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Cardiovascular Surgery and Interventions

Original Article Open Access

Comparison of the sternal wires and sternal cable in closure of the sternum during cardiac surgery

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Objectives: This study aims to compare the effectiveness of the sternal cable system (Cable group) with the standard monofilament system (Wire group) in the sternal closure of cardiac surgery patients.

Patients and methods: Between January 2014 and September 2014, a total of 56 patients were included. The patients were divided into two groups according to the closure modality. The Cable group in whom the sternal cables were used consisted 24 patients, whereas the Wire group included 32 patients. Risk factors such as obesity, chronic obstructive pulmonary disease, diabetes mellitus, reoperation and closure with figure-of-8 were considered in the selection of these patients. The length of intensive care unit and hospital stay, blood drainage, infection and sternal complications were compared between the groups.

Results: Preoperative and perioperative variables between two groups were similar. There was no postoperative sternal complications for the Cable group, however, sternal dehiscence and superficial wound infections were observed in two patients in the Wire group. An inflammatory reaction to the wire developed within one month in a patient.

Conclusion: We recommend using sternal cable system instead of wires in the patients having risk factors for sternal instability.

Keywords: Cable; obesity; sternal dehiscence.

Median sternotomy is the standard approach in open heart surgery. It is also necessary to perform sternal closure properly. Although this procedure is relatively simple, sternal complications such as dehiscence, sternal nonunion or infection may occur about 0.25-5%.[1,2] The mortality rate is observed up to 25% in patients with a deep sternal wound infection.[3,4] Furthermore, higher costs for hospitalization are present due to prolonged hospital stay.

The predisposing factors which may cause such complications, namely chronic obstructive pulmonary disease (COPD), high body mass index, diabetes mellitus, older age and smoking are defined in several studies.[4] We assume that sternal dehiscence and infection ratios can be reduced by using a reliable closure technique. In this study, we compare the patients in whom we used a sternal cable and sternal wire in aspects of postoperative complications.

PATIENTS AND METHODS

The sternal cable system (Pioneer Surgical Technology, Inc., Marquette, Michigan, USA) was inserted in 24 patients during a six-month period. The patients in whom we performed open heart surgery by median sternotomy were divided into two groups. We also included the patients whose body mass index was over 30 and sternum was closed by figure-of-8 in both groups. The patients with a sternal wire closure were selected retrospectively. We compared postoperative drainage, the length of intensive care unit (ICU) and hospitalization stay, admission time, sternal infection and sternal dehiscence ratio between two groups.

Surgical technique

The cables were in the same diameter with the standard wires. They were inserted by using multiple figure-of-8 suturing constructs, each were tightened with a gauged instrument and were fixed in place with a reproducible crimp type device (Figure 1). We provided the 8 figure by passing the wire through the intercostal space and secured it with special clips (Figure 2). Three cables were used for each patient which resulted a tighter and more

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Figure 1. Closure device.

evenly distributed force than the use of wires. It also eliminated the human variable of determining how tight each wire actually was and the potential for wire fatigue and breakage due to over tightening.

Statistical analysis

Statistical analysis was performed using SPSS version 15.0 software (SPSS Inc., Chicago, IL, USA). Compliance with the normal distribution of variables were analyzed by visual (histograms and probability graphics) and analytical (Kolmogorov-Simirnov/ Shapiro-Wilk tests) methods. Descriptive analyses were done for categorical variables. Descriptive statistics for categorical data was presented in the mean and the standard deviation of the bionormally distributed samples. Median and interquartile values were used for samples with non-normal distributions. The significance between the Cable group and Wire group for abnormally distributed parameters was assessed with the Mann-Whitney U test. Categorical parameters between the Cable group and Wire group were compared with the chi-square and Fisher's exact test. A p value of <0.05 was considered statistically significant.

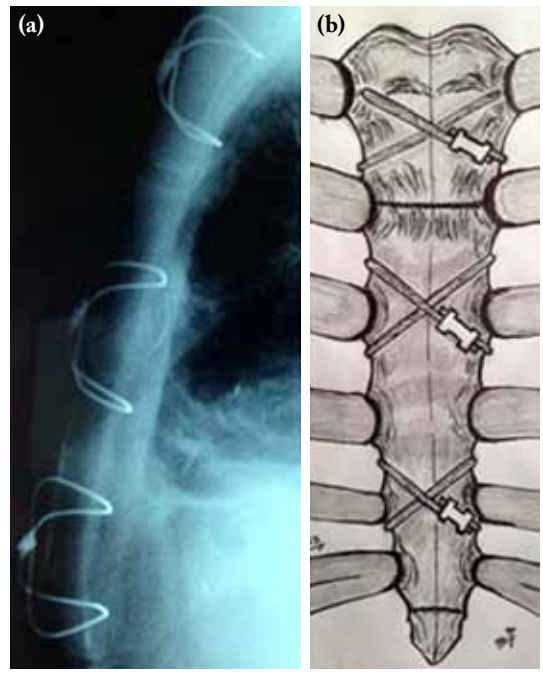

Figure 2. Figure-of-8 suturing **(a)** X-ray image. **(b)** Figure-of-8 which made by crossing intercostal spaces.

RESULTS

Demographic data of two groups are shown in Table 1. There were no statistically significant differences between preoperative variables. Surgical interventions of the patient groups are shown in Table 2.

Table 1
Demographic data of the patients

Parameter	Cable group (n=24)			Wire group (n=32)			
	n	%	Mean±SD	n	%	Mean±SD	p
Age			66.2±8.9			64.0±9.0	0.4
Sex							
Male	15	62.5		23	71.9		0.80
Body mass index (kg/m^2)			34.4±3.1			34.2±2.7	0.92
Smoking	11	45.8		8	25		0.02
Diabetes mellitus	6	25		5	15.6		0.29
Chronic obstructive pulmonary disease	4	16.6		5	15,6		0.68
Renal failure	1	4.1		2	6,3		0.85
Operative time (min)			156±45			176±64	0.71
Ejection fraction			52±13			49±24	0.58
Logistic EuroSCORE			16±13			19±17	0.44

Table 2
Surgical procedures

Variables	Cable group (n=24)	Wire group (n=32)
CABG	15	18
AVR	2	3
MVR	3	1
CABG + AVR	1	2
AVR + MVR	0	1
CABG + MVR	1	3
AASGI + CABG	1	2
REDO CABG	1	2

CABG: Coronary artery bypass graft; AVR: Aortic valve replacement; MVR: Mitral valve replacement; AASGI: Ascending aortic separated graft interposition.

