness, and OPP in patients with low cardiac output. Our results showed that choroidal thickness, retinal vascular caliber, and foveal thickness were similar among patients with chronic systolic heart failure and healthy individuals. Additionally, no significant correlation was observed between EF and retinal-choroidal vessel thickness, and OPP did not significantly affect the RAC, RVC, or SFCT.

Retinal vessel diameter provides information about the microcirculation and can reflect the vascular effects of some systemic diseases.[7-10] A narrower RAC is associated with systemic arterial hypertension and coronary heart disease, whereas a wider one is associated with diabetes mellitus, lipid abnormalities, and smoking.[7-10] In our study, we found that low cardiac output was associated with neither RVC nor RAC alterations. These outcomes may suggest that the inner retina receives enough blood flow to function properly even with low cardiac output.

Choroidal thickness measurements have become popular, since the development of enhanced depth OCT, and among the various results reported in researches, systemic diseases have been shown to influence choroidal thickness.[11-14] The choroidal thickness increases with diabetes mellitus, hypercholesterolemia, and acromegaly, yet decreases with systemic sclerosis.[11-14] In our study, however, low EF did not significantly affect the choroidal thickness. In another study, Altinkaynak et al.[5] found that SFCT was lower in patients with chronic heart failure, resulting possibly from different patient characteristics or systemic medications used. The aforementioned study included patients who had EF lower than 55%, whereas our study included those with EF lower than 40%.

Several systemic diseases such as diabetes mellitus and arterial hypertension are known to be associated with a thicker macula.[15,16] We found that chronic heart failure did not cause any significant increase or decrease in the macular thickness, and the similarity of visual acuity values in the study and control groups might confirm those outcomes regarding the macular thickness. The IOP values were also found to be similar in both groups. In contrast to our results, Meira-Freitas et al.[17] reported that chronic heart failure was associated with lower IOP, whereas similar to our results, Altinkaynak et al.[5] found no significant difference in the IOP measurements between the heart failure patients and healthy controls.

Furthermore, several peripheral vascular compensatory mechanisms may contribute to low cardiac EF due to chronic heart failure.[18] Choi et al.[19] reported that cerebral blood flow decreased with chronic heart failure and their results might be generalized for ocular blood flow, as well. However, the authors found that cerebral blood flow was not associated with EF.[19] Although alterations in the RAC, RVC, and SFCT concurred with the peripheral vascular effects of chronic heart failure, the differences were not statistically significant in our study. According to our results, gross pathological ocular vascular alterations in chronic heart failure are unlikely, since patients with such conditions usually do not have visual or ocular problems, as assessed by routine ophthalmological examinations.

Regarding the clinical relevance, our study showed that potential ocular alterations related to low amounts of ocular blood flow in chronic heart failure did not include choroidal thickness or retinal vessel caliber. By contrast, ocular ischemia occurred when a stenosis of 90% of the common or internal carotid arteries was present and retinal-choroidal vascular thickness decreased as a result of low ocular blood flow.[20,21] The choroid nourishes the outer retinal layers, and retinal vessels supply blood to the inner retinal layers. The proper functioning of both structures is essential for normal vision, and their anatomy does not change with low cardiac output.

Nonetheless, there are some limitations to this study. First, having fundus fluorescein and indocyanine green angiographies to show additional chorioretinal vascular parameters such as hypoperfusion would have been helpful. Second, the sample size could have been larger, despite the difficulty of identifying low cardiac output patients without any associated systemic diseases. Third, we included patients with heart failure due to low EF in this study. However, EF patients with normal/preserved heart failure are also present. Hence, if an EF with normal/preserved heart failure patient group was available, it might have resulted in a more accurate comparison. Fourth, the EF of the patient group in the study ranged from 30 to 40%. If patients with lower EFs (such as 20 to 30% versus 10 to 20%) were included, interesting results could have been obtained. Finally, the patients included in the study were those with non-ICPM. If ICMP patients were included, more robust results might have been attained.

In conclusion, low ejection fraction due to chronic systolic heart failure does not significantly alter the retinal vessel or choroidal thickness measurements. Additionally, this condition exerts no significant effect on intraocular pressure, ocular perfusion pressure, or foveal thickness. We, thus, suggest that there is no need to measure cardiac ejection fraction for the evaluation of subfoveal choroidal thickness and retinal vessel caliber. Nevertheless, future studies investigating the effects of coexistent systemic disorders in addition to heart failure would likely clarify the hemodynamic autoregulation of the posterior pole.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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Cardiovascular Surgery and Interventions

Original Article Open Access

Comparison of radiofrequency and cryoablation procedures for mitral valve surgery patients with atrial fibrillation

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ABSTRACT

Objectives: This study aims to compare the success of two different energy sources, radiofrequency *versus* cryoablation, in patients with atrial fibrillation.

Patients and methods: Between August 2012 and August 2017, a total of 55 patients (27 males, 28 females; mean age 51.6±11.2 years; range, 44 to 71 years) with atrial fibrillation who underwent isolated left atrial ablation during mitral valve surgery in our clinic were included. Radiofrequency was applied to 41 patients and cryoablation to 14 patients. In both procedure, ablation was performed to isolate all pulmonary veins. Radiofrequency ablation utilized a RF current that was applied in a point-by-point mode, heating the tissue and leading to cellular necrosis. Cryogenic ablation induced necrosis by pumping refrigerant (nitrous oxide) through a balloon in a single-step mode, thereby freezing the tissue. The success of both techniques was evaluated through control echocardiography and electrocardiography.

Results: There was no statistically significant difference in the success rates of both techniques in terms of returning to the sinus rhythm. Two patients in the radiofrequency ablation group developed third-degree atrioventricular block with the need of permanent pacemaker implantation. In contrast no patient in the cryoablation group developed the same block. In patients who underwent radiofrequency ablation, the need for inotropic support in the postoperative period was higher with prolonged length of stay in the intensive care unit.

Conclusion: Our study results show that the success rate of both techniques is similar in patients with atrial fibrillation undergoing mitral valve surgery.

Keywords: Atrial fibrillation, cryoablation, radiofrequency ablation.

Atrial fibrillation (AF) is the most common chronic arrhythmia in clinical practice. Its incidence increases with age. Increased life expectancy in recent years has led to a rise in the incidence of AF. In earlier studies, the incidence was found to be 0.4% in the population and 4% in the age group above 65 years.[1,2]

The incidence of AF ranges between 30 and 90% in patients with mitral valve disease.[3,4] The risk of stroke in patients with AF is almost five to seven-times higher.[4] This rate increases up to 17% annually in cases with mitral valve diseases. Atrial fibrillation is also responsible for 15% of all strokes.[5]

Mitral valve diseases have been implicated as one of the main causes of AF due to the high incidence of AF in these patients. However, the rate of return to sinus rhythm was found to be 23%, if no additional treatment is given in addition to the surgical treatment. Some authors have shown that treatment of valvular disease alone remains insufficient.[6] On the other hand, the rate of return to the sinus rhythm has been reported as 68 to 70% with ablation therapy in mitral valve disease. Based on these results, the treatment of AF has been also improved.[6]

In the present study, we aimed to evaluate early results and possible complications of cryoablation and radiofrequency ablation in patients with AF undergoing mitral valve surgery.

