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*Review*

# Challenges to Acute Aortic Dissection in a Regional Hospital

**Michiya Kageyama,[1] Satoshi Koizumi,[1] Koichi Iwamatsu,[1] Fumiya Saito,[1] Tomohisa Sakata,[1] Ryu Umezono,[1] Haruka Yokoyama,[1] Masateru Kanai,[1] Sawa Takayama,[1] Masahide Aoyagi,[1] Masahisa Okuchi,[1] Kentaro Minami,[2] Shigeru Toyoda[2] and Teruo Inoue[1,2]**

[1]Department of Cardiovascular Medicine, Nasu Red Cross Hospital, Otawara, Japan
[2]Department of Cardiovascular Medicine, Dokkyo Medical University School of Medicine, Mibu, Japan

Acute aortic dissection is often a life-threatening disorder; in particular, type A aortic dissection necessitates urgent surgical intervention. Therefore, in regions where there are no cardiovascular surgeons, its treatment is quite challenging. Our facility, the Nasu Red Cross Hospital, located in the northern part of Tochigi Prefecture, is a core hospital for advanced emergency medical care, with eight cardiologists who can provide emergency coronary angioplasty for patients with acute coronary syndrome. However, we have no cardiovascular surgery section, so it is challenging to treat patients who require urgent surgical intervention. Therefore, we promptly transfer patients with type A aortic dissection to 8 facilities inside and outside the prefecture that have cardiovascular surgery sections. In regional hospitals like ours, without cardiovascular surgeons, it is necessary to provide a qualified diagnosis, initiate treatment for patients with acute aortic dissection including immediate blood pressure lowering and pain control using narcotics, and transfer patients eligible for urgent surgical intervention promptly to facilities with cardiovascular surgery sections. For smooth patient transfer, it is essential to build a close medical cooperation system that has daily interactions.

**Keywords:** aortic dissection; cardiovascular surgery; emergency care; medical cooperation; regional hospital
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## Introduction

Acute aortic dissection is often a life-threatening disorder (Mészáros et al. 2000; Clouse et al. 2004), despite well-established treatment guidelines (Feldman et al. 2009; Ramanath et al. 2009; Subramanian and Roselli 2009). In particular, type A aortic dissection may present with numerous lethal complications, such as intra-pericardial rupture causing cardiac tamponade, acute aortic regurgitation, coronary ischemia, and branch vessel occlusion, necessitating urgent surgical intervention (Scholl et al. 1999). Therefore, in areas with no cardiovascular surgeons, treatment is quite challenging.

Our facility, Nasu Red Cross Hospital, located in the northern area of Tochigi Prefecture, Japan, is a core hospital in charge of advanced critical and emergency care, and it has a heliport. The northern area of Tochigi Prefecture consists of Otawara City, Nasu-Shiobara City and Nasu Town, and its population is about 210,000, which is equivalent to 11% of the total population of the prefecture and is the most active agricultural area in the prefecture. The total area of this region is 1,319 km$^2$, which is 20.6% of the total area of the prefecture. Our facility has a cardiovascular medicine department with 8 full-time cardiologists, and it is available 24 hours a day, 365 days a year for emergency coronary angioplasty for patients with acute coronary syndrome. However, there is no cardiovascular surgery section in our facility, so it is difficult to respond to patients with type A acute aortic dissection or impending aortic aneurysm rupture, which sometimes requires urgent surgical intervention. No facility within a radius of 50 km of our hospital is equipped to perform open heart surgery. Therefore, it takes

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Correspondence: Michiya Kageyama, M.D., Ph.D., Department of Cardiovascular Medicine, Nasu Red Cross Hospital, Nakadawara, Otawara, Tochigi 324-8666, Japan.
e-mail: michiyakageyama@gmail.com

over one hour to transport a patient requiring emergency surgery to a facility capable of doing it. However, our hospital is the only core hospital in this area, and its missions are to treat any disease and to provide lifesaving services for local residents. Here, we describe our challenges associated with the treatment of acute aortic dissection at our regional hospital without cardiovascular surgeons.

### Diagnostic Procedure for Aortic Dissection

Patients with acute aortic dissection complain mainly of chest, back or abdominal pain. It is essential to differentiate acute aortic dissection from acute coronary syndrome in patients complaining of chest pain. Chest pain in aortic dissection is similar to that in acute myocardial infarction, in that it appears abruptly, but its peak is earlier than in acute myocardial infarction. Chest pain in acute myocardial infarction is expressed as a tightness or squeezing sensation, whereas pain in acute aortic dissection is "like tearing". In cases of aortic dissection, the pain travels to the area affected by the dissection (Hagan et al. 2000). Measurement of D-dimer is recommended in patients suspected of having acute aortic dissection, since a cut-off value of 500 ng/ml is useful for exclusion, with a sensitivity of 94% and a specificity of 57% (Li et al. 2017). Transthoracic echocardiography is often useful, not only to distinguish acute aortic dissection from acute myocardial infarction that represents as left ventricular wall asynergy, but also to detect a dissecting ascending aortic wall. Ultimately, contrast-enhanced computed tomography (CT) enables a definitive diagnosis.

