

# Improving outcomes in acute aortic dissection

## ABSTRACT

Aortic dissection remains a serious cardiovascular emergency with significant early and late mortality and morbidity. Improving outcomes is directly linked to early clinical diagnosis, swift confirmation by appropriate imaging and management by dedicated teams with high levels of expertise in a complex clinical condition.

**A**ortic dissection is defined as disruption of the medial layer (tunica media) of the aorta as a result of an intimal tear, leading to separation of the aortic wall layers and subsequent formation of two lumens within the aorta; a true and a false lumen. This can be followed by aortic rupture or impaired blood flow (malperfusion) to a range of organs compromised either by an intimal flap or as a result of compression from the false lumen (i.e. heart, brain, bowels, kidney and limbs), resulting in a wide spectrum of impact depending on the affected organ (Hiratzka et al, 2010; Erbel et al, 2014).

The incidence of diagnosed aortic dissection is 3.5–6/100 000 per year, tends to be higher in men and increases with age. Interestingly, it is estimated that physicians suspect the diagnosis correctly in only 15–43% of patients (Mészáros et al, 2000). Furthermore, aortic dissection is the cause of death in 1.1–1.5% of cases of sudden death in non-hospitalized patients undergoing post-mortem (Mészáros et al, 2000).

The most common risk factor associated with aortic dissection is poorly controlled hypertension, which is observed in 65–75% of individuals. Other risk factors include pre-existing aortic diseases or bicuspid aortic valve disease, inherited aortic diseases (Marfan, Loeys–Dietz syndromes), history of previous cardiac surgery, cigarette smoking, direct blunt chest trauma and intravenous drug

abuse (Hagan et al, 2000; Januzzi et al, 2004; Hiratzka et al, 2010; Erbel et al, 2014).

Aortic dissection is classified using either the Stanford or DeBakey classification (*Figure 1*), both of which separate dissections into different types based upon their anatomical location. The Stanford classification divides dissections into two types, type A and type B. Type A involves the ascending aorta regardless of the distal extension (DeBakey types I and II) (*Figure 2a*) and type B involves only the aorta beyond the left subclavian artery (DeBakey type III) (*Figure 2b*) (Hiratzka et al, 2010; Erbel et al, 2014).

Occasionally, a tear or a false lumen can not be demonstrated in the aorta despite the presence of haematoma in the media of the aortic wall. This is called intramural haematoma, defined as a circular or crescent-shaped thickening of >5 mm of the aortic wall in the absence of detectable blood flow. It is classified and treated in a similar manner to aortic dissection.

## Presentation and diagnosis

When patients present to the emergency department they can have a range of symptoms. However, abrupt onset of severe ripping, sharp chest and/or back pain is the most frequently reported symptom, occurring in up to 85% of patients with anterior chest pain. This presentation is more commonly associated with type A dissections whereas patients with type B present more frequently with pain in the back or abdomen (Hagan et al, 2000; Hiratzka et al, 2010; Erbel et al, 2014).

The abruptness of its onset is the most specific characteristic that can help differentiate aortic dissection from other causes of acute chest pain (Erbel et al, 2014). Moreover, pain can migrate following the extension of aortic dissection flap and associated organ injury in up to 20% of patients (Hagan et al, 2000; Erbel et al, 2014). Cases presenting with no pain are more difficult to diagnose and usually tend to be missed (Alter et al, 2015). However, a thorough history and a low threshold for the inclusion of aortic dissection in the differential diagnosis can help.

Patients can also have symptoms related to organ injury secondary to dissection (malperfusion or obstruction) such as cerebrovascular events, abdominal pain, myocardial infarction and limb ischaemia. Interestingly, the classical teaching of pulse deficit only occurs in 15–30% of patients but where present is pathognomonic. The murmur of aortic regurgitation can be detected in 12–44% and cardiac tamponade second to intrapericardial bleeding may be associated with shock with cardiogenic or obstructive haemodynamics.

**Dr Emma Redfern**, Consultant in Accident and Emergency, Department of Accident and Emergency, Bristol Royal Infirmary, Bristol BS2 8HW

**Dr Mark Callaway**, Consultant Radiologist, Department of Radiology, Bristol Royal Infirmary, Bristol

**Mr Mustafa Zakkar**, Academic Clinical Lecturer in Cardiac Surgery, Department of Cardiac Surgery, Bristol Royal Infirmary, Bristol

**Mr Alan J Bryan**, Consultant Cardiac Surgeon, Department of Cardiac Surgery, Bristol Royal Infirmary, Bristol

Correspondence to: Dr E Redfern  
([Emma.Redfern@UHBristol.nhs.uk](mailto:Emma.Redfern@UHBristol.nhs.uk))

Chest pain is a very common presentation to the emergency department. To ensure timely clinical diagnosis of aortic dissection, detailed history taking, a high index of clinical suspicion and an understanding that aortic dissection can mimic several other acute serious conditions (acute coronary syndrome and pulmonary embolus) are paramount, as individual signs and symptoms lack sensitivity and specificity. Without clinical suspicion, patients are not immediately channelled into an appropriate imaging pathway, especially as some patients can be completely asymptomatic when arriving at the emergency department.

