Incidence and Outcome of Acute Myocardial Infarction in Patients with Aortic Dissection and Risk Factor Control

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Abstract

Background

The contradiction of management modality between acute myocardial infarction (AMI) and aortic dissection (AD) may result in clinical catastrophe. Data on risk factors, incidence and outcome of AD and AMI are limited, and there have been no studies on the long-term outcomes of AMI in patients with AD. So we aimed to investigate long-term outcomes after AMI in patients with AD, and propose a useful diagnostic paradigm.

Methods

Consecutively enrolled patients with AD and AMI who were referred to our center from 2010 to 2017. Baseline patient characteristics, risk factors, all medical treatments, echocardiographic parameters, laboratory data and treatment were recorded. All patients were followed up from the first hospitalization until a first heart event, death or 17 March, 2018.

Results

0.13% in AMI and 7.49% in AD patients had a concomitant diagnosis of AD and AMI. The average patient age was 53.3 ± 12.1 years and 84.6% were male. The most prevalent vascular risk factors were hypertension (69.2%) and current smoker (64.1%). Of all the 39 patients, 66.7% were managed surgically. Overall in-hospital mortality was 10.3%. The 30-day and 5-year fatality rates were 23.1% and 35.9%, but were higher for female than for male (66.7% vs 30.3%, log-rank P = 0.045) on 5-year mortality. The overall survival of females was inferior to the males (log-rank P = 0.045).

Conclusions

Patients with AMI and AD exhibit high 5-year fatality rates. For these patients, surgical management tend to have lower mortality. Improved management of hypertension and smoking, may reduce future incidence rates.

Background

Acute myocardial infarction (AMI) and aortic dissection (AD) are both very serious diseases with high rates of morbidity and mortality which have the same manifestations of chest pain. Acute aortic dissection (AAD) is the most common acute aortic condition requiring urgent surgical therapy,1 with an incidence of about 3 cases in 100,000 per year.2-3 Complications such as tamponade, aortic valve insuiciency, and malperfusion occur when the aortic side branches are involved.4 Thus, AAD represents a medical and/or surgical emergency.5 Presenting features are similar, and progression to dissection may occur.6-8 While the initiating event is unknown, most patients have a structural abnormality of the arterial wall and/or systemic hypertension9,10. Despite improved surgical techniques and perioperative care, mortality remains high, between 15% and 30%.11,12

Many patients with AAD are diagnosed and treated as having acute coronary syndrome (ACS), which is a much more frequent condition than AAD.13 The triple rule-out protocol has been described as the one-stop computed tomography (CT) examination for chest pain designed to differentiate ACS, pulmonary embolism, and AAD.14 But there are a small proportion of patients with AD represent with AMI (approximately 1% ~3.6%) at the same time.15 However, clinical pathways of efficient streamlined care, similar to in ACS, have not yet been implemented.14 For cardiologists, prompt treatment with antiplatelet, antithrombotic, and thrombolytic agents is important once AMI is diagnosed. But the contradiction of management modality between AMI and acute aortic dissection may result in clinical catastrophe.16 Moreover, data on risk factors, incidence and outcome of AD and AMI are limited, and there have been no studies on the long-term outcomes of AMI in patients with AD. This study, therefore, aimed to investigate long-term outcomes after AMI in patients with AD, and propose a useful diagnostic paradigm.
Methods

Study Population and Baseline Characteristics

All patients (age \( \geq 18 \) years) with AD and AMI who were referred to Anzhen Hospital in Beijing, China, from January 2010 and December 2017, were consecutively enrolled in this study. Aortic dissection was classified according to the Stanford system into type A (proximal to left subclavian artery origin) or type B (distal to left subclavian artery origin). AD diagnosis was based on history, imaging study findings, visualization at surgery, and/or postmortem examination. AMI was diagnosed if a patient had a cardiac troponin I level >99th percentile with \( \geq 1 \) of the following: chest pain lasting >20 min or diagnostic serial electrocardiographic changes consisting of new pathological Q waves, new ST-segment T-wave changes, or new left bundle branch block. The exclusion criteria included rheumatic heart disease, severe congestive heart disease, malignant tumor, and use of the oral contraceptive pill or pregnancy.

Baseline patient characteristics were recorded from the patients, their hospital records, and their general practice records, details of the clinical event, medication, past medical history, all investigations relevant to their admission, and all interventions occurring subsequent to the event. Standardized clinical history and cardiovascular examination were recorded. Risk factors analyzed included age, sex, body mass index (BMI), current smoker, hypertension, diabetes and hyperlipidemia. Clinically relevant comorbidities included cardiac failure, atrial fibrillation, known coronary artery disease, prior aortic dissection, prior myocardial infarction, anterior myocardial infarction, known aortic aneurysm, prior stroke/TIA, carotid artery disease, peripheral artery disease chronic renal insufficiency and prior cardiac surgery. All medical treatments during hospitalization were recorded, including aspirin, clopidogrel, statin, nitrates, diuretic, warfarin and antihypertensives.

Echocardiographic parameters were assessed using transthoracic echocardiography with the Teichholz method prior to coronary angiography. Parameters analyzed included pericardial effusion, acute aortic valve insufficiency, left ventricular ejection fraction (LVEF) and ascending aortic diameters.

