Role of arch debranching in TEVAR cases(early experience)

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INTRODUCTION

Aortic arch disease incidence is 2.6 for every million in Americans. It is much higher in Asia, however in Africa no records available .Aortic dissection incidence is 0.0001 of hospitalized patients; approximately 2000 newly reported cases yearly in the United States. [(1)]

A type B aortic dissection (TBAD) accounts for 25-40% of aortic dissections, involving the aorta distal to the subclavian artery. Most of them (75%) are uncomplicated with no malperfusion or ischemia. Many consensus declarations recommend thoracic endovascular aortic repair (TEVAR) as the treatment of choice for acute complicated type B aortic dissections, while uncomplicated type B dissections are traditionally treated with medical management alone. However, with medical treatment alone, the morbidity, including aneurysm degeneration of the affected segment, is 30%, and mortality is 10% over 5 years. For both chronic and acute uncomplicated type B aortic dissections, growing evidence that supports the use of both best medical therapy and TEVAR.[(2)]

Hybrid repair, which consists of arch debranching(complete or partial) and TEVAR, is a valid option for the treatment of complex aortic dissection and other aortic arch diseases. There are several types of hybrid repair with various arch debranching techniques have been reported to obtain the desired result,[(3)]. The management of TBAD by hybrid technique is considered demanding as less invasive management by heart lung machine.[(4)]

PATIENT AND METHODS

All patients were represented to Kasr Al aini outpatient clinic and emergency department, in the period between March 2015- January 2019.

This is a prospectively collection of data that was retrospectively written and recorded .The patients who underwent aortic arch debranching with thoracic endovascular aortic(TEVAR) repair were included in the study.

The inclusion criteria includes ; atherosclerotic or post dissection aortic arch aneurysms, post-traumatic aneurysm of the aortic arch or isthmus, acute aortic dissections, penetrating ulcers of the aortic arch, and aneurysms of subclavian artery involving the aortic arch. The exclusion

Criterion was the patients who underwent TEVAR without arch debranching.

The aim of the study is to evaluate technical success, morbidity and mortality of early experience of arch debranching

Demographic data is spread in table 1.

case	age	sex	co morbidity	C/P	investigation showing	plane	zone	procedure	morbidity	mortality
1	35	m	Behçet disease	chest pain	left subclavian aneurysm involving the aortic arch, right subclavian aneurysm	Complete arch debranching +TEVAR	0	aorto-brachiocephalic, aorto-carotid(bifurcated Dacron graft),carotid-subclavian +TEVAR(staged)	Early: Right femoral artery aneurysm Late: Left graft occlusion with left common carotid and left subclavian	-
2	32	m	Takayasu, previous sternotomy(previous CABG)	chest pain	thoraco abdominal aneurysm(type II)	Carotid-left subclavian bypass(partial debranching)+ TEVAR Then visceral debranching +EVAR	2	Carotid-subclavian(PTFE) (one stage)	Previous CABG, MI,endoleak type Ib	Late: Died After visceral debranching operation
3	35	m	Aortic root replacement (Previous sternotomy) due to previous type A aortic dissection.	chest pain	Type B Aortic dissection	Complete arch debranching +TEVAR	0	aorto-brachiocephalic, aorto-carotid(bifurcated Dacron graft),carotid-subclavian	No TEVAR	-
4	45	m	HTN	chest pain	Type B Aortic dissection	Complete arch debranching +TEVAR	0	aorto-brachiocephalic,aorto-carotid(bifurcated Dacron graft),carotid-subclavian		-
5	41	m	HTN	chest pain	Type B Aortic dissection	Carotid-carotid (pretracheal), carotid subclavian+ TEVAR	1	Carotid-carotid, carotid subclavian +TEVAR(staged)		-
6	49	m	HTN, huge goiter	chest pain	Type B Aortic dissection	Carotid-carotid (pretracheal), carotid subclavian +TEVAR	1	Carotid-carotid, carotid subclavian(Dacron) +TEVAR(staged)		Late: Died after 6 months
7	45	m	HTN	chest pain	Type B Aortic dissection	Carotid-carotid(retro pharyngeal), carotid subclavian +TEVAR	1	Carotid-carotid, carotid subclavian(PTFE) +TEVAR(staged)	Hoarseness of voice after debranching , transient paraplegia	-
8	51	m	HTN	chest pain	Type B Aortic dissection	Carotid subclavian (partial debranching)+TEVAR	2	Carotid subclavian bypass(Dacron)+TEVAR(staged)	-	-
9	49	m	HTN	chest pain	Type B Aortic dissection	Carotid subclavian (partial debranching)+TEVAR	2	Carotid subclavian bypass(Dacron)+TEVAR(staged)	Stroke, immediate post-operative	Died 3 days post operative
10	45	m	HTN	chest pain	Type B Aortic dissection	Carotid subclavian (partial debranching)+TEVAR	2	Carotid subclavian bypass(Dacron)+TEVAR (staged)	Endoleak type I	-
11	40	m	HTN	chest pain	Type B Aortic dissection	Carotid subclavian (partial debranching)+TEVAR	2	Carotid subclavian bypass(Dacron)+TEVAR (staged)	-	-
12	62	f	HTN,DM.IHD,PCI &stenting ,EF 48%	chest pain (emergency)	Type B Aortic dissection complicated by aortic aneurysm (Aneurysm)	Carotid-carotid (pretracheal), carotid subclavian (partial debranching)+ TEVAR	2	Carotid-carotid, carotid subclavian(PTFE)2 separate grafts TEVAR(staged)	-	Died after 1 week.
13	54	m	HTN	chest pain	Type B Aortic dissection	Carotid subclavian (partial debranching)+ TEVAR	2	Carotid subclavian bypass(Dacron)+ TEVAR (staged)	-	-
14	49	m	HTN		Type B Aortic dissection	Carotid subclavian (partial debranching)+ TEVAR	2	Carotid subclavian bypass(Dacron)+ TEVAR(staged)	-	-

