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Outcomes of acute type A aortic dissection repairs in Iceland

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ABSTRACT

Objectives: Acute type A aortic dissection is a life-threatening disease associated with significant morbidity and mortality. Treatment is challenging and usually requires emergency surgery. This study presents for the first time the short- and long-term outcome of acute type A aortic dissection repairs in Iceland.

Materials and methods: A retrospective review of 45 patients (mean age 60.7 ±13.9 years, 68.9% male) treated for type A aortic dissection at Landspitali University Hospital between 1992 and 2014. Data was gathered from medical records about known risk factors, presenting symptoms, type of surgical procedure, complications and operative mortality.

Results: Out of 45 operations, the majority (73.3%) was performed in the second half of the study period. Nearly all patients presented with chest pain and 46.7% were in shock on arrival. Malperfusion syndrome was apparent in 26.7% of cases. A variety of operative methods were used, including hypothermic circulatory arrest in 31.1% of the cases and one third of patients needed aortic root replacement. Reoperation rate for postoperative bleeding was 29.3% and perioperative stroke occurred in 14.6% of patients. The 30-day mortality rate was 22.2% (10 patients) and 5- and 10-year survival was 71.4% ± 8.2% and 65.4% ± 9.4%, respectively.

Conclusions: The outcomes of surgical of surgical repair for acute type A aortic dissection in Iceland is comparable to other countries, including 30-day mortality and long-term survival. Complications, however, are common, especially reoperations for bleeding.

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Introduction

Aortic dissection is a life-threating disease associated with high rates of morbidity and mortality.[1]

The pathogenesis of aortic dissection involves initial intimal tear and the ensuing separation of the aortic layers into true and false lumen. Different classification systems have been used for aortic dissection, but the one used most commonly in clinical practice is the Stanford classification system. Stanford classification divides aortic dissection in type A and B, where type A always involves the ascending aorta and type B only involves the descending aorta distal to the left subclavian artery.[2]

The main risk factors for aortic dissection includes hypertension, thoracic aortic aneurysm, connective tissue diseases such as Marfan syndrome, atherosclerosis and bicuspid aortic valve.[1] Inherent weakness of any kind involving the aortic wall increases the risk of the individual developing aortic dissection. Sudden increase in blood pressure can induce a primary tear and subsequent dissection.[3] The most common signs and symptoms for thoracic aortic dissection are sudden chest pain with radiation to the back, syncope and hypotension. Other common symptoms portending malperfusion syndrome appear when the aortic dissection interrupts the blood flow to main arterial branches causing ischemia to major organs causing stroke, cardiac failure and pain from the abdomen and extremities.[4]

The treatment depends on the type of dissection. Patients with type A are, with few exceptions, taken for emergency surgery. Otherwise there is considerable risk of sudden death due to rupture of the aortic wall or pericardial tamponade.[5] There is also significant risk of a myocardial infarction if the coronary ostia are compromised or of acute aortic valve insufficiency if the dissection involves the aortic root. Aortic dissection repair are often very complicated and extensive. Therefore, morbidities are common such as post-operative bleedings, kidney damage, respiratory and multi-organ failure which increase the length of stay for these patients. [6-8]

In Iceland there are no prior reports published about the outcome of these complex operations. The aim of this research was to investigate and report the short-term outcome and long-term survival of operations for acute type A aortic dissection in Iceland.

Materials and Methods

Data was retrospectively collected utilizing databases from the Landspitali University Hospital. All patients that underwent an operation for acute type A aortic dissection from 1 January 1992 to 31 December 2014 were included in the study. In order to capture all cases, extended search criteria were used including both ICD-9 and ICD-10 diagnostic codes for aortic dissec-

tion, aortic dilation and arterial dissection. Operative databases were searched using codes for surgeries involving the thoracic aorta. In total, 45 individuals underwent an operation in the 23-year study period and of them all were included. Four senior cardiothoracic surgeons performed the operations.

