NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of aortic remodelling hybrid stent insertion during surgical repair of an acute type A aortic dissection

An acute type A aortic dissection is a tear in the upper part of the main blood vessel that carries blood from the heart to the body (aorta). The aorta may rupture or reduce blood flow to the organs. In this procedure, which is done during surgical repair of the dissection, a stent with material sewed on one end (hybrid stent) is inserted into part of the aorta (the aortic arch). The aim is to improve blood flow and encourage healing (remodelling) of the aorta.

Contents

Abbreviations

Word or phrase	Abbreviation
Acute type A aortic dissection	ATAAD
Acute DeBakey I aortic dissection	ATAD I
Automatic implantable cardioverter-defibrillator	AICD
Ascyrus medical dissection stent	AMDS
Deep hypothermic circulatory arrest	DHCA
False lumen	FL
Left ventricular assist device	LVAD
Interquartile range	IQR
Supra-aortic vessel	SAV
Standard deviation	SD
True lumen	TL

Introduction

The National Institute for Health and Care Excellence (NICE) prepared this interventional procedure overview to help members of the interventional procedures advisory committee (IPAC) make recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and professional opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in August 2021 and updated in March 2022.

Procedure name

- Aortic remodelling hybrid stent insertion during surgical repair of an acute type A aortic dissection

Professional societies

- Society of Cardiothoracic Surgery in Great Britain and Ireland
- British Cardiovascular Society
- British Cardiovascular Intervention Society
- British Society of Interventional Radiology
- Vascular Society of Great Britain and Ireland.

Description of the procedure

Indications and current treatment

An aortic dissection is a serious condition in which a tear occurs in the inner layer of the aorta. Blood flows through the tear and into the wall of the aorta. This forces the inner and middle layers of the aorta to split apart (dissect), creating 2 passages (a TL and a FL). As more blood flows into the new FL the dissection extends along the aorta. This can lead to aortic rupture or decreased blood flow (ischaemia or malperfusion) to organs.

Aortic dissections are classified into 2 types, depending on which part of the aorta is affected. Type A dissection involves a tear in the ascending part of the aorta. The tear may also occur in the aortic arch, which may extend into the abdomen or back into the ascending aorta. Type B dissection involves a tear in the aorta beyond the arch, usually in the descending thoracic aorta. Dissections can be acute or chronic.

Treatments for aortic dissection include medicines (to control hypertension) and surgery (to repair the aorta and possible replacement of the aortic valve). Type of treatment depends on the chronicity, site location, and whether there are complicating features. ATAAD is life threatening and needs immediate surgery. The goals of surgical repair are to seal the FL and resolve malperfusion.

What the procedure involves

Insertion of aortic remodelling hybrid stent is incorporated into open hemiarch repair for an acute type A aortic dissection, under general anaesthesia. The device is a self-expanding bare-metal stent with a short felt sewing cuff end. It aims to resolve malperfusion and promote positive remodelling of the aorta.

During the hemiarch aortic reconstruction, once circulatory arrest is established, the ascending aorta is transected and resected in the standard manner. A hybrid stent is then inserted until the entire device is inside the TL. This is usually done under direct vision, although it can be implanted using a guidewire. The cuff end of the stent is placed level with the edge of the transected aorta and attached with interrupted sutures. The uncovered portion of the stent expands along the aortic arch into the descending aorta. The remainder of the surgical hemiarch aortic reconstruction is completed in the usual way.

Efficacy summary

Remodelling in aorta and SAVs

Aortic and SAV dimensions

In a clinical trial of 46 patients with ATAD I, 35 patients had at least 1-year follow-up CT. When comparing with baseline (the first postoperative CT was used as a baseline), the total aortic diameter remained stable or decreased in 100% (35/35) of patients in zone A (aortic arch at the level of left common carotid artery), 77% (27/35) in zone B1 (2.5 cm distal to the left subclavian artery), 80% (28/35) in zone B2 (at the level of T6), 80% (28/35) in zone B3 (at the level of the distal end of the AMDS), and 74% (26/35) in zone C (proximal to the celiac trunk) at 1 year after procedure (Bozso 2021).