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PATIENTS AND METHODS

This retrospective study included a total of 55 patients (27 males, 28 females; mean age 51.6±11.2 years; range, 44 to 71 years) with AF who underwent isolated left atrial ablation during mitral valve surgery at Medipol University Hospital, Department of Cardiovascular Surgery in our clinic between August 2012 and August 2017. Medical data of the patients were retrieved from the hospital records. Those with AF who underwent open heart surgery due to other indications were excluded. A written informed consent was obtained from each patient. The study protocol was approved by the Ethics Committee of Medipol University. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Radiofrequency ablation was performed in 41 of 55 patients and cryoablation was performed in 11 patients. All patients had permanent AF for more than three months. All patients were using beta-blocker, calcium channel blocker, and digitalis for heart rate control in addition to vitamin K antagonist for preoperative persistent AF.

Echocardiography (ECHO) and electrocardiography (ECG) measurements were recorded before and immediately after the operation and on the day of discharge and at one month postoperatively. All patients underwent isolated left atrial ablation with a radiofrequency catheter or cryoablation catheter. The left atrial appendix ostium was treated with box lesions which were created in such a way that the right and left pulmonary vein pair was separated and the boxes applied to the orifice of the pulmonary veins were combined with lesions to form a line lesion. The right line lesion was created to the P2-P3 leaflet of the mitral valve. The ablation period was approximately five to seven minutes with both methods. Ablation was performed in all patients prior to other surgical procedures. Left atrial appendage was closed in all patients. Epicardial temporary pacing was placed into the right ventricle and right atrium in all patients. Both ablation procedures were performed in the same region.

After the removal of the cross-clamp, all patients were treated with amiodarone 900 mg/day. Amiodarone 200 mg tablets t.i.d. once daily for the maintenance therapy were continued for seven days, and then b.i.d once daily for one week, and one tablet for two weeks. Additionally, metoprolol was started at a dose of 25 to 100 mg in all patients.

Statistical analysis

Statistical analysis was performed with PASW version 17.0 program (SPSS Inc., Chicago, IL, USA). The normal distribution of the variables was examined by histogram graphs and the Kolmogorov-Smirnov test. Mean, standard deviation, median and

Table 1
Baseline demographic and clinical characteristics of patients

Parameters	n	%	Mean±SD
Age (year)			51.6±11.2
Gender			
Female	28	50.9	
Male	27	49.1	
Smoking	10	18.2	
Alcohol	6	10.9	
Height (cm)			164.0±8.9
Weight (kg)			78.8±15.6
Body mass index (kg/m^2)			29.0±6.9
Preoperative heart rate (beat/min)			84.1±14.2
Left atrium diameter			
Radiofrequency patients (cm)			5.2±1.9
Cryoablation patients (cm)			5.1±2.7

SD: Standard deviation.

Table 2
Returning to sinus rhythm at different time points following radiofrequency ablation versus cryoablation

	Radiofrequency		Cryoablation		Chi-square
	n	%	n	%	*p*
Early postoperative	27	65.9	12	85.7	0.158
At discharge	31	77.5	9	81.8	0.757
After one month	33	82.5	9	81.8	0.958

Table 3
Postoperative inotropic support requirement following radiofrequency ablation versus cryoablation

	Radiofrequency		Cryoablation		
	n	%	n	%	*p*
Yes	38	92.7	9	64.3	
No	3	7.3	5	35.7	
Total	41		14		0.009

Table 4
Pacemaker requirement following radiofrequency ablation *versus* cryoablation

	Radiofrequency		Cryoablation		Chi-square
	n	%	n	%	*p*
Yes	16	39	4	28.6	
No	25	61	10	71.4	
Total	41		14		0.483

minimum-maximum values were used to present descriptive analyzes. Pearson chi-square and Fisher's exact tests were compared with 2×2 Tables. While normally distributed (parametric) variables were evaluated among the groups, Student t-test was used. Mann-Whitney U test was used to evaluate nonparametric variables. P-values <0.05 were evaluated as statistically significant results.

RESULTS

Of all patients, radiofrequency was applied to 41 patients (74.5%) and cryoablation to 11 patients (25.5%). Baseline demographic and clinical characteristics of the patients are shown in Table 1.

In the early postoperative period, 27 (65.9%) of radiofrequency patients returned to sinus rhythm, whereas 12 (85.7%) of cryoablation patients returned to sinus rhythm, indicating no statistically significant difference. On the day of discharge, 31 (77.5%) of radiofrequency patients and nine (81.8%) of cryoablation patients were in sinus rhythm, indicating no statistically significant difference. Thirty three (82.5%) *versus* nine patients (81.8%) were still in sinus rhythm at one month (Table 2).

Table 5
Length of intensive care unit and hospital stay following radiofrequency ablation *versus* cryoablation

	Radiofrequency		Cryoablation			
	Mean	Min-Max	Mean	Min-Max	Z*	*p*
Length of ICU stay (day)	2.0	1.0-24.0	1.0	1.0-24.0	-2.159	0.031
Length of hospital stay (day)	10.0	7.0-34.0	7.0	2.0-25.0	-3.151	0.002

Min: Minimum; Max: Maximum; * Mann-Whitney U test; ICU: Intensive care unit.

A total of 38 patients (92.7%) who underwent radiofrequency ablation needed inotropic support, while nine (64.3%) of the patients who underwent cryoablation needed inotropic support. The need for inotropic support was higher in patients who underwent radiofrequency (Table 3).

Sixteen (39.0%) of the patients who underwent radiofrequency ablation and four (28.6%) of the patients who underwent cryoablation required postoperative permanent pacemaker implantation. There was no statistically significant difference in the need for permanent pacemaker between the two ablation techniques (Table 4).

In addition, the length of hospital and intensive care unit stay was higher in the patients who were treated with radiofrequency ablation compared to those treated with cryoablation (Table 5).