Demographics, medical history, risk factors and clinical symptoms, totaling 146 variables, of them were collected for all patients. This included age, sex, risk factors for cardiovascular disease, history of coronary artery disease, chronic obstructive pulmonary disease, chronic renal insufficiency, connective tissue disease, presence of bicuspid valve, known thoracic aneurysm, family history of dissection (as recorded from hospital chart) and former thoracic surgeries. Symptoms on arrival to hospital were also noted as well as the time from diagnosis to operation.

Malperfusion syndrome was defined from clinical signs and symptoms indicating diminished blood flow to the organ systems in question: *Heart*: ST-changes on ECG, elevated CK or TnT; *Brain:* Stroke; *Extremities:* weak pulses and diminished sensation or weakness; *Kidneys:* Elevation of creatinine or anuria on arrival to hospital; *Spine:* paraplegia; *Abdomen:* Abdominal pain and elevation of serum lactate. In order to confirm the diagnosis of malperfusion syndrome signs of compromised blood flow also had to be demonstrated by radiologic imaging or direct observation intraoperatively. Height and weight was recorded from the anesthesia medical records and the body mass index (BMI) calculated. Euro-SCORE II, which is a risk factor model used for prediction on 30-day mortality for cardiac surgery, was calculated for every patient.[9]

Variables related to the surgical procedures included how the cannulation for the heart and lung machine was performed, the level of aortic replacement and whether the aortic valve was repaired or replaced. Data was also gathered about the use of hypothermic circulatory arrest and for how long, time on heart-lung machine, aortic cross clamp time and operative time (skin-to-skin).

The post-op variables included the amount of bleeding in the first 24 hours, time on the respirator in hours and the amount of blood products used.

Post-op complications were recorded until discharge from hospital or the patient's death. Complications were categorized into major or minor. Major complications included reoperation for post-op bleeding, other cardiac reoperations, mediastinitis, acute kidney failure requiring hemodialysis, respiratory failure requiring tracheostomy, perioperative stroke and myocardial infarction. The myocardial infarction had to been related to the operation and was defined as elevation of the cardiac enzyme CK-MB over 70μg/L postoperatively. Post-op kidney failure was categorized according to the rifle criteria to RISK, INJURY, FAILURE or LOSS.[10] Minor complications included cardiac arrhythmias, superficial surgical wound infection, urinary tract infection, pneumonia, pleurocentesis and transient ischemic attack (TIA). The length of the hospital stay was recorded in days, both in the intensive care unit (ICU) and on a cardiothoracic surgical ward. The 30-day mortality was collected and defined as operative mortality.

Table I. *Demographics on 45 patients that underwent operations for acute type A aortic dissection in Iceland 1992-2014. Number and % or mean with SD.*

	Number	%
Male	31	68.9
Age	60.7 ± 13.9	
Hypertension (n=42)	23	54.8
Diabetes (n=43)	1	2.2
History of smoking (n=39)	22	56.4
Active smoking	11	28.2
Body mass index	26.8 ± 5.1	
Chronic obstructive pulmonary disease	2	4.4
Peripheral vascular disease	2	4.4
Stroke	3	6.7
Coronary artery disease (n=44)	9	20.4
Family history of dissection	7	15.6
Bicuspid aortic valve	3	6.7
Marfan syndrome	2	4.4
History of ascending aortic aneurysm	7	15.5
Diameter of aorta (mm)	53.4 ± 10.8	
EuroSCORE II	8.7 ± 10.3	

SD: standard deviation.

Statistical analysis

Data was collected using Microsoft Excel® (Microsoft, Redmond WA) and SPSS® (IBM, Armonk, NY) was used for general statistical calculations. Kaplan-Meier curves were drawn to estimate overall survival and the end of the follow-up used for the calculation was the 31st of December 2014. The day of demise was noted from the Cause of Death Registry of Iceland (Statistics Iceland). The average follow-up time for each patient was 4.6 years (range: 0-22.7) or in total 208 patient years. The study was approved by the Icelandic National Bioethics Committee and the Icelandic Data Protection Commission. As individual patients were not identified, obtaining individual consent for the study was waived.

