10.2478/abm-2010-0050

Asian Biomedicine Vol. 4 No. 3 June 2010; 413-420

Original article

Endovascular aortic stent for thoracic and abdominal aortic aneurysm: imaging consequences and complications

Seksan Kittivanakul, Somjai Wangsuphachart

Department of Radiology, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand

***Background*:** Endovascular stent-graft implantation has been used as an alternative to conventional open surgery in treatment of aortic aneurysm. Computed tomographic angiography (CTA) has been requested for follow-up and evaluation of aortic stent complications.

***Objective*:** Find the incidence of endovascular aortic stent complications and analyze the CTA features of post-endovascular aortic stent consequences.

***Methods*:** Two radiologists reviewed CTA images of 635 patients who attended King Chulalongkorn Memorial Hospital between Sep 1, 2003 and Aug 31, 2008. Thirty-eight patients had endovascular aortic stent installation with 95 CTA images. The incidence of endovascular aortic stent complications, the image appearances including consequences and time-interval of endoleak were analyzed.

***Results*:** There were 23 thoracic aortic stents, 10 abdominal aortic stents and five combined stents for thoracic and abdominal aortic aneurysms. Twenty-eight cases had aortic stent complications (73.7%). Two cases had immediately post procedural complication of groin hematomas (7.1%). Ten patients had more than one finding. Findings of the stent-graft complications were as follows: 19 endoleaks, 15 stent thrombosis, five stents without covered-dissection, two stent kinkings, two iatrogenic focal aortic dissection, two air within aneurysm after stent installation and one spreading infected aortitis. The most common complication was endoleaks (53.6%), which could progress, be persistent or resolvable. Time-interval to detect endoleak was between 1 and 464 days.

***Conclusion*:** CTA can be used as modality of choice in demonstration of stent location, consequences, and complications. The stent complication was still high in the first five-year experience.

Keywords: Aortic stent complication, computed tomographic angiography (CTA), endoleak, endovascular aortic stent

Ruptured abdominal aortic aneurysms are a leading cause of death in Asian and Pacific region. They occur 1.1% in 2004 [1]. For decades, the standard treatment of abdominal aortic aneurysms has been open surgery. Parodi et al. [2, 3] reported the first series of patients with abdominal aortic aneurysms treated with stent-grafts. Endovascular stent-graft implantation has been used as an alternative to conventional open surgery in the treatment of aortic aneurysm, especially in high-risk patients. Advantages of endovascular procedures are less blood loss, shorter stays in intensive care units, subsequent hospitalization, and quicker recovery.

Many studies showed that endovascular stent-graft therapy was safe and effective. However, complications related to this treatment were also recognized [4-8].

In Thailand, King Chulalongkorn Memorial Hospital (KCMH) started to treat aortic aneurysm by endovascular stent in 2004, with a multi-detector computed tomographic scanner (MDCT), installed in 2003 [9]. Computed tomographic angiography (CTA) has been requested for follow-up and evaluation of aortic stent complications. This study was designed

Correspondence to: Somjai Wangsuphachart, MD. Department of Radiology, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand. E-mail:fmedsws@yahoo.co.th

to investigate the incidence of endovascular aortic stent complications in Thailand. To find incidence of complications, we analyzed all consecutive images including consequences and time-interval of endoleak.

Subjects and methods

Between September 1, 2003 and August 31, 2008 (five-year period), all patients whom endovascular aortic stent were installed and requested for aortic CTA, were reviewed via Barco pixels monitor from the picture archiving communication system (PACS). All patients underwent MDCT (Somatom Sensation 16, Siemens Medical Solution, Forchheim, Germany) according to the KCMH aortic CTA protocol. All findings of aortic stent complications were analyzed by two radiologists. Consensus was achieved in all cases. Consequences and time interval were also recorded.

Selected cases

According to Scheme classifications [10], we classified endoleak into five types as shown in **Table 1.**

All patients who had endovascular aortic stent implantation and underwent CTA of the aorta at KCMH and all cases of which the discharge summary was recorded as vascular stent complication on International Classification of Diseases 10 (ICD10= T825) or endovascular implant on International Classification of Diseases 9 (ICD9=39.71).