The American College of Cardiology/American Heart Association (ACC/AHA) guideline recommends use of the aortic dissection detection risk score (ADD-RS), which is a tool to provide clinicians with a simple, systematic method for screening large volumes of patients at the bedside (Hiratzka et al. 2010). Focusing on specific high-risk predisposing conditions, high-risk pain features, and high-risk physical examination findings, an ADD-RS of 0, 1, 2, or 3 is assigned to patients on the basis of the number of categories in which at least one risk marker is present (Fig. 1). Diagnostic algorithms combining the ADD-RS with D-dimer have been suggested. In patients with an ADD-RS score of 0 or 1 and a D-dimer level of $< 0.5$ $\mu$g/mL, acute aortic dissection can be ruled out, and CT examination is not required (sensitivity 99%, specificity 35%). Even in patients with an ADD-RS score of 0 or 1, a CT scan should be performed if the D-dimer level is $\geq 0.5$ $\mu$g/mL. Patients with an ADD-RS score of 2 or 3 should undergo a CT scan regardless of the D-dimer level (Erbel et al. 2014). In our hospital, we diagnose acute aortic dissection primarily according to our own algorithm created based on these evidences (Fig. 2).

Coronary ischemia may be present in 10-15% of patients with acute aortic dissection and may result from

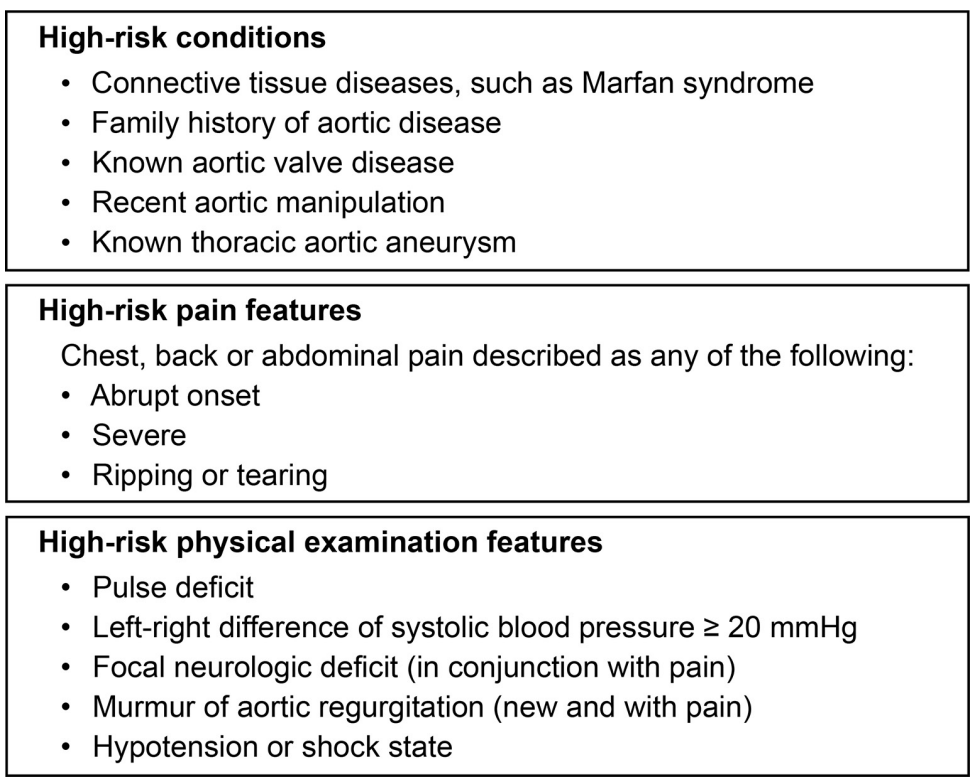


Fig. 1. Aortic dissection detection risk score (ADD-RS).
The ADD-RS consists of 3 categories: specific high-risk predisposing conditions, high risk pain features, and high-risk physical examination findings. Based on the number of categories in which at least one risk marker is present, an ADD-RS score of 0, 1, 2, or 3 is assigned.

