

Growth Rate of Aortic Diameter in Post Treatment of Aortic Dissection

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Objective: To evaluate growth rate of aortic diameter, true lumen, and false lumen in post endovascular aortic repair of aortic dissection.

Material and Method: Between January 2005 and September 2010, 48 consecutive patients with aortic dissection were followed with computed tomographic angiography (CTA), including 18 post-surgical repaired type A patients and 30 type B (14 conservative treatment and 16 post stent-grafting therapy). CTA were performed with a mean of 5.2 scans per patient, and a mean follow-up of 37.08 months. The diameter of the aorta, true lumen, and false lumen were measured by axial scan images and multi-planar reformatting (MPR).

Results: In medically managed patients with type B aortic dissection, the aortic diameter increased over time at mean rate 1.49 mm/year at proximal descending aorta with greater increased in size of the false lumen diameters than the true lumen diameter. In post-surgical repaired type A and post stent-grafting therapy type B aortic dissection, aortic diameter did not change over time. In addition, 12 of 16 patients (75%) patients with post stent-grafting therapy type B dissection had partial thrombosed in false lumen and 4 of 16 patients (25%) had complete resolution of false lumen.

Conclusion: In post-surgical repaired type A and post stent-grafting therapy type B aortic dissection, aortic diameter did not change over time. Type B aortic dissection with medical treatment had minimal increased in aortic diameter over time. The results suggested that uncomplicated type B aortic dissection requires on-going medical treatment.

Keywords: Aortic dissection, Stent-graft, True lumen, False lumen, Medical treatment, Aortic diameter

J Med Assoc Thai 2015; 98 (9): 902-9

Full text. e-Journal: <http://www.jmatonline.com>

Aortic dissection is the most common acute emergency condition of the aorta and often has a fatal outcome. The incidence of aortic dissection has been reported to be 2,000 new cases per year in the United States and 3,000 in Europe⁽¹⁾. Acute type A aortic dissection is a surgical emergency. Medical management alone is associated with a high mortality rate⁽²⁾. Surgery is advised immediately in acute type A aortic dissection. The aim of surgery is to prevent aortic rupture, pericardial tamponade, and relieve aortic regurgitation. Implantation of a composite graft in the ascending aorta with or without reimplantation of coronary arteries is a simple standard in a world of emerging new and sophisticated surgical options. The operations are very dependent on location of aortic dissection area⁽³⁾.

Patients with uncomplicated acute type B aortic dissection are typically managed with antihypertensive therapy^(2,4-9). During the chronic

phase, medically managed type B dissection are increased risk for aneurysmal dilatation and rupture of the affected aorta^(4-6,10), because of the relatively high incidence of increasing aortic diameter in type B aortic dissection. Careful follow-up with non-invasive imaging has been recommended for evaluation of growth rate of the aortic diameter, true lumen, false lumen, and complication⁽¹¹⁾. In general, a descending aortic diameter greater than 6 cm is indicated for immediate surgery⁽¹⁾.

Patients with complicated acute type B aortic dissection such as malperfusion of vital aortic side branches, interventional therapy by stent-grafting or catheter-guided fenestration of an occlusive lamella was performed. Indications for operative treatment in patients with acute type B are limited to the prevention or relief of life-threatening complications such as intractable pain, a rapidly expanding aortic diameter, or development of periaortic or mediastinal hematoma⁽¹²⁾.

Several studies had shown that the maximum aortic diameter increased over time, with the growth rate vary about 0.5 to 10.6 mm/year measuring in different methods. At present, there is paucity data regarding the rate of aortic enlargement of aortic

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dissection type A and B in Thailand, specifically, the rates of true lumen and false lumen enlargement have not been well documented^(11,13-15).

The purpose of the present study was to evaluate the growth rate of aortic diameter, true lumen and false lumen in post-repaired type A, stent-grafting therapy type B and medical therapy type B aortic dissection.