One key issue that impacts on the early diagnosis of aortic dissection is the fact that most available emergency department chest pain algorithms are designed primarily to detect acute coronary syndromes and do not take aortic dissection into account, resulting in substantially delayed diagnosis in almost half of cases (Spittell et al, 1993; Hiratzka et al, 2010; Erbel et al, 2014). This is entirely understandable given that for every aortic dissection presenting to the emergency department there will be about 200 patients presenting with an acute coronary type syndrome, and more with symptoms of chest pain. In fact, myocardial infarction and the associated rise in the troponin level can be present in a considerable number of patients with aortic dissection; this can be the result of the false lumen expansion causing the compression of coronary ostia or the propagation of the dissection flap into the coronary arteries (Jánosi et al, 2009; Kelley et al, 2009). Both troponin elevation and electrocardiogram abnormalities may mislead the physician to a diagnosis of acute coronary syndrome and delay proper diagnosis and management of acute aortic dissection (Spittell et al, 1993; Hansen et al, 2007).

As clinical diagnosis can be elusive it would be ideal if there was a biochemical marker that could be used as a diagnostic tool. D-dimer measurement can be useful as its level is immediately typically very high in aortic dissection, compared with other disorders such as pulmonary embolus where the D-dimer level tends to increase gradually (Sutherland et al, 2008). However, D dimer is not sensitive or specific enough to make it practically useful as a 'rule in or rule out' test.

A range of markers have been investigated, such as  $\alpha$ -smooth muscle actin, smooth muscle myosin heavy chain, soluble elastin fragments and polycystin-1, with some success but so far none of these has translated into routine clinical practice (Ranasinghe and Bonser, 2010; Peng et al, 2015).

In 2010 the American College of Cardiology / American Heart Association proposed a risk assessment and scoring system based on predisposing conditions, pain features and clinical examination that divides patients into three categories based on the probability of aortic dissection (Table 1) (Hiratzka et al, 2010). Proper adoption of such a scoring system in the emergency department is the key to prompt and appropriate triaging

Figure 1. Classification of aortic dissection.

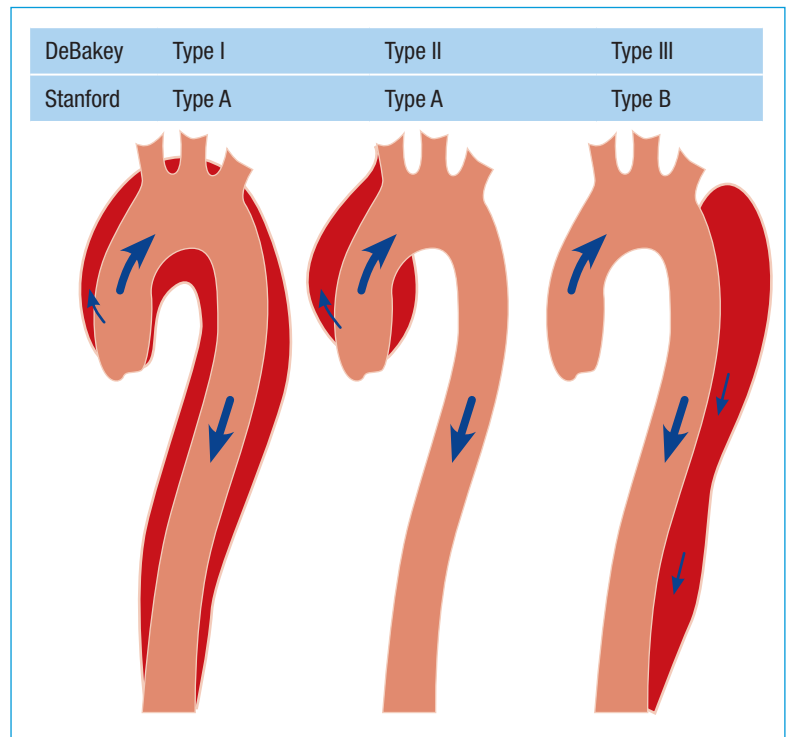
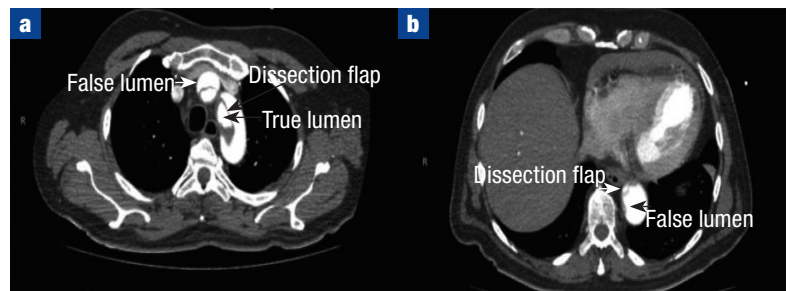


Figure 2. Axial computed tomography scan view of (a) ascending aortic dissection and (b) descending aortic dissection.



of patients toward the most suitable diagnostic modality for confirmation of diagnosis. Moreover, developing teaching programmes in local emergency departments and the dissemination of approved protocols to educate medical staff to appreciate that pain associated with aortic dissection can be transient or absent and to dispel the common misconceptions based on historical teaching of aortic dissection can play an important role in improving outcomes by facilitating correct diagnosis, early and prompt referral to specialist services leading to improved outcomes (Kung et al, 2007; Harris et al, 2011; Alter et al, 2015).

**Imaging**

Once aortic dissection is suspected, the patient should undergo suitable imaging to make the diagnosis as quickly and accurately as possible. Imaging can also provide a comprehensive assessment of the entire aorta including diameters, shape, dissection flap extent, and aortic valve and aortic branch involvement.

