

# Acute Descending Aortic Dissections: Management of Visceral, Spinal Cord, and Extremity Malperfusion

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Acute descending aortic dissection is considered the most catastrophic event affecting the aorta and occurs two to three times more often than rupture of abdominal aortic aneurysms. The therapeutic aim in treating acute dissection is not only directed at the prevention of aneurysmal development and rupture but also to prevent and treat complications such as malperfusion syndrome. According to Lauterbach and coworkers patients with symptomatic malperfusion syndromes have a 51% mortality rate compared with a 29% mortality rate in patients who do not. The surgical in-hospital mortality rate in patients with mesenteric or peripheral vascular ischemic complications may be as high as 89%. Despite an improvement in diagnosing dissections and malperfusion syndromes, and despite improved operative techniques and a better understanding of the significance of perioperative care, the surgical mortality rate can be as high as 50%. Endovascular techniques are constantly evolving that provide an alternative to open procedures. The goal of this article was to review the pathogenesis of malperfusion syndromes in aortic dissection, discuss the current modalities to treat malperfusion of the spinal cord, viscera, and extremities, and examine the results of the treatments used today.

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Acute aortic dissection is a devastating event affecting the aorta and in most reports occurs two to three times more frequently than rupture of abdominal aortic aneurysms. The classification of a dissection as acute is reserved for those with an onset of 2 weeks or less. Any dissection older than 2 weeks is termed subacute or chronic. This classification system is used not to determine therapeutic options but rather to determine the likelihood of survival in an individual patient.<sup>1</sup> Up to 40% of patients die instantly from acute dissection,<sup>2</sup> whereas the mortality rate of medically and surgically treated patients with a type B dissection who survive the first 30 days is 10.7 and 31.4%, respectively, according to the International Registry of Acute Aortic Dissection (IRAD).<sup>3</sup> Two-thirds of aortic dissections involve the ascending portion with the remaining one-third limited to the descending aorta.<sup>4</sup>

The etiologic factors predisposing to aortic dissection include hypertension, connective tissue disorders such as Marfan and Ehlers–Danlos syndromes, pregnancy, and

trauma.<sup>5</sup> Hypertension is the most common predisposing factor for aortic dissection and according to several authors is seen in 70 to 90% of patients.<sup>2,3,6</sup> Those surviving the immediate event may suffer complications including rupture and ischemia, accounting for up to a 30% mortality rate.<sup>4</sup> Occlusion of aortic branch vessels such as the celiac, superior mesenteric, renal or iliac arteries, or the aorta itself may result in ischemia and possible end-organ damage. Despite the improvements made with regard to treatment of acute aortic dissection, the initial management remains controversial. Several large series have reported that medical management is justified in the acute setting in the stable patient with no evidence of rupture, leak, or malperfusion. However emergency operative intervention is crucial to prevent or relieve life-threatening complications in the patient with a complicated aortic dissection.<sup>5</sup>

## History

Early descriptions of aortic dissections emerged in the 17th and 18th centuries by several authors, most notably, Morgagni, who described in detail the pathology of a dissecting aneurysm in 1761.<sup>2,5,7</sup> Maunoir further described the entity of dissection 40 years later.<sup>2,5</sup> The term dissection was

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Table 1 Incidence of Aortic Branch Vessel Obstruction

Author	Year	Cases	Thoracoabdominal						
			Coronary	Subclavian	Carotid	Mesenteric	Renal	Spinal	Iliofemoral
Crowell	1921	215		12 (5.6)	35 (16.2)	9 (4.2)	7 (3.2)		65 (30)
Shennan	1934	300			20 (6.6)	7 (2.3)			
Hirst et al	1958	505	39 (7.7)	71 (13.9)	89 (28)	60 (11.9)	63 (12.4)	9 (1.8)	132 (26.1)
Hume and Porter	1963	61			20 (6.6)	7 (2.3)			
DeBakey et al	1982	527			21 (4)	35 (6.6)		10 (1.9)	36 (6.8)
Cambria et al	1988	325		17 (5.2)	26 (8)	19 (5.8)	17 (5.2)		43 (13.2)
Sarris and Miller	1989	102		18 (17.6)	6 (5.8)	14 (13.7)		7 (6.8)	20 (19.6)
Fann et al	1990	272		18 (6.6)	7 (2.6)	14 (5.1)	24 (8.8)	9 (3.3)	48 (17.6)
Heinemann et al	1994	320	15 (4.7)		19 (5.9)	33 (10.3)			