History taking including onset, course, duration severity of symptoms, association of comorbidities, history of previous interventions either endo or open. Examination to assess previous surgical incisions or other surgeries that may affect the decision of surgery, and the way to do surgery. Assessment of the patient full labs especially serum creat, serum urea, echo heart, ECG,CT angiography of head, neck, chest, abdomen and pelvis (1 mm cut), this to be assessed by the axial cuts and by reconstruction. The aortic arch type, the origin of branches, the origin of vertebral arteries, which is the dominant vertebral artery, the site of the tear and reentry in aortic dissection, the landing zone either proximally or distally which should be no less than 2 cm, the diameter of aneurysm, the length and diameter of the neck, the whole aorta, iliac arteries and femoral diameters,

The primary outcome of the procedure were the 30 days morbidity (spinal cord ischemia, stroke, myocardial infarction) and mortality.

The secondary outcome is the short term results with the following 3 years.

Technical success of the arch debranching was defined by partial or complete arch debranching of the landing zone exclusion of the diseased aorta without endoleak(I.III) on completion angiography and without need for conversion to an open procedure(4).The goal of the hybrid approach(debranching followed by TEVAR) is to create a sufficient landing zone in the aortic arch or the ascending aorta. In general, a hybrid approach is defined as debranching of one or more aortic arch branches in order to reduce the number of aortic arch vessels, thus simplifying the exclusion of the arch pathology with a tubular stent-graft.[5]

The Follow up evaluations were done at 1, 6, and one year ,and yearly , to assess any complication concerning endoleaks, stent graft migration, aneurysm size, and remodeling in cases of aortic dissection

The Operative procedure.

It is either one stage hybrid procedures where arching debranching is done in the Angiosuite followed by TEVAR in the same setting (zone 2 cases), or two stages where the debranching is done first in the operating theater followed by the TEVAR in another stage to ensure the success of the open surgical part and to prepare to the endovascular intervention(TEVAR) as it is better done in the Angiosuite(in zone 0,1 cases) as the hybrid room is not available yet.

The incisions used were: median sternotomy preceded by bilateral longitudinal neck incisions as the neck landmarks will be obscured if the median sternotomy is done first, left transverse incision to expose the left common carotid and left subclavian, or separate left longitudinal neck incision with left supraclavicular incision.

No thoracic duct was ligated during exposure of the left common carotid and left subclavian.