**Table 1. Clinical data to assess the probability of acute aortic dissection**

High risk conditions	Marfan syndrome or other connective tissue diseases	
	Positive family history of dissection	
	Known thoracic aortic aneurysm	
	Previous aortic intervention	
High risk features	Chest, back or abdominal pain described as follows:	Abrupt onset
		Severe intensity
		Ripping
High risk examination features	Evidence of malperfusion	Pulse deficit
		Systolic blood pressure differences
		Neurological deficit
	New aortic murmur	
	Hypotension or shock	

*Based on American Heart Association guidelines (Hiratzka et al, 2010)*

The role of plain chest radiograph is limited. Chest radiograph cannot diagnose aortic dissection, but a proportion of patients with suspected aortic dissection have an abnormal chest radiograph that can direct physicians toward suspecting aortic dissection. However, it should be omitted in unstable patients to avoid delays in performing more specific imaging modalities (Erbel et al, 2001).

Computed tomography, magnetic resonance imaging and transoesophageal echo are equally reliable in the diagnosis of aortic dissection. Computed tomography and magnetic resonance imaging are superior to transoesophageal echo because they offer assessment of extension and branch involvement. Although transoesophageal echo does give functional information about the aortic valve and cardiac function, this is now a routine part of intraoperative care once the diagnosis is made (Nienaber et al, 1993; Shiga et al, 2006).

Computed tomography is currently the most commonly used imaging modality because of its speed, availability and high sensitivity and specificity. A multi-slice computed tomography with and without contrast should be used to perform the examination in combination with cardiac gating and three-dimensional reconstruction to allow careful evaluation of both the aorta and its branches (McMahon and Squirrell, 2010; Abbas et al, 2014). Optimum imaging is achieved by contrast administration via the right arm as this reduces the streak artefact in the region of the brachiocephalic vein. If there is no alternative but to use the left arm vein, a saline bolus can be used in addition to the contrast to minimize the streak artefact from the inferior vena cava.

Gated computed tomography scanning can significantly improve accuracy by timing the acquisition of the images to the cardiac cycle and reducing artefact from the base of

the aortic root caused by both valvular and cardiac motion. This can overcome one of the challenges for the radiologist, which is the potential for overdiagnosis of dissection on standard computed tomography (Meyersohn et al, 2015). The scan should cover the whole of the aorta from the root to the bifurcation so if there is a dissection it can be tracked in its extent, particularly assessing the great vessels of the arch and the vessels arising in the abdomen.

Clinicians should have a low threshold for using other modalities such as magnetic resonance imaging or transoesophageal echo in cases where computed tomography cannot confirm or rule out the diagnosis (<5%) (Hagan et al, 2000; Erbel et al, 2014). Transoesophageal echo gives particularly clear views of the aortic root and can be extremely useful when there is diagnostic uncertainty or in unstable patients with high suspicion of aortic dissection as it can be carried out in the operating theatre or intensive care, although it does require operator expertise (Nienaber et al, 1993). However, a significant number of patients will require multiple imaging modalities to establish the correct diagnosis and plan the extent of surgical intervention. The International Registry of Acute Aortic Dissection reported that more than 50% of the patients in the registry required multiple imaging modalities such as computed tomography and echocardiography, suggesting that the diagnosis of acute aortic dissection cannot be excluded confidently based on negative findings of a single test. Another imaging test is strongly recommended if the initial diagnostic test does not identify aortic dissection when the diagnosis is strongly suspected clinically (Moore et al, 2002).

A one-step 64-slice or higher multi-detector computed tomography examination for chest pain – a ‘triple rule-out’ protocol to evaluate patients with acute chest pain in the emergency department – has been proposed to investigate the main three potential major causes: aortic dissection, pulmonary embolus and coronary artery disease (Gallagher and Raff, 2008). Different studies of triple rule-out computed tomography angiography for chest pain have demonstrated that it can provide a cost-effective evaluation of the coronary arteries, aorta, pulmonary arteries and adjacent intrathoracic structures for the patient with acute chest pain, especially in patients judged to have low to intermediate increased risk for acute coronary syndrome, and whose chest pain symptoms might also be attributed to acute pathological conditions of the aorta or pulmonary arteries (Gallagher and Raff, 2008; Shapiro, 2009; Yoon and Wann, 2011).

### Management of aortic dissection

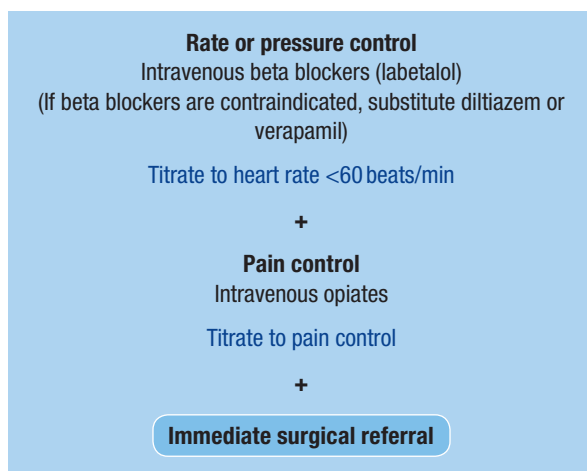
Most of the contemporary evidence concerning the treatment of aortic dissection has been derived from the International Registry of Acute Aortic Dissection (Hagan et al, 2000) with similar supporting evidence from the German Registry for Acute Aortic Dissection Type A (Conzelmann et al, 2011; Rylski et al, 2014). Treatment depends very much on the anatomical location and the type of dissection (Hagan et al, 2000; Erbel et al, 2014).