Note. Numbers in parentheses are percentages.  
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coined in 1819 by Laennec, who described an *aneurysme dissequant*.<sup>7</sup> In 1935 Gurin performed the first successful fenestration of the dissecting membrane in an iliac artery to reperfuse an ischemic extremity; however, the patient subsequently died to renal failure.<sup>5,7</sup> Before this historic procedure, the diagnosis of aortic dissection had been a finding only at the time of autopsy.<sup>2</sup> Cooley and DeBakey paved the way for the treatment of aortic dissection following their first successful repair of a dissection in 1955.<sup>7</sup> More recently the goal in aortic dissection has focused on minimizing the complications of malperfusion. In 1957 Cooley and associates began using left heart bypass to maintain perfusion to the spinal cord and other organs while replacing the descending aorta. Wheat and colleagues and Austen were at the forefront in defining the role of medical therapy in the treatment of aortic dissection and described the benefit of antihypertensive medication. The advent of endovascular techniques in the treatment of aortic dissection and associated malperfusion is a long way from the medieval writings of Sennertus, who first described separation of the aortic wall as a disease process.<sup>5</sup>

## Mechanisms of Malperfusion

Aortic dissection occurs when blood enters the aortic wall through an intimal tear splitting the aortic tunica media resulting in two communicating flow channels known as the true and false lumens. These channels are separated by a dissecting membrane known as the intimomedial membrane or flap. The dissection may re-enter the true lumen at a distal site or may end in a blind pocket which may then thrombose. The dissection classically weakens the outer wall of the media, which may lead to dilation of the false lumen and subsequent aortic rupture. According to the IRAD study, in patients with type B dissection the most common cause of death is aortic rupture, accounting for 38.5% of deaths.<sup>3</sup> Dissection of the thoracoabdominal aorta most commonly occurs in the left posterolateral aspect of the aorta, thereby routinely affecting the intercostal arteries. Below the diaphragm the left renal artery most often arises from the false lumen and is often at ischemic risk in patients with dissection. The right renal artery as well as the visceral arteries often arise from the true lumen, but may nevertheless be compromised. Beyond the

aortic bifurcation the left-sided vessels tend to be involved in 80% of patients.<sup>5</sup>

Occlusion of aortic branch vessels is thought to occur in approximately 30% of patients with acute dissection.<sup>7</sup> The presence of occluded aortic branches increases morbidity and mortality and changes treatment strategies. Several authors have reported the incidence of aortic branch vessel obstruction in their experience (Table 1).

There are several mechanisms by which malperfusion can occur in the setting of aortic dissection. A circumferential tear with intimomedial intussusception can cause complete aortic obstruction; however, this is rare. More commonly the true lumen is compressed by the false lumen. This compression of the true lumen by the false lumen is also seen in the aortic branches at the vessel's origin or more distally within the branch vessel as the dissection extends into the artery. Occlusion of a branch artery may also occur if the dissection causes an intimal disruption at the origin of the vessel resulting in an intimal flap, which then occludes the ostia of the vessel. Thrombosis may ensue and further compromise the vessel. The resulting ischemia depends on the degree and duration of the obstruction as well as the presence of a collateral circulation. Vague ischemic symptoms may cause a delay in diagnosis and result in further end-organ damage or chronic ischemia.<sup>4</sup>

