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J-sternotomy incision for aortic valve surgery: an initial experience of a tertiary care hospital

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ABSTRACT

Objectives: This study aims to present our single-center experience of an aortic valve replacement using a minimally invasive J-sternotomy incision and to compare the early clinical outcomes of these procedures with a median sternotomy.

Patients and methods: Between January 2014 and May 2015, 38 patients underwent isolated aortic valve replacement operations using a minimally invasive or a conventional sternotomy. A J-sternotomy (group JS) incision was used on 18 patients (12 males, 6 females; mean age 57.0±17.9 years; range 19 to 62 years), whereas a median sternotomy (group MS) incision was performed on 20 patients (13 males, 7 females; mean age 57.4±16.3 years; range 22 to 65 years). Preoperative characteristics, perioperative data and early outcomes were compared. Patient selection techniques, the surgical approach and our experience during the procedures were presented.

Results: No mortality developed. The types (p=0.36) and dimensions (p=0.99) of implanted aortic valves were similar between the groups. There was no significant difference between the JS and MS groups in terms of cross-clamp (68.4±30.1 vs. 64.7±29.9 minutes, p=0.70) and cardiopulmonary bypass time (112.3±43.1 vs. 94.8±43.8 minutes, p=0.22). In the group JS, conversion to full sternotomy was needed in one patient due to poor surgical exposure. The lengths of intensive care unit [1.7±1.7 vs 2.2±1.2 days, (p=0.33)] and hospital [7.1±2.7 vs 7.2±1.2 days, (p=0.66)] stays were similar between the groups. A mediastinal exploration due to bleeding was performed using a full sternotomy in two patients (11.2%) from group JS. There was no significant difference in postoperative complications.

Conclusion: Since it is minimally invasive for aortic valve replacement using a J-sternotomy incision is a safe and reproducible procedure. The use of a minimally invasive aortic valve replacement technique does not lead to a higher incidence of postoperative complications and associated mortality.

Keywords: Aortic valve replacement; J-sternotomy; minimally invasive surgery.

Minimally invasive techniques have been used to perform aortic valve procedures to reduce surgical trauma for more than a decade. After the original description of minimally invasive aortic valve replacement (AVR) with a right thoracotomy in the early 1990s, this approach, with a number of different variations, remains a viable alternative to a conventional sternotomy.[1-7] Despite the more common use of the parasternal and transverse approaches in the initial reports, upper hemisternotomy and right anterior minithoracotomy are frequently used in the current surgical practice.[3-5] The more frequent use of sutureless valves along with growing expertise may be expected to result in the more frequent use of minimally invasive approaches for AVR.[8,9] Clinically, surgery performed using smaller incisions offer a number of advantages such as reduced postoperative pain and surgical trauma.[3-5] Also, a minimally invasive AVR appears to be superior to aortic valve surgery with a conventional sternotomy in terms of less bleeding, shorter ventilation and a reduced length of time in the intensive care unit and a shorter hospital stay.[1-7]

Since we have only recently introduced minimally invasive AVR procedures in our center, we decided to share our clinical experience on AVR with a J-sternotomy during a one-year period in comparison with the conventional AVR in terms of clinical outcomes, early morbidity and early challenges.

PATIENTS AND METHODS

This was a retrospective analysis of prospectively collected data from a single center series of AVR using either a partial (upper J-sternotomy) or complete

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sternotomy approach between January 2014 and May 2015. The Institutional ethical committee approved this study. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki. Data collection was obtained using patient records and the department database. During the study period, 45 consecutive patients underwent isolated AVR procedures. Thirty-eight patients undergoing AVR were included in the study. The patients were divided into two groups; 18 were operated on using a partial upper J mini-sternotomy (group JS; 12 males, 6 females; mean age 57.0±17.9 years; range 19 to 62 years) and 20 using a conventional median sternotomy (group MS; 13 males, 7 females; mean age 57.4±16.3 years; range 22 to 65 years). Operations were all performed by consultant surgeons. The decision about the choice of procedure type was based entirely on the patient's general status, anatomical considerations and at the discretion of the attending surgeon. Exclusion criteria were the presence of infective endocarditis or endocarditis requiring emergent care in seven patients. A chest wall deformity such as a pectus excavatum, history of radiation exposure, previous cardiothoracic surgery, combined procedures and intervention on the aortic root or ascending aorta, morbid obesity and concomitant cardiac pathologies requiring surgical repair were the other exclusion criteria.

Procedures were performed using the same technique in each group and performed by the same surgical team. The surgical technique was described previously.[3,4] After the induction of general anesthesia, in the minimally invasive group (group JS), a 6-8 cm midline skin incision was made beginning 2 cm above the angle of Louis until 4 to 6 cm below the angle. The sternotomy was incised with the oscillating saw down until the intercostal space between the second and fourth depending on the topographic relationships of the anatomic structures (Figure 1). After the retractors were placed, the pericardium was accessed. Aortic cannulation was directly performed through the ascending aorta. A single femoral vein cannulation was performed percutaneously through the right femoral vein (Medtronic Biomedicus femoral 21 or 24 Fr venous cannula–Minneapolis, USA). In patients with inadequate venous flow, venous drainage was supported by selective cannulation of the vena cava superior. Figure 2 shows the intraoperative exposure of a patient, who underwent an AVR with J-sternotomy. In the group MS, a conventional AVR was performed via a full median sternotomy applying double stage venous cannulas with the same methods of myocardial protection.

An intraoperative transesophageal echocardiography was used routinely to assess cardiac function, evaluate surgical results and confirm the de-airing process. There was also a routine examination during peripheral cannulation. Myocardial protection of both groups was achieved with systemic hypothermia (28-32 °C), and antegrade isothermic blood cardioplegia. Cardioplegia doses were selectively maintained through coronary ostia every 20 minutes. The left ventricular vent

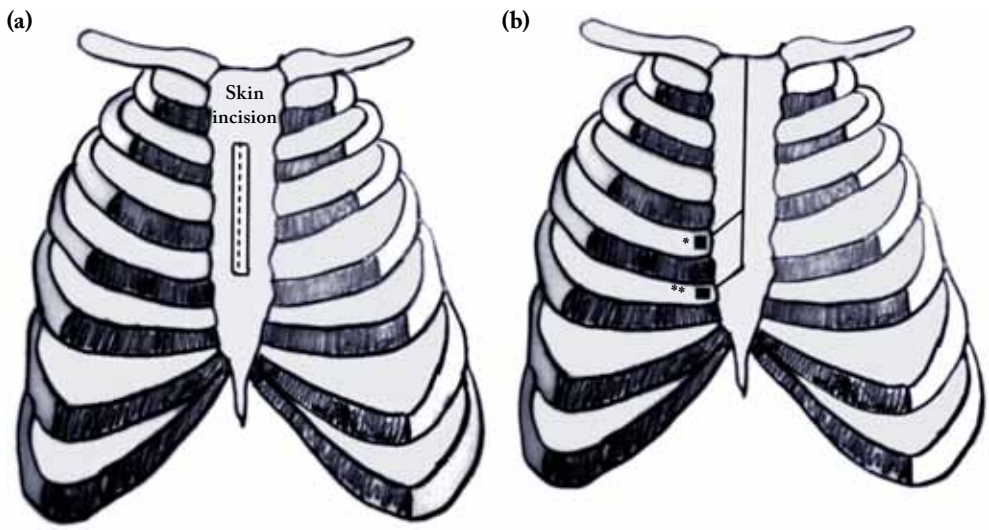

Figure 1. Surgical incisions. **(a)** Skin incision and **(b)** partial sternotomy incision.
* Third intercostal space; ** Fourth intercostal space.

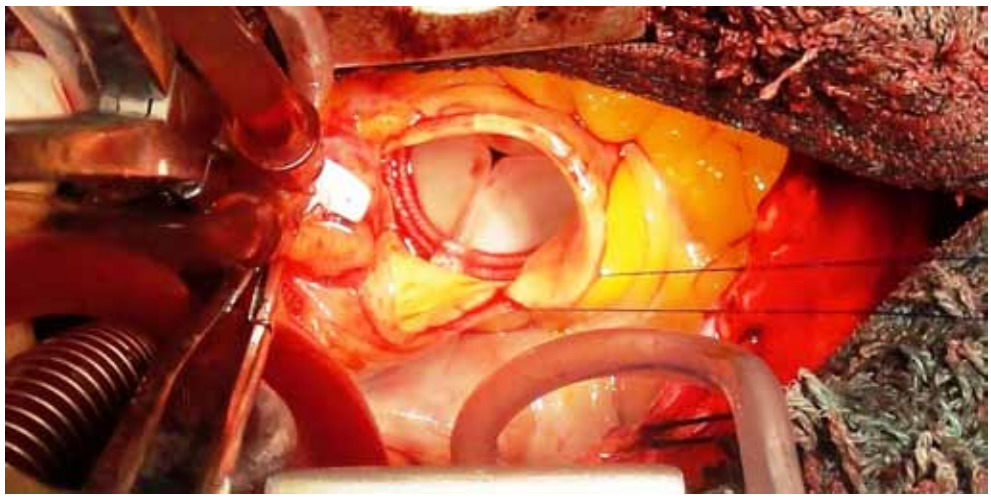

Figure 2. Surgical exposure of the aortic valve through an upper J-sternotomy after implantation of a bioprosthetic aortic valve.

was provided through the right upper pulmonary vein. Carbon dioxide insufflation was used in all procedures. At the end of each procedure, a single ventricular epicardial pacemaker was placed before aortic declamping. A single 32 F chest tube was placed immediately after cardiac arrest and removed 48 hours after the operation.

Clinical, operative and outcome data was prospectively collected in a computerized database. All patients had eight weeks of follow-up care after being discharged from the hospital. During this time, operative variables and postoperative complications were recorded. Follow-up visits took place in our unit.

Statistical analysis

NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) pack was used for

Table 1
Demographic characteristics, aortic valve pathology and comorbid conditions

	Group JS (n=18)			Group MS (n=20)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (years)			57.0±17.9			57.4±16.3	0.93
Gender							
Female	6	33.3		7	35		0.91
New York Heart Association class			2.1±1.3			2.1±1.5	0.56
Obesity (BMI ≥30)			26.3±3.8			32.6±18.5	0.16
Hypertension	9	50		7	35		0.35
Obstructive lung disease	7	38.9		8	40		0.94
Diabetes	6	33.3		5	25		0.57
Renal failure	0	0		1	5		0.33
TIA/CVA	1	5.6		0	0		0.28
Cigarette use	13	72.2		12	60		0.42
Atrial fibrillation	1	5.6		1	5		0.93
Ejection fraction (%)			60.5±4.8			57.8±9.4	0.28
Aortic valve pathology							
Aortic failure	3	16.7		4	16		
Aortic stenosis	7	38.9		5	25		0.65
Mixed	8	44.4		11	55		

SD: Standard deviation; BMI: Body mass index, renal failure: (creatinine ≥1.5 mg/dL); TIA/CVA: Transient ischemic attack or cerebrovascular accident.

statistical analyses. For data analysis, in addition to descriptive statistical methods (mean, standard deviation), an independent t-test was used for the pairwise comparison of the groups. Preoperative and postoperative comparisons were performed using the paired t-test, and chi-square and Fisher's exact tests were used for the comparison of qualitative data. The level of significance was set at a *p* value of less than 0.05.

RESULTS

The preoperative demographic data of the patients is shown in Table 1. Members of each group were similar in terms of age, sex, New York Heart Association functional class, left ventricular ejection fraction, obesity (body mass index above 30), hypertension, diabetes, obstructive pulmonary disease, renal failure, previous ischemic cerebral event, atrial fibrillation (AF) and history of smoking. The incidence of aortic valve pathologies was also similar between the groups (p=0.65). In the group JS and MS, aortic regurgitation presented in three patients (16.7%) and four patients (16%), aortic stenosis in seven patients (38.9%) and five patients (25%) and mixed aortic pathology presented in eight patients (44.4%) and 11 patients (55%), respectively.