Results

During the course of the study on average 2 operations were performed per year. The number of the operations increased significantly from 12 operations (26.7%) in the first half of the study period (1992-2002) to 33 (73.3%) in the second half (2003 – 2014) (p=0.02). In the second part of the study 2.8 operations were performed on average per year (fig. 1).

Demographics of the patients are shown in table I. Males were 31 (68.9%) and the average age of all patients was 60.8 ± 13.9 years

Table II. *Symptoms and workup of 45 patients undergoing operations for acute type A aortic dissection in Iceland 1992-2014. Patients can have more than one symptom or imaging work-up. Number and %.*

	Number	%
Chest pain	43	95.6
Heart failure	4	8.9
Syncope	13	28.9
Hypotension (SBP <90 mmHg)	21	46.7
Cardiac tamponade	14	31.1
Malperfusion syndrome	12	26.7
Cardiac	5	11.1
Cerebral	1	2.2
Extremities	5	11.1
Renal	1	2.2
Spinal	3	6.7
Mesenteric	2	4.4
Computerized Tomography	42	93.3
Magnetic Resonance Imaging	0	0
Transthoracal echocardiogram	28	62.2
Transesophageal echocardiogram	5	11.1
Aortogram	5	11.1
Coronary angiography	13	28.8

SBP: systolic blood pressure.

Table III. *Operative variables of 45 patients that underwent operations for acute type A aortic dissection in Iceland 1992-2014. Number and % or mean with SD.*

	Number	%
Arterial Cannulation (initial)		
Femoral	30	66.7
Axillary	9	20.0
Ascending aorta	2	4.4
Arcus aorta	4	8.9
Distal operation (anastomosis)		
Ascending aorta	30	66.7
Hemiarch	9	20.0
Total arch	5	11.1
Other	1	2.2
Circulatory arrest	14	31.1
Length (min)	30 ± 18	
Proximal operation		
Aortic valve resuspension	10	22.2
Aortic root replacement	10	22.2
Valve sparing root replacement	4	8.9
Length of operation (min)	394 ± 162	
Cardiopulmonary bypass (min)	214 ± 87	
Cross-clamp time (min)	115 ± 58	

SD: standard deviation

where the youngest patient was 21 and the oldest 80 years of age. Majority of the patients 23/45 (56.4%) had a history of hypertension of which 9/23 (39.1%) did not take any anti-hypertensive medication. History of smoking was present in 56.4% of the patients. Family history of aortic dissection was present in 7 individuals (15.6%) and the same number of patients had a known of aneurysm involving the ascending aorta or aortic root. Only 2 patients had both confirmed history of aortic aneurysm and a family history of dissection. The same number of patients had a known of aneurysm involving the ascending aorta or aortic root?"

Symptoms and diagnostic imaging are shown in table II. Nearly all of the patients (95.6%) had chest pain on arrival, almost third (28.9%) a history of syncope, almost half of the patients (46.7%) were hypotensive (<90 mmHg in systolic blood pressure) on arrival at hospital and a third (31.1%) had pericardial tamponade. Malperfusion syndrome was present in 26.7% of the patients and was most common in the extremities (11.1%) and the heart (11.1%).