Procedure of analysis

In craniocaudal scanning, CTA of thoracic aorta began from chest apex to lower border of left hemidiaphragm. The CTA of abdominal aorta started from dome of right diaphragm to symphysis pubis. Finally, the CTA of whole aorta began from chest apex to symphysis pubis. Pre-contrast imaging was first performed. Then, post contrast and delayed images by intravenous injection of one hundred mL of nonionic contrast medium (300 mgI/mL), flow rate 3-3.5 mL/second, with 50 mL of normal saline chasing.

The region of bolus tracking of CTA of thoracic aorta was located on proximal ascending aorta; abdominal aorta was located on distal thoracic aorta at left diaphragmatic dome level. The whole aorta was located on proximal descending aorta.

Results

Thirty-eight patients had endovascular aortic stents installed (25 males, 13 females). Patients' age range was 24-90 years old (median age 74 years old). The youngest patient had thoracic aortic aneurysm from hypertension.

Durations of hospital stay for endovascular stent installation were 3-64 days (median 12 days). The patient who had the longest hospital stay had underlying congestive heart failure and pneumonia. There was no acute mortality after endovascular stent installation.

There were 23 thoracic aortic stents, nine infrarenal abdominal aortic stents, one suprarenal abdominal aortic stent, and five combined stents (one thoracic and suprarenal aortic stents (one thoracic and infrarenal aortic stents, and three supra-/infra-/renal aortic stents).

In KCMH, two types of aortic stents were used, i.e., Talent and Zenith, both of which are covered stents by Dacron. Most of patients had Talent stents (Medtronic) installed, which were self-expandable, tubular or bifurcated modular devices with Nitinol covered (Nickel titanium). Only one patient had a Zenith stent (Cook) installed, which was bifurcated, modular, and self-expandable with stainless steel Z stent [8].

Table 1. Five types of endoleaks, according to Scheme classifications.

Endoleak type	Findings
I	Attachment site leak (proximal or distal stent)
II	Leak from collateral vessels (lumbar artery, inferior mesenteric artery (IMA), accessory renal artery)
III	Graft failure (midgraft hole, junctional leak or disconnect)
IV	Graft wall porosity: faint blush of contrast leakage (spontaneous resolving)
V	Endotension: expansion of aneurysm without contrast leakage
IV	Graft wall porosity: faint blush of contrast leakage (spontaneous resolving)
V	Endotension: expansion of aneurysm without contrast leakage

One to seven times CTA examinations were done in each patient. There were 95 CTA serial images from 38 patients. Time intervals for CTA follow-up were one day to two years (median: seven months). There was one mortality during this time.

Twenty-eight patients (73.7%) had endovascular aortic complications (**Fig. 1**). There were two cases of immediate post-procedural complication of groin hematoma (7.1%). Ten out of 28 patients had more than one finding including three endoleaks and