Laboratory data were collected upon admission to the hospital, including levels of total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), creatine kinase-MB (CK-MB), troponin-I (TNI), D-Dimer, homocysteine (HCY) and high-sensitivity C-reactive protein (hs-CRP).

 Coronary angiography was performed according to standard criteria. Offline analysis of digital angiograms was performed in the core laboratory using an automated edge detection system (CMS; Medis Medical Imaging Systems, Leiden, the Netherlands). Binary stenosis was defined as stenosis of >50% of the luminal diameter.

Follow-up and Definition of Endpoints

The follow-up started on the day of admission. In the hospital, major adverse events recorded included death, cardiogenic shock, ventricular tachyarrhythmia (VT), ventricular fibrillation (VF), acute left-sided heart failure and acute kidney injury (AKI).

After hospital discharge, adverse events including cardiac death, recurrent myocardial infarction (re-MI), re-hospital admission and recurrent angina. If a recurrent vascular event was suspected, the patient was assessed by a study physician. Event rates were defined as the total number of vascular events that led to separate clinical presentations during the study period. An extension of a previous dissection was not considered to be a recurrent event if it occurred within 6 months of the first event.

All patients were followed up from the first hospitalization until a first coronary event, death or 17 March, 2018. Endpoint status was ascertained via clinic visits, medical records, telephone contact and text messages. For deceased patients, death certificates were obtained, and the next of kin were interviewed to determine when death occurred. This study conformed to the principles defined in the Declaration of Helsinki. Local ethical committee approval was obtained. All patients provided their informed consent prior to their inclusion in the study.

Statistical Analysis
Continuous variables with normal distributions were expressed as mean ± standard deviation, and compared using one-way ANOVA analysis of variance or Fisher's exact test. Categorical variables were expressed as frequencies with percentages, and compared using the chi-square test where appropriate. The 95% confidence interval (CI) of annual mortality rate was calculated using the binomial approximation. Survival was graphically represented using Kaplan-Meier curves. Differences in survival rates were compared using the log-rank test. Univariate and multivariate Cox proportional hazards models were used to identify study endpoint predictors. Variables with univariate p values <0.10 were selected for multivariate analysis and expressed as hazard ratios (HRs) with 95% CIs. Multivariate Cox regression analysis was performed using an enter method. The 95% CI of annual mortality rate was calculated using GraphPad Prism 7 (GraphPad Software Inc., La Jolla, USA). All other analyses were performed using SPSS statistical software, version 25.0 (SPSS Inc., Chicago, USA). All tests were 2-tailed, and statistical significance was defined as p <0.05.

Results

Demographics and Risk Factors

From 2010 to 2017, 29,015 patients who were hospitalized in Anzhen Hospital with AMI and 5,202 patients with AD were identified. Of these, 39 AMI patients had a concomitant diagnosis of AD (0.13% in AMI vs 7.49% in AD) (Figure, 1). Table 1 shows the demographics and risk factors for AMI patients with AD by sex and by Stanford classification. The average patient age was 53.3±12.1 years and 84.6% were male. Of the 39 patients, 31 (79.5%) were Stanford type A and 8(20.5%) were Stanford type B. 6 patients had previous aorta dissection during study period (3 of them are Stanford type A, 3 are Stanford type B); 11 patients had prior myocardial infarction (9 are Stanford type A, 2 are Stanford type B). The most prevalent vascular risk factors were hypertension (69.2%) and current smoker (64.1%). Hypertension tended to be more common in Type B patients (p =0.042, Table 1). There were no statistically significant sex differences in risk factors for AMI patients with AD, although men were more likely to be on triple antihypertensive medication (p =0.040, Table 1). Compared with Type B patients with AMI, Type A patients were less likely to present with ST-elevation myocardial infarction (45.2% vs 87.5%, P = 0.049) (Table 1). A history of cardiac surgery was present in 14 patients (35.9%). In hospital, Type A patients had lower rates of medication use compared to Type B patients, including statin (32.3% vs 75.0%, P = 0.045), aspirin (38.7% vs 87.5%, P = 0.020), clopidogrel (22.6% vs 75.0%, P = 0.010) and nitrates (38.7% vs 87.5%, P = 0.020) (Table 1). 18 (58.1%) of Type A patients had pericardial effusion and 19 (61.3%) of them had acute aortic valve insufficiency, the mean ascending aortic diameter was 46.2±12.1 mm in the Type A group with a range from 24.3 to 69.6 mm.

Presenting Signs, Symptoms and Diagnostic imaging

Hypertension at initial presentation was more common among patients with Type B dissection (61.3% vs 100%, P = 0.042). Despite 79.5% of patients being on antihypertensive medication, the control of blood pressure (BP) was poor. Maximum previously recorded systolic BP was ≥180 mmHg in 51.9% of patients and was similar for type B dissections (52.6%) and type A dissections (50.0%), but tended to be more common in women (75.0%) in comparison with men (47.8%) (Table 2).

