Review Article

Intraoperative aortic dissection

Ajmer Singh, Yatin Mehta

Department of Cardiac Anaesthesia, Institute of Critical Care and Anesthesiology, Medanta-The Medicity, Gurgaon, Haryana, India

ABSTRACT

Intraoperative aortic dissection is a rare but fatal complication of open heart surgery. By recognizing the population at risk and by using a gentle operative technique in such patients, the surgeon can usually avoid iatrogenic injury to the aorta. Intraoperative transesophageal echocardiography and epiaortic scanning are invaluable for prompt diagnosis and determination of the extent of the injury. Prevention lies in the strict control of blood pressure during cannulation/decannulation, construction of proximal anastomosis, or in avoiding manipulation of the aorta in high-risk patients. Immediate repair using interposition graft or Dacron patch graft is warranted to reduce the high mortality associated with this complication.

Received: 12-07-15
Accepted: 24-09-15

Key words: Cardiac surgery; Iatrogenic; Intraoperative aortic dissection

INTRODUCTION

Intraoperative aortic dissection (IAD) is a rare but potentially fatal complication of open heart operations. Once dissection has occurred, prompt diagnosis and immediate surgical intervention is required to reduce the high mortality associated with this complication. Several authors have reported the incidence of IAD ranging from 0.12% to 0.35% after open heart surgery and operative mortality from 14.8% to 43%.[1,2] A higher incidence (0.6%) has been reported after aortic valve replacement.[3] Unfortunately, these numbers take into account not only IAD but also dissections that occur weeks and days after cardiac surgery. Late dissection occurring many years after a successful cardiac surgery is also reported.[4] Since the first report of successful treatment of IAD in 1974, the incidence of IAD has not changed.[5,6] Spontaneous aortic dissection is known to occur in patients with hypertension and Marfan syndrome, IAD is most commonly iatrogenic in origin and can occur in any patient at any phase of cardiac surgery.[7]

MECHANISM OF AORTIC DISSECTION

IAD is related to the procedures disrupting the wall of the aorta or its branches. Acute aortic dissection occurs as a result of a primary tear in the intima with blood from aortic lumen penetrating into the diseased media creating a true and a false lumen. Rupture of vasa vasorum leads to hemorrhage in the aortic wall with subsequent intimal disruption creating the intimal tear. When blood enters through an intimal tear, it passes longitudinally along the tunica media separating the intima from the adventitia. Intimal injury can be the result of direct laceration, mechanical compression, or torsion of the aorta. DeBakey and Stanford are the commonly used classifications for aortic dissection. The most common sites of aortic injury are the ascending aortic cannulation site, cross-clamp site, the site of partial-occlusion clamp, the proximal anastomosis site, antegrade cardioplegia cannulation site, and axillary artery cannulation site. Retrograde aortic

Access this article online

Website: www.annals.in

DOI: 10.4103/0971-9784.166463

Quick Response Code:

Address for correspondence: Dr. Ajmer Singh, Department of Cardiac Anaesthesia, Institute of Critical Care and Anesthesiology, Medanta-The Medicity, Gurgaon, Haryana, India. E-mail: ajmersingh@yahoo.com

Cite this article as: Singh A, Mehta Y. Intraoperative aortic dissection. Ann Card Anaesth 2015;18:537-42.

dissection from femoral artery cannulation is another mechanism for aortic injury and occurs in as high as 3% of patients.[8] Retrograde dissections resulting during or after endovascular stenting of the thoracic aorta or aortic arch have also been reported.[9,10]

PREDISPOSING FACTORS

Patients predisposed to aortic injury are those with severe atherosclerotic changes in the aortic wall, family history of aortic aneurysm/dissection, arteritis, bicuspid aortic valve, a thin or dilated ascending aorta, Marfan syndrome, or collagen vascular disease [Table 1]. Other predictors for the occurrence of IAD are older age, high blood pressure at the time of dissection, pregnancy, cocaine abuse, aortic trauma, aortic instrumentation, and use of intra-aortic balloon counterpulsation. However, it is difficult to find significant predictors for IAD on multivariate analysis because of its low incidence. By recognizing the population at risk and by using a gentle operative technique in such patients, the surgeon can usually avoid iatrogenic injury to the aorta.

