Current surgical approaches in Takayasu's arteritis: a single-centre experience

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ABSTRACT

Objective. *We investigated cardiovascular surgical interventions in a group of patients with Takayasu's arteritis (TAK) diagnosed and followed by a single centre.*

Methods. *Twenty patients with TAK (5 males, 15 females, mean current age: 38.1±10.7) who were operated for a broad spectrum of cardiovascular diseases ranging from coronary heart disease to coeliac stenosis or aneurysm between July 2008 and April 2016 were studied. One patient underwent operation related to aneurysm of ascending aorta and aortic insufficiency, 2 patients had operations for both coronary arteries originating from aortic arch, 6 patients for only arteries originating from aortic arch, 1 patient for both carotid and infra-inguinal artery, 5 patients for aorta-iliac or femoral revascularisation, 5 patients for renal artery and/or coeliac or superior mesenteric artery revascularisations. Three of these interventions were endarterectomy and patch plasty.*

Results. *The mean time between diagnosis and surgical intervention was 6.1±3.1 years (range: 3 months-12 years). A total of 4/32 (12.5%) grafts were occluded during the follow up period of mean 39.2±24.6 months. Secondary interventions like cross-femoral, or graft to superficial femoral artery bypasses were needed in 2 patients who underwent aorta-bifemoral bypasses to keep patency. There was no operative mortality. We did not observe any anastomotic aneurysm. One patient died due to graft infection 3 months after the operation. Stroke occurred in 2 patients who underwent revascularisations of the arteries originating from aortic arch.*

Conclusion. *In our series, we have a relatively good midterm patency rates in patients with TAK and did not observe any anastomotic pseudoaneurysm. Stroke developed in 2 patients and mortality occurred in one patient due to the graft infection 3 months after the operation. In patients with limited carotid or aorta-iliac stenosis, chance for endarterectomy should be evaluated. Well-controlled disease activity with intensive medical treatment and multi-disciplinary approach could be associated with a favourable long-term outcome.*

Introduction

Takayasu's arteritis (TAK) is a rare chronic granulomatous vasculitis involving aorta and its major branches (1-4). Females are more frequently affected. TAK is more common in Asia than that observed in Europe and North America.

Arterial involvement may manifest as concentric arterial wall stenosis of diverse width and length, occlusions or aneurysms (3). End organ ischaemia depending on the supplying arteries involved is the major factor playing role in most of the clinical manifestations. Patients may present with angina pectoris, myocardial infarctions, if coronary arteries are involved, amaurosis fugax, transient ischaemic attacks, stroke and upper extremity ischaemia, if aortic arch vessels are involved, chronic renal failure, if renal arteries are involved, lower extremity ischaemic symptoms, such as claudication, rest pain and tissue loss, if abdominal aorta and/or iliac arteries are involved or abdominal angina, if coeliac and mesenteric arteries are involved (1-4). Additionally, up to 70% of patients may suffer from hypertension. Cardiovascular and neurological complications lead to serious morbidity such as heart failure or stroke and increased mortality in these patients (1-4). However, some patients may remain symptom free for long

time, most probably due to the rich collateral arteries.

Corticosteroids are the mainstay treatment (4). Immunosuppressive and several biological agents are also used to control disease activity (4). However, medical treatment alone may not be sufficient in the management of arterial lesions that are haemodynamically significant; in these cases revascularisations are required (5-7). Indications for revascularisation include cerebrovascular disease due to cervico-cranial vessel stenosis, coronary artery disease, moderate to severe aortic regurgitation, severe coarctation of the aorta, renovascular hypertension, limb claudication, and progressive aneurysm enlargement with risk of rupture or dissection (5). Most of the arterial lesions may not be suitable for endovascular interventions and may require surgical corrections to restore arterial insufficiency (5-7).

In this study, we evaluated retrospectively clinical characteristics and surgical techniques of 20 patients with TAK who underwent surgical interventions for arterial stenoses or aneurysms.

Patients and methods

Twenty (15 F/ 5M) patients with TAK (mean current age: 38.1 ± 10.7, range: 23-57) who underwent cardiovascular surgery between July 2008 and April 2016 were studied. All patients fulfilled ACR criteria for TAK (8). The methods used during the operations, their complications and the postopera-

Table I. Clinical and surgical details of the Takayasu's patients included in the study.

Name	Gender/ age/ dis. Dur	Symptom, signs vascular lesions	Operation	Follow up (mos.)	Complications	Outcome
1-ZK	F/32/7	Fatigue, dyspnea, NYHA IV, HT Severe AI, An Asc Ao Mid aortic and right renal artery (stent 2 years ago) restenosis	Aortic valve sparing repair of the aortic root and hemiarch replacement (David op.) (30mm Dacron) Modified Cabrol for coronary button implantation (10 mm Dacron)	*48*	30 mo. After op. Occlusion of the right coronary graft.	Surviving with mod. AI Partially controlled HT
2-SE	F/31/9	Angina pectoris, LMCA disease, An of left SV An of Left SA	CABGx2 (VSM), Repair of An of SV with autolog pericardium, Resection of left SA & Left CSB with 6 mm PTFE	*49*	---	CSB graft patent, NC
3-HB	M/54/5	Dizziness Near occlusion of innominate and left carotid arteries at the ostiums, Stenosis in prox. LAD	CABGx1(VSM) off pump, Asc Ao to innominate& Left CCA bypass with 16x8 mm bifurcated Dacron graft	*1*	Hypotensive episode during op. Slight paresis left upper extremity (Small infarction on the frontoparietal lobe of brain on cranial MR)	Stroke except 1/5 strength loss in the right arms.
4-ST	F/42/4	Claudication of right arm and hand, Left SA artery An and occlusion of left brachial artery	Aneurysmectomy to left SA An. and SA to interosseos artery bypass with composite graft composed of 8 mm fusion (PTFE covered with dacron) graft (25 cm in length) and VSM (7 cm in length)	*25*	Graft thrombosisin the first postoperative day, Thrombectomy did not provide patency rethrombosis occurred	Claudication of right arm and hand exists
5-ST	F/48/3	Claudication of left arm and hand, ischaemic stroke	1- End to side anastomosis of the innominate artery to the right common carotid artery bypass with PTFE graft.	*3*	Graft infection	Graft patent Died due to graft infection
6-AKR	F/27/4	Right haemiplegia 1 month ago Occlusions of both CCA	Asc Ao to Bilateral CCAs bypass with 14x7 mm bifurcated Dacron graft	*13*	-----	Grafts occluded no cerebro-vascular event since the operation
7-AK	F/35/6	Faintness, fatigue, dizziness, Amaurosis fugax on the right eye Occlusions of both CCA	Asc Ao to right CCA bypass with 8mm Dacron graft (left CCA was not eligible to bypass)	*48*	-----	Graft patent NC
8-KA	F/42/2	Left haemiparesia before the first admission to hospital	1-Right carotid aneurysmectomy and 8 mm PTFE graft interposition	*21*	-----	Graft patent (right)
		Aneurysms of both CCA with wall thickness	2- Left carotid aneurysmectomy and 8 mm Dacron graft replacement	*10*	Right haemiplegia and motor aphasia 10 hrs after op. Graft thrombosis. Major infarcts on left MCA areas were seen.	Graft occlud. (left) Stroke (Motor aphasia and right haemiparesia)
9-AV	F/53/8	Claudication of left arm and hand, fatigue, Left SA artery occlusion,	1-Left CSB with with 6 mm PTFE	*96*	-----	CSB graft Patent
		Left carotid artery stenosis (Asymptomatic, >%80)	2-Left carotid endarterectomy VSM patch plasty	*27*		Carotid artery open NC