In a case series of 16 patients with ATAD I and affected SAVs, the mean total lumen area changed from 214.82 mm^2 before operation to 221.42 mm^2 after operation in the innominate artery, from 67.12 mm^2 to 54.84 mm^2 in the right common carotid artery, from 57.13 mm^2 to 62.60 mm^2 in the left common carotid artery, from 749.75 mm^2 to 728.00 mm^2 in the proximal-descending aorta, and from 602.13 mm^2 to 621.63 mm^2 in the mid-descending aorta (Montager 2021).

TL diameter

In the clinical trial of 46 patients, when comparing with baseline (the preoperative CT was used as a baseline) the TL diameter remained stable or increased at 1 year postoperation in 100% (35/35) of patients in zone A, zone B1, zone B2, zone B3 and zone C (Bozso 2021).

In the case series of 16 patients, the mean TL diameter increased from 9.15 mm before operation to 11.51 mm after operation in the innominate artery, from 4.24 mm to 5.98 mm in the right common carotid, from 5.91 mm to 7.51 mm in the left common carotid, from 18.34 mm to 23.91 mm in the proximal-descending aorta, and from 16.13 mm to 19.43 mm in the mid-descending aorta. For the indexed TL area (a percentage of the whole vessel area), there was a statistically significant increase from 32% before operation to 55% after operation ($p=0.002$) in the innominate artery, from 34% to 72% ($p=0.01$) in the right common carotid artery, from 37% to 64% ($p<0.001$) in the proximal-

descending aorta and from 35% to 51% (p=0.002) in the mid-descending aorta. The increase in the left common carotid artery was not statistically significant (from 64% to 83%, p=0.13; Montagner 2021).

FL diameter

In the clinical trial of 46 patients, when comparing with baseline (the preoperative CT was used as a baseline) the FL diameter remained stable or decreased at 1-year follow-up in 100% (35/35) of patients in zone A, 97% (34/35) in zone B1, 74% (26/35) in zone B2, 86% (30/35) in zone B3 and 77% (27/35) in zone C. Complete obliteration or thrombosis of the FL was reported in 74% (29/39) of patients in zone A, 53% (20/38) in zone B1, 31% (11/36) in zone B2, 24% (8/34) in zone B3, and 15% (5/34) in zone C at 1 year. Partial thrombosis of the FL was described in 10% (4/39) of patients in zone A, 16% (6/38) in zone B1, 36% (13/36) in zone B2, 32% (11/34) in zone B3, and 44% (15/34) in zone C (Bozso 2021).

In the case series of 16 patients, the mean FL diameter decreased from 13.67 mm before operation to 10.18 mm after operation in the innominate artery, from 7.04 mm to 3.21 mm in the right common carotid artery, from 3.89 mm to 2.37 mm in the left common carotid artery, from 24.30 mm to 16.36 mm in the proximal-descending aorta, and from 22.12 mm to 19.34 mm in the mid-descending aorta (Montager 2021).

Resolving malperfusion

In the clinical trial of 46 patients, 57% (26/46) of patients had clinical or radiographic malperfusion involving 66 individual vessels at baseline (Bozso 2021). In this malperfusion subgroup (n=26), malperfusion resolved in 95% (63/66) of the malperfused vessels at 1 year after operation, including 96% (21/22) supra-aortic, 93% (13/14) visceral, 94% (15/16) renal, and 100% (10/10) extremity (Bozso 2019).

In the case series of 16 patients, elimination of antegrade FL perfusion in the aortic arch was reported in 88% of patients, with partial or full FL thrombosis of the descending aorta in 69% of patients. In the same study, the innominate artery presenting with dissection without impaired perfusion, subtotal occlusion or total occlusion decreased from 75%, 25% and 0% of patients before operation to 69%, 6% and 0% of patients after operation. There were also decreases in the right common carotid artery (from 25%, 38% and 19% to 19%, 19% and 0%) and the left common carotid artery (from 25%, 13% and 6% to 25%, 0% and 0%; Montagner 2021).

