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Rupture of Donor Ascending Aorta following Heart Transplantation

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ABSTRACT

Among 81 patients who underwent orthotopic heart transplantation between July 1986 and December 1990, we found rupture of the donor ascending aorta in three patients, all with severe ventricular dysfunction secondary to aortic valvular disease. The mechanism for this may be compliance mismatch between the recipient ascending aorta and the donor ascending aorta. This situation is a unique complication in heart transplantation for the recipients who have severe athero-sclerotic changes in the systemic aortic wall, especially for those with valvular diseases caused by calcification.

***Key words**: Heart transplantation, Aortic rupture, Compliance mismatch*

Today, heart transplantation is performed by an almost well-established technique and procedure. However, as the number of heart transplantations has increased, complications specific to this operation have come to be reported. We performed 81 cases of heart transplantation during the period from July 15 1986 through December 1990 and experienced 3 cases of rupture of the donor's aorta at the anastomotic site or sub-anastomotic region. These cases are reported below.

CASE REPORTS

Case 1: The recipient was a 51-year-old male, who had undergone, 9 years earlier, excision of left ventricular aneurysm after myocardial infarction and aortic valve replacement as treatment for aortic insufficiency. However, the left ventricular function decreased. Thus, on July 15 1986, he underwent heart transplantation employing a 22-year-old male as the heart donor. After the operation, there were no problems worth special note,and the case was followed up on an outpatient basis. However, in the 18th month after the operation, he met with a traffic accident and died after 5 days. Autopsy revealed that the death was caused by loss of blood due to the rupture of the anastomotic site of the donor ascending aorta (D-AO). Pathological study showed no rejection reaction in the anastomotic site but revealed a rupture of the sutured region on the D-AO side, 2 cm from the aortic valve. On the other hand, arterial sclerosis (atherome grade II; Yater's classification) accompanied by striking intimal hypertrophy was found in the recipient ascending aorta (R-AO). In addition, the left ventricular free wall had a thickness of 2.2 cm, while the left ventricular septum had a thickness of 2 cm, indicating concentric hypertrophy of the left ventricle (Fig. 1).

Case 2: The recipient was a 60-year-old male. He repeatedly experienced heart failure due to mitral regurgitation and aortic insufficiency, re-

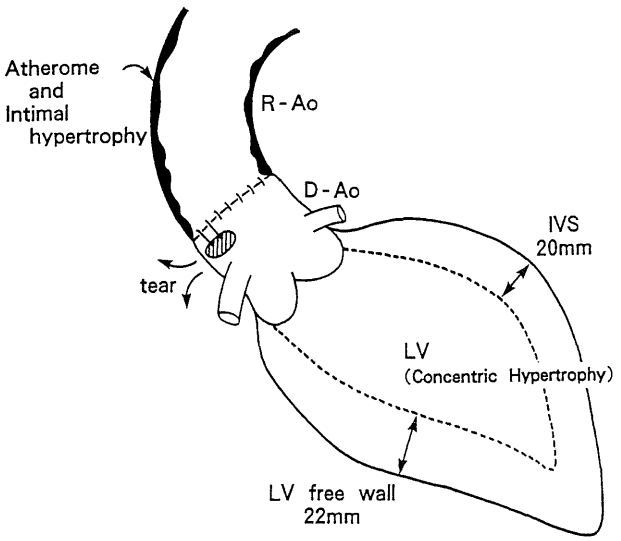

Fig. 1. Case 1 51 y.o. male (the D-AO ruptured on the 18th month after heart transplantation)

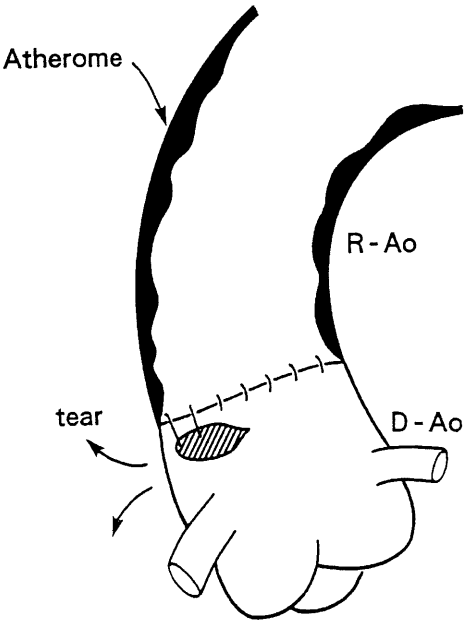

Fig. 2. Case 2 60 y.o. male (the D-AO ruptured on the 17th day after heart transplantation)