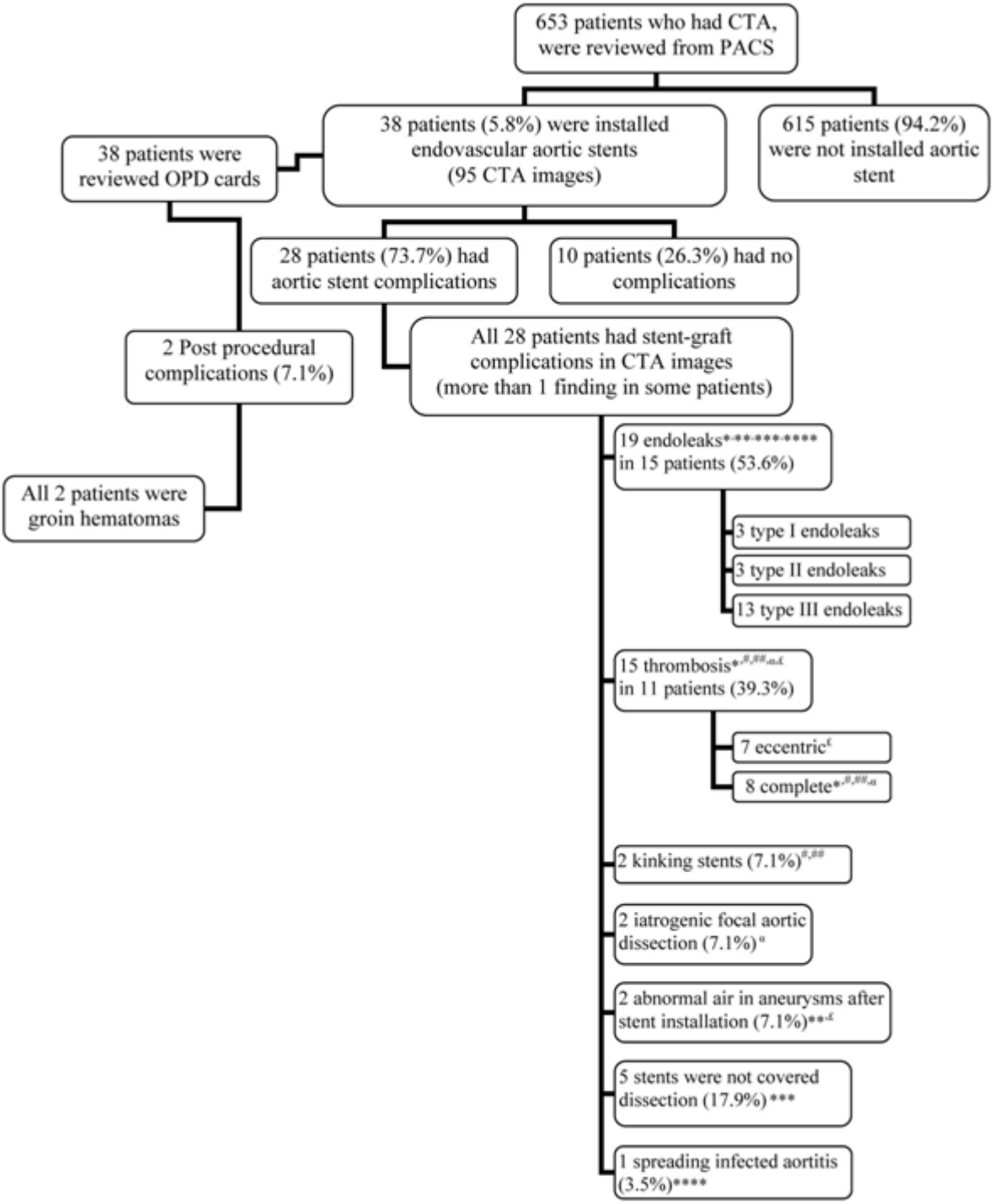

Fig. 1 Diagrammatic flow chart for investigating complications of endovascular aortic stent. *three endoleaks and complete thrombosis, **one endoleak and abnormal air in aneurysm, ***one endoleak and stent not covered dissection, ****one endoleak and infected aortitis, #one stent kinking and one site of complete thrombosis, ##one stent kinking and two sites of complete thrombosis, one eccentric thrombosis and abnormal air in aneurysm, αone iatrogenic focal aortic dissection and complete thrombosis.

thrombosis, one endoleak and abnormal air in aneurysm, one endoleak and stent not covered dissection, one endoleak and infected aortitis, one stent kinking and complete thrombosis, one eccentric thrombosis and abnormal air in aneurysm, one iatrogenic focal aortic dissection and complete thrombosis and the only one who had three findings (one stent kinking, and two sites of complete thrombosis). There were six patients who had multiple sites of single finding, i.e., two sites of thrombosis in three patients, three endoleaks in one patient, and two endoleaks in two patients.