Reintervention

In the clinical trial of 46 patients, a secondary procedure was needed in 4 patients, including malperfusion-related (n=3) and aortic growth-related (n=1). No reintervention was done in the aortic arch (Bozso 2021). In the malperfusion subgroup (n=26) from the clinical trial, reintervention was carried out in 3 patients and all related to malperfusion (Bozso 2019).

Length of stay

In the clinical trial of 46 patients, the median lengths of stay were 6 days (IQR 4.0 to 12.0 days) in the intensive care unit and 13 days (IQR 8.0 to 18.0 days) in the hospital (Bozso 2021). In the malperfusion subgroup (n=26) from the clinical trial, the median lengths of stay in the intensive care unit and hospital were 9 days (IQR 5.8 to 13.3 days) and 14 days (IQR 9.0 to 19.5 days) respectively (Bozso 2019).

In the case series of 16 patients, the mean length of stay in the intensive care unit was 11±8 days after operation (Montagner 2021).

Safety summary

Mortality

30-day mortality was reported in 6 patients and 1-year mortality in 9 patients in the clinical trial of 46 patients. The causes of death included multisystem organ failure (n=3), myocardial infarction (n=2), hypoxemic encephalopathy (n=2), massive pulmonary embolism (n=1) and uncontrollable intraoperative haemorrhage (n=1). Of these deaths, 2 deaths related to malperfusion (Bozso 2021). In the malperfusion subgroup (n=26) from the clinical trial, 30-day mortality was reported in 2 patients. One patient died of multiorgan failure at postoperative day 4, and life-sustaining therapy was withdrawn from another patient after a severe stroke (Bozso 2019).

30-day mortality was reported in 3 patients in the case series of 16 patients (Montagner 2021).

Neurologic dysfunction

Stroke

New stroke was reported in 3 patients at 30 days after operation, with no new strokes between 30 days and 1 year, in the clinical trial of 46 patients. All new strokes happened in patients with dissection involving 1 or several SAVs (Bozso 2021).

Postoperative stroke was reported in 6 patients in the case series of 16 patients (Montagner 2021).

Neurologic deficit

New neurologic deficit was identified in 2 patients at 30 days after operation in the malperfusion subgroup (n=26) from the clinical trial of the 46 patients (Bozso 2019).

New postoperative neurological deficits were diagnosed in 3 patients during the perioperative period in the case series of 16 patients (Montagner 2021).

Renal failure

Acute renal failure needing dialysis was described in 5 patients in the clinical trial of 46 patients (Bozso 2021). These 5 patients had ATAD I complicated by clinical or radiographic malperfusion (Bozso 2019).

Dialysis was needed in 2 patients in the case series of 16 patients (Montagner 2021).

Rehospitalisation

In the case series of 46 patients, rehospitalisation was reported in 8 patients at 1 year after operation. The causes were gastrointestinal bleed (n=1), epistaxis (n=1), low-flow alarm on LVAD (n=1), sternal re-wiring (n=1), pleural effusion drainage (n=1), implantation of AICD (n=1) and non-specific chest pain (n=2; Bozso 2021).

Anecdotal and theoretical adverse events

In addition to safety outcomes reported in the literature, professional experts are asked about anecdotal adverse events (events which they have heard about) and about theoretical adverse events (events which they think might possibly occur, even if they have never happened).

For this procedure, professional experts listed the following theoretical adverse events: aortic injury, aortic branch obstruction, stent fracture and stent failure.

The evidence assessed

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to aortic remodelling hybrid stent insertion during surgical repair of an acute type A aortic dissection. The following databases were searched, covering the period from their start to 15 March 2022: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches (see the literature search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The inclusion criteria were applied to the abstracts identified by the literature search. Where selection criteria could not be determined from the abstracts the full paper was retrieved.

Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, or a laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising study methodology, unless they reported specific adverse events that were not available in the published literature.
Patient	Patients with ATAAD.
Intervention/test	Insertion of aortic remodelling hybrid stent during surgical repair of ATAAD.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the IP overview

This IP overview is based on 62 patients from 1 single-arm trial (Bozso 2021), 1 retrospective case series (Montagner 2021), and 1 additional paper which reported the outcomes of the malperfusion subgroup from the clinical trial (Bozso 2019).

