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Presentation, Diagnosis, and Outcomes of Acute Aortic Dissection

17-Year Trends From the International Registry of Acute Aortic Dissection

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ABSTRACT

BACKGROUND Diagnosis, treatment, and outcomes of acute aortic dissection (AAS) are changing.

OBJECTIVES This study examined 17-year trends in the presentation, diagnosis, and hospital outcomes of AAD from the International Registry of Acute Aortic Dissection (IRAD).

METHODS Data from 4,428 patients enrolled at 28 IRAD centers between December 26, 1995, and February 6, 2013, were analyzed. Patients were divided according to enrollment date into 6 equal groups and by AAD type: A (n = 2,952) or B (n = 1,476).

RESULTS There was no change in the presenting complaints of severe or worst-ever pain for type A and type B AAD (93% and 94%, respectively), nor in the incidence of chest pain (83% and 71%, respectively). Use of computed tomography (CT) for diagnosis of type A increased from 46% to 73% ($p < 0.001$). Surgical management for type A increased from 79% to 90% ($p < 0.001$). Endovascular management of type B increased from 7% to 31% ($p < 0.001$). Type A in-hospital mortality decreased significantly (31% to 22%; $p < 0.001$), as surgical mortality (25% to 18%; $p = 0.003$). There was no significant trend in in-hospital mortality in type B (from 12% to 14%).

CONCLUSIONS Presenting symptoms and physical findings of AAD have not changed significantly. Use of chest CT increased for type A. More patients in both groups were managed with interventional procedures: surgery in type A and endovascular therapy in type B. A significant decrease in overall in-hospital mortality was seen for type A but not for type B. (J Am Coll Cardiol 2015;66:350–8) © 2015 by the American College of Cardiology Foundation.

Much has been written about the challenges of diagnosing and treating acute aortic dissection (AAD) and the lethal consequences of failing to do so (1). The often cited historical account of George II's death in 1760 vividly describes the symptoms and catastrophic, fatal course of AAD (2). In recent years, media reports of the deaths of a number of celebrities from unrecognized AAD

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have increased the public's awareness of what remains a very dangerous and unpredictable condition (3,4). Over the past 2 decades, the exciting discovery of genetic mechanisms underlying thoracic aortic disease has begun to affect medical treatment (5,6). Greater availability and increased use of advanced imaging modalities, particularly computed tomography (CT), have the potential to improve the diagnosis of AAD (7,8). Improvement in surgical and anesthetic techniques have led to improved survival of patients with type A dissection, whereas the expanded use of endovascular interventions is having a growing effect on management of type B dissection (9,10).

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AAD usually results from a tear in the aortic intima, which allows a pressurized hematoma to form within the media between the inner two-thirds and outer one-third of the aorta. 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, which causes aortic insufficiency. Because the blood in the false lumen is contained by only the thin outer third of the media and the loose adventitial connective tissue, rupture into the pericardial space, pleural space, or mediastinum is common. Thus, AAD represents a medical and/or surgical emergency.

Although severe, abrupt onset, chest or back pain is widely known as the classic presentation of AAD, a significant minority of AADs are not diagnosed in life (11–14). Because autopsies are infrequently performed in the current era, the frequency of missed diagnoses of AAD is unknown (14). Many patients with AAD are diagnosed and treated as having acute coronary syndrome, which is a much more frequent condition than AAD. Patients who present without pain present a diagnostic challenge and are more likely to have a missed or delayed diagnosis (13–16). Advanced imaging, especially CT, has been employed with increasing frequency in emergency departments for the "triple rule out," but whether this practice has improved the diagnosis of AAD is unknown (17). Surgical treatment is indicated for all type A AADs, and medical management is used for uncomplicated type B AAD; however, long-term outcomes indicate significant late mortality from late complications in both groups (18). These complications, especially those that involve the descending thoracic aorta of type B AAD or operated type A patients with persistent false lumens, are increasingly being managed by endovascular techniques (19–21).

The International Registry of Acute Aortic Dissection (IRAD) was established in 1996 for the purpose of enrolling patients at major aortic centers to assess the presentation, management, and outcomes of AAD (22). IRAD, which includes 28 international referral centers, is a unique registry that currently allows examination of trends in patient presentation, use of advanced imaging (CT, transesophageal echocardiography [TEE], and magnetic resonance [MR]), management, and hospital outcomes over 17 years of prospective data collection.

ABBREVIATIONS AND ACRONYMS

AAD = acute aortic dissection
CT = computed tomography
MR = magnetic resonance
TEE = transesophageal echocardiography

METHODS

PATIENT SELECTION. Twenty-eight referral centers throughout North America, Europe, and Asia participated in this study. Data were collected on an unselected population of all 4,428 IRAD patients who presented with AAD from January 1996 through February 2013. Patients included in the study were identified at hospital presentation, on the basis of hospital imaging or surgical databases and/or by searching hospital diagnosis records. The diagnosis of AAD was based on patient history, diagnostic testing (including imaging results), operative findings, and/or autopsy results. Institutional Review Board approval for this study was obtained at each participating institution.