Name	Gender/ age/ dis. Dur	Symptom, signs vascular lesions	Operation	Follow up (mos.)	Complications	Outcome
10-HK	M/57/13	Rest pain in the left lower limb, An of left CFA and SFA occlusion, Left carotid artery stenosis (Asymptomatic, >%80)	1-Left carotid endarterectomy PTFE patch plasty 2-Left CFA aneurysmectomy, CFA to prox. PA. 8 mm PTFE bypass	*59* *58*	----- -----	Carotid artery open Fempop graft patent, NC
11-AR	F/52/12	HT (left renal artery stent, 12 years ago) Rest pain in lower limbs	1-ABF bypass with 16x8 mm bifurcated PTFE 2-Right to left cross Fem. bypass 8 mm fusion (PTFE covered with dacron)graft	*92* *28*	Occlusion of the left leg of the bifurcated graft at 64 month -----	Right leg of ABF and cross fem. grafts Patent NC
12-ED	F/40/6	Rest pain in the left lower limb,	1-ABF bypass with 14x7 mm bifurcated PTFE 2-Bypass from left limb of the bifurcated PTFE to SFA with VSM	*69* *11*	We defined postanastomotic critical stenosis on the left side 58 months after 1st op.	Grafts patent, NC
13-İA	F/49/7	Rest pain in lower limbs	ABF bypass with 14x7 mm bifurcated Dacron	*52*	-----	Graft patent, NC
14-FG	F/32/0.25	Rest pain in lower limbs	ABI bypass with 14x7 mm bifurcated Dacron	*23*	-----	Graft patent NC
15-HI	F/31/3	Rest pain in the left lower limb,	ABI Endarterectomy PTFE patch plasty	*22*	-----	Abdominal Ao and iliac arteries patent, NC
16-ED	F/28/6	Abdominal and back pain, uncontrolled HT Diffuse stenosis of right renal artery	Infrarenal Abdominal Ao. to right renal artery bypass with VSM	*28*	-----	Improvement in HT, NC
17-EA	M/25/9	Uncontrolled HT Restnosis in left renal artery (stent placement 5 years ago)	Infrarenal Abdominal Ao. to left renal artery bypass with VSM	*44*	-----	Improvement in HT, NC
18-AY	M/45/5	Postprandial abdominalpain CeA and SMA stenosis	Bypasses to CeA and SMA from supracoeliac Aorta with 14x7 mm bifurcated PTFE	*26*	-----	Graft patent NC
19-ET	F/23/6	Postprandial abdominal pain (Stent placement to coeliac artery 1year ago) Ischaemic ulceration of fingers on both hands	Bypass to CHA from supracoeliac Aorta with 8 mm PTFE, Bypass to SMA from Infrarenal Abdominal Ao. with VSM	*36*	-----	Grafts patent, NC But she had finger resections because of subclavian artery occlusions not amenable to bypass
20-SY	M/26/5	Headache, HT, postprandial abdominal pain (Hydrocephalus Ventriculo-peritoneal shunt 2001)	1-Thoracal Ao to left CIA bypass with 16 mm Dacron graft 2-Resections of renal artery and coeliac aneurysms and Bypasses to left renal, CeA, and right renal arteries with bifurcated 14x7 PTFE and 8 mm PTFE anastamosed its body	*47* *46*	----- 3 months later occlusion of right renal artery graft and loss of right kidney	Grafts Patent (except to right renal artery) improvement in HT and intestinal angina NC

F: female; M: male; Dis. Dur.: disease duration; mos: months; HT: hypertension; AI: aortic insufficiency; An: aneurysm; Asc: ascending; Ao: aorta; Op: operation; Mod: moderate; LMCA: left main coronary artery; SV: sinus of valsalva; SA: subclavian artery; CSB: carotico-subclavian bypass, PTFE: polytetrafluoroethylene, Prox: proximal , LAD: left anterior descending coronary artery, Compl: complaint, CCA: common carotid artery; NC: no complaint; CFA: common femoral artery; SFA: superficial femoral artery; PA: popliteal artery; VSM: greater saphenous vein; ABF: aorta-bifemoral; ABI: aorta-biiliac; CeA: coeliac artery; SMA: superior mesenteric artery; CHA: common hepatic artery; CIA: common iliac artery.

tive outcomes and long-term follow-ups were evaluated. Thirteen patients (13/20) have already been followed up by the rheumatology department of the same faculty, whereas seven (7/20) were referred from outside hospitals. All patients were preoperatively evaluated by the rheumatologists and prepared for operations. All patients received immunosuppressive treatment with corticosteroids during the preoperative and perioperative period. Pulse corticosteroids were administered in case of high disease activity during the perioperative course and maintenance corticosteroids dose was increased in all patients.

Computed tomography angiography (CTA), magnetic resonance angiography (MRA), digital subtraction angiography (DSA), coronary angiography and echocardiography were the diagnostic modalities performed to define the level of cardiovascular involvement and surgical planning according to patients' individual requirement. All patients were consulted to invasive radiology and cardiology departments before the decision of surgery. None of them were found to be eligible for endovascular treatment. All excised arterial tissues during the operations were sent to the pathology department for examination. Similarly, the parts of saphenous veins that were not used in operations were sent to the pathology department. No pathological lesion was found in parts of saphenous veins. Patients were discharged with 100 mg acetyl-salicylate and 10 or 20 mg statins along with immunosuppressive/corticosteroid treatment regulated by the rheumatologists. After discharge from the hospital, patients were evaluated at 1 week, 1 month, and every 6 months thereafter.