DISCUSSION

Ablation procedures are recommended in the guidelines for patients with AF undergoing open heart surgery.[7] Electrophysiological studies performed during the operation show that the focus of AF is concentrated in the orifice of the left atrium appendix and the left pulmonary veins, and in some patients, the focus is in the right pulmonary vein orifice.[8-10] Based on previous study findings, isolated left atrial appendix procedures have been increasingly used.[11,12]

In our study, no significant difference was found between the two techniques. In similar studies in the literature, the rate of establishing the sinus rhythm was about 63 to 92% with radiofrequency ablation and 59 to 82% with cryoablation,[6,13] consistent with our study results. However, delayed return to sinus rhythm was observed in long-term follow-up patients who were ablated for AF.[14,15]

Although there are many studies using energy sources and procedures, no consensus has been established, yet. Previous studies using similar methods demonstrated similar rates of sinus node dysfunction, nodal rhythm, and complete atrioventricular block (AV) block rates in the early postoperative period. In our study, no atrial flutter was seen, compared to the other studies, which was found to be 4 to 6% of occurrence.[16-18] Meta-analyses showed that the rate of permanent pacemaker requirement in patients undergoing radiofrequency ablation procedure ranged from 0 to 10% and the rate of patients who required permanent pacemakers in patients undergoing cryoablation procedure was 0 to 21%.[7,13] In our study, two patients who underwent radiofrequency ablation required permanent pacemaker implantation due to complete AV block; however, none of the cryoablation patients required permanent pacemaker.

In the literature, isolated left atrial ablation-related complications such as esophageal injury, trachea injury, circumflex artery injury, and pulmonary vein stenosis have been reported.[19-22] It was also shown that patients undergoing maze procedure had longer hospitalizations, but there were no differences between the ablation methods.[23] In our study, these complications were not encountered, although the need for inotropic support was found to be higher with longer intensive care unit and hospital stay in the patients who underwent radiofrequency ablation than cryoablation. In another study, the risk of thromboembolism was found to be higher in the radiofrequency ablation group than cryoablation,[24] although thromboembolism complications were not seen in both methods in our study.

In conclusion, our study results suggest that radiofrequency ablation and cryoablation can be used in patients with atrial fibrillation scheduled for open heart surgery. The success rate of both techniques is also similar in our study. However, further, large-scale and long-term studies are needed to fully elucidate the effects of both energy sources.

Declaration of conflicting interests

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Rehospitalization with surgical site infections after cardiac surgery

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ABSTRACT

Objectives: This study aims to investigate rehospitalization rates in patients with surgical site infections (SSIs) after cardiac surgery.

Patients and methods: This cross-sectional study included a total of 153 patients (121 males, 32 females; mean age 58.7±10.9 years; range, 18 to 80 years) who underwent open heart surgery in our cardiovascular surgery clinic and readmitted with SSI within 30 days after surgery between September 2014 and December 2014. Risk factors which were related to the patient, surgery, and hospital stay were evaluated.

Results: Of the patients, 73.8% had coronary artery bypass grafting (CABG). A total of 22 patients (14.4%) were readmitted to hospital after discharge with SSI. Half of them had saphenous infections (superficial infection n=8, deep infection n=3), while the other half had sternal infections (superficial infection n=7, deep infection n=4). Nine of these patients were rehospitalized. The mean length of hospital stay was 14.2±3.8 (range, 10 to 20) days. The risk factors for SSI development included patient, surgery, and hospitalization and hospital setting.

Conclusion: Our study results show that several risk factors may play a role in the development of SSIs and rehospitalization. Therefore, it is recommended that nurses consider that SSI is certainly a major complication after cardiac surgery and the risks should be minimized during procedure and after discharge.

Keywords: Cardiac surgery, rehospitalization, surgical site infection.

Surgical site infections (SSIs) are serious perioperative complications which accounts for about 2% of surgical procedures and they may have a devastating impact on the course of treatment.[1-3] These infections are also associated with increased treatment intensity and prolonged length of hospital stay, and higher cumulative healthcare costs and substantial morbidity and mortality rates.[3]

Infectious complications after cardiac surgery, which occur in 5 to 21% of cases, are well-known and difficult-to-treat problems which increase patients' suffer, healthcare cost, and postoperative mortality rates by more than five times with prolonged recovery.[4,5]

There are three types of SSI defined by the Centers for Disease Control and Prevention (CDC). According to the CDC, SSIs are classified as either incisional or organ/space with incisional SSIs being further subcategorized as superficial (involving only skin and subcutaneous tissue) and versus deep SSIs (involving underlying soft tissue).[3,6]

In cardiac surgery, the most common sites of infections are the respiratory tract (45.7 to 57.8%), surgical site (27.7%), and catheters or devices (20.5 to 25.2%).[5] Surgical site infections include superficial infections of the postoperative scar and deep wound infections.[7] Superficial sternal wound infections complicate 0.5 to 8% of cardiac surgery cases and involve the skin, subcutaneous tissue, and pectoralis fascia. Deep sternal wound infections involve the sternal bone, substernal space, and mediastinum, but are less common than superficial sternal wound infections with an incidence ranging between 0.4 and 2%.[5]

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The contamination of the operative site may be due to the patient's endogenous flora or to the surgical team's or operating room's exogenous flora and is often perioperative. In addition, some factors promote the occurrence of SSI from this contamination such as tissue necrosis, hematoma, foreign body of a prosthesis or of an implant, and poor vascularization.[7]

Patients may be contaminated before, during, or after surgery, and any reoperation exposes to the risk of SSIs. The risk factors are related to three factors including patient, surgery, and hospitalization. Risk factors related to the patient are age, sex, obesity, diabetes mellitus (DM), respiratory insufficiency, stroke, heart failure, atrial fibrillation, smoking, peripheral vascular disease, renal failure, cardiogenic shock, and myocardial infarction (MI). Risk factors related to surgery are type of emergency, type of surgery, operation time, prolonged perfusion time, postoperative hemorrhage, early surgical revision for bleeding, steroids, prolonged mechanical ventilation, use of intra-aortic counterpulsation devices, blood transfusion, and reoperative heart surgery (redo) surgery. Risk factors related to hospitalization and hospital setting are duration of preoperative stay and patient preparation.[2,5,7] These predictors may result in development of SSIs after cardiac surgery through three common physiological pathways: decreased collagen synthesis, vasoconstriction, and increased immunosuppression.[3]

In the literature, several studies have been undertaken to identify high-risk patients for infectious complications in an attempt to modify risk factors. Early recognition of an infection is of utmost importance for optimal treatment and management of the patient.[4]

In the present study, we aimed to investigate rehospitalization rates in patients with SSIs after cardiac surgery.