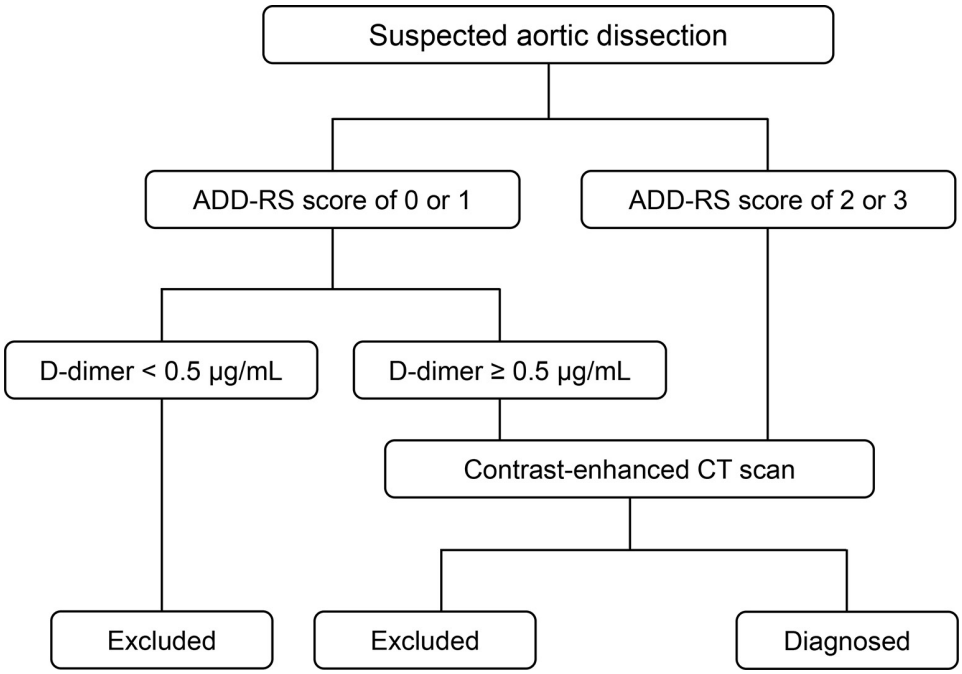


Fig. 2. A suggested algorithm combining the ADD-RS and D-dimer level for diagnosis of acute aortic dissection.
In patients with an ADD-RS score of 0 or 1 and a D-dimer level < 0.5 $\mu$g/mL, acute aortic dissection is ruled out, and CT examination is not required. Patients with an ADD-RS score of 0 or 1 and a D-dimer level ≥ 0.5 $\mu$g/mL and those with an ADD-RS score of 2 or 3 should undergo a contrast-enhanced CT scan.

aortic flap expansion with subsequent compression or obliteration of the coronary artery ostium or propagation of the dissection process into the coronary tree (Janosi et al. 2009). Both an elevated level of cardiac troponin and ST-T abnormalities on electrocardiography, which may fluctuate over time, may mislead the physician to diagnose acute coronary syndrome and delay proper diagnosis and management of acute aortic dissection. If myocardial ischemia caused by coronary artery involvement complicates acute aortic dissection, patients are at serious life-threatening risk. Therefore, in our hospital, when proceeding with a diagnosis of acute aortic dissection, we always keep coronary involvement in mind and, if in doubt, following or preceding a CT scan, we perform coronary angiography if necessary.

For patients with out-of-hospital cardiopulmonary arrest who are dead on arrival, in our hospital, aortic dissection is diagnosed by autopsy imaging with a postmortem CT scan.

## Cooperation with Hospitals that can Perform Cardiovascular Surgery

In Tochigi Prefecture, where the Nasu Red Cross Hospital is located, only 4 facilities are equipped to perform cardiovascular surgery and can handle emergency surgery: Dokkyo Medical University Hospital, Jichi Medical University Hospital, Saiseikai Utsunomiya Hospital, and Ashikaga Red Cross Hospital. However, those 4 hospitals are not able to handle all of the cases at our hospital that require emergency surgery. Thus, we sometimes transfer our patients to 4 other facilities outside the prefecture: Gunma Prefectural Cardiovascular Center and Maebashi Red Cross Hospital (Gunma Prefecture), Shinkuki General Hospital (Saitama Prefecture) and Hoshi General Hospital (Fukushima Prefecture). To transfer patients who need emergency surgery promptly, such as those with type A aortic dissection, we have established a close cooperation system with these 8 facilities inside and outside the prefecture (Fig. 3). Because of this close cooperation with facilities capable of performing emergent cardiovascular surgery, our hospital accepts patients with acute aortic dissection day and night.

Here, we describe the clinical course of 109 patients who were diagnosed with acute aortic dissection at our hospital over 3 years, from January 2018 to December 2021. Of those 109 patients, type A aortic dissection was present in 69 (63.3%) patients and type B was present in 40 (36.7%) patients.