The most frequent presentation is sudden-onset chest pain (79.5%). 17.9% of patients presented with feelings of pressure or tightness or throat/jaw pain (Table 2), which were more like symptoms of AMI. Not infrequently, 1 male patient with type A dissection presented with syncope and transient blindness without other neurological findings, 5 type A patients presented with paraparesis or paraplegia.

Most patients had multiple imaging studies performed (Table 2). CT was more often the initial study tool for 53.8% of all the patient, particularly in patients with type B dissection. Echocardiography and magnetic resonance imaging (MRI) were rarely used initially. 3 male patients with type A dissection were not diagnosed until coronary angiography done.

Angiographic Features, and Treatment Characteristics

Of all the 39 patients, 66.7% were managed surgically (Table 3), 16 of them were treated AMI and AD at the same time.

The vascular involvement number was significantly different between patients with type A dissection and patients with type B dissection (P = 0.007); patients with type A dissection were more likely to have one vessel involvement than patients with type B
dissection (Table 3). Left anterior descending (LAD) and left circumflex (LCx) were more often involved in patients with type B dissection (LAD: 100.0% vs 29.0%, LCx: 62.5% vs 16.1%, P <0.05) (Table 3).

A total of 18 open procedures were performed following acute dissection during the study period. The average cardiopulmonary bypass time is (236 ± 118) min, cross-clamp time is (121±56) min, selective cerebral perfusion time is (27.5 ± 8.1) min. As for Type A patients, Aortic root replacement was performed in 17 patients (43.6%); Hemi-arch replacement was performed in 1 patients (2.6%); Total arch replacement was performed in 11 patients (28.2%); Aortic valve replacement was performed in 7 patients (17.9%) (Table 3), and simultaneous coronary artery bypass grafting was provided in 12 patients (70.6%). Of 8 patients with type B dissection, percutaneous fenestration and/or stenting was performed in 3 patients (37.5%).

In-Hospital Management and Follow-Up

Overall in-hospital mortality was 10.3%. Death all occurred in patients receiving surgery (10.9%). For patients surviving until hospital discharge, median length of stay was 15.3±11.8 days. Follow-up at 3.02 ± 2.68 years was available for all of the patients, 14 died during the study period. Mortality was highest within the first 7 days of presentation (Figure, 2). The 30-day and 5-year fatality rates (Figure, 3) were 23.1% and 35.9%, but were higher for female than for male (66.7% vs 30.3%, log-rank P = 0.045) on 5-year mortality. In patients with incident type A dissection who survived to hospital admission, 30-day mortality was 25.8%. Among those who survived to hospital discharge, subsequent 5-year survival rates were high (61.3% for type A; 75% for type B). After reported, 42.9% of death was caused by cardiac, 28.6% was caused by aortic rupture (Table 4).

Female patients tended to be older (60.8 vs 51.9, P =0.098) (Table 1) (Figure, 4) and the overall survival of females was inferior to the males (log-rank P =0.045; Figure, 3). However, it seems that there is no specific difference in mortality between type A and type B dissection (P >0.05).

Of 31 patients with type A dissection, 20 (64.5%) were managed surgically (Supplemental Table). The overall surgical in-hospital mortality was 15.0%; medically treated patients had an in-hospital mortality of 0%. Surgery was not performed in 35.5% of patients with type A dissection because of advanced age, comorbidity, patient refusal, intramural hematoma, and death prior to planned surgery. Of type B patients, 6 were managed surgically resulting in 1 death (16.7%), 2 were managed medically resulting in 0 death (0%). Patients treated medically had lower mortality in-hospital but as for the long-term outcome, surgical management tend to have lower mortality. Among type A patients, 20 received surgical therapy, of whom 6 died (30.0%), and 11 received medical therapy, of whom 6 died (54.5%); Of type B patients, 1 death (16.7%) occurred after surgery and 1 death (50.0%) happened with medical management.

Cox proportional hazards models for all-cause mortality are shown in Table 6. By sex, the independent determinants of deaths were aortic dissection type (HR: 30.432, 95% CI: 1.092-848.183), prior cardiac surgery (HR: 0.048, 95% CI: 0.003-0.745), auscultated murmur of aortic insufficiency (HR: 18.258, 95% CI: 1.436-232.18), and medications such as nitrates (HR: 0.045, 95% CI: 0.003-0.578) and warfarin (HR: 0.033, 95% CI: 0.001-0.915). As for by type, the independent determinants of deaths were male (HR: 0.001, 95% CI: 9.296-5355.344), prior cardiac surgery (HR: 0.004, 95% CI: 0.001-0.266), and medications such as antihypertensives (HR: 0.036, 95% CI: 0.074-0.915) and warfarin (HR: 0.020, 95% CI: 0.001-0.528).

Discussion

Patients suffered from both AMI and AD may be uncommon, but complications occur often and early, and the outcome is frequently fatal. Although clinicians today are better equipped to deal with complex threat posed by AMI and AD, mortality rates remain high. Besides that, there haven't been any research focus on the long-term outcome of AMI patients with AD. The results of our study demonstrated that patients with AMI and AD exhibit high 5-year fatality rates of 35.9%, especially in female (66.7%). For patients with AMI and AD, surgical management tend to have lower mortality.

