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EUROPEAN SOCIETY OF CARDIOLOGY®

Original Scientific Paper

French registry of cases of type I acute aortic dissection admitted to a cardiac rehabilitation center after surgery

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Received 2 May 2008 **Accepted** 28 October 2008

Background **After surgery for type I acute aortic dissection, the aorta remains partly dissected. This new population of patients is now referred to cardiac rehabilitation centers (CRCs). The feasibility of subsequent physical exercise is unknown.**
Methods **Thirty-three consecutive patients (aged 55.1 ± 9.3 years) were included in a prospective registry with clinical and radiological follow-up for 1 year after admission to a CRC. Twenty-six patients had undergone standard training sessions with exercise on a bicycle ergometer. Physical training programs included calisthenics, respiratory physiotherapy, walking, and cycling. Seven patients did not perform standard exercise training sessions but only walking and respiratory physiotherapy.**
Results **For trained patients, the sessions (18 ± 10) were carried out at 11.3 ± 1.5 on the Borg scale ('light'), with blood pressure monitoring on exercise (<160 mmHg in 75% of patients). Maximum workload during exercise test (bicycle ergometer, 10 watts/min) increased from 62.7 ± 11.8 to 91.6 ± 16.5 watts ($P=0.002$). We identified three complications in two patients requiring further thoracic aorta surgery during follow-up. There was also one case of aortic valve replacement after 5 months and three cases of peripheral ischemia. No deaths, cerebral vascular accidents, or myocardial infarctions were recorded. Ten of the 19 patients of working age were able to return to work.**
Conclusion **Physical training of moderate intensity seems feasible and beneficial in postsurgical type I aortic dissection patients.** ***Eur J Cardiovasc Prev Rehabil*** **00:000–000** **© 2009 The European Society of Cardiology**

European Journal of Cardiovascular Prevention and Rehabilitation 2009, **00**:000–000

Keywords: aortic dissection, cardiac rehabilitation, exercise training

Introduction

The prognosis of acute dissections of the ascending aorta has considerably improved over recent years by advances in diagnosis and emergency surgery [1–3]. The surgical period is often long and may lead to a loss of physical condition, functional capacities, and quality of life. Surgeons frequently refer their patients to cardiac rehabilitation centers (CRCs) after surgery. These centers aim at rehabilitating patients through physical exercise training [4], optimization of medical treatment, and education.

The replacement of the ascending aorta and the treatment of all intimal tears (type II aortic dissection) results in complete aortic repair and these patients can then undertake a standard physical training program. However, other patients (type I aortic dissection) have, incomplete aortic repair, with a segment of the aorta remaining dissected downstream from the repair and fed by residual tears. Therefore, there is a risk of progression of the patent false lumen: aortic expansion, aneurysm formation, and rupture or malperfusion syndrome. It is

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An oral communication relating to part of this study was presented at the 1st Forum of Prevention and Cardiac Rehabilitation, February 2007, Paris

1741-8267 © 2009 The European Society of Cardiology DOI: 10.1097/HJR.0b013e32831fd6c8

not clear whether physical exercise aggravates such persistent lesions or under which conditions physical exercise is advisable for such patients.

Despite the recent publications and recommendations concerning the treatment and management of acute aortic dissection [5,6], these questions have never been directly addressed. It is difficult to evaluate the benefit/risk ratio of exercise rehabilitation in these patients because of heterogeneity in the types of program used and opinions expressed on the patient. We set up a prospective registry with the aims of: (i) describing current practice regarding exercise rehabilitation at several French CRCs and (ii) evaluating the incidence of events over a 1-year follow-up period in patients undergoing rehabilitation.

Methods

Patients

We set up a prospective registry based on nine CRCs. All patients admitted to these centers between April 2004 and May 2005 with a patent false lumen after surgery for De Bakey type I acute aortic dissection were included. Patients with complete aortic repair (no dissection or persistent entry tear) were not included. Investigators designed the physical training program without restriction, based on their standard practice.

Evaluation criteria

Initial clinical examination included evaluations of morphometric features, arterial blood pressure (BP) at rest, and drug treatments. Details of the physical training program – content, frequency, and intensity of sessions – were noted, together with the results of exercise tests at the beginning and end of the training program.

The following events were recorded (months 6 and 12) over a 12-month follow-up period: (i) further surgical interventions relating to the aortic condition, the occurrence of malperfusion syndrome, myocardial infarction, stroke, and death (and its cause); (ii) change in the diameter of the initial segment of the descending thoracic aorta on computed tomography (CT) scan and the occurrence of abnormal images for the descending thoracic and abdominal aorta; and (iii) return to work (functional evaluation criterion).