Among the 69 patients with type A dissection, 33 (47.8% of those with type A dissection and 30.3% of the total population of patients with aortic dissection) had an out-of-hospital cardiopulmonary arrest, were confirmed dead on arrival, and were diagnosed by autopsy imaging with a postmortem CT scan. The remaining 36 patients (52.2% of those with type A dissection and 33.0% of the total population of patients with aortic dissection) were alive at hospital arrival. Of those 36 patients, however, 3 died soon after arrival from cardiac tamponade. Three patients who achieved in-hospital survival underwent conservative treatment alone, because they were elderly

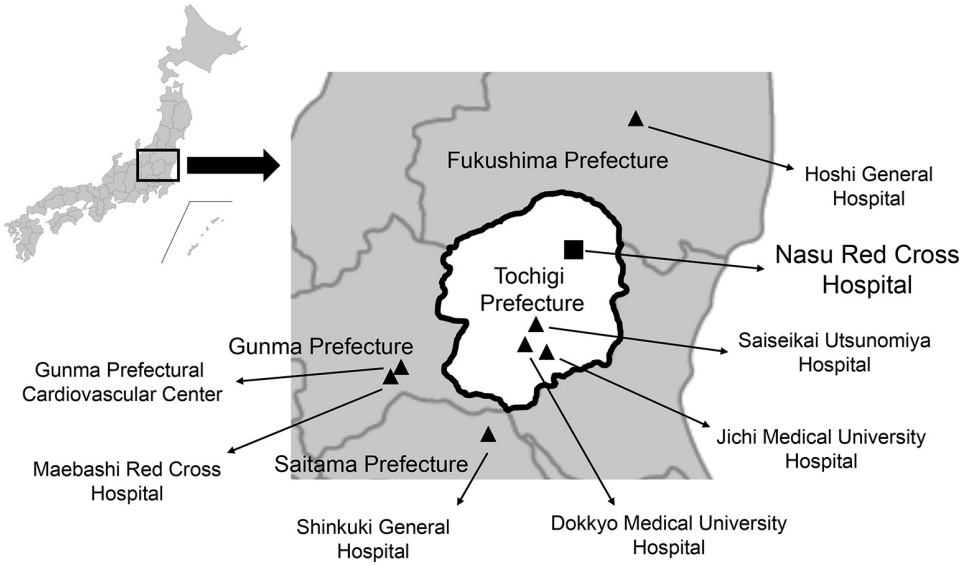


Fig. 3. Location of our hospital, Nasu Red Cross Hospital, and 8 affiliated facilities capable of cardiovascular surgery.

patients with low activities of daily living, and thus, rejected surgical treatment. The remaining 30 patients (83.3% of patients alive at hospital arrival) were immediately transferred to hospitals that could perform cardiovascular surgery. Twenty patients were transferred to cardiovascular surgery facilities within the prefecture (Dokkyo Medical University Hospital: 9 patients; Saiseikai Utsunomiya Hospital: 7 patients; and Jichi Medical University Hospital: 4 patients), and the remaining 10 were transferred to facilities outside the prefecture (Hoshi General Hospital: 6 patients; Gunma Prefectural Cardiovascular Center: 2 patients; Maebashi Red Cross Hospital: 1 patient; and Shinkuki General Hospital: 1 patient). Among the 30 transferred patients, the dissection involved the ostium of the coronary arteries in 3 patients. Of those 3, one patient was transferred to a facility for cardiovascular surgery after undergoing emergent coronary angioplasty. Among the 30 patients transferred to hospitals with the facilities to perform cardiovascular surgery, 2 patients died before surgery because of developing rupture of the ascending aorta and cardiac tamponade, respectively, just after hospital arriving. Of the 28 patients who underwent surgery, 2 died postoperatively in the hospital; 23 were discharged home or transported to rehabilitation hospitals; and the postoperative outcome was unknown in the 3 remaining patients. Among the 30 patients transferred to the cardiovascular surgery facilities, in-hospital staying time in our hospital until transfer to cardiovascular surgery facility was 161 minutes on average, with the shortest of 86 minutes and the longest of 367 minutes. The staying time was 138 minutes on average with the shortest of 86 minutes and the longest of 254 minutes on the daytime of weekdays (n = 8), 138 minutes on average with the shortest of 90 minutes and the longest of 305 minutes on the nighttime of weekdays (n = 13), and 216 minutes on average with the shortest of 90 minutes and the longest of 367 minutes on the holidays (n = 9). Namely, the staying time was evidently longer on the holiday. Sixteen patients were transferred by ambulance and 14 by doctor helicopter. The transfer time was 48 minutes on average, with the shortest time of 10 minutes (doctor helicopter) and the longest of 120 minutes (ambulance). Overall, there appeared to be no clear causal relationship between the patient's outcome and either the in-hospital staying time or the transfer time. In one of the 2 patients transferred to a cardiovascular surgery facility, who died before surgery, however, in-hospital staying time was 240 minutes and transfer time was 120 minutes, because of response on a holiday and transfer to an outside prefecture. If the response had been quicker, the patient might have been saved. Therefore, we believe that it is our future challenges to improve our in-hospital medical treatment system on holidays.