The pathophysiology of AD is diverse and affected by histopathology and genetic components, which usually results from a tear in the aortic intima. The blood typically propagates rapidly along the length of the aorta and often compromises branch vessels along its path and/or disrupts aortic valve function.
Occasionally, dissection and myocardial infarction may occur concomitantly.

For one reason, AMI may happen when the dissection flap involves the coronary. Iatrogenic acute aortic dissection can also occurred during percutaneous coronary intervention. For other reasons, the two diseases just happen on the same patient occasionally.

In the present study, the overall in-hospital mortality was 10.3% which was relatively low compared with those in previous studies. One reason may result from the improvement of diagnostic equipment and surgical techniques in recent years. Another reason might be that some patients died in the emergency department before confirmative diagnosis was made. In the IRAD registry, a history of hypertension, which is considered the most common predisposing factor for aortic dissection, was present in more than 70% of patients. This was consistent with our study for the most prevalent vascular risk factors were hypertension (69.2%) and current smoker (64.1%). Despite 79.5% of patients being on antihypertensive medication, the control of blood pressure (BP) was poor. Improved primary prevention, in particular, more aggressive management of hypertension and smoking cessation, may reduce future incidence rates, but treatment-resistant hypertension is likely to remain a challenge.

This study has limitations. First, this was a retrospective cohort study, may underestimate incidence and case fatality by the incomplete inclusion of deaths before hospital admission, which might also bias the assessment of risk factors and predictors of outcome. Second, although this study was the first to fulfill a substantial follow-up of a large series of patients with AMI and AD, its sample size was relatively small in comparison with that of many studies regarding AMI or AD only. Because AMI occurring in patients with AD is a rare condition, it seems impractical for a single center to enroll a large study population with both AMI and HCM. Multicenter studies enrolling much larger study populations are necessary to validate our finding.

**Conclusion**

Patients with AMI and AD exhibit high 5-year fatality rates. For these patients, surgical management tend to have lower mortality. Improved management of hypertension and smoking, may reduce future incidence rates.

**Abbreviations**

AAD = Acute aortic dissection  
ACS = acute coronary syndrome  
AMI = acute myocardial infarction  
CABG = coronary artery bypass grafting  
CI = confidence interval  
HRs = hazard ratios  
PCI = percutaneous coronary intervention

**Declarations**

**Ethics approval and consent to participate**  
Not applicable.

**Consent for publication**  
Not applicable.

**Availability of data and materials**
The datasets generated and/or analyzed during the current study are not publicly available due regulations of patient information to be released in public but are available from the corresponding author on reasonable request, after anonymization.

**Competing interests**

The authors declare that there is no duality of interest associated with this manuscript.

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**Author contribution**

FL and SCQ contributed to the conception or design of the work. FL, SCQ, XCY and MLC contributed to the acquisition, analysis, or interpretation of data for the work. FL drafted the manuscript. XCY critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of the work ensuring integrity and accuracy. All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation. FL and SCQ contributed equally to this work and should be considered co-first authors.

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Tables
| Table 1. Demographics and Risk Factors for Incident Aortic Dissection by Sex and Type. |
|-------------------------------------------------|-------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                                  | Total n=39  | Male n=33       | Female n=6      | P Value         | Type A n=31     | Type B n=8      |
| Mean (SD) age, y                                  | 53.3±12.1   | 51.9±11.9       | 60.8±11.3       | 0.098           | 52.0±11.4       | 58.4±14.1       |
| Male, n (%)                                       | 33 (84.6)   | 25 (80.6)       | 8 (100.0)       | 0.313           |
| BMI, n (%)                                        | 25.5±3.3    | 25.5±3.2        | 25.4±3.9        | 0.920           | 25.1±3.5        | 27.2±1.8        |
| KILLIP≥2, n (%)                                   | 26 (66.7)   | 21 (63.6)       | 5 (83.3)        | 0.643           |
| Risk Factors                                     |             |                 |                 |                 |                 |                 |
| Current smoker, n (%)                             | 25 (64.1)   | 21 (63.6)       | 4 (66.7)        | 1.000           |
| Hypertension, n (%)                               | 27 (69.2)   | 23 (69.7)       | 4 (66.7)        | 1.000           |
| Diabetes mellitus, n (%)                          | 6 (15.4)    | 6 (18.2)        | 0 (0.0)         | 0.564           |
| Dyslipidemia, n (%)                               | 8 (20.5)    | 6 (18.2)        | 2 (33.3)        | 0.583           |
| Cardiac failure, n (%)                            | 13 (33.3)   | 10 (33.3)       | 3 (50.0)        | 0.380           |
| Atrial fibrillation, n (%)                        | 3 (7.7)     | 2 (6.1)         | 1 (16.7)        | 0.403           |
| AMI Characteristics                                |             |                 |                 |                 |                 |                 |
| Anterior infarction, n (%)                        | 16 (41.0)   | 13 (39.4)       | 3 (50.0)        | 0.674           |
| Inferior infarction, n (%)                        | 26 (66.7)   | 22 (66.7)       | 4 (66.7)        | 1.000           |
| ST-segment elevation myocardial infarction, n (%) | 21 (53.8)   | 20 (60.6)       | 1 (16.7)        | 0.077           |
| Previous vascular disease                         |             |                 |                 |                 |                 |                 |
| Known coronary artery disease, n (%)              | 13 (33.3)   | 10 (33.3)       | 3 (50.0)        | 0.380           |
| Prior aortic dissection, n (%)                    | 6 (15.4)    | 5 (15.2)        | 1 (16.7)        | 1.000           |
| Prior myocardial infarction, n (%)                | 11 (28.2)   | 8 (24.2)        | 3 (50.0)        | 0.323           |
| Known aortic aneurysm, n (%)                      | 23 (59.0)   | 20 (60.6)       | 3 (50.0)        | 0.674           |
| Stroke, n (%)                                     | 5 (12.8)    | 4 (12.1)        | 1 (16.7)        | 1.000           |
| Carotid artery disease, n (%)                     | 2 (5.1)     | 2 (6.1)         | 0 (0.0)         | 1.000           |
| Peripheral arterial disease, n (%)                | 1 (2.6)     | 1 (3.0)         | 0 (0.0)         | 1.000           |
| Chronic renal                                     | 3 (7.7)     | 2 (6.1)         | 1 (16.7)        | 0.403           |