## Surgical versus Medical Management

Gore and Hirst describe the *triad of clinical recognition* in diagnosing aortic dissection, which underscores the importance of recognizing signs and symptoms of vessel occlusion.<sup>5</sup> Patients may present with atypical signs and symptoms (different from the classic chest pain) such as abdominal pain, ischemic extremities, or sudden paraplegia. A high index of suspicion is necessary to prevent a delay in diagnosis and further propagation of organ injury. Once the diagnosis of aortic dissection has been confirmed, many operative approaches are available that are directed at the aortic lesion itself or the ischemic manifestations.<sup>4</sup> Fann and coworkers have reported the results of a 30-year retrospective study that

**Table 2** Early Mortality in Acute Distal Aortic Dissection (Medical and Surgical)

Authors	Year	Time Span	Treatment	Mortality (Patients)	Mortality (%)
Appelbaum et al	1976	1966-1973	Medical	7/22	32
Pate et al	1976	1973	Medical	5/18	28
Doroghazi et al	1984	1963-1978	Medical	7/35	20
Glower et al	1990	1975-1988	Medical	10/56	18
Masuda et al	1991	1979-1989	Medical	4/61	6.5
Elefteriades et al	1992	1973-1990	Medical	10/49	20
Reul et al	1975	1964-1974	Surgical	12/49	24
Appelbaum et al	1976	1966-1973	Surgical	4/11	36
Pate et al	1976	1973	Surgical	9/20	45
Miller et al	1979	1963-1979	Surgical	9/20	45
Doroghazi et al	1984	1963-1978	Surgical	21/43	49
Miller et al	1984	1963-1982	Surgical	10/26	38
Crawford et al	1988	1956-1988	Surgical	22/62	35
Glower et al	1990	1975-1988	Surgical	11/33	33

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revealed an improvement in surgical results in patients with acute aortic dissection between 1963 and 1992. Earlier diagnosis and intervention have contributed to this improvement in mortality rates.<sup>8</sup> However, the past 15 years have revealed a trend toward avoiding surgical treatment in stable patients with isolated descending aortic dissections. This evolution has occurred because rupture risk is lower than that seen in ascending aortic dissections and surgical risk is higher for descending dissections. Several authors have reported their experience with surgical versus medical therapy for uncomplicated acute descending aortic dissections and have found the results to be similar or improved with medical therapy (Table 2). Despite this, the treatment of descending aortic dissections remains a challenge to surgeons since failure of medical therapy approaches one-third of all cases.<sup>9</sup>

Initial medical management includes control of pain, blood pressure, and tachycardia. This can be accomplished by B-blockers alone for mild hypertension or in combination with morphine sulfate and a vasodilator such as sodium nitroprusside (Nipride, Roche, Nutley, NJ) or an ACE inhibitor to reach a target systolic blood pressure of 110 mmHg. Verapamil (Calan, Searle, Skokie, IL) or diltiazem (Cardizem, Biovail, Morrisville, NC) may be used if B-blockers are contraindicated.<sup>10</sup> Medical management of distal aortic dissection should continue provided no surgical indications develop. Surgical indications include failure of medical

therapy, persistent pain, uncontrollable blood pressure, an expanding false lumen, branch vessel occlusion, or signs of imminent rupture such as mediastinal hematoma.<sup>10,11</sup> Whether treatment is performed medically or surgically, continued vigilance is necessary to recognize the development of any associated ischemic signs and symptoms.

