Research Article

Endovascular Repair of Infra Renal Abdominal Aortic Aneurysm with Challenging Neck

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Abstract
Introduction and aim: Endovascular repair of abdominal aortic aneurysm (EVAR) has evolved to become the treatment of choice for patients with infra-renal aortic aneurysms (AAAs). Proximal neck is a key point in determining success of endovascular aortic repair. The most common instructions for graft use recommend a neck length of 1.5 cm and an angulation of up to 60º. Therefore, a short (<1.5 cm) and angulated (>60°) neck is an off-label indication for most devices, leading to high rates of treatment failure. However, some approaches may improve results in high-risk patients. **Patients & Methods:** A prospective study that was done in the period between December 2013 and 2018 included 10 patients, from Cairo and El-Minia University hospitals. All patients were presented with infra renal abdominal aortic aneurysm with challenging neck and candidate for treatment. **Results:** In our study, 85% of the patients were between (36 -70) years old and 95% of them were males. The aneurysm diameter was highly variable, in 30% of the patients was (5.5 to 6.5) cm, in 20% of them was (6.5 to 8) cm and 50% of the patients had aneurysmal diameter > (8 cm). Concerning proximal neck length, it ranged from 10.2 mm to 14 mm. As regard the neck diameter, it varied from 18 to 27mm. neck angulation varied from 60-75 and the circumferential neck thrombus also varied from 50% to 75%. According to complications occurred in our study we found that wound infection occurred in 2 patients, groin hematoma in one, type IA endoleak in one patient, one patient had type II endoleak which is resolved spontaneously within one month by follow up and one patient had stent graft limb occlusion. **Conclusion:** Endograft technology has substantially improved. However, unfavorable anatomy continues to represent a major drawback, restraining endovascular procedures. More substantial data and stronger, evidence-based results are needed.. EVAR may be performed safely in high-risk patients with unfavorable neck anatomy using particular commercially available endografts, appropriate patient selection and operator training will allow improvement of long-term results

Keywords: infra renal, abdominal aortic aneurysms, challenging neck, EVAR.

Introduction
Endovascular aneurysm repair (EVAR) is defined as image-guided treatment of an AAA by using a stent-graft device, also known as an endoprosthesis. The device is placed within the native abdominal aorta and is secured proximally and distally to the diseased aneurysmal portion of the aorta, creating a new conduit for blood flow and eliminating the AAA sac pressurization[(1)].

EVAR is considered a safe and effective alternative to open repair (OR) for the treatment of selected cases of abdominal aortic aneurysm (AAA)[(2)].

However, the efficacy and safety of EVAR for aneurysms with challenging anatomies remains disputable, due to the technical difficulties of achieving a reliable seal with a stent-graft[(3)]. The overall success of endovascular repair depends largely upon adequate proximal fixation of the endograft to the aortic wall, which serves to prevent type Ia endoleaks and stent migration[(4)].

Difficult or hostile aortic neck anatomy is defined as neck length of less than 15 mm, neck angulation greater than 60 degrees, greater than 50% calcification of the aortic circumference, and a reverse taper morphology [(10)].

Strict anatomic criteria are provided by each stent graft manufacturer in the instructions for use (IFU). With an increasing trend toward utilization of endovascular, as opposed to open surgical, techniques for the treatment of infra-renal aneurysmal disease, many intervention lists are treating an increasing number of patients with unfavorable or "hostile neck" anatomy as chimney, snorkel and periscope.[11].

Patients and Methods

This study is a prospective study that was between December 2013 and August 2016 included 10 patients, from Cairo and El-Minia University hospitals.