Three cables were used to maintain 8 figures. Hemi-sternums were converged with the use of equal pressure by closure device. Postoperative data of the Wire group and Cable group are presented in Table 3. The drainage amount of the Wire group was less than the Cable group (p=0.001). The hospitalization time was significantly shorter in the Cable group (p=0.004). Sternal dehiscence in three patients and sternal revision in five patients were observed in the Wire group, however, there was no statistically difference among two groups. The closure via cable was longer than the closure time with a wire. The right internal mammary artery was injured by the cable put through the intercostal space in one patient. In the Cable group, one patient in whom cardiovascular resuscitation was performed about 15 minutes had a ventricular fibrillation attack at early postoperative period. This patient was discharged without sternal dehiscence.

DISCUSSION

Median sternotomy was first described by Minton[5] in 1887 and still remains the most common surgical approach in cardiac surgery. The incidence of sternal dehiscence was reported to be 0.5% to 8% depending on the presence of a mechanical defect, and type and degree of the infection.[6] In addition, several techniques have been described for the sternal closure. This study was conducted to investigate whether a sternal cable could be an alternative to the sternal wire. In this study, we compared the patients with sternal closure via a cable by a single surgeon and those via a wire by several surgeons. The selection of the patients were utilized by the body mass index >30 and the use of figure-of-8 in the sternal closure in both groups. Urgent cases were excluded from the study.

Although many materials have been used for the sternal closure so far, a sternal wire has been widely adopted currently. Grapow et al.[7] used a new material namely ZipFix, which had successful results. Permut et al.[8] performed the cable system in pediatric patients and reported that the ratio of postoperative pain and restlessness were relatively low in this patient population. The postoperative pain and painkiller use were relatively low in patients in the Cable group. Corset was not used in any patient. Superficial wound infection was observed in one patient, while dehiscence was not found in any patient. The length of hospital stay was significantly shorter in the Cable group.

In conclusion, although there were no statistically significant difference between two groups, we conclude that sternal cable system can be used safely instead of standard sternal wire in patients whose body mass index are >30 and those with comorbidities. However, further large-scale studies are required to establish a conclusion.

Declaration of conflicting interests

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

Table 3
Postoperative variables

Parameter	Cable group (n=24)			Wire group (n=32)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Drainage (mL)			499.0±218.3			741.9±243.3	0.001
Intensive care unit stay (day)			2.4±0.8			4.3±4.5	0.14
Hospitalization time (day)			7.2±2.0			13.6±15.1	0.004
Bleeding revision	1	4.16		3	9.4		1
Dehiscence	0	0		3	9.4		0.27
Superficial wound infection	1	4.16		5	15.6		0.38

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Cardiovascular Surgery and Interventions

Case Report Open Access

Simultaneous nephrectomy, intracaval and right atrial tumor excision, caval patchplasty and coronary artery bypass grafting in patient with renal cell carcinoma

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The most common type of tumor occupying the inferior vena cava and extending to the right atrial cavity is renal cell carcinoma. Herein, we report a 54-year-old male patient with renal cell carcinoma with a tumor extending into the inferior vena cava and right atrium along with coronary artery disease. The patient successfully underwent simultaneous nephrectomy, intracaval and right atrial tumor excision, caval patchplasty and coronary artery bypass grafting under normothermic cardiopulmonary bypass without cross clamping or cardioplegic arrest. To the best of our knowledge, this is the first case reported in the literature in whom all the operations were performed simultaneously.

Keywords: Cardiopulmonary bypass; coronary bypass; nephrectomy; renal cell carcinoma; right atrial mass; tumor.

The most common type of tumor occupying the inferior vena cava and extending to the right atrial cavity is renal cell carcinoma (RCC). The rate of such extension in RCCs has been reported to be 4 to 25%.[1] Renal cell carcinomas were classified into four categories preoperatively according to the level of thrombus extension in the inferior vena cava starting from the infrahepatic renal vein (Stage 1) to the right atrium (Stage 4). The coexistence of the right atrial thrombus (Stage 4) is less than 1%.[2-4]

In patients with non-metastatic RCC who underwent radical nephrectomy and complete thrombectomy, five-year survival rates of 30% to 72% have been reported.[1] However, surgical indication for patients with metastatic RCC and the use of cardiopulmonary bypass (CPB) during vena caval thrombectomy are still controversial.[1] The risk of CPB use may be a possibility of tumor dissemination; however, some reports indicated that the use of extracorporeal circulation during the resection of tumor thrombus in the inferior vena cava did not affect the long-term survival.[5] A very small percentage of non-metastatic RCC patients die from the surgical intervention and postoperative complications.[1-4] The presence of metastasis at the time of surgery significantly is associated with a poor survival.[6] Atrial extension of the tumors is associated with a significantly higher risk of the development of metastatic spread, but not with significantly increased risk of operation.[6] Some reports have shown that adjuvant medical therapy combined with surgery may increase the survival of RCC patients with distant metastases.[2-4]

Concomitant disorders such as coronary artery disease may also accompany in patients with RCC.[4] Additional coronary artery bypass grafting (CABG) surgery may be required for such patients like as in our case.

CASE REPORT

A 54-year-old male patient was admitted to our hospital with syncope, angina, right flank pain, hematuria and weight loss. Electrocardiography revealed sinus rhythm, left axial deviation and ischemic pattern in precordial leads. A huge renal tumor mass was identified using abdominal ultrasound, while the tumor and thrombus extension were detected using abdominal computed tomography and transthoracic echocardiography. The tumor and thrombus were extended to the right atrial cavity. Tumor extension was on Stage 4. Radiological examination showed no metastatic spread. Coronary angiography revealed a

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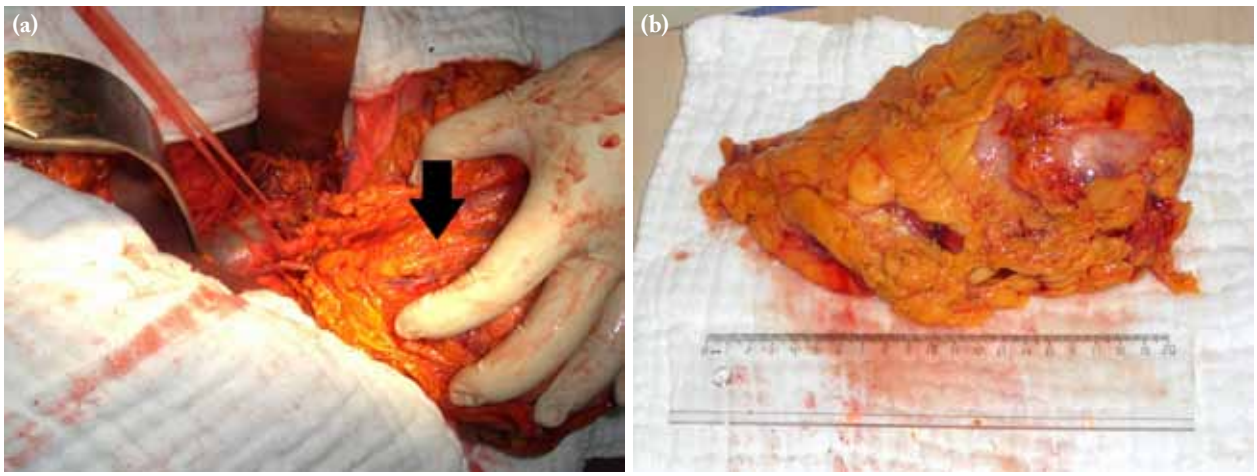

Figure 1. Images showing **(a)** a renal tumor mass and **(b)** nephrectomy specimens after resection.