Page 9/14
|                          | n (%) | n (%) | n (%) | n (%) | p-value |
|--------------------------|-------|-------|-------|-------|---------|
| **Prior cardiac surgery**| 14 (35.9) | 11 (33.3) | 3 (50.0) | 0.647 | 10 (32.3) | 4 (50.0) | 0.424 |
| **Aortic valve replacement** | 3 (7.7) | 2 (6.1) | 1 (16.7) | 0.403 | 3 (9.7) | 0 (0.0) | 1.000 |
| **Descending aorta replacement** | 4 (10.3) | 4 (12.1) | 0 (0.0) | 1.000 | 1 (3.2) | 3 (37.5) | 0.022* |
| **Coronary artery bypass graft surgery** | 1 (2.6) | 0 (0.0) | 1 (16.7) | 0.154 | 1 (3.2) | 0 (0.0) | 1.000 |
| **Percutaneous Coronary Intervention** | 5 (12.8) | 4 (12.1) | 1 (16.7) | 1.000 | 4 (12.9) | 1 (12.5) | 1.000 |
| **Aortic root surgery** | 2 (5.1) | 1 (3.0) | 1 (16.7) | 0.287 | 2 (6.5) | 0 (0.0) | 1.000 |

**Medications**

|                          | n (%) | n (%) | n (%) | n (%) | p-value |
|--------------------------|-------|-------|-------|-------|---------|
| **Statin** | 16 (41.0) | 13 (39.4) | 3 (50.0) | 0.674 | 10 (32.3) | 6 (75.0) | 0.045* |
| **Aspirin** | 19 (48.7) | 17 (51.5) | 2 (33.3) | 0.661 | 12 (38.7) | 7 (87.5) | 0.020* |
| **Clopidogrel** | 13 (33.3) | 10 (33.3) | 3 (50.0) | 0.380 | 7 (22.6) | 6 (75.0) | 0.010* |
| **Nitrates** | 19 (48.7) | 17 (51.5) | 2 (33.3) | 0.661 | 12 (38.7) | 7 (87.5) | 0.020* |
| **Diuretic** | 21 (53.8) | 20 (60.6) | 1 (16.7) | 0.077 | 16 (51.6) | 5 (62.5) | 0.702 |
| **Warfarin** | 11 (28.2) | 9 (27.3) | 2 (33.3) | 1.000 | 11 (35.5) | 0 (0.0) | 0.078 |

**Antihypertensives**

|                          | 0.040* | 0.201 |
|--------------------------|--------|-------|
| 0, n (%) | 8 (20.5) | 8 (24.2) | 0 (0.0) | 8 (25.8) | 0 (0.0) |
| 1, n (%) | 9 (23.1) | 6 (18.2) | 3 (50.0) | 8 (25.8) | 1 (12.5) |
| 2, n (%) | 10 (25.6) | 7 (21.2) | 3 (50.0) | 6 (19.4) | 5 (50.0) |
| ≥3, n (%) | 12 (30.8) | 12 (36.4) | 0 (0.0) | 9 (29.0) | 3 (37.5) |

**Echocardiography**

|                          | n (%) | n (%) | n (%) | n (%) | p-value |
|--------------------------|-------|-------|-------|-------|---------|
| **Pericardial effusion** | 19 (48.7) | 16 (48.5) | 3 (50.0) | 1.000 | 18 (58.1) | 1 (12.5) | 0.044* |
| **Acute aortic valve insuficiency** | 21 (53.8) | 18 (54.5) | 3 (50.0) | 1.000 | 19 (61.3) | 2 (25.0) | 0.112 |
| **LVEF≤40** | 7 (17.9) | 6 (18.2) | 1 (16.7) | 1.000 | 4 (12.9) | 3 (37.5) | 0.137 |
| **Ascending aortic diameters (n=33)** | 44.4±11.4 | 44.7±11.3 | 42.7±12.6 | 0.695 | 46.2±12.1 | 37.5±3.0 | 0.001* |