Inclusion criteria:

Aneurysms measure ≥ 5.5 cm in diameter, aneurysm with challenging neck that includes: a-Hourglass neck. b. Angulated neck >60. c. Short neck < 15 mm d-Significant thrombus or calcification e- Reverse conical neck

Exclusion criteria:

Infra renal aneurysm with favorable neck, thoraco-abdominal aortic aneurysm, complicated AAA that indicated emergency intervention, asymptomatic aneurysms less than 5 cm in the maximum diameter and patient refusal**.**

Preoperative planning

For all the patients the whole procedure planned to him was explained and the possible benefits and risks including failure, complications and possible alternatives were discussed and an informed consent was obtained following the ethical committee requirement of the university.

Clinical history taking and examination was meticulously done for all patients concluding the following criteria: age, gender, possible risk factors and co-morbidities that are supposed to associated with AAA or may affect the general condition of the patient such as smoking, hypertension, dyslipidemia, cardiac condition, chest condition, renal function and diabetes.

Contrast-enhanced MDCT was performed using 128-slicesat a thickness of 0.6 mm. All analyses were performed on a dedicated workstation (Aquarius iNuition, Terarecon, San Mateo, CA, USA) with center line reconstruction.

AAA anatomy evaluation (pre-procedural and on follow-up) included maximum aorta diameter, neck diameter and length, neck angulation, neck calcifications and thrombus, iliac diameter, and length. Functional proximal neck length was defined as the distance from the lower renal artery to the aneurysm. Proximal neck angle was defined as the angle between the proximal neck and the aneurysm.

Neck length is defined as the length of parallel segment of the neck proximal to the AAA sac itself; it was determined by the length from a level beginning below the lower portion of the lowest renal artery to the point where the diameter increased greater than 1 mm. It is possible that the sealing zone could be longer than the true neck length, if the neck were conical. We sized to the largest neck diameter. Of note, the actual neck length using the central lumen line is potentially longer than the length measured using axial length

Preoperative determination of the most optimal C-arm position with cranio-caudal and right and left anterior oblique projections was evaluated to guarantee the maximal sealing and fixation of the stent-graft in the hostile proximal neck. All stent-graft devices were oversized by 15–20%

Preparing the patient:

All patients were admitted to the hospital the day before the procedure and the following measures were taken:

Ensuring good general fitness and monitoring the medical condition of patients with medical illness as regarding diabetes, hypertension and cardiac or chest disease. Anesthesia consu-ltation was done for every patient.

Proper hydration was ensured by adequate fluid intake especially the day before the procedure.

N-acetyl cysteine was given in large doses 600 mg pre and post-procedurally .The patients were instructed to ensure the cleanliness and personal hygiene especially for both groins.

Surgical procedure:

General anesthesia was used in 6 patients while in 4 patients combined spinal epidural anes-thesia was used, Bilateral open access via femoral cut-down was done open in 6 patients. The choice of the ipsi lateral side (i.e. side of

the main body) was decided for each case according to the anatomy with preference to the more tortuous iliac. If both iliac arteries were similar in tortuosity, the right side was chosen by default for the ipsi lateral side.

In 4 patients, brachial-femoral access is required to adequately overcome tortuosity. In this maneuver, we placed a single guide wire from the brachial (usually left) approach and retrieve the wire from a femoral artery.

Based on the preoperative simulated angiography, the C-arm was placed with the right orientation to allow optimum visualization of the proximal aortic neck. We performed the first angiography at the level of the renal arteries, which requires lower volume contrast injection, with the stent-graft in place ready for release. In order to avoid unintentional renal artery occlusion in the case of a proximal aortic neck length of less than 15 mm, we placed two guide wires in the renal artery, to facilitate performance of a chimney technique if necessary. When the proximal neck is not completely covered we preferred to place a proximal stent-graft extension after the final angiography, even without a type I endoleak.

The endograft was successfully deployed in all patients, with bifurcated devices used in 7 patients while aorto-uni-iliac with femoro femoral by bass was done in 3 patients.
We used Endurant (Medtronic) stent graft with supra renal fixation in 7 patients while Zenith stent graft used in 3 patients.