PATIENTS AND METHODS

This cross-sectional study was conducted at a university-affiliated hospital, located in Istanbul, Turkey between September 2014 and December 2014. A total of 153 patients (121 males, 32 females; mean age 58.7±10.9 years; range, 18 to 80 years) who underwent open heart surgery in our cardiovascular surgery clinic and readmitted with SSI within 30 days after surgery were included. *Inclusion criteria were as follows:* having open heart surgery via median sternotomy under standard cardiopulmonary bypass (CPB) including coronary artery bypass grafting (CABG), valve repair, atrial/ventricular septal defect (ASD/VSD) repair surgery, aneurysm surgery, atrial mass excision, and redo surgery. *Exclusion criteria were as follows:* having heart transplantation and pacemaker implantation. A written informed consent was obtained from each patient. The study protocol was approved by the Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The data were obtained with the Structured Patient Information Form which included demographic and perioperative data. The standard anesthesiology management, myocardial protection techniques, and ventilator-weaning process were performed. The perfusion temperature was allowed to decrease to 28°C during CPB and standard cold potassium cardioplegia solution was used for all patients. The patients were transferred directly from the operating room to the cardiovascular intensive care unit (CVICU). All patients were mechanically ventilated on synchronized intermittent mandatory ventilation (SIMV) with a tidal volume of 10 to 12 mL/kg, a respiratory rate of 10 to 12/min, and a fraction of inspired oxygen rate of 100%. The nurses evaluated the hemodynamic, neurological, and respiratory state of the patients. Once the patients were fully awake, the nurse made the decision to extubate the patient, if they met the extubation criteria. Education and training were also given to all patients before operation and before discharge about what they should pay attention. All patients were followed for 30 days after surgery for SSI development.

The preoperative variables were defined as the age, sex, body mass index (BMI), documented DM, renal failure, heart failure, respiratory insufficiency (chronic obstructive pulmonary disease [COPD]), peripheral vascular disease, cardiogenic shock, MI, and smoking. The intraoperative variables included type of emergency, type of surgery, duration of aortic cross-clamp and CPB, total operation time, blood transplantation, use of intra-aortic counterpulsation devices (i.e., intra-aortic balloon pump [IABP]), and redo rates. Other variables including the surgeon, anesthesiology technique, cardioplegia solution, and hypothermia were stable and they were not tested.

Statistical analysis

Statistical analysis was performed using the SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean ± standard deviation (SD) or number and frequency. The chi-square test, Fisher's exact test, Student's t-test, and Mann-Whitney U test were used to evaluate rehospitalization as the dependent variable and demographic and perioperative variables as the independent variables. A *p* value of p<0.05 was considered statistically significant.

RESULTS

Of the patients, the mean BMI was 28.0±4.2 kg/m^2. A total of 24.8% patients were smokers. The majority of the patients underwent CABG (n=113, 73.8%), followed by valve surgery (n=21, 13.7%), combined CABG + valve surgery (n=9, 5.8%), ASD/VSD repair surgery (n=2, 1.3%), aneurysm surgery (n=2, 1.3%), atrial mass excision (n=2, 1.3%), and redo surgery (n=2, 1.3%). A total of 11 patients (7.2%) underwent an emergent surgical procedure. Baseline demographic and clinical characteristics of the patients are presented in Table 1.

A total of 22 patients (14.4%) readmitted with SSI. Eleven (50%) of them had saphenous infections (superficial infection n=8, deep infection n=3), while the remaining patients had sternal infections (superficial infection n=7, deep infection n=4). Culture examples were obtained from 14 of these patients and

Table 1
Demographic and preoperative variables of patients

	Rehospitalization (n=22)			Not rehospitalization (n=131)			Total (n=153)			
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			58.5±14.7			59.9±10.2			59.6±10.9	0.578
Sex										0.408
Female	6	27.3		26	19.8			20.9		
Male	16	72.7		105	80.2			79.1		
BMI			29.0±4.2			27.8±4.2			27.9±4.2	0.209
Life										0.331
Alone	2	9.1		7	5.3		9	5.9		
With family	20	90.1		124	94.6		144	94.1		
Smoking										**0.002**
Yes	12	54.5		26	19.8		38	24.8		
No	10	45.5		105	80.2		115	75.2		
Diabetes mellitus										0.374
Yes	9	40.9		41	31.3		50	32.7		
No	13	59.1		90	68.7		103	67.3		
Renal failure										**0.003**
Yes	3	13.6		0	0.0		3	2.0		
No	19	86.4		131	100.0		150	98.0		
Heart failure										0.217
Yes	0	0.0		13	9.9		13	8.5		
No	22	100.0		118	90.1		140	91.5		
Peripheral vascular disease										0.374
Yes	1	4.5		2	1.5		3	2.0		
No	21	95.5		129	98.5		150	98.0		
COPD										0.587
Yes	2	9.1		11	8.4		13	8.5		
No	20	90.9		120	91.6		140	91.5		
Cardiogenic shock										0.268
Yes	1	4.5		1	0.8		2	1.3		
No	21	95.5		130	99.2		151	98.7		
Preoperative myocardial infarction										0.691
Yes	8	36.4		42	32.1		50	32.7		
No	14	63.6		89	67.9		103	67.3		

SD: Standard deviation; BMI: Body mass index; COPD: Chronic obstructive pulmonary disease.

were found to be positive in eight. In total, 5.9% (n=9) and 41% (n=8) of SSI patients were rehospitalized. The mean length of hospital stay in these patients was 14.2±3.8 (range, 10 to 20) days (Figure 1).

Of a total of 22 patients who were rehospitalized, the majority was male (72.7%) with a mean age of 58.5±14.7 years and a mean BMI of 29.0±4.2 kg/m^2. However, there was no statistically significant difference between the patients with and without rehospitalization.

In terms of patient-related risk factors, there was no statistically significant difference between the patients with rehospitalization in terms of the living alone or with their family, DM, heart failure, peripheral vascular disease, COPD, cardiogenic shock, and MI before surgery (p>0.05). However, there was a statistically significant difference between the patients with rehospitalization in terms of smoking and having renal failure (p<0.05) and a higher number of these patients were readmitted to hospital with SSI (Table 1).