There was an infected aortitis misdiagnosed as aortic dissection, showing rim enhancing fluid collection at thoracic aorta and leukocytosis (**Fig. 2a**). The patient went back home seven days after stent installation and then readmitted about 1 month later with hemoptysis and leukocytosis. Aortic CTA was done showing increased size of fluid collection with rim enhancement (**Fig. 2b**). Aortic repair and graft installation were performed. The pathological and microbial analysis was infected aortic aneurysm (*S. aureus*). The patient died two and half months after endovascular stent implantation.

Two cases (7.1%) had abnormal air in the non-dependent part of the aneurysm after stent installation in day 4 and 8. There were no leukocytosis and the air was resolved spontaneously.

Fifteen patients (53.6%) had endoleaks **(Table 2)**. There were 19 endoleaks in those 15 patients. The thoracic stents showed 10 endoleaks (40%), type I (n=1) and type III (n=9). The abdominal stents showed nine endoleaks (60%), type I (n=2), type II (n=3), type III (n=4). Findings included endoleak type I (n=3, 15.8%), type II (n=3, 15.8%), and type III (n=13, 68.4%). All of our type I endoleaks leaked from distal end of the stents (**Fig. 3**).

Type II endoleaks were supplied from IMA and left lumbar artery at L5 level (**Fig. 4a, 4b**).

Type III endoleaks showed leakage from aortic arch (n=3), thoracic aorta (n=6), infrarenal aorta (n=1) and CIA-common iliac arteries (n=3) (**Fig. 5a, 5b**). Three cases (15%) showed resolved endoleak in 2, 5 and 7-months CTA follow-up (**Fig. 6a, 6b**).

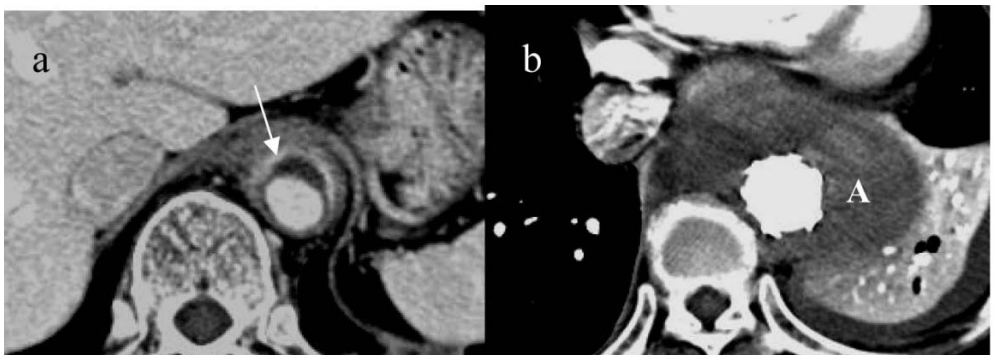

Fig. 2 (**a**) Axial delayed CTA showing rim enhancing soft tissue density at anterior aspect of abdominal aorta (arrow), likely infected aortitis but misdiagnosed as aortic dissection. (**b**) Two months after aortic stent installation, axial CTA showed increase in size of the infected aortitis with periaortic abscess (**A**).

Table 2. Details of 15 patients who had 19 endoleaks.

Number of leaking sites	Number of patients (%)	Location	Type of endoleaks
3 sites	1 (6.7%)	2 thoracic	III & III
		1 abdominal	I
2 sites	2 (13.3%)	1 thoracic	III & III
		1 abdominal	II & II
1 sites	12 (80%)	6 thoracic	I (n=1)
			III (n=5)
		6 abdominal	I (n=1)
			II (n=1)
			III (n=4)

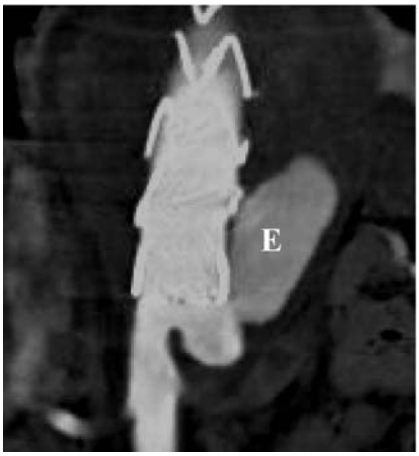

Fig. 3 Coronal CTA showing distal type I endoleak (**E**).