Investigations

Radiological follow-up involved thoracic CT scans recorded on a CD-Rom and read by the same radiologist in all cases to ensure homogeneity of measurement. The diameter of the descending thoracic aorta was measured on axial sections at the level of the left branch of the pulmonary artery. If no CD-Rom recording of the scan was available, measurements were taken on photographs of the scan. Exercise tests were carried out at start and end of rehabilitation, on a bicycle ergometer using a 10 watts/minute (W/min) incremental protocol. After 6 and 12 months, information was obtained by telephoning the patients or their doctors.

Statistics

The results are expressed as means ± standard deviations. Paired nonparametric Wilcoxon's test was used to compare maximal workload before and after rehabilitation and to compare aortic diameters on admission (initial), at 6 and 12 months. Statistical analyses were performed using Statistica software 6.1 (StatSoft Inc., Maison Alfort, France). Given the small sample size and the heterogeneity of the population, other statistical analysis would be inappropriate.

Results

In total, 33 patients (25 men and eight women) were included in the registry 27 ± 21 days after surgery (days 10–110). The mean age of the patients was 55 ± 9.3 years (range: 38–78). Four patients had Marfan syndrome or a related condition. Fifteen patients had no known history of arterial hypertension (45%; Table 1).

Surgical intervention, involved the only implantation of a tube graft in 19 of the 33 patients. In the 14 others, reimplantation of the coronary arteries and surgical aortic valve treatment were also required. The tube had integrated valves (Bentall procedure) in nine and the aortic sigmoids were resuspended in five cases (Yacoub procedure). Immediate postoperative complications were surgical reintervention for bleeding ($n = 4$), neurological complications [persistent confusional state ($n = 3$), transient ischemic attack ($n = 4$), and stroke ($n = 3$)],

Table 1 Characteristics of the patients

		Total ($N=33$)	
		Patients with complications ($n=6$)	Patients with no complication ($n=27$)
Age	55.1 ± 9.3	54.6	53.8
Male (%)	25 (76)	4 (66)	21(78)
Marfan syndrome	4	0	4
Type of intervention	19SCT, 5Y, 9B	3SCT, 2Y, 1B	16SCT, 3Y, 8B
Arch surgery (%)	13 (39)	3 (50)	10 (37)
Hypertension treated before dissection (%)	15 (45)	5 (83)	10 (37)
Aortic diameter on admission (mm)	35.6 ± 8.3	39.2 ± 8.5	34.5 ± 4.6
Training sessions (n)	18 ± 10	20.5[a]	18.5[b]
Length of stay	44.8 ± 48	42 ± 15	45 ± 53
Systolic BP at rest (mmHg)	120.4 ± 12.8	123.3 ± 10.8	119.6 ± 13.1
Maximum systolic BP during training (mmHg)	150.4	157.5[a]	148.6[b]
Intensity of exercise (Borg scale)	11.3 ± 1.5	11.25[a]	11.3[b]

B, Bentall procedure; BP, blood pressure, mm, millimeters; SCT, subcoronary tube; Y, Yacoub procedure. [a]Mean calculated for four trained patients. [b]Mean calculated for 22 trained patients.

ischemia of the lower limb ($n = 9$), sepsis ($n = 7$), renal insufficiency and temporary dialysis ($n = 3$) myocardial infarction ($n = 1$), and rhabdomyolysis ($n = 1$). At initial evaluation, treatment for hypertension included 1.3 medications and hemoglobin rate was 10.1 ± 1.25 g/dl.

At discharge from the rehabilitation center, the mean rest systolic BP was at 120.4 ± 12.8 mmHg. Treatment included β-blockers for 97% of the patients and three or more antihypertensive medication for 45%. The hemoglobin rate was 10.8 ± 1.0 g/dl.

Seven patients had not taken part in standard sessions with exercise on a bicycle ergometer for the following reasons: poorly controlled BP at rest ($n = 1$), major cognitive function problems ($n = 1$), femoral lesion bothering pedaling ($n = 1$), and decision taken by the attending doctors ($n = 4$). These patients were, however, allowed to walk and participate in relaxation and respiratory physiotherapy sessions.