99% stenosis on the proximal left anterior descending artery.

We performed simultaneous nephrectomy, intracaval and right atrial tumor excision, caval patchplasty and CABG under normothermic CPB without cross clamping or cardioplegic arrest. The patient was discharged from the hospital uneventfully in the eight postoperative day. His overall condition is currently stable.

Surgical technique

Chevron incision and median sternotomy were used together for simultaneous operation. Radical nephrectomy was performed first via retroperitoneal approach (Figures 1a, b). After radical nephrectomy, heparin was given at a dose of 300 IU/kg before CPB. An aortic cannula was inserted to the ascending aorta. Venous drainage was achieved using a proximal cannula inserted to the superior vena cava and a distal cannula inserted to the inferior vena cava below renal veins through a femoral vein. Superior vena cava, intrapericardial and infrarenal inferior vena cava were encircled with tapes and CPB was initiated. Before opening the right atrium, superior vena cava and infrarenal inferior vena cava snares were snugged and right atrium was opened with conventional oblique incision. Right atrial tumor and thrombus were extracted under normothermic CPB without cross clamping or cardioplegic arrest (on-pump beating heart). During the tumor excision, venous return from the hepatic veins and contralateral renal vein were aspirated from the right atrial cavity by coronary suction. The whole tumor and thrombus were able to be extracted without any fragmentation through the right atrial cavity (Figure 2). After the tumor and thrombus extraction through the right atrial cavity, intrapericardial inferior caval snare was snugged and infrarenal caval snare was released and then the right atrial cavity was closed. After the closure of atrial incision, dual vascular clamping was applied in the infrahepatic and suprarenal segment of vena cava (Figure 3a). Vena cava between these areas was reconstructed with a Dacron graft due to the invasion of the vein wall preserving the contralateral renal vein (Figure 3b). Finally, the left anterior descending artery was revascularized with saphenous vein grafting. No difficulties were encountered in weaning from extracorporeal circulation.

Figure 2. Complete material of vena cava and right atrial tumor thrombus extracted without any fragmentation. Non-fragment material matching the first 10 cm of the vena caval portion and between 10-11 cm fits the diaphragmatic portion, the rest of the material after 11 cm belongs right atrial portion of the tumor thrombus.

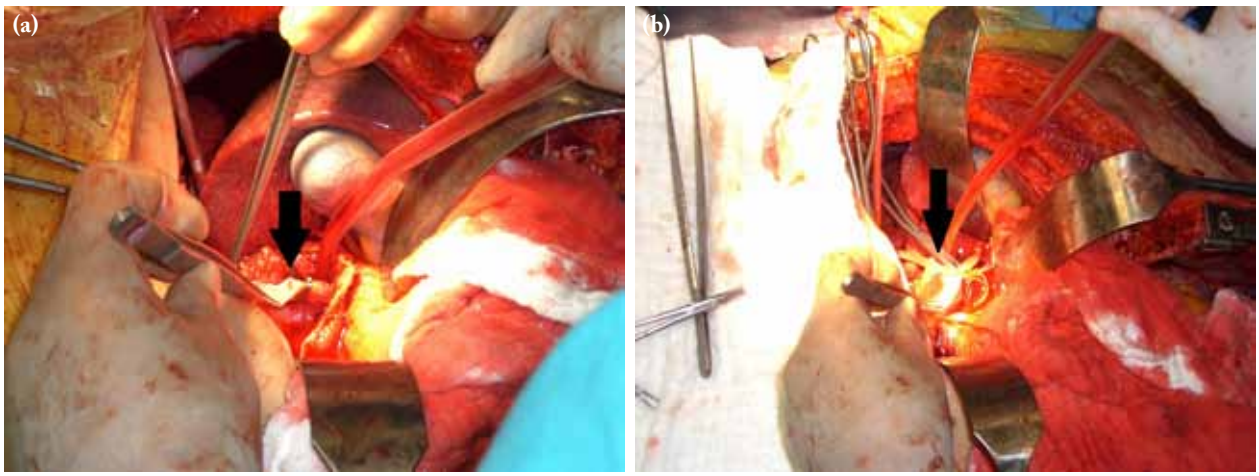

Figure 3. **(a)** Resection of the tumor invading the infrahepatic and suprarenal segment of vena cava and **(b)** reconstruction with a Dacron graft of this vascular segment.

DISCUSSION

Renal cell tumors with thrombi in the right atrium require immediate surgical treatment. However, there is no consensus regarding the surgical technique of choice.[1-7] The major critical factor is successful surgery, mainly managing the interior vena cava. The main goals are to minimize bleeding and prevent embolism from the thrombus during surgery.[4] In addition, CPB may be required in patients with a bulky, intraatrial thrombus.[8] However, those with a minimal and non-adherent atrial thrombus may not require CPB.[9] The choice of a circulatory support technique consisting of either normothermic perfusion with venous drainage or total circulatory arrest with profound hypothermia has not been defined yet. The main variables to be considered in choosing the most appropriate method are the surgeon's personal preference and experience. An increased CPB time and the use of deep hypothermia in circulatory arrest may result in a several well-known complications such as hemorrhage, neurological dysfunction, and organ failures. Similarly, our patient had a 99% LAD stenosis. In the light of the literature data, we performed simultaneous nephrectomy, intracaval and right atrial tumor excision, caval patchplasty and CABG under normothermic CPB without cross clamping or cardioplegic arrest.[7]

To the best of our knowledge, this is the first case reported in the literature in whom all the operations were performed simultaneously.