Among the 40 patients with type B dissection, communicating dissection was present in 25. Of those 25 patients, 9 were transferred to cardiovascular surgery facilities (Dokkyo Medical University Hospital: 5 patients; Saiseikai Utsunomiya Hospital: 1 patient; and Jichi Medical University Hospital: 3 patients) because of ileus due to mesenteric artery involvement (n = 3), renal artery involvement (n = 3) and enlargement of false lumen (n = 3). The remaining 16 patients with communicating dissection and 15 patients with non-communicating dissection underwent conservative therapies. None of the patients with type B patients experienced an in-hospital death (Fig. 4).

## Preceding Coronary Angioplasty in Patients with Type A Aortic Dissection Complicated with Acute Myocardial Infarction

Patients with type A aortic dissection have an extremely poor prognosis when acute myocardial ischemia due to involvement of the coronary arteries occurs concurrently. It has been reported that the mortality rate of acute

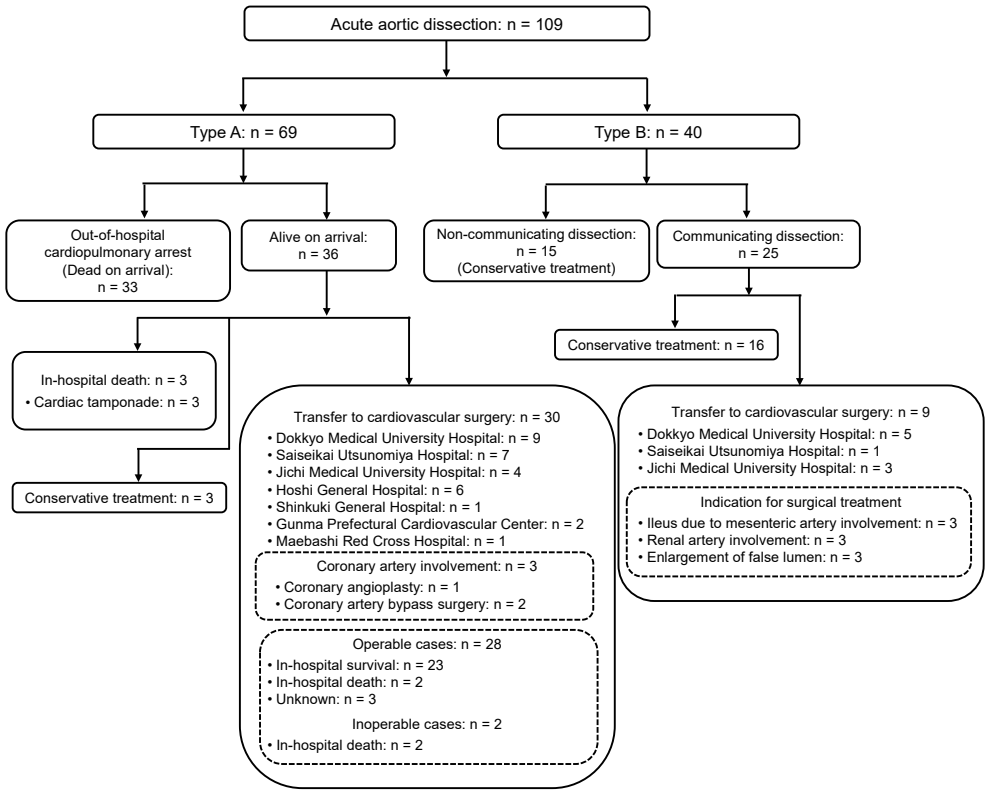


Fig. 4. Clinical course of 108 patients with acute aortic dissection in Nasu Red Cross Hospital from January 2018 to December 2021.
Type A aortic dissection was present in 68 (63%) patients and type B was present in 40 (27%) patients. In the 68 patients with type A dissection, 26 (38% of all patients with type A dissection and 24% of the total population of patients with aortic dissection) experienced an out-of-hospital cardiopulmonary arrest, were dead on hospital arrival and were diagnosed by autopsy imaging. Of 42 patients who were alive at hospital arrival, 34 were transferred to cardiovascular surgery facilities (within the prefecture: n = 25, outside the prefecture: n = 9). Six patients who could not undergo surgical treatment died in the hospital. In 40 patients with type B dissection, 9 patients were transferred to cardiovascular surgery facilities within the prefecture. No patient with type B dissection experienced in-hospital death.

