Impact of surgical era on outcomes of patients undergoing elective atherosclerotic ascending aortic aneurysm operations

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Abstract

Objective: This retrospective study evaluates if recent refinements in peri-operative management, have an impact on clinical outcome of patients undergoing elective repair of their ascending thoracic aorta. Methods: One hundred sixty five (n = 165) consecutive patients were operated during a 7 year period at our department. The cohort was divided in an early group I (from Jan 1997 to Dec 1999, n = 75) and a late group II (from Jan 2000 to Jan 2003, n = 90). The mean age was 60.9 ± 13.1 years in group I versus 58.1 ± 13.6 years in group II. In group I 50 patients (66.6%) underwent replacement of the ascending thoracic aorta alone, 17 patients (22.6%) received a composite graft, 8 patients (10.6%) had an additional aortic valve replacement and 14 patients (18.6%) needed concomitant coronary artery bypass grafting. In group II the procedures were as follows: interposition graft alone in 58 patients (64.4%), composite graft in 26 patients (28.8%), aortic valve replacement in 6 (6.6%) and CABG in 11 patients (12.2%). Results: Overall hospital mortality for the entire cohort was 6.6% (11/165) with no significant differences between the early and late group with 6.6% (5/75) and 6.6% (6/90), respectively, P = 0.985. Causes were multiorgan failure in 63.3% (n = 7), stroke in 9% (n = 1), myocardial infarction in 18.1% (n = 2) and refractory bleeding in 9% (n = 1). Concomitant CABG, repair of the aortic valve and composite graft, emerged as independent risk factor for mortality in multivariate logistic regression analysis with P = 0.001. Differences, became apparent in ICU as well as hospital stay with a median ICU stay in group I of 7.1 ± 12.9 days versus 4.4 ± 6.8 days in group II, and median hospital stay of 16.7 ± 5.3 days versus 9.5 ± 8.4 days for group I and II, P < 0.05, respectively. Furthermore through the implementation of blood conservation techniques, a substantial reduction of transfusion requirements could be achieved (PRBC from 3.2 ± 4 to 1.1 ± 1.7 units, FFP 5.2 ± 3 to 2.3 ± 0.5 units, Platelets from 1.3 ± 2 to 0.3 ± 0.07 units). Conclusions: Even with the implementation of various refinements in surgical and anaesthetic techniques, the current risk of mortality for ascending aortic aneurysm repair has not changed in the last 7 years However, shortened ICU and hospital stays as well as diminished usage of blood derivates are mainly the result of a more aggressive and improved peri- and post-operative management due to economic considerations.

Keywords: Ascending thoracic aorta; Surgical repair; ICU stay; Hospital stay; Peri-operative management

1. Introduction

Since 1956, when Cooley and De Bakey reported the first successful replacement of the ascending thoracic aorta with the use of cardiopulmonary bypass, substantial advances in surgical technique as well as in peri-operative management have reduced the risk of surgery and improved long term outcome [1]. Mortality rates have been substantially reduced from 60% before 1970 to 5% presently [2–4].

However, patients eligible today for surgery of the ascending thoracic aorta are older and have frequently more than one concomitant risk factor. In this study we attempted to evaluate the possible impact of a more aggressive peri-operative management on early clinical outcome, particularly in ICU and hospital stay, after ascending aortic aneurysm repair during a 7 year period.
2. Material and methods

2.1. Patient cohort

From Jan 1997 to Jan 2003, 165 consecutive patients underwent elective replacement of the ascending thoracic aorta in our department. Indication for surgical repair was atherosclerotic aneurysm with increasing diameter approaching 6 cm in all except 1 patient, who underwent surgery due to a chronic type A dissection. In 22 (13%) patients, the aneurysm was associated with a bicuspid aortic valve.

Mean age was 59.6 years (±13.3 years, ranging from 20 to 84 years) with a female to male ratio of 62:103.

The cohort was further divided into two groups representing the early period (group I) from Jan 1997 to Dec 1999 and the late period (group II) from Jan 2000 to Jan 2003. Group I consisted of 75 patients with a median age of 60.9 ± 13.1 years (32 females, 43 males) and group II was formed by 90 patients (median age 58.1 ± 13.6 years, female to male ratio 31:59). Both groups were comparable regarding pre-operative profiles, co morbidities and risk stratification (Table 1).