Bifurcated Dacron grafts were used in cases of complete arch debranching while straight 8 mm straight non ringed Dacron, PTFE grafts were used in cases of partial arch debranching. In cases of arch debranching the aortic arch branches are ligated with silk rather than the use of coils or plugs. The decision to do debranching is done after the study of the aortic arch and sufficient 2 cm landing zone in the arch as the classification done by Ishimaru[6]

The zones are 0,1,2

In zone 0, all of the aortic arch branches need revascularization using complete debranching through median sternotomy without heart-lung machine fig(1,2) .In zone 1, a carotid-carotid bypass using pretracheal tunnel that was performed in combination with left subclavian artery (LSA) revascularization which was done by transposition(end of LSA to side of left carotid artery or bypass(end of left carotid to side of the graft that revascularize the LSA, or, side of carotid to end of the graft that revascularize end of graft to side of LSA). Fig (3,4)

Fig. 1: Median sternotomy showing:(a) ascending aorta,(b) aortic graft anastomosis with Dacron bifurcated graft, (c) right graft limb with anastomosis to brachio-cephalic artery,(d) left graft limb.(complete arch debranching

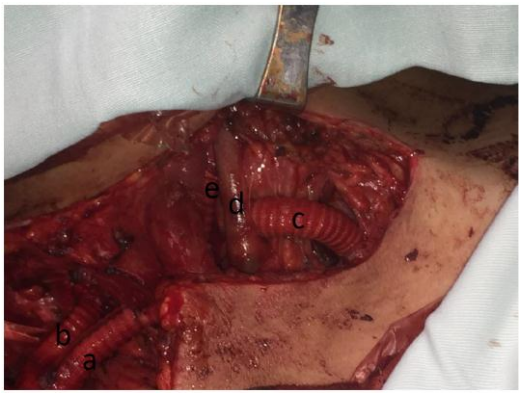

Fig. 2: (a,e)left limb graft , tunneled under left sternal head of sternomastoid muscle to be anastomosed to left common carotid artery , left internal jugular vein(d),(b) right limb graft anastomosed to brachio-cephalic artery.

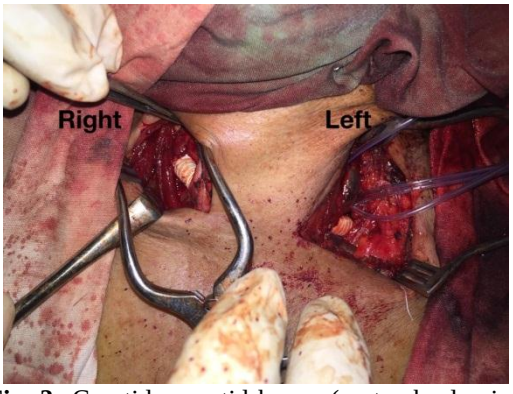

Fig. 3: Carotid –carotid bypass(pretracheal using PTFE graft(as part of partial aortic arch debranching)

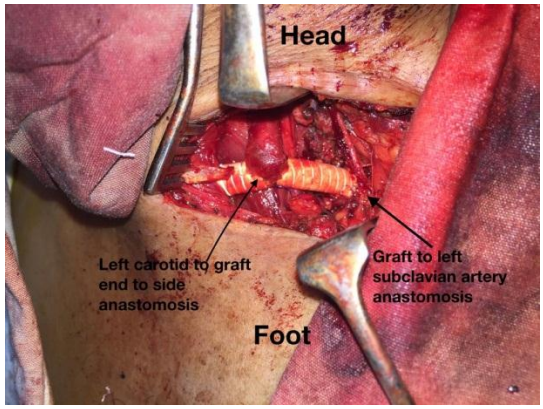

Fig. 4: (a) left common carotid artery (end to side) anastomosis to PTFE, end to end anastomosis to the left subclavian artery

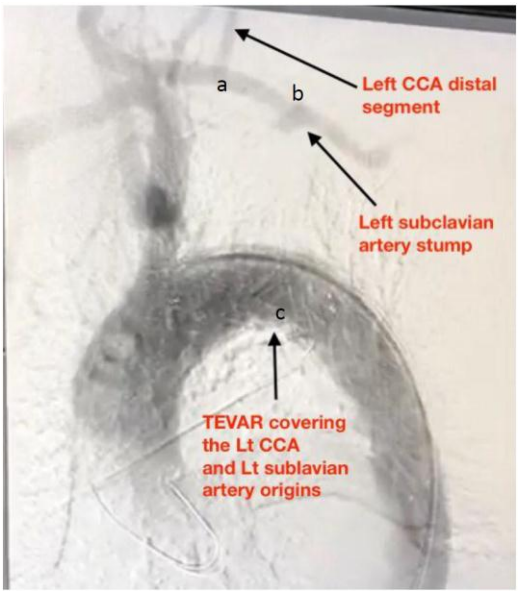

Fig. 5: The same patient in figure 4 showing (a) anastomosis of left common carotid artery to the PTFE graft. (b) left subclavian anastomosis with PTFE graft,(c)TEVAR deployed in zone 1 with no endoleak type I.