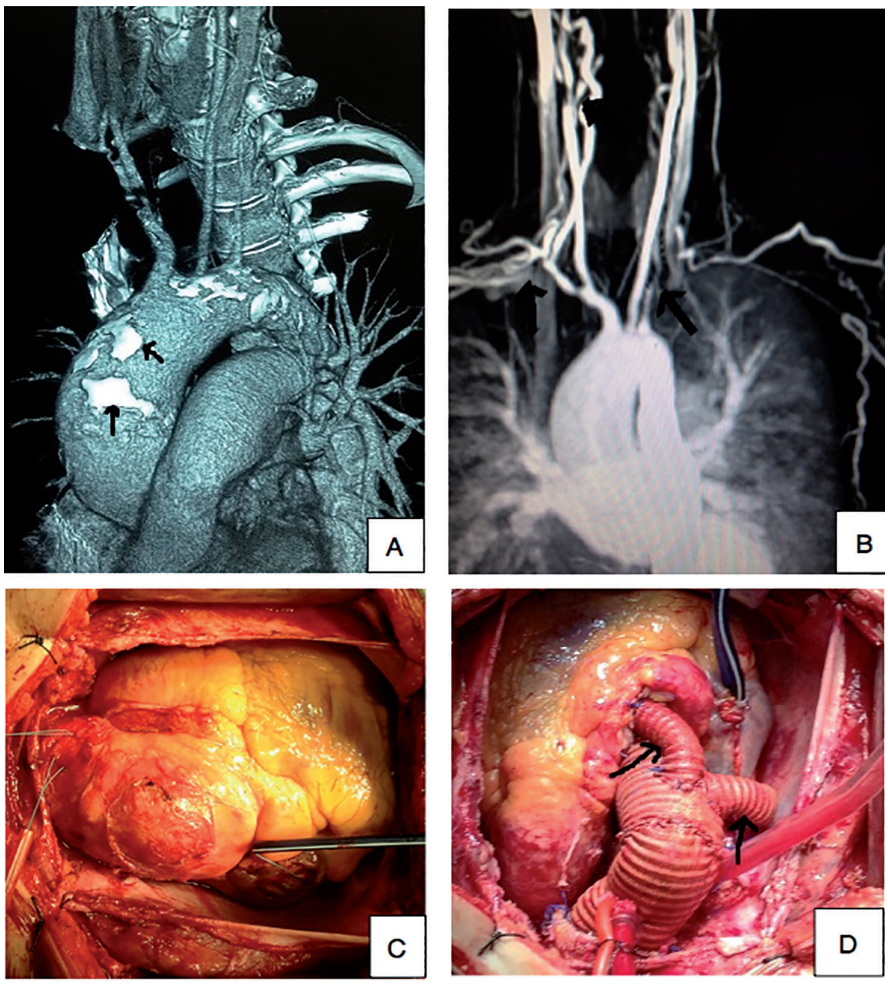


Fig. 1. CTA view of the aneurysm of ascending aorta of the patient also showing some areas of calcification (arrows) **(A).** MRA of the arcus aorta and its branches demonstrating occlusions of the subclavian arteries and stenosis of right carotid artery at the bifurcation (arrows) **(B).** Operative view of the aneurysm of ascending aorta **(C)**. After valve sparing replacement of the ascending aorta and haemiarchus and anastomosis of coronary buttons via 10 mm Dacron grafts to main body (arrows) **(D)**.

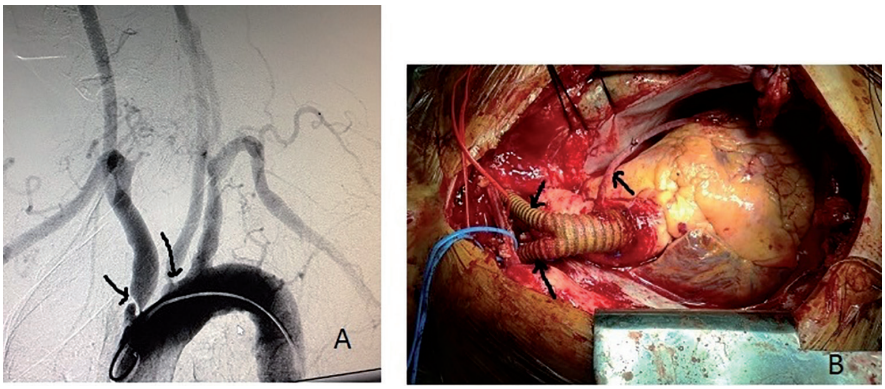
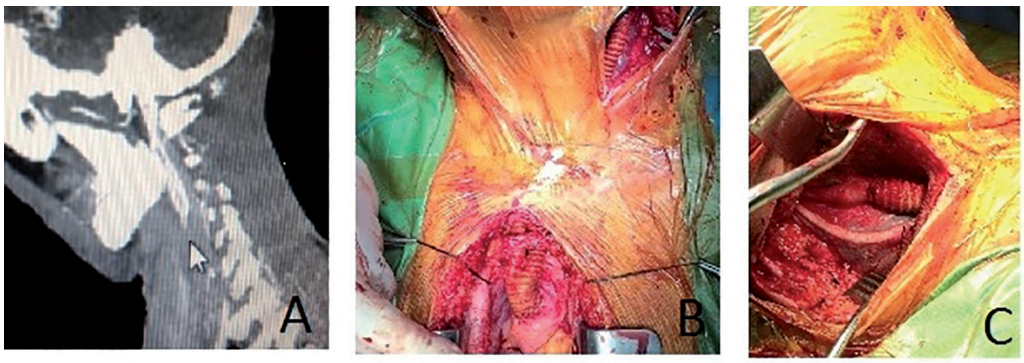


Fig. 2. DSA of the patient showing critical stenoses of the origins of the innominate and left common carotid artery (arrows) **(A).** Operative view: Body of the bifurcated Dacron graft (16x8 mm) anastomosed to ascending aorta and its one leg to innominate and the other leg to the left common carotid artery end to end fashion and proximal anastomosis of the VSM bypassed to LAD (off-pump) was made on the Dacron graft also (arrows) **(B)**.