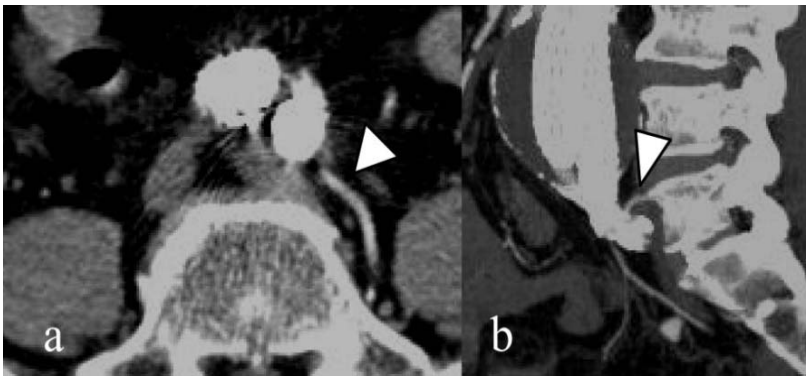

Fig. 4 (a, b) Axial CTA and sagittal MIP showing type II endoleak supplied by left lumbar artery at L5 level (arrowhead).

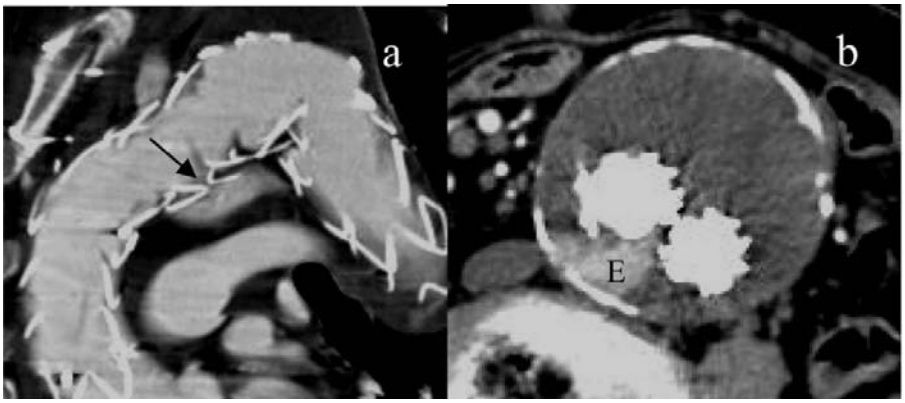

Fig. 5 **(a)** Sagittal CTA showing type III endoleak at aortic arch (arrow). **(b)** Axial CTA showing type III endoleak from right CIA stent (**E**).

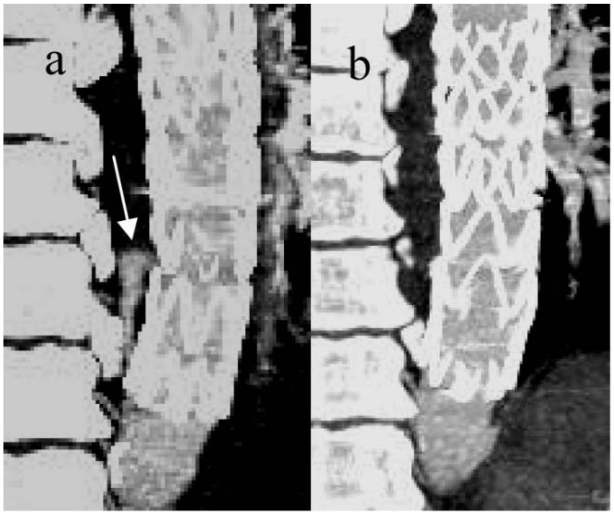

Fig. 6 (**a**) Coronal CTA showing type III endoleak at mid descending thoracic stent (arrow). (**b**) Seven months later, disappearing of endoleak without treatment.