Bare metal supra renal stent in 4 patients (40%), unilateral chimney was done in 2 patients (20%) and bilateral chimney was done in one patient (10%)

All patients were transferred to ICU postoperatively for proper monitoring and controlled hydration. Postoperative Hemoglobin level was measured at day-1 and serum creatinine level was measured at day-2 postoperatively.

Endpoints:
The endpoints were early technical and clinical success. Primary technical success, assessed on an intention-to-treat basis, was defined as successful implantation of a stent-graft in the absence of surgical conversion, mortality, type I or III endoleaks, or stent-graft occlusion in the first 24 h after surgery. The need for postoperative adjunctive endovascular procedures and postoperative re-intervention was noted.

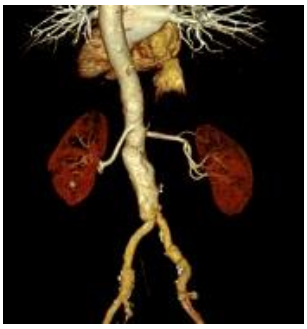
Clinical success was defined as the absence of any significant intraoperative, 30-day or in-hospital mortality or morbidity. Late rupture, major adverse event (MAE), minor adverse event (minor AE), AAA-related mortality and all-cause mortality were noted.

Follow-up protocol
Routine follow-up was planned according to the standard requirements suggested by the European Society for Vascular and Endovascular Surgery's recent clinical practice guidelines. Our patients had a CTA and plain radiographs with antero-posterior and lateral projections 30 days after the procedure. In the case of any endoleak, less than one stent component or iliac overlap, CTA with plain radiographs were performed again at 6 and 12 months. In patients with no early endoleak and good component overlap, a CTA alone was performed at 12 months.

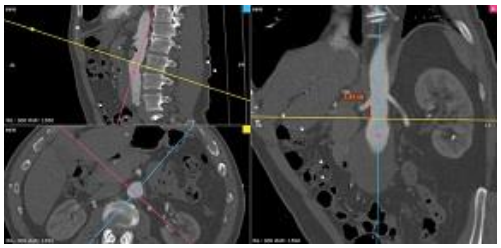
The statistical analysis

The data were presented as numbers and percentage using Statistical SPSS for Windows, issue 15.8.

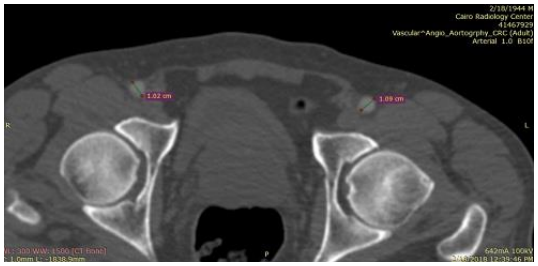
Case 1:



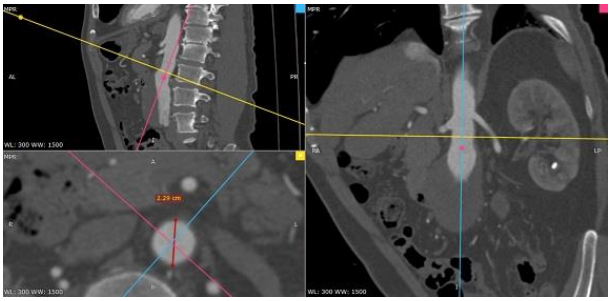
-10 mm Neck Length and 15 degree angulation



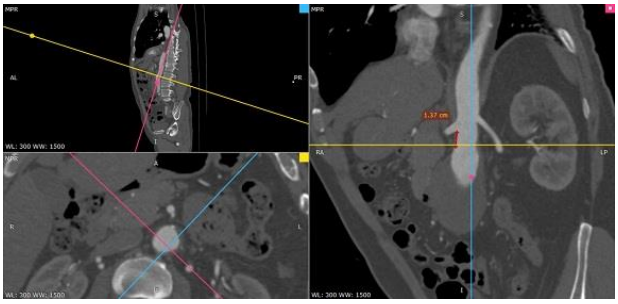
- Access vessels



-Neck Diameter= 22-25 mm;