**Biochemical**

|                          | | | | | |
|--------------------------|--------|--------|--------|--------|--------|
| **TC** | 3.9±1.0 | 4.0±1.1 | 3.5±0.6 | 0.461 | 4.0±1.0 | 3.7±1.2 | 0.535 |
| **TG** | 1.6±1.0 | 1.5±1.1 | 1.7±0.3 | 0.709 | 1.6±1.0 | 1.6±0.9 | 0.852 |
| **HDL** | 1.0±0.6 | 1.0±0.7 | 1.0±0.2 | 0.985 | 1.0±0.7 | 0.8±0.3 | 0.293 |
| **LDL** | 2.3±0.9 | 2.4±0.9 | 1.9±0.4 | 0.262 | 2.3±0.8 | 2.3±1.0 | 0.944 |
| CK-MB | 150.4±98.6 | 141.3±101.1 | 222.8±17.8 | 0.284 | 133.3±99.5 | 210.0±78.0 | 0.177 |
|-------|------------|-------------|------------|-------|------------|------------|-------|
| TNI   | 46.0±30.7  | 42.9±30.0   | 74.6±27.4  | 0.171 | 40.2±29.8  | 69.2±25.4  | 0.092 |
| D-DIMER | 1964.8±2720.2 | 2209.2±2833.5 | 259.3±406.6 | 0.256 | 2276.6±3004.4 | 796.6±439.7 | 0.292 |
| HCY   | 14.3±3.0   | 14.8±2.9    | 11.8±1.9   | 0.021* | 13.4±2.0   | 17.8±3.5   | 0.000* |
| hs-CRP | 18.3±14.1  | 19.1±14.0   | 13.2±16.3  | 0.536 | 18.7±13.5  | 17.0±16.6  | 0.773 |

Abbreviations: AMI, acute myocardial infarction; BMI, body mass index; CK-MB, creatine kinase isoenzymes; HCY, homocysteine; HDL, high-density lipoprotein cholesterol; hs-CRP, hypersensitive-c reactive protein; LDL, low-density lipoprotein; LVEF, left ventricular ejection fraction; TC, total cholesterol; TG, triglycerides; TNI, troponin I.

*P < 0.05.

| Hypertension, n (%) | Total n=39 | Male n=33 | Female n=6 | P Value | Type A n=31 | Type B n=B | P Value |
|---------------------|------------|-----------|------------|---------|-------------|------------|---------|
|                     | 27 (69.2)  | 23 (69.7) | 4 (66.7)   | 1.000   | 19 (61.3)   | 8 (100.0)  | 0.042*  |
| Control under 140/90 mmHg, n (%) | 17 (43.6) | 15 (45.5) | 2 (33.3) | 0.679 | 15 (48.4) | 2 (25.0) | 0.426 |

Degree

| Stage 1, n (%) | Total n=39 | Male n=33 | Female n=6 | P Value |
|----------------|------------|-----------|------------|---------|
|                | 7 (25.9)   | 6 (26.1)  | 1 (25.0)   | 0.782   |
| Stage 2, n (%) | Total n=39 | Male n=33 | Female n=6 | P Value |
|                | 6 (22.2)   | 6 (26.1)  | 0 (0.0)    | 1.000   |
| Stage 3, n (%) | Total n=39 | Male n=33 | Female n=6 | P Value |
|                | 14 (51.9)  | 11 (47.8) | 3 (75.0)   | 0.895   |

Presenting symptoms

| Chest pain, n (%) | Total n=39 | Male n=33 | Female n=6 | P Value |
|-------------------|------------|-----------|------------|---------|
|                   | 31 (79.5)  | 26 (78.8) | 5 (83.3)   | 0.514   |
| Feelings of pressure or tightness, n (%) | Total n=39 | Male n=33 | Female n=6 | P Value |
|                   | 5 (12.8)   | 5 (15.2)  | 0 (0.0)    | 0.782   |
| Pain throat/jaw, n (%) | Total n=39 | Male n=33 | Female n=6 | P Value |
|                    | 2 (5.1)    | 1 (3.0)   | 1 (16.7)   | 0.782   |
| Syncope, n (%)     | Total n=39 | Male n=33 | Female n=6 | P Value |
|                    | 1 (2.6)    | 1 (3.0)   | 0 (0.0)    | 0.782   |
| Auscultated murmur of aortic insufficiency, n (%) | Total n=39 | Male n=39 | Female n=6 | P Value |
|                   | 12 (30.8)  | 11 (33.3) | 1 (16.7)   | 0.645   |

Diagnostic imaging of AD

| Computed tomography, n (%) | Total n=39 | Male n=39 | Female n=6 | P Value |
|----------------------------|------------|-----------|------------|---------|
|                            | 21 (53.8)  | 19 (57.6) | 2 (33.3)   | 0.467   |
| Echocardiography, n (%)     | Total n=39 | Male n=39 | Female n=6 | P Value |
|                            | 11 (28.2)  | 8 (24.2)  | 3 (50.0)   | 0.782   |
| Magnetic resonance imaging, n (%) | Total n=39 | Male n=39 | Female n=6 | P Value |
|                            | 3 (7.7)    | 2 (6.1)   | 1 (16.7)   | 0.782   |
| Coronary angiography, n (%) | Total n=39 | Male n=39 | Female n=6 | P Value |
|                            | 3 (7.7)    | 3 (9.1)   | 0 (0.0)    | 0.782   |

Abbreviations: AD, aortic dissection.