Operative data is presented in Table 2. There was no significant difference between the JS and MS groups in terms of aortic cross-clamp (68.4±30.1 vs. 64.7±29.9 minutes, p=0.70) and cardiopulmonary bypass (112.3±43.1 vs. 94.8±43.8 minutes, p=0.22) times. In the JS group, conversion to full sternotomy was made in one patient due to inadequate intraoperative exposure. The types of implanted aortic valves (p=0.36) and valve dimensions (p=0.99) were similar between the groups. In the JS group, nine (50%) mechanical and nine (50%) biological aortic valves were implanted. Of biological valves, eight of them were of the sutureless-type. In the group MS, 10 (50%) mechanical and 10 (50%) biological aortic valves were implanted. Of biological valves, six of them were sutureless. Most patients had an aortic valve size of 21 or above in the group JS, as in the group MS (p=0.99). In each group, only three patients had size 19 aortic valves implanted. No procedure related morbidity developed. All operations were completed uneventfully.

The postoperative data for the patients is shown in Table 3. No mortality developed in either group. The length of stay in the intensive care unit (1.7±1.7 vs 2.2±1.2 days (p=0.33) and hospital stay (7.1±2.7 vs 7.2±1.2 days (p=0.66) were statistically similar between patients with J-sternotomy and median sternotomy. The incidences of postoperative AF were similar

Table 2
Operative data

	Group JS (n=18)			Group MS (n=20)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Cross-clamp time			68.4±30.1			64.7±29.9	0.70
Cardiopulmonary bypass time			112.3±43.1			94.8±43.8	0.22
Conversion to full sternotomy	1	5.6		-	-		
Aortic valve type							0.36
Mechanical	9	50		10	50		
Biological	9	50		10	50		
With stent	1	5.6		4	20		
Sutureless	8	44.4		6	30		
Type of sutureless valve							0.63
Medtronic enable	2	11.2		1	5		
Perceval	1	5.6		1	5		
Edwards intuity	5	27.8		3	15		
Aortic valve no							0.99
19	3	16.7		3	15		
21	8	44.4		10	50		
23	4	22.2		4	20		
25	3	16.7		3	15		

SD: Standard deviation.

Table 3
Postoperative data

	Group JS (n=18)			Group MS (n=20)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Mortality	0	0		0	0		
Intensive care unit stay (day)			1.7±1.7			2.2±1.2	0.33
Hospital stay (day)			7.1±2.7			7.2±1.2	0.66
New-onset atrial fibrillation	2	11.2		4	20		0.45
Need for blood products (unit/patient)			2.7±1.7			3.3±2.3	0.39
TIA/CVA	1	5.6		2	10		0.61
Acute renal failure	1	5.6		0	0		
Prolonged ventilation (>48 h)	2	11.2		4	20		0.45
Pneumonia	1	5.6		1	5		0.93
Pleural effusion	1	5.6		2	10		0.61
Re-exploration for bleeding	2	11.2		3	15		0.93
Mediastinal drainage			390.5±232.2			430.2±265.2	0.63
Reoperation	1	5.6		0	0		
Sternal wound site infection	2	11.2		1	5		0.28
Transient pacemaker	0	0		1	5		
Intra-aortic balloon pump	0	0		0	0		

SD: Standard deviation; TIA/CVA: transient ischemic attack or cerebrovascular accident; Acute renal failure: (creatinine ≥1.5 mg/dL).

between the groups (p=0.45). There were no significant differences in new-onset renal failure (creatinine above 1.5 mg/dL), respiratory problems, sternal wound infection, need for a temporary pacemaker, and all other characteristics were comparable between the groups. There were not any groin complications associated with femoral cannulation. The amount of mediastinal drainage was similar between the groups. However, a mediastinal exploration due to bleeding was performed using a full sternotomy on two patients (11.2%) from the group JS. The bleeding site was in a branch of the right internal thoracic artery in one patient and, the other patient bled from the aortotomy incision In the group JS, one (5.6%) patient with a sutureless biological AVR had severe paravalvular leakage during the early follow-up period and a mechanical valve replacement was performed on postoperative day 3 through a full conventional sternotomy.

DISCUSSION

In this study, our initial experience showed that AVR using J-sternotomy incision is a safe and reproducible procedure. The use of a minimally invasive AVR technique does not lead to a higher incidence of postoperative complications and associated mortality. Because this was an initial experience, the duration of the procedures in the J-sternotomy approach was relatively longer in the first cases, compared to the sternotomy approach. As our technical experience increased, we observed the feasibility and safety of the J-sternotomy approach. Exposure of the surgical field and aortic valve was satisfactory in the J-sternotomy cases. The clinical results of this approach were similar to the conventional sternotomy approach. There were no significant differences in postoperative complications. No mortality was observed.

In the current era, right anterior thoracotomy, median mini-sternotomy (J, L, reverse C and T) and percutaneous aortic valve implantation represent the most preferred minimally invasive AVR approaches by cardiovascular surgeons.[1-10] The technique utilized in our unit, i.e. J-sternotomy is also known as an upper hemisternotomy and is a routinely performed minimally invasive AVR technique in many centers.[3-5] Previous studies of minimally access and conventional median sternotomy approaches for AVR have showed comparable early mortality and postoperative complications.[1-7] In our study, the two groups were not only comparable in terms of cross-clamp and CPB time, but also in terms of the hospital and ICU stay. In this small series, mortality was not observed.

In minimally invasive procedures, especially in the beginning of a learning curve, patient selection

is paramount for AVR using J-sternotomy incision. Procedures should be performed in isolated pathologies and therefore a detailed clinical assessment should be made preoperatively including biochemical tests, chest graphics, echocardiography, coronary angiography, computed tomography (CT) of the thoracic cavity and even peripheral vessels for CPB.[3-5] In this study, the decision about the choice of procedure type was entirely based on the patient's general status, anatomical considerations and at the discretion of the attending surgeon. Exclusion criteria were the presence of infective endocarditis or endocarditis requiring emergent care, combined procedures and intervention on the aortic root or ascending aorta. Patients with concomitant coronary disease, valve pathology or poor ventricular function were also excluded. Additionally, the chest anatomy was examined before the operation. Because we made an upper partial sternotomy, any deformity of the sternum, ribs or vertebra might be a limitation on the feasibility of the procedure and complicate surgical exposure.

In minimally invasive procedures, surgical exposure is the most important step for the feasibility of the operation, as done in conventional cases. Nevertheless, some technical tips and pitfalls are paramount for improving the experience of the surgeon especially in the learning curve. In the initial cases, operation times can be longer than the expected time of the operation. This can relate to limited exposure of the surgical field, manipulation of instruments in a relatively small area and the difficulty of synchronizing the surgeon with the assistant surgeon in a limited space towards the aortic valve.

In a meta-analysis by Murtuza et al.[11] reviewing minimally invasive AVR procedures, although longer cross-clamp and CPB times were observed, a positive effect on the duration of hospital and ICU stay has been reported. Actually, in our initial patients, surgical set-up, exposure after skin incision and valve procedures took a relatively longer time. We believe that, with increased experience, the duration of the surgery may be shortened, leading to shorter hospital and ICU stays in our unit as well. Again, recent studies have suggested that an improvement in these parameters, i.e. length of hospital and ICU stay, may be likely with the development of sutureless valves or valves that can be replaced quickly.[12] Similarly, reports on the intermediate- and late-term outcomes with sutureless valves may increase their use, facilitate valve replacement, and shorten the duration of surgery in minimally invasive procedures with limited surgical exposure.

The operation technique has been described previously,[3-5] but some points need to be clarified. Technically, the sternotomy incision is a J-shape and goes down to the third or fourth intercostal space on the right. The decision of which intercostal space use is made using a chest X-ray or CT image to define the level of the aortic annulus. One of the most important details is to avoid an injury to internal thoracic artery on the right side. Then, the sternum is opened. Pericardial suspension sutures are placed before stabilizing the sternal retractor. Pericardial sutures are placed deep enough and, with a gentle force, they are fixed on the skin. By this way, the aorta and the annulus come towards the surgeon. After starting CPB, a mediastinal chest tube is placed and carbon dioxide insufflation starts using this tube. This is helpful during de-airing maneuvers and while weaning from CPB. At this stage, an additional cannula to superior vena cava or left pulmonary vein can be placed. Transesophageal echocardiography is an essential component of the procedures because the heart is partially seen macroscopically.

A J-sternotomy can be accomplished with the use of widely available surgical material, rendering this technique a more feasible approach. However, even in centers routinely performing J-sternotomy for many years, the reported rates of transition to conventional sternotomy to prevent potential complications vary between 1.8 and 4%.[13] The reasons for such transition are generally categorized into two groups: early and late.[5] The reasons for early transition include porcelain aorta and inadequate surgical exposure, while late transitions are generally due to dissection, bleeding at the cannulation site (internal iliac vein, jugular vein, coronary sinus), bleeding at sites other than the cannulation site (left atrium, aorta), persistent ventricular fibrillation, and formation of thrombi within the left ventricle. In our preliminary series of 18 patients, a need for transition to full median sternotomy occurred in only one patient due to inadequate exposure. This was made to perform a safer and effective removal of annular calcification. In the postoperative period, mediastinal exploration due to bleeding was performed using a full sternotomy in two patients (11.2%) from group JS. The bleeding site was a branch of the right internal thoracic artery in one patient and, in the other patient, was at the aortotomy incision that was controlled primarily.

The cannulation site in minimally invasive AVR procedures has an influence on the occurrence of neurological complications and on the need for transition to open surgery. Initially, femoral artery cannulation was more frequently used in minimally invasive AVR, with a subsequent increase in the use of central aortic cannulation through the J-sternotomy incision.[14] The latter approach has been reported to be associated with a lower incidence of neurological complications. Again, another alternative to femoral vein cannulation, i.e. cannulation through the appendix of the right atrium, is being used increasingly.[15] Similarly, although we performed femoral artery cannulation in our initial cases, now we routinely perform central aortic cannulation, so we can provide a better venous drainage through superior vena cava cannulation in cases with inadequate drainage after a femoral vein cannulation.

In the literature, previous studies have shown that AVR procedures using J-sternotomy have similar clinical results with conventional procedures through median sternotomy.[3-7] Postoperative complications such as AF, bleeding, re-exploration, renal failure or the pericardial effusion rate have been reported to be comparable to conventional operations, as done in our study. Actually, some of the reported superiorities of J-sternotomy include early mobilization, less pain and a decreased hospital stay.[3-7] We believe that with increased experience using the J-sternotomy approach, the difference between the two methods would be in favor of limited incision, rather than a full sternotomy approach. Our results could be a result of the small number of patients in the groups as well as the initial experience of our center.

The only consideration for the surgeon is the exposure. After establishing an adequate control of the surgical field and aortic root, we experienced that removal of the valve or calcifications as well as placement of sutures is feasible. With this approach, some centers routinely perform aortic valve, root and ascending aorta procedures as well as even proximal aortic arch reconstruction.[3-5]

The reported risk of postoperative neurological complications in patients undergoing minimally invasive AVR is 2-3%.[3] Methods such as carbon-dioxide insufflation into the surgical field to prevent air embolisms as well as the use of antegrade root vent and transesophageal echocardiography are important measures to prevent such neurological complications. Another factor associated with increased risk of neurological complications is represented with new-onset AF. In patients undergoing minimally invasive AVR, an incidence of up to 34% has been reported for new-onset AF.[16] In our study, one patient in the J-sternotomy group had left hemiparesis during the early postoperative period and it was medically treated. Again, two patients (11.2%) had new onset AF postoperatively. However, the patient with the neurological complications had no AF.