A history of previous heart surgery was present in 24 patients (14.5%), with 14 patients being of group I and 10 patients of group II, respectively.

2.2. Surgical considerations

All patients were operated on via median sternotomy, using right atrial cannulation and direct cannulation of the ascending thoracic aorta in 108 patients (65.4%), whereas the femoral artery was used for arterial access in 44 patients (26.6%). In the remaining 13 patients (7.8%) the subclavian artery was used as arterial line for cardiopulmonary bypass. Systemic hypothermia to 32°C was utilized in most cases, except in cases where deep hypothermic circulatory arrest (DHCA) was necessary, the patients were cooled to 18 (femoral cannulation) or 25°C (subclavian cannulation and employment of antegrade cerebral perfusion).

Myocardial protection was achieved with multiple doses of cold cardioplegia, delivered antegrade and retrograde in 20 min intervals with additional topical cooling with ice slush.

In cases of composite graft replacement a modified technique of the Bentall and de Bono procedure with re implantation of the coronary buttons was accomplished [5,17,18].

Gelatine coated Dacron prostheses (Sulzer Vaskutek Carbomedics, Renfewshire, Scotland, or Collagen coated Dacron prostheses (Sorin Biomedica SpA, 13040 Saluggia, Italy) were used in all procedures. Teflon strips were not used routinely unless there was evidence of severe aortic fragility.

An open distal anastomosis with 4–0 prolene running suture was performed in the patients were aortic cross clamping was not feasible through the involvement of the distal ascending aorta. After completion of the anastomosis, perfusion was reinstituted in an antegrade manner via a side graft or the subclavian artery, the graft was de aired and the aortic graft was clamped. During rewarming the proximal anastomosis and concomitant aortic valve replacement was performed.

2.3. Anaesthetic and perfusion management

In group I anaesthesia was induced by IV administration of midazolam 0.1 mg/kg, etomidate 0.25 mg/kg, fentanyl 5 µg/kg, and pancuronium 0.1 mg/kg. The patients were intubated, and mechanical ventilation was adjusted to maintain PETCO2 near 35 mHg. Anaesthesia was maintained with fentanyl 0.3 mg/h and midazolam 4 mg/h and patients’ lungs were ventilated with oxygen and air. A transesophageal echo cardiology probe was placed in all patients after anaesthesia induction. Cardiopulmonary bypass (CPB) was performed using a Stoeckert Shiley heart-lung machine. A membrane oxygenator (Stoeckert Shiley, Munich, Germany) and an arterial filter (Dideco, Mirandola, Italy) were used in all procedures. Teflon strips were not used routinely unless there was evidence of severe aortic fragility.

Rewarming began upon completion of the proximal anastomosis to a nasopharyngeal temperature near 36.5°C and a bladder temperature near 36°C. Rewarming was accomplished using a heat exchanger on the CPB machine at a flow of 3.0 l/min/m²; the water bath temperature was

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Table 1
Clinical profile of AL patients

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<thead>
<tr>
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<tbody>
<tr>
<td>Number of patients</td>
<td>75</td>
<td>90</td>
<td>n.s.</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>60.9 ± 13.1</td>
<td>58.1 ± 13.6</td>
<td>n.s.</td>
</tr>
<tr>
<td>Male gender</td>
<td>43</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Female gender</td>
<td>32</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>ASA score (median)</td>
<td>3</td>
<td>3</td>
<td>n.s.</td>
</tr>
<tr>
<td>Euro score (median)</td>
<td>7</td>
<td>9</td>
<td>n.s.</td>
</tr>
<tr>
<td>Chronic type A dissection</td>
<td>0</td>
<td>1</td>
<td>n.s.</td>
</tr>
<tr>
<td>Atherosclerotic aneurysm (%)</td>
<td>75 (100)</td>
<td>89 (99)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Previous heart surgery (%)</td>
<td>14 (18.6)</td>
<td>10 (11)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Coronary artery disease (%)</td>
<td>19 (25.3)</td>
<td>17 (18.8)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Aortic insufficiency (%)</td>
<td>17 (22.6)</td>
<td>26 (28.8)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

ASA score: Ref. [20]; Euro score: Ref. [21].
maintained approximately 8 °C greater than core temperature. CPB was subsequently discontinued, and patients were transferred incubated and sedated to the intensive care unit.