## Radiographic Diagnosis

The goal of radiographic imaging in the diagnosis of aortic dissection is to visualize the dissection flap and blood flow within the two lumens. Angiography has been used for many years for evaluation in patients suspected to have aortic dissection. However when flow is slow or nonexistent in the false lumen, the sensitivity is low. With the availability of CT and MR angiography, catheter-based arteriography has been phased out as the diagnostic modality of choice. The benefit of angiography still lies in the fact that endovascular procedures can be performed at the time of diagnosis. According to Macura and coworkers, the sensitivity and specificity of aortography are 88 and 94%, respectively.<sup>12</sup> Moore and coworkers reported results from the IRAD study which found similar results (Table 3).<sup>13</sup> Transesophageal echocardiography (TEE), while highly sensitive and specific for ascending dissections, has little value in the diagnosis of descending aortic dissections below the diaphragm. In this case subsequent addi-

**Table 3** Sensitivity of Four Imaging Modalities

Image Modality	Overall	Stanford Classification of Aortic Dissection	
		Type A	Type B
TEE	88% (170/193)	90% (144/158)	80% (28/35)
CT	93% (353/379)	93% (180/193)	93% (173/186)
MRI	100% (9/9)	100% (2/2)	100% (7/7)
Aortography	87% (21/24)	87% (13/15)	89% (8/9)

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tional diagnostic testing, such as CT or MRI, is warranted. CT and CTA, more recently, have become the imaging modality of choice for evaluating patients with aortic dissection. The sensitivity of CT for diagnosis is anywhere from 83 to 100% with a specificity of 100%. Unfortunately, motion artifacts can mimic dissection on CT and can occur in up to 57% of patients imaged. Newer generation scanners, however, virtually eliminate this artifact. MR angiography is the most sensitive modality for imaging aortic dissection with sensitivity and specificity, both at 100%. However long imaging time in critically ill patients and its limited availability may preclude its use. It does offer the advantage of eliminating nephrotoxic contrast and ionizing radiation.<sup>12</sup> The data from the IRAD reveal a high sensitivity for all four diagnostic modalities. Despite these results, CT, TEE, and angiography are associated with considerable false-negative rates and should not be used as the sole imaging modality to rule out aortic dissection when the clinical suspicion is high.<sup>13</sup>

## Visceral Malperfusion

Ischemia involving the visceral organs can present with abdominal pain or may be asymptomatic if only one of the mesenteric arteries is affected. In fact mesenteric ischemia may be clinically occult for hours before a true diagnosis is discovered.<sup>11</sup> In the case of major life-threatening ischemic bowel, urgent exploratory laparotomy is warranted to prevent associated morbidity and mortality since acute dissection associated with mesenteric ischemia has an operative mortality rate near 50%.<sup>4,11</sup> More recently there has been a renewed interest in the fenestration procedure in treating acute dissection that is complicated by malperfusion. This can be accomplished through an open technique or endovascularly. The open technique can be performed through a left retroperitoneal approach with transection of the aorta below the renal artery takeoff, in theory creating a reentry tear.<sup>14,15</sup> The septum is resected proximally to the clamp while the layers of the distal segment are reapproximated by a continuous suturing of the intimal to the adventitial layer. The proximal and distal segments are then anastomosed using a running suture for a primary closure of the proximal adventitial layer to the distal full-thickness aortic segment, or alternatively, a short Dacron interposition graft may be used.<sup>14</sup> Closure may also be accomplished using an aortobi-iliac graft. We favor a transperitoneal approach, which allows for visualization of the abdominal viscera and better exposure of the aorta. The aorta is transected below the renal arteries and a proximal septectomy is performed. The aortic layers are reapproximated distally and a Dacron graft is used to close the aorta to prevent suture line tension caused by a primary re-anastomosis. The mechanism behind fenestration is that it is thought to decrease the distention in the false lumen thereby relieving obstruction of the branched vessel inflow tract and restoring flow to the ischemic organ.<sup>15</sup> Some authors advocate a longitudinal aortotomy, which allows for visualization of the renal as well as the visceral vessels and facilitates thrombectomy of these branched vessels if necessary.<sup>15</sup> Webb and William describe fenestration in which a

longitudinal aortotomy is performed with exposure of the origin of the visceral arteries.<sup>16</sup> This allows direct visualization of any intimal flaps that may then be excised or tacked down. Aortic tailoring is then performed by closing it to a diameter of 2 centimeters. This prevents aneurysmal deterioration and reduces wall tension.<sup>9,14</sup> In the event that the dissection extends into one of the branch vessels, fenestration can be performed in the individual vessel. This is most commonly performed in the superior mesenteric artery or iliac arteries. The distal wall layers may need to be conjoined and a patch angioplasty should be performed to prevent narrowing of the artery.<sup>5</sup>