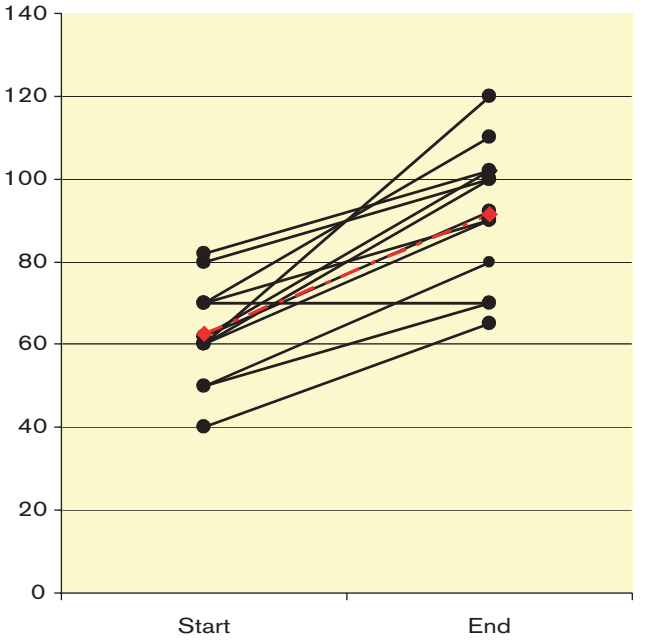
Twenty-six patients had undergone physical training programs on a bicycle ergometer. Twenty of this group underwent an initial exercise test. The other six patients did not perform exercise testing because of peripheral neurological or muscular conditions, extreme fatigue, or severe arrhythmia.

In 13 cases, the maximal workload attained was measured at both the start and end of the program. The mean value increased from 62.7 ± 11.8 to 91.6 ± 16.5 W (Fig. 1). The difference is statistically significant ($P = 0.002$). One of the two measurements was missing for the other seven patients evaluated. Patients underwent 18 ± 10 days (5–50) of physical exercise training.

Calisthenics sessions (30–45 min/session) took place five times per week in mixed groups. They involved light exercise of the upper or lower parts of the body (stretching, muscle extension, and dexterity exercises) in series of 10 movements without forced respiration. Sixteen patients also carried out isolated segmental dynamic resistance exercises.

The bicycle ergometer training session (three to five times per week) included 5 min of warm up, 30 min of aerobic activity, and 5 min of cooling down. Bicycle ergometer exercise was of moderate intensity (mean of 11.3 ± 1.5 or 'light' on the Borg scale) [7]. Maximum intensity of exercise reached 13/20 ('somewhat hard') in three cases, 12/20 in 11 cases, 10/20 in three cases, and only 8/20 ('very light') in four cases. BP was monitored during exercise on the bicycle ergometer. It remained below 150 mmHg in a quarter of the patients, reached 150–160 mmHg in half the patients and increased up to 170 mmHg in the remaining quarter.

Fig. 1



Maximum workload in watts during exercise tests at start and end of rehabilitation for 13 patients. The mean is shown as a dotted red line corresponding to an increase from 62.7 to 91.6 W ($P = 0.002$).

The program also included group respiratory physiotherapy session (one to two per week) with additional individual daily sessions if required (pleural effusion and atelectasis). All patients walked, accompanied, on the flat for 30 min between three and five times per week and attended group relaxation sessions. None of the centers offered isometric resistance exercises.

All the patients received specific information emphasizing the importance of antihypertensive medication and CT scans follow-up and the long-term benefits of regular exercise for reducing BP [8–10]. Most of them (73%) received education for weight carrying.

Follow-up over 12 months

Twelve-month follow-up results were available for 31 patients (one lost to follow-up and one suicide at 10 months).

Two types of complication were observed. The first was secondary to changes in aortic diameter (central complications) and was life-threatening in the short term. The other complications concern malperfusion because of dynamic or static obstruction of the true lumen (peripheral complications) indirectly caused by progression of the aortic dissection.

Four major central complications were observed in three patients (three of 33: 9.1%). Progression of aortic arch

dilation from 55 to 66 mm was observed after discharge from CRC (between day 29 and 150 postdischarge) and required aortic stent graft implantation. This patient did not participate in bicycle training session (habit of this center). We observed a case of false aneurysm (day 30 postdischarge) secondary to failure of the suture anastomosing the aortic tube requiring emergency surgery. This patient underwent further surgery on day 60 for periprosthetic leakage (maximum training workload 65 W and maximum BP 140/80 mmHg). In another patient, aortic valve replacement was required because of aortic regurgitation with a severity score of 3/4. This patient presented aortic insufficiency immediately after initial surgery but the decision to replace the valve was not taken until 5 months later, when the patient's symptoms worsened (maximum training workload 70 W and maximum BP 140/70 mmHg).

No stroke, death (other than the patient who committed suicide), or myocardial infarction was observed during the rehabilitation period or the 12-month follow-up period.

Three peripheral ischemia-type complications were detected, after 2, 9, and 10 months. Two cases of debilitating ischemia of the lower limbs required percutaneous fenestration of the intima. One patient was not physically trained and for the second, mean workload during training was 60 W and maximum BP 160/100 mmHg. In the third case, renal insufficiency worsened, necessitating renal artery stenting (maximum workload during training was 100 W and maximum BP 170/90 mmHg).