Data on patient demographic characteristics, presenting history, physical examination, imaging studies, management, and hospital outcomes were collected by each of the 28 IRAD referral centers and entered into case report forms developed by IRAD investigators; these forms include 290 variables. Case report forms were collected and reviewed by the IRAD Coordinating Center at the University of Michigan.

Patients identified as having either type A ($n = 2,952$) or type B AAD ($n = 1,476$) were divided into 6 equal groups based on 6 roughly equal time spans in chronological order over the 17-year period. Group data were analyzed for historical trends in demographic characteristics, presentation, evaluation, management, and hospital outcomes.

STATISTICAL ANALYSIS. Categorical variables were compared using 2-sided chi-square analysis or Fisher's exact test where appropriate. Linear-by-linear association was used to evaluate linear trends across time groups. Differences among patient groups stratified by time periods for continuous variables were determined utilizing 1-way analysis of variance. A p value of ≤ 0.05 was considered statistically significant. SPSS (version 20.0, IBM Corp., Armonk, New York) was used for all analyses.

RESULTS

DEMOGRAPHICS CHARACTERISTICS. Across the 17-year period, a total of 67% (n = 2,952) of all patients enrolled in IRAD presented with type A AAD, whereas the remaining 33% (n = 1,476) presented with type B AAD (Table 1). The mean age of patients with type A AAD was 62 ± 14.6 years. The mean age of those with type B AAD was older, at 64 ± 14.1 years. Two-thirds of patients were men, a proportion that did not change over time. The majority of patients enrolled in the overall study were identified as white (87%). Almost 70% of all patients were referred from a primary site to an IRAD center. An increase was seen in the proportion of patients referred from a primary site to an IRAD center for type A patients over the 17-year period (from 62% to 71%) but there was no significant trend for type B patients (from 62% to 68%).

Slightly >4% of all patients enrolled in the study had Marfan syndrome (5% and 4% of type A and type B AAD, respectively). Over time, fewer patients presenting with type A AAD also had Marfan syndrome, whereas the proportion of those presenting with type B AAD who had Marfan syndrome did not change significantly. A majority of patients had a history of hypertension (77% overall), which was more prevalent in those with type B AAD than in those with type A AAD (81% vs. 74%). This prevalence did not change.

TABLE 1 Demographics and History of Patients With Acute Aortic Dissection

Category	Total (N = 4,428)	Type A (n = 2,952)	Type B (n = 1,476)	p Value Type A vs. Type B
Demographics				
Age, yrs		61.5 ± 14.6	63.6 ± 14.1	<0.001
Male	2,964 (66.9)	1,992 (67.5)	972 (65.8)	0.272
Referred from primary site to IRAD center	3,089 (69.7)	2,022 (68.5)	1,067 (72.2)	0.010
Ethnicity				
White	3,609 (86.4)	2,455 (88.6)	1,154 (82.1)	<0.001
Asian	184 (4.4)	101 (3.6)	83 (5.9)	
Black	295 (7.1)	164 (5.9)	131 (9.3)	
Hispanic	57 (1.4)	29 (1.0)	28 (2.0)	
Other	31 (0.7)	22 (0.8)	9 (0.6)	
Patient history				
Marfan syndrome	178 (4.4)	122 (4.5)	56 (4.0)	0.404
Hypertension	3,247 (76.6)	2,089 (74.4)	1,158 (80.9)	<0.001
Atherosclerosis	1,079 (26.5)	636 (23.8)	443 (31.7)	<0.001
Known aortic aneurysm	628 (15.5)	337 (12.7)	291 (20.7)	<0.001
Previous AAD	232 (5.7)	107 (4.0)	125 (8.9)	<0.001
Diabetes mellitus	316 (7.8)	204 (7.7)	112 (8.0)	0.673
Previous cardiac surgery	643 (16.1)	374 (14.2)	269 (19.6)	<0.001
Aortic valve replacement	203 (5.1)	118 (4.5)	85 (6.2)	0.022
Aortic aneurysm and/or AAD	368 (9.2)	168 (6.4)	200 (14.5)	<0.001
Coronary artery bypass graft surgery	196 (4.9)	130 (5.0)	66 (4.8)	0.851
Mitral valve replacement	35 (0.9)	24 (0.9)	11 (0.8)	0.726
Iatrogenic	118 (2.8)	85 (3.0)	33 (2.3)	0.212

Values are mean ± SD or n (%).
AAD = acute aortic dissection; IRAD = International Registry of Acute Aortic Dissection.