aortic dissection was 33% in patients complicated with acute myocardial infarction, which is significantly higher than the rate of 8.2% in those without it (Kawahito et al. 2003). In patients with hemodynamic disruption caused by coronary perfusion failure, the operative mortality rate and the rate of postoperative low cardiac output syndrome are significantly higher when preceded by aortic surgery than when preceded by coronary angioplasty (Imoto et al. 2013). The incidence of acute myocardial ischemia secondary to type A acute aortic dissection has been reported to range from 5.7% to 11.3% (Neri et al. 2001; Eren et al. 2007), and it was 4.8% in our hospital.

In our hospital, one patient with type A aortic dissection that involved the coronary artery ostium was transferred to a cardiovascular surgery facility after undergoing an emergent coronary angioplasty. The patient was an 80-year-old woman. She complained of chest pain and subsequently became unconscious and was transported to our hospital by ambulance. On arrival at our hospital, her 12-lead electrocardiogram showed a slight ST elevation in the anterior chest leads, but her troponin I level was 0.027 ng/mL, which was slightly above the upper limit (0.016 ng/mL). However, her plasma D-dimer level was greatly elevated to 35.7 $\mu$g/mL, suggesting aortic dissection. Her echocardiogram showed extensive hypokinesis of the left ventricular anterior-to-lateral wall and the flap of the ascending aorta. She underwent contrast-enhanced CT emergently. As a result, a type A communicating aortic dissection was observed. The dissection extended from the aortic root to the aortic arch and to the thoracic descending aorta (Fig. 5). We immediately performed emergent coronary angiography and confirmed that the dissection involved the left main coronary artery wall. Subsequently, coronary angioplasty with stent implantation was performed for the left main coronary artery dissection (Fig. 6). After preservation of left ventricular function and hemodynamics was confirmed, the patient was transferred to the cardiovascular surgery facility, Dokkyo Medical University Hospital, to undergo graft replacement of the ascending aorta and the total aortic arch. Dual anti platelet therapy (aspirin plus plasugrel) was administered before PCI, and surgery was performed under aspirin alone on the next day. The patient received aspirin alone also during post-operative course. Thereafter, the patient recovered and was discharged home.

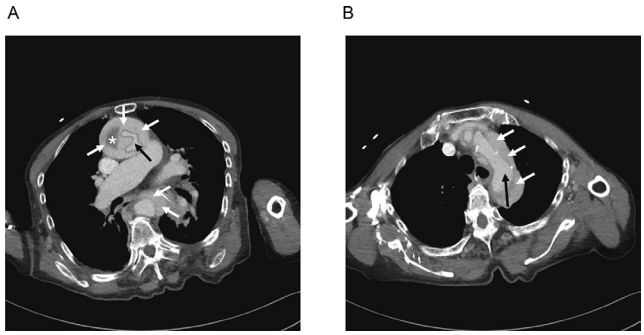


Fig. 5. Contrast-enhanced CT of an 80-year-old woman with type A communicating aortic dissection who was transferred to a facility for cardiovascular surgery after undergoing emergent coronary angioplasty.
The dissection extended from the aortic root (A) to the aortic arch (B) and to the thoracic descending aorta (A). Black and white arrows indicate true and false lumens, respectively. Thrombus formation was in part observed in the false lumen (asterisk).

## Patients with Cardiopulmonary Arrest at Hospital Arrival

Since our hospital is a core hospital that is in charge of advanced critical and emergency care, almost all cases of cardiopulmonary arrest in our area are transported to our hospital by ambulance. In our hospital, autopsy imaging using postmortem CT scans are aggressively performed for unknown cause death cases. The diagnostic accuracy of non-enhanced postmortem CT for aortic dissection is very high when three diagnostic criteria, i.e., dislocated calcification, intimomedial flap or double sedimentation are indicated (Ampanozi et al. 2015). We had 511 out-of-hospital patients who experienced cardiopulmonary arrest and were transported to our hospital by ambulance during the 3 years from January 2018 to December 2021. All patients were dead when they arrived at the hospital. Of these 511 patients, 411 (80.4%) underwent autopsy imaging with postmortem CT. Of these 411, type A aortic dissection was found in 33 patients (8.0%) (Fig. 7). It has been reported that the incidence of type A acute aortic dissection was 7% to 8% in patients who experienced out-of-hospital cardiopulmonary arrest, with a high rate of pre-hospital death (Takeuchi et al. 2020). Cardiac tamponade due to aortic rupture to the intrapericardial space has been considered the major cause of death in patients who experienced out-of-hospital cardiopulmonary arrest with type A acute aortic dissection (Tanaka et al. 2016; Takeuchi et al. 2020). In our hospital, 33 patients who had acute aortic dissection experienced out-of-hospital death (30.3% of the total population of patients with aortic dissection), while there were only 7 patients who experienced in-hospital death (6.4% of the total population of patients with aortic dissection). Therefore, 82.5% of the patients who died during the acute phase after the onset of acute aortic dissection were patients with out-of-hospital death. On the other hand, in all of 39 patients (type A: 30 patients; type B: 9 patients [35.8% of the total population of patients with aortic dissection]) who were transferred to a hospital for cardiovascular surgery, only 4 (3.7% of the total population of patients with aortic dissection) had in-hospital death (Fig. 4). According to data from the Tokyo Acute Aortic Super-network database, the