According to Elefteriades and coworkers, the surgical procedure for impending rupture is replacement of the proximal aorta with an aortic graft, although one must be aware that replacing a large segment of thoracic aorta risks spinal cord devascularization.<sup>14</sup> Despite this technique and redirecting blood flow into the true lumen, persistent ischemia of the limbs or organs may persist. This may require additional procedures to relieve the malperfusion and restore blood flow. Such options then include distal aortic fenestration as described above, direct revascularization by reimplantation, or aortic or extra-anatomic bypass grafting.<sup>15</sup> Endovascular procedures have more recently become the first line of treatment for mesenteric ischemia associated with acute dissection. Percutaneous balloon fenestration can be used to create a tear in the septum between the true and false lumens in the aorta, thus equalizing flow and pressure in both lumens.<sup>11</sup> This has been found to be useful in the setting of a critically ill patient since it provides a rapid means of restoring perfusion to the affected bowel or visceral organ.<sup>15</sup> This in effect redirects blood flow across the dissection flap to perfuse branches off the true lumen that are isolated by the dissection.<sup>11</sup> In the event that the mesenteric vessels are supplied by the false lumen, extra-anatomic bypass may be required to restore perfusion to the affected viscera if balloon fenestration and stenting are not possible or successful. Stenting can be employed when a branch vessel is compromised by the dissection flap or the false lumen and has been quite successful in restoring blood flow to the affected vascular bed. In the event that endovascular techniques are used as the only therapy to correct malperfusion syndromes, care of the patient must include close scrutiny to detect any progression of mesenteric ischemia.

## Extremity Malperfusion

Among patients with acute dissection, one-third will have an aortic branch occlusion with associated end-organ ischemia. Twenty-four percent of these patients will have malperfusion of the extremities.<sup>11</sup> The first successful aortic fenestration was performed for treatment of lower extremity ischemia by Shaw in 1955.<sup>15</sup> Clinically, ischemia of the lower extremities is most commonly recognized by loss of bilateral or unilateral femoral pulses.<sup>4</sup> Bossone and coworkers reported from data collected in the IRAD study that one-third of patients with type A dissection have pulse deficits and 29% of patients with these deficits have limb ischemia. In addition the overall

mortality rate seen in these patients with pulse deficits is 41% as opposed to a 30% mortality rate overall in patients with Type A dissection.<sup>17</sup> Clinical evidence of lower extremity arterial obstruction alone may mask the presence of aortic dissection. Any delay in diagnosis can be devastating especially if attempts are mistakenly made to thrombectomize extremity vessels.<sup>11</sup> Careful attention to any associated clinical signs and symptoms should suggest aortic dissection. A hypertensive patient with chest or abdominal pain accompanying sudden lower extremity ischemia should indicate acute aortic dissection until proven otherwise. Unfortunately the clinical picture may not always be as telling and a high index of suspicion should persist.

In a patient with aortic dissection and lower extremity ischemia one option may be to repair the aorta to reestablish flow within the true lumen and restore flow to the lower extremities. Fann and coworkers found that approximately 90% of peripheral pulse deficits caused by dissection could be restored by repair of the thoracic aorta.<sup>18</sup> However in a series reported by Elefteriades and coworkers 25% of patients who underwent aortic graft replacement still required subsequent fenestration for persistent lower extremity ischemia.<sup>14</sup>