DIAGNOSIS

Intraoperative recognition of aortic dissection requires a high index of suspicion and good clinical judgment. The sudden disappearance of radial arterial pressure waveform during surgery or endovascular stenting should raise the suspicion of IAD.[10] Patients in whom dissection does complicate cardiopulmonary bypass (CPB) procedures, prompt recognition of the dissection, and expeditious surgical repair are necessary to achieve a successful outcome. Malperfusion of the vessels supplying the brain, coronary arteries, mesentery, and renal arteries leads to an adverse patient outcome. The most common cause of death is full thickness rupture with cardiac tamponade.

Table 1: Predisposing factors for aortic dissection

Hypertension
Atherosclerosis
Genetic/congenital disorders
Family history of aortic aneurysm/dissection
Thin/dilated ascending aorta
Bicuspid aortic valve
Coarctation of aorta
Marfan syndrome
Turner's syndrome
Vascular Ehlers-Danlos syndrome
Loeys-Dietz syndrome
Pregnancy
Trauma (blunt/iatrogenic)
Motor vehicle accident
Intra-aortic balloon pump
Catheter or stent
Surgery
Aortic/vascular surgery
Coronary artery bypass surgery
Cocaine use
Inflammatory/infectious diseases
Giant cell arteritis, Takayasu arteritis
Behcet's disease, aortitis, syphilis

A dissection must be differentiated from a subadventitial hematoma that is commonly encountered during operations with the use of CPB. A subadventitial hematoma is usually small, soft, easily compressible, enlarges slowly, and stops enlarging as CPB is initiated. Aortic dissection, on the other hand, can rapidly involve the entire exposed aorta, giving it a tense, blue to purple discoloration, circumferentially dilated appearance like a sausage. Rapid bleeding occurs when the adventitia is incised. The most important factor that should raise the suspicion of IAD is high impedance to aortic cannula flow at the beginning of CPB, and it requires immediate evaluation of the position of aortic cannula. Modalities to confirm the diagnosis of IAD include transesophageal echocardiography (TEE), epiaortic scanning, and aortography (if the facility for the hybrid operating room is available). Among the ominous signs and symptoms of late dissection occurring after cardiac surgery are acute neurologic deficits, tearing chest or back pain, sudden loss of peripheral pulses, widened mediastinum, or more subtle visceral ischemic changes leading to lactic acidosis.

Intraoperative transesophageal echocardiography

TEE has become a routine for operations involving CPB, and as greater expertise is gained in its use, it has become a valuable diagnostic tool, both intraoperatively and postoperatively, for the identification of aortic dissection.[11] Detection of intimal flap during intraoperative TEE examination carries a sensitivity of 94–100% and a specificity of 77–100% [Figures 1-3].[12] TEE is helpful for additional information in the form of identification of true and false lumens, site of entry point, the involvement of arch vessels and coronary arteries, aortic regurgitation, ventricular function, and tamponade. It may be difficult to differentiate the true from the false lumen, especially when the dissection involves the entire aorta. Some of the indirect findings to differentiate the two are (i) True lumen expands during systole and is compressed during diastole, (ii) the false lumen is larger than

the true lumen, (iii) spontaneous echo contrast and thrombus are frequently present in false lumen as a consequence of stagnant flow, and (iv) color flow Doppler imaging identifies forward systolic flow in the true lumen [Figure 4]. Other potential advantages of TEE over other imaging modalities include its easy portability, real-time information, lack of radiation, and usefulness in unstable patients. Disadvantages of TEE are operator-dependent technique, the presence of "blind-spot" (by the interposition of the bronchus), and inability to visualize the abdominal aorta.[13]

Lin *et al*.[14] studied 5247 consecutive adult patients undergoing elective cardiac surgery with TEE monitoring during an 8-year period. Aortic dissection was identified in 7 (0.13%) patients and diagnosed immediately by TEE in five of them; two were diagnosed later by TEE. All aortic dissections were type-A, and they occurred after completion of the primary procedure. Two patients treated conservatively died within 5 days. Four of the five patients who underwent immediate reoperation survived with serious postoperative complications. They concluded that TEE should be carried out when there is a risk of aortic dissection during cardiac operations, especially in the posterior wall of the ascending aorta to avoid missing the diagnosis and delaying treatment. Ruchat *et al*.[15] have recommended that cannulation site should be checked routinely by TEE before initiating CPB. Conventionally, intraoperative TEE evaluation is performed after induction of general anesthesia, and later on, after completion of the contemplated surgical procedure. Early recognition and prompt management of IAD can be achieved if TEE examination is performed soon after the institution of CPB, during CPB, and early after discontinuation of CPB.