PRESENTING SYMPTOMS AND PHYSICAL EXAMINATION. Most patients presented with severe pain of abrupt onset, regardless of AAD type. Overall, over time, there was no change in the presenting complaint of severe or worst-ever pain (93% in type A, 94% in type B) or in the incidence of chest pain (83% in type A, 71% in type B). Overall, a higher proportion of patients with type A complained of chest pain (85% in type A vs. 67% in type B), and more patients with type B reported back pain (70%) compared with those with type A AAD (43%). Far more patients with type A presented with syncope than those with type B, with no change over time (19% and 3%, respectively). More patients with type B presented with hypertension than patients with type A (66% and 28%, respectively), with no difference seen over time. There was no change in the prevalence of pulse deficits on presentation for type A or for type B (type A: 31% and type B: 19%).

DIAGNOSTIC TESTING. In the later years of data collection, fewer abnormal chest x-rays were reported for both type A and type B AAD patients. Reports of a widened mediastinum on chest x-ray decreased among those with type A (from 61% to 52%) and among those with type B (from 56% to 39%). Furthermore, reports of a normal chest x-ray on presentation increased significantly in type A (from 13% to 29%) and in type B (from 19% to 36%).

A normal electrocardiogram was noted in 36% of type A patients and 38% of type B patients and increased slightly over time in both type A and type B patients.

The frequency of the use of chest CT as the initial diagnostic imaging modality increased over time in type A patients, from 46% to 73%, over the 17-year period. However, the frequency in type B patients did not change. Conversely, the use of TEE as the first diagnostic imaging study decreased from 50% to 23% in type A patients. TEE was used less often (12%) to initially evaluate those with type B, with no change over time. Invasive aortography and MR imaging were rarely used as initial diagnostic imaging modalities, and the frequency of their use did not change over time for either dissection type.

MANAGEMENT AND OUTCOMES. Discharge medications changed significantly over time. In type A AAD, patients were more frequently discharged on beta-blockers, diuretics, and statins in the later time periods. Fewer vasodilators were prescribed in this group. Compared with earlier time periods, more recent type B patients were more commonly given

TABLE 2 Management and Outcomes of Acute Aortic Dissection

Category	Type A (n = 2,952) Management				Type B (n = 1,476) Management			
	Surgical	Medical	Endo	Hybrid	Surgical	Medical	Endo	Hybrid
n	2,552 (86.4)	329 (11.1)	34 (1.2)	36 (1.2)	192 (13.0)	923 (62.5)	341 (23.1)	21 (1.4)
In-hospital mortality*	502 (19.7)	188 (57.1)	24 (70.6)	5 (13.9)	33 (17.2)	80 (8.7)	42 (12.3)	3 (14.3)
Total mortality ($p < 0.001$)	721 (24.4)				158 (10.7)			

Values are n (%). *$p < 0.001$ for Type A mortality between management types; $p = 0.003$ for Type B mortality between management types.
Endo = endovascular.

angiotensin receptor blockers, beta-blockers, and statins and also showed a decrease in the prescription of other vasodilators.

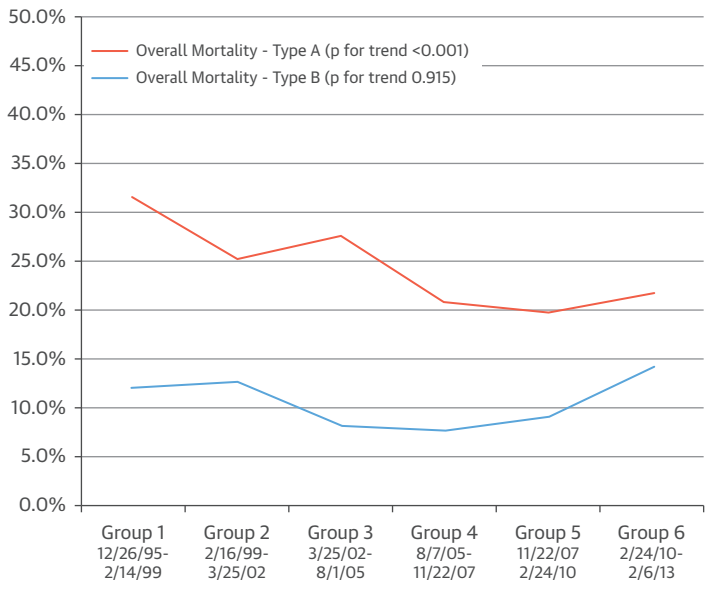
The majority of patients presenting with type A AAD were managed surgically (86% overall) (Table 2), with significantly more operative procedures undertaken in the later time periods (79% to 90%) (Table 3). Over time, the in-hospital mortality rate of patients presenting with type A decreased significantly from 31% to 22% (Figure 1), primarily due to a decline in the