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Cardiovascular Surgery and Interventions

Case Report Open Access

Upper extremity deep vein thrombosis after *in vitro* fertilization treated with ultrasound accelerated catheter directed thrombolysis

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Upper extremity deep vein thrombosis (UEDVT) is an important clinical entity, presenting with an increased risk for developing fatal pulmonary thromboembolism. A 32-year-old woman was admitted to our hospital complaining swelling and pain of the right upper extremity for five days. The patient was diagnosed as primary infertility and underwent in vitro fertilization after stimulation with gonadotropin-releasing hormone analog one month prior to her admission. An ultrasound scan showed thrombosis of the right brachiocephalic and subclavian veins with partial obstruction of the lumen. The patient was successfully treated with EkoSonic® Mach4e Endovascular device with an overnight infusion of recombinant human tissue plasminogen activator. Catheter-directed thrombolysis may represent a potential therapeutic alternative for patients with severe UEDVT, particularly in those in whom medical management fails or conventional thrombolytic therapy and surgical thrombectomy are contraindicated or considered extremely risky.

Keywords: Catheter directed thrombolysis; deep vein thrombosis; *in vitro* fertilization; ultrasound.

Upper extremity deep venous thrombosis (UEDVT) is a serious disease, which is based on the pathogenesis and in view of the individual patient's prognosis and must be divided into primary and secondary presentations.[1] Primary UEDVT is a rather benign disease with an excellent prognosis, having only a minor potential of developing disabling post-thrombotic syndrome (PTS). Secondary UEDVT, on the other hand, typically occurs in older patients with severe comorbidities, mainly related to indwelling central venous catheters and cancer. It may also present during pregnancy or as a complication of assisted reproductive techniques. As a consequence of the underlying diseases, prognosis of secondary UEDVT remains poor.[2]

Regardless of the etiology, the cornerstone of therapy is anticoagulant treatment with low molecular weight heparin or unfractionated heparin and vitamin K antagonists to prevent thrombus progression and pulmonary embolism. Due to the lack of evidences, the optimal duration of treatment still remains unclear.[2,3]

Recent advances in catheter-based interventions have led to the development of a variety of minimally invasive endovascular strategies to remove venous thrombus.

Ultrasound accelerated catheter-directed thrombolysis (UACDT) has been developed to resolve the existing thrombus in a rapid and complete manner. This technique integrates high frequency, low intensity ultrasound (US) with standard CDT to accelerate clot dissolution, reducing treatment time as well as the incidence of thrombolysis-related complications.[4,5] It is hypothesized that catheter-directed thrombolysis for UEDVT provides an effective solution with less severe PTS than during traditional anticoagulation. Herein, we report a case of UEDVT following *in vitro* fertilization (IVF) who was successfully treated with UACDT.

CASE REPORT

A 32-year-old woman was admitted to our hospital with complaints of swelling and painful right upper extremity during the preceding five days. The patient was previously diagnosed with primary infertility and underwent IVF after stimulation with a gonadotropin-releasing hormone analogue one month prior to her admission. On admission, the patient described a tight, painful swelling of her face, upper chest, and arms. The patient history also revealed slight swelling

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of the neck and face lasting for a month, mainly noticed during morning hours, which resolved later during the day. On clinical examination, her body temperature was 37.2 °C, pulse was 78 beats/min, respiratory rate was 18 breaths/min, blood pressure was 116/70 mmHg, and oxygen saturation was 94% on room air. She was plethoric with deep swelling of her face, neck and right arm. Her heart sounds were normal and abdomen was soft and non-tender without any evidence of mass or organomegaly. Complete blood count and biochemistry results were also normal. Chest X-ray produced unremarkable findings with no evidence of pneumothorax, consolidation, tracheal deviation, pleural effusion, or mediastinal widening. An ultrasound scan showed thrombosis of brachiocephalic and subclavian veins with partial obstruction of the lumen (Figure 1a).

The patient underwent UACDT using the EKOS EkoSonic Endovascular System (EKOS Corporation, Bothell, WA), which consisted of a 5.2 F, 106 cm long infusion catheter, an ultrasonic core wire, and a control unit with catheter interface cables. We preferred a 30 cm length treatment zone catheter in our case, which was appropriate for the thrombus length. The drug delivery catheter was navigated over a 0.035-inch guide wire, therefore, the treatment zone traversed the entire clot and the tip exited the thrombus. After final positioning, the guide wire was exchanged for a matching ultrasonic core wire containing a series of US transducer elements (2.2 MHz, 0.45 W) distributed 1.0 cm apart to evenly deliver US energy radially along the distal coaxial infusion zone (Figure 1b). After priming the drug lumens of the catheter with sub-therapeutic heparin (1,000 U/mL), continuous infusion of thrombolytic agent was initiated through the side-holes of the infusion delivery catheter using Alteplase (Actilyse, Boehringer Ingelheim GmbH, Germany), a recombinant human tissue plasminogen activator, at a 5 mg bolus, followed by an ultrasound accelerated infusion at 0.02 mg/kg/h over 14 hours. Normal saline, which included 1 mg Alteplase, was infused via a coolant port connected to the central lumen (and discharging from the distal end) at a rate of 35 mL/hr to dissipate any small amount of heat-generated by the US energy. The energy was delivered via the core wire with simultaneous infusion of the thrombolytic drug. Fibrinogen and activated partial thromboplastin time (aPTT) levels were taken every six hours during thrombolytic infusion.

The patient was monitored at the intensive care unit and post-procedure venography was performed prior to removing the introducer. Venography showed excellent flow in the subclavian and brachiocephalic vein (Figure 1c). There were no bleeding complications due to the treatment. The patient was discharged on the second postoperative day on vitamin K antagonist therapy for six months. The follow-up US scan showed normalized subclavian vein and upper extremity veins (Figure 2). Her symptoms improved immediately after the UACDT and she continues to be symptom-free a week after the procedure.

DISCUSSION

Compared to lower extremity DVT, UEDVT is an uncommon disease representing about 10% of all DVTs.[1] It can be associated with mechanical or anatomical factors (e.g. insertion of central venous

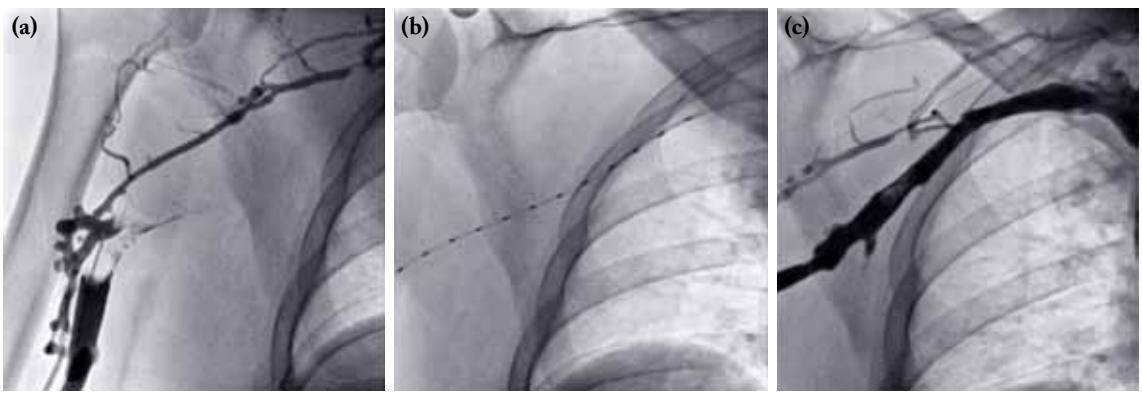

Figure 1. **(a)** Venography showing the absence of filling of the subclavian and brachiocephalic vein, consistent with thrombosis. **(b)** EKOS catheter with a 30 cm treatment length was placed into the thrombus (note the radiopaque ultrasound transducers). **(c)** Final venogram showing complete resolution.