-Slight Neck Thrombus atb 13 mm



.CT angiography post (1):

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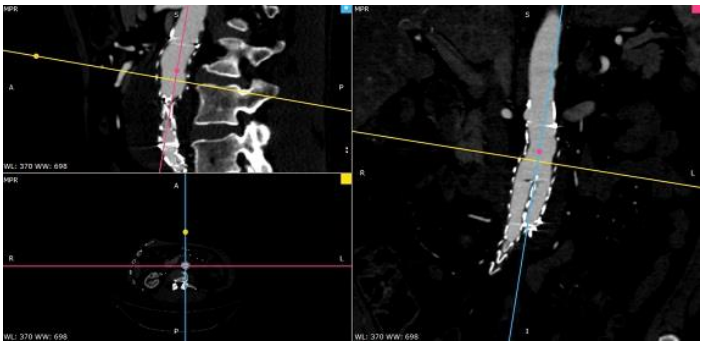
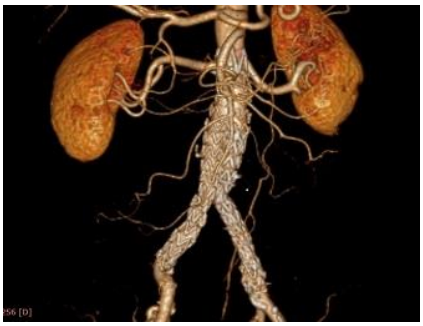
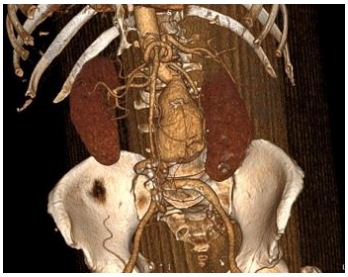
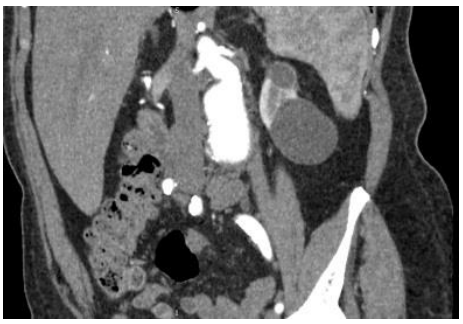


- CT angiography post (2)

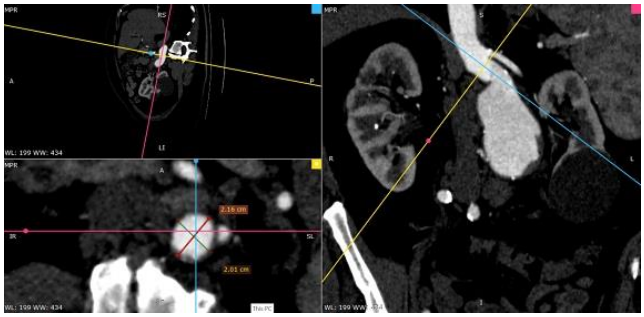
Case 2:

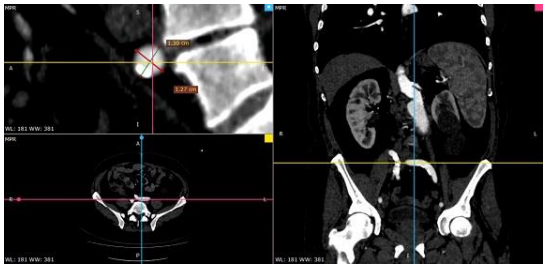






- Neck Diameter= 20-21 mm



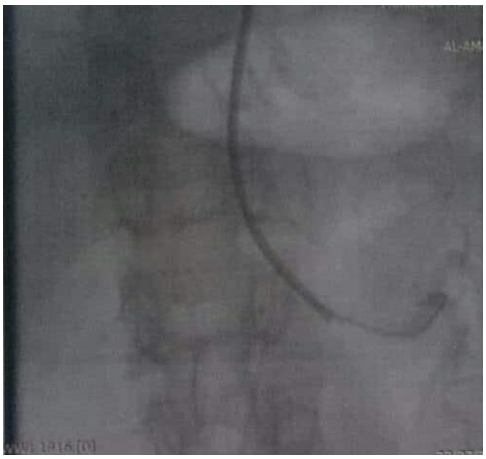


-Left iliac Diameter= 13 mm

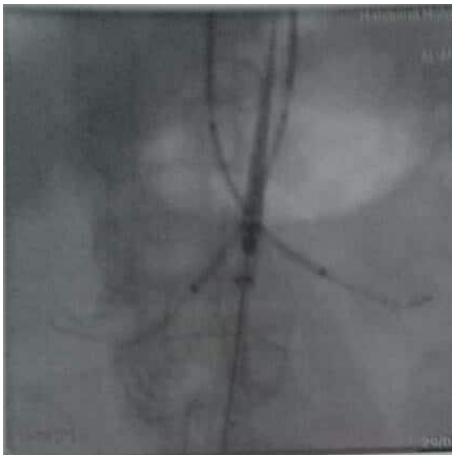
- CT angiograohy post:

Case 3:

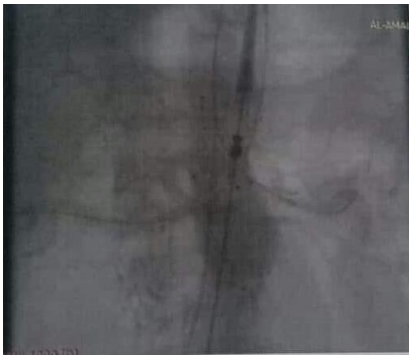
- Canuulation of left renal artery in chimney technique:



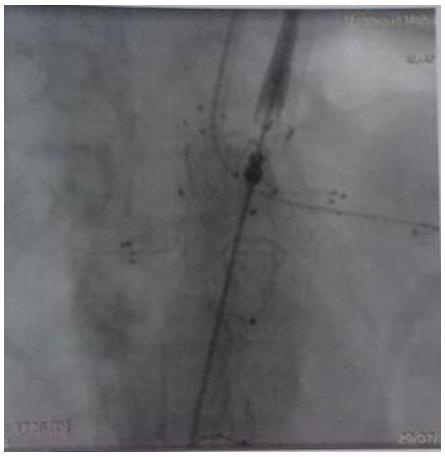
Cannulation of right renal artery and introduce of the main body in chimney technique:



Deployment of stent graft in chimney technique:



Completion angiography in chimenny technique:



Results

This study included 10 patients presented to Cairo and El-Minia university hospitals having an infra-renal abdominal aneurysm with challenging neck from December 2013 to August 2018.

The age distribution of patients ranged between 36 -70years old and 19 (95%) of them were males. dyslipidemia, hypertension, peripheral vascular disease and ischemic heart disease were the main risk factors as shown in Table (1):

The aneurysm diameter in (30%) of our patients was between (5.5 to 6.5) cm, in (20%) of the patients it was between (6.5 to 8) cm ad the aneurysm diameter was > 8cm in 50% of the patients .

Proximal neck length ranged from 10.2 mm to 14 mm with the highest incidence of 13mm neck length in (30%) only one patient (10%) had a neck length 14mm as shown in table (2).

As regard the neck diameter (50%) of patients had a neck diameter between 18- 20 mm, as in table (3).