TABLE 3 Trends in Type A Dissection

Category	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	p Value	Trend p Value
History and demographics								
Age, yrs	61.3 ± 14.8	60.7 ± 15.1	61.3 ± 14.5	61.4 ± 14.7	61.9 ± 14.0	62.5 ± 14.4	0.540	–
Male	314 (64.1)	316 (67.2)	350 (68.9)	339 (71.1)	345 (66.5)	328 (67.1)	0.294	0.413
White	377 (88.5)	401 (91.8)	461 (94.7)	394 (86.2)	420 (85.5)	402 (85.0)	<0.001	0.009
Referred from primary center	304 (62.0)	312 (66.4)	344 (67.7)	351 (73.6)	365 (70.3)	346 (70.8)	0.003	<0.001
Marfan syndrome	26 (5.7)	26 (6.2)	17 (4.0)	23 (5.1)	10 (2.1)	20 (4.5)	0.041	0.033
Hypertension	331 (70.9)	330 (73.0)	371 (79.3)	327 (70.8)	382 (76.7)	348 (75.5)	0.014	0.125
Atherosclerosis	124 (27.0)	121 (28.3)	109 (25.6)	91 (20.4)	107 (22.2)	84 (19.4)	0.006	<0.001
Previous cardiac surgery	69 (16.4)	82 (21.0)	67 (15.2)	60 (13.4)	49 (10.1)	47 (10.6)	<0.001	<0.001
Presenting symptoms and signs								
Severe or worst-ever pain	362 (91.6)	309 (92.5)	367 (94.1)	353 (92.4)	398 (92.6)	365 (93.1)	0.854	0.604
Chest pain: anterior	313 (78.3)	293 (75.9)	333 (83.7)	307 (85.5)	323 (93.4)	328 (93.4)	<0.001	<0.001
Tearing or ripping pain	112 (64.4)	88 (80.0)	75 (49.7)	75 (27.3)	58 (16.7)	72 (23.8)	<0.001	<0.001
Syncope	67 (16.1)	82 (20.8)	94 (22.9)	60 (13.6)	84 (17.2)	93 (21.6)	0.003	0.648
Presenting hypertension	134 (28.8)	114 (25.9)	105 (23.5)	135 (32.0)	138 (28.6)	121 (27.0)	0.108	0.674
Pulse deficits on presentation	112 (29.6)	90 (28.8)	105 (32.5)	99 (29.6)	88 (31.5)	75 (31.9)	0.885	0.451
Normal chest x-ray	49 (12.7)	49 (14.6)	74 (25.2)	92 (31.6)	99 (30.1)	72 (28.6)	<0.001	<0.001
Widened mediastinum on chest x-ray	233 (60.8)	195 (59.3)	158 (54.5)	118 (42.8)	130 (43.6)	108 (52.2)	<0.001	<0.001
Normal ECG	152 (33.5)	135 (31.3)	153 (35.4)	143 (36.4)	178 (38.9)	166 (40.7)	0.050	0.002
Use of CT as initial imaging modality	214 (45.8)	232 (54.5)	299 (61.1)	313 (70.5)	326 (68.2)	312 (72.9)	<0.001	<0.001
Use of TEE as initial imaging modality	233 (49.9)	178 (41.8)	176 (36.0)	122 (27.5)	134 (28.0)	99 (23.1)	<0.001	<0.001
Discharge medications								
ACE inhibitors	124 (39.2)	118 (38.4)	115 (43.7)	114 (41.8)	165 (47.1)	144 (43.2)	0.234	0.051
Angiotensin II receptor blockers	1 (33.3)	3 (14.3)	6 (7.8)	9 (7.8)	64 (22.5)	35 (11.4)	<0.001	0.555
Beta-blockers	248 (76.3)	263 (84.6)	253 (86.9)	249 (86.2)	331 (85.8)	304 (87.6)	0.001	<0.001
Calcium-channel blockers	104 (34.2)	110 (37.5)	105 (40.5)	99 (36.4)	110 (31.9)	121 (36.1)	0.347	0.602
Diuretics	13 (86.7)	10 (43.5)	16 (22.9)	41 (36.9)	104 (37.5)	166 (53.2)	<0.001	0.016
Statins	0 (0.0)	2 (11.1)	7 (10.6)	16 (20.8)	77 (30.9)	107 (38.8)	<0.001	<0.001
Vasodilators	57 (19.1)	56 (19.4)	37 (14.7)	25 (11.3)	24 (9.4)	20 (7.2)	<0.001	<0.001
In-hospital management and outcomes								
Surgical management	384 (78.7)	409 (87.0)	439 (86.4)	424 (88.9)	455 (87.7)	441 (90.2)	<0.001	<0.001
Medical management	99 (20.3)	57 (12.1)	53 (10.4)	35 (7.3)	46 (8.9)	39 (8.0)	<0.001	<0.001
Overall mortality	154 (31.4)	119 (25.3)	140 (27.6)	99 (20.8)	103 (19.8)	106 (21.7)	<0.001	<0.001
Surgical mortality	96 (25.0)	80 (19.6)	97 (22.1)	76 (17.9)	72 (15.8)	81 (18.4)	0.015	0.003
Medical mortality	54 (54.5)	37 (64.9)	34 (64.2)	17 (48.6)	24 (52.2)	22 (56.4)	0.512	0.626

Values are mean ± SD or n (%).
ACE = angiotensin-converting enzyme; CT = computerized tomography; ECG = electrocardiography; TEE = transesophageal echocardiogram.