In zone 2, carotid subclavian bypass by synthetic graft or transposition of the LSA to the left common carotid artery was performed.

The LSA, or vertebral) arteries were always revascularized. The subclavian artery stump was closed by over sewing in cases of LSA transposition ,or ligation proximal to the origin of left vertebral artery after the left carotid-subclavian bypass

Perioperative details

All cases were operated upon under general anaesthesia, either the hybrid cases or the TEVAR cases(second stage).There were two case of previous median sternotomy , one due to previous CABG, the other was due to aortic root replacement (Type A aortic dissection)

All patient who were planned to have TEVAR either simultaneously hybrid, or as the second stage got cerebrospinal fluid(CSF)drainage with the catheter inserted the day preceding the TEVAR procedure and continued for 2-3 days post-operative in ICU.

All patients had controlled hypotension during the deployment of the TEVAR to properly allocate the proximal part of the stent graft. In the beginning of the cases, transesophageal echo

(TOE) was used during passage of the wire in the true lumen to ensure that the wire is not in the false lumen in cases of aortic dissection with narrow true lumen. The IVUS is either used alone in aortic dissection or in combination with the TOE .All stent grafts were deployed retrogradely through femoral access , none of the cases done had narrow iliac arteries the necessitates conduit or iliac covered stent(pave and crack).

Concerning the stent graft used, there were different market available stent graft systems : the Talent, and the Valiant (Medtronic Inc, Santa Rosa, Calif) (9 cases), the Cook-Zenith (Cook, Bloomington, Ind) (three cases) before being obsolete in aortic dissection in sept 2018, the Bolton Relay (Bolton Medical, Sunrise, Fla) (one case), and. E-vita THORACIC 3G(Jotec, GmbH) (one case) .

Concerning the diameter of the stent graft was usually 0% to 10% oversized in aortic dissection, and 10 % to 15% in aortic aneurysms, in relation to the outer diameter of the proximal landing zone. There was no use of aortic balloon in dissection cases,

RESULTS

All patients were presented to the outpatient vascular clinic at kasr Alaini between march 2015 to January 2019.Aortic arch debranching was done in 14 consecutive cases. The demographic data, comorbidities and aortic disease ,and anatomic description are recorded in table 1. The study included 14 patients. There were twelve male patients, and one female. The mean age was 45.14 y.

Post operative

All patient were admitted to ICU post operative either for 2-3 days to ensure maintained proper CSF drainage and proper mean pressure and systolic pressure

Early post operative:

In 30 days postoperative either after the arch debranching or the TEVAR, there was one case of immediate postoperative stroke after TEVAR deployment , the patient died 3days later. The TEVAR was deployed in zone 2.There was one cases of spinal cord ischemia in the second day where it was managed by elevating the systolic pressure and CSF drainage. The CSF drainage kit was blocked in 5 cases so it was reinserted in second or the third day.

There was one case post operative chest pain for a patient with thoracoabdominal aneurysm after hybrid procedure in one stage(carotid-LSA bypass),suspecting myocardial infarction as there was ECG changes and elevated cardiac enzymes. The patient was referred for the cardiologist who did emergency coronary angiography(previous CABG) where nothing was revealed.

The early mortality were two case ,one after partial debranching (landing zone 2), the other after partial arch debranching (zone 1). The cases of complete arch debranching(landing zone 0) were without mortalities in the 30 days postoperative. There was a case of late mortality after 6 months post TEVAR. Figure 6

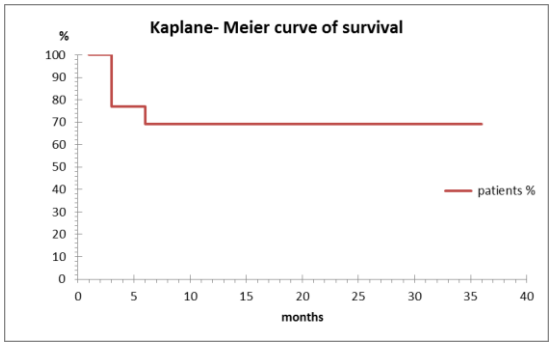

Fig. 6: Kaplan-Meier survival rate in of 13 patients of aortic arch debranching over 3 years

Technical success was achieved in 92.8% (13/14) as one patient didn't do TEVAR after doing complete arch debranching .This patient had previously presented with type A aortic dissection where he underwent aortic root replacement and implantation of the coronary arteries. The aortic root was too short and not floating inside the aortic arch enough that any TEVAR nozzle may cause the synthetic aortic valve to stuck causing immediate death so decision was done to do complete arch replacement.