There are certain conditions limiting the use of minimally invasive AVR. Some surgeons do not perform mini-incisions in patients with severe aortic regurgitation due to left ventricular distention. Nevertheless, surgical expertise clearly correlates with the success of these procedures.[17-19] Venting of the left ventricle can be performed through a left superior pulmonary vein cannulation. This is possible immediately after starting CPB through a limited exposure. And also, selective delivery of antegrade cardioplegia is feasible after exposing the aortic root. Alternatively, in some centers, specially designed percutaneous catheters are inserted through the right internal jugular vein and coronary sinus under transesophageal echocardiography guidance to deliver cardioplegia solutions.[3-5] After our initial experience with minimally invasive surgery with this group of patients, our target is to gain further experience with this approach as to expand its use to include ascending aorta interventions.

Due to limited surgical exposure, minimally invasive AVR is a challenging and stressful procedure for surgeons inexperienced with this technique. Also, minimally invasive surgery involves more technical details. However, with expertise, these challenges can be overcome and in appropriately selected patients, minimally invasive AVR can be accomplished as easily as the conventional methods. Furthermore, several centers reported the use of this approach even for ascending aorta surgery and reoperations after adequate experience had been gained.[3-6]

The limitations of our study include the small sample size, absence of randomization and the short duration of follow-up. This study was a retrospective analysis of prospectively collected data. The decision to perform AVR in each case was made by reviewing the general patient status, anatomical considerations and at the discretion of the attending surgeon. There

may be a limitation on preoperative selection of patients who were candidates for AVR.

In conclusion, a minimally invasive procedure for aortic valve replacement using a J-sternotomy incision is a safe and reproducible procedure. The use of a minimally invasive aortic valve replacement technique does not lead to a higher incidence of postoperative complications and mortality. We believe that this procedure can be increasingly used in cardiac surgery to decrease surgical trauma and associated complications.

Declaration of conflicting interests

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Case Report Open Access

A giant intrathoracic right subclavian artery aneurysm: a case report

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ABSTRACT

Aneurysms of the subclavian artery are extremely rare in the clinical setting. Intrathoracic segmental aneurysms of the subclavian artery can occur secondary to atherosclerosis, cystic necrosis of the tunica media, trauma or infections. Open surgical repair is one of the main treatment choice. However, in case of intrathoracic segment involvement, it commonly necessitates a more invasive surgical approach with sternotomy or high lateral thoracotomy. Herein, we present a 40-year-old male case with an expanding pulsatile mass throughout the right neck and dysphonia due to recurrent laryngeal nerve palsy. Computed tomography demonstrated an 8.5 cm in size proximal right subclavian artery saccular aneurysm with partial thrombosis. On angiography, the aneurysm was originating from about 1 cm after the origin of the right subclavian artery. As the aneurysm was very close to the brachiocephalic bifurcation, open surgical repair via a right supraclavicular incision with mini-sternotomy was performed. Pathological report of the aneurysmal sac was consistent with cystic medial degeneration.

Keywords: Subclavian artery; surgery; thoracic aneurysm.

Aneurysms of the subclavian artery, which are rarely seen in the clinical setting, represent less than 1% of all aneurysms.[1] Subclavian artery aneurysms are classified based on their anatomical locations which typically reflects the etiology as intrathoracic and extra-thoracic aneurysms.[2] Those in the extrathoracic site are more common and about three-quarters of aneurysms at this site are related to thoracic outlet syndrome or to previous injuries.[3] Intrathoracic segmental aneurysms of the subclavian artery can occur secondary to atherosclerosis, cystic necrosis of the tunica media, trauma or infections.[2,5] Open surgical repair is the one of the treatment option; however, in case of intrathoracic segment involvement, it necessitates a more invasive surgical approach with sternotomy or high lateral thoracotomy. Herein, we present a case with an expanding pulsatile mass throughout the right neck and dysphonia due to recurrent laryngeal nerve palsy.

CASE REPORT

A 40-year-old man was admitted with a three-month history of pulsatile mass on his right neck and progressive dysphonia. His medical history did not reveal any chest trauma or pulmonary infection. On admission, his vital signs were normal and blood pressure was equal on both arms. His laboratory test results were nonspecific. His chest X-ray demonstrated a superior mediastinal mass with a deviated trachea from the midline. The laryngoscopic findings confirmed a right vocal cord palsy and hoarseness, which were considered to be due to recurrent laryngeal nerve palsy. Computed tomography demonstrated an 8.5 cm in size proximal right subclavian artery saccular aneurysm with partial thrombosis (Figure 1). On angiography, the aneurysm was originating from about 1 cm after the origin of the right subclavian artery. Arcus aortography also revealed a saccular aneurysm beginning near the subclavian origin As the aneurysm was very close to the brachiocephalic bifurcation, open surgical repair via right supraclavicular incision with mini-sternotomy was planned. A written informed consent was obtained from the patient.

Repair of the aneurysm was performed through an incision with partial upper sternotomy (J-shaped incision to the upper third of the sternum) and the incision curved to right supraclavicular region with a 6 cm transverse skin incision (Figure 2).

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Figure 1. Computed tomography showing an 8.5 cm in size proximal right subclavian artery saccular aneurysm with partial thrombosis.

The ascending aorta and innominate artery were exposed, and the subclavian artery was dissected above the supraclavicular region. The aneurysmal sac was, then, dissected from the surrounding tissues. The right common carotid artery was tightly adhered to the aneurysmal sac and the right common carotid artery was carefully separated from the aneurysm.

Afferent and efferent loops of the aneurysm were dissected and secured. The aneurysm cavity was about 8x8x7 cm in size. After clamping, the aneurysm sac was opened. It was partially thrombosed and the origin of vertebral artery was able to be saved. Graft interpositioning between the proximal and distal parts of the subclavian artery was considered. As the vascular tissue was fragile, dissection was performed on the proximal part of the subclavian artery during the graft anastomosis. The dissection was progressed to the truncus of the brachiocephalic artery. We occluded the brachiocephalic artery at its origin on the arcus aorta.

The distal part of the subclavian artery was, then, interposed to the ascending aorta by an 8 mm in size expanded polytetrafluoroethylene (ePTFE) graft. Proximal anastomosis was done to the ascending aorta easily by a side biting clamp. Common carotid artery was separated from the innominate artery at its origin. The distal end of the carotid artery was also anastomosed to the graft by end-to-side technique (Figure 3). Pathological report of the aneurysmal sac was consistent with cystic medial degeneration, a rare cause of an intrathoracic subclavian aneurysm (Figure 4). The microscopic findings were the basophilic ground substance in the media and disruption of the elastic lamina. Repeated digital subtraction angiography revealed a patent subclavian graft and carotid artery flow (Figure 5).

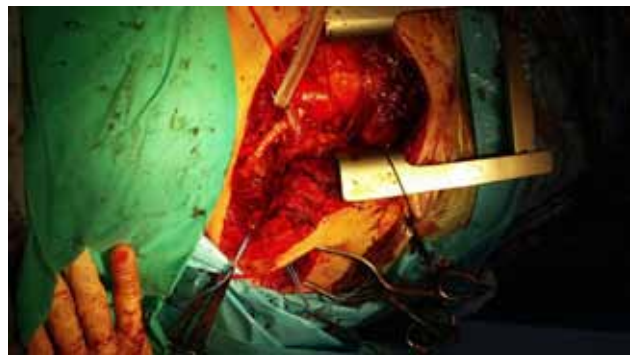

Figure 2. An intraoperative image showing mini-sternotomy and right supraclavicular incision.

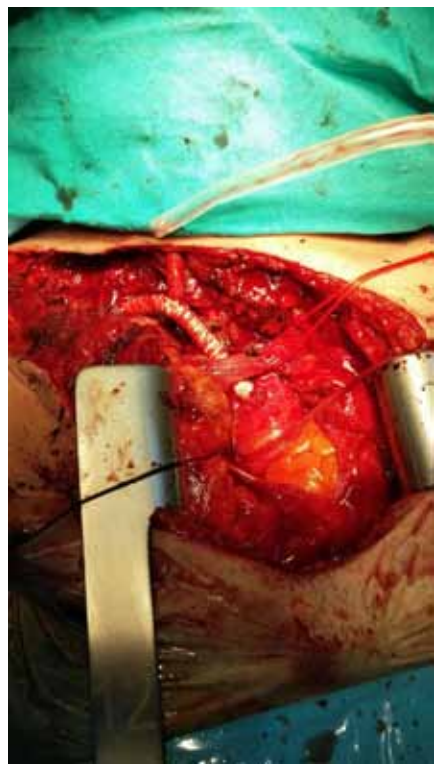

Figure 3. Subclavian artery graft and native carotid artery.

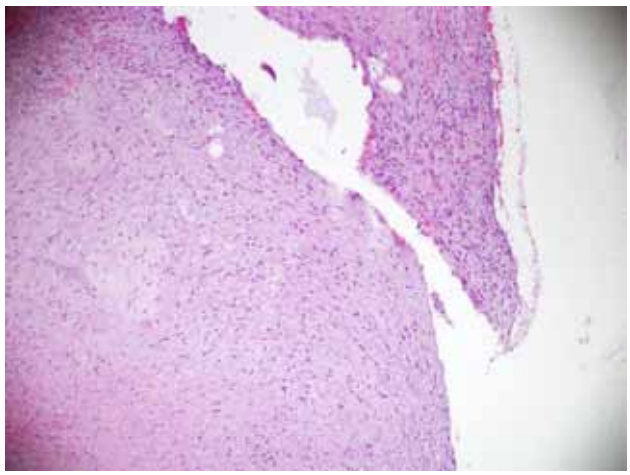

Figure 4. Pathology report of an aneurysmal sac consistent with cystic medial degeneration. Basophilic ground substance in the media and disruption of the elastic lamina.

DISCUSSION

Aneurysms of the subclavian artery accounts for about %1 of all peripheral arterial aneurysms.[1,2] In a literature review, Hobson et al.[13] identified 195 cases of aneurysms and found only 1% of all peripheral aneurysms originated from the subclavian artery. The aneurysms can be classified in terms of location on the subclavian artery, as extrathoracic and intrathoracic.[2] While the aneurysms of extrathoracic subclavian artery are mostly related to thoracic outlet syndrome or to previous injuries (iatrogenic), intrathoracic aneurysms are mainly due to atherosclerosis or less often seen with cystic medial degeneration, Ehler Danlos syndrome, Marfan's syndrome, giant cell arteritis, Takayasu's arteritis, infection, or injuries.[5,7] Herein, we discuss the surgical management of a young and non-atherosclerotic, vasculopathy in a case with a giant intrathoracic right subclavian artery aneurysm, as a rare pathological cause of intrathoracic subclavian aneurysms.

Although intrathoracic aneurysms of the subclavian artery are often asymptomatic, they may present with symptoms caused by compression or acute aneurysm expansion, such as upper chest or shoulder pain, tumor body can erode the apex of the lung may cause hemoptysis, compression to the recurrent laryngeal nerve resulting in hoarse voice; however, dyspnea caused by trachea compression is seldom reported.[5] Distal embolization to the upper limb and ischemia is an unusual complication.

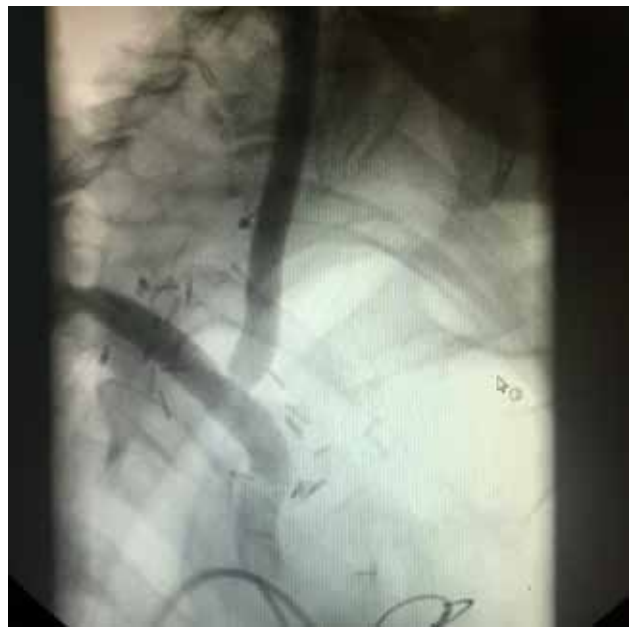

Figure 5. Postoperative digital subtraction angiography showing a patent subclavian graft and carotid artery flow.