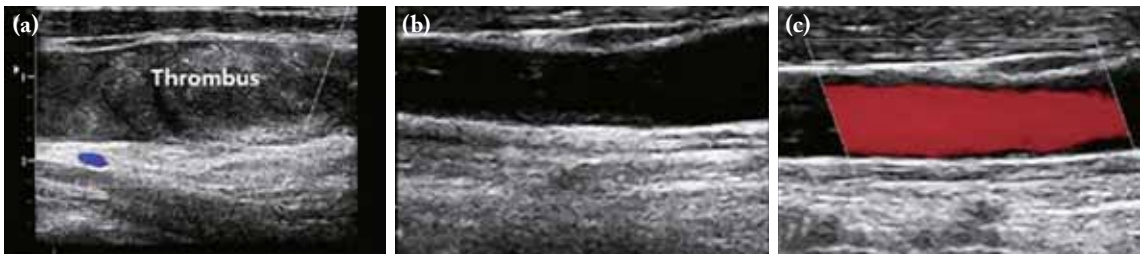

Figure 2. **(a)** The longitudinal image of the right neck shows thrombosis of the right subclavian vein with obstruction of the lumen. **(b, c)** The follow-up ultrasound scan reveals normalized subclavian vein.

catheters or narrowing of veins by cervical rib) and hypercoagulable states (e.g. anti-thrombin deficiency, malignancy and anti-phospholipid syndromes).[2] In addition, UEDVT can be associated with pulmonary embolism (PE) with reported incidence rates of about up to one third of all patients.[3] Since our patient's vital signs were normal and there was little clinical evidence of PE, the possibility of PE was considered to be low. Moreover, echocardiographic examination showed normal right ventricular function and normal pulmonary arterial pressure.

It has been assumed that thrombolytic therapy for UEDVT may reduce the risk of long-term complications, especially the troubling PTS, characterized by chronic arm and hand aching and swelling due to early restoration of venous patency, thereby minimizing damage to vessel valves and endothelium. Recent retrospective[6] and prospective[7,8] cohort studies of conventional anticoagulant therapy for unselected UEDVT reported to be 27% to 44% mild PTS and almost no severe PTS. Although some cohort studies have evaluated short-term efficacy, adverse events, and reocclusion rates, we found no reports assessing the development of PTS after initial UACDT with subsequent conventional anticoagulant therapy for UEDVT.

Due to its rarity and possible variations in anatomical obstruction associated with UEDVT, there is no unique and unequivocal management strategy. Most patients are unresponsive to anticoagulation alone, which appears to be effective only in the mildest cases. However, life-long anticoagulation following definitive endovascular therapy may be important to reduce the incidence of reocclusion and may play a role in maintaining collateral circulation.[9]

Endovascular stents have become the treatment of choice for acute symptom relief of such patients. When stent placement is difficult or dangerous due to the presence of a large amount of thrombus, thrombectomy, or thrombolysis should be attempted prior to stent deployment. On the other hand, stent placement for treatment of UEDVT is not devoid of complications. Infections, pulmonary embolus, stent migration, hematoma at the insertion site, bleeding, and rarely, perforation or rupture of the venous structures resulting in death, have been previously reported.[10]

As thrombus is deemed to be the cause of the upper extremity deep venous obstruction, removing it using UACDT with a low dose of thrombolytic agent may result in reduced risk of hematoma, gastrointestinal bleeding, and shorter length of hospital stay with all the relevant cost and comorbidities. To overcome the limitations posed by long-term treatment and high-drug doses in catheter directed thrombolysis, UACDT enhances drug permeation through thrombus by disaggregating the fibrin matrix, exposing additional plasminogen receptor sites to the thrombolytic agent.[4,5] The US energy affects thrombus in the entire venous segment, increasing the probability of complete thrombus clearance. The significant benefit of complete thrombolysis, compared to partial lysis, has been demonstrated in previous studies of standard thrombolysis.[11] Therefore, the ability of this technique to penetrate and resolve the entire thrombus may potentially lead to increased long-term patency rates and better long-term outcomes.

Recent literature data have shown a potential benefit of adjuvant angioplasty and stent implantation of the residual venous stenosis in patients with UEDVT.[12] Also, Alteplase has a high-degree of safety with few complications when delivered by a catheter rather than the traditional systemic infusion.

In conclusion, UACDT may represent a potential therapeutic alternative in patients with severe UEDVT, particularly in those in whom medical management

fails or conventional thrombolytic therapy and surgical thrombectomy are contraindicated or considered extremely risky.

Declaration of conflicting interests

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Cardiovascular Surgery and Interventions

Case Report Open Access

Coronary artery bypass graft surgery in a pediatric patient with a giant coronary aneurysm

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Kawasaki disease or mucocutaneous lymph node syndrome is an acute, febrile vasculitis of unknown etiology affecting mainly infants and children under five years of age. Coronary artery involvement, which occurs in approximately 20% of such patients, may be the most important feature of this syndrome. In this paper, we report a successful coronary artery bypass graft in a nine-year-old boy with a giant coronary artery aneurysm and diffuse coronary artery disease.

Keywords: Aneurysm; coronary artery bypass grafting; Kawasaki disease.

Kawasaki disease (KD), previously known as mucocutaneous lymph node syndrome, is an acute, febrile, self-limiting generalized vasculitis of unknown etiology which occurs predominantly in infants and young children. It mainly affects small- and medium-sized arteries, particularly the coronary arteries, and was described by Kawasaki in 1967.[1] Gulhan et al.[2] reported a 42.4% incidence of coronary involvement in Turkish patients with KD. Kawasaki disease causes aneurysm formation at the proximal sites of the coronaries, while the distal sites are usually protected. Dilatation equal to or larger than 8 mm is categorized as a giant aneurysm, which may cause coronary artery stenosis secondary to compression or thrombosis.[3] Early diagnosis and rapid therapeutic interventions such as aspirin and intravenous gamma globulin may decrease the risk of coronary artery pathology development by approximately 20%.[4]

In this paper, we present a successful coronary artery bypass grafting (CABG) in a boy who had one of the largest reported childhood coronary artery aneurysms to date.