One of them was type III endoleak, resolved in seven-month CTA follow-up and then re-endoleak at different site of right CIA stent after two years. Five patients had increased degree of endoleak type I (n=1), type II (n=1), and type III (n=3).

Time-interval range that could detect endoleaks from CTA images, were 1-464 days [type I: 7-85 days (median 53 days), type II: 50-78 days (median: 59 days), and type III: 1-464 days (median: 125 days)].

Eleven patients showed thrombosis (39.3%), presented with 15 thrombosed sites. Of these 15 sites, there were 12 intra-stent thrombosis (80%) and three extra-stent thrombosis (20.0%). Seven of them were eccentric thrombosis located at the left subclavian and the left common carotid arteries with steal phenomenon (n=1), mid thoracic stent (n=1), distal thoracic stent (n=1), bifurcation of abdominal aorta (n=2) and CIA (n=2)**.**

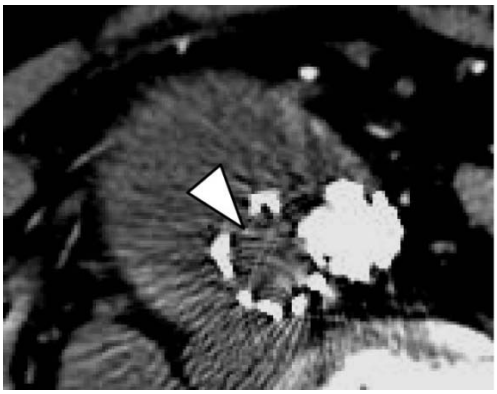

Fig. 7 Axial CTA showing complete thrombus (arrowhead) in right CIA stent.

Eight patients had complete thrombosis located at the left subclavian artery with steal phenomenon (n=2), left common carotid artery (n=2), left vertebral artery (n=1), left CIA (n=1), left CIA extended to external iliac artery (n=1), and right CIA (n=1) (**Fig. 7).**

Two patients (7.1%) had kinking of left common iliac stents. All of the kinking stents had consequence of complete thrombosis.

Two patients (7.1%) had kinking of left common iliac stents. All of the kinking stents had consequence of complete thrombosis.

There were two cases (7.1%) of post-procedural focal aortic dissection (iatrogenic) at the suprarenal aorta (**Fig. 8a, 8b**) and infrarenal aorta just distal to IMA.

The stent was not covered the exit of distal aortic dissection in five cases (17.9%).

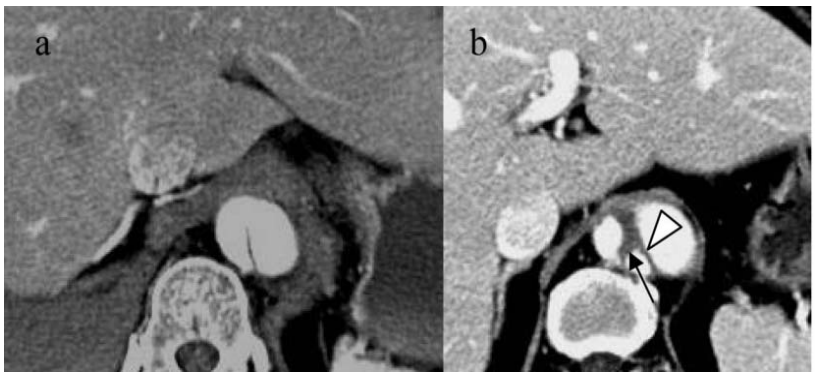

Fig. 8 **(a)** Axial CTA showing false dissecting lumen at the left suprarenal abdominal aorta. **(b)** Two months after stent installation, axial CTA showed new small flap (arrow) at the right inferior aspect of abdominal aneurysm, representing iatrogenic focal aortic dissection. There was no significant change of the left false aortic dissection (arrowhead).