Aneurysms of extrathoracic subclavian artery most commonly presents with a pulsatile mass in the superior fossa and is often tender.[6] Brachial plexopathy and distal embolization are complications of the extrathoracic aneurysms.[3,4,6]

Elective surgical repair is the treatment of choice for most subclavian aneurysms, as they have an increased risk of rupture, embolization, thrombosis, and other complications.[1,7,9] Surgical approach for aneurysms of the left subclavian artery, a left-side lateral thoracotomy is used, for aneurysms on the right subclavian, are best approached by median sternotomy, improved control of the ascending aorta and the aneurysm's neck can be achieved with sternotomy with or without a supraclavicular incision and the sternoclavicular joint may or may not be disarticulated.[4,10] The resection of the aneurysm is preferred to simple ligation, as continued growth and rupture of ligated aneurysms have been reported.[8,9] Soylu et al.[10] reported a case presented with an intrathoracic giant subclavian artery aneurysm and the performed sternotomy and bypass with aortoasubclavian graft procedures successfuly.

We preferred combined mini-sternotomy and supraclavicular incision, as a safe and acceptable method for such young and non-atherosclerotic vasculopathy suspected patients. Fragile vasculature due to the connective tissue abnormality may cause

some technical challenges during the operation, as in our case. Recently, as a less invasive alternative to surgical repair, endovascular stent grafting has become possible. However, it necessitates an acceptable proximal and distal neck, which serves as a proximal and distal landing zone for the stent graft. On the other hand, the upper extremity has an extensive collateral circulation which may lead to a potential risk for leakage during endoluminal treatment.[11,12] Therefore, surgery still the standard treatment of choice in the literature in such cases. In our case, pathological report of the aneurysmal sac was reported as cystic medial degeneration and supported our suspicion for vasculopathy and open surgery decision.

In conclusion, surgical treatment should be preferred for young and non-atherosclerotic vasculopathy suspected patients. Aneurysmectomy in conjunction with graft interposition via mini-sternotomy and right supraclavicular incision is a safe and precautionary approach in such cases.

Declaration of conflicting interests

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Cardiovascular Surgery and Interventions

Case Report Open Access

Iliac vein perforation caused by an ultrasound-accelerated thrombolysis catheter: An unusual complication of EKOS EndoWave

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ABSTRACT

EKOS EndoWave system is an ultrasound-accelerated catheter-directed thrombolysis device designed for the treatment of deep vein thrombosis. This system acts by emitting ultrasonic waves that enhance the diffusion of the simultaneously administered thrombolytic infusion inside the clot. EKOS operates inside the thrombosed veins and is categorized as such among the group of pharmaco-mechanical thrombolysis devices. In this article, we present a case of an iliac vein perforation and extravasation of the EKOS EndoWave system that has not been encountered in the current practice thus far.

Keywords: Catheter-directed; complication; deep vein thrombosis; thrombolysis; ultrasound-accelerated.

Deep venous thrombosis (DVT) and pulmonary embolism (PE) can develop as a complication of venous thromboembolism (VTE). Venous thromboembolism-associated morbidity and mortality are frequently seen during everyday life and hospital stays.[1] The primary therapy for the VTE is oral or parenteral anticoagulation medication provided there is no contraindication.[2] After the initial anticoagulation medication, maintenance treatments should be administered to prevent recurrences, embolism and postthrombophlebitic syndrome (PTS). With proper treatment, the spontaneous lysis and recanalization rate of the thrombus can be as low as 10% in proximal (iliofemoral and iliocaval) DVT.[3] Likewise, administration of systemic thrombolysis therapy can constitute a risk of major bleeding not strictly restricted to the thrombotic area.[4] Catheter-directed ultrasound-enhanced thrombolysis devices provide a combination of the local thrombolytic infusion together with a mechanical thrombolysis action.[5] In this article, we presented an unusual case with an iliac vein perforation and extravasation of an operating ultrasound-enhanced thrombolysis catheter following a sudden movement of thigh hyperflexion.

CASE REPORT

A 39-year-old male was admitted to the emergency department with a complaint of pain and swelling in his left leg. His symptoms had been present for the last week and had progressively gotten worse. On inspection, his left thigh circumference was remarkably larger than the right. On physical examination, his left thigh was tender to the touch, and there was a moderate pretibial edema with intact peripheral pulses. He was unable to stand and also unable to bend his left leg. Color Doppler ultrasound examination revealed a DVT starting from the popliteal vein proceeding upwards to the common iliac vein. After diagnosis as a subacute DVT, the patient decided to be treated with an ultrasound-enhanced catheter-directed thrombolysis system (EndoWave System, EKOS Corporation, Bothell, WA, USA). A written informed consent was obtained from the patient.

The patient was taken to the operating room, and he layed in a prone position. The left popliteal vein was accessed percutaneously by 7F sheath via Seldinger technique under local anesthesia. An ultrasound was used to facilitate the percutaneous access. A 0.035-inch hydrophilic guide wire (Terumo Corporation, Shibuya-ku, Tokyo, Japan) was progressed to the inferior vena cava through the thrombotic segment. The infusion delivery catheter was advanced over the wire until the tip of the catheter passed through the thrombotic section. The guide wire was removed and

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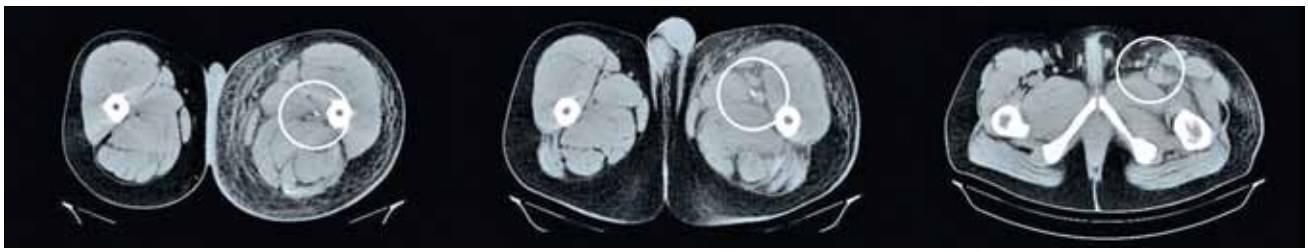

Figure 1. Computed tomography angiography scans showing the upward course of the EKOS EndoWave catheter from the popliteal vein to the common femoral vein. Note the subcutaneous changes of the left leg caused by the edema.

the microsonic ultrasound core containing multiple ultrasound transducers was inserted into the delivery catheter. The infusion of the lytic drug (Actilyze) started in the ultrasonic core. The whole process was overseen using the C-armed fluoroscopy.

After the implantation of the ultrasound-enhanced catheter, he was taken to the in-patient ward where he spent the next 24 hours in the EKOS EndoWave System operation. However, after 10 hours of the ultrasound-enhanced catheter-directed thrombolysis process, he started to feel a burning and piercing pain in his left lower abdominal wall. On anamnesis, he described a sudden involuntary movement of hyperflexion of the left thigh while asleep during the night. On physical examination, his lower left abdomen was tender, and he was feeling increased pain during external compression. The ultrasonic catheter was immediately stopped, and a computed tomography (CT) scan was performed to visualize the course and the tip of the catheter. The course of the catheter was normal until the external iliac vein (Figure 1). However, the anteroposterior plain X-ray and CT views revealed that the catheter had ripped during its route perforating the iliac vein and had advanced into the rectus abdominalis muscle (Figure 2). The transverse slices of the CT showed that the extravasation point was somewhere at the external iliac vein level (Figure 3). The EKOS EndoWave catheter system was entirely withdrawn and removed. The patient's abdominal pain instantly faded away.

The abdominal examination was repeated with frequent intervals so as not to miss an intraabdominal

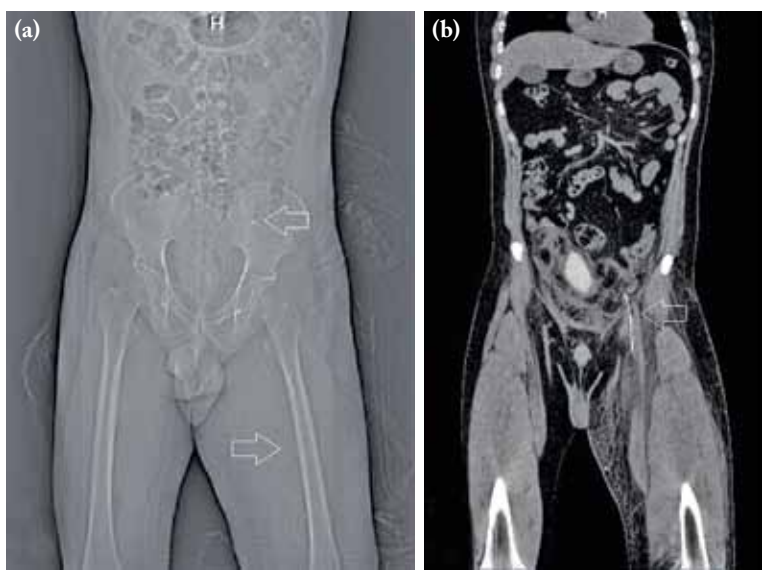

Figure 2. Plain anteroposterior roentgenogram showing the course of the EKOS EndoWave catheter. **(a)** Note the upper arrow that points to the extravasated tip of the catheter. **(b)** The computed tomography is showing a segment of the EKOS EndoWave catheter inside the iliac vein.

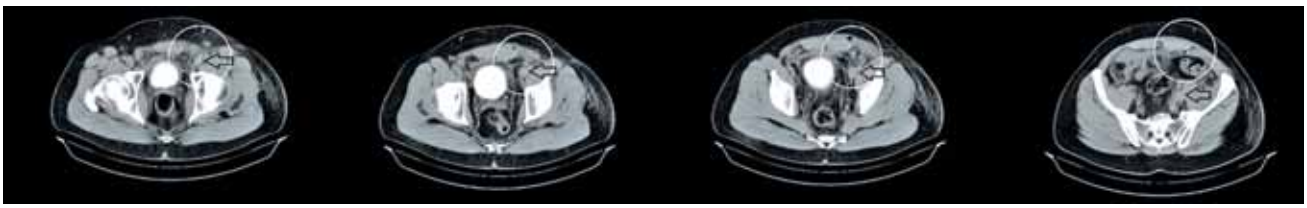

Figure 3. Consecutive slices of the computed tomography angiography showing the course of the EKOS EndoWave catheter during the extravasation from the iliac vein. Note the arrows are pointing at the iliac vein. The circles are showing the route the catheter tip took while passing out of the iliac vein into the abdominal wall.

bleed. The patient's total blood count was monitored for the detection of blood loss through the perforated iliac vein wall. Fortunately, no physical or hemodynamic changes implicating an active hemorrhage were observed. The patient was mobilized 12 hours later with no tenderness or hematoma on his abdominal wall.

Since the ultrasonic treatment was left undone, an intravenous (unfractionated heparin 15 IU/kg/h) and oral (calcium dobesilate and warfarin) medication was continued for 10 days until a regression of the symptoms was observed. After the recession of symptoms, the patient was discharged with a scheduled future follow-up. Oral warfarin (5 mg/day) was prescribed to keep the international normalized ratio (INR) between 2.0 to 2.5.