Description of the surgeries
- Ascending aortic aneurysm (patient 1, Table I)

Patient 1 who had ascending aortic aneurysm (diameter: 52 mm) and severe aortic insufficiency underwent valve sparing aortic root and hemiarch replacement. We defined a pressure gradient between the ascending aorta and radial arteries more than 110 mmHg at measurements during the operation. She had also renal artery stent stenosis and midaortic syndrome. It was impossible to implant the coronary buttons directly to the ascending aortic graft due to the increased wall thickness and



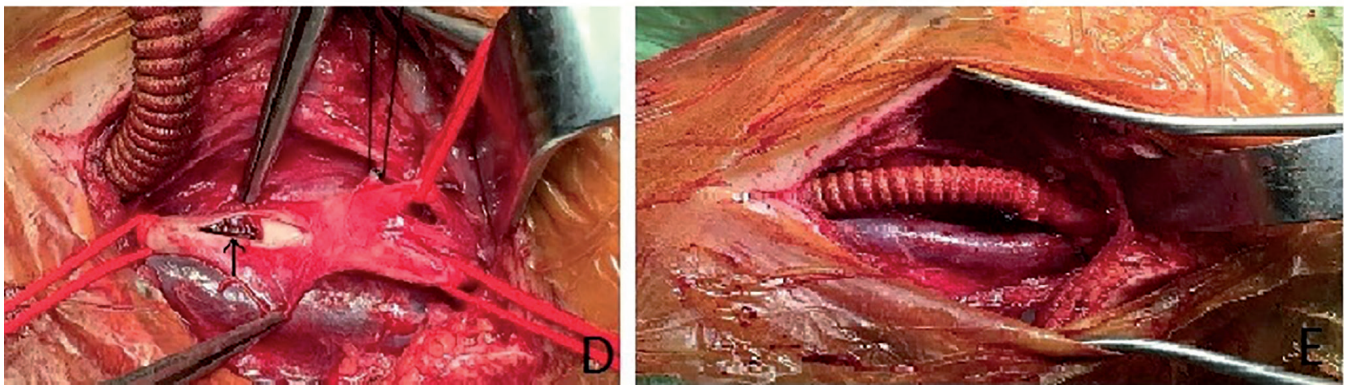


Fig. 3. CTA view of the left common carotid artery occlusion just proximal to bifurcation (white arrow) **(A)**. Operative view: Body of the bifurcated Dacron graft (14x8 mm) anastomosed to ascending aorta and its legs to bilateral common carotid arteries **(B)**. End to side anastomosis to the right common carotid artery **(C)**. Fresh thrombus inside the left common carotid artery (arrow) **(D)**. End to end anastomosis to the left common carotid artery **(E)**.

stiffness. That is why we used modified Cabrol procedure with 10 mm Dacron grafts for implantations of coronary buttons (Fig. 1). She suffered from right heart failure due to the inadequate use of antihypertensive drugs 30 months after the operation. She was found to have total occlusion of the right coronary graft in CTA. Additionally, she had moderate aortic insufficiency not requiring reoperation. She improved after intensive antihypertensive treatment and diuretics.

- Aortic arch vessels and coronary artery involvement
(patients 2, 3, 4 and 5, Table I)

Patient 2 underwent coronary artery bypass grafting *(CABG)* with saphenous veins due to the left main coronary artery stenosis. She also had repair of aneurysmatic dilatation of left sinus of valsalva with pericardium, resection of the proximal left subclavian artery aneurysms and left carotico-subclavian bypass with polytetrafluoroethylene (PTFE) graft.

Patient 3 who had critical stenotic lesions in the innominate, left carotid and proximal left anterior descending coronary artery (LAD) underwent ascending aorta to innominate artery and to the left common carotid artery bypasses with bifurcated Dacron graft and CABG to LAD on beating heart (Fig. 2). He complained of slight haemiparesis of the right upper extremity after operation. We observed an infarction on the left frontoparietal areas of the brain on cranial CT. We thought that it was due to the hypoperfusion resulting from hypotensive episode during left carotid anastomosis.

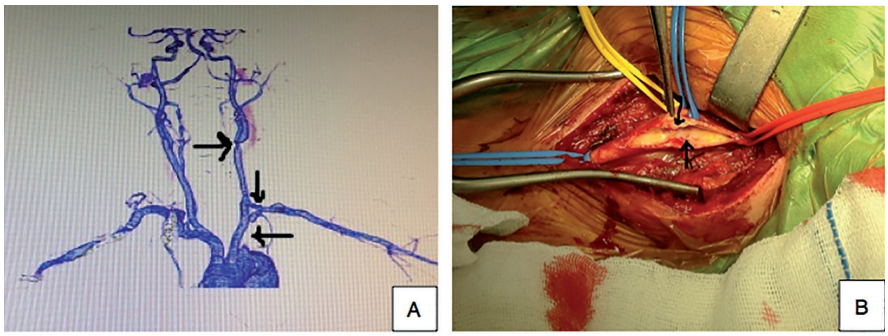


Fig. 4. CTA of a female patient showing patent caroticosubclavian bypass graft (6 mm PTFE) for 96 months, left subclavian artery occlusion and critical stenosis of left at the level of bifurcation (arrows) **(A)**. Operative view of the same patient during carotid endarterectomy and VSM patch plasty before temporary shunt was inserted and at the time of arteriotomy exposing plaque causing stenosis (arrows) **(B)**.

Patient 4 with right subclavian artery aneurysm and brachial artery occlusion, underwent resection of aneurysm and bypass from proximal subclavian artery to interosseous branch of brachial artery with a composite graft composed of 8 mm fusion (PTFE covered with Dacron) graft and saphenous vein. Brachial artery was the only suitable vessel (2-3 mm in diameter) found in the proximal forearm. We also checked the patency of the graft and anastomosis during the operation using duplex scanning. The patient had graft thrombosis in the first postoperative day. Thrombectomy was done immediately, however, the graft thrombosed the day after. As the patient had no rest pain, medical treatment was instituted.

Patient 5 underwent end to side anastomosis of the innominate artery to the

right common carotid artery bypass with PTFE graft. She died due to graft infection 3 months after the operation.

Carotid artery involvement (Patients 6, 7, 8, 9, and 10, Table I)

Patients 6 and 7 underwent ascending aorta to carotid artery bypasses because of carotid occlusions. We saw fresh, partially organised thrombus inside the left carotid bifurcation of the one who had bypasses to both carotid arteries. That was probably responsible for the patient's recent history of right haemiplegia (Fig. 3). Other patient underwent bypass from ascending aorta to only right common carotid artery because there was no place suitable for bypass on the left carotid artery.

Patient 8 who had fusiform aneurysms of both common carotid arteries underwent aneurysm resections and graft interpositions with 11 months interval. She had right haemiplegia and motor aphasia after 10 hours of the second bypass operation performed on the left side, due to early graft occlusion. Cranial MRI showed acute infarctions on the left hemisphere area supplied by the middle cerebral artery.

Patient 9 underwent left carotid endarterectomy and saphenous patch plasty. The patient had the history of caroticosubclavian bypass with PTFE graft which was still patent after 96 months (Fig. 4).

Patient 10 underwent left carotid endarterectomy and PTFE patch plasty, along with resection of common femoral artery aneurysm and femoro-popliteal bypass with PTFE graft.