CASE REPORT

A nine-year-old boy with KD was admitted to our institution with complaints of chest pain and fatigue. The patient's history revealed KD. He experienced the first attack at the age of two with prolonged fever. Neither intravenous gamma globulin nor steroid therapy was given. Laboratory examination showed leukocytosis, high C-reactive protein, and elevated liver enzymes. Echocardiography showed pancarditis and a giant calcified and thrombotic coronary artery aneurysm. The diameter of the left main coronary artery aneurysm was measured as 40 mm. The patient was enrolled in a treadmill exercise test according to the modified Bruce protocol. Ischemic signs were found in the anterior leads. Coronary angiography revealed a giant left main coronary artery aneurysm, a totally occluded left anterior descending artery, and a diffusely diseased circumflex artery (Figure 1). The patient underwent CABG with upper mini-sternotomy. Perioperatively, the giant calcified coronary aneurysm was seen between the aorta and the pulmonary artery (Figure 2). Myocardial protection was achieved with antegrade cold blood cardioplegia and topical cooling. In situ, the left internal thoracic artery -the first obtuse margin branch of the circumflex artery, and the right internal thoracic artery- the left anterior descending artery anastomoses were performed under cardiopulmonary bypass. The aneurysm wall was calcified and non-resectable. The postoperative course was uneventful. Dual antiplatelet therapy was started and the patient was discharged at the postoperative seventh day in a good condition. The patient's

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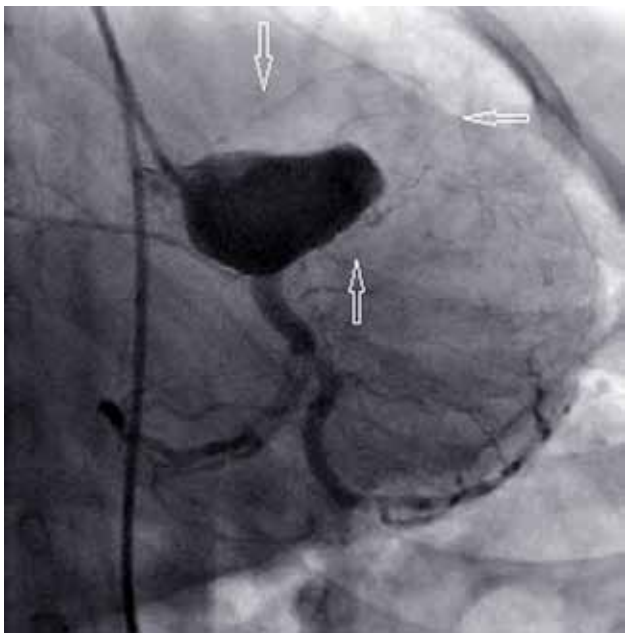

Figure 1. Coronary angiography showing partially thrombosed aneurysm, left anterior descending artery and circumflex artery with involvement (arrows show calcific wall of the aneurysm).

cardiologic follow-up data was reviewed retrospectively and the postoperative course was found uneventful without angina pectoris and ideal functional capacity.

DISCUSSION

Coronary artery aneurysm occurs in approximately 20% of untreated patients with KD, whereas it accounts for only 4% to 8% of children who receive intravenous gamma globulin.[4] Currently, early high-dose intravenous gamma globulin is accepted as the standard initial therapy. Late intravenous gamma globulin administration may also decrease inflammation, but may not be able to prevent coronary artery lesions.[5,6] In the presence of clinical suspicion, persisting fever less than five days may be considered to be a positive diagnostic criterion and intravenous gamma globulin can be employed.[7] Chen et al.[8] analyzed nine studies investigating the progression of coronary involvement in KD and concluded that the combination of a corticosteroid with the conventional regimen of intravenous gamma globulin as the initial treatment strategy might reduce the risk of coronary abnormality.[8,9] Currently, TNF alpha antagonists are used, particularly in patients with intravenous gamma globulin resistance.[10] Therefore, our patient was

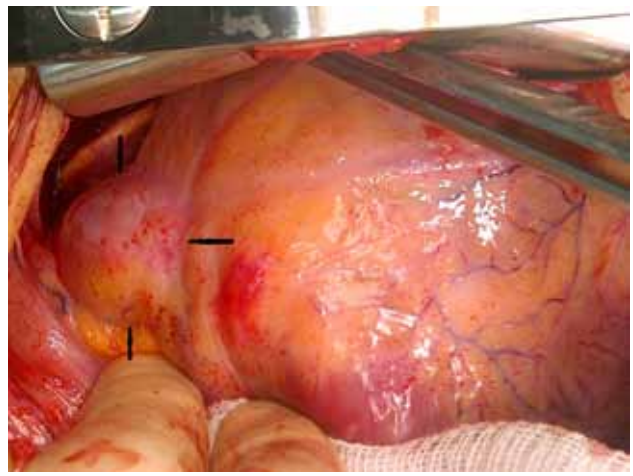

Figure 2. Perioperative appearance of proximal coronary artery aneurysm (arrows show aneurysm).

considered inappropriate for TNF alpha antagonist therapy due to late presentation.

Kawasaki disease generally affects proximal segments of the coronaries. In our patient, the left anterior descending artery was diffusely diseased and the circumflex artery was segmentally involved. Our patient received neither immunoglobulin nor steroid therapy previously and experienced prolonged periods of fever several times. The association of prolonged fever with coronary artery lesions has been well established.[11] Frequent cardiac imaging in fever episodes may be helpful, since children cannot distinguish ischemic symptoms.

Although coronary aneurysms due to KD may be asymptomatic, myocardial infarction and rupture are life-threatening complications which are rarely reported in the literature. Aneurysms may cause thrombosis, distal embolization, calcification, coronary stenosis, myocardial ischemia, infarction, rupture, cardiac tamponade and even death. Akagi et al.[12] reported a 1.5% incidence of myocardial infarction in patients with a giant coronary artery aneurysm during a four-year follow-up period. Coronary aneurysms do not tend to rupture except in acute illness. Ruptured aneurysms have been noted as case reports and, to the best of our knowledge, there is no satisfactory study investigating the incidence and risk factors for aneurysm rupture. The selection of the ideal surgical technique is still controversial. In symptomatic patients, CABG with or without aneurysmectomy is the preferred approach. Aneurysmectomy can be

performed in selected cases, however, it may cause difficulties in revascularization and the protection of branches. On the other hand, ligation of the aneurysm and distal bypass is a controversial alternative due to the risk of subsequent graft failure.[13] Coronary artery bypass graft surgery with internal thoracic artery graft is the gold standard in patients suffering from myocardial ischemia.[13] The internal thoracic artery is the preferred graft with a high long-term patency rate.[13] In our patient, we utilized bilateral internal thoracic artery grafts for revascularization.