DISCUSSION

Massive DVT and the PE are life-threatening conditions associated with a high incidence of fatalities comparable to that of acute myocardial infarction. Its clinical course can vary from a mild leg edema to a prolonged hospitalization with lifelong morbidity related to the PE and cardiopulmonary dysfunction or even mortality.[6] The conventional treatment for acute DVT is immediate anticoagulation with low-molecular-weight heparin or unfractionated heparin. It is then followed by an oral anticoagulation with warfarin for three to six months.[5] This treatment aims to prevent thrombus propagation and to reduce the risks of PE and DVT recurrence. Although anticoagulation with unfractionated or low-molecular-weight heparin followed by long-term warfarin therapy is widely regarded as the gold standard, this treatment does not provide a significant fibrinolytic activity in the patients with severe, extensive, proximal DVTs who have a high risk of developing subsequent PE or a PTS.[6]

Different treatment modalities have been used in patients with massive DVT or PE, including the systemic anticoagulation, surgical embolectomy, catheter directed thrombolysis, and percutaneous mechanical thrombectomy.[6] Prior to the invention of catheter-based interventional techniques, anticoagulation was the only therapeutic modality used in massive DVT. However, anticoagulation has no direct thrombolytic effect.[7] As a result, anticoagulation-based DVT treatments often do not restore the venous patency, causing permanent damage to the venous valves.[5] In addition, eventual venous stenoses are predisposed to recurrent thrombosis and may cause May-Thurner syndrome if left untreated.[4] The combination of venous obstruction and venous reflux significantly increases the risk of PTS. However, catheter-directed mechanical thrombolysis can remove the thrombus and restore the venous patency and may prevent a recurrent thrombosis, PE or PTS.[6]

The EKOS EndoWave Infusion Catheter System (EKOS Corporation, Bothell, WA) is a catheter directed thrombolysis in which the fibrinolytic process acceleration is done via ultrasound waves. The EndoWave System, produced by EKOS Corporation, consists of a 5.2 F, 106-cm-long infusion catheter, an ultrasound treatment core catheter, and a control unit with the interface cables. A series of laser-cut microinfusion pores are located along the external infusion catheter for the delivery of the thrombolytic drug. The core catheter consists of microsonic transducer elements (2 MHz, 0.45 W) that were distributed evenly 1.0 cm apart from each other along its leading tip. They deliver the ultrasound energy radially along the coaxial infusion zone. The microinfusion pores are positioned to optimize the interaction with the corresponding ultrasound transducers. This improves the efficiency of the thrombolytic process and it decreases the treatment time and the administered lytic dose. Moreover, the overall expense and the

risk of associated complications such as bleeding are reduced.[8]

This extravasation of the catheter by perforating the iliac vein was the first such complication of the EKOS EndoWave system encountered thus far and no similar case was found in the recent literature. The probable mechanism is thought to be mechanical. A sudden flexor movement of the thigh might have conducted a direct force to the catheter. This axial force might have caused a forward displacement of the whole catheter. As a result, the bare tip of the catheter displaced and ripped the iliac vein and went outside through the abdominal muscles.

As a conclusion, EKOS EndoWave catheters should always be secured to avoid sudden movements of the implanted limb. Elevation of the leg or the body should be restricted to a particular angle that does not disturb the alignment of the catheter inside the vein. If movement of the patient becomes inevitable, the system should be temporarily shut down. If an iliac vein injury occurs during the catheter-based thrombolysis, the catheter should be withdrawn immediately, and the administration of anticoagulant or thrombolytic agents should be stopped as soon as possible. The patient's blood count should be monitored, and an abdominal examination should be repeated at short intervals during the first 24 hours.

Declaration of conflicting interests

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Cardiovascular Surgery and Interventions

Case Report Open Access

Congenital cleft of right atrioventricular valve in partial atrioventricular canal defect: a rare entity

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ABSTRACT

A cleft of the right atrioventricular valve is an extremely rare congenital entity. Herein, we report a case of 15 year old female diagnosed with primum atrial septal defect with cleft in both left and right atrioventricular valves. This diagnosis was obtained using an echocardiography. Surgical closure of the clefts of the left as well as the right atrioventricular valves was completed with a closure of the primum atrial septal defect. We will discuss the morphology, diagnostic modalities and management guidelines for this rare entity.

Keywords: Cleft right atrioventricular valve; echocardiography; partial atrioventricular canal defect; right atrioventricular valve insufficiency.

A congenital cleft of the right atrioventricular (AV) valve is very rare. It may or may not be associated with other cardiac anomalies.[1-3] The most commonly associated congenital cardiac anomalies are atrial septal defect (ASD), ventricular septal defect, and tetralogy of Fallot.[1-3] In this article, we report a case diagnosed partial atrioventricular canal defect, moderate left and right atrioventricular valve regurgitation. Diagnosis was obtained with echocardiography and surgical closure of the cleft in left and right atrioventricular valve was done with closure of primum ASD. We discuss here morphology, diagnostic modalities and management guidelines for this rare entity.

CASE REPORT

A 15-year-old female was referred to our outpatient department with a history of dyspnea New York Heart Association (NYHA) class II and a recurrent respiratory tract infection. Upon physical examination, there was a grade 2/6 pansystolic murmur at the apex and the subxiphoid area. The second heart sound was loud with wide and fixed split. The chest X-ray showed a cardiothoracic ratio of 0.6, with an enlarged right atrium and main pulmonary artery. The electrocardiogram showed deviation of the sinus rhythm in the left axis. The two dimensional echocardiography revealed: situs solitus, levocardia, normal pulmonary venous drainage and interrupted inferior vena cava (IVC) with hemiazygos continuation. It also showed dilated coronary sinus, ostium primum and an ostium secundum defect Furthermore, they discovered a left to right shunt, a cleft in the anterior left AV leaflet with mild and moderate regurgitation, a moderate right AV valve regurgitation and a cleft in the right AV valve. (Figure 1).

The right ventricular systolic pressure (RVSP) was 35 mmHg, showing normal biventricular function. The patient was taken up to surgery and the intraoperative findings showed the cardiomegaly in the left superior vena cava was draining into the dilated coronary sinus. Large primum ASD, complete cleft in left AV valve leaflet with moderate regurgitation, complete cleft in right AV valve with moderate regurgitation. The cleft in the left AV valve was sutured with interrupted 5-0 polypropylene sutures. The primum ASD was closed with an autologous untreated pericardial patch which keeping the coronary sinus on the right atrial side. The cleft in the right AV valve was repaired with 5-0 polypropylene suture (Figure 2). The posterior right AV valve annuloplasty was done using 4-0 polypropylene pledgeted suture.

The intraoperative transesophageal echocardiography revealed no residual shunt in the trivial left and right AV valve regurgitation and good biventricular function. The postoperative course

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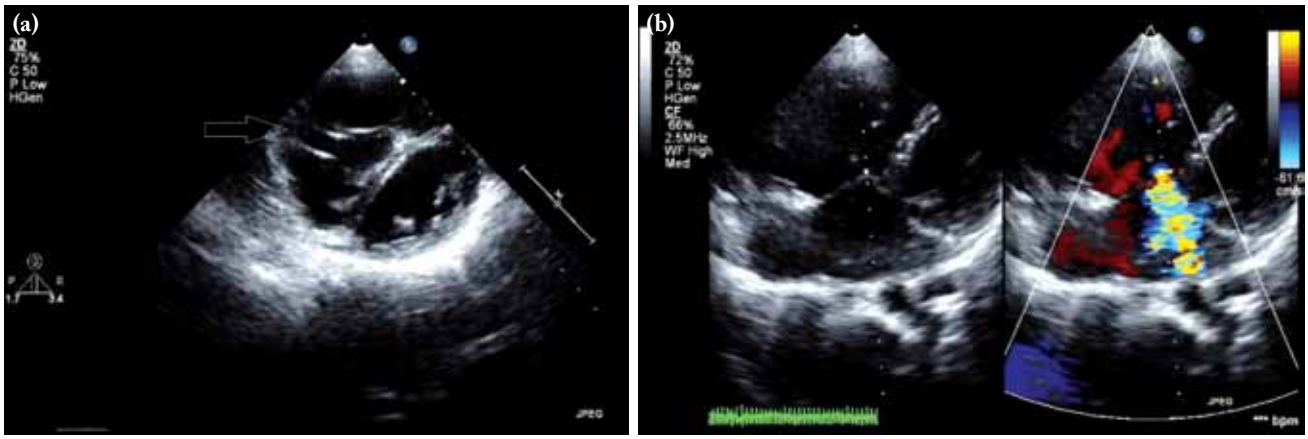

Figure 1. Transthoracic echocardiography. **(a)** Parasternal short axis view showing, a cleft in the right atrioventricular valve (Arrow). **(b)** Apical four chamber view showing a well coapted right atrioventricular valve with moderate regurgitation.

was uneventful. The transthoracic echocardiography before discharge showed, there was not any residual ASD, trivial left and right AV valve regurgitation, RVSP 22 mmHg, mild right ventricular dysfunction, no pericardial effusion, and normal left ventricular function.

During the three-month follow-up appointment, the patient was in NYHA class I, and the echocardiography showed, no residual shunt or trivial left and right AV valve regurgitation. There was good ventricular function. A written informed consent was obtained from the patient.

DISCUSSION

The cleft of the left AV valve is a well known entity and it is most commonly associated with atrial and ventricular septal defects, endocardial cushion defects, transposition of the great arteries and even as isolated anomalies.[1] In contrast, an isolated congenital tricuspid cleft is a rare condition.[1-3]

The so-called ostium primum defect is an AV septal defect found in a common AV junction, but in which the fused bridging leaflets of the common AV valve are also fused to the scooped-out crest of the ventricular septum. As a result, shunting across the AV septal defect occurs only at atrial level.[4] These leaflets, irrespective of whether they guard a common AV orifice or separate orifices for the right and left ventricles, bear scant resemblance to the arrangement of the leaflets of the normal mitral and tricuspid valves.[4]

In the currently accepted definition of the cardiac morphology, it is true that the partial AV canal defect

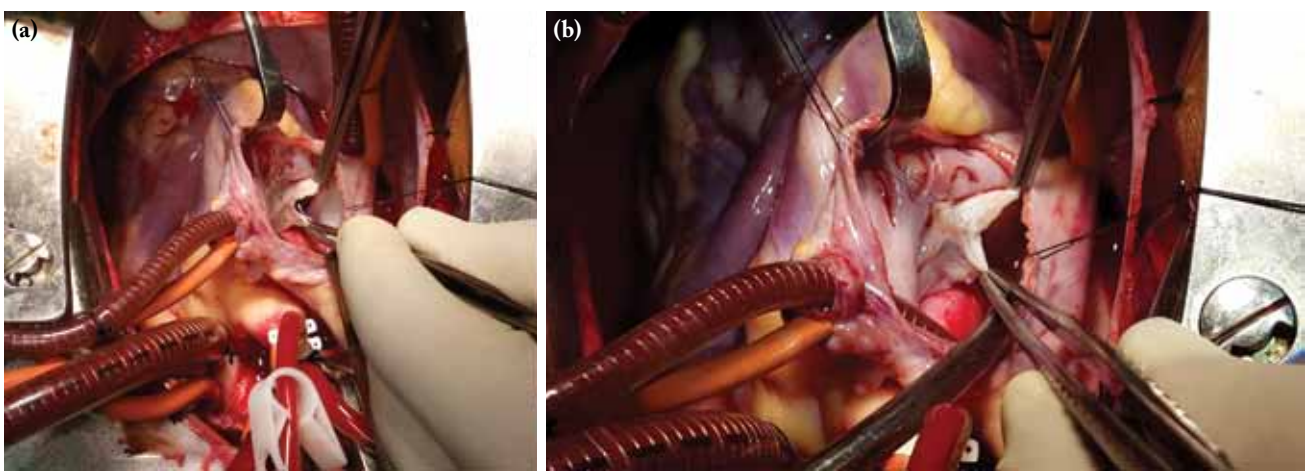

Figure 2. Intraoperative pictures. **(a)** Complete cleft of a right atrioventricular valve. **(b)** A suture closed cleft.