Material and Method

Patients

After receiving the Institutional Review Board approval, retrospective review of computed tomographic angiography (CTA) in patients with post-repaired type A aortic dissection and type B aortic dissection who had conservative treatment and stent-grafting therapy at Siriraj Hospital was performed. Between January 2005 and September 2010, 48 consecutive patients, 39 males and nine females (age range 26 to 83 years, mean age 55.5 years) were included.

The diagnosis of type A and B were obtained with CTA using the Stanford (type A, type B) classification. Eighteen patients were type A and 30 were type B. In type B, 14 of 30 patients were managed conservatively with antihypertensive therapy according to the medical standard care, the other 16 patients underwent stent-graft therapy. According to standard treatment, the patients were divided into three groups; group I was type A aortic dissection with surgical repair, group II was type B aortic dissection with medical treatment and group III was type B aortic dissection with stent-grafting therapy (Fig. 1). The 14 patients of type A and three patients of type B had no initial study performed.

Imaging acquisition

CTA was performed with 64 slices multidetector scanner, LightspeedVCT (General Electric Medical System, Milwaukee, WI) or Somatom Dual Source CT scan (Siemens, Germany). The CT protocol consisted of unenhanced and arterial phase contrast-enhanced scans. No oral contrast agent was administered. On contrast-enhanced scan, 100 to 150 ml of nonionic contrast material was administered into antecubital vein with a power injector at a rate of 5 ml/sec using bolus-tracking technique. In average, 5.2 scans were obtained per patient (range 2-11 scans; type A 4.1 scans, type B 8.9 scans) and the mean total follow-up interval was 37.1 months (range 6-98.2 months). The follow-up interval between studies varied according to the clinical

course of the patient and was at the discretion of the referring physicians. Almost all intervals follow-up scans at least 1 year and at least two studies after the time of acute diagnosis were included in the study.

Image analysis

Image analysis was performed on a picture archiving and communication system (PACS). Two radiologists with five and seven years of cardiovascular imaging experience obtained all measurements. Axial scan and multi-planar reformatting (MPR) images were displayed. Aortic diameter was measured from the outer contours of aortic wall. The craniocaudal extent of dissection was recorded in millimeters. The short axis diameter of the aorta was measured as well as true and false lumen diameters were measured perpendicular to the contour of the intimal flap at this level. The affected aortas were divided into five segments such as aortic arch, proximal descending aorta, celiac, aortic bifurcation, right, and left iliac arteries.

Statistical analysis

Growth rate for aortic diameter, true lumen diameter and false lumen diameter were estimated with linear regression using a linear mixed-effects model. Linear mixed-effect models with two different covariance structures were considered. Linear regressions for group I (patient that post-repaired type A aortic dissection), group II (patient that type B

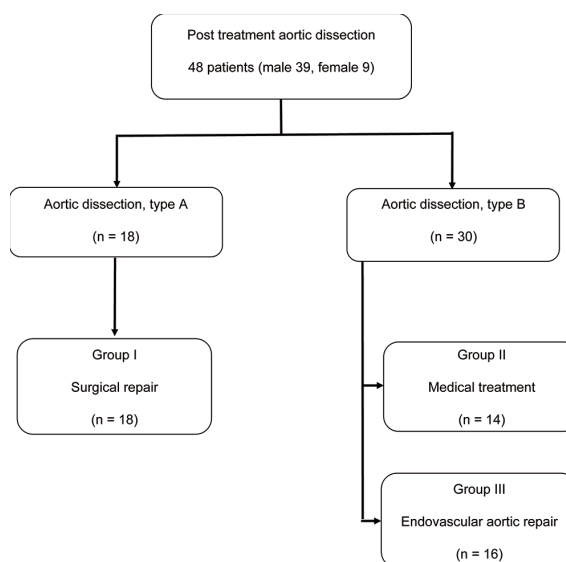


Fig. 1 Flowchart demonstrates study population enrollment into three groups.

aortic dissection with conservative treatment), group III (patient that post stent-graft type B aortic dissection) were performed with random intercept and slope covariance model. All linear regression analyses were performed using SPSS Release 13.0. Group comparisons, aortic diameter, true lumen and false lumen in diameter within type A and type B aortic dissection were performed with Mann-Whitney U test and comparison before and after surgery within type A or after stent-grafting within type B with Wilcoxon Signed Ranks test. A *p*-value <0.05 was considered as statistically significant.