Generally more than one diagnostic imaging modality was used for diagnosing aortic dissection. Computed tomography (CT) scanning was used in 93.3% of the patients and cardiac echocardiogram in 66.7%. The mean largest diameter of the ascending

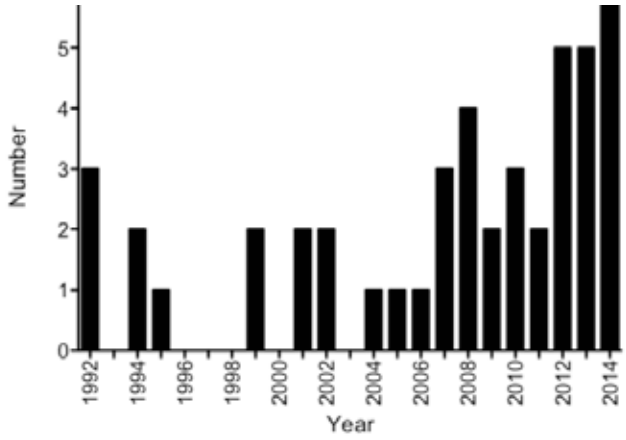

Figure 1. *Yearly rates of operations for acute type A aortic dissection in Iceland 1992-2014.*

Table IV. *Use of blood components in 41 patients that underwent operations for acute type A aortic dissection in Iceland 1992-2014. Four patients that died intraoperatively are excluded. Mean with SD (range).*

	Mean	Range
Bleeding first 24 hours (mL)	1505 ± 1649	(125-9715)
Packed red blood cells (Units)	16.4 ± 15.0	(2-68)
Fresh frozen plasma (Units)	18.1 ± 17.0	(2-74)
Pooled platelets (Units) (n=38)	5.2 ± 3.4	(2-14)
Fibrinogen (g) (n=27)	4.8 ± 3.1	(2-12)
Tranexamic acid (g) (n=29)	5.0 ± 4.7	(1-17.3)
Recombinant factor VIIa (mg) (n=11)	8.9 ± 7.2	(2.4-28.8)

SD: standard deviation

Table V. *Postoperative complications of 41 patients that underwent operations for acute type A aortic dissection in Iceland 1992-2014. Each patient can have more than one complication. Four patients that died intraoperatively were excluded. Number of patient and %.*

	Number	%
Major complication	25	60.1
Reoperation for bleeding	12	29.3
Postoperative myocardial infarction* (n=35)	7	20.0
Tracheostomy	4	9.8
Renal replacement therapy	4	9.8
Stroke	6	14.6
Mediastinitis	1	2.4
Minor complications	36	87.8
Atrial fibrillation/flutter	26	63.4
Ventilator >48 hours	26	63.4
Transient ischemic attack	2	4.9
Pneumonia	13	31.7
Pleurocentesis	15	36.6
Urinary tract infection	3	7.3
Superficial wound infection	0	0.0
Intraoperative death (n=45)	4	8.9
Operative mortality (< 30 days) (n=45)	10	22.2

*CK-MB > 70 µg/L

aorta on diagnostic imaging (CT scanning and echocardiogram) was 53.3 ± 10.8 mm (range: 39-87). Coronary catheterization was performed on 13 patients (28.9%), the indication being suspected myocardial infarction in 6 individuals and in 5 individuals the procedure was done to evaluate the coronary arteries for potential occlusive disease. In two individuals an aortic dissection was induced during cardiac catheterization (iatrogenic).

The median time from arrival at hospital until an operation was performed was 7.3 hours while the mean was 147 hours. The reason behind the disparity of the mean and the median time is mainly explained by two patients that were initially thought to be too high-risk for the operation but then underwent an operation 14 and 37 days after arrival to the hospital.