In conclusion, giant coronary aneurysm is a very rare and life-threatening complication of KD. Early diagnosis and aggressive treatment may prevent aneurysm formation. Coronary artery bypass grafting is a safe and preferred approach with encouraging long-term results in patients suffering from myocardial ischemia.

Declaration of conflicting interests

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Cardiovascular Surgery and Interventions

Case Report Open Access

Urgent carotid endarterectomy in carotid artery stenosis with a pedunculated thrombus: a case report

Muhammet Akyüz, Onur Işık, Mehmet Fatih Ayık, Yüksel Atay

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Intraluminal thrombus in the context of carotid artery stenosis is rarely encountered. The prevention of major disabling stroke is one of the foremost goals of the urgent treatment of carotid lesions with an intraluminal thrombus. Urgent carotid endarterectomy following non-disabling stroke or crescendo transient ischemic attacks is a safe and feasible procedure with favorable outcomes. Endovascular therapy may not be suitable in selected cases. Carotid artery stenosis with a pedunculated thrombus, as in the present case, has a higher risk of embolization than other intraluminal thrombi. Herein, we describe a case with recurrent episodes of amaurosis fugax, who underwent urgent carotid surgery due to a pedunculated thrombus.

Keywords: Carotid endarterectomy; endarterectomy; pedunculated thrombus.

Intraluminal carotid artery thrombus (ICAT) is an infrequent finding in patients presenting with transient ischemic attack (TIA) or ischemic stroke.[1] It can be found both in the presence or absence of carotid artery stenosis.[2] An intraluminal thrombus may occur secondary to the extension of intraplaque hemorrhage and may produce significant morbidity and mortality, in case of proceeding to thrombotic occlusion or embolic events.

In the North American Symptomatic Carotid Endarterectomy Trial (NASCET), the risk of perioperative stroke and death doubled in the patients with ICAT who underwent carotid endarterectomy (CEA) compared to the patients without ICAT who underwent CEA (12% vs. 6%, respectively).[3] Therefore, the optimal management of the patients with symptomatic ICAT still remains poorly defined. Treatment options include medical management utilizing anticoagulation with or without antiplatelet drugs,[3] early carotid revascularization with CEA or carotid artery stenting (CAS).[1]

Percutaneous transluminal angioplasty (PTA) and CAS have been increasingly employed for the treatment of high-risk patients with carotid artery stenosis,[4] however, surgical treatment for the presence of carotid artery stenosis with pedunculated thrombus is a proper option. The major concern for carotid endarterectomy procedures with a pedunculated thrombus was the timing of surgery. Urgent surgical treatment was advocated for patients with an intraluminal thrombus to prevent neurologic deterioration. The present paper describes a case of carotid artery stenosis with a pedunculated thrombus in the light of literature data.

CASE REPORT

A 68-year-old woman with a history of hypercholesterolemia presented with a one-month history of TIA with amaurosis fugax. She was hospitalized in the neurology department. She had three to four attacks within one month, each lasting for 30 to 40 minutes. Physical examination revealed a blood pressure of 140/90 mmHg. A right carotid bruit was noted and the neurological examination findings were normal. A computed tomography (CT) brain scanning was normal and carotid duplex scanning showed significant stenosis of the right internal carotid artery (ICA). The left carotid artery had normal flow patterns. Following a diagnosis of carotid artery stenosis, the patient received aspirin (100 mg/day) and clopidogrel (75 mg/day). Neurological status was stable and elective CAS was planned. Computed tomography angiography was planned for the evaluation of cerebral parenchyma and supra-aortic vessel before elective CAS. However, the patient was diagnosed with

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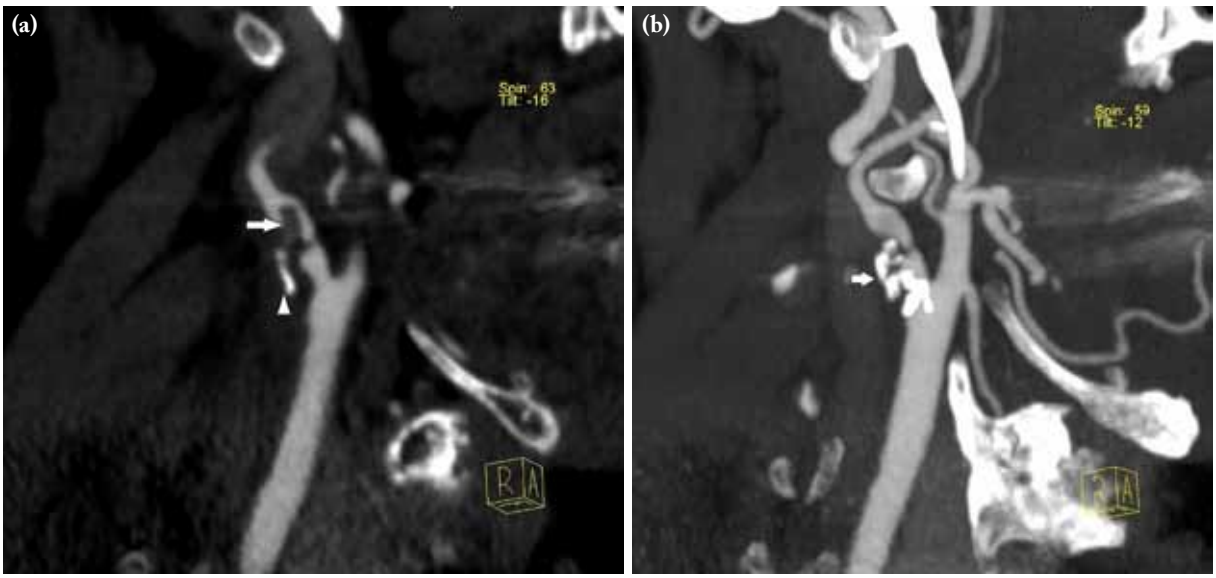

Figure 1. **(a)** Computed tomography angiography showing a right severe carotid bulb stenosis with deep plaque ulceration (arrow, pedunculated thrombus; arrowhead, bulb plaque ulcer). **(b)** A markedly right carotid artery stenosis (approximately 90%, arrow).

intraluminal pedunculated thrombus by diagnostic CT angiography (Figure 1). Thus, urgent right CEA was planned and performed to prevent an ongoing distal embolism or acute occlusion. Under general anesthesia, CEA was performed. Cerebral oximetry using near-infrared spectroscopy (NIRS) was used to monitor cerebral oxygenation during operation. Regional cerebral oxygen saturation (rSO_2) was monitored continuously throughout the procedure. We based on the typical range of rSO_2 is 55-80% and absolute rSO_2-values <50% or a 20% drop from individual rSO_2 baseline are commonly considered as an intervention trigger.