Patients in group II received midazolam 0.1 mg/kg, etomidate 0.25 mg/kg, fentanyl 5 μg/kg, and cisatracurium 0.1 mg/kg. Anaesthesia was maintained with IV administration of fentanyl 0.3 μg/kg and propofol 6 mg/kg/h. Throughout normothermic periods the patients were actively warmed using a forced air warmer (Augustine Medical, Inc., Eden Prairie, MN).

2.4. Blood conservation methods

Emphasis was placed to achieve meticulous haemostasis t the time of protaminisation.

In addition we used a combination of local haemostytic agents as Fibrin glue (Tisseel VH, Baxter Healthcare Corp, Glendale, California, USA) and Surgicel (Ethicon Inc, Sommerville, NJ, USA) for suture line bleeding and re transfusion of washed salvaged red blood cells. Moreover, as recent studies have proven the feasibility and safety of blood dilution, the haematocrit was allowed to drift towards 22% in contrast to 26% in group I.

Pre-operative hemodilution with controlled exsanguina- tion of 500 ml of whole blood and infusion of crystalloid solutions towards 22% hematocrit was performed routinely. After administration of protamine fresh frozen plasma and coagulation factors were given to enhance haemostasis. Moreover, the pre-operative collected blood in conjunction with cell savior blood was administered after discontinuation of CPB. Erythrocytes in group I were transfused when the haemoglobin concentration was <10 g/dl after discontinuation of CPB and <9 g/dl during CPB with the corresponding values of <8 and <7 g/dl for group II, respectively.

2.5. Statistical analysis

Results are depicted as mean and SD. Univariate analysis, respectively Mann–Whitney–White test was performed to identify risk factors. Multivariate logistic regression analysis was subsequently performed to validate results from univariate analysis, SPSS Sigma Stat 2.0 was used for statistical analysis. A P value less than 0.05% was considered significant.

3. Results

3.1. Intra operative details

Replacement of the ascending thoracic aorta with an interposition graft alone was feasible in a total of 108 patients (65%), consisting of 50 patients from group I and 58 from group II. In 2 patients from group I and 5 patients from group II, remodelling of the aortic root, in accordance with Tirone David’s technique was performed [6]. The aortic valve was insufficient or stenotic in 57 patients (35%) which mandated replacement of the valve. This was accomplished with a composite graft in 43 patients (26.1%, 17 patients in group I and 26 patients in group II) and additional aortic valve replacement in 14 patients (8.5%, 8 patients from group I versus 6 patients from group II). In the patients who received a composite graft, we used a modification of the technique originally described by Bentall and de Bono in 42 patients. The modification of this technique by Cabrol was accomplished in the remaining patients [5,7–9].

Additional CABG had to be performed in 26 patients (16%, 14 versus 11 patients from group I and II, respectively). There were no significant differences in operating times as well as cardiopulmonary bypass and aortic cross clamp times in the two groups which were further supported by univariate analysis which detected no statistically significant differences. In group I the median operating time was 309.1 ± 116.9 min, CPB time 161.9 ± 69.2 min, and ACC time 99.2 ± 38.9 min, respectively. The corresponding values for group II were the following: 316.2 ± 101.6 min, 142.9 ± 62.4 min and 104.4 ± 36.5 min. However, operating times greater than 300 min were associated with longer ICU and hospital stays in both groups (P < 0.05), (Table 2).

Deep hypothermic circulatory arrest was employed in 39 patients (23.6%) with a median CA time of 32 min (∆± 50 min). 18 patients were operated with DHCA in group I with a median arrest time of 33.3 min (∆± 19.3 min). In contrast in 21 patients from group II who underwent DHCA, CA times were shorter with median times of 17.4 min (∆± 18.9 min) but this did not reach statistically significance in univariate analysis (P = 0.822).

On the other hand, an influence of CA on operating time, ICU and hospital stay was noted with longer operating times as well as cardiopulmonary bypass and aortic cross clamp times in the two groups which were further supported by univariate analysis which detected no statistically significant differences. In group I the median operating time was 309.1 ± 116.9 min, CPB time 161.9 ± 69.2 min, and ACC time 99.2 ± 38.9 min, respectively. The corresponding values for group II were the following: 316.2 ± 101.6 min, 142.9 ± 62.4 min and 104.4 ± 36.5 min. However, operating times greater than 300 min were associated with longer ICU and hospital stays in both groups (P < 0.05), (Table 2).