Other studies that were considered to be relevant to the procedure but were not included in the main summary of the key evidence are listed in the appendix.

Summary of key evidence on aortic remodelling hybrid stent insertion during surgical repair of an acute type A aortic dissection

Study 1 Bozso SJ (2021)

Study details

Study type	Single-arm trial (DARTS)
Country	Canada (5 centres) and Germany (1 centre)
Recruitment period	2017 to 2019
Study population and number	n=46 Patients with ATAD I
Age and sex	Mean 62.5 years; 67.4% (31/47) male
Patient selection criteria	Inclusion criteria: patients provided informed consent, between 18 to 80 years of age, diagnosed with an ATAD I or acute DeBakey I intramural hematoma, based on CT angiography, within 0-14 days. Exclusion criteria: Patients <18 years or >80 years, in extreme hemodynamic compromise needing cardiopulmonary resuscitation, had an arch or proximal descending thoracic aortic aneurysm measuring more than 45 mm, or had a diagnosis of connective tissue disorder.
Technique	Surgical aortic repair with adjunct AMDS implantation
Follow-up	Median 631 days
Conflict of interest/source of funding	This trial was funded by Ascyrus Medical.

Analysis

Follow-up issues: Of the 47 patients, 1 patient was excluded from all analysis because of implantation of an AMDS after an iatrogenic intraoperative dissection. Another patient was excluded from efficacy analysis because of incomplete resection of the dissection flap proximal to the device seal zone, contradicting the instructions for use of the device in the trial. Patients were followed up at 1, 3, 6, and 12 months postoperatively and then annually through 5 years. The outcomes were reported at 1 year after operation.

Study design issues: This was a multicentre, prospective, non-randomised, single-arm trial evaluating the safety and performance of the AMDS device for the treatment of ATAD I. This report summarised the acute and midterm outcomes of the dissected aorta repair through stent implantation (DARTS) prospective international trial. The primary endpoint was all-cause mortality and serious adverse events within 30 days of the initial procedure. Secondary endpoints were malperfusion resolution, secondary procedures required, aortic remodelling, and FL status. For analysis of total aortic diameter, the first postoperative CT was used as a baseline. For all other measurements, the preoperative CT was used as a baseline.

The aorta was measured at zone A (aortic arch at the level of left common carotid artery), zone B1 (2.5 cm distal to the left subclavian artery), zone B2 (at the level of T6), zone B3 (at the level of the distal end of the AMDS), and zone C (proximal to the celiac trunk). Aortic remodelling was defined according to internationally agreed on criteria based on changes in aortic dimensions, including total aortic diameter, TL size, and FL size. Malperfusion was defined as loss of blood supply to a vital organ resulting from branch arterial obstruction secondary to the dissection and was assessed clinically and radiographically. Radiographic vessel malperfusion was defined as high-grade stenosis (>75%) or occlusion of the vessel because of compression by the nonperfused FL and leading to interruption of flow within the affected vessel.

Study population issues: All patients had a perfused FL preoperatively and verified intraoperatively. At baseline, malperfusion presented in 57% (26/46) of patients, reoperation in 4.3% (2/46), hypertension in 63% (29/46), chronic renal failure in 13% (6/46), chronic obstructive pulmonary disease in 13% (6/46) and preoperative stroke in 19.6% (9/46).

Other issues: This trial was non-randomised, and patients were enrolled as all-comers without selection input from the sponsor, representing a real-world scenario.