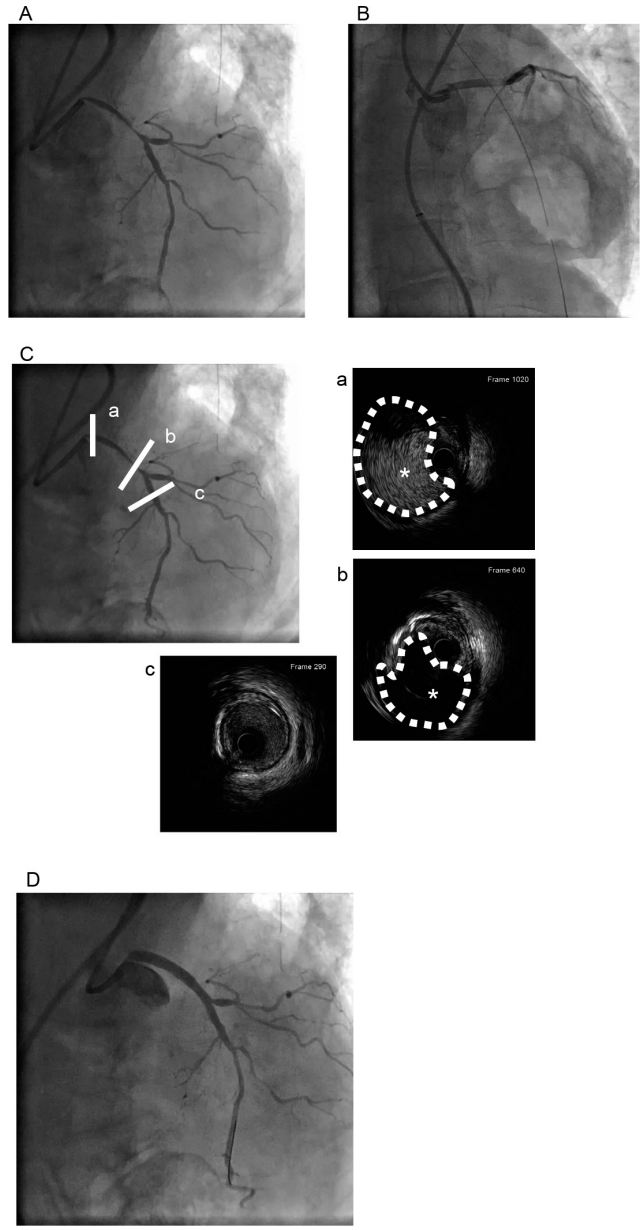


Fig. 6. Coronary angiography and subsequent coronary angioplasty.
Coronary angiography showed a tandem severe stenosis in the left main coronary artery suggesting that the dissection might involve the left coronary artery (A, B). Intravascular ultrasound imaging confirmed that the dissection involved the proximal (ostium) (C-a) and distal (C-b) left main coronary artery and thatthe true lumen was compressed. The white asterisks indicate the false lumen. The imaging of the proximal left anterior descending artery showed some plaque was present but dissection was not progressed (C-c). Subsequent coronary angioplasty with stent implantation successfully repaired the left main coronary artery dissection (D).