*P < 0.05.
|                               | Type A n=31 | Type B n=8 | P Value |
|-------------------------------|-------------|------------|---------|
| **Surgical Management**       |             |            |         |
| On AMI, n (%)                 | 20 (64.5)   | 6 (75.0)   | 0.694   |
| On AD, n (%)                  | 19 (61.3)   | 6 (75.0)   | 0.686   |
| On AMI and AD, n (%)          | 17 (54.8)   | 4 (50.0)   | 1.000   |
| **AMI Treatment strategy**    |             |            |         |
| Angiographic features         |             |            |         |
| LAD, n (%)                    | 9 (29.0)    | 8 (100.0)  | 0.000*  |
| LCx, n (%)                    | 5 (16.1)    | 5 (62.5)   | 0.016*  |
| RCA, n (%)                    | 22 (71.0)   | 5 (62.5)   | 0.682   |
| Involvement of the LMCA, n (%)| 1 (3.2)     | 0 (0.0)    | 1.000   |
| Vascular involvement number   |             |            | 0.007*  |
| Nonstenotic vessels, n (%)    | 5 (16.1)    | 0 (0.0)    |         |
| 1-vessel disease, n (%)       | 18 (58.1)   | 2 (25.0)   |         |
| 2-vessel disease, n (%)       | 6 (19.4)    | 1 (12.5)   |         |
| 3-vessel disease, n (%)       | 2 (6.5)     | 5 (62.5)   |         |
| **Treatment strategy**        |             |            |         |
| Thrombolysis, n (%)           | 2 (6.5)     | 0 (0.0)    | 1.000   |
| Percutaneous coronary intervention, n (%) | 6 (19.4) | 1 (12.5) | 1.000 |
| Coronary artery bypass grafting, n (%) | 13 (41.9) | 4 (50.0) | 0.709 |
| No revascularization, n (%)   | 11 (35.5)   | 3 (37.5)   | 1.000   |
| **AD Treatment strategy**     |             |            |         |
| n=16                          | n=2         |            |         |
| **Procedural times(min)**     |             |            |         |
| Cardiopulmonary bypass        | 209±93      | 451±30     | 0.003*  |
| Cross-clamp                   | 118±57      | 149±45     | 0.004*  |
| Selective cerebral perfusion  | 25.0±5.7    | 41.0±5.7   | 0.467   |
| **Type A**                    |             |            |         |
| Aortic root replacement       | -           | -          | -       |
| Hemiarch replacement          | -           | -          | -       |
| Total arch replacement        | -           | -          | -       |
| Aortic valve replacement      | -           | -          | -       |

Abbreviations: AD, aortic dissection; AMI, acute myocardial infarction; LAD, left anterior descending; LCx, left circumflex; LMCA, left main coronary artery; RCA, right coronary artery.

*P < 0.05.
Table 4. In- and Out-Hospital Outcomes.

|                                             | Total n=39 | Male n=33 | Female n=6 | P Value | Type A n=31 | Type B n=8 | P Value |
|---------------------------------------------|------------|-----------|------------|---------|-------------|-----------|---------|
| **In-hospital outcome**                     |            |           |            |         |             |           |         |
| Death, n (%)                               | 4 (10.3)   | 2 (6.1)   | 2 (33.3)   | 0.104   | 3 (9.7)     | 1 (12.5)  | 1.000   |
| **Complications**                           |            |           |            |         |             |           |         |
| Cardiogenic shock, n (%)                   | 6 (15.4)   | 5 (15.2)  | 1 (16.7)   | 1.000   | 4 (12.9)    | 2 (25.0)  | 0.583   |
| VTA, n (%)                                 | 4 (10.3)   | 4 (12.1)  | 0 (0.0)    | 1.000   | 2 (6.5)     | 2 (25.0)  | 0.180   |
| VF, n (%)                                  | 3 (7.7)    | 2 (6.1)   | 1 (16.7)   | 0.403   | 2 (6.5)     | 1 (12.5)  | 0.508   |
| Acute left-sided heart failure, n (%)      | 9 (23.1)   | 8 (24.2)  | 1 (16.7)   | 1.000   | 6 (19.4)    | 3 (37.5)  | 0.355   |
| AKI, n (%)                                 | 4 (10.3)   | 4 (12.1)  | 0 (0.0)    | 1.000   | 3 (9.7)     | 1 (12.5)  | 1.000   |
| Length of stay, d                          | 15.3±11.8  | 16.2±11.6 | 10.8±12.9  | 0.316   | 13.9±11.0   | 20.9±14.0 | 0.138   |
| **Out-hospital outcome**                   |            |           |            |         |             |           |         |
| Follow-up, y                               | 3.0±2.7    | 3.3±2.7   | 1.5±1.8    | 0.129   | 2.8±2.7     | 3.9±2.7   | 0.336   |
| Death, n (%)                               | 14 (35.9)  | 10 (33.3) | 4 (66.7)   | 0.163   | 12 (38.7)   | 2 (25.0)  | 0.686   |
| Aortic rupture, n (%)                      | 4 (28.6)   | 2 (20.0)  | 2 (50.0)   | 0.104   | 4 (33.3)    | 0 (0.0)   | 1.000   |
| Cardiac death, n (%)                       | 6 (42.9)   | 4 (12.1)  | 2 (50.0)   | 0.224   | 3 (33.3)    | 2 (100.0) | 0.583   |
| MI, n (%)                                  | 3 (7.7)    | 2 (6.1)   | 1 (16.7)   | 0.403   | 2 (6.5)     | 1 (12.5)  | 0.508   |
| Re-hospital, n (%)                         | 3 (7.7)    | 2 (6.1)   | 1 (16.7)   | 0.403   | 1 (3.2)     | 2 (25.0)  | 0.101   |
| Recurrent angina, n (%)                    | 2 (5.1)    | 2 (6.1)   | 0 (0.0)    | 1.000   | 0 (0.0)     | 2 (25.0)  | 0.038*  |