sulting in a severe decrease in the left ventricular function. Thus, employing a 19-year-old male as the donor, he underwent heart transplantation on August 8 1988. However, during follow-up in the general ward on an inpatient basis, he died on the 17th day after the operation due to sudden cardiac arrest. Autopsy revealed ruptures at 2 stitches on the anastomotic region of the donor's aortic posterior wall (Fig. 2). Pathological study of the donor's aortic wall revealed inflammatation due to the suturing thread but revealed no image of infiltration by lymphocytes indicative of rejection.

Case 3: The recipient was a 54-year-old male. In 1980, he underwent replacement of the mitral valve plus replacement of the aortic valve as treatment for mitral insufficiency and aortic insufficiency. However, there was no improvement: he repeatedly experienced left heart failure and the disease worsened to grade IV of the NYHA classification. Dysfunction of the replaced valve was found, and the left ventricular ejection fraction was 9%. Thus, on January 18 1990, heart transplantation was performed employing a 39-year-old as the heart donor. The ECGs of this case presented very interesting findings. When the ECGs of the thoracic lead taken on the first and the 17th day (the day before rupture) after transplantation are compared, it is seen that the left ventricular hypertrophy advanced strikingly within a period of only 17 days (Fig. 3). Moreover, on the 18th day after the operation, during ob-

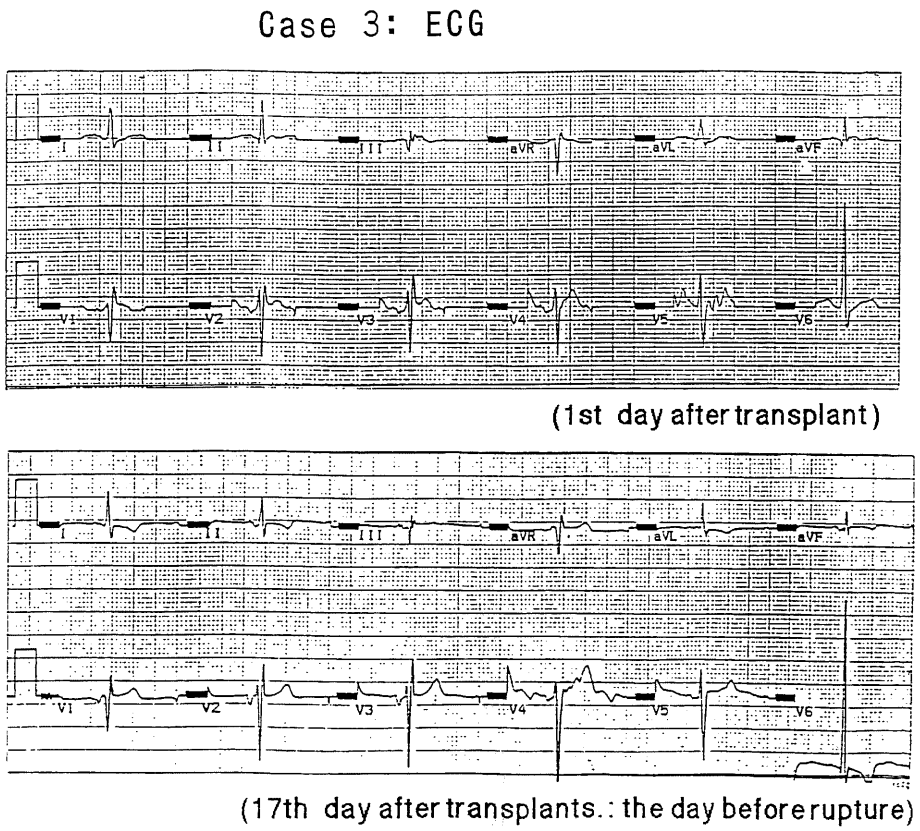

Fig. 3. The ECGs of Case 3 show that the left ventricular hypertrophy advanced strikingly within 17 days after heart transplantation.