FIGURE 1 Mortality Over Time by Dissection Type



Trends in mortality among patients with type A and type B acute aortic dissection over 17 years of International Registry of Acute Aortic Dissection data collection.

surgical mortality rate from 25% to 18% (**Central Illustration**). The in-hospital mortality rate among those managed medically remained high (57%) and did not change. Endovascular repair alone was performed to treat distal malperfusion in a very limited number of Type A patients; these patients had a high mortality rate (71% overall).

The majority of patients with type B AAD were treated medically (63% of the entire cohort). This percentage decreased (75% to 57%) as endovascular management increased from 7% to 31% (**Table 4**). Traditional surgical management of type B also decreased (17% to 8%), although there was an increase in hybrid procedures that used surgical debranching techniques (left subclavian artery bypass or transposition) to facilitate endovascular intervention (0% to 5%). The overall in-hospital mortality rate of patients presenting with type B did not change significantly (**Figure 1**). Although a decreasing number of type B patients underwent surgical management, the mortality for these few patients improved over time, which possibly suggests an improved selection of management strategy for those patients who required further intervention.

DISCUSSION

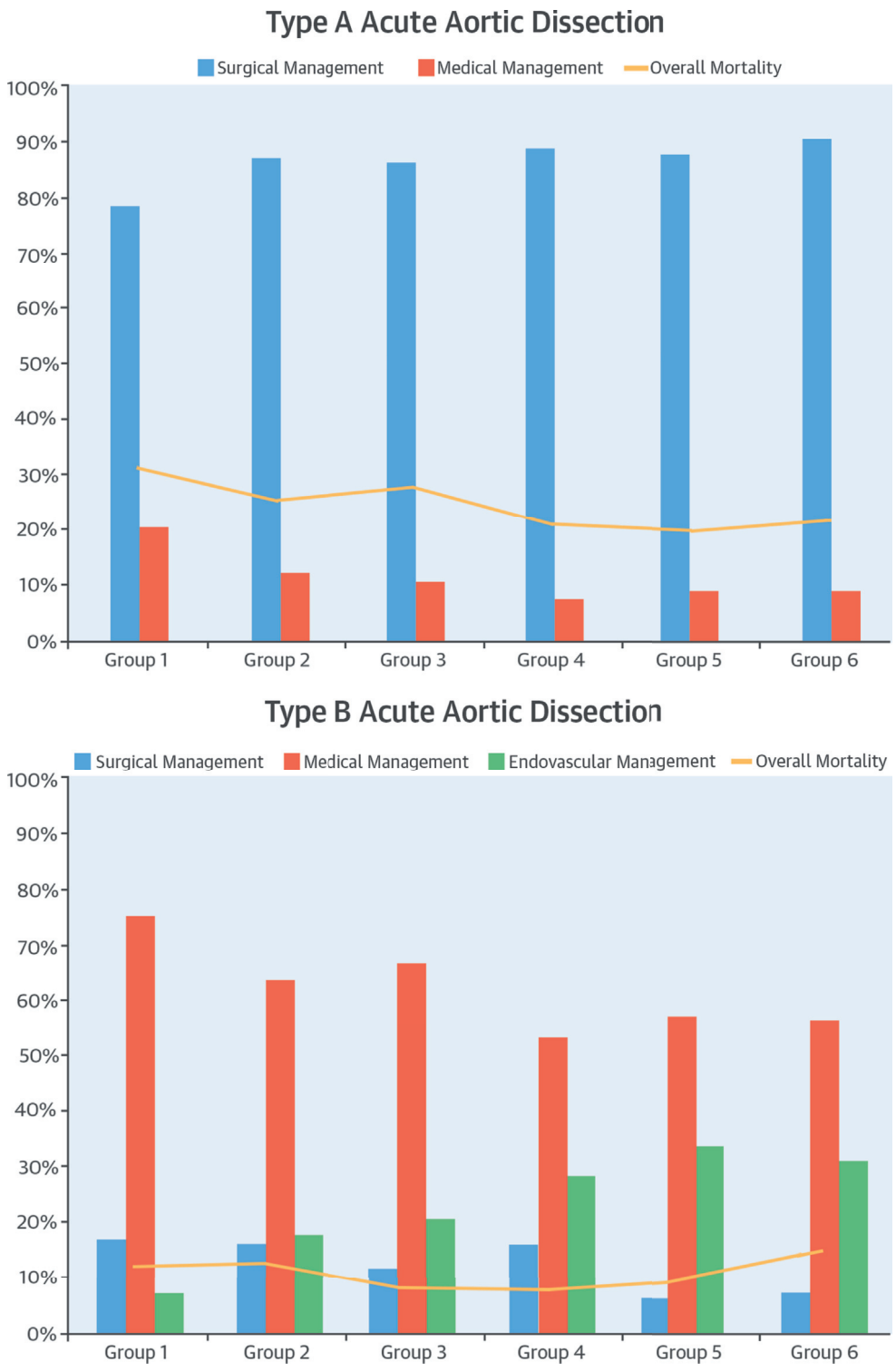
Acute aortic dissection is a life-threatening condition that remains challenging to diagnose and treat. Patients present as acutely ill with a variety of symptoms and signs, many of which can mimic more common conditions such as myocardial ischemia or pulmonary embolism. Since their first publication in 2000, IRAD investigators have reported a number of clinical observations derived from the large registry of patients with AAD, not only to raise awareness of this challenging and often fatal condition but also to provide insights to help guide diagnosis and treatment (22,23). These reports have included snapshot observations regarding presenting symptoms, physical findings, results of diagnostic imaging, management, and hospital outcomes of patients with both type A and type B AAD. In this analysis, we have sought to evaluate the temporal changes in these parameters over a 17-year time frame.