will have two separate AV valves although they will not always be well defined. The right AV valve can have three or four cusps depending on the degree of fusion between the anterior and posterior bridging leaflets. If these leaflets are completely fused we can observe a "right atrioventricular valve" made of three cusps namely the fused superior and inferior bridging leaflet, the right anterosuperior leaflet and the right mural leaflet.[4] Unlike with the cleft left AV valve, the cleft right AV valve does not produce severe symptoms because of the low pressure of the right ventricle and so this condition is often underdiagnosed and it can be associated with other congenital anomalies.[1-3]

Eichhorn et al.[1] first reported a 0.6% incidence of right AV valve cleft in patients with a diagnosis of congenital heart disease, and a 0.018% isolated cleft causing right AV valve regurgitation. Embryologically, the right AV valve develops from the inner wall of the right ventricle, by a process called undermining. Eichhorn et al.[1] described two theories. First, the right AV valve cleft, develops where the lateral endocardial cushion meets the right dorsal conus swelling. Therefore, the cleft might be the result of an anomalous fusion. Second, defective undermining process lead to variable anatomic structure of the right AV valve which may lead to the formation of cleft. Variability makes it difficult to differentiate a cleft from additional valves[1,2]

The anomalous fusion theory is the most widely accepted theory for complete cleft especially when a partial AV canal defect or endocardial cushion defect is present. The clinical features depend on the severity of tricuspid regurgitation and the associated congenital cardiac anomalies. Most patients commonly have right heart failure and supraventricular arrhythmias. At cardiac auscultation, a grade 2-3/6 holosystolic murmur is audible along with evidence of an associated cardiac malformation. The electrocardiography often demonstrates a right heart volume overload or right bundle branch block, or both. In most cases, the chest X-ray film shows marked enlargement of right-sided heart chambers without signs of pulmonary venous congestion. An echocardiography is the diagnostic tool used for this rare anomaly. Two and three dimensional transthoracic as well as transesophageal echocardiography can delineate this anomaly.[3]

The most common findings are a visible cleft in the right AV valve and a regurgitation jet in well aligned right AV valve leaflets. If the alignment deformity or prolapse is visible, it may be associated with a congenitally malformed valve and a cleft is very difficult to find in such a scenario. In this case, surgical closure of the cleft with or without a suture or a ring annuloplasty is the treatment of choice.[1,2] The ultimate decision depends on the severity of the right AV valve regurgitation and the associated congenital anomaly. Isolated mild AV valve regurgitation doesn't require any surgical treatment but the mild regurgitation associated with congenital cardiac anomaly requires correction of the anomaly with the closure of the cleft. For moderate or severe regurgitation some sort of annuloplasty technique will help in the long-term results.

In conclusion, the cleft of the right atrioventricular valve is a rare congenital anomaly. It is probably a result of a malformation of the right atrioventricular valve which occurred during embryologic morphogenesis. The diagnosis is easily made with an echocardiography. In most cases, the treatment of choice is surgical reconstruction of the deficient leaflet with or without suture or ring annuloplasty.

Declaration of conflicting interests

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Cardiovascular Surgery and Interventions

Case Report Open Access

Quadricuspid aortic valve: a word of caution!

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ABSTRACT

Quadricuspid aortic valve is a rare cardiac malformation that usually appears as an isolated anomaly. It may cause either pure regurgitation or regurgitation accompanied by stenosis. Herein, we report a 54-year-old male patient who was referred to us for the surgical management of severe aortic valve regurgitation. Although preoperative echocardiography showed tricuspid aortic valve, we detected quardicuspid aortic valve intraoperatively. Aortic valve was replaced with great caution to the coronary ostia and conduction system. Postoperative course was uneventful. As quadricuspid aortic valve might be encountered incidentally during surgery, surgeons should be aware of anatomical difficulties with this morphology.

Keywords: Mechanical valve; quadricuspid, aortic valve; valve replacement.

Quadricuspid aortic valve (QAV) is a rare developmental cardiac anomaly. Its estimated incidence is 0.0031-0.043% of all congenital heart diseases.[1] It usually appears as an isolated anomaly; however, several other malformations may accompany, the most common being coronary artery ostial anomalies.[1,2] Advances in diagnostic modalities enabled us to diagnose this anomaly with using noninvasive techniques; however, most of the reported cases have still been diagnosed incidentally at autopsies or during cardiac surgery.[2] It frequently leads to aortic regurgitation or aortic stenosis with regurgitation and eventually requires surgery. Therefore, prompt detection is of utmost importance in this population.

CASE REPORT

A 54-year-old man was admitted to our clinic for aortic valve replacement. His medical history revealed acute rheumatic fever at the age of 12 years. He was New York Heart Association (NYHA) class II. Transthoracic echocardiography showed severe aortic regurgitation and mild mitral regurgitation with a left ventricular end-diastolic diameter of 56 mm and an ejection fraction of 69%. Aortic valve was reported as tricuspid and heavily calcified. Preoperative coronary angiography revealed normal coronary arterial anatomy with mild atherosclerosis. Aortic root angiography confirmed severe aortic regurgitation. Elective surgery was planned for the valve replacement. A written informed consent was obtained from the patient.

Following a median sternotomy, cardiopulmonary bypass was initiated with aortic and single atrial cannulation. Following antegrade cardioplegic arrest, a transverse aortotomy was made and aortic valve was inspected. As opposed to preoperative echocardiography, aortic valve was quadricuspid with mild thickening and calcification. The valve had one large, two intermediate and one small cusp (Type D in Hurwitz and Roberts' anatomical classification). Accessory cusp was located between the right and left coronary cusps (Figure 1). There was no abnormality regarding coronary arteries. Native valve was excised and a 25 mm mechanical bileaflet valve was implanted. Postoperative period was uneventful and he was discharged in the fifth postoperative day. Follow-up echocardiography revealed that the valve was functioning well, the left ventricular dimensions and functions were preserved.

DISCUSSION

Among patients undergoing aortic valve replacement, the incidence of QAV ranges from 0.55% to 1.46%.[2] Since QAV is not considered in the differential diagnosis of aortic valve regurgitation, preoperative diagnosis with transthoracic echocardiography

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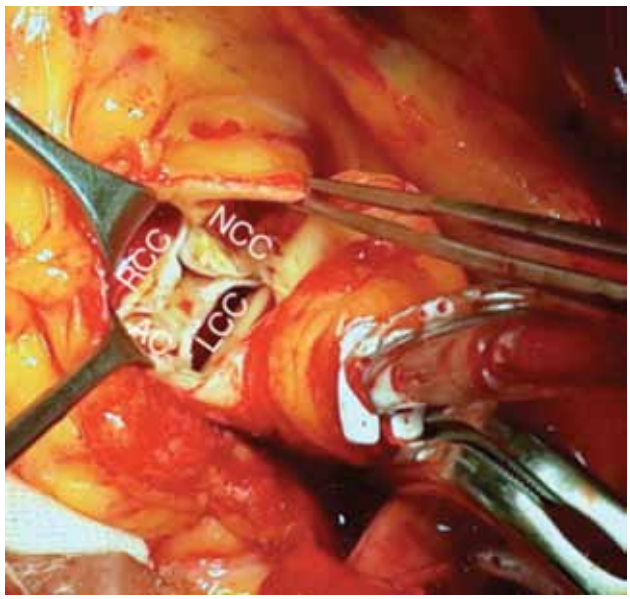

Figure 1. Accessory cusp (AC) located between right coronary cusp (RCC) and left coronary cusp (LCC). Note that non-coronary cusp (NCC) is large, RCC and LCC are intermediate, and the accessory cusp is small (Type D).

is highly challenging. In a series of 627 patients undergoing aortic valve surgery, only three QAV cases were encountered and none of them had been diagnosed preoperatively.[1] Therefore, authors concluded that real-time three-dimensional transesophageal echocardiography might be helpful in diagnosis.

Hurwitz and Roberts' anatomical classification is the most commonly used systematization tool, which classifies QAV into seven types depending on the relative size of the valve leaflets (Type B is the most common). The most common positions of the accessory cusp is between the right and non-coronary cusps.[3] Our case is unique and extremely rare considering the size and positional classification of QAV (Type D and accessory cusp between right and left coronary cusps).

Review of the literature revealed that several cardiac abnormalities may coexist with QAV: anomalies of the coronary arteries, ventricular septal defect, patent ductus arteriosus, and pulmonary valve stenosis. As one of the most common accompanying anomaly, displacement of the coronary ostia has been reported in approximately 10% of cases.[1,3] From the surgical point of view, it is critical to inspect each coronary ostium to prevent ostial obstruction at the time of valve surgery. In our case, no accompanying ostial anomaly was detected.

Another pitfall for surgeon is the downward displacement of the annulus in QAV setting, which may cause complete heart block during valve replacement.[4] In this case, it is recommended to place supra-annular sutures, which lie anteriorly high within the membranous septum. We also placed valve sutures high in between non-coronary and right coronary cusps in our case. The patient had no rhythm disturbances during the postoperative course.

Despite aortic valve replacement for QAV is a traditional treatment of choice for patients with aortic regurgitation, there are only few reports utilizing aortic valve repair techniques (tricuspidization or bicuspidization) in QAV cases.[5] Short-term results are satisfactory; however, further studies and continued follow-up are warranted to elucidate long-term results.

In conlusion, cardiac surgeons keep in mind that QAV is a rare developmental anomaly but possesses low risk in terms of surgical outcome.

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Cardiovascular Surgery and Interventions

Case Report Open Access

Surgical removal of a fractured balloon catheter from deep femoral artery: a case report

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ABSTRACT

An intravascular fracture of balloon catheters during peripheral catheterization is uncommon. This is a rare, but a serious complication of interventional procedures, which may lead to bleeding or lower limb ischemia and require an emergency surgical intervention. Herein, we present a 71-year-old male case in whom a balloon catheter was broken inside of the deep femoral artery and retrieved surgically. A broken and entrapped catheter is one of the extraordinary complications in this type of applications. Fortunately, it is seen rarely and treated either interventional or surgical techniques.

Keywords: Deep femoral artery; fractured balloon catheter; pseudoaneurysm.

The percutaneous interventions are commonly used in the treatment of peripheral vascular diseases. There is a number of complications related to these procedures. A fractured segment of angioplasty balloon catheter in a peripheral artery is one of them. Herein, we report a case in whom a balloon catheter was broken inside of the deep femoral artery and retrieved surgically.

CASE REPORT

A 71-year-old man was admitted our hospital with a pain on the right inguinal area for a month after a coronary intervention via the right femoral artery. Doppler ultrasound confirmed a pseudoaneurysm originating from the deep femoral artery, which was measured 100x70x50 mm in size. An endovascular treatment was planned. The interventionists placed a covered stent across the hole in the arterial wall to prevent blood flow from the deep femoral artery to the pseudoaneurysm sac. However, it broke down from the neck during retrieval of the balloon catheter. The interventionists tried several attempts to snare it out; however, all attempts failed. The patient was referred to us for surgery. A written informed consent was obtained from the patient. Following the skin incision, a large hematoma was seen and, then, drained. The common femoral artery and distal portion of the deep femoral artery were freed with careful dissection and nylon tapes were placed around the vessel (Figure 1). The broken end of the balloon catheter was seen into the deep femoral artery and removed (Figure 2). The artery was, then, repaired with 6-0 prolene sutures. The procedure was performed under local anesthesia. After surgery, the patient was followed for three days in the ward and, then, he was discharged.

DISCUSSION

The percutaneous interventions are routinely being used worldwide for the management of peripheral vascular diseases such as stenosis, arteriovenous fistulas or pseudoaneurysm. However, there is a number of complications which may arise during this process. A fractured segment of angioplasty balloon catheter in a peripheral artery poses the risk of undesired complications, such as bleeding or acute embolism, leading to lower limb ischemia.[1]

Non-surgical retrieval of broken catheters has been reported and most of them were totally localized in the intravascular space.[2,3] Earlier, ultrasound was used to show the location and size of any radiolucent foreign body and percutaneous retrieval of non-opaque foreign bodies were carried out under the ultrasound guidance.[4] In this case, retrieval of a broken catheter was performed surgically, although interventional methods were tried before surgery.