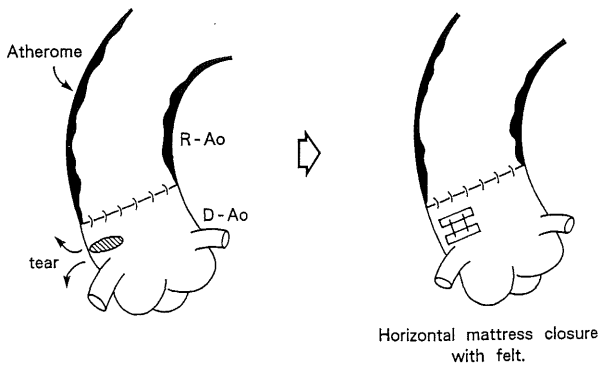

Fig. 4. Case 3 54 y.o. male (the D-AO ruptured on the 18th day after heart transplantation)

servation in the ICU, the patient's blood pressure suddenly dropped. On the basis of echographic findings, cardiac tamponade due to some cause was suspected, and the chest was immediately opened. A tear was found in the aortic posterior wall about 2 cm posterior to the anastomotic region (Fig. 4). Using polypropyrene thread with felt, horizontal mattress anastomosis was performed to achieve hemostasis. Thereafter, the clinical course has been good, and he is being followed up on an outpatient basis.

DISCUSSION

With regard to heart transplantation, there have been many reports which indicated problems requiring careful operative and postoperative management[2]. Now on the basis of our experience,we have come to conclude that postoperative rupture of ascending aorta caused by compliance mismatch – this phenomenon without infection[5] not having been reported to date – is a postoperative complication specific to heart transplantation (especially that performed for cases with an aortic valvular disease accompanied by systemic arterial sclerosis). We performed 81 cases of heart transplantation during the past 4 years and 6 months. In 3 of these cases, the operation was indicated for the treatment of cardiac valvular diseases accompanying underlying aortic valvular diseases due to calcification. Postoperative aortic rupture occurred in all 3 cases. (The other cases consisted of 33 cases of idiopathic cardiomyopathy, 38 cases of myocardial impairment secondary to ischemic heart disease, 3 cases of unrepairable congenital heart disease, one case of reoperation due to rejection, and 3 other cases.)

Generally, the age of recipients is higher by 20–40 years than that of donors, especially for patients with advanced aortic valvular disease due to calcification, who also have severe atherosclerotic changes in the systemic aortic wall. Today, the incidence of rheumatic aortic valvular disease has decreased, but it has been reported that[3,4] in patients with aortic valvular disease in whom arterial sclerotic changes are highly advanced, the aortic wall is also severely damaged, resulting in lowering of the compliance. In the present 3 cases, we observed marked calcification of the ascending aorta of the anastomotic region during the operation. Accordingly, there was a possibility of compliance mismatch between the D-AO and the R-AO. An aorta with normal compliance reduces the left ventricular afterload as the Windkessel function, and in addition, has the important function of sending the blood to the peripheral tissue. However, the aortic compliance decreases as sclerosis of the arterial wall progresses, and this increases the left ventricular afterload. Due to arterial sclerosis, the heart of hypertensive patients continuously pumps out blood against excessive afterload. On the other hand, patients who have undergone heart transplantation have a D-AO with a sufficient compliance between the left ventricle and the R-AO. After heart transplantation, the heart pumps out a sufficient amount of the blood into the D-AO, the aortic valve shows normal closure, and thus the Windkessel function is achieved. However, a R-AO which is sclerotic does not synchronize and causes excess afterload for the Windkessel function of the D-AO, which causes constant overinflation of the wall of the D-AO. Moreover, due to the difference in the compliance of the D-AO and the R-AO, the D-AO is required to assume the Windkessel function for the systemic arterial system. The increase in the volume change on the arterial wall and the increase in the tension of the arterial wall due to the above mechanism gives an excess load on the D-AO including the anastomotic region, which is the connecting point of the compliance mismatch. In addition, although sufficient trimming is performed at the time of anastomosis of the ascending aorta, some degree of unevenness is unavoidable; it being impossible to achieve perfect alignment with the intact blood vessel. This may also be related to the excess load on the D-AO (Fig. 5).