### Type A aortic dissection

Acute type A aortic dissection is associated with a mortality rate of 1–2%/hour immediately after the onset of symptoms (50% within the first 48 hours if not operated on) (Hagan et al, 2000). Emergency surgical intervention is the treatment of choice in acute type A aortic dissection and is associated with more favourable outcomes, even in patients with unfavourable presentations and/or major comorbidities (Hagan et al, 2000; Hiratzka et al, 2010; Pocar et al, 2010; Conzelmann et al, 2011; Tsukube et al, 2011). Mortality rates can vary in different units, but the reported overall in-hospital mortality of patients undergoing surgery for type A aortic dissection in the International Registry of Acute Aortic Dissection is 25%. Despite being high, this remains significantly better than conservative management which carries mortality rates of 60% (Perko et al, 1995; Hagan et al, 2000; Trimarchi et al, 2005). It is important to note that the mortality rates from the International Registry of Acute Aortic Dissection registry include returns from different units and although they present a real world picture, specialized units with large volume and great expertise have reported much lower in-hospital mortality (10–15%) (Bavaria et al, 2001; Yekeler et al, 2005).

Upon confirmation of type A aortic dissection at a community hospital, the patient should be transferred to an area which offers critical care services (monitored bed, oxygen and direct nursing care) such as an emergency department resuscitation area or a critical care unit. Initial medical treatment should be focused on reducing shear stress on the aorta by controlling pain, blood pressure and heart rate and prompt referral to a specialist centre for definitive management. Pain can be controlled by the administration of opioids such as morphine while blood pressure and heart rate can be controlled by intravenous beta-blockers with some alpha effects such as labetalol, aiming for a systolic blood pressure of 100–120 mmHg and heart rate of 60 beats/min (Hiratzka et al, 2010; Erbel et al, 2014) (Figure 3). Swift transfer of the patient should

**Figure 3. Initial management algorithm for patients with acute type A aortic dissection.**

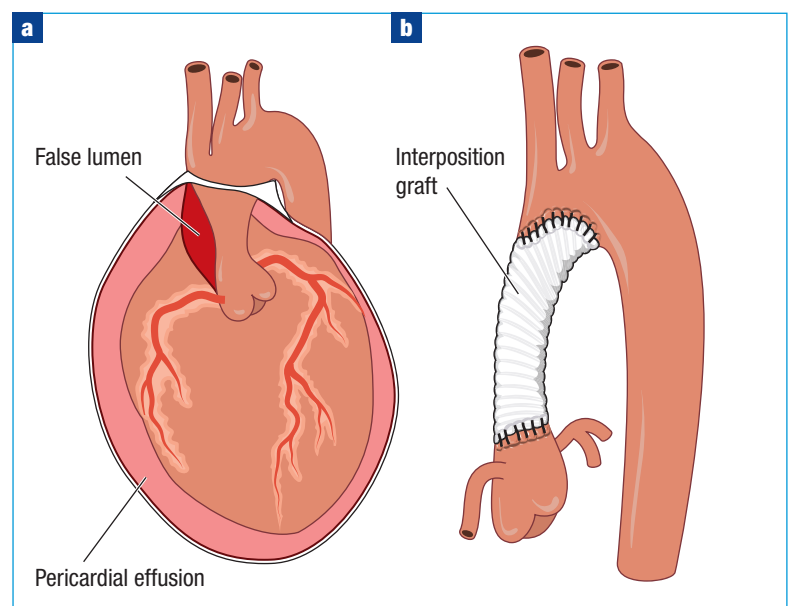


be arranged promptly by an emergency ambulance with paramedic crew present and a trained transfer doctor (with airways and circulation skills) escort for patients who are unstable or requiring inotropic support.

Upon arrival at the tertiary centre, the patient is moved to the operating room and monitored invasively using bilateral arterial lines (which are placed depending on the configuration of the dissection flap), central venous line, near-infra red spectroscopy and transoesophageal echo. The first step is to establish cardiopulmonary bypass in a safe and effective manner, considering the extent of the planned surgical intervention. There are different surgical options based on the extent of the dissection, involvement of the aortic valve and surgical expertise. These options can vary from interposition graft replacement of the ascending aorta (Figure 4) with or without valve repair or replacement, composite root replacement and valve-sparing techniques (David or Yacoub operations) (Hagan et al, 2000; Hiratzka et al, 2010; Erbel et al, 2014). Aortic valve replacement is needed in 20–25% while the rest of the patients presenting with aortic regurgitation can be managed by valve repair (resuspension) (Erbel et al, 2014). Most patients will have the distal anastomosis fashioned using an open technique (no cross clamp) and the surgery will include hemi arch or total arch replacement under deep hypothermic arrest which necessitates the use of techniques to manage cerebral perfusion during repair (Conzelmann et al, 2011; Krüger et al, 2011; Erbel et al, 2014).