Femoral (patients 11, 12 and 13) or aorto-iliac involvement (patients 14 and 15, Table I)

Patients 11, 12 and 13 underwent aorta-bifemoral bypass with bifurcated grafts. In one a cross femoral bypass was performed 64 months after the first operation, because of the occlusion of the left leg of the graft. In another, postanastomotic critical stenosis at the left femoral anastomosis developed 58 months after the operation and was solved by a saphenous bypass from left leg of the bifurcated graft to superficial femoral artery (Fig. 5). No graft occlusion was observed in the third patient during a follow up of 52 months.

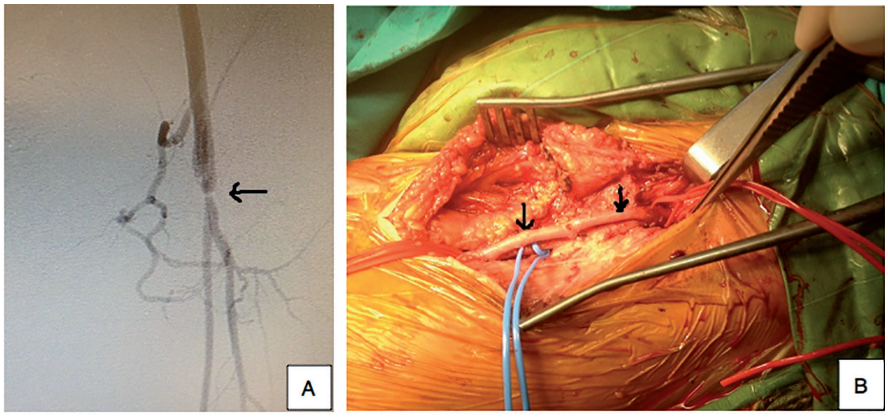


Fig. 5. DSA of the patient who underwent ABF bypass (PTFE 14x7) showing critical stenosis of left common femoral artery just distal to anastomosis (arrow) **(A).** Operative view of the graft to SFA bypass with VSM (arrows) **(B)**.

Patients 14 and 15 underwent operations for aorta-iliac arterial stenosis or occlusions. One had patent graft 22 months after aorta-biiliac bypass until now. Another had also patent arteries after 23 months following aorta-iliac endarterectomy and patch plasty.

Renal and visceral artery stenosis; (Patients 16, 17, 18, 19 and 20, Table I)

We made aorta-right renal and aorta-left renal artery (history of stent insertion 1 year ago) bypasses with saphenous vein in 2 patients with renal artery stenosis. They had good patency 28 and 44 months after the operations (Patients 16 and 17).

We made coeliac and superior mesenteric artery (SMA) bypasses in 2 (1 M/1 F) patients (Patients 18 and 19). The male patient underwent bypasses from supracoeliac aorta to coeliac and SMA with bifurcated PTFE graft. The female patient had history of coeliac artery stent placement 1 year ago and SMA occlusion. She underwent 8 mm PTFE graft bypass from supracoeliac aorta to common haepatic artery and saphenous vein bypass from infrarenal abdominal aorta to SMA (Fig. 6).

In the first operation of a young male patient (Patient 20) with diffuse stenosis and aneurysms in the supracoeliac and abdominal aorta along with stenoses of coeliac, SMA, and bilateral renal arteries, we performed a bypass procedure with 16 mm Dacron graft which passed retroperitoneal from thoracic aorta to the left common iliac artery to provide a sufficient inflow for visceral and renal revascularisations planning to take place during the second operation. One month later in the second session, we used right common iliac artery as an inflow site for visceral and renal revascularisations because there was a good connection between left and right common iliac arteries through the distal aorta. Body of a bifurcated 14x7 mm PTFE graft was anastomosed to the left common iliac artery. His left leg was anastomosed to the left renal artery after resection of aneurysm; his right leg passed under the pancreas to reach the coeliac artery. A 8 mm PTFE graft was anastomosed to the right renal artery after resection of its aneurysmatic segment and transferred and anastomosed to the right side of the body of the bifurcated graft. Three months after these operations, he was re-hospitalised with complaints of right lumbar pain, nausea and vomiting lasting for 6 days. We observed the occlusion of the graft going to right renal artery and right kidney had lost functionality. The patient was discharged after a 4-day conservative treatment (Figs. 7 and 8). He is now well doing, 46 months after his extensive operations.

Results

The mean time between diagnosis and surgical intervention was a 6.1±3.1 years (range: 3 months- 12 years). There was no peri-operative mortality. The follow-up period after surgical operation was 39.2±24.6 months (1-96 months). We did not observe any anas-

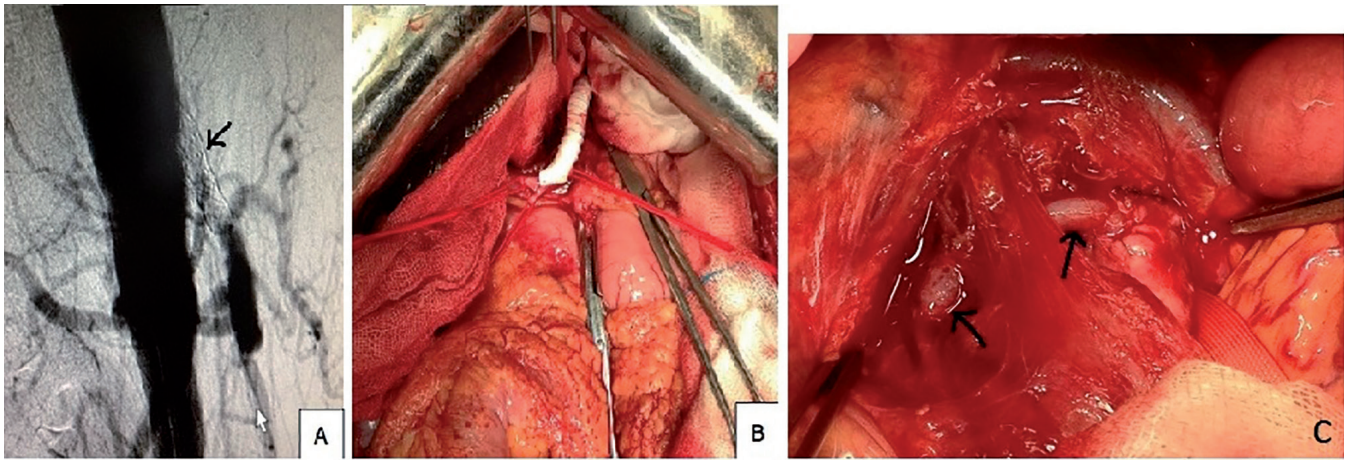


Fig. 6. DSA of the patient showing occlusion of the coeliac artery stent (arrow) and occluded SMA (white arrow) **(A).** Operative view of the 8 mm PTFE graft anastomosed between supracoeliac aorta and CHA **(B)**. VSM anastomosed between infrarenal abdominal aorta and SMA (arrows) **(C)**.