Notably, patients with type A dissection were increasingly transferred from referral centers to IRAD hospitals. Although IRAD could not discern the exact reasons for this trend, it is possible that increased attention to the need for emergent surgery in this patient population precipitated the rise in transfers. In addition, the increased use of CT imaging over time in type A patients (but not type B) might have contributed to earlier recognition of type A AAD. As reported by IRAD and many earlier investigators, severe or worst-ever chest pain continues to be the most common presenting feature in both type A and type B AAD (24,25). One dramatic change, however, has been the decrease in the reporting of "ripping or tearing" pain among patients with AAD. This is in contrast to earlier studies that highlighted the characteristics of ripping and tearing, along with "migratory," as common terms used by patients to describe the quality of their presenting pain and as a way of differentiating pain that suggested AAD from that indicating other clinical conditions (25). We believe this difference in qualitative pain description is likely related to a change in emphasis on history taking and/or data collection, rather than an actual change in presenting symptoms. In addition, retrospective data collection from hospital records for the majority of the registry patients might also not have captured this information accurately.

Patients with type B AAD remain more likely to present with hypertension than those with type A AAD. As expected, patients with type A are more likely to present with pulse deficits, an observation that has not changed over time. However, pulse deficits are identified in only a minority of patients with dissection, and thus have little negative predictive value.

With regard to diagnostic testing, chest x-rays historically have been said to "almost always reveal an abnormal aortic contour" (25,26). For example, in 1 study that antedated the use of modern

CENTRAL ILLUSTRATION **Trends in Acute Aortic Dissection Over 17 Years**



Pape, L.A. et al. J Am Coll Cardiol. 2015; 66(4):350–8.

Type A (n = 2,952) and type B (n = 1,476) acute aortic dissection patients divided into equal-sized groups based on time of enrollment, 1996 to 2013.