Key efficacy findings

Number of patients analysed: 46

Procedural data:

- Successful device deployment: 100% (n=46)
- Hemiarch repair: 97.8% (n=45)
- Total arch replacement: 2.2% (n=1)
- Aortic root replacement: 45.7% (n=21)
- Arterial cannulation through the right axillary artery: 89.1% (n=41)
- Arterial cannulation through the left femoral artery: 10.9% (n=5)
- Median DHCA duration (minutes): 33.5 (IQR 26.0 to 41.5)
- Median AMDS implantation time (minutes): 3.0 (IQR 2.0 to 5.0)
- Median cerebral perfusion duration (minutes): 30.5 (IQR 23.0 to 37.8)
- Median intensive care unit length of stay (days): 6.0 (IQR 4.0 to 12.0)
- Median hospital length of stay (days): 13.0 (IQR 8.0 to 18.0)
- Blood transfusion needed: 60.9% (n=28)
- Median number of units transfused within 24 hours: 3.0 (IQR 2.0 to 6.0)

Malperfusion-related outcomes after surgical repair and AMDS implantation:

- Preoperation: malperfusion in 56.5% of patients (26/46, with 66 individual vessels malperfused)
- Postoperation:

- 95.45% of vessel malperfusions (63/66) resolved without an additional procedure, including 3 patients presenting with spinal cord ischemia manifesting as paralysis which resolved postoperatively.
- Cerebral malperfusion involving the SAVs anatomically resolved in 85.7% of the vessels (18/21) involved.

Aortic remodelling at 1 year postoperatively, change from baseline (n=35)

Aortic zone	A	B1	B2	B3	C
Total aortic diameter					
Decrease	34.3% (n=12)	8.6% (n=3)	2.9% (n=1)	0% (n=0)	2.9% (n=1)
Stable	65.7% (n=23)	68.6% (n=24)	77.1% (n=27)	80.0% (n=28)	71.4% (n=25)
Increase	0% (n=0)	22.9% (n=8)	20.0% (n=7)	200% (n=7)	25.7% (n=9)
TL diameter					
Decrease	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)
Stable	11.4% (n=4)	14.3% (n=5)	31.4% (n=11)	22.9% (n=8)	51.4% (n=18)
Increase	88.6% (n=31)	82.9% (n=29)	65.7% (n=23)	74.3% (n=26)	45.7% (n=16)
FL diameter					
Decrease	88.6% (n=31)	88.6% (n=31)	40.0% (n=14)	54.3% (n=19)	25.7% (n=9)
Stable	11.4% (n=4)	8.6% (n=3)	34.3% (n=12)	31.4% (n=11)	51.4% (n=18)
Increase	0% (n=0)	2.9% (n=1)	22.9% (n=8)	11.4% (n=4)	20.0% (n=7)

35 patients had at least 1-year follow-up CT. Change from baseline, maximum diameter measure.

FL response at 1 year postoperatively

Aortic zone	A (n=39[a])	B1 (n=38[b])	B2 (n=36[c])	B3 (n=34[d])	C (n=34[e])
Obliterated	61.5% (n=24)	26.3% (n=10)	11.1% (n=4)	2.9% (n=1)	2.9% (n=1)
Completely thrombosed	12.8% (n=5)	26.3% (n=10)	19.4% (n=7)	20.6% (n=7)	11.8% (n=4)
Partially thrombosed	10.3% (n=4)	15.8% (n=6)	36.1% (n=13)	32.4% (n=11)	44.1% (n=15)
Patent	15.4% (n=6)	31.6% (n=12)	33.3% (n=12)	44.1% (n=15)	41.2% (n=14)

[a]Thirty-nine patients had ≥1 follow-up CT, and the latest CT was used for analysis compared with the preoperative CT as a baseline.
[b]One dissection ended in distal arch.
[c]Two dissections ended in proximal descending.
[d]Two dissections ended in the mid/distal descending.

AMDS promoted FL closure at the distal anastomosis: 90%

Secondary procedures:

- Malperfusion-related: 6.5% (n=3)

One patient had successful left renal artery stenting for distal malperfusion during index hospitalisation. Another patient with persistent visual field deficits had successful left common carotid artery stenting because of de novo dissection of the carotid artery distal to the origin of the vessel, and 1 patient had successful superior mesenteric artery stenting for residual static malperfusion.

- Aortic growth-related: 2.2% (n=1)

  This patient had left common carotid interposition graft, left subclavian covered stent, and coiling of the FL because of expansion of the proximal and mid-descending aorta. This reintervention induced obliteration of the FL in the proximal and mid-descending aorta and positive remodelling with a reduction in total aortic size.