In terms of surgery risk factors, there was a statistically significant difference only between the patients with rehospitalization with SSI in terms of the use of IABP (p<0.05). On the other hand, there was no statistically significant difference between the patients with rehospitalization with SSI in terms of the type of emergency, type of surgery, CPB, aortic cross-clamp time, operation time, and blood transfusion. In addition, there was no statistically significant difference between the patients with rehospitalization with SSI in terms of having normal or higher blood glucose level (Table 2). In terms of hospitalization and hospital setting, all patients received the same preparation to surgery and were hospitalized in the same hospital the day before surgery. After surgery,

Table 2
Intra- and postoperative data of patients

	Rehospitalization (n=22)			Not rehospitalization (n=131)			Total (n=60)			
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
Type of surgery										0.367
Elective	22	100.0		120	91.6		142	92.8		
Emergency	0	0.0		11	8.4		11	7.2		
Cardiopulmonary bypass time (min)			117.4±42.7			112.0±45.7			112.8±45.2	0.459
Aortic cross-clamping time (min)			78.2±38.1			74.8±35.2			75.3±35.5	0.706
Operation time (h)			4.7±0.9			4.5±1.0			4.5±1.0	0.488
Stay in CVICU (h)			32.1±18.9			36.8±25.5			36.1±24.7	0.224
IABP used										**0.039**
Yes	3	13.6		3	2.3		6	3.9		
No	19	86.4		128	97.7		147	96.1		
Blood Tx in CVICU										0.785
Yes	18	81.8		101	77.1		119	77.8		
No	4	18.2		30	22.9		34	22.2		
Blood Tx in Clinic										1.000
Yes	3	13.6		18	13.7		21	13.7		
No	19	86.4		113	86.3		132	86.3		
Blood glucose regulation in CVICU										0.532
Normal	9	40.9		63	48.1		72	47.1		
High	13	59.1		68	51.9		81	52.9		
Blood glucose regulation after										0.976
CVICU	12	54.5		71	54.2		83	54.2		
Normal	10	45.5		60	45.8		70	45.8		
High										
Length of stay in hospital (day)			8.9±4.1			7.9±3.2			8.0±3.3	0.081

SD: Standard deviation; CVICU: Cardiovascular intensive care unit; IABP: Intra-aortic balloon pump; Tx: Transplantation/transfusion.

Table 3
Patient data after discharge

	Rehospitalization (n=22)		Not rehospitalization (n=131)		Total (n=60)		
	n	%	n	%	n	%	*p*
Wound appearance before discharge							0.540
Clean	21	95.5	128	97.7	149	97.4	
Swollen	1	4.5	3	2.3	4	2.6	
Bath after discharge							**0.020**
Yes	20	90.9	131	100.0	151	98.7	
No	2	9.1	0	0.0	2	1.3	
Bath frequency							0.110
Everyday	1	4.5	0	0.0	1	0.7	
Every other day	6	27.3	39	29.8	45	29.4	
Once a week	14	63.6	87	66.4	101	66.0	
Two in a week	1	4.5	5	3.8	6	3.9	

the mean length of stay in hospital was 8.9±4.1 days in rehospitalization patients and 7.9±3.2 days in non-SSI patients. There was no statistically significant difference between the patients with rehospitalization with SSI in terms of the length of stay in hospital ($p>0.05$) (Table 2).

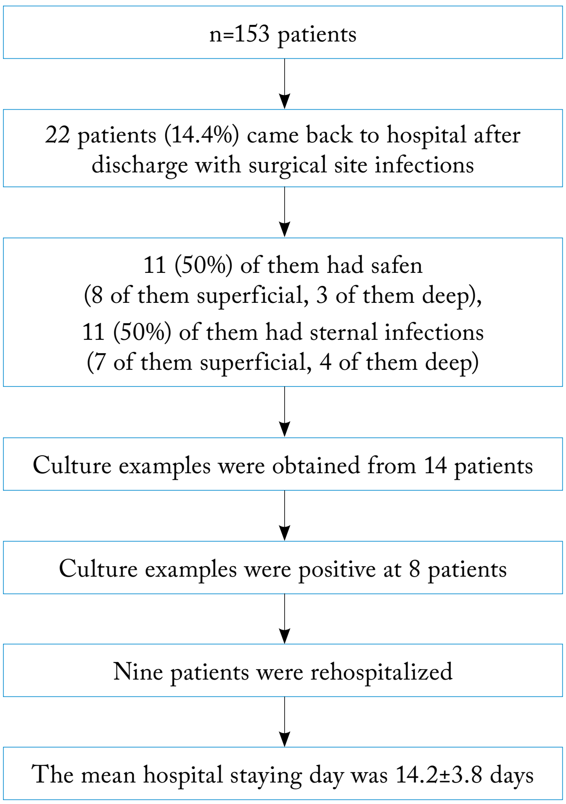

Figure 1. Flow chart of rehospitalization of patients after cardiac surgery.

On the other hand, we found a statistically significant difference between the patients with rehospitalization with SSI in terms of having bath after discharge ($p<0.05$) and having bath was associated with decreased SSI rates (Table 3).

DISCUSSION

Surgical site infections have a negative effect on the postoperative recovery period. They are associated with increased treatment intensity, prolong lenght of stay, higher costs, morbidity, and mortality.[1,3,8-10] Major postoperative infections including bloodstream infections and SSIs occur in up to 5% of patients after cardiac surgery.[10,11]

The reported incidence of infectious complications after cardiac surgery has ranged between 5 to 21% of cases.[12] While superficial sternal wound infections include skin, subcutaneous tissue and pectoralis fascia, deep sternal wound infections involve the sternal bone, substernal space and the mediastinum, and occur in 0.5 to 8% and 0.4 to 2% respectively.[5] In this study, the SSI rates were found to be similar with the literature.

Hannan et al.[13] and Li et al.[14] reported an all-cause readmission rate of 16.5 and 13.2%, respectively within 30 days of CABG. Both aforementioned authors concluded that postoperative infection was the most common reason for rehospitalization, consistent with our study findings.

The mortality rate of patients who develop SSI after cardiac surgery is significantly higher than those without SSI, ranging between 22 and 40%.[3] In our study, there were no infection-related mortality.

In recent years, there are many attempts to identify predictors for the development of SSI after cardiac surgery in the field of surgery.[3] The management of SSI is complex and prevention according to the risk factor modification offers the most effective intervention. A host of independent risk factors have been identified for SSIs.[5] These predictors have been also examined in terms of patient, surgery, and hospitalization.

The patient-related predictors are age (>85 years), sex, obesity (BMI >30 kg/m^2), concomitant diseases (i.e., COPD, respiratory failure, renal failure and hemodialysis, DM, cardiogenic shock, history of MI, and aortic calcification), the use immunosuppressive agents, and smoking. Risk factors for surgery are type of surgery (combined valve + CABG and aortic procedures), reexploration (reopening) for bleeding, blood transfusions, CPB time, and using IABP. Risk factors for hospitalization are preoperative length of stay in hospital more than three days, and preparation of the patient for surgery.[5,15,16] In this study, the age, sex, BMI, DM, heart failure, peripheral vascular disease, COPD, cardiogenic shock, and preoperative MI did not show a significant correlation with SSIs. However, smoking and renal failure were significantly associated with SSI development.

Several studies demonstrated that age, female sex, high preoperative serum glucose levels (>200 mg/dL), DM, obesity, and smoking were statistically significantly correlated with SSI development.[11,17,18] Bhatia et al.[17] reported that, in patients over the age of 66 years, the changes of developing wound infections were twice as high as in patients aged between 21 and 50 years.