An alternative to aortic repair is percutaneous balloon fenestration, which can be used to relieve ischemic symptoms in a stable patient immediately postdissection and allow for elective repair of the aorta when the tissue is less friable. Stent grafting of the aorta to compress the false lumen may also restore blood flow to the distal aorta and lower extremities. Stent grafting of the proximal intimal tear may redirect blood flow into the true lumen thereby restoring lower extremity perfusion. However if branch vessels are supplied by the false lumen, this may precipitate ischemia of the respective organs.<sup>6</sup> Direct endovascular stenting of the occluded branch vessel can also be used to restore perfusion to the lower extremities. Percutaneous procedures are ideal at treating patients with isolated lower extremity malperfusion. However, should these techniques not be available, or if they are not successful, open procedures should be employed. Open techniques available to alleviate extremity malperfusion include cross-femoral bypass in the case of unilateral ischemia, axillary-bifemoral bypass for bilateral involvement, and femoro-femoral bypass should the dissection extend into the femoral bifurcation.<sup>5</sup> We prefer extra-anatomic grafting techniques for patients with isolated lower extremity malperfusion syndromes, as no contrast is required and these operations can be done quickly and are quite efficacious and durable. In addition, the morbidity and mortality of a laparotomy or thoracotomy are avoided.

## Spinal Cord Malperfusion

Ischemia of the spinal cord can be a devastating consequence of aortic surgery as well as dissection. Spinal cord ischemia caused by dissection may be impossible to treat pathophysiologically and mechanistically. Several series have found the incidence of paraplegia resulting from aortic dissection to be around 4%.<sup>5,19</sup> The risk of neurologic deficit after thoracoabdominal reconstructive surgery is about 10% in the most experienced hands and can be as high as 40%. Deficits can be

classified as delayed or immediate onset.<sup>20</sup> Clinical symptoms of spinal cord ischemia related to aortic dissection range from the Brown–Sequard syndrome to paraplegia and paraparesis.<sup>4</sup> The symptoms may be irreversible or gradually improve. When the deficit is transient, it is referred to as spinal cord TIA. Since the anterior spinal arteries are usually more severely involved, sensation can be preserved in the lower extremities.<sup>19</sup> Preservation of the blood supply to the spinal cord is essential in preventing neurologic complications associated with aortic dissection as well as procedures on the aorta to repair the dissection. It is important to differentiate the etiology of lower extremity paralysis between spinal cord ischemia and lower extremity ischemia from involvement of the abdominal aorta or iliac arteries by the dissection. Restoration of lower extremity perfusion may sometimes restore function; however, the prognosis for spinal cord ischemia is grim. Patients with spinal cord ischemia due to compromise of the intercostal and lumbar arteries or the artery of Adamkiewicz relate artery of Adamkiewicz to aortic dissection have a poor prognosis for restoration of lower extremity function.<sup>5</sup>

Many techniques have evolved over time to prevent these neurologic complications from arising during aortic reconstruction as well as in the immediate postoperative period. Distal aortic perfusion has been proven effective in protecting the spinal cord as well as the kidneys and the abdominal viscera. Distal perfusion also provides aortic decompression, which may be important for avoiding clamp injury or rupture during aortic clamping.<sup>4</sup> Distal perfusion can be accomplished with left heart bypass with permissive hypothermia or total cardiopulmonary bypass with mild or profound hypothermia.<sup>21</sup> We favor left heart bypass with cerebrospinal drainage as a way to preserve distal perfusion. Kouchoukos and coworkers have reported in a large series of patients with extensive disease of the descending thoracic and thoracoabdominal aorta that profound hypothermic cardiopulmonary bypass in association with an interval of circulatory arrest has several advantages. This procedure precludes extensive dissection of the involved aortic segments, eliminates the need for aortic clamping, provides a bloodless field, and reduces blood loss due to its return to the perfusion circuit. Protection of the spinal cord is further achieved by reperfusion of critical spinal arteries via reimplantation or by insertion of synthetic bypass grafts. Preoperative angiography if performed can assist in identifying these critical spinal arteries, but we make no special effort to do this. The profound hypothermia protects the visceral organs as well as the spinal cord. Also reported was a reduction in the need for adjunctive measures such as cerebrospinal drainage, evoked potential monitoring, and epidural cooling of the spinal cord. There is some skepticism about the detrimental effects of hypothermia and circulatory arrest on the function of platelets and coagulation factors; however, this appears to be offset by the protective effect of hypothermia on visceral organs in preventing coagulopathy that can be a result of visceral ischemia.<sup>22</sup>