TABLE 4 Trends in Type B Dissection

Category	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	p Value	Trend p Value
History and demographics								
Age, yrs	66.7 ± 12.7	61.8 ± 13.9	63.9 ± 14.0	61.7 ± 14.5	63.1 ± 15.0	64.7 ± 14.2	<0.001	—
Male	173 (69.8)	180 (67.2)	146 (63.2)	178 (68.2)	137 (62.3)	158 (63.5)	0.400	0.108
White	191 (82.3)	207 (80.9)	195 (87.1)	190 (78.8)	162 (77.5)	209 (86.0)	<0.001	0.617
Referred from primary center	153 (61.7)	205 (76.5)	175 (75.8)	204 (78.2)	160 (72.7)	170 (68.3)	<0.001	0.327
Marfan syndrome	5 (2.1)	15 (5.7)	7 (3.1)	7 (2.9)	13 (6.2)	9 (4.0)	0.140	0.363
Hypertension	193 (79.1)	203 (76.9)	191 (83.8)	204 (83.6)	172 (80.4)	195 (82.3)	0.310	0.190
Atherosclerosis	98 (41.4)	85 (32.2)	81 (36.2)	50 (21.1)	57 (27.1)	72 (32.0)	<0.001	0.003
Known aortic aneurysm	48 (19.9)	52 (19.9)	49 (21.9)	52 (21.4)	44 (21.1)	46 (20.4)	0.993	0.803
Presenting symptoms and signs								
Severe or worst-ever pain	200 (93.0)	198 (95.2)	175 (94.1)	203 (91.9)	186 (94.4)	201 (93.3)	0.781	0.995
Chest pain: anterior	109 (54.0)	143 (64.7)	99 (58.9)	116 (70.7)	109 (80.1)	129 (78.2)	<0.001	<0.001
Tearing or ripping pain	74 (67.3)	71 (79.8)	52 (56.5)	46 (28.4)	51 (29.1)	51 (29.7)	<0.001	<0.001
Syncope	6 (2.5)	11 (4.2)	4 (1.9)	6 (2.5)	5 (2.5)	13 (6.0)	0.129	0.223
Presenting hypertension	169 (69.0)	164 (63.1)	151 (70.6)	137 (60.4)	139 (68.8)	141 (63.5)	0.134	0.432
Pulse deficits on presentation	31 (14.9)	48 (20.9)	30 (15.9)	36 (17.8)	30 (21.0)	33 (24.3)	0.220	0.075
Normal chest x-ray	46 (19.4)	36 (15.7)	55 (28.8)	74 (36.8)	62 (35.2)	62 (36.3)	<0.001	<0.001
Widened mediastinum	132 (56.4)	117 (52.5)	63 (34.2)	57 (30.8)	51 (32.5)	50 (39.1)	<0.001	<0.001
Normal ECG	74 (31.1)	67 (26.7)	81 (38.9)	91 (42.1)	93 (47.7)	100 (47.4)	<0.001	<0.001
Use of CT as initial imaging modality	187 (77.9)	190 (82.3)	183 (82.4)	187 (86.2)	175 (91.1)	153 (78.1)	0.003	0.119
Use of TEE as initial imaging modality	36 (15.0)	26 (11.3)	28 (12.6)	26 (12.0)	10 (5.2)	33 (16.8)	0.012	0.566
Discharge medications								
ACE inhibitors	84 (41.4)	126 (56.3)	112 (56.6)	100 (55.2)	97 (53.6)	98 (54.4)	0.019	0.061
Angiotensin II receptor blockers	—	1 (7.1)	6 (9.7)	10 (10.9)	27 (16.4)	40 (23.4)	0.034	0.002
Beta-blockers	183 (83.9)	214 (91.8)	196 (96.1)	171 (91.9)	186 (94.4)	177 (91.2)	<0.001	0.011
Calcium-channel blockers	114 (55.3)	144 (64.6)	130 (64.7)	121 (66.5)	124 (65.6)	116 (63.7)	0.207	0.098
Diuretic	—	9 (64.3)	25 (38.5)	33 (34.0)	61 (37.7)	79 (45.7)	0.114	0.546
Statins	—	1 (7.1)	8 (14.3)	20 (28.6)	62 (43.1)	72 (45.6)	<0.001	<0.001
Vasodilators	58 (29.1)	83 (39.2)	60 (31.9)	28 (18.8)	40 (28.0)	33 (24.3)	0.001	0.014
In-hospital management and outcomes								
Surgical management	43 (17.3)	45 (16.8)	28 (12.1)	43 (16.5)	14 (6.4)	19 (7.6)	<0.001	<0.001
Medical management	187 (75.4)	173 (64.6)	155 (67.1)	140 (53.6)	127 (57.7)	141 (56.6)	<0.001	<0.001
Endovascular management	18 (7.3)	49 (18.3)	48 (20.8)	74 (28.4)	75 (34.1)	77 (30.9)	<0.001	<0.001
Hybrid management	0 (0.0)	1 (0.4)	0 (0.0)	4 (1.5)	4 (1.8)	12 (4.8)	<0.001	<0.001
Overall mortality	30 (12.1)	34 (12.7)	19 (8.2)	20 (7.7)	20 (9.1)	35 (14.1)	0.103	0.915
Surgical mortality	13 (30.2)	12 (26.7)	1 (3.6)	3 (7.0)	0 (0.0)	4 (21.1)	0.003	0.007
Medical mortality	17 (9.1)	16 (9.2)	11 (7.1)	10 (7.1)	9 (7.1)	17 (12.1)	0.630	0.705
Endovascular mortality	0 (0.0)	6 (12.2)	7 (14.6)	7 (9.5)	10 (13.3)	12 (15.6)	0.528	0.216

Values are mean ± SD or n (%).
Abbreviations as in Table 3.

cross-sectional imaging, 85% of patients were found to have chest x-rays with an abnormal aortic contour, widened superior mediastinum, or separation of the aortic wall intimal calcification from the outer margin of the aorta (25). The reported incidence of normal chest x-rays among patients with AAD has increased over time. Furthermore, the finding of a widened mediastinum on chest x-rays of IRAD patients has been less frequent than historic norms and has been found in only 54.3% of type A patients and 43.1% of type B patients. The reason for this change is not entirely clear. One possibility is that with the increased use of and emphasis on the diagnostic capabilities of chest CT, less attention has been paid to the conventional chest x-ray. It is also possible that chest x-rays are currently obtained in only a subset of patients because many patients with suspected AAD are referred directly to chest CT. In addition, many patients with AAD do not have dilation of the aorta, which would be evident on a chest x-ray (27).