On the other hand, there are conflicting reports on sex as a risk factor for SSI development. Some authors have reported an increased risk, while some others have shown a decreased risk in males.[19] There are also reports showing no significant correlation between sex and SSI development. Rogers et al.[20] reported that women were more likely to receive allogeneic red blood cells or platelets than men. The authors found that patients who received allogeneic blood were 4.4 times more likely to develop an infection than those who did not and women had a greater risk of infection.

Kanafani et al.[21] and Fowler et al.[11] reported that a BMI of >40 kg/m^2, chronic renal failure with hemodialysis, and chronic lung disease had a higher risk of developing major infections after cardiac surgery. In addition, Rahmanian et al.[22] reported that a BMI value of exceeding 30 kg/m^2 and diabetes were the main predictors for SSI development.

Furthermore, several studies have shown that obesity has a weak correlation with SSI and having sternotomy.[23] The possible reason for obesity being a risk factor include ineffective dose of prophylactic antibiotics, difficulty in proper skin preparation, adipose tissue providing a good substrate for infection and difficulties in vascular graft harvesting.[17]

Diabetes, particularly uncontrolled diabetes, is a significant independent risk factor for the development of SSI in perioperative cardiac surgical patients.[3,11,16,17,24] High perioperative blood glucose concentrations have been identified as a risk factor for SSI after cardiothoracic surgery.[15,21,25] In patients with diabetes, postoperative hyperglycemia has been also associated with adverse outcomes such as death, MI, stroke, and septic complications before hospital discharge.[3,21,25-27] Maintaining a serum glucose of <180 mg/dL with continuous insulin infusions in patients with and without DM reduces morbidity and mortality, lowers the incidence of sternal wound infections, shortens hospital length of stay, and improves long-term survival.[28] Poor glycemic control prior to surgery, however, contributes to poor diabetes control after hospital discharge and increases the incidence of complications, such as poor wound healing and higher rates of SSI, and rehospitalization and increased mortality, eventually.[29,30] It is likely that the benefits of glucose control extend to cardiac surgical patients, as most of the large-scale glucose control studies included cardiothoracic surgery patients and as poor glucose control is associated with a higher risk of SSI.[5,31,32]

In this study, CPB time, aortic cross-clamp time, operation time, length of stay in the ICU, blood transfusion, blood glucose regulation, and type of surgery did not show a significant correlation with the SSI development. However, the use of IABP was found to be significantly associated with the SSI development.

In our study, the mean duration of surgery was 4.5±1.0 (min: 2-max: 8) hours. Duration of surgery may be also a risk factor. Operations lasting for more than two hours are known to be associated with increased infection rates.[17] Fowler et al.[11] reported that infections were associated with perfusion time (200 to 300 min), placement of IABP, and the presence of three or more distal anastomoses.

In recent studies, blood transfusion has been identified as an independent risk factor. Blood transfusion is associated with impaired immunocompetence.[17] Although transfusion may be necessary to prevent or treat tissue hypoxia, the immunomodulatory effects of allogeneic blood transfusion have been recognized for decades. Transfusion-related immunomodulation has been also shown to result in an increased risk of nosocomial infections and mortality in many patient cohorts.[3] Rogers et al.[20] reported that patients who received allogenic blood transfusion were four times more likely to develop infection after cardiac surgery. However, in our study, there was no statistically significant correlation between the use of blood transfusion and rehospitalization.

Postoperative SSI increased the length of hospital stay and cost in proportion to the severity of infection. The cost increased by 3.8%, 14.7%, and 29.4% in mild, moderate, and severe infections, respectively.[17] In a study, the length of hospital stay was found to be 5.9 and 15 days, respectively.[17] Fowler et al.[11] showed that 47% of cardiac surgery patients with SSI required more than 14 days in the hospital. In another study, the presence of SSI prolonged the length of stay by about 9.7 (range, 6 to 14) days.[3] This increase in the length of stay is also consistent with our study findings.

Skin preparation for surgery is one of the key elements to prevent postoperative infections. Investigating skin preparation modalities, such as hair removal and preoperative antiseptic showering, would build further evidence for best nursing practice and help nurse managers to develop and implement a protocol for appropriate preoperative skin preparation.[2,3]

Although postoperative wound care and dressing is well-investigated in the literature, there is a limited number of data regarding the timing for the first dressing as the predictor for SSIs. Timing of the first postoperative dressing affects the inflammatory phase of wound healing.[33] The duration of the inflammatory phase of wound healing is about two to three days. Investigating whether to cover the wound for two to three days affects the wound infection rate would be helpful to develop and implement a protocol for the wound care postoperatively.[3]

In their study, Dal et al.[34] reported that, after discharge, 24.5% of patients experienced a problem related to caring at home, 60.4% had surgery wound infections, and 63.5% patients were readmitted to hospital. Good discharge planning and home-based care services would improve patient recovery following surgery and prevent complications. Postoperative bathing and showering may also remove the dead skin cells, dirt, microorganisms, and sweat that have collected around the wound edges. It may also reduce contamination of the surgical site, help to prevent infection, and promote wound healing.[35,36] However, in a study, Toon et al.[36] reported no statistically significant difference in the rate of SSI development between the patients having early versus late postoperative bathing. In another study, Ucar[37] also reported that the postoperative rate of infectious complications was similar in patients having early versus late postoperative bathing.

This study has some limitations. First, all of the patients studied were from a single academic medical center, and our results may not represent patients developing SSI in other institutions. Second, this study does not take into account the socioeconomic status that may lead to infection development while addressing some factors affecting the development of infection.

In conclusion, infectious complications can be reduced with many simple measures, starting with risk factor modification at the first anesthetic preoperative screening visit thorough to postoperative risk factor vigilance in the intensive care unit and after discharge. Nurse-led reminder systems, care bundles, admission order sets, and discharge protocols appear to be particularly effective at meeting the quality targets in the management of Surgical site infections.[3,38] Of note, Surgical site infections are certainly major complications of cardiovascular surgery. It should be, therefore, kept in mind that risk factors should be minimized during the procedure to employ more effective preventive measures for postoperative wound infections.

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Cardiovascular Surgery and Interventions

Case Report | Open Access

Endovascular treatment of penetrating aortic ulcer: A case report

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ABSTRACT

A 51-year-old male patient was admitted with a penetrating aortic ulcer. Endovascular aortic reconstruction was performed. The revascularization success was satisfactory, and the patient had no pain after the procedure. On control computed tomography angiography, the correct position and functionality of the endovascular stent graft was established without a penetrating ulcer of the aorta.

Keywords: Endovascular aneurysm repair, penetrating atherosclerotic ulcer, syndrome.