Results

Growth rate of aortic diameter

Group I, aortic diameter was not significantly changed over time. However, the maximum growth rate was detected at aortic bifurcation, 0.99 mm/year. In group II, aortic diameter was mildly increased over time at mean growth rate 1.49 mm/year at proximal descending aorta due to greater increased in size of the false lumen diameter than the true lumen diameter. In group III, aortic diameter was not significantly changed over time. However, there is increasing in true lumen diameter (2.88 mm/year), whereas decreasing in false lumen diameter (-2.15 mm/year) especially at proximal descending aorta, which is location of stent-graft placement (Table 1).

Comparison of diameter changed in each group

Group I, the median false lumen diameter change was significantly more than true lumen at aortic arch (3.8 mm vs. -0.2 mm, *p* = 0.04), proximal descending aorta (4.3 mm vs. 0.9 mm, *p* = 0.01), celiac artery (2.7 mm vs. -0.5 mm, *p*<0.01), and aortic

bifurcation (2.2 mm vs. 0.1 mm, *p*<0.01). In group II, the median false lumen diameter change was significantly more than true lumen at proximal descending aorta (3.8 mm vs. -0.05 mm, *p*<0.01). In group III, the median true lumen diameter change was significantly more than false lumen at proximal descending aorta (4.2 mm vs. -3.9 mm, *p*<0.01) (Table 2).

Complete resolution of the thrombosed false lumen

In group III, 12 patients had partial thrombosed false lumen and four patients had complete resolution of the thrombosed false lumen.

Discussion

Management of acute type A aortic dissection is a surgical emergency, but for acute type B aortic dissection, management includes both medical and surgical options. Medical management is typically reserved for patients without complications such as rupture or organ ischemia. During the subacute and chronic phases, medical treatment of patients with type B dissection has produced acceptable outcomes^(7,10,14,16). However, endovascular or surgical intervention is indicated if the patient develops a new complication or the aortic diameter enlarges. Follow-up imaging studies with close analysis of the aortic diameter changes are therefore critical in the chronic phase of type B aortic dissection⁽¹⁴⁾.

Several studies had been reported regarding the aortic diameter change in patients with type A aortic dissection after surgical repair. Kelly et al⁽¹³⁾ reported mid-point aortic diameters operated type A aortic dissection increased significantly over time compared with the baseline (*p*<0.001), showing average rates of

Table 1. Growth rate of aorta and arterial diameter, true lumen and false lumen in type A (group I), medically managed patients with type B (group II) and post stent-grafting therapy type B aortic dissection (group III)

Group	Location	Growth rate diameter (mm/year)					
		Aortic arch	Proximal descending aorta	Celiac level of aorta	Aortic bifurcation	Right iliac artery	Left iliac artery
I (n = 18)	Diameter	0.001	0.003	-0.01	0.99	-0.11	1.23
	True lumen	-0.002	-0.31	-0.21	0.32	0.36	0.406
	False lumen	0.001	0.11	0.22	0.68	0.95	0.445
II (n = 14)	Diameter	0.03	1.49	0.45	1.26	0.35	-0.27
	True lumen	0.01	-1.15	-0.37	-0.24	0.34	-0.33
	False lumen	0.004	2.39	0.83	1.41	0.64	0.601
III (n = 16)	Diameter	0.02	-0.20	0.001	1.20	-0.85	1.36
	True lumen	0.009	2.88	1.47	-0.57	1.09	0.11
	False lumen	0.01	-2.15	0.003	1.83	-3.27	0.68

Table 2. Comparison of diameter changed of true and false lumen before and after treatment within each group (mm)