During surgical exposure, manipulation of the carotid artery was avoided due to the presence of a pedunculated thrombus. After systemic heparinization, the common, internal, and external carotid arteries (CCA, ICA, ECA) were clamped. Conventional CEA was performed through a longitudinal arteriotomy from the CCA bifurcation to the ICA on the anterior surface of the artery. In the arteriotomy, pedunculated thrombus was noted association with the plaque in ICA and the thrombus was removed from the proximal end of the ICA (Figure 2). Endarterectomy was carried out following a careful identification of the cleavage plane. The distal intima was secured to prevent intimal dissection with 6-0 prolene sutures. The arteriotomy site was closed primarily without using the shunt due to distal ICA systolic tension over 50 mmHg pressured after cross-clamping and the rSO_2 did not drop to more than 12% of the preclamping value during clamping.

Figure 2. Carotid endarterectomy in progress. Plaque can be seen in the lumen of the common carotid artery (CCA) and the internal carotid artery (ICA). The pedunculated thrombus in the lumen of the ICA is also identified with a forceps (arrow).

The patient was discharged three days later with combined clopidogrel-aspirin therapy and anti-hypertensive medication. At the follow-up, the duplex showed normal flow in the carotid arteries.

DISCUSSION

The optimal strategy for the treatment of carotid artery stenosis with intraluminal thrombus remains controversial. This condition is rarely encountered. Buchan et al.[1] reported that stroke and occlusion did not occur in 14 patients with ICA stenosis and concomitant thrombus treated medically (e.g., heparin and warfarin). In contrast, Walters et al.[5] advocated emergent surgical treatment for patients with an intraluminal thrombus to prevent neurologic deterioration. However, there are relatively few reports describing outcomes of PTA and CAS for the treatment of carotid artery stenosis with an intraluminal thrombus.[6]

In the NASCET study, Villarreal et al.[3] reported that the 30-day risk of stroke or death for patients with an intraluminal thrombus was 12.0% and 10.7% for patients treated with surgery or medical therapy, respectively. Urgent carotid surgery versus percutaneous approach seems to be the most feasible option as in the present case. On the other hand, there are no clear guideline recommendations for the management of the patients with acute stroke or high-risk of acute stroke.

There are three groups of symptomatic patients presenting with possible indications for emergent carotid endarterectomy, including crescendo transient ischemic attacks, fluctuating neurological deficit, and acute stroke in evolution.[2] The goal of surgery is to improve the existing perfusion by removing the thrombus or the source of emboli and to protect against further stroke. Furthermore, early surgery before a possible acute stroke may decrease the higher risk of intracranial bleeding and embolization due to treatment options as thrombolysis or endovascular intervention.

The American Heart Association's Guidelines for prevention of stroke in patients with ischemic stroke or transient ischemic attack recommend surgery within two weeks, when CEA is indicated for patients with TIA or stroke (Class IIa, level of evidence B).[7] The risk of treatment options in relation to the clinical condition and type of stenosis may decrease with appropriate timing of treatment. If the patient, as in the present case, is diagnosed with carotid artery stenosis with a pedunculated thrombus, surgery should be planned immediately. The authors of the current study performed CEA, as soon as the diagnosis was made by CT.

Although CAS was feasible in the presence of an intraluminal thrombus with or without carotid artery stenosis, it has the higher risk of procedure-related thromboembolic events.

In conclusion, the authors believe that urgent endarterectomy compared to CAS remains the best option in patients of carotid artery stenosis with a pedunculated thrombus.

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Cardiovascular Surgery and Interventions

Letter to the Editor Open Access

Removal of an embolized transcatheter occluder device: the contradictious surgical treatment of a percutaneous complication

Hamit Serdar Başbuğ, Kanat Özışık

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Dear Editor,

I wish to provide some perspective about the embolization of an Amplatzer ductal occluder with regard to a recent case report which appeared in your journal. The author, Mr. F. Gümüş,[1] reported his experience on the removal of an embolized Amplatzer patent ductus arteriosus (PDA) occluder device.[1] It was clear from his paper that he had no attempt to perform percutaneous methods before the surgical operation.

As a basic information considering the transcatheter treatment of atrial septal defect and PDA, Amplatzer septal/ductal occluder (ASO/ADO) device has been used safely, efficiently and with success. Unfortunately, the worst complication of this procedure, which is the device embolization, requires immediate intervention either percutaneous or surgical. The device embolization can be seen in 0.55-3.8% of these cases.[2-4] However, this complication should be overcome primarily by percutaneous methods before an open surgical approach. Balbi et al.[2] reported that the success rate of percutaneous retrieval of an embolized device is 50%. Similarly, Chan et al.[5] presented a case of embolized device into the right ventricle and a successful retrieval by using percutaneous gooseneck snare. An embolized device may be simply rescued by using a loop snare, an endocardial biopsy forceps, a Fogarthy catheter, or a 15 mm Amplatz GooseNeck Snare, through a femoral arterial percutaneous access instead of this massive surgical operation.[3-5] In the light of all these aforementioned references, which are the obvious examples of how can an embolized device be rescued, the preference of a surgical option without trying any previous percutaneous maneuver seems to be incorrect.

As the authors mentioned themselves, Gümüş et al. did not try a percutaneous intervention and, instead, they directly switched to an extensive open surgery. What was the reason for making this decision? Why did they not consider percutaneous options before surgery? Moreover, this contradictiously extensive surgery including both median sternotomy and median laparotomy together in a five-year-old child may cause more serious morbidity and unfortunate results, compared with an existence of PDA itself.

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Author's Reply

Dear Editor,

We thank for the insightful comments and the opportunity to clarify a number of points from our case report titled 'Open abdominal surgery for migration of patent ductus arteriosus (PDA) occluder device' which appeared in the recent publication of your journal.[1]

As previously mentioned, percutaneous treatment of PDA is a safe and efficient method, but device embolization is a well-known, but rarely seen complication which requires an immediate percutaneous or surgical intervention.[2] Indeed, we agree that, device embolization should be overcome primarily by percutaneous approach before surgery. As mentioned in our case report, 'Several attempts by catheter retrieval failed' and also 'Preoperatively monitorized femoral pulses became feeble'.

We did not directly switch to open abdominal surgery, contrarily we tried percutaneous attempts to rescue the embolized device.

In conclusion, surgical approach is a useful, but not primarily used method for device embolization.

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