Cerebrospinal fluid drainage has been used in aortic surgery as a means of reducing neurologic sequelae since the 1960s. It is used by many surgeons during the intraoperative and perioperative periods in combination with other therapies to prevent immediate or delayed-onset neurologic defi-

cit. CSF drainage decreases CSF pressure while increasing spinal cord perfusion pressure. It is used in combination with distal aortic perfusion, distal aortic perfusion with intercostal reimplantation, as well as monitored evoked potentials and pharmacologic therapy, ie, naloxone (Narcan, Endo, Chadds Ford, PA) and papaverine. A study by Coselli and coworkers reported a 2.6% incidence of paraplegia or paraparesis in patients with CSF drainage versus 13% in the control group when maintaining CSF pressure at less than 10 mmHg intraoperatively and for 48 hours postoperatively in patients undergoing left heart bypass with mild hypothermia and reimplantation of intercostal arteries. Most reports use 10 mmHg as the critical drainage point but a CSF pressure of 10 mmHg has not prevented the occurrence of neurologic deficits.<sup>19</sup> Regardless of the mechanism of therapy, the importance of accurate detailing of the neurologic examination perioperatively must be underscored.

As discussed with visceral and extremity malperfusion, endovascular techniques may become more reliable and effective at relieving spinal cord ischemia in the setting of acute aortic dissection. This may be accomplished by stent-grafting of the dissection itself or the proximal intimal tear. Redirecting flow into the true lumen and obliterating the false lumen may restore flow to the intercostals arteries. Use of this technique not only may provide rapid restoration of blood flow to the spinal cord but also avoids open surgery and the need for suturing to friable aortic tissue in the early stages of dissection. As is true in open repair of aortic dissection, however, the prognosis is poor for reversal of neurological sequelae resulting from spinal artery obstruction.

## Conclusion

Aortic dissection is the most common lethal entity affecting the aorta. One-third of patients suffering from aortic dissection will have aortic branch involvement.<sup>23</sup> The importance in early diagnosis of aortic dissection is to prevent the disastrous complications that can be associated with this condition. According to the IRAD study the mortality rate in patients undergoing surgical repair for type B dissection is 31.4%. As recently as 10 years ago, a large series reported by Spittell and coworkers showed that 38% of patients were incorrectly diagnosed at initial examination and suspected to have another condition.<sup>3</sup> Advances have been made in both the therapeutic and the diagnostic realms; however, there is much still to be done in the treatment of this disease to improve overall mortality rates. Endovascular techniques have provided a novel way of treating aortic dissection that is less invasive than traditional techniques. This is obviously of tremendous benefit in certain cases. However there is no clear-cut algorithm in the treatment of aortic dissection. Appropriate management comes from evaluating each individual situation on a case-by-case basis. The only commonality among these patients is the urgency in making a correct diagnosis to begin the appropriate treatment.