A recent publication by Thorsgard *et al*.[16] on "impact of intraoperative TEE on acute type-A aortic dissection" has concluded that intraoperative TEE provides incremental information to the original imaging examination in nearly two-third of patients leading to a change in the planned surgery in 39% of patients, thus supporting

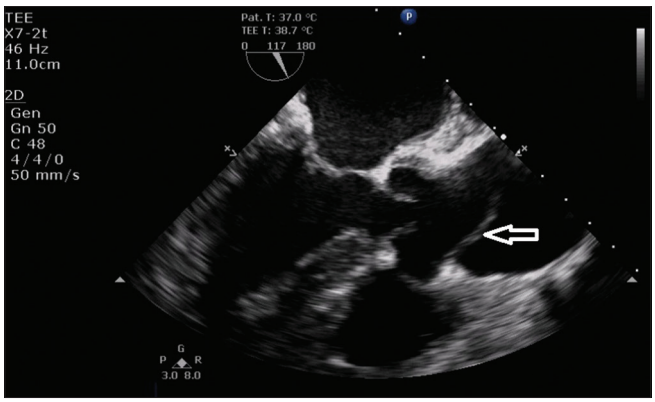

Figure 1: Transesophageal echocardiographic image demonstrating dissection flap (arrow) in the proximal ascending aorta (midesophageal aortic valve LAX view)

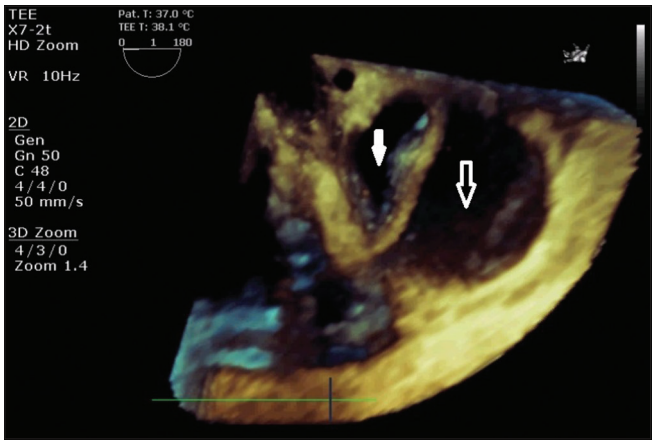

Figure 3: Three-dimensional echocardiographic image of descending aorta SAX view demonstrating true lumen (white arrow) and false lumen (black arrow)

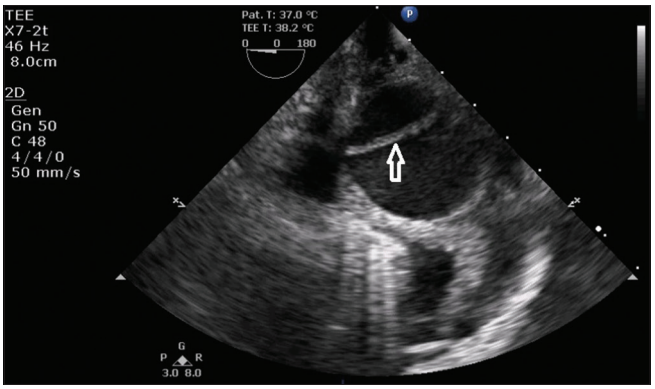

Figure 2: Transesophageal echocardiographic image showing dissection flap (arrow) in descending aortic SAX view

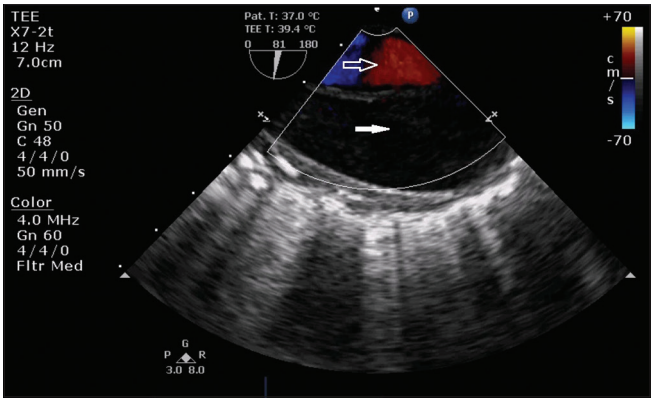

Figure 4: A color flow Doppler image of descending aorta LAX view showing systolic flow within the true lumen (black arrow) and no flow in the false lumen (white arrow)

its role as suggested in recent guidelines.[11] During endovascular stent-graft placement, TEE is helpful to guide proper positioning of stent-graft, guidewire reposition from false to true lumen, and to detect peri-stent leaks.