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<table>
<thead>
<tr>
<th>(a)</th>
<th>Operating time</th>
<th>n = 86</th>
<th>Mean 169.1 ± 111.8 min</th>
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<tbody>
<tr>
<td></td>
<td>&lt; 300 min</td>
<td>ICU stay</td>
<td>4.4 ± 7.6 days</td>
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<td></td>
<td>Hospital stay</td>
<td>9.0 ± 8.1 days</td>
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<tr>
<td></td>
<td>&gt; 300 min</td>
<td>ICU stay</td>
<td>6.5 ± 11.7 days</td>
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<td></td>
<td></td>
<td>Hospital stay</td>
<td>9.3 ± 6.4 days</td>
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(b) | Operated without CA | n = 126 |
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<tbody>
<tr>
<td></td>
<td>ICU stay</td>
<td>Mean 5.1 ± 10.2 days</td>
</tr>
<tr>
<td></td>
<td>Hospital stay</td>
<td>9.2 ± 7.4 days</td>
</tr>
<tr>
<td>Operated with CA</td>
<td>n = 59</td>
<td></td>
</tr>
<tr>
<td>MICU stay</td>
<td>Mean 7.0 ± 9.1 days</td>
<td></td>
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<tr>
<td>Hospital stay</td>
<td>9.2 ± 7.4 days</td>
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times, as well as longer ICU and hospital stays ($P < 0.05$). (Table 2).

When we compared operating times of 300 min or less with more than 300 min and its impact on ICU and hospital stay, significant differences were found in both variables with a $P$ value less than 0.05 in univariate analysis. (Table 2).

3.2. Blood product usage

Previously, the average number of intra operative requirements for blood and blood derivatives were $3.2 \pm 3.2$. Blood product usage stay, significant differences were found in both variables with more than 300 min and its impact on ICU and hospital stay, (Table 2).

3.3. ICU and hospital stay

Through the above mentioned refinements, early extubation was feasible in the majority of patients. In group I the patients were extubated after median 10 ± 4 h, whereas these values shortened to 4 ± 4 h in group II.

Patients of group I spent an average of 7.1 ± 12.9 days in the ICU versus patients of the latter group who stayed a median of 4.4 ± 6.8 days, $P = 0.157$ [Fig. 1]. Moreover, patients from the early group were on average 16.7 ± 5.3 days in the hospital in contrast patients from the late group could be discharged after 9.5 ± 8.4 days, which resulted in a statistical significant difference with a $P < 0.002$ [Fig. 1]. There was a steady decline in ICU stay from an average of 8.2 ± 17.2 days in 1998 to 1.0 ± 0 day in 2003. The same was observed with hospital stay which decreased from 11.9 ± 11.4 days in 1998 to 6.8 ± 3.1 days in 2003.

Based on our median age of 62 years, we compared patients less than 65 years of age with those over 65 years. Statistically significant differences in ICU as well as hospital stay became apparent in both groups. In multivariate logistic regression analysis age over 65 emerged as an independent predictor for prolonged ICU and hospital stay with a $P < 0.001$ in both groups. (Table 3).

![Differences in median ICU and hospital stay between group I and group II.](image-url)

We detected no differences in ICU and HOS stay when comparing female versus male patients.

3.4. Complications and early mortality

Overall hospital mortality was 6.6% (11/165) for the entire cohort. After division into the early and late period mortality rates were 6.6% (5/75) and 6.6% (6/90), respectively. Causes for death were as follows: multi organ failure in 63.3% ($n = 7$), stroke and refractory bleeding in 9% ($n = 1$) each and myocardial infarction in 18.1% ($n = 2$). Concomitant CABG, aortic valve repair and use of a composite graft emerged as independent risk factors for mortality in multivariate logistic regression with a $P = 0.001$ (Table 4).

Adverse outcome was present in 16 patients (21.3%) of group I and 12 patients (13.3%) of group II which had no statistical significance in univariate analysis with a $P = 0.35$.

When we analysed our mortality data we found that all the risk factors for mortality namely age over 65 years, op time over 300 min and concomitant CABG were apparent in those patients. For example in the 5 patients (1 male and 4 females) from group I who died, the median age was 68.6, median op time was 312.5 min. The corresponding values for the 6 patients (5 males and 1 female) from group II who died were age 67.6 years, op time 312.2 min (Table 3). Two patients from each group were operated with DHCA and received additional CABG. Gender and the use of DHCA emerged not as a predictor for mortality with a $P$ value of 0.985 each.