Operative variables are shown in table III. The primary tear was present in the ascending part of the aorta in 18 (40.0%) patients, in the aortic root in 10 (22.2%) and in the aortic arch in 7 patients (15.6%). The site of primary tear was unknown in 10 patients (22.2%). An aortic root replacement was performed in 14 patients (31.1%) where composite valve and root replacement was performed in 10 of these patients but the other four patients underwent a valve sparing root replacement. The aorta was replaced with a Dacron® graft in 86.7% of the patients but in four individuals an intraluminal ring graft was placed in the diseased part of the aorta. The intraluminal ring graft technique was only used in the first four years of the study period and since 1995 this technique has not been used in Iceland. In one patient no graft was used and the layers of the aorta sutured together. Five patients (11.1%) also underwent coronary artery bypass grafting during the procedure. The hypothermic circulatory arrest technique was used in 14 patients (31.1%) and the average time of the arrest was 30 ± 18 minutes. The technique became more popular during the study period and for the last 6 years of the study period (2009-2014) 47.8% of the procedures were performed using hypothermic circulatory arrest compared to 13.6% before 2008 (p=0.04). The mean operative time was 394 ± 162 minutes (range: 207-944), time on heart-lung machine was 213 ± 87 minutes (range: 75-477) and aortic cross clamp time was 114 ± 58 (range: 18-327).

Post-operative bleeding and the usage of blood products in patients that survived the operation and were admitted to the ICU are shown in table IV. All of the patients received packed red blood cells and fresh frozen plasma following the operation and all but four patients received platelet transfusion (91.1%). Fibrinogen was administered to 27 patients (60.0%), transexamic acid was given to 29 (64.4%) and recombinant factor VII (Novoseven®) to 11 patients (24.4%).

Post-operative complications are shown in table V. Major complications occurred in 60.1% of the patients the most common being re-operation for bleeding (29.3%). Two patients underwent more than one re-operation for bleeding and in 7 patients the chest cavity was left temporarily open due to excessive bleeding. Other major complication included myocardial infarction (20.0%) and stroke (14.6%). Minor complications occurred in 87.7% of the patients where respiratory failure with ventilator requirement for more than 48 hours and atrial fibrillation/flutter was the most common (63.4% for each). The mean time on ventilator was 68 hours (range: 13-2477). Serum creatinine values were available for 40 patients. Kidney failure according to the RIFLE criteria occurred in 19 individuals (47.5%); 9 were categorized in the RISK group (22.5%), 3 in the INJURY group (7,5%) and 7 in the FAILURE group (17.5%). [10]

Hemodialysis was needed in four patients but none of them required permanent dialysis. Two patients underwent several lower extremity operations because of malperfusion syndrome but in neither case an amputation was required. Median stay in the ICU was 5 days (range: 1-61) and the median total hospital stay was 17 days (range: 1-125). Ten patients (22.2%) died within 30 days of the operation, including four that died during the initial operation. There was no significant change in the 30-day mortality when comparing the first to the second study period (25.0% vs. 21.2% p=0.79). The overall survival (Kaplan-Meier) was 71.4% ± 8.2% at five years and 65.4% ± 9.4% at 10 years.

Discussion

Aortic dissection is a relatively uncommon disease with high mortality.[1] The diagnosis can be challenging but expeditious treatment is important as the mortality increases with every hour that passes from the index event.[2] This is the first study on the outcome of operations for acute type A dissections in Iceland, but all the operations were performed in the same hospital and by only four senior surgeons.

In the first half of the study period about one operation was performed per year but the number of procedures increased markedly in the second half of the study. This increase was even more marked in the last three years of the study period (2012 – 2014)

when more than 5 operations were performed each year. The reasons behind this increase in the number of operations are not clear, however, recent publication from Sweden indicates that the incidence of thoracic aortic aneurysms and dissections is rising.[11] Increased and better access to diagnostic imaging, such as CT scanning and echocardiography, together with more awareness of the disease, can lead to more expeditious diagnosis of the disease. It is also plausible that in the beginning of the study the patients were not offered the possibility of an operation since the experience in performing these complex operations in Iceland was limited. In the coming years we hope these questions can be answered upon a completion of a current research project where the incidence and mortality of aortic dissections in Iceland is studied in more detail.