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## References

1. Nienaber CA, Eagle KA: Aortic dissection: new frontiers in diagnosis and management. Part I: From etiology to diagnostic strategies. *Circulation* 108:628-635, 2003
2. Green GR, Kron IL: Aortic Dissection, in *Cardiac Surgery in the Adult*. New York, NY, McGraw-Hill, 2003, pp 1095-1122
3. Hagan PG, Nienaber CA, Isselbacher EM, et al: The International Registry of Acute Aortic Dissection (IRAD). New insights into an old disease. *JAMA* 283:897-903, 2000
4. Rutherford RB: *Vascular Surgery* (ed 5). Philadelphia, PA, Saunders, 2000, pp 1326-1342
5. Borst HG, Heinemann MK, Stone CD: *Surgical Treatment of Aortic Dissection*. New York, NY, Churchill Livingstone, 1996
6. Dyet JF, Ettles DF, Nicholson AA, et al: Endovascular repair of thoracic and dissecting aneurysms and aortic coarctation, in *Textbook of Endovascular Procedures*, Philadelphia, PA, Churchill Livingstone, 2000, pp 439-455
7. Svensson LG, Crawford ES: *Cardiovascular and Vascular Disease of the Aorta*. Philadelphia, PA, WB Saunders, 1997
8. Fann JI, Smith JA, Miller DC, et al: Surgical management of aortic dissection during a 30-year period. *Circulation* 92:113-121, 1995
9. Roseborough G, Burke J, Sperry J, et al: Twenty-year experience with acute distal thoracic aortic dissections. *J Vasc Surg* 40:235-245, 2004
10. Nienaber CA, Eagle KA: Aortic dissection: new frontiers in diagnosis and management. Part II: Therapeutic management and follow-up. *Circulation* 108:772-778, 2003
11. Williams DM, Lee YD, Hamilton BH, et al: The dissected aorta: percutaneous treatment of ischemic complications—principles and results. *J Vasc Interv Radiol* 8(4):605-625, 1997
12. Macura KJ, Szarf G, Fishman EK, et al: Role of computed tomography and magnetic resonance imaging in assessment of acute aortic syndromes. *Semin US CT MRI* 24:232-254, 2003
13. Moore AG, Eagle KA, Bruckman D, et al: Choice of computed tomography, transesophageal echocardiography, magnetic resonance imaging, and aortography in acute aortic dissection: International Registry of Acute Aortic Dissection (IRAD). *Am J Cardiol* 89:1235-1237, 2002
14. Elefteriades JA, Lovoulos CJ, Coady MA, et al: Management of descending aortic dissection. *Ann Thorac Surg* 67:2002-2005, 1999
15. Panneton JM, Teh SH, Cherry KJ, et al: Aortic fenestration for acute or chronic aortic dissection: an uncommon but effective procedure. *J Vasc Surg* 32:711-720, 2000
16. Webb TH, Williams GM: Abdominal aortic tailoring for renal, visceral and lower extremity malperfusion resulting from acute aortic dissection. *J Vasc Surg* 26:474-481, 1997
17. Bossone E, Rampoldi V, Nienaber CA, et al: Usefulness of pulse deficit to predict in-hospital complications and mortality in patients with acute type A aortic dissection. *Am J Cardiol* 89:851-855, 2002
18. Fann JI, Sarris GE, Mitchell RS, et al: Treatment of patients with aortic dissection presenting with peripheral vascular complications. *Ann Surg* 212:705-713, 1990
19. Killen DA, Weinstein CL, Reed WA: Reversal of spinal cord ischemia resulting from aortic dissection. *J Thorac Cardiovasc Surg* 119:1049-1052, 2000
20. Ackerman LL, Traynelis VC: Treatment of delayed-onset neurological deficit after aortic surgery with lumbar cerebrospinal fluid drainage. *Neurosurgery* 51:1414-1421, 2002
21. Kouchoukos NT, Masetti P, Rokkas CK, et al: Safety and efficacy of hypothermic cardiopulmonary bypass and circulatory arrest for operations on the descending thoracic and thoracoabdominal aorta. *Ann Thorac Surg* 72:699-708, 2001
22. Kouchoukos NT, Masetti P, Murphy SF: Hypothermic cardiopulmonary bypass and circulatory arrest in the management of extensive thoracic and thoracoabdominal aortic aneurysms. *Semin Thorac Cardiovasc Surg* 15:333-339, 2003
23. Lauterbach SR, Cambria RP, Brewster DC, et al: Contemporary management of aortic branch compromise resulting from acute aortic dissection. *J Vasc Surg* 33:1185-1192, 2001