![Predictors of mortality in multivariate logistic regression analysis](image-url)
4. Discussion

Recent advantages in the management of ascending thoracic aneurysms have led to a substantial improvement in the clinical outcome of these patients as illustrated in a 10 year experience from 1987 to 1997 from Shapira and colleagues, who reported a reduction in operative mortality rate of 26% in 1987 to 3% in 1997 [4]. During 1987 until 1997 several new technologies were introduced, namely gelatine, albumine and collagen impregnated grafts, heparin bonded circuits, antifibrinolytic agents, antegrade and retrograde cerebral perfusion, which were all associated with a substantial decrease in operative mortality [10–13].

The intention of our study was to review a single centre experience, in respect to reductions in ICU and hospital stay over a 7 year period where no significant modifications in surgical techniques were performed. It reflects the fact that the main modifications in operative management were implemented before 1997 as outlined in the reports by Shapira and Cohn [4,14].

Regarding our patient population, the clinical profile did not differ between the two groups. As a result of decreased mortality and morbidity rates, indications for elective repair expanded to a broader patient population, which can be assumed as one cause for maintaining our mortality rate at 6%. An increase in ASA as well as Euro score further supports this hypothesis.

Surprisingly, the median age (62 years for the whole cohort) of our patient population did not increase. Furthermore, patients less than 65 years of age increased from 59 to 64%. This may be due to the fact that CT scans are performed for a variety of reasons these days and therefore more patients with unknown aneurismal disease are detected.

Our mortality rate for the entire cohort maintained at 6.6% during the early period from 1997 to 1999 and late period from 2000 to 2003.

We observed, that patients who died were median 10 years older than the average patient population. Age older than 65 years emerged as independent predictor for increased ICU and hospital stay ($P = 0.001$). Moreover age $>65$ years was a predictor for mortality in multivariate logistic regression analysis with a $P < 0.001$. In contrast the risk for mortality in patients over 65 years did not increase further when additional CABG or a composite graft was performed ($P = 0.732$ and $P = 0.958$, respectively). These interesting results are in accordance with a recently published report by the Mount Sinai Group of New York where concomitant procedures did not increase the risk of death in patients older than 65 years [15].

Notably, when calculated for the entire patient population with a median age of 59 years concomitant CABG, aortic valve repair and use of composite graft emerged as risk factors for mortality in multivariate logistic regression analysis with a $P$ value less than 0.001.

Although modifications in surgical technique did not impact the overall mortality rate, refinements in peri-operative care and blood conservation techniques led to reduced ICU and hospital stay in group II (2000–2003) compared to group I (1997–1999).

Time to extubation could be significantly shortened in group II, which could be predominantly accomplished through the introduction of propofol and short acting neuromuscular blocking agents as outlined by Myles and Murphy [16,17]. Shortening the duration of respiratory support time proved to be beneficial to the patient in many ways, such as reduced patient discomfort during controlled ventilation and therefore, diminished requirements of sedatives and analgesics. As a consequence this permits earlier patient mobilisation with improved pulmonary function due to less atelectasis formation.

Pre-operative hem dilution, with subsequent re transfusion immediately after protamine administration, was routinely performed in all our patients of group II. Recent studies, have proven the safety and superior hemodynamics of lower hematocrit values during CPB, which improves perfusion through lower blood viscosity [18].

With the implementation of blood conservation methods and hem dilution we were able to substantially reduce the need for peri-operative blood product usage [11,19]. This could be mainly accomplished through allowing haematocrit values to drift towards 22% before considering blood transfusions, pre-operative hem dilution, as well as transfusing cell saver collected blood.

The major limitation of this study lies in its retrospective design. We are aware that potential selection bias might influence our results. Furthermore as the patients were operated in sequence, a gain in experience in surgical technique as well as in peri-operative management after operation can not be excluded.

The current risk for ascending aortic aneurysm repair has not changed during the last 7 years even though implementation of various refinements in surgical and anaesthetic techniques. Shortened ICU and hospital stay as well as reduced transfusion requirements are pre-dominantly the result of a more aggressive and improved peri- and post-operative management due to economic considerations.

References