One case of stent malposition(inaccurate stent graft deployment) during deployment however no endoleak type I detected and nothing was done.

Cases of endoleak were 14.2%(2/13). One case of type Ia endoleak that disappeared in follow up CT angio after one month, the other type Ib was in staged thoracoabdominal aneurysm management.

Late results :

One case of femoral access complication where the patient with Beçhet disease developed femoral artery aneurysm which was treated by replacement with Dacron graft and primary sartorius muscle flap. One case of stroke due to occluded conduit of left common carotid and subclavian as the patient was known Behçet disease, stopped medication by his own. However medical treatment was resumed again and no further intervention is needed either open or endo.

One case of thoraco abdominal aneurysm died (had partial arch debranching and TEVAR) ,and had visceral debranching and developed myocardial infarction and died before the EVAR.

There was no aortic rupture or aorta related deaths during the follow up period. There was no recorded endoleak in the follow up period. There was no further migration in the stent graft migrated during deployment or other stent graft migration in the follow up CT angio.

DISCUSSION

Aortic arch debranching either complete or partial is risky.it is technically demanding and has known perioperative mortality. The rate of mortalities in other centers 0%(7), 5% to 19% (8),11.5%(9) .The treatment of aortic arch disease either type B dissection, or thoraco-abdominal aneurysm. The early mortality in this series was 2 cases (14.2%)

The aortic disease were mainly treated by open surgery but the development of endovascular aneurysm repair systems treat some disease but due to insufficiency of landing zones, the debranching technique either complete or partial developed , by time and development of new technologies and systems in chimneys and branched grafts , the debranching procedures will decrease and the treatment will be totally by endovascular (chimneys ,and branched grafts). Others say that with the development of branched stent grafts for treatment of aortic arch, hybrid approaches to arch reconstruction will increase currently and in future.[10], this may be due insufficient long term results of branched grafts and chimney, till then, hybrid aortic arch debranching are to be used especially in high risk patients.[11][12][13][14]

Regarding the morbidity, there was one case of femoral access complication where the patient with Behçet disease developed femoral artery aneurysm which was treated by replacement with Dacron graft and primary Sartorius muscle flap. One case of stroke due to occluded conduit of left common carotid and subclavian as the patient was known Behçet disease, stopped medication by his own. However medical treatment was resumed again and no further intervention is needed either open or endo,

There were 2 cases of previous median sternotomies which adds to the morbidity and the mortality however none of them had death related procedure.one of these two cases had CABG, at the time of the partial debranching there was difficulty to ligate the left subclavian proximal to the origin of internal mammary(bypass to LAD[left anterior descending]),and the vertebral artery.on coronary angio, the internal mammary was used as free vascular graft(aorto-LAD). The MI was suspicious post operative and should always be considered in such patients. All patients with previous CABG should be properly investigated up to coronary angio to ensure safety of the procedure or do CT coronary.The other case of previous sternotomy, and previous aortic root replacement, after complete arch debranching there was problem in the TEVAR to be deployed, all of the commercially available nozzles of TEVAR are long ,and cause stuck aortic valve which is lethal.The options were to try retrieve TEVAR of GORE® TAG® which has small nozzle, use what is called bullet technique which covers the tip of TEVAR, another redo surgery to put aortic graft floating in the aorta, or to do full arch replacement (will be much easier than elephant trunk replacement due to previous complete arch debranching).