Patients presenting with evidence of visceral malperfusion in acute type A dissection may benefit from extended surgery or endovascular intervention in order to close the primary entry tear and decompress the false lumen. However, this can be technically demanding and associated with increased morbidity and mortality, and alternative methods such as septal fenestration techniques

**Figure 4. Schematic intraoperative image of ascending aortic dissection. a. Pre-surgery. b. Post-interposition graft replacement.**



### 66 Patients undergoing surgical intervention on the thoracic aorta should be followed up regularly, particularly in the first year after surgery. 99

can be used to decompress the false lumen and establish flow to visceral vessels (Williams et al, 1990; Erbel et al, 2014). Similarly, limb ischaemia not reversed by the primary operation may require concomitant vascular reconstruction such as femoro-femoral bypass to alleviate the malperfusion.

New data have emerged to support a potential role for endovascular stenting in a small selected group of patients with limited type A aortic dissection and favourable anatomy who are deemed very high risk for conventional surgery (Roselli et al, 2015), and this is likely to be an area of development in the future. Some groups have also advocated more extensive primary surgery to include complete arch replacement as primary therapy or the use of interval endovascular stenting of the descending thoracic aorta to treat the distal aorta either concomitantly or during the same hospital stay (Chen et al, 2010, 2016; Martin et al, 2016).

#### Type B aortic dissection

Type B aortic dissection can be divided into uncomplicated or complicated. Complicated dissections are associated with persistent or recurrent pain, uncontrolled hypertension despite optimal treatment, early aortic expansion, malperfusion, and signs of rupture such as haemothorax or mediastinal haematoma (Hiratzka et al, 2010; Erbel et al, 2014).

Most type B aortic dissections are uncomplicated and evidence from the International Registry of Acute Aortic Dissection suggests that such patients will benefit from medical treatment rather than surgery which can be associated with significant morbidity and mortality. Medical treatment should be directed towards controlling pain, heart rate and blood pressure with close surveillance to identify signs of disease progression that may require endovascular intervention (thoracic endovascular aortic repair) (Hagan et al, 2000; Nienaber et al, 2013). These procedures are usually carried out in specialist theatre facilities (hybrid) that can provide advanced imaging modalities and allow concomitant open and endovascular interventions to be carried out if needed.

Initially, patients should be treated in a similar manner to acute type A aortic dissection (as discussed above) in a high dependency unit aiming to control heart rate, blood pressure and pain. Intravenous  $\beta$ -blockers are started immediately with a low threshold for adding more arterial vasodilator if needed. Oral antihypertensives are usually introduced within the first 24 hours of presentation and doses titrated according to blood pressure (Erbel et al, 2001). Patients can be discharged once blood pressure is controlled and they are pain free. Upon discharge, patients

are advised against strenuous activities and informed to attend the emergency department if they have any new onset of chest pain or back pain or any symptoms that could be related to malperfusion syndrome such as claudication or abdominal pain.

It is recommended that patients are monitored carefully over the first year after the event (3–6-month intervals) then yearly if they are stable. Assessment should include clinical assessment and imaging of the aorta (usually a computed tomography scan) (Erbel et al, 2014). There are no clear recommendations about antiplatelet or anticoagulation medications in patients with type B aortic dissection (Lachat et al, 2008), so the authors' strategy is to restart patients on their regular antiplatelet or anticoagulation medication early.

Complicated type B aortic dissection, on the other hand, requires urgent intervention to restore normal blood flow in the true lumen and improve distal perfusion. Open surgical repair of type B aortic dissection is extremely demanding and outcomes remain suboptimal despite refinement of techniques, with in-hospital mortality that can be as high as 50% (Fattori et al, 2008; Grabenwoger et al, 2012). Thoracic endovascular aortic repair is the preferred approach over open surgery, with associated 30-day mortality of 8% and stroke and spinal cord ischaemia of 8% and 2% respectively (Grabenwoger et al, 2012). However, although recommended by different steering bodies in Europe and USA, thoracic endovascular aortic repair remains underused in the UK because of limited expertise and variability in providing ad-hoc out of hours endovascular services.

Patients undergoing surgical intervention on the thoracic aorta should be followed up regularly, particularly in the first year after surgery, with the first follow up performed 1 month post-intervention to exclude any early complications. This is followed by regular surveillance with either computed tomography or magnetic resonance imaging within 6 months, 12 months and then yearly to monitor for late complications such as aneurysmal changes in the remaining aorta (Raudkivi et al, 1989; Erbel et al, 2014).

A major step toward improving outcomes in aortic dissection surgery starts with appreciating the fact that most patients are diagnosed in peripheral hospitals and transferred to the nearest cardiac centre for definitive treatment which means that they may undergo surgery by a team with limited experience in initial management or even advanced adjunctive techniques such as different arterial cannulation techniques, cerebral protection, valve reconstruction and extended procedures. This may impact on both early and late mortality and morbidity as a large body of evidence is emerging to support the notion that favourable outcomes in aortic surgery are related to volume and expertise. Thus, there is a need to concentrate expertise within established programmes of aortic surgery. Specific on-call arrangements are needed for multidisciplinary aortic teams which should include dedicated surgeons,

anaesthetists, scrub team and endovascular interventionists, allowing patients to benefit from the volume–outcome relationship (Iribarne et al, 2015).