- Aorta-related: 0% (n=0)

  The Kaplan-Meier estimate of freedom from malperfusion and aorta-related reintervention at 1 year was 91.3%.

Key safety findings

Mortality:

- 30-day: 13% (n=6)

  Causes of death included multisystem organ failure (n=2), myocardial infarction (n=1), hypoxemic encephalopathy (n=1), massive pulmonary embolism (n=1) and uncontrollable intraoperative haemorrhage (n=1)

- 1-year: 19.6% (n=9)

  31 days to 1 year: 6.5% (n=3) Causes of death included multisystem organ failure (n=1), myocardial infarction (n=1) and hypoxemic encephalopathy (n=1)

  The Kaplan-Meier estimate of freedom from all-cause mortality at 1 year was 80.4%.

- aorta-related: 0%
- malperfusion-related: 7.7% (n=2)

New stroke:

- 30-day: 6.5% (n=3, all new strokes happened in patients with dissection involving 1 or several SAVs)
- 1-year: 6.5% (n=3)

Acute renal failure needing dialysis: 10.9% (n=5)

No spinal cord ischaemia, aortic injury associated with device implantation, stent fracture, distal stent-induced new entry tear and device-related reintervention.

Causes of rehospitalisation: GI bleed (n=1), epistaxis (n=1), low-flow alarm on LVAD (n=1), sternal re-wiring (n=1), pleural effusion drainage (n=1), implantation of AICD (n=1) and non-specific chest pain (n=2).

Study 2 Bozso SJ (2019)

Study details

Study type	Single-arm trial (DARTS)
Country	Canada (5 centres) and Germany (1 centre)
Recruitment period	2017 to 2019
Study population and number	n=26 Patients with ATAD I complicated by clinical or radiographic malperfusion
Age and sex	Mean 66 years; 62% (10/16) male
Patient selection criteria	Inclusion criteria: patients who provided informed consent, ≥18 years of age or ≤80 years of age (male or female), diagnosed with an ATAD I, based on CT angiography, within 14 days. Exclusion criteria: Patients <18 years or >80 years, in extreme hemodynamic compromise needing cardiopulmonary resuscitation, had an arch or proximal descending thoracic aortic aneurysm measuring more than 45 mm, or had a diagnosis of Marfan, Loeys-Dietz, or Ehlers-Danlos syndrome.
Technique	Surgical aortic repair with adjunct AMDS implantation
Follow-up	Median 283 days (IQR 147 to 351 days)
Conflict of interest/source of funding	This trial was funded by Ascyrus Medical.

Analysis

Follow-up issues: Of the 26 patients in the malperfusion group, 2 patients were excluded from efficacy analysis because of early death without a postoperative CT. These 2 patients had severe SAV malperfusion and left lower extremity malperfusion, respectively.

Study design issues: This was a multicentre, prospective, non-randomised, single-arm trial evaluating the safety and performance of the AMDS device for the treatment of ATAD I. This report focused on the outcomes of patients presenting with ATAD I complicated by clinical or radiographic malperfusion, or both, treated with surgical repair and implantation of the AMDS (malperfusion subgroup's outcomes).

The primary end point was status of malperfusion after AMDS implantation. Secondary end points within 30 days were death, new neurologic dysfunction, device-related reintervention, disease-related reintervention, and serious adverse events. Malperfusion is defined as loss of blood supply to a vital organ caused by branch arterial obstruction secondary to the dissection and was assessed clinically and radiographically on the immediate postoperative multislice CT scans. SAV malperfusion was defined as a high-grade stenosis (>75%) or occlusion of the vessel because of compression by the nonperfused FL leading to interruption of flow within the affected vessel.

Study population issues: Overall, 66 vessel malperfusions were identified, consisting of 1.5% (n=1) coronary, 33.3% (n=22) supraaortic, 21.2% (n=14) visceral, 24.2% (n=16) renal, and 15.1% (n=10) extremities