One case of stent malposition(inaccurate stent graft deployment) during deployment however no endoleak type I detected and nothing was done. Boufi et al analysis the risk of malposition in TEVAR and found it is more in pin-pull technique rather than torque transfer mechanism,16%,and 10% respectively .Also the tortuous anatomy and iliac diameters affect the positioning of the stent graft. The use of low

profile devices will decrease the incidence of malposition.[15]

There was only was case of endoleak type Ia that disappears on one month follow up CT angiography. There was another case of endoleak type Ib in case of thoracoabdominal aneurysm where the proximal part is done(partial arch debranching with TEVAR, there was a remaining distal part of the aneurysm where it was managed by visceral debranching to followed by EVAR, however the patient died by MI before EVAR. Some authors reported no endoleak in their series[16]. Management of endoleak type Ia include balloon angioplasty ,conservative management, deployment of proximal stent graft(extension),deployment of bare metal stent, doing further partial arch debranching to lengthen the proximal landing zone, deploying a parallel snorkeling stent graft in cases of partial coverage of brachio-cephalic artery. They also mentioned the foreshortening of bare metal stent during deployment to almost half of its length[17].

Regarding the spinal cord ischemia, one case of the study series developed spinal cord ischemia which was managed and symptoms disappears by management mentioned earlier. The patient got insertion of CSF drainage the day preceding the TEVAR procedure, it was done routinely, in all patient. CSF drainage was maintained to 2-3 days postoperative in the ICU .The post-operative mean arterial pressure (MAP) to be kept above 70 mmHg as this the cut off where spinal cord ischemia can occur, if MAP is less, then elevation of blood pressure is combine by CSF drainage to avoid paraplegia.(18).Brant et al mentioned in his study over 424 patients , where the spinal cord ischemia was found in 12 patients (2.8%),where the average of beginning of onset is 10.6 hours ,and it was delayed in 10 patients(83%).There were 9 patients recover from neurological symptoms after adjustment of blood pressure and CSF drainage.[19]. In cases where the whole descending thoracic aorta (thoracic or thoraco abdominal aneurysms ,some advocates staged coverage to give time to collateral to develop.[20][21]. Some prefer to have the CSF drainage in the day preceding the procedure in only high risk patient , others prefer to do CSF drainage at the time of the procedure to decrease financial cost of admission one day before. The CSF drainage has some contraindications: emergency procedure, coagulopathy before presentation, and cases of increased intracranial pressure. The CSF drainage to be done to maintain the CSF pressure < 10 mmHg by draining 10-15 ml/ hour with a maximum of 250 ml /day.[22]

Regarding the myocardial infarction (MI) , there was one case o MI post partial arch debranching and TEVAR which was managed properly up to emergency coronary angiography . It is known that patients with thoracic aorta disease who will have TEVAR have also coronary artery disease .They need proper preoperative evaluation regarding the symptoms, ECG, echocardiography and close care in the post-operative period. In this study there was one case of post-TEVAR suspected MI[23].

in this series there were no cases of retrograde aortic dissection in type B aortic dissection. It is rare 1-3%& however lethal. Emergency surgery by cardiothoracic to replace aortic root[24]. Some proposed anatomical criteria for endovascular management of type A dissection or retrograde dissection which are; entry tear distal to sinotubular junction, proximal and distal landing zone length >20 mm, proximal landing zone diameter< 38mm, no involvement of aortic valve, no coronary grafts arising from ascending aorta, adequate iliofemoral access vessels [24Fr].[25]

Stroke incidence in this study was one case after carotid subclavian bypass jut post the TEVAR procedure(7.7%).Allmen et al mentioned in his meta analysis in 215 studies among 2594 patients that the incidence of stroke with uncovered subclavian, covered and revascularized, covered and not revascularized is 3.2%,5.3%,and 8% respectively.[26]. The stroke may be silent or clinically detected. Kahlert et al did a study over 19 patient with TEVAR without cerebral protection and found clinical and silent cerebral emboli detected by MRI in 12 patients(63%)[27]. Janosi et al in his 5 patients series where he examined pathologically the material entangled in the cerebral protection devices used with TEVAR; found acute thrombus, organized thrombus, calcification, and foreign material with 100%,70%,10%,and 80% respectively.[28]. It may be after sometime with further studies, the cerebral protection device to be used in all patients with TEVAR.

CONCLUSION

Aortic arch debranching is demanding procedure with TEVAR. it helps to have proper and adequate proximal landing zone , in aortic arch diseases, it is also used as a bailout in cases of endoleak type Ia. It is not with out risks. It has considerable mortality. It is considered less invasive than open surgery using heart lung machine. It has special morbidities to be considered and to guard against which are, MI, SCI, retrograde dissection cerebral ischemia.

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