## Conclusions

Aortic dissection remains a serious cardiovascular emergency where short- and long-term mortality and morbidity are significant and in need of improvement. Recent clinical and technical advances have improved mortality over the years, but the average operative mortality remains unsatisfactorily high. Improving outcomes is directly linked to early clinical diagnosis, swift confirmation by appropriate imaging and management by dedicated teams with high expertise in such a complex condition. The principle of arrangements between local hospitals and aortic specialized centres to allow immediate direct transfer of patients with suspected diagnosis of aortic dissection based on validated scoring systems seems appealing. However, it is important to recognize that not all patients will have dissection and some will need a more general medical presence that some super-specialized centres may lack.

High-quality studies to address the effectiveness, safety and cost benefit of such a strategy are required to improve outcomes of patients with type A aortic dissection without denying appropriate treatment for other patients. **BJHM**

*Conflict of interest: none.*

Abbas A, Brown IW, Peebles CR, Harden SP, Shambrook JS (2014) The role of multidetector-row CT in the diagnosis, classification and management of acute aortic syndrome. *Br J Radiol* **87**(1042): 20140354. <https://doi.org/10.1259/bjr.20140354>

Alter S, Eskin B, Allegra J (2015) Diagnosis of aortic dissection in emergency department patients is rare. *West J Emerg Med* **16**(5): 629–631. <https://doi.org/10.5811/westjem.2015.6.25752>

Bavaria JE, Pochettino A, Brinster DR et al (2001) New paradigms and improved results for the surgical treatment of acute type A dissection. *Ann Surg* **234**(3): 336–342; discussion 342–333.

Chen LW, Dai XF, Lu L, Zhang GC, Cao H (2010) Extensive primary repair of the thoracic aorta in acute type a aortic dissection by means of ascending aorta replacement combined with open placement of triple-branched stent graft: early results. *Circulation* **122**(14): 1373–1378. <https://doi.org/10.1161/CIRCULATIONAHA.110.946012>

Chen LW, Wu XJ, Dai XF et al (2016) Repair of acute Type A aortic dissection with ascending aorta replacement combined with open fenestrated stent graft placement. *Ann Thorac Surg* **101**(2): 644–649. <https://doi.org/10.1016/j.athoracsur.2015.07.060>

Conzelmann LO, Krüger T, Hoffmann I et al; Teilnehmenden GERAADA-Zentren (2011) German Registry for Acute Aortic Dissection Type A (GERAADA). *Herz* **36**(6): 513–524. <https://doi.org/10.1007/s00059-011-3512-x>

Erbel R, Alfonso F, Boileau C et al; Task Force on Aortic Dissection, European Society of Cardiology (2001) Diagnosis and management of aortic dissection. *Eur Heart J* **22**(18): 1642–1681. <https://doi.org/10.1053/euhj.2001.2782>

Erbel R, Aboyans V, Boileau C et al; ESC Committee for Practice Guidelines; The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC) (2014) 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases. *Eur Heart J* **35**(41): 2873–2926. <https://doi.org/10.1093/eurheartj/ehu281>

Fattori R, Tsai TT, Myrmet T et al (2008) Complicated acute type B dissection: is surgery still the best option?: a report from the International Registry of Acute Aortic Dissection. *JACC Cardiovasc Interv* **1**(4): 395–402. <https://doi.org/10.1016/j.jcin.2008.04.009>

Gallagher MJ, Raff GL (2008) Use of multislice CT for the evaluation

## KEY POINTS

- Consider aortic dissection if there is a sudden onset of abrupt chest pain.
- Normal chest X-ray and equal blood pressures in each arm do not exclude aortic dissection.
- Education programmes are needed for emergency department staff to heighten awareness.
- Developing biochemical markers for aortic dissection would be beneficial, but none have yet shown clinical promise.
- Prompt recognition of aortic dissection and early referral to a specialist centre is pivotal for improving outcomes.
- Concentrate expertise within established programmes of aortic surgery and specific on-call arrangements for multidisciplinary aortic teams after investing in high quality research to support such strategy.

of emergency room patients with chest pain: the so-called Triple rule-out. *Catheter Cardiovasc Interv* **71**(1): 92–99. <https://doi.org/10.1002/ccd.21398>

Grabenwöger M, Alfonso F, Bachet J et al; European Association for Cardio-Thoracic Surgery (EACTS); European Society of Cardiology (ESC); European Association of Percutaneous Cardiovascular Interventions (EAPCI) (2012) Thoracic Endovascular Aortic Repair (TEVAR) for the treatment of aortic diseases: a position statement from the European Association for Cardio-Thoracic Surgery (EACTS) and the European Society of Cardiology (ESC), in collaboration with the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *Eur J Cardiothorac Surg* **42**(1): 17–24. <https://doi.org/10.1093/ejcts/ezs107>

Hagan PG, Nienaber CA, Isselbacher EM et al (2000) The International Registry of Acute Aortic Dissection (IRAD): new insights into an old disease. *JAMA* **283**(7): 897–903. <https://doi.org/10.1001/jama.283.7.897>

Hansen MS, Nogareda GJ, Hutchison SJ (2007) Frequency of and inappropriate treatment of misdiagnosis of acute aortic dissection. *Am J Cardiol* **99**(6): 852–856. <https://doi.org/10.1016/j.amjcard.2006.10.055>

Harris KM, Strauss CE, Eagle KA et al; International Registry of Acute Aortic Dissection (IRAD) Investigators (2011) Correlates of delayed recognition and treatment of acute type A aortic dissection: the International Registry of Acute Aortic Dissection (IRAD). *Circulation* **124**(18): 1911–1918. <https://doi.org/10.1161/CIRCULATIONAHA.110.006320>