The use of chest CT has increased significantly in AAD and has become the imaging modality of first choice for the diagnosis of AAD. Improved spatial resolution, faster scanning rates, algorithms to limit radiation dose, increased availability, and reduced cost likely account for its greater rate of use. The

frequency of the use of TEE as the initial diagnostic imaging study has also decreased.

Significant trends in type A medications prescribed at discharge were noted, with more beta-blockers and statins being prescribed in recent years, but fewer diuretics and other vasodilators. Type B patients received more discharge angiotensin receptor blockers, beta-blockers, and statins but received fewer vasodilators. As awareness of the importance of blood pressure management increases, especially in the post-dissection patient, it is possible that physicians have more diligently attempted to achieve the blood pressure targets recommended by national guidelines (28). Furthermore, studies on the impact of angiotensin on aortic dilation have correlated temporally with a significant increase in the use of these drugs in type B AAD patients with descending thoracic aortic disease (29,30). It was not possible to ascertain the reasons for some of these trends from the data available through IRAD.

Advances in the treatment of AAD were reflected in our IRAD findings. The number of type A patients who underwent surgical intervention increased significantly over time, likely due in part to more rapid diagnosis, the increased safety and efficacy of aortic replacement procedures, and advances in hypothermic circulatory arrest, cerebral perfusion strategies, cardiopulmonary bypass, and post-operative care. In type B patients, the use of endovascular therapies as alternatives to medical and open surgical strategies increased significantly over time (20). The potential impact of aortic remodeling on longer term aortic and clinical outcomes in patients who received a stent graft requires further study. A single randomized study demonstrated improved survival for uncomplicated type B patients at 5 years post-dissection compared with those who received medical therapy alone (10,19). Furthermore, the less invasive endovascular strategy was shown in observational studies to favorably influence mortality in complicated type B AAD patients, who would have required open surgical management in the past (31).

In the 17-year span over which this analysis was performed, overall mortality in patients with type A AAD declined. Notably, surgical mortality in patients with type A and type B AAD decreased significantly. Bekkers et al. (32) recently reported the evolution of surgical techniques and reduced mortality in an observational series of 232 type A AAD patients operated on between 1972 and 2011. Improvements in AAD outcomes were likely due to a number of factors: earlier detection, improved diagnostic imaging, advances in surgical and endovascular techniques, and coordinated post-operative and medical management. One of the goals of reporting the observations from IRAD is to increase awareness of AAD, its various presentations, diagnostic and treatment strategies, and outcomes, thereby improving the care of these patients worldwide.

Detailed data on the use of differing surgical techniques, such as methods of cerebral perfusion and hybrid procedures, were not included in the initial IRAD data collection, although more detailed surgical data are being collected prospectively in a subset of patients. Endovascular stent grafting for complicated type B AAD has only recently become a component of routine care, based largely on observational outcomes.

STUDY LIMITATIONS. IRAD participation is voluntary; thus, our observations were limited by the constraints imposed by data collection from a limited number of sites involved in the care of patients with AAD. There is no core laboratory to review images, and all investigators are responsible for reporting patient findings at their institutions. Most of the data regarding patient history and physical examination findings are obtained by retrospective chart review. The participating centers are tertiary referral centers, and thus the patients are by definition those who survive to arrive at such centers. Although participating investigators attempt to include all patients at their institutions, there is no certainty that the registry is representative of all patients with AAD. Little information is available regarding cause of death in the IRAD population; therefore, we could not evaluate changes in the cause of death over time.

CONCLUSIONS

The most notable changes over time in the presentation, diagnosis, treatment, and outcomes of patients with AAD include an increase in the frequency of use of chest CT as the primary imaging modality, an increase in the frequency with which normal chest x-rays are reported, more frequent treatment of type A patients with surgery, and increased use of endovascular therapies for the management of patients with complicated type B AAD. Type A patients demonstrated improved mortality over time, both overall and among surgical patients alone. Observational registry data of the type reported from IRAD are an important source of information that can be used to influence algorithms for diagnosis and treatment.

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PERSPECTIVES

COMPETENCY IN SYSTEMS-BASED PRACTICE: Patients with type A AAD have been more frequently managed surgically in recent years with decreasing mortality, and endovascular repair is increasingly used at referral centers for patients with complicated type B dissection.

TRANSLATIONAL OUTLOOK: Evaluation of the relative efficacy of available alternative management strategies for patients with AAD dissection would optimally be derived from randomized trials. Because of the acuity, unpredictability, and diversity of clinical presentations, resources, and practice patterns, innovative regionally oriented trial designs are needed.

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