Epiaortic scanning

The traditional method of identifying aortic atheroma by manual palpation is inadequate, potentially harmful, and misses atheroma in half of the patients. Epiaortic scanning prior to cannulation or proximal anastomosis site selection can identify the presence of soft or hard plaque, calcification, as well as dissection. Using a 7 MHz transducer, entire aortic root, ascending aorta, and arch can be viewed. Five views are recommended by the American Society of Echocardiography for epiaortic ultrasound of the ascending aorta: Short axis view of proximal aorta/mid ascending aorta/distal ascending aorta, and long-axis view of ascending aorta/proximal aortic arch.[17] However, neither epiaortic scanning nor TEE has completely eliminated aortic dissection.

Aortography

Aortography can identify intimal flap, true and false lumen, aortic regurgitation, and branch vessel involvement. Its accuracy is 90–95%. Disadvantages include inability to identify intramural hematoma, radiation, and contrast exposure. Computed tomography (CT) and magnetic resonance imaging (MRI) are helpful for diagnosis of late dissections, and for follow-up of the patients. The sensitivity and specificity of CT and MRI as diagnostic tools ranges from 94% to 100%. Recently, guidelines for multimodality imaging of diseases of thoracic aorta in adults have been published, describing merits and demerits of each technique.[18]

PREVENTION OF AORTIC INJURY

Measures to prevent intraoperative aortic injury include control of systolic blood pressure (82–90 mmHg systolic) during cannulation, placement of the aortic cannula away from atheromatous plaque, use of deep partial thickness or full thickness bites in the purse-string sutures for cannulation, use of aortic cross-clamps with padded inserts, avoidance of torsion and proximity of the heel of a partial-occlusion clamp to the aortic cannula, careful application and removal of all clamps, and reduction of pump flow (0.5–1 L/min) during clamping or declamping. By recognizing those patients at risk and employing the gentle operative technique, the surgical team can minimize the risk of dissection.

During off-pump coronary artery bypass graft (CABG) surgery, careful manipulation of the aorta with a single side-clamping and control of the arterial pressure (by pharmacological means in the form of beta blockers or calcium channel blockers or by temporary partial clamping of inferior vena cava) should be used to minimize aortic trauma. Avoidance of greater curvature of aorta, a classical site of dissection, for the placement of proximal anastomosis, and preference for the inner portion of aorta after dissection of the aortopulmonary space may decrease the risk of complications.[19] High-risk patients should undergo CABG without side-clamping of the aorta to prevent this complication. This can be achieved by exclusive use of bilateral mammary artery, construction of Y or T grafts, or use of subclavian/brachiocephalic artery as proximal anastomotic site.[20] Special connector systems to create sutureless venous anastomoses on aorta without applying side-clamping have also been developed, but occurrence of IAD has been reported with these devices also.[21]

Many investigators have found a higher incidence of early postoperative aortic dissection in patients undergoing off-pump CABG (OPCAB) surgery compared with on-pump CABG.[3,19,22] In a retrospective analysis by Chavanon *et al.*,[19] IAD was found to occur in 3 out of 308 patients (0.97%) after OPCAB compared with one out of 2723 patients (0.04%) after on-pump CABG ($P < 0.00001$). They speculated that the use of partial-occlusion clamp on the pulsating, and often diseased aorta could increase the risk of aortic dissection during off-pump surgery. In addition, in the absence of autopsies, some sudden deaths after OPCAB are secondary to rupture of unrecognized dissection and not to the commonly thought events such as fatal arrhythmias or massive pulmonary embolism. Tabry *et al.*[22] have concluded that determining the true frequency of early dissection after OPCAB will require honest reporting of all such cases, and that autopsies be conducted after all delayed sudden deaths that occur after OPCAB.