Hiratzka LF, Bakris GL, Beckman JA et al; American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines; American Association for Thoracic Surgery; American College of Radiology; American Stroke Association; Society of Cardiovascular Anesthesiologists; Society for Cardiovascular Angiography and Interventions; Society of Interventional Radiology; Society of Thoracic Surgeons; Society for Vascular Medicine (2010) 2010 ACCF/AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM guidelines for the diagnosis and management of patients with thoracic aortic disease. *J Am Coll Cardiol* **55**(14): e27–e129. <https://doi.org/10.1016/j.jacc.2010.02.015>

Iribarne A, Milner R, Merlo AE, Singh A, Saunders CR, Russo MJ (2015) Outcomes following emergent open repair for thoracic aortic dissection are improved at higher volume centers. *J Card Surg* **30**(1): 74–79. <https://doi.org/10.1111/jocs.12470>

Jánosi RA, Buck T, Erbel R (2009) Mechanism of coronary malperfusion due to type-a aortic dissection. *Herz* **34**(6): 478. <https://doi.org/10.1007/s00059-009-3272-z>

Januzzi JL, Isselbacher EM, Fattori R et al; International Registry of Aortic Dissection (IRAD) (2004) Characterizing the young patient with aortic dissection: results from the international registry of aortic dissection (IRAD). *J Am Coll Cardiol* **43**(4): 665–669. <https://doi.org/10.1016/j.jacc.2003.08.054>

Kelley WE, Januzzi JL, Christenson RH (2009) Increases of cardiac troponin in conditions other than acute coronary syndrome and heart failure. *Clin Chem* **55**(12): 2098–2112. <https://doi.org/10.1093/clinchem/bap112>