Quite frequently patients arrived at the hospital in a very critical condition. This is reflected in almost half of the patients being in shock and almost third having a pericardial tamponade. About a quarter of patients had malperfusion syndrome, which is similar to publications from various centers where it ranges from 25 to 31%.[4, 12, 13] Clinical condition of the patients on arrival at hospital has repeatedly been shown to be an accurate predictor for short-term mortality, but patients with both systemic hypoperfusion (shock) and localized malperfusion on arrival have eight times higher mortality than patients without these symptoms.[14]

CT scanning was the most common diagnostic method used to diagnose aortic dissection. It is a widely available diagnostic tool in Iceland but requires intravenous contrast that can cause kidney damage.[15] Around one-fourth of the patients underwent cardiac catheterization pre-operatively, either to evaluate the coronary arteries for occlusive disease or because the primary differential diagnosis at the time was myocardial infarction. Current guidelines do not recommend routine catheterization because the incidence of severe coronary disease is low and if present seems not to directly affect post-operative recovery. Additionally, catheterization of a dissected vessel can result in further damage of the aortic wall and cause fatal complications.[4, 16]

The operating technique changed and evolved during the study period, both between different surgeons and for each individual surgeon. The evolution of the surgical techniques here in Iceland are comparable to the progression of techniques in both the United States and Europe.[7, 17-23] This is especially true for hypothermic circulatory arrest technique, a method that saw a dramatically increased use in the second part of the study period.[18]

The morbidity rate was high, especially the rate of re-exploration for post-operative bleeding. Almost one third of the patients needed a re-operation for excessive bleeding and within this group there were two patients that needed more than one reoperation. In 7 out of 12 patients the chest was temporarily left open to prevent the development of tamponade, or until the bleeding stopped. Our re-exploration rate is considerably higher than other studies have reported, which usually are in the 6 - 19% range.[4, 24] The reason for this is not clear, however, previous studies have shown that re-operations after cardiac surgeries in Iceland is high.[25] One possible reason is that the threshold, or the amount of bleeding that triggers re-exploration, is lower in Iceland than elsewhere. However, these findings provide an opportunity to address this issue and hopefully decrease the rate of re-exploration after complex heart surgery in Iceland. Importantly the rate of other co-morbidities such as perioperative stroke, acute kidney failure that required hemodialysis and severe respiratory failure was comparable to other studies.[4]

The 30-day mortality was 22.2%, which is similar to the IRAD (International Registry of Aortic Dissection) database where it was 26%.[1, 8] In larger referral hospitals with specialized aortic surgical teams the 30-day mortality rate is usually lower, or often in the 10 – 13% range, but can be as low as 3%.[7, 26] It has to be taken to account that the patient populations differ between studies. For instance it is possible that in larger referral hospital the sickest patients do not survive the transportation from a smaller hospitals, and patients in these larger institutions have higher ratio of patients in better condition on arrival. Studies have also demonstrated that the experience of the surgical team and the surgeon is of significant importance. This is reflected in a large study where the 30-day mortality rate was considerably lower for surgeons that performed more than 5 operations per year and in hospitals that performed more that 13 operations per year.[27] For obvious reasons this is not applicable in Iceland since the yearly number of operations for type A aortic dissection is much lower than that.

In this study the 5-year survival was 71.4% and survival at 10-years 65.4%. Other studies have reported 5-year survival of 72 - 77% and 10-year survival of 53 - 56%, which is similar to what we report. [7, 21, 28]

The main strength of this study is that it is population based, covering a well-defined cohort of patients that represent a whole nation over 23 years. The patients were all treated at a single institution with only four senior surgeons performing all the operations. Furthermore, the follow-up for survival was 100%. The main limitation is the relatively small number of patients, but also the changing operative techniques during the study that make comparison of one technique to another and to other studies difficult.

This is the first report about operation for type A aortic dissections in Iceland. The number of operations has increased for the past decade without obvious reasons. There was no significant change in the operative mortality during the study period but the number of patients included is low affecting the statistical strength of the study. The morbidity rate following these operations is high but in general the outcome in the present study is comparable to other studies, which is encouraging in light of the small population here in Iceland.

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