MANAGEMENT

Once the diagnosis of aortic dissection is made, it is imperative to know whether it is type A or type B dissection. While type B dissection can be managed medically or by stent-graft placement, type A dissection needs an immediate surgical intervention. For type A dissection, arterial cannulation site is rapidly changed

to another site (commonly femoral artery), and the patient is cooled to 18–20°C to achieve a total circulatory arrest. Facility for head cooling must be immediately available while achieving systemic hypothermia for cerebral protection. Femoral cannulation is preferred over subclavian or other sites, as it is easy and fast to expose with enough workspace available for the second surgeon.[23] The aortic cross-clamp is placed more distally on the aorta to expose the area of injury. These patients are at increased risk of perioperative bleeding. Antifibrinolytic lysine analogs, ε-aminocaproic acid or tranexamic acid are commonly used along with pharmacological glue to control excessive bleeding. Using retrograde or antegrade cerebral perfusion and cerebral oximetry monitoring, immediate repair is undertaken to limit both the extent of dissection and its complications. For specific neuroprotection, hypothermic circulatory arrest with antegrade cerebral protection is favorably most centers. Technically factors, such as perfusion site, perfusate temperature, flow rate, and pH management, also play an important role in the successful outcome.

Hwang *et al*.[2] have reviewed their experience of IAD (type-A) during cardiovascular surgery. From January 1998 to May 2009, IAD occurred in ten of 3421 (0.29%) cardiac surgical patients (male: female = 4:6, mean age 62.4 ± 8.0 years). Preoperative diagnoses were valvular heart disease (n = 6), ischemic heart disease (n = 2), combined disease (n = 1), and aortic aneurysm (n = 1). IAD was related with cannulation of ascending aorta (n = 4), axillary artery (n = 2), aortic root (n = 2), femoral artery (n = 1), and aortotomy repair (n = 1). All underwent total circulatory arrest with retrograde cerebral perfusion, and the torn aorta was replaced (n = 8) or repaired (n = 2). Mortality rate was 40% (4/10). After adoption of routine intraoperative TEE, mortality rate decreased from 75% (3/4) to 17% (1/6) (P = 0.190). There was a trend of increased mortality when the disease extended beyond the aortic arch.

The primary aim is to secure antegrade blood flow to the coronary and arch vessels as quickly as possible. The appropriate repair for aortic dissection is determined by the extent and location of the injury. For all dissections, the torn intima must be reapproximated, and the false lumen obliterated. The tear site is repaired within the lumen using multiple transverse mattress sutures reinforced with Teflon felt. Primary repair with the shortest possible bypass time is the procedure of choice in patients with localized intimal disruption. For more extensive lesions, interposition grafting or Dacron patch graft repair of the injured aorta may be required. The classical Bentall procedure involves composite graft replacement of the aortic valve, aortic root, ascending aorta with coronary implantation.[24] The need for this type of repair should be recognized quickly and expeditious repair performed, again to limit ischemic time. Any delay in diagnosis and with subsequent ventricular dysfunction secondary to myocardial ischemia increases the mortality manifolds. Follow-up of these patients includes evaluation by CT or MRI before discharge, at 3, 6, 12 months in the 1st year, and 6–12 monthly thereafter.

SUMMARY

IAD is a rare but fatal complication of open heart surgery. By recognizing the population at risk and by using a gentle operative technique in such patients, the surgeon can usually avoid iatrogenic injury to the aorta. Intraoperative TEE and epiaortic scanning are invaluable for prompt diagnosis and determination of the extent of the injury. Immediate repair using interposition graft or Dacron patch graft is warranted to reduce the mortality associated with this complication.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Still RJ, Hilgenberg AD, Akins CW, Daggett WM, Buckley MJ. Intraoperative aortic dissection. Ann Thorac Surg 1992;53:374-9.
2. Hwang HY, Jeong DS, Kim KH, Kim KB, Ahn H. Iatrogenic type A aortic dissection during cardiac surgery. Interact Cardiovasc Thorac Surg 2010;10:896-9.
3. De Smet JM, Stefanidis C. Acute aortic dissection after off-pump coronary artery surgery. Eur J Cardiothorac Surg 2003;24:315-7.
4. Hirose H, Svensson LG, Lytle BW, Blackstone EH, Rajeswaran J, Cosgrove DM. Aortic dissection after previous cardiovascular surgery. Ann Thorac Surg 2004;78:2099-105.
5. Reinke RT, Harris RD, Klein AJ, Daily PO. Aortoiliac dissection due to aortic cannulation. Ann Thorac Surg 1974;18:295-9.
6. Williams CD, Suwansirikul S, Engelman RM. Thoracic aortic dissection following cannulation for perfusion. Ann Thorac Surg 1974;18:300-4.
7. Polat A, Mataraci I, Polat E, Tuncer A, Erentug V, Kirali K, *et al*. A highly fatal intraoperative urgency – Aortic dissection complicating heart surgery. Kardiol Pol 2009;67:858-63.