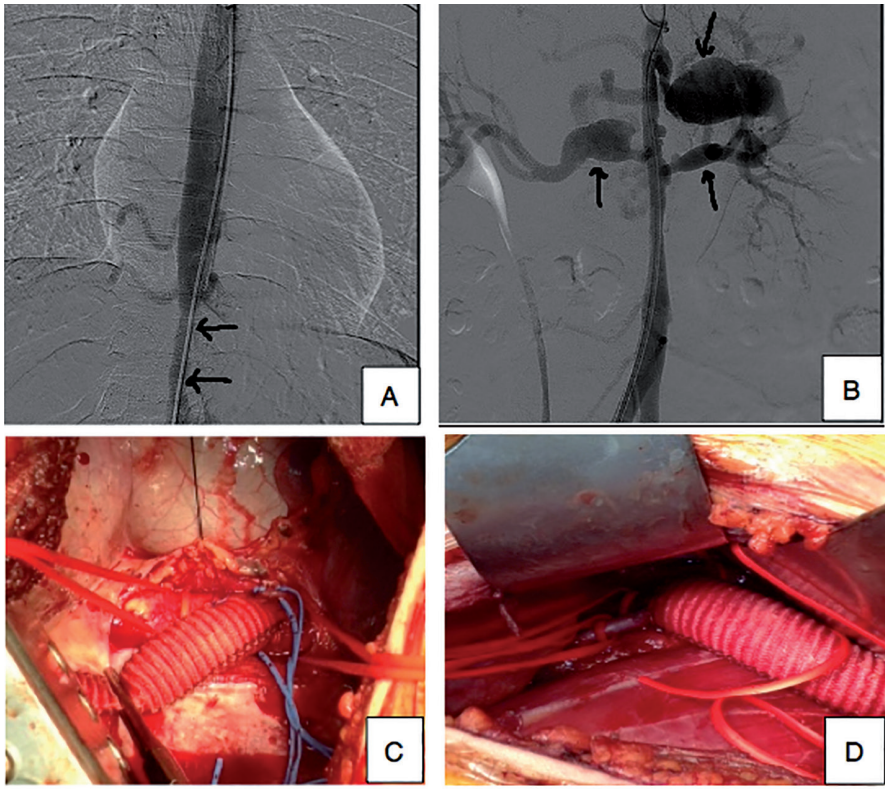


Fig. 7. DSA of the patient showing diffuse stenosis of proximal and mid parts of abdominal aorta (arrows) and thoracic aorta was spared from the disease **(A).** Distal abdominal aorta and iliac arteries were also spared from the disease process, but here is seen aneurysms and stenoses of coeliac and both renal arteries and occlusion of the SMA (arrows) **(B)**. A view from the first operation showing proximal anastomosis of the 16 mm Dacron graft made to thoracic aorta **(C)** and distal anastomosis was made to left common iliac artery to obtain sufficient inflow **(D)**.

tomotic aneurysm, however, 1 patient developed graft infection and died due to sepsis 3 months after the operation.

In surgical interventions involving heart, we used 5 bypass grafts comprising 3 vena saphena magna (VSM) for coronary revascularisation and 2 Dacron grafts for coronary buttons in Cabrol modification including 30 mm Dacron graft for aortic root and hemiarch replacement. For revascularisations of branches originating from aortic arch; 4 bypasses to carotid arteries and 1 to innominate artery with Dacron grafts anastomosed to ascending aorta proximally and 3 caroticosubclavian bypasses (including 1 carotid to innominate) were performed with PTFE grafts. In one patient with bilateral carotid aneurysms, we made bypasses from proximal to distal common carotid arteries in right side with PTFE and Dacron in the contralateral side. Totally 8 target arteries were revascularised using Dacron, 4 with PTFE, and 3 with VSM (coronary arteries). In one patient forearm revascularisation was made by composite graft constructed with fusion (PTFE covered with Dacron) and VSM. Overall, when we considered target anastomoses; 2 of the 8 bypasses (25%) made by using Dacron graft occluded (Cabrol graft to right coronary button, 30 months after operation and carotid artery bypass graft on the left side of the patient with bilateral carotid artery aneurysm 10 hours after the operation). When we consider revascularisations for branches (including coronary arteries) of supra-diaphragmatic aorta, 3 of the 15 grafts (20%) were occluded and could not be saved.

Related to infra-diaphragmatic aorta and its branches, 17 bypasses had been performed with PTFE (n=7), Dacron (n=5), VSM (n=4), fusion (n=1). Only 2 of the 7 PTFE grafts (29%) were occluded. One of them was used for revascularisation of the right renal artery (Patient 20). Occlusion occurred 3 months after operation. The other occluded graft was the left leg of the bifurcated PTFE bypass in Patient 11. Occlusion occurred 64 months after the operation. In this patient, secondary pa-

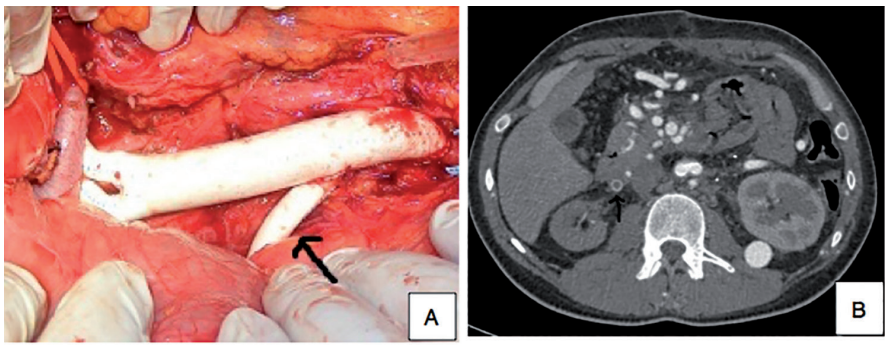


Fig. 8. Same patient as described in Fig. 7. (**A**) A view from the second operation showing body of the bifurcated 14x7 mm PTFE graft anastomosed to right common iliac artery and its left leg to the left renal artery, right leg to the coeliac artery and another 8 mm PTFE graft anastomosed to the body of previous graft to the right renal artery (arrow). Abdominal CT of the patient made 3 months after operation showing occlusion of the right renal artery graft atrophy of the right kidney (arrow), while other grafts were patent (**B**).

tency after 92 months was achieved by cross-femoral bypass. The fusion graft was still patent 28 months after the second operation (Patient 11). In another patient (Patient 12) with aorto-bifemoral (ABF) bypass with PTFE was subjected to bypass from left leg of ABF graft to superficial femoral artery (SFA) with VSM because of post-anastomotic stenosis developing 58 months after first operation. primary assisted patency reaching 69 months was thus achieved in this patient. When we consider overall, only 1 of 17 grafts (5.8%) could not be resuscitated in this lower part of the arterial system.