Penetrating aortic ulcer (PAU) is a disease which affects the aortic wall with aortic dissection and intramural aortic hematoma and forms the so-called acute aortic syndrome. Penetrating aortic ulcer accounts for about 7.5% of all cases of acute aortic syndrome.[1]

Penetrating aortic ulcer can be asymptomatic or symptomatic. In symptomatic cases, it presents with chest pain in the form of tearing, splitting, and pulsing, but it can also present with chronic back pain and misdiagnosed as lumbar syndrome.[2]

Diagnosis of PAU mainly depends on clinical presentation and morphology of the ulcer. It can be treated with conservative treatment with follow-up, open classical surgery and ulcer resection, or endovascular placement of the stent-graft to exclude the ulcer from the circulation.[3]

Herein, we report a successful case of endovascular treatment of PAU.

CASE REPORT

A 51-year-old male patient was admitted with PAU to the vascular surgery outpatient clinic. The diagnosis of PAU was made using Duplex ultrasonography and confirmed by computed tomography angiography (CTA) of the aortoiliac segment. His medical history revealed low back pain which was previously misdiagnosed as lumbar syndrome. The patient had also several comorbidities including nicotinism, hypertension, hyperlipoproteinemia, ischemic chronic cardiomyopathy with a left ventricular ejection fraction of only 35%, chronic obstructive pulmonary disease, and non-significant stenosis of the internal carotid arteries bilaterally. The CTA (Siemens SOMATOM Sensation 16; Siemens Healthcare GmbH, Erlangen, Germany) showed peripheral arterial occlusive disease with a PAU, 18 mm in diameter, located in the first lumbar vertebra (Figure 1).

A written informed consent was obtained from the patient. Stent grafting with endovascular aneurysm repair (EVAR) using Medtronic was performed at the Radiology Center under general endotracheal anesthesia. Endovascular procedure was performed satisfactory without local and systemic complications, and the procedure lasted for 100 min. The patient was discharged in the postoperative third day with a good mobilization and reduced back pain. Control CTA which was performed at one and six months and at one year revealed a correct stent-graft position without thrombosis and stenosis within the lumen (Figure 2).

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Figure 1. Computed tomography angiography confirming the diagnosis of penetrating aortic ulcer (white arrow).

Figure 2. Abdominal computed tomography angiography showing correct stent-graft position at one year.

DISCUSSION

Magnetic resonance angiography has been shown to be most useful method for PAU morphology and intramural hematoma and dissection. However, in symptomatic PAU cases, CTA is also indicated and, as in our case, it is a simple and more available method for a rapid diagnosis.[2]

The diameter of PAU in our case was 18 mm. In the literature, larger diameters of PAU have been reported. Batt et al.[3] reported that the course of PAUs was very unpredictable and that the diameter and location of the ulcer did not have a significant effect, and a prompt treatment was needed, due to a high risk of rupture.

In our case, EVAR was performed under general endotracheal anesthesia. Lately, there has been an increase in the number of EVAR procedures under local anesthesia, and local anesthesia has been given priority for lower mortality and morbidity rates and shorter length of intensive care unit and hospital stay.[4]

The major early complication of EVAR is endoleak. On control CTA, endoleak was not seen in our patient. In addition, intra- and postoperative EVAR-related complications include those arising from an femoral access, systemic complications, ischemic complications due to unintended embolization, stenosis, or stent graft occlusion.[3] In our case, none of these complications were seen.

In conclusion, endovascular stent grafting for the treatment of penetrating aortic ulcer is a very successful treatment method with less complications and it is a good alternative to conventional open surgery in selected cases.

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Cardiovascular Surgery and Interventions

Case Report Open Access

Inter-arterial course of left coronary artery in a case of non-specific chest pain

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ABSTRACT

A 17-year-old female presented with a history of short and sharp chest pain which was not exacerbated by effort for one year. Computed tomography angiography revealed a left coronary artery arising from the right coronary sinus with inter-arterial compression. In conclusion, computed tomography angiography can give excellent information about the anomalous origin and course. A high index of suspicion is needed in the diagnosis of coronary artery anomalies with an insidious clinical course.

Keywords: Congenital, coronary artery anomalies, left main coronary artery.

Coronary artery anomalies are rare in the general population and usually an incidental finding during coronary angiography. In the literature, the diagnosis of coronary artery anomalies is usually based on angiography or autopsy. Imaging modalities including computed tomography (CT) and magnetic resonance (MR) angiography provide excellent information about the course of coronary arteries.

Herein, we report an adolescent case of an inter-arterial course of the left coronary artery (LCA) in the light of literature data.

CASE REPORT

A 17-year-old female presented with a history of chest pain for one year. Chest pain was short and sharp and not exacerbated by effort. Her medical history was non-specific and her family history revealed a sudden cardiac death two months ago in her father aged 42 years.

Physical examination was normal including blood pressure, heart rate, and heart sound. Chest X-ray and electrocardiogram were also normal. Routine biochemistry including troponin I and lipid profile was not remarkable. Coronary artery anomaly was suspected based on echocardiography findings (Figure 1). Therefore, coronary CT angiography was performed. Coronary CT angiography showed the anomalous origin of the LCA from the right coronary sinus (Figure 2) and courses between the aorta and pulmonary artery which is divided into the left anterior descending artery (LAD) and left circumflex artery (LCx) (Figures 3). The LAD appeared to have a normal course. However, the LCx showed a course anteriorly to the left ventricle rather than the

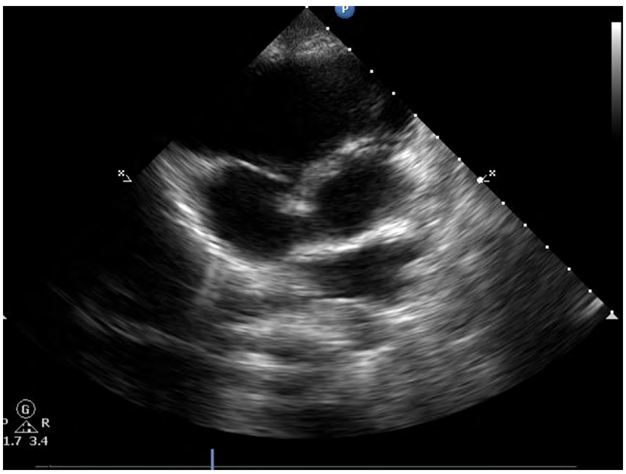

Figure 1. Echocardiography showing a suspected anomalous origin of left coronary artery.