8. Black LL, McComb RJ, Silver MD. Vascular injury following heart valve replacement. Ann Thorac Surg 1973;16:19-29.
9. Kpodonu J, Preventza O, Ramaiah VG, Shennib H, Wheatley GH 3rd, Rodriquez-Lopez J, *et al.* Retrograde type A dissection after endovascular stenting of the descending thoracic aorta. Is the risk real? Eur J Cardiothorac Surg 2008;33:1014-8.
10. Rawat RS, Mehta Y, Saxena P, Bhan A. Iatrogenic aortic dissection. J Cardiothorac Vasc Anesth 2011;25:e23.
11. Hahn RT, Abraham T, Adams MS, Bruce CJ, Glas KE, Lang RM, *et al*. Guidelines for performing a comprehensive transesophageal echocardiographic examination: Recommendations from the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr 2013;26:921-64.
12. Evangelista A, Flachskampf FA, Erbel R, Antonini-Canterin F, Vlachopoulos C, Rocchi G, *et al.* Echocardiography in aortic diseases: EAE recommendations for clinical practice. Eur J Echocardiogr 2010;11:645-58.
13. Arora D, Mehta Y. Imaging the aorta. Ann Card Anaesth 2015;18:115.
14. Lin TY, Chen YS, Chiu KM, Hsu RB, Yu HY, Wang MJ. Eight-year experience of intraoperative aortic dissection. Asian Cardiovasc Thorac Ann 2009;17:408-12.
15. Ruchat P, Hurni M, Stumpe F, Fischer AP, von Segesser LK. Acute ascending aortic dissection complicating open heart surgery: Cerebral perfusion defines the outcome. Eur J Cardiothorac Surg 1998;14:449-52.
16. Thorsgard ME, Morrissette GJ, Sun B, Eales F, Kshettry V, Flavin T, *et al.* Impact of intraoperative transesophageal echocardiography on acute type-A aortic dissection. J Cardiothorac Vasc Anesth 2014;28:1203-7.
17. Glas KE, Swaminathan M, Reeves ST, Shanewise JS, Rubenson D, Smith PK, *et al*. Guidelines for the performance of a comprehensive intraoperative epiaortic ultrasonographic examination: Recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists; endorsed by the Society of Thoracic Surgeons. Anesth Analg 2008;106:1376-84.
18. Goldstein SA, Evangelista A, Abbara S, Arai A, Asch FM, Badano LP, *et al.* Multimodality imaging of diseases of the thoracic aorta in adults: From the American Society of Echocardiography and the European Association of Cardiovascular Imaging: Endorsed by the Society of Cardiovascular Computed Tomography and Society for Cardiovascular Magnetic Resonance. J Am Soc Echocardiogr 2015;28:119-82.
19. Chavanon O, Carrier M, Cartier R, Hébert Y, Pellerin M, Pagé P, *et al.* Increased incidence of acute ascending aortic dissection with off-pump aortocoronary bypass surgery? Ann Thorac Surg 2001;71:117-21.
20. Peigh PS, DiSesa VJ, Collins JJ Jr, Cohn LH. Coronary bypass grafting with totally calcified or acutely dissected ascending aorta. Ann Thorac Surg 1991;51:102-4.
21. Okada K, Sueda T, Orihashi K, Imai K. Early type A dissection with the aortic connector device. Eur J Cardiothorac Surg 2004;25:902-4.
22. Tabry IF, Costantini EM. Acute aortic dissection early after off-pump coronary surgery: True frequency underestimated? Tex Heart Inst J 2009;36:462-7.
23. Fleck T, Ehrlich M, Czerny M, Wolner E, Grabenwoger M, Grimm M. Intraoperative iatrogenic type A aortic dissection and perioperative outcome. Interact Cardiovasc Thorac Surg 2006;5:11-4.
24. Bentall H, De Bono A. A technique for complete replacement of the ascending aorta. Thorax 1968;23:338-9.