The proximal neck angle of the aneurysm varied from 60-75 degree, (20%) of our patients had an angle between 60-65 degree while (40%)

of our patients had an aneurysm angle between 70-75 degree as shown in table (4)

As regard device selection, Zenith Flex (Cook) was used in (30%) of the patients, while in (70%) Endurant (Medtronic) was used. According to special techniques used in our patients we used bare metal supra renal stent in 4 patients (40%), unilateral chimney was done

in 2 patients (20%) and bilateral chimney was done in one patient (10%) as shown in table (5) As regard blood loss it varied from 350 to 1000 ml, (40%) of patients had blood loss 750 and (10%) of patients had 1000 ml blood loss

According to complications, wound infection occurred in 3patients (30%) that successfully treated with triple antibiotics, groin hematoma in one patient (10%) that spontaneously resolved, type 1A endoleak in one patient (10%) which were treated with a compliant molding balloon only one patient(10%) had type 2 endoleak which is resolved spontaneously within one month.

And one patient (10%) had stent graft limb occlusion which discovered one month post-operative by Duplex scan and CT angiography and femoro- femoral cross over graft was done.

Table (1) Showing the co-morbidities and risk factors among studied patients

Co-morbidities and risk factors	No. of patients	Percentage
Smoking	9	90%
Dyslipidemia	6	60%
Hypertension	4	40%
Peripheral vascular disease	2	20%
Ischemic heart disease	5	50%
Diabetes	3	30%
Chest disease	2	20%

Table (2): Showing the proximal neck length in the studied patients.

Neck length	No. of patients	Percentage
14 mm	1	10%
13.7 mm	2	20%
13 mm	3	30%
11.6 mm	2	20%
10.2 mm	2	20%

Table (3): Showing the neck diameter

Neck diameter	No. of patients	Percentage
18- 20 mm	5	50%
22 mm	1	10%
23 mm	1	10%
24 mm	1	10%
26 mm	1	10%
27 mm	1	10%

Table (4): Showing the proximal neck angle

Neck angle	No of patients	Percentage
60-65	2	20%
65-70	4	40%
70-75	4	40%

Table (5): Special techniques used in the studied patients

Techniques	No of patients	Percentage
supra renal stent	4	40%
unilateral chimney	2	20%
bilateral chimney	1	10%

Table (6): Showing complications

Complication	No of patients	Percentage
Wound infection	2	20%
Groin hematoma	1	10%
Endo leak type 1A	1	100%
Endo leak type 2	1	10%
Iliac limb occlusion	1	10%

Discussion

The choice between open surgical repair and EVAR in patients with challenging aortic neck anatomy still remains controversial. Challenging aortic morphology requires adequate preoperative planning in order to minimize procedure-related complications[(12)].

In this study, there were multiple risk factors for the presence of the aneurysm as smoking in 90% of the patients, dyslipidemia in 60% and hypertension in 40% and peripheral vascular disease in 20%. This was in agreement with a study done by Broos et al., where 70% of the patients had hypertension, 52.6% of the patients had dyslipidemia, 43.3% of the patients were smokers and 20.4% of the patients had peripheral vascular disease [(13)].

Kent et al., assured that these were well-defined clinical risk factors that associated with the pathogenesis of AAA and reported in his literature that dyslipidemia and smoking considered as the main risk factors in pathogenesis of AAA[(14)].

As regard aneurysmal sac diameter 50% of the patients had aneurysmal diameter of 8cm, followed by 5.5-6.5cm in 30%. While, in a study done by Setacci et al., 2012 the maximum diameter was 6.5cm [(12)].

In this study, 20% of patients had a proximal neck length 10.2mm, 5 patients (50%)had a neck diameter between 18m to 20mm and 4 patients (40%) had a neck angle between 70 to 75.