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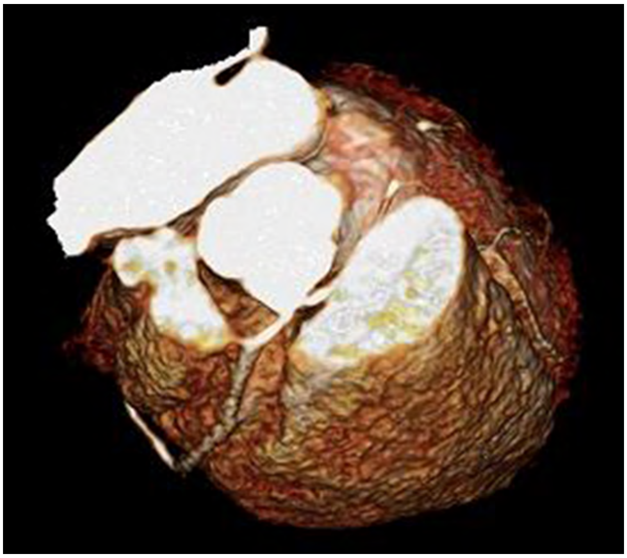

Figure 2. Coronary computed tomography angiography showing anomalous origin of left coronary artery from right coronary sinus.

atrioventricular groove. On exercise test, she remained asymptomatic and tolerated exercise test using the standard modified Bruce protocol. Surgical repair was decided due to the inter-arterial course of the left main coronary artery (LMCA). However, her parents are still indecisive about the surgical repair.

DISCUSSION

In this article, we report an interesting case of inter-arterial course of LCA originating from the right coronary sinus. Although the multi-detector CT provided excellent information about the origin and inter-arterial course of coronary artery, echocardiography is also helpful to detect such suspicious cases.

The incidence of congenital coronary anomalies ranges between 1 and 5% undergoing coronary angiography and 0.3% in autopsy series.[1,2] Echocardiographic studies in pediatric population reported an incidence of 0.3%.[3] Potentially serious coronary anomalies include ectopic coronary origin from the pulmonary artery, ectopic coronary origin from the opposite sinus, single coronary artery, and coronary fistula.[1] Our patient had LCA originating from right sinus. The pattern of single or common ostium is considered to represent single coronary artery, as in our case.

Four anatomical variants have been described according to the course of the LMCA to the left side of the heart in single coronary artery arising from the right coronary sinus: *(i) anterior:* LMCA courses anteriorly to the right ventricular outflow tract; *(ii) inter-arterial:* LMCA passes between the great vessels; *(iii) septal:* LMCA has an intramyocardial septal course; and

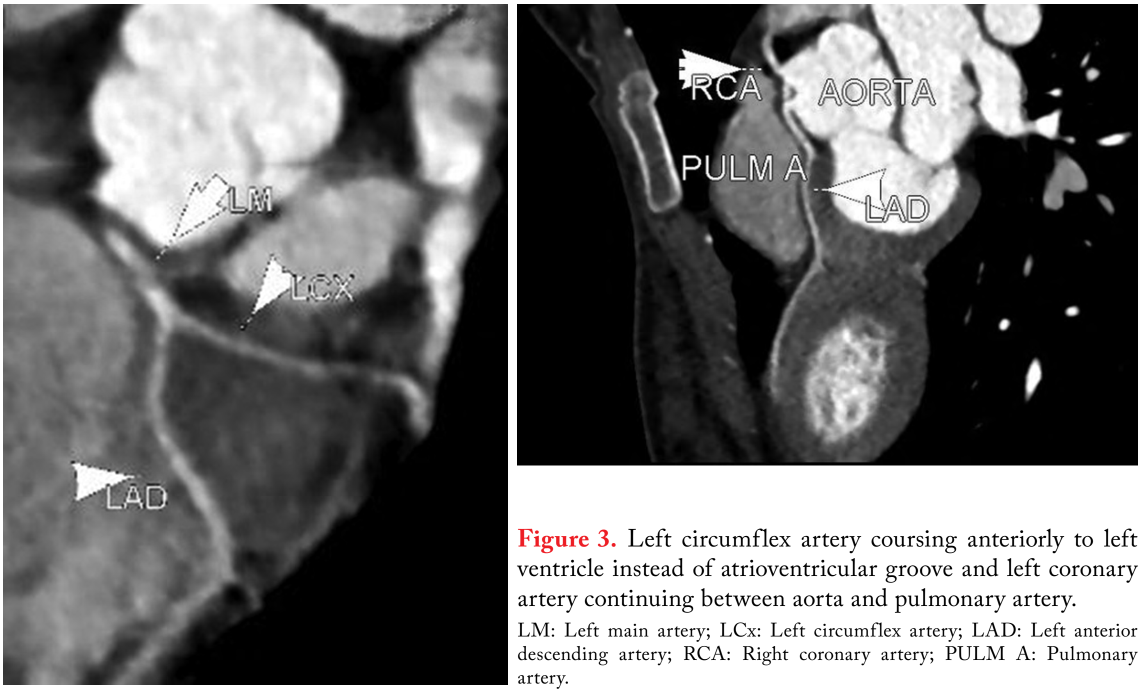

Figure 3. Left circumflex artery coursing anteriorly to left ventricle instead of atrioventricular groove and left coronary artery continuing between aorta and pulmonary artery.

LM: Left main artery; LCx: Left circumflex artery; LAD: Left anterior descending artery; RCA: Right coronary artery; PULM A: Pulmonary artery.

(iv) posterior: LMCA courses posteriorly behind the aorta in the inferoposterior direction.[4] Our patient had an inter-arterial variant. The incidence of inter-arterial variant ranges between 0.03 and 0.05%.[1] However, the inter-arterial course has been known as a cause of sudden cardiac death. Ischemia or sudden cardiac death are thought to occur due to the vascular kinking or compression. According to the most common postulated hypothesis, exercise results in enlargement of the aorta, which obstructs the acutely angulated slit-like orifice of the LMCA.[1] Van Camp et al.[5] reported that coronary anomalies accounted for 11.8% of deaths in high school and college athletes. In addition, the Sudden Death Committee of the American Heart Association states that coronary anomalies account for 19% of deaths in athletes.[6] In a study concerning death in young athletes with coronary anomalies arising wrong sinus, premonitory symptoms including chest pain and syncope were substantially rare, and electrocardiography and exercise tests were within normal limits in most cases.[7]

Echocardiography is essential in the diagnosis of coronary anomalies. However, it is imperative to define the course of coronary arteries to predict prognosis. Coronary angiography may cause some misinterpretations in cases with coronary anomalies. Therefore, imaging methods such as CT or MR angiography have been suggested.[4] Multi-detector CT offers an excellent delineation of the LCA origin and provides the surgeon with a clear image of course of anomalous coronary artery. Therefore, we did not use conventional angiography in our case. Although patients are commonly asymptomatic, surgical repair is recommended, particularly after 10 years of age.[8]

In conclusion, coronary anomalies can be lethal during or shortly after vigorous physical activity, typically in young individuals. Diagnosis of coronary artery anomalies requires a high index of suspicion. Although echocardiography is useful, computed tomography angiography provides an excellent information about the coronary anomalies, as in our case.

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