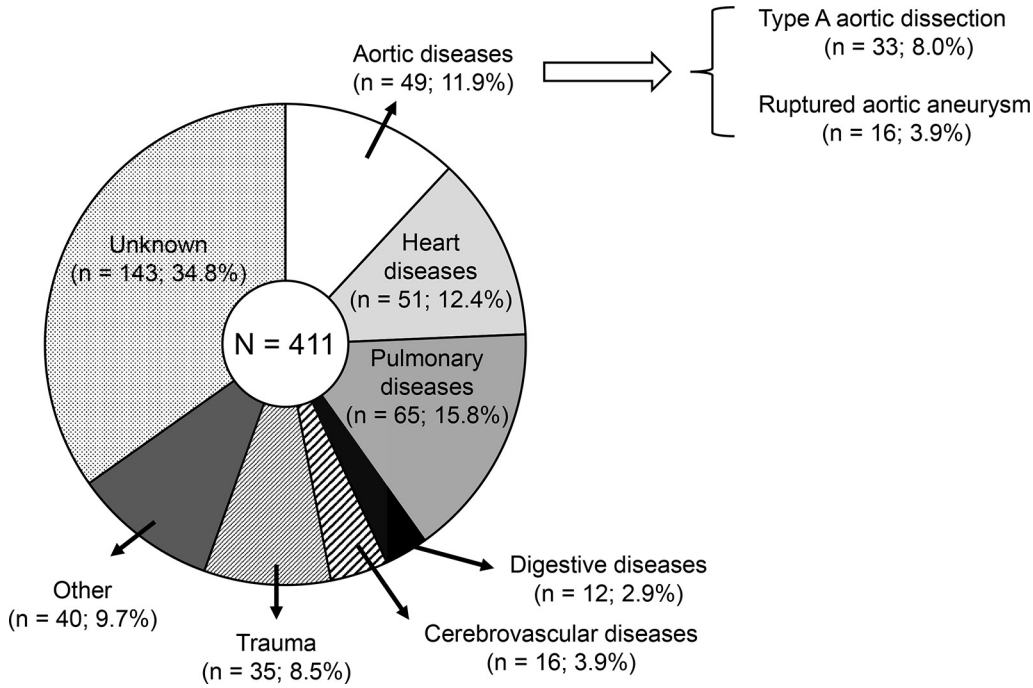


Fig. 7. Causes of death in 411 patients who underwent autopsy imaging (AI) with a postmortem CT scan.
Aortic diseases were observed in 49 patients (11.9%). Of those 49 patients, type A aortic dissection was seen in 33 (67.3% of patients with aortic diseases and 8.0% of all patients who underwent AI). Heart diseases included acute myocardial infarction, acute heart failure, cardiac tamponade, etc.; pulmonary diseases included acute pneumonia, etc.; digestive diseases included gastrointestinal rupture, gastrointestinal bleeding, etc.; cerebrovascular diseases included subarachnoid hemorrhage and cerebral hemorrhage; other diseases included carbon monoxide poisoning, drug addiction, foreign body aspiration, drowning, suicide by hanging, malnutrition, etc. In those patients, the final diagnosis was based on both clinical history and findings of autopsy imaging, as noted on the death certificate.

acute mortality rate for Type A dissection in patients who underwent surgery was 8.9%, with risk factors reported as male, use of assisted circulation, shock, cardiac arrest, myocardial ischemia, and cerebral ischemia (Yamasaki et al. 2021). Even in our hospital, the mortality rate of patients who underwent surgery at the transfer facility was never inferior to that of Tokyo, indicating that the patients were properly diagnosed and promptly transferred. Therefore, even in regional hospitals without cardiovascular surgeons, like ours, we believe that by maintaining close cooperation with cardiovascular surgery facilities and facilitating rapid transfers, it is possible for the regional hospitals to treat patients with acute aortic dissection on the same level as those in big cities.

## Challenges to Acute Aortic Dissection in a Regional Hospital Without Cardiovascular Surgeons

In regional hospitals without cardiovascular surgeons, like ours, it is difficult to treat patients with acute aortic dissection. At hospitals with cardiologists, it is important that they provide an accurate diagnosis and initial treatment and that they arrange for eligible patients to be transferred promptly to facilities equipped to perform cardiovascular surgery. To ensure a smooth transfer of patients to facilities with cardiovascular surgery, it is necessary to build a close medical cooperative system that communicates daily. In our hospital, we introduce cases while sharing images with cardiovascular surgeons on the Web to facilitate smooth transfer and post-transfer treatment. In terms of the regional medical system, it is a major problem that no hospital can perform cardiovascular surgery in the northern area of Tochigi Prefecture. Therefore, our hospital is currently preparing to establish a cardiovascular surgery section to be available in the future. However, patients with acute aortic dissection who experience out-of-hospital cardiopulmonary arrest are at high risk of death. Therefore, close cooperation between hospitals and emergency services is essential. Furthermore, it is important to educate citizens about this disease and measures for its prophylaxis.

*Conclusion*

In regional hospitals without cardiovascular surgeons, like ours, it is required to provide a qualified diagnosis and initial treatment for patients with acute aortic dissection, and for patients eligible for urgent surgical intervention to be transferred promptly to facilities with cardiovascular surgery. To ensure a smooth transfer of patients to facilities with cardiovascular surgery, it is essential to build a close medical cooperative system that communicates daily.

## Conflict of Interest

The authors declare no conflict of interest.

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