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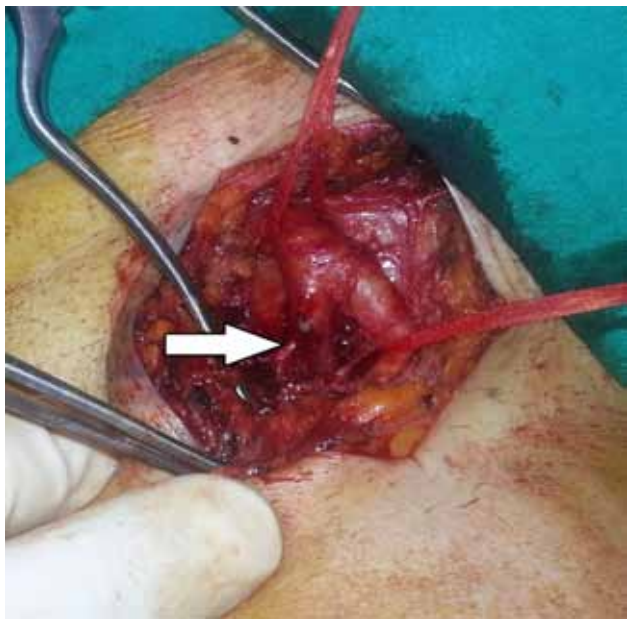

Figure 1. An intraoperative image. Arrow shows a broken balloon catheter into the deep femoral artery.

Furthermore, the selection of an optimal catheter material and appropriate size is critical. Improper entry point on the vessel can cause serious complications. In our case, the interventionists put the sheath on the deep femoral artery. Choosing the common femoral artery for access could have reduced angulation on the neck of the catheter and prevented breakage. If catheter size is incompatible with the sheath size, the interventionist can face similar challenges. Therefore, using a longer sheath and choosing the common femoral artery for entry point would have been precluded this complication in our case. In recent years, interventional techniques have become widely adopted thanks to their easy-to-use nature without pain and not requiring general anesthesia.

In conclusion, although intravascular fractures of angiography catheters during peripheral catheterizations are rare complications, retrieval of a broken and entrapped catheter fragments may be possible with either interventional or surgical methods. Therefore, physicians should be aware of such problems and inform patients . We believe that this report will guide to physicians on how to manage this type of complication surgically.

Figure 2. The broken balloon catheter.

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Cardiovascular Surgery and Interventions

Case Report Open Access

Endovascular treatment of aortoiliac occlusion in a young patient with Behçet's disease

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ABSTRACT

Behçet's disease is an autoimmune systemic disorder based on vasculitis which may affect the blood vessels of all sizes and sites, both arteries and veins. Although arterial involvement is rare, it is the major cause of death. Aneurysms are common in patients with Behçet's disease with a low incidence of artery stenosis or occlusion. An isolated common iliac artery or bilateral aortoiliac bifurcation stenosis were treated with balloon angioplasty and stent implantation in patients with Behçet's disease. Herein, we report a 40-year-old female case of Behçet's disease with aortoiliac occlusion treated with endovascular stent implantation.

Keywords: Aortoiliac occlusion; Behçet's disease; endovascular treatment; iliac artery stenosis; stent implantation.

Behçet's disease (BD) is a multi-system inflammatory disorder with characteristic pathological findings including recurrent oral and genital ulcers, skin lesions, and uveitis. Vasculitis is the predominant histopathological lesion in BD.[1] Arteries and veins of all sizes and sites may be involved. Vascular involvement is typically seen in the form of superficial thrombophlebitis or deep vein thrombosis. Arterial manifestation is less frequent, but is a serious cause of morbidity and mortality. Aneurysm is more frequent than stenosis or occlusion with arterial involvement in BD.[1,2] An isolated common iliac artery or bilateral aortoiliac bifurcation stenosis in patients with BD treated with balloon angioplasty and stent implantation have been reported in an only limited number of cases.[3,4] Herein, we report a female case of BD with aortoiliac occlusion treated with endovascular stent implantation.

CASE REPORT

A 40-year-old woman with a five-year history of BD was admitted to our hospital with severe pain after only a few meters walking distance on both legs. Computed tomography (CT) angiography showed an occlusion at the distal aortic lumen, aortic bifurcation, and bilateral common iliac artery (Figure 1a).

Medical history revealed recurrent oral and genital ulcers, skin lesions, and uveitis since the age of 35 years. The pathergy test result was positive at the time of diagnosis. She was on systemic immunosuppressive therapy including steroids, colchicine, and cyclophosphamide. She had also a history of deep vein thrombosis five years ago and nephrectomy for atrophic right kidney. She was a life-long non-smoker.

On physical examination, there were oral ulcers and skin lesions. Pulses were weakly palpable in the groin on both sides, but absent in the infrapopliteal arteries. The ankle-brachial index (ABI) was markedly reduced bilaterally to 0.58 on the right side and to 0.57 on the left side. Color Doppler ultrasonography (DUS) demonstrated a damped monophasic waveform on both common femoral arteries. Laboratory test results were as follows: hemoglobin 12.90 g/dL, erythrocyte sedimentation rate (ESR) 22 mm/h (normal range: 0 to 20 mm/h), and C-reactive protein (CRP) 7.23 mg/L (normal range: 0 to 6 mg/L). Serum complement was normal. There were no anti-nuclear antibodies and rheumatoid factor was negative. Other laboratory parameters were within normal ranges.

As the patient suffered from severe claudication, digital subtraction angiography was scheduled. Before angiography and subsequent treatment, potential risks and benefits were explained in detail, and a written

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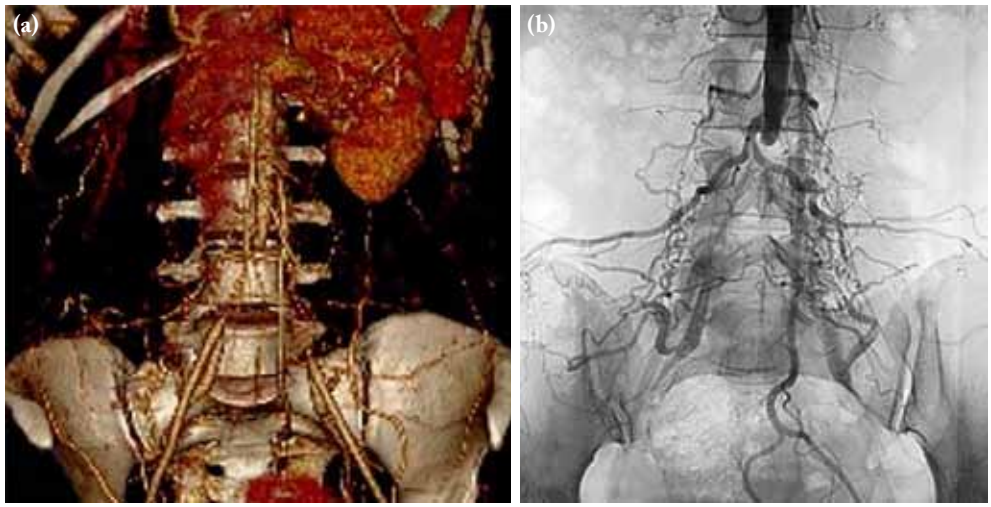

Figure 1. Computed tomography angiography **(a)** and pre-interventional angiography **(b)** showing chronic aortoiliac occlusion with reperfusion of the external iliac arteries via collaterals.

informed consent was obtained from the patient. The patient was punctured on the right brachial artery and a long sheath was placed in the abdominal aorta. Abdominal aortogram and pelvic arteriography revealed occlusion at the distal aortic lumen, aortic bifurcation, and bilateral common iliac artery (Figure 1b). Distal vessels were normal. After puncture of the common femoral artery on both sides, vascular sheaths (6F) were placed. Aortoiliac occlusion was crossed subintimally from the aortic side using a stiff hydrophilic-coated 0.035 inch guidewire supported by a diagnostic catheter. Guide wires were grasped with a snare from the ipsilateral side and they were exchanged to super stiff wires. After cautious pre-dilatation of the occluded aortoiliac arteries with a 5 mm balloon, retrograde stents were placed using two 8x60 mm in size self-expanding nitinol stents with the "kissing stents" technique (Figure 2a). Complementary kissing

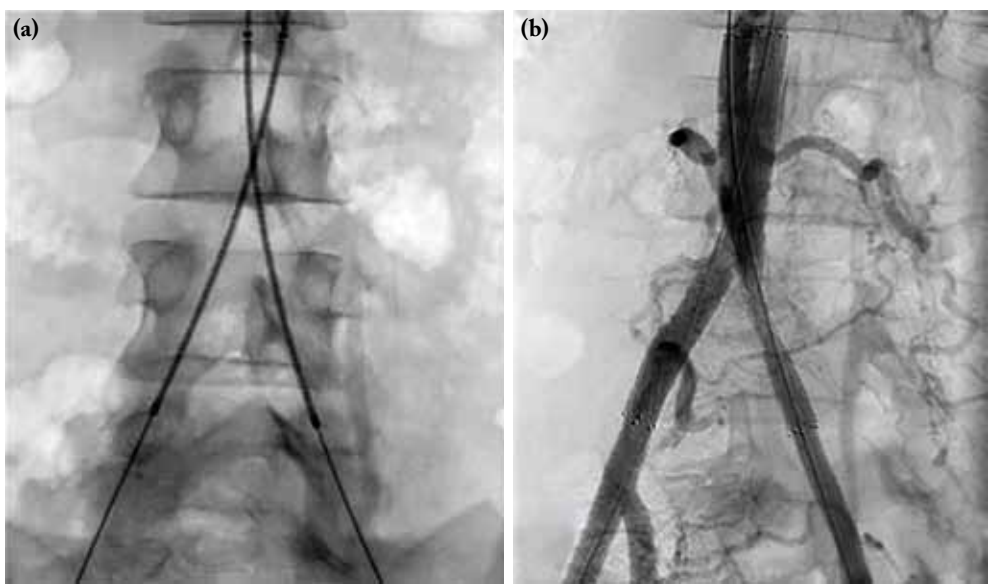

Figure 2. **(a)** Stent reconstruction with standard nitinol stents in "kissing" technique. **(b)** The final angiogram showing residual stenosis on the left side related to pressure-resistant plaque and an optimal result without residual stenosis on the right side.

balloon angioplasty was performed simultaneously with two 7x60 mm balloons to expand the stents to their nominal diameters. The final angiogram demonstrated residual stenosis (30 to 40% by visual estimation) on the left side related to pressure-resistant plaque. There was an optimal result without residual stenosis on the right side (Figure 2b). No procedure-related complications were observed. Brachial and femoral puncture sites were managed by manual compression. There was no early or late puncture site problem. The patient was discharged on the second hospital day. She was prescribed acetylsalicylic acid (100 mg/day).

The patient was scheduled for a follow-up visit at six months. She was able to walk regular distances without pain. She only complained of mild pain on the left side, when climbing stairs. Doppler waveform was triphasic on both common femoral arteries. Her ABI was normal (1,2) on the right side and acceptable (0.9) on the left side. Due to less invasive technique compared to DSA, CT angiography was obtained to check potential complications or recurrence. It showed no significant interval change in the residual stenosis on the left side (Figure 3a-c). No aortoiliac or femoral aneurysm appeared.