Location	Group I (n = 18)			Group II (n = 14)			Group III (n = 16)		
	True lumen (mm)	False lumen (mm)	p-value	True lumen (mm)	False lumen (mm)	p-value	True lumen (mm)	False lumen (mm)	p-value
Aortic arch	-0.20 (-2.80 to 9.10)	3.80 (-5.50 to 8.30)	0.04	-4.30 (-6.80 to -1.50)	11.80 (9.10 to 16.40)	0.10	3.35 (-3.60 to 5.20)	-3.15 (-11.40 to 22.30)	0.49
Proximal descending thoracic aorta	0.90 (-4.50 to 4.70)	4.25 (-11.10 to 19.50)	0.01	-0.05 (-4.00 to 3.40)	3.75 (-10.60 to 19.20)	<0.01	4.20 (-3.20 to 23.60)	-3.90 (-46.60 to 29.40)	<0.01
Celiac level of aorta	-0.45 (-3.50 to 3.50)	2.70 (-0.20 to 11.20)	<0.01	0.30 (-5.50 to 2.70)	1.80 (-3.60 to 11.10)	0.08	1.50 (-2.00 to 9.30)	0.10 (-7.20 to 13.50)	0.25
Aortic bifurcation	0.05 (-2.50 to 5.70)	2.15 (-0.90 to 11.50)	<0.01	0.20 (2.10 to 8.80)	1.25 (-4.80 to 8.10)	0.41	-0.10 (-1.60 to 3.70)	1.45 (-4.50 to 15.00)	0.14
Right iliac artery	1.20 (-0.80 to 3.30)	2.55 (-7.30 to 5.50)	0.70	1.10 (-3.90 to 3.30)	0.20 (-1.30 to 3.30)	0.55	2.05 (1.40 to 2.70)	-1.50 (-1.10 to 0.80)	0.33
Left iliac artery	1.00 (-0.50 to 6.30)	1.35 (0.10 to 6.20)	0.29	1.15 (-6.10 to 1.50)	0.70 (-3.20 to 6.00)	0.82	-0.55 (-2.30 to 0.90)	1.40 (0.20 to 2.60)	0.23

0.8 mm/year. Heinemann et al⁽¹⁷⁾ reported 58 patients who underwent emergency operation for acute type A aortic dissection and followed-up from 3 months to 10 years, 10 patients (17%) had dilatation of the distal aorta (diameter size range, 6 to 10.5 cm). Ergin et al⁽¹⁸⁾ reported that rate of enlargement of the residual dissection was 17% at three years from the initial operation and 37% at five years in patients who underwent resection of arch tear for type A aortic dissection. Contrary to the present study, the aortic diameter was not significantly changed over time in post-repaired type A aortic dissection (Table 1).

In aortic dissection with medical treatment, several studies had been reported concerning growth rate of the aorta. Sueyoshi et al⁽¹¹⁾ reported a mean growth rate of 4.1 mm/year in the thoracic aorta of 62 medically managed patients with type B dissection. Onitsuka et al⁽¹⁰⁾ reported a mean growth rate of 3.8 mm/year in 76 medically managed patients with type B dissection. Kelly et al⁽¹³⁾ reported a rate of 1.5 mm/year in 24 medically managed patients with type A or type B dissection. Blount and Hagspiel⁽¹⁴⁾ reported a rate of 7.1 mm/year in 19 medically managed patients with type A or type B dissection. The authors showed that aortic diameter increased over time at mean rate 1.49 mm/year at proximal descending aorta in 14 medically managed patients with type B aortic dissection due to greater increased in size of the false lumen diameters than the true lumen diameter (Table 1, 2 and Fig. 2, 3).

In group of aortic dissection with stent-grafting therapy, Lee et al⁽¹⁹⁾ reported that about three quarters of the patients in acute and subacute-phase of post stent-grafting therapy type B dissection showed the thrombosed thoracic false lumen reduction in 15% and complete resolution of the thrombosed false lumen occurred in two to three months later in most cases. One third of patients treated in the chronic phase of dissection showed complete resolution of the false lumen and the thrombosed thoracic false lumen shrank in about half of this subgroup. The authors showed that patients with post stent-grafting therapy type B dissection had the partial thrombosed of the false lumen in 12 out of 16 (75%) and complete resolution of the thrombosed false lumen occurred from one month to 2.9 years in 4 out of 16 (25%) (Fig. 4, 5). The authors showed that aortic diameter was not significantly changed over time and significantly greater increased in size of the true lumen diameter than the false lumen diameter at proximal descending aorta in post stent-grafting therapy type B aortic dissection