Schanzer et al., reported that AAA repair with a hostile neck is more challenging compared to that with friendly neck anatomy [(7).] Unfavorable anatomical characteristics have been shown to be associated with specific EVAR-related complications, such as device migration and a high incidence of type IA endoleak and re-intervention. Further insight on how to expand EVAR treatments to more challenging cases with difficult necks and how to prevent potential complications will be key for improvements in the efficacy and applicability of EVAR[(7)].

Antoniou GA et al., reported that an angulated neck > 60° and/or a neck length < 15 mm remain the two most common reasons why a vascular specialist might not be able to offer EVAR [10].
This is particularly true if both factors are present in the same patient. Reports of successful treatment of patients with isolated short infra-renal necks (10–15 mm) are increasing in his literature[10].

EVAR is also possible in severely angulated necks (> 60°), provided the neck length is adequate to maintain stent-graft neck wall apposition, however when more of the hostile neck factors are present, the challenge becomes intensified and demands extreme precision in order to deliver the stent-graft into the exact position that would allow it to remain effective in the long run. It becomes increasingly important to take advantage of every millimeter of the infra-renal sealing zone when multiple hostile neck features are present [10].

In our study 60% of patients had general anesthesia while only 40% had combined spinal epidural general anesthesia with muscle relaxation and artificial ventilation provides excellent surgical conditions, combined spinal and epidural anesthesia are all appropriate for EVAR. Sedation is usually required with a benzodiazepine or a target controlled infusion of propofol.

The procedure can be performed using local infiltration anesthesia (LA), general anesthesia (GA) or regional anesthesia (RA). The latter may be performed as a spinal, epidural or combined spinal epidural (CSE). The potential advantages of LA and RA are that there is usually excellent perioperative and post-operative analgesia with a stable cardiovascular system. However, there is no evidence to suggest that outcome is improved with LA or RA compared with GA[16].

Local infiltration anesthesia of the groins is equally successful since it is only this anatomical area in which anesthesia is required. Deployment of the stent graft within the aorta is usually pain free. The right hand is used for the venous and arterial cannulation as access to the aorta via the left axillary artery may be required on very rare occasions. Such an occasion would be when the radiologist wishes to reduce hemorrhage by placement of a balloon catheter above the aneurysm when direct femoral cannulation has failed. This requires conversion to GA. Regional anesthesia is usually supple-mented with sedation, either by a continuous low dose infusion of propofol or small intermittent boluses of midazolam. In an extremely restless patient, conversion to GA may be required [17].

In our study, in (30%) of the patients the Zenith Flex (Cook) graft was used and in7 (70%) of the patients Endurant (Medtronic) stent graft was used.
The challenges in the treatment of highly angulated and short necks lie in being able to utilize the entire proximal seal zone[18].

In a study done by Setacci et al., 2012 only the Endurant stent-graft was used. The device has greater flexibility due to shorter and wire-formed M-shaped body stents. This increased flexibility allows the stent-graft to be successfully used in aneurysms with severely angulated and tortuous anatomies [12]. Similar results have been published by Bastros Gonçalves et al., who considered treatment with the Endurant stent-graft feasible and safe, achieving satisfactory results in angulated and non-angulated anatomies [22].

The device has greater flexibility due to shorter and wire-formed M-shaped body stents. This increased flexibility allows the stent-graft to be successfully used in aneurysms with severely angulated and tortuous anatomies. The suprarenal anchoring pins and the controlled release of the top stent ensure exact proximal fixation to the aortic wall and reduce the risk of migration. Recent series have sought to analyze the short-term results of this new stent-graft, particularly in patients with complex aortic morphologies.

The final results of the prospective European multicenter non-rando-mized trial of the Endurant stent-graft for EVAR showed that this stent-graft was successfully delivered and deployed in all cases, with safe and effective performance in all patients, including those with unfavorable (angulated) proximal neck anatomy.

However Mertens et al., reported that in elective EVAR using the Cook Zenith endograft provided excellent results through a mean follow-up of >5 years [20]. Also, Lederle et al., . 2009 used Zenith Flex (Cook) graft in 37.4% of the patients [21].