Discussion

CTA is an imaging modality of choice for evaluation of endovascular aortic stent complications such as endoleak, thrombosis, complete occlusion, kinking of stent, or post-procedural iatrogenic focal aortic dissection.

Tillich M et al. [11] reported CTA as imaging modality of choice for assessment of aortic stent complications. They found that 39 patients had 24 complications (79%) with incidences as endoleaks, shrinkage of abdominal aortic aneurysms, angulation of bifurcated stents, distal migration of stents, graft thrombosis, progressive enlargement of aneurysms, and aortoduodenal fistula.

Mita T et al. [7] reported complications of endovascular repair for aortic aneurysm showing 49 patients had 25 complications (51%) with incidences such as endoleaks, graft thrombosis, graft kinkings, pseudoaneurysm, graft occlusion, shower embolism, perforation of mural thrombus, colon necrosis, aortic dissection and groin hematoma.

Stolzmann et al. [12] reported 52 (44%) endoleaks from 118 patients. There were eight (15%) type I endoleaks and 44 (85%) type II.

In our study, 28 patients (73.7%) had complications, which was comparable to Tillich's study. [11] Our incidences were endoleaks, intra or extra-stent thrombosis, stent not covered dissection, stent kinkings, iatrogenic focal aortic dissection, abnormal air in aneurysm after stent installation and spreading infected aortitis. No severe complication that needed further surgical management was observed except for one case of infected-aortitis. This case was missed-diagnosed as aortic dissection, and managed with aortic stent installation leading to mortal complication. This stent installation was not advantageous but increased morbidity and mortality. The patient developed periaortic abscess (*S. aureus*) and died from aortic rupture after 2.5-month stent installation.

Most common stent-graft complications in our study were endoleaks (53.6%), which was at a higher rate than the previous reports [12]. Our most common endoleak occurred at the thoracic stent graft and was type III (68.4%), which was different from Stolzmann's study [12]. The cause of type III endoleak depended on stent material and coverage. Type I endoleak occurred from incomplete sealing of the stent-graft at the attachment sites [13]. Cause of type V endoleak or endotension was unknown. The management of endoleaks in each type was different as follows [14, 15]:

- Type I and III endoleaks (high pressure) should be repaired immediately.
- Type II and V endoleaks (low pressure) require no urgent management. Sac pressurization was performed if continued aneurysmal sac growth or symptomatic patients such as abdominal or back pain.
- Type IV endoleak was self-limited, requiring no treatment.

In our study, type I or III endoleaks had no further urgent surgical management. However, these cases were closely followed-up based on CTA images. There were three spontaneously resolved endoleaks (15.0%); type II (n=1), and type III (n=2). Two of the resolved type III endoleaks had small leakage.

Chernyak V et al. [16] reported the follow-up period in detection of endoleak ranged from 0-80 months (mean: 24.6 months) in all patients, from 0-80 months (mean: 24.3 months) in patients with type I or III endoleak, and from 0-54 months (mean: 25.6 months) in patients with type II endoleak. They found four in six type II endoleaks that were spontaneously resolved. The time-duration between endoleak emergence and resolution ranged from 1.5 to 40 months (mean: 14.4 months).

Therasse E et al. [17] stated that contrast enhanced thoracic CT should be performed at the time of discharge and at 3, 6, and 12 months after stent-graft insertion and annually thereafter.

Time-intervals for detection and follow-up endoleak in CTA imaging were variable with a wide-range in our study. Time-interval for follow-up endoleaks is still controversial. Thus, follow-up CTA interval or aggressive management should depend on the size of contrast leakage and the patient's clinical manifestation. CTA follow-up is usually helpful for management determination whether the endoleak would be resolved, persistent, progressing or from newly-developed sites.

Intra-stent complete occlusion was found following stent kinking in all cases.

We found two cases of abnormal air in aneurysms after stent installation, which had never been reported. These could be observed in the first week without evidence of infection or leukocytosis and were self resolving.