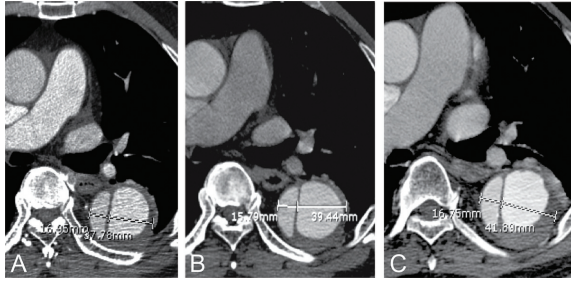


Fig. 2 A 78-year-old male with medically managed type B aortic dissection and increasing aortic diameter at proximal descending aorta. (A) Image at baseline shows aortic diameter of 54.73 mm (16.95+37.78). (B) Image obtained 1 year after (A) shows aortic diameter is 55.23 mm (15.79+39.44). (C) Image obtained 2 years 7 months after (A) shows aortic diameter has increase to 58.64 mm. And false lumen had increased to 41.89 mm (16.75+41.89).

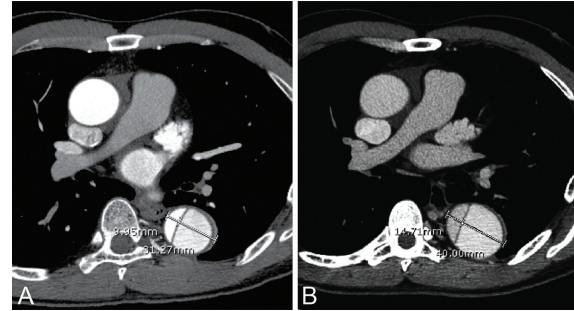


Fig. 3 A 52-year-old male with medically managed type B aortic dissection and increasing aortic diameter at proximal descending aorta. (A) Image at baseline shows aortic diameter of 42.95 mm (9.95+31.27). (B) Image obtained 3 years after (A) shows aortic diameter is 54.70 mm (14.71+40.00).

(Table 1, 2). The median true lumen diameter post stent-grafting implantation was significantly larger than before stent-grafting implantation in type B aortic dissection ($p = 0.02$). The median false lumen diameter of post stent-grafting implantation was significantly smaller than before stent-grafting implantation in type B aortic dissection ($p = 0.033$) (Table 2). These are representing with good results of this treatment due to proximal descending aorta is located of the stent-grafting implantation.

The limitations in the present study were relatively small sample size, variable follow-up interval, retrospective design, and using of axial

images rather than images perpendicular to the long axis of the aorta. Larger prospective studies with longer and more regular follow-up intervals are needed to further assess the natural history of post-surgical repaired type A and type B aortic dissection.

Conclusion

In post-surgical repaired type A and post stent-grafting therapy type B aortic dissection, aortic diameter did not change over time. However, at celiac level, the aortic diameter, and false lumen diameter in post grafting stent implantation in type B aortic dissection is larger than before grafting stent implantation, these results suggested close follow-up