Radiological imaging follow-up were not available for four patients at 6 month and for six patients at 1 year. Instead, summaries were available, describing the dissected aorta and the absence of dilation or abnormality on repeated examinations, interpreted by the radiologist. The mean diameter of the thoracic descending aorta had increased from 36.1 ± 5.9 mm (initial) to 36.8 ± 7.5 mm at 6 month ($P = 0.005$) and to 37.6 ± 7.0 mm at 12 months ($P = 0.07$ vs. 6 month and $P = 0.002$ vs. initial). A residual entry tear was found in all cases for which a CD-Rom of the scan was available (66%). The mean aortic diameter of the six patients who presented central complications was 39.2 ± 9.5 mm on admission, whereas that for the other patients was 35.3 ± 4.6 mm.

Ten of the 19 patients who were working before their accident and were below the age of 59 years returned to work.

Discussion

This prospective registry study is the first attempt to evaluate the feasibility of an exercise training program after surgery for acute aortic dissection in patients with a patent false lumen. We found that moderate-intensity exercise training is currently used (79%) in patients referred to CRC in France. Our data confirm differences in practice between CRC, as expected from the absence of published data.

The principal major complications observed after surgery for aortic dissection are dissection extension, fissuring, or lethal rupture. The mechanisms accounting for this progression are imbalance between the resistance of the aortic wall and the force exerted on it. This force – wall stress – is regulated by the Laplace law: wall stress = pressure × diameter/2 × wall thickness [11].

In these patients, the dissected aorta has an enlarged diameter and a thin wall. These two elements are given at admission to CRC. BP is therefore the only variable element in Laplace's equation. The aortic wall must also bear the wall stress and is rendered fragile by atherosclerosis, inflammation, metabolic factors and, in certain cases, by genetic factors. BP must therefore be kept as low as possible to prevent an increase in wall stress. In this registry study, Marfan's syndrome and age did not seem to be predictive of an event but the power of our study to detect such factors was low.

During static exercises, BP (systolic and diastolic) increases considerably [12,13]. This type of exercise would therefore seem to be contraindicated for these patients. Conversely, during dynamic exercise only small increases in systolic BP are observed (with no increase observed in some cases of low-intensity exercise) and diastolic BP remains stable [14]. In contrast, complete bed rest and a total absence of physical exercise are deleterious, leading to muscle wasting, joint stiffness, loss of adaptation to exercise, problems with social and professional reintegration, and depressive syndrome.

It is important to minimize both sedentary behavior and the risks of aggravating the dissection. The physical training regime used here was of moderate intensity and the monitoring of systolic BP during exercise was particularly rigorous. Exercise intensity was limited by increases in systolic BP. Mean systolic BP on exercise differed little between the 22 patients with no complications and the four patients with complications.

Determination of the exact diameter of the aorta before starting a physical training program seems to be important. European and North American consensus guidelines [5,6] recommend surgical intervention if thoracic aorta diameter exceeds 55 mm and/or if this diameter increases by more than 5 mm in 6 months. Most of our patients had thoracic aorta diameter below 40 mm on admission. This diameter increased by only 1.5 mm during 12-month follow-up. One of the major complications

observed in our study concerned a nontrained patient with an aortic diameter of 55 mm on admission.

Treatment of the intimal tear (in the aortic root or arch) was reported by the surgeon in 97% of the cases described here, but other residual tears were identified on scans in most cases. None of the patients with central complications had undergone aortic arch replacement. New techniques combining surgical treatment of the ascending aorta with simultaneous aortic stent graft implantation are being developed to minimize this problem [15].

At 5 years, a frequency of 10–15% late deaths [1,3] has been reported. According to Nienaber [6], one-third of patients surviving initial surgical treatment for aortic dissection experience dissection extension or aortic rupture or undergo further surgery for aneurysm. The central major complications observed in our population during 1 year of follow-up are consistent with these findings.

Limitations of the study

This is a registry-based study with very few patients for detail statistical analysis. The results cannot be therefore considered to prove that exercise training is innocuous in these patients. The main aims of this study were therefore to describe routine practice for exercise training and to follow the incidence of adverse events over a 12-month period in the two groups. The small sample size was a direct consequence of the rarity of this disease.

We have no quantitative data from questionnaires concerning quality of life, but a clear improvement in exercise capacity was observed. The frequency of return to work (around 50%) is remarkable for patients of this type after major thoracic surgery.

Conclusion

In this prospective multicenter study, we found that a moderate-intensity physical training program was offered to most patients with a patent false lumen downstream from the repair after surgery for type I aortic dissection and admitted to CRCs in France. Moreover, BP on exercise and the diameter of the thoracic descending aorta are taken into account. Although the sample studied was very small for definitive confirmation, our results suggest that moderate physical exercise is feasible in these patients and improves functional capacity.

Acknowledgements

No financial support for this study. No conflicts of interest.

Investigators

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