Conclusion

Aortic CTA has benefit for evaluation of aortic aneurysm (type, location, dissection, or infected aortitis), planning for endovascular stent, and follow-up post-endovascular stent complications, including consequences such as endoleak, thrombosis, stent kinking, iatrogenic focal aortic dissection or groin hematoma. Endoleak is the most common complication with highest incidence of type III that may occur mostly from thoracic stent.

Acknowledgements

The authors appreciate the Medical Records and Statistical Departments, and all staffs at CT unit of KCMH for providing the patients'data. The authors have no conflict of interest to declare.

References

1. http://www.cdc.gov/men/lcod/04asian.pdf
2. Rydberg J, Kopecky KK, Johnson MS, Patel NH, Persohn SA, Lalka SG. Endovascular repair of abdominal aortic aneurysms. Am J Radiol. 2001; 177:607-14.
3. Parodi JC, Palmaz JC, Barone HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. Ann Vasc Surg. 1991; 5:491-9.
4. Dake MD, Miller DC, Mitchell RS, Semba CP, Moore KA, Sakai T. The "first generation" of endovascular stent-grafts for patients with aneurysms of the descending thoracic aorta. J Thorac Cardiovasc Surg. 1998; 116:689-703.
5. Mitchell RS, Miller DC, Dake MD, Semba CP, Moore KA, Sakai T. Thoracic aortic aneurysm repair with an endovascular stent graft: the "first generation". Ann Thorac Surg. 1999; 67:1971-4.
6. Ehrlich M, Grabenwoeger M, Cartes-Zumelzu F, Grimm M, Petzl D, Lammer J, et al. Endovascular stent graft repair for aneurysms on the descending thoracic aorta. Ann Thorac Surg. 1998; 66:19-24.
7. Mita T, Arita T, Matsunaga N, Furukawa M, Zempo N, Esato K, et al. Complications of endovascular repair for thoracic and abdominal aortic aneurysm: an imaging spectrum. Radiographics. 2000; 20:1263-78.
8. Thurnher S, Cejna M. Imaging of aortic stent-grafts and endoleaks. Radiol Clinics N Am. 2002; 40:799-833.
9. Sereeborwornthanasak K, Wangsuphachart S. The utility of computed tomographic angiography for final diagnosis of aortic dissection. Asian Biomed. 2007; 1:195-201.
10. Stavropoulos SW, Charagundla SR. Imaging techniques for detection and management of endoleaks after endovascular aortic aneurysm repair. Radiology. 2007; 243:641-51.
11. Tillich M, Hausegger KA, Tiesenhausen K, Tauss J, Groell R, Szolar DH. Helical CT angiography of stent-grafts in abdominal aortic aneurysms: morphologic changes and complications. Radiographics. 1999; 19: 1573-83.
12. Stolzmann P, Frauenfelder T, Pfammatter T, Peter N, Scheffel H, Lachat M, et al. Endoleaks after endovascular abdominal aortic aneurysm repair: detection with dual-energy dual-source CT. Radiology. 2008; 249:682-91.
13. Napoli V, Bargellini I, Sardella SG, Petruzzi P, Cioni R, Vignali C, et al. Abdominal aortic aneurysm: contrast-enhanced US for missed endoleaks after endoluminal repair. Radiology. 2004; 233:217-25.
14. Agarwal PP, Chughtai A, Matzinger F, Kazerooni EA. Multidetector CT of thoracic aortic aneurysms. Radiographics. 2009; 29:537-52.
15. Bashir MR, Ferral H, Jacobs C, McCarthy W, Goldin M. Endoleaks after endovascular abdominal aortic aneurysm repair: management strategies according to CT findings. Am J Radiol. 2009; 192:W178-86.
16. Chernyak V, Rozenblit AM, Patlas M, Cynamon J, Ricci ZJ, Laks MP, et al. Type II endoleak after endoaortic graft implantation: diagnosis with helical CT arteriography. Radiology. 2006; 240:885-93.
17. Therasse E, Soulez G, Giroux MF, Perreault P, Bouchard L, Blair JF, et al. Stent-graft placement for the treatment of thoracic aortic diseases. Radiographics. 2005; 25: 157-73.