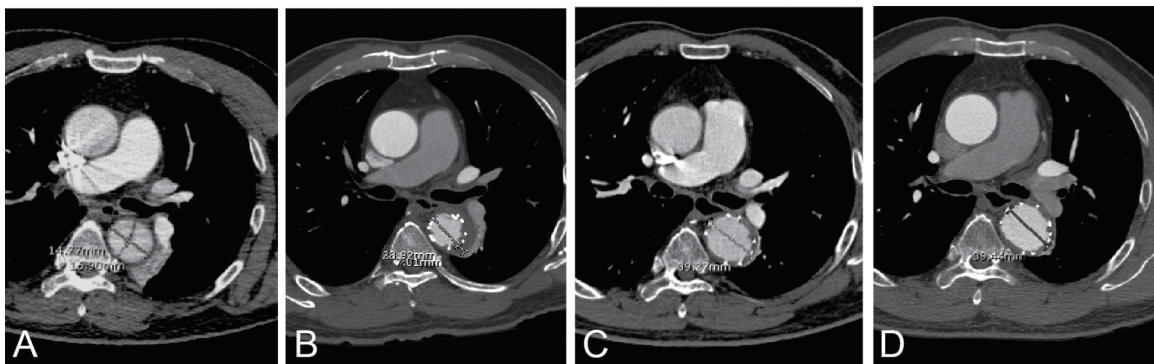


Fig. 4 A 60-year-old male with stent-grafting therapy type B aortic dissection and complete resolution of thrombus. (A) CT scans before treatment show true lumen collapse with false lumen expansion at the level pulmonary artery. (B) Follow-up CT scan 8 days after stent-graft placement (at the same levels as (A)) showing more expansion of the true lumen in the thoracic aorta by the stent-graft. (C, D) Follow-up CT scan 3 months and 6 months after stent-graft placement (at the same levels as (A)) showing full expansion of the true lumen in the thoracic aorta by the stent and complete resolution of thrombus at 3 months after stent-graft placement.

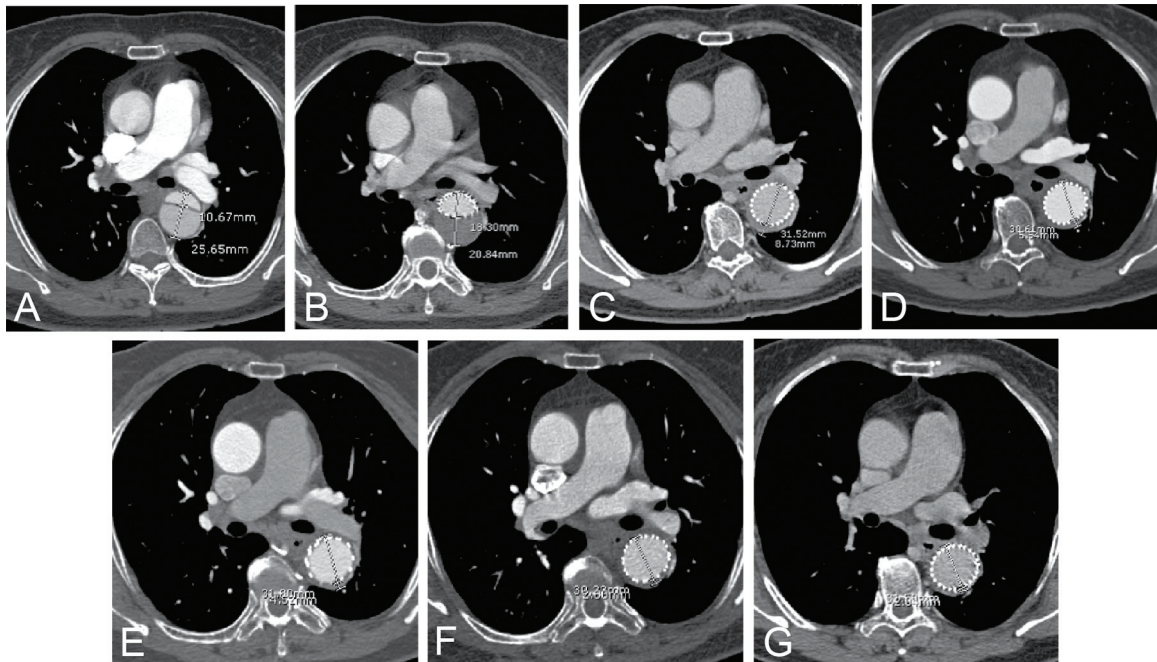


Fig. 5 A 63-year-old male with stent-grafting therapy type B aortic dissection and complete resolution of thrombus. (A) CT scans before treatment show true lumen collapse with false lumen expansion at the level pulmonary artery. (B-F) Follow-up CT scan 2 weeks (B), 6 months (C), 1 year (D), 1 year 5 months (E), and 1 year 10 months (F) after stent-graft placement (at the same levels as (A)) showing more expansion of the true lumen in the thoracic aorta by the stent. (G) Follow-up CT scan 2 years 11 months after stent-graft placement (at the same levels as (A)) showing full expansion of the true lumen in the thoracic aorta by the stent.

imaging with particular attention to increasing aortic diameter, which may be reliable indicator for endovascular intervention at this level.