According to special techniques used in our patients we used bare metal supra renal stent In 4 patients (40%), unilateral chimney was done in 2 patients (20%) and bilateral chimney was done in one patient (10%).

According to complications occurred in our study we found that wound infection occurred in two patients that successfully treated with triple antibiotics, groin hematoma in one patient that spontaneously resolved, type IA endoleak in one patients which treated with a compliant molding balloon, only one patient had type II endoleak which is resolved spontaneously within one month and one patient had stent graft limb occlusion which discovered one month post-operative by Duplex scan and CT angiography and femoro- femoral cross over graft was done.

Liaw et al., reported that local wound complications include groin hematoma, infection, or lymphocele, and the incidence is 1 to 10%. Although clinical surveillance with or without medical treatment or surgical repair are mostly enough for definitive treatment, ultrasound (US) or computed tomography (CT) evaluation can be needed to evaluate the extent of the lesion [23].

Maleux, et al., reported in his literature that limb occlusion of aortic stent-grafts mostly occurs shortly after EVAR and can be related to underlying kinking of the metallic skeleton, extension of the stent-graft into the external iliac artery, or migration and dislocation of an endograft limb. Satisfactory and durable clinical outcomes can be obtained after appropriate revascularization[24].

Cochennec et al., in another study reported that stent graft limb occlusion occurred in 3- 7% of procedures, and mostly within 6 months and they found that it was more frequent in patients who have aortoiliac occlusive disease, a small distal aorta (<14 mm), or tortuous iliacs or in those who require external iliac artery landing [25].

Earlier-generation stent grafts with unsupported limbs were at greatest risk for limb kinking. However, newer stent grafts are protected from graft limb kinking by more limb support. In a review of 460 patients, current-generation stent grafts were associated with a graft limb occlusion rate of 4.3% compared with 18.7% in first generation devices [25].

Meta-analysis of 23 publications involving 1118 patients with successful EVAR yielded an endoleak rate of 24%. Of these endoleaks, 66% were present immediately after stent graft placement and 37% were persistent over time. The clinical significance of endoleaks and their impact on the natural history of aneurysms is uncertain and poorly understood [26].

John et al., reported that persistent type II endoleak is associated with an increased incidence of adverse outcomes, including aneurysm sac growth, the need for conversion to open repair, re-intervention rate, and rupture. These data suggest that patients with persistent type II endoleak (>6 months) should be considered for more frequent follow-up or a more aggressive approach to re-intervention [27].
Huang et al., 2013 found in his study that endoleak occurred in 31 cases (14.8%) during operation, including 11 cases of type I endoleak (8 cases of type IA and 3 cases of type IB), 18 cases of type II endoleak, and 2 cases of type III endoleak (type IIIB). The patients were followed up 2-8 months (mean, 3.1 months). At 2 months after operation, contrast agent endoleak was found in the remnant aneurysm cavity of 12 cases (5.7%). At 6 months after operation, contrast agent endoleak was found in 10 cases (4.8%) by CTA. In 8 patients receiving DSA, there were 4 cases of type I endoleak (3 cases of type IA and 1 case of type IB), 3 cases of type II endoleak, and 1 case of type III (type IIIB) endoleak. In 5 patients having type I and type III endoleak, collateral movement of stent graft was observed in different degree; after increased stent graft was implanted, the endoleak disappeared after 2-4 months. The patients having type II endoleak were not given special treatment, endoleak still existed at 2 months

after reexamination of CTA, but the maximum diameter of AAA had no enlargement[28].

Conclusion

In patients with challenging neck anatomy, preoperative planning with adequate sizing is of utmost importance. High image quality and optimal alignment of the C-arm in the cranial caudal position are crucial to obtain maximum sealing in short necks. Aneurysm size is a predictor of survival after EVAR.

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