In postoperative cardiac catheter examination performed in 3 other cases (ischemic heart disease group) , moreover, the R-AO compliance was lower than the D-AO compliance, which seems to support the above hypothesis (the mean ratio of the R-AO/D-AO compliance in the 3 cases was 0.67; the aortic compliance was calculated in accordance with the method reported by Maeta et al4); the diameter of the R-AO and the D-AO were measured at two sites 2 cm superior and inferior to the anastomotic site) (Fig. 6).

The ECGs findings of Case 3 can be adequately explained if we assume that the recipient's arterial system, whose compliance had been decreased,

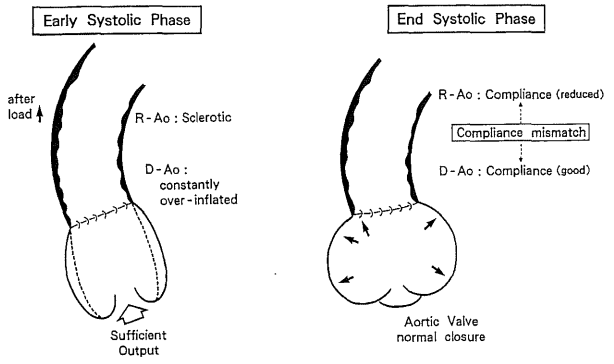

Fig. 5. Schema of compliance mismatch between the D-AO and the R-AO after heart transplantation.

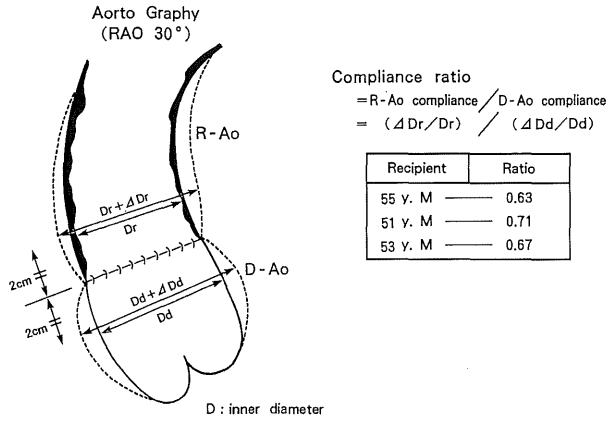

Fig. 6. Reduced compliance ratio after heart transplantation.

was burdened by excess afterload on the transplanted donor's left ventricle.

We have described our hypothesis above, but the details must be further clarified on the basis of the results of future studies. Meanwhile, we wish to emphasize that (1) as shown in the pathological findings for Cases 1 and 2, no rejection reaction was seen in the D-AO wall of the aortic anastomosis, (2) this complication (i.e. aortic rupture) did not develop in the other 79 cases in spite of the fact that the same anastomotic method (continuous anastomosis using 4–0 polypropylene suture) was employed, and (3) aortic rupture occurred in all 3 cases which had aortic valvular diseases.

Nitroglycerine, coronary-vasodilatator etc., are thought to be useful in that they not only exert direct efficacy on the coronary artery but also reduce the D-AO afterload by their action in dilating the systemic vascular system, thereby improving the coronary blood flow which has been reduced due to a decrease in the Windkessel function. It has been reported that cyclosporin itself may induce hypertension due to its action on the renin-angiotensin system[1], and thus it is thought that some anti hypertensive drug should be administered concomitantly to control the blood pressure. We think that it may be necessary to apply some means of reinforcement to the site of anastomosis in future heart transplantation to patients with aortic valvular diseases.

METHOD OF CALCULATION OF COMPLIANCE

Generally, the vascular compliance (Cv) is expressed by the following equation.

$$Cv = 2\Delta D / D \cdot \Delta P \quad mmHg{-}1 \qquad (1)$$

D is the inner diameter of the aorta. If the aortic pressure increases by ΔP then the aortic inner diameter increases by ΔD. This method was reported by Maeta et al[4]. Now, in the calculation of the ratio of the compliance of the R-AO and the D-AO (Cvr/Cvd), ΔP (arterial pressure change) can be regarded as the same value within the same individual, so the following equation can be obtained from equation (1)

$$Cvr/Cvd = (\Delta Dr / Dr) / (\Delta Dd / Dd) \qquad (2)$$

Thus, the ratio of Cvr/Cvd can be expressed as the ratio between the rates of change in the inner diameter of the R-AO and D-AO.

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