DISCUSSION

Behçet's disease is most common among the Mediterranean, Middle and Far East Asia populations along the old silk route. The etiology is still unclear, but likely to be multi-factorial. Although the usual onset of disease is in the third decade of life, it can occur at any age.[1] Men and younger patients often have more severe disease than women and older patients. Behçet's disease has various clinical features and progresses with unpredictable attacks and remissions. Vasculitis is considered to underlie these clinical manifestations.[1,2] Vascular involvement may be seen in up to 50% of patients depending on the population studied. Involvement in BD can be arterial or, more commonly, venous and may involve both systems in a single patient. The most frequent type of vascular manifestation is superficial and deep vein thrombosis, mostly in the lower extremities. After the first vascular lesion, usually venous thrombosis, the risks are increased for other vascular lesions. Although rare, arterial involvement is the main predictor of morbidity and mortality. Arterial lesions are often isolated, but may be multiple and frequently coexist with venous thromboses. Arterial manifestation includes true aneurysm or pseudoaneurysm formation and less commonly stenosis or occlusion. The main locations of the arterial lesions are the aorta followed by the pulmonary and femoral arteries. Other reported arterial lesions include subclavian, common carotid, coronary, brachial, radial, ulnar, common iliac, external iliac, tibial, renal, cerebral, axillary, and splenic arteries.[1,2,5-7] Our case had a history of deep vein thrombosis five years ago and claudication thereafter.

The diagnosis of disease is primarily based on clinical criteria, as there are no specific laboratory or histopathological findings. The ESR and CRP

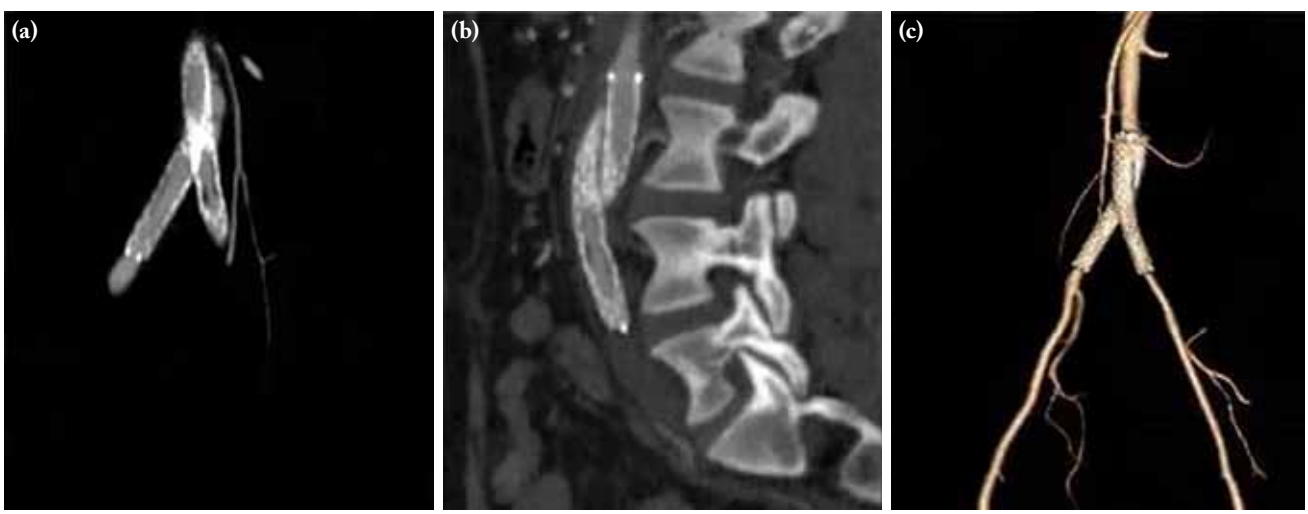

Figure 3. Computed tomography angiography **(a-c)** six months after intervention showing no significant interval change in the residual stenosis on the left side. No aortoiliac or femoral aneurysm appeared.

are usually moderately elevated; however, they do not correlate well with the disease activity. Previous studies recommended immunosuppressive therapy to normalize the ESR and CRP values preoperatively or before endovascular treatment.[6,7] Postoperative therapy was also reported to be critically important to prevent recurrent aneurysmal disease or formation of pseudoaneurysms at the site of artery access.[8,9]

Furthermore, vasculo-BD patients usually have a dramatic course and prognosis. Ischemia of the arterial wall due to an inflammatory obliteration of the vasa vasorum may result in true or false aneurysm formation with an increased incidence of rupture and bleeding. The rupture of a aneurysm is a major cause of death.[5,6] Arterial complications may lead to difficult surgical problems, as surgical repair may provoke development of new aneurysms at the site of vascular interference or anastomosis and may be complicated by the graft thrombosis in high percentage of patients. To avoid surgical complications, endovascular treatment have been recommended increasingly, since it is less invasive and has fewer complications.[5,8-10]

Although arterial stenosis or occlusion in BD is rare, nearly every major artery has been reported to be involved by this disease.[6,11-13] Some of them were treated by balloon angioplasty and stent implantation to improve symptoms. In a previous study, long-term results in the recanalization of chronic iliac occlusions were acceptable compared to conventional surgical techniques.[14] However, experience with endovascular treatment of the iliac artery stenosis or occlusion in BD and their long-term results are very limited. Only two cases of endovascular treatment of an isolated common iliac artery stenosis or bilateral aortoiliac bifurcation stenosis in patients with BD have been reported previously.[3,4] To the best of our knowledge, our case, who presented with aortoiliac occlusion in BD, is the first case of this type reported. Because of severe claudication symptoms, angioplasty and stent implantation was performed for management of aortoiliac occlusion. At the time of the procedure, she was on systemic immunosuppressives and her ESR and CRP values were close to the upper of normal ranges. Endovascular treatment was successful, in our case, without any complication related to angiography and angioplasty.

Arterial punctures or insertion of a vascular sheath for angiography may induce either a thrombosis or a pseudoaneurysm formation in the puncture site.[15] As a result, CT angiography was obtained after six months for discovery of a new pseudoaneurysm, stenosis or occlusion. No aortoiliac or femoral aneurysm appeared. There was no significant interval change in the residual stenosis on the left side.

In conclusion, arterial stenosis or occlusion are extremely rare, particularly at the aortoiliac bifurcation or common iliac arteries due to Behçet's disease. Endovascular stent implantation with the "kissing stents" technique is an appropriate therapeutic choice for these patients. Not only the vascular or endovascular interventions, but also medical treatment strategy for the Behçet's disease should be taken into consideration.

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Anomalous circumflex artery arising from the right coronary sinus

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Coronary artery anomalies are seen in approximately 6% of the population.[1] Coronary artery anomalies which originate from the wrong coronary sinus may cause a risk of sudden death in young populations.[2] The incidences of anomalous circumflex artery (CxA) arising from the wrong coronary sinus occur in 0.67% of the total population.[1] We reported an uncommon anatomical variation of the CxA which emphasized the anatomic variabilities of the vascular structures.

CASE REPORT

A 71-year-old male was referred to the Emergency Department with a complaint of angina pectoris. His blood pressure was normal (130/65 mmHg) and his heart rate was slightly increased (119 bpm). Troponin-I levels were 15.7 ng/mL (Normal <0.01 ng/mL) on admission. The electrocardiography revealed an ST elevation in D3 and aVF leads. He was diagnosed with an acute inferior myocardial infarction (AMI) and a coronary angiography was performed to intervene the responsible coronary lesion. A rare anatomic variation was seen on the right coronary vasculature. The CxA was originating from the right coronary sinus with its own separate ostium (Figure 1). The distal course of the CxA was normal following the anatomic grooves

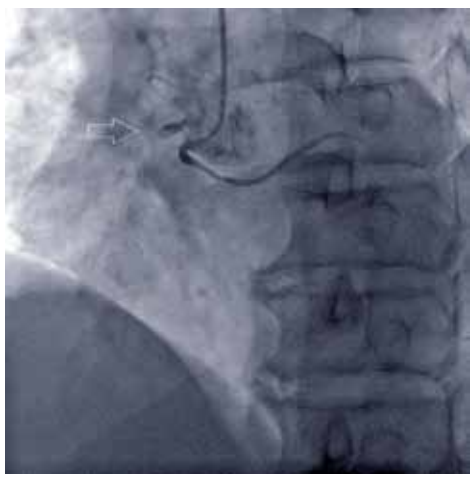

Figure 1. Left anterior oblique view showing the separate orifices of the right coronary artery and the circumflex coronary artery. The arrow showing the right coronary artery stump.

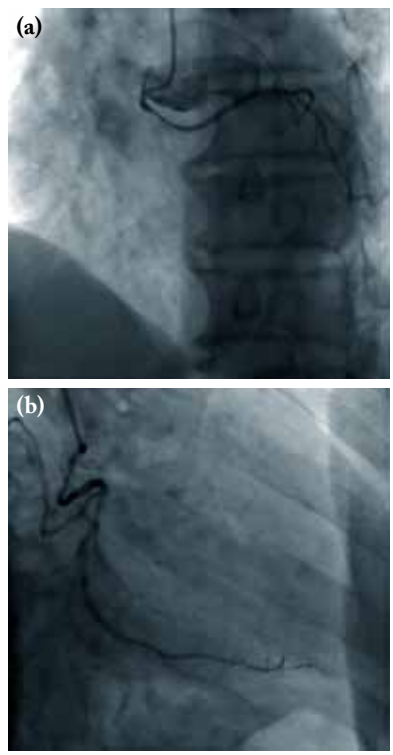

Figure 2. Left anterior oblique **(a)** and right anterior oblique **(b)** views of the circumflex artery showing the anomalous origin from the ordinary course.

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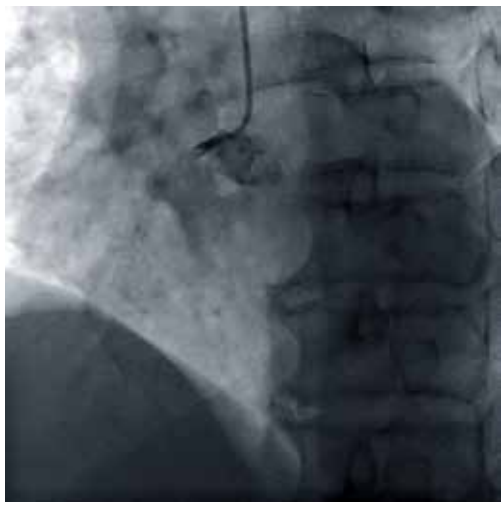

Figure 3. Right coronary artery proximal occlusion stump and the distal silhouette.

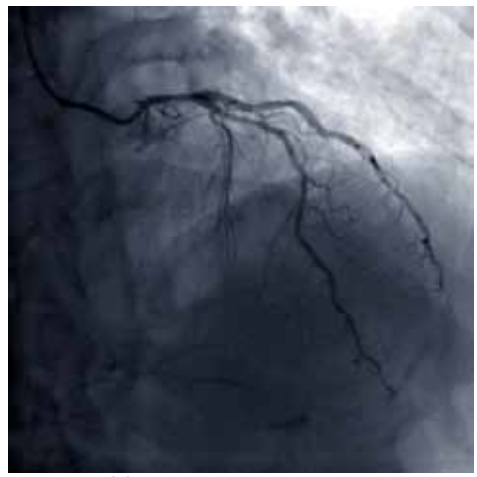

Figure 4. Typical origin and course of the left anterior descending artery and its diagonal branch.

(Figure 2). There were some atherosclerotic lesions in the CxA including a 60% segmental lesion in the proximal portion (Figure 2a) and a diffuse endothelial irregularity in the middle portion (Figure 2b). He had a separate right coronary artery orifice with a total proximal occlusion that was responsible for the acute myocardial infarction (Figure 3). The left anterior descending artery was emerging from the left coronary ostium in a typical manner, having no prominent atherosclerotic lesion (Figure 4). A written informed consent was obtained from the patient.

Coronary artery anomalies should be well known regarding the appearance, prevalence and the clinical importance given by the interventionists.[3] The intervention should be adjusted according to the existing coronary artery anomaly.

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