If we take all bypasses (altogether supra and infra aortic) into consideration, 28 of the 32 (87.5%) bypasses are still patent for mean 39.2±24.6 months of follow up.

In pathological examinations, there was no disease process in the arterial walls macroscopically seen normal and excised to form a hole mostly for proximal anastomosis. But we had the pathology reports demonstrating features of healed inflammation with intimal fibrosis with collagen fibers, lymphocytic infiltrations of media and adventitia and epitheloid granulomas in varying amounts in the arterial walls supporting TAK in for 6 of 8 patients. Pathological findings were rather similar to that seen in atherosclerosis in 2 of 8 patients' specimens.

Discussion

In this retrospective study of a single tertiary centre, we evaluated surgical techniques and clinical outcomes of 20 patients with TAK who underwent surgical interventions for arterial stenoses or aneurysms between 2008 and 2016. A total of 4/32 (12.5%) grafts were occluded during the follow up period of mean 39.2±24.6 months. Patency rates were 80 % and 94 % for supra-aortic and infra-aortic involvement, respectively. There was no operative mortality. We did not observe any anastomotic aneurysm. One patient died due to graft infection 3 months after the operation. Stroke occurred in 2 patients who underwent revascularisations of the arteries originating from aortic arch.

Restenosis of vascular lesions after revascularisation by surgical or endovascular interventions is well established among patients with TAK (9-10). Persistent inflammation at the site of intervention seems to be responsible for this phenomenon (9). Park *et al*. observed that the restenosis rate was lower when the vascular interventions were performed at the stable stage and when post-interventional immunosuppressive treatment was used (9). Similarly, Perera *et al*. suggested that the outcomes of vascular intervention in TAK may be improved by ensuring detailed preoperative assessment and optimal immunosuppressive therapy before and after the procedure (10). In their series of 97 patients, 87 patients (90%) received immunosuppression. Thirty-seven (38%) underwent 64 procedures (open surgical procedures: n=33 and endovascular procedures: n=31). After a median follow-up of 6 years, the overall success rate was 79% for open surgery and 52% for endovascular procedures (p=0.035). Procedural failure was significantly reduced in patients receiving preoperative immunosuppression. Our current approach to the management of patients with TAK is in line with the literature (7, 9, 10). A detailed preoperative assessment that includes clinical examination, measurement of acute-phase reactants, and utilisation of a combination of invasive and non-invasive imaging modalities is essential to identify arterial lesions and monitor treatment outcomes. We believe that preoperative medical immunosuppression alone with preoperative assessment is as much as important as postoperative surveillance in reducing complications and improving patency.

TAK has a considerable mortality rate, mainly due to cardiovascular and cerebrovascular diseases (11). A Japanese study investigated recent changes in the clinical characteristics of TA patients whose disease onset was before 1999 and after 2000, and found that vascular involvement was less severe in latter group which may be related to the improved medical treatment and the introduction of newer imaging modalities leading to early diagnosis (12). However, there was no change in the proportion of TA patients who required surgery (12). Revascularisation of the affected vessel during the chronic stages of TAK may be done by surgery or endovascular interventions (13-15). Although endovascular interventions are safe and less invasive, restenosis is a major concern, occurring in up to 78% of the procedures in the long term (16-17). It was determined that active inflammation at the time of revacularisation increased the likelihood of complications by 7 times (13, 17). Moreover, surgical treatment was suggested to be associated with an increase in the long-term survival of TA patients (18). In our patient group, 4 patients had the history of percutaneous transluminal angioplasty (PTA) and stent placement (3 for renal arteries, 1 for coeliac artery). Only one was still patent after 12 years of follow-up. The remaining were severely stenosed making further operations more complicated. Therefore,

our group prefers to do open surgery in TAK patients requiring revascularisation. In our hands, 28 of the 32 (87.5%) bypasses are still patent after a mean follow-up of 39.2±24.6 months.

The clinical spectrum of supra-aortic arterial involvement in TAK may range from being asymptomatic to having stroke. Surgical or endovascular treatment is required in patients with neurological symptoms related with cerebral hypoperfusion (19). Additionally, surgery may be considered in asymptomatic patients with large aneurysmal lesions because of the rupture risk of the lesions (20). However, aneurysms of carotid arteries have technical problems, since resection and replacement of these arteries are associated with relatively high risk of stroke (21). Bypass surgery has been found to have better results regarding the artery patency when compared to endovascular treatment. However, it may be complicated with intracranial haemorrhage due to the postoperative cerebral hyperperfusion (21-22). In our series, 5 patients underwent a surgery and 2 patients had an endarterectomy. Among these patients, 1 graft (Patient 4) was thrombosed without a cerebrovascular event, two patients (Patient 8 due to graft thrombosis and patient 3 due to cerebral hypoperfusion) had an ischaemic stroke during operation and one patient (Patient 5) died due to graft infection. Patient 7 did not experience an early postoperative complication and his graft is still patent after 48 months. Here, we should criticise ourselves retrospectively for the second operation that we performed for the patient with bilateral common carotid artery aneurysms (Patient 8) that resulted in graft thrombosis and stroke. We might have avoided these complications if we had used the ascending aorta for inflow anastomosis instead of the carotids. Therefore, we used ascending aorta as an inflow side for carotid artery revascularisations in 3 patients operated afterwards (Patients 3, 6 and 7).

We are encouraged to suggest that endarterectomy can be a choice in selected patients with TAK with limited stenoses of carotid bifurcation and distal aorta-iliac arteries. On the other hand, the current knowledge does not advise endarterectomy since in a panarteritis setting all three layers of arteries are involved. However, these layers have different tissue characteristics, such as elasticity and dynamics and these characteristics may sometimes allow easy separation from each other in the endarterectomy (especially subadventitial) procedure. We did carotid endarterectomy in 2 patients (Patient 9 and 10) and aorta-iliac endarterectomy in 1 (Patient 15) with a limited but critical stenosis. We used patch in closure of the arteriotomies to prevent future aneurysmal dilatations. Although we have limited experience with this procedure, we did not observe a restenosis/occlusion or aneurysm after 22, 27 and 59 months.