Abbreviations: AKI, acute kidney injury; MI, myocardial infarction; VF, ventricular fibrillation; VT, ventricular tachyarrhythmia.

*P < 0.05.
### Table 5. Cox Regression Analysis for Death Over the Follow-Up.

|                  | Univariate                  |          | Multivariate                  |          |
|------------------|-----------------------------|----------|-----------------------------|----------|
|                  | HR 95% CI                    | P Value  | HR 95% CI                    | P Value  |
| **By sex**       |                             |          |                             |          |
| Aortic dissection type | 0.727 (0.154-3.424)         | 0.687    | 30.432 (1.092-848.183)      | 0.044    |
| Prior cardiac surgery | 0.097 (0.012-0.774)         | 0.028    | 0.048 (0.003-0.745)         | 0.030    |
| Auscultated murmur of aortic insufficiency | 2.999 (1.040-8.647)         | 0.042    | 18.258 (1.436-232.18)       | 0.025    |
| On AD            | 0.301 (0.093-0.973)         | 0.045    |                             |          |
| On AMI and AD    | 0.289 (0.080-1.047)         | 0.059    |                             |          |
| Antihypertensives| 0.398 (0.212-0.746)         | 0.004    |                             |          |
| Nitrates         | 0.243 (0.065-0.902)         | 0.035    | 0.045 (0.003-0.578)         | 0.017    |
| Warfarin         | 0.125 (0.016-0.977)         | 0.047    | 0.033 (0.001-0.915)         | 0.033    |
| **By type**      |                             |          |                             |          |
| Male             | 2.814 (0.841-9.414)         | 0.093    | 223.123 (9.296-5355.344)    | 0.001    |
| KILLIP≥2         | 3.891 (0.866-17.472)        | 0.076    |                             |          |
| Inferior infarction | 2.803 (0.945-8.310)        | 0.063    |                             |          |
| Prior cardiac surgery | 0.241 (0.054-1.086)        | 0.064    | 0.015 (0.001-0.266)         | 0.004    |
| Auscultated murmur of aortic insufficiency | 2.678 (0.886-8.100)        | 0.081    |                             |          |
| On AD            | 0.266 (0.083-0.859)         | 0.027    |                             |          |
| On AMI and AD    | 0.306 (0.084-1.106)         | 0.071    |                             |          |
| Antihypertensives| 0.431 (0.237-0.783)         | 0.006    | 0.261 (0.074-0.915)         | 0.036    |
| Aspirin          | 0.316 (0.081-1.231)         | 0.097    |                             |          |
| Nitrates         | 0.180 (0.037-0.889)         | 0.035    |                             |          |
| Warfarin         | 0.117 (0.015-0.908)         | 0.040    | 0.018 (0.001-0.528)         | 0.020    |

Abbreviations: AD, aortic dissection; AMI, acute myocardial infarction.

### Supplemental Table. Management and outcomes of acute aortic dissection

|                  | Male (n = 33) management, No.(%) | Female (n = 6) management, No.(%) | Type A (n = 31) management, No.(%) | Type B (n = 8) management, No.(%) |
|------------------|----------------------------------|----------------------------------|-----------------------------------|----------------------------------|
|                  | Surgical | Medical | Surgical | Medical | Surgical | Medical | Surgical | Medical |
| No. , n (%)      | 22 (66.7) | 11 (33.3) | 4 (66.7) | 2 (33.3) | 20 (64.5) | 11 (35.5) | 6 (75.0) | 2 (25.0) |
| In-hospital mortality, n (%) | 2 (9.1) | 0 (0.0) | 2 (50.0) | 0 (0.0) | 3 (15.0) | 0 (0.0) | 1 (16.7) | 0 (0.0) |
| Out-hospital mortality, n (%) | 4 (18.2) | 6 (54.5) | 3 (75.0) | 1 (50.0) | 6 (30.0) | 6 (54.5) | 1 (16.7) | 1 (50.0) |