In medically managed patients with type B aortic dissection, aortic diameter minimal increased over time at proximal descending aorta, primarily because of the increasing size of the false lumen, these results suggest that uncomplicated type B aortic dissections required continue medical treatment.

What is already known on this topic?

Aortic dissection is urgent aortic condition that required surgical or medical treatment. The surgical treatment was recommended in type A and complicated type B dissection. The others were medical treatment.

Clinical outcome, survival probability, and growth rate of uncomplicated type B aortic dissection had been documented.

What this study adds?

1. Growth rate of aorta after surgical treatment of type A dissection.

2. Growth rate of aorta after stent-graft treatment of type B dissection.

3. Comparison of growth rate of aorta in type A and B in same study.

Potential conflicts of interest

None.

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อัตราการขยายขนาดของ *aorta* ที่เกิดขึ้นใน *aortic dissection* ภายหลังจากได้รับการรักษา

จิตรลัดดา วะสินรัตน์, เมธินีรัฐ เลิศโกวิท, ทนงชัย สิริอภิสิทธิ์

วัตถุประสงค์: เพื่อศึกษาอัตราการขยายขนาดของ *aorta*, *true lumen* และ *false lumen* ที่เกิดขึ้นใน *aortic dissection* ภายหลังจากการได้รับการรักษาด้วย *endovascular aortic repair*

วัสดุและวิธีการ: ผู้ป่วยจำนวน 48 ราย ที่ได้รับการวินิจฉัย *aortic dissection* ในช่วงเดือนมกราคม พ.ศ. 2548 จนถึง กันยายน พ.ศ. 2553 ได้รับการตรวจวินิจฉัยด้วยเอกซเรย์คอมพิวเตอร์ ในจำนวนนี้มีผู้ป่วย 18 ราย เป็นชนิด A และได้รับการผ่าตัด 30 ราย เป็นชนิด B ได้รับการรักษาด้วยยา 14 ราย และด้วยการใส่ *stent* 16 ราย ผู้ป่วยได้รับการติดตามผลด้วยเอกซเรย์คอมพิวเตอร์ เฉลี่ยจำนวน 5.2 ครั้ง และระยะเวลา 37.08 เดือน ขนาดของ *aorta*, *true lumen* และ *false lumen* ได้จากการวัดในภาพตัดขวาง และภาพ *multi-planar reformatting*

ผลการศึกษา: ผู้ป่วยที่เป็นชนิด B ที่ได้รับการรักษาด้วยยาพบว่าอัตราการขยายขนาดของ *aorta* เพิ่มขึ้น 1.49 มม./ปี โดยเฉพาะในส่วน *false lumen* มากกว่า *true lumen* ในกลุ่มผู้ป่วยที่เป็นชนิด A ที่ได้รับการผ่าตัด และชนิด B ภายหลังจากใส่ *stent* ไม่พบว่ามีการขยายขนาดของ *aorta* นอกจากนี้ยังพบว่าผู้ป่วยชนิด B ภายหลังจากใส่ *stent* มีผู้ป่วย 12 จาก 16 ราย (75%) ที่มีลิ้มเลือดเกิดขึ้นใน *false lumen* และมีผู้ป่วย 4 จาก 16 ราย (25%) ที่ *false lumen* หายไปได้

สรุป: ผู้ป่วยที่เป็นชนิด A ที่ได้รับการผ่าตัด และชนิด B ภายหลังจากใส่ *stent* ไม่พบว่ามีการขยายขนาดของ *aorta* ผู้ป่วยที่เป็นชนิด B ที่ได้รับการรักษาด้วยยาพบว่าอัตราการขยายขนาดของ *aorta* เพิ่มขึ้นเล็กน้อย ซึ่งทำให้ผู้ป่วยชนิด B ควรได้รับการรักษาอย่างต่อเนื่องต่อไป