Upper limb claudication rarely needs revascularisation because the muscle mass is relatively small and there is rich arterial collateral circulation (19). Bypass surgery for upper extremities were performed in 3 patients with ongoing complaints despite medical treatment. Carotico-subclavian bypasses were successful and are still patent in 2 patients (49 and 96 months respectively) with short synthetic grafts and good outflow arteries (patients 2 and 9). On the other hand, a young female patient who had long composite graft and insufficient outflow arteries encountered early graft thrombosis (Patient 4). Emergency thrombectomy was unsuccessful. We can conclude that patients who require long grafts for upper extremity revascularisation and who have insufficient outflow arteries carry increased risk for graft failure.

We performed aortic root and hemiarch replacement in one patient with severe aortic insufficiency and ascending aortic aneurysm sparing aortic valve (Patient 1). Valve sparing aortic root replacement is an ideal option over Bentall procedure when the patient is young and long-term anti-coagulation therapy is a concern (23, 24). There are some conflicting case reports whether this procedure should be avoided in TA patients because of the probability of the recurrence of aorta regurgitation (25). In contrast, some authors recommend valve sparing procedure in patients with normal aortic valves (26, 27). However, there is no enough evidence to make a decision between these surgery options. Patient 1 developed acute congestive heart failure 30 months after the valve sparing aortic root replacement due to the uncontrolled hypertension. Her complaints improved after strict control of hypertension and she has a moderate AI after a follow-up of 48 months.

Internal mammary graft has a longer patency rate than VSM graft in atherosclerotic patients undergoing coronary bypass surgery (28). On the other hand, some authors recommend not to use internal mammary arteries in TA patients since they are mostly affected (29). Therefore, we used VSM grafts in both patients and their grafts are still patent.

Renal artery stenosis due to TAK may lead to hypertension, renal failure, stroke and death (1). Revascularisation includes surgery and endovascular interventions (30-31). A randomised controlled study showed that arterial stenting had a better patency rate than open angioplasty in patients with renal artery atherosclerosis (32). Indeed, such a non-invasive method seems to be more suitable when considering the complications of bypass surgery. On the other hand, TAK patients have a more complex renal involvement that makes endovascular treatment unfeasible in most cases. PTA was the most widely used procedure, however angiographic outcomes have been often unfavourable because of the significant residual stenosis or dissection after balloon dilatation (31). If PTA fails, then stent placement could be another option. However studies report conflicting results (30-31). While Park *et al*. observed that compared with stent placement, angioplasty demonstrated better long term patency and similar clinical benefit on renovascular hypertension (31); Peng *et al*. reported that that stent placement resulted in lower 2-year primary patency rate, higher occlusion rate and higher re-intervention rate compared with PTA alone (30). Moreover, arterial stenting may complicate further surgical revascularisation (33). Feng *et al*. reported a 79% patency rate at 5-year follow-up in 24 patients who underwent aorta-renal

bypass surgery with VSM graft and suggested this procedure as a safe, effective and durable treatment (34). In our series, 2 VSM grafts are still patent whereas 1 PTFE graft was occluded. Using a long graft may be the most important risk factor for graft failure in the last patient who had extensive disease as we mentioned above. Regarding the other visceral arteries, 2 patients underwent coeliac bypasses with PTFE graft, 2 patients underwent SMA bypasses with PTFE in and with VSM in the other and 1 underwent a common haepatic artery bypass with PTFE. All these grafts are still patent.

Six patients with lower limb claudication underwent open surgery. Among them, 3 Dacron grafts are still patent whereas 2 PTFE grafts occluded 69 and 92 months after operation (Patients 11 and 12). These were successfully revascularised with minor operations such as cross-femoral bypass and short segment saphenous bypass. We performed aorta-iliac endarterectomy with PTFE patch plasty in the last patient (Patient 15). Her graft is still patent.

In our current study, we had 6 (6/20; 30%) patients with aneurysms, of whom 2 had multiple aneurysms. One patient had aneurysm of ascending aorta, 2 had subclavian aneurysms, one had CFA aneurysm, one had bilateral carotid artery aneurysms and the last one had coeliac and bilateral renal artery aneurysms. The frequency of aneurysm formation in our cohort is somewhat higher than that reported previously (1), whereas similar to that found earlier by Matsumura *et al*. (35). They had observed that aneurysms had developed in 36 of 113 patients (32%) and indicated that the rupture risk was rather low (1/36) (35). Kieffer et al performed operative treatment on 33 patients with descending thoracic or thoracoabdominal aortic aneurysms due to TAK between 1974 and 2001 (36). They reported satisfactory surgical outcome despite the extent of aneurismal lesions and high frequency of association with visceral and supra-aortic vessel lesions. During the early post-operative period, 3 (9%) patients died, 3 (9%) patients developed paraplegia and 2 (6%) patients required re-operation.

We have previously showed that atherosclerosis is accelerated in TA (37, 38). About one third of the patients may have carotid artery plaques and approximately half have diffuse concentric arterial wall calcifications (37, 38). It has to be noted that the great majority of these patients who show both vasculitic and atherosclerotic lesions are premenopausal women of 30-40 years of age with rather limited risk factors for atherosclerosis. It is suggested that inflammation of the aorta and its branches in TA results in atherosclerosis of these arteries and hypertension also accelerates this process (39). Evidence for premature atherosclerosis is present in the current study as well. CTA image of the aneurysm of ascending aorta of a 32 years old female patient had disclosed areas of calcification compatible with premature atherosclerosis (Fig. 1) and in 2 of 8 patients pathological description of the lesions were compatible with atherosclerosis.

The major limitation of the current study is its retrospective nature and descriptive methodology. Lack of a control group with another disease group or with another management modality could be another limitation.

In conclusions, in TA patients VSM can be used safely in CABG and visceral/renal artery revascularisation. Aorta-femoral bypasses also can be performed safely and have favourable results regarding the patency rate. In revascularisations of aortic arch vessels, we should not hesitate to use ascending aorta as a safe inflow side and we have to keep in mind caroticosubclavian bypass in selected cases for upper extremity revascularisations. In visceral and renal arterial bypasses we should use every possibility to shorten the graft length as much as possible. However, surgeries involving carotid arteries may be complicated with stroke, graft infection or graft failure. Hence, the patient selection should be done on a case-by-case basis in patients who requires carotid surgery. Preoperative immunosuppressive treatment seems to reduce the risk of graft failure. We suggest prevention of elective surgical interventions in the presence of active inflammation. Preoperative detailed assessment and postoperative careful surveillance by surgeons and rheumatologists together should be mandatory.

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