- org/10.1373/clinchem.2009.130799
- Kung SW, Ng WS, Ng MH (2007) Aortic dissection in an accident and emergency department in Hong Kong. *Hong Kong Med J* **13**(2): 122–130.
- Krüger T, Weigang E, Hoffmann I, Blettner M, Aebert H; GERAADA Investigators (2011) Cerebral protection during surgery for acute aortic dissection type A: results of the German Registry for Acute Aortic Dissection Type A (GERAADA). *Circulation* **124**(4): 434–443. <https://doi.org/10.1161/CIRCULATIONAHA.110.009282>
- Lachat M, Criado FJ, Veith FJ (2008) The case for anticoagulation in patients with acute type B aortic dissection. *J Endovasc Ther* **15**(1): 52–53. <https://doi.org/10.1583/07-2337.1>
- Martin G, Riga C, Gibbs R, Jenkins M, Hamady M, Bicknell C (2016) Short- and long-term results of hybrid arch and proximal descending thoracic aortic repair: a benchmark for new technologies. *J Endovasc Ther* **23**(5): 783–790. <https://doi.org/10.1177/1526602816655446>
- McMahon MA, Squirell CA (2010) Multidetector CT of aortic dissection: a pictorial review. *Radiographics* **30**(2): 445–460. <https://doi.org/10.1148/rg.302095104>
- Mészáros I, Mórocz J, Szlávi J, Schmidt J, Tornóci L, Nagy L, Szép L (2000) Epidemiology and clinicopathology of aortic dissection. *Chest* **117**(5): 1271–1278. <https://doi.org/10.1378/chest.117.5.1271>
- Meyersohn NM, Ghemigian K, Shapiro MD, Shah SV, Ghoshhajra BB, Ferencik M (2015) Role of computed tomography in assessment of the thoracic aorta. *Curr Treat Options Cardiovasc Med* **17**(8): 35. <https://doi.org/10.1007/s11936-015-0395-9>
- Moore AG, Eagle KA, Bruckman D et al (2002) 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**(10): 1235–1238. [https://doi.org/10.1016/S0002-9149\(02\)02316-0](https://doi.org/10.1016/S0002-9149(02)02316-0)
- Nienaber CA, von Kodolitsch Y, Nicolas V et al (1993) The diagnosis of thoracic aortic dissection by noninvasive imaging procedures. *N Engl J Med* **328**(1): 1–9. <https://doi.org/10.1056/NEJM199301073280101>
- Nienaber CA, Kische S, Rousseau H et al; INSTEAD-XL trial (2013) Endovascular repair of type B aortic dissection: long-term results of the randomized investigation of stent grafts in aortic dissection trial. *Circ Cardiovasc Interv* **6**(4): 407–416. <https://doi.org/10.1161/CIRCINTERVENTIONS.113.000463>
- Peng W, Peng Z, Chai X, Zhu Q, Yang G, Zhao Q, Zhou S (2015) Potential biomarkers for early diagnosis of acute aortic dissection. *Heart Lung* **44**(3): 205–208. <https://doi.org/10.1016/j.hrtlng.2015.01.006>
- Perko MJ, Nørgaard M, Herzog TM, Olsen PS, Schroeder TV, Pettersson G (1995) Unoperated aortic aneurysm: A survey of 170 patients. *Ann Thorac Surg* **59**(5): 1204–1209. [https://doi.org/10.1016/0003-4975\(95\)00132-5](https://doi.org/10.1016/0003-4975(95)00132-5)
- Pocar M, Passolunghi D, Moneta A, Donatelli F (2010) Recovery of severe neurological dysfunction after restoration of cerebral blood flow in acute aortic dissection. *Interact Cardiovasc Thorac Surg* **10**(5): 839–841. <https://doi.org/10.1510/icvts.2009.228908>
- Ranasinghe AM, Bonser RS (2010) Biomarkers in acute aortic dissection and other aortic syndromes. *J Am Coll Cardiol* **56**(19): 1535–1541. <https://doi.org/10.1016/j.jacc.2010.01.076>
- Raudkivi PJ, Williams JD, Monro JL, Ross JK (1989) Surgical treatment of the ascending aorta. Fourteen years experience with 83 patients. *J Thorac Cardiovasc Surg* **98**(5 Pt 1): 675–682.
- Roselli EE, Idrees J, Greenberg RK, Johnston DR, Lytle BW (2015) Endovascular stent grafting for ascending aorta repair in high-risk patients. *J Thorac Cardiovasc Surg* **149**(1): 144–154. <https://doi.org/10.1016/j.jtcvs.2014.07.109>
- Rylski B, Hoffmann I, Beyersdorf F et al; Multicenter Prospective Observational Study (2014) Acute aortic dissection type A: age-related management and outcomes reported in the German Registry for Acute Aortic Dissection Type A (GERAADA) of over 2000 patients. *Ann Surg* **259**(3): 598–604. <https://doi.org/10.1097/SLA.0b013e3182902cca>
- Shapiro MD (2009) Is the triple rule-out study an appropriate indication for cardiovascular CT? *J Cardiovasc Comput Tomogr* **3**(2): 100–103. <https://doi.org/10.1016/j.jcct.2008.12.011>
- Shiga T, Wajima Z, Apfel CC, Inoue T, Ohe Y (2006) Diagnostic accuracy of transesophageal echocardiography, helical computed tomography, and magnetic resonance imaging for suspected thoracic aortic dissection: systematic review and meta-analysis. *Arch Intern Med* **166**(13): 1350–1356. <https://doi.org/10.1001/archinte.166.13.1350>
- Spittell PC, Spittell JA Jr, Joyce JW, Tajik AJ, Edwards WD, Schaff H, Stanson AW (1993) Clinical features and differential diagnosis of aortic dissection: experience with 236 cases (1980 through 1990). *Mayo Clin Proc* **68**(7): 642–651. [https://doi.org/10.1016/S0025-6196\(12\)60599-0](https://doi.org/10.1016/S0025-6196(12)60599-0)
- Sutherland A, Escano J, Coon TP (2008) D-dimer as the sole screening test for acute aortic dissection: a review of the literature. *Ann Emerg Med* **2**(4): 339–343. <https://doi.org/10.1016/j.annemergmed.2007.12.026>
- Trimarchi S, Nienaber CA, Rampoldi V et al; International Registry of Acute Aortic Dissection Investigators (2005) Contemporary results of surgery in acute type A aortic dissection: The International Registry of Acute Aortic Dissection experience. *J Thorac Cardiovasc Surg* **129**(1): 112–122. <https://doi.org/10.1016/j.jtcvs.2004.09.005>
- Tsukube T, Hayashi T, Kawahira T et al (2011) Neurological outcomes after immediate aortic repair for acute type A aortic dissection complicated by coma. *Circulation* **124**(11 suppl 1): S163–S167. <https://doi.org/10.1161/CIRCULATIONAHA.110.011551>
- Williams DM, Brothers TE, Messina LM (1990) Relief of mesenteric ischemia in type III aortic dissection with percutaneous fenestration of the aortic septum. *Radiology* **174**(2): 450–452. <https://doi.org/10.1148/radiology.174.2.2136956>
- Yekeler I, Ates A, Ozyazicioglu A, Balci AY, Erkut B, Erol MK (2005) Time and risk analysis for acute type A aortic dissection surgery performed by hypothermic circulatory arrest, cerebral perfusion, and open distal aortic anastomosis. *Heart Surg Forum* **8**(5): E337–E347. <https://doi.org/10.1532/HSF98.20051121>
- Yoon YE, Wann S (2011) Evaluation of acute chest pain in the emergency department: triple rule-out computed tomography angiography. *Cardiol Rev* **19**(3): 115–121. <https://doi.org/10.1097/CRD.0b013e31820f1501>



British Journal of

# CARDIAC NURSING

## PROFESSIONAL DEVELOPMENT FOR CARDIAC NURSES

British Journal of

### CARDIAC NURSING

Promoting excellence in cardiovascular care

**EDITORIAL**  
Encouraging patients to become more active

**POLICY UPDATE**  
Lipid modification and prevention of CVD

**CLINICAL**  
Rate vs rhythm control in paroxysmal atrial fibrillation: Novel approach for supporting heart failure patients in primary care

**RESEARCH AND DEVELOPMENT**  
An integrated approach to cardiac rehabilitation and cognitive behavioural therapy: Screening and nutritional assessment of cardiac patients

**MEETING REPORT**  
Using patients and nurses at Heart Rhythm Congress

**COMMENT**  
Can cholesterol be defined as just 'good' or 'bad'?

**NURSING CARE FOR POST-IMPLANTATION ARTIFICIAL HEART RECIPIENTS**

ECG OF THE MONTH | RESEARCH ROUNDUP | BANCOS | PATIENT PERSPECTIVE

[www.magsubscriptions.com/cardiac](http://www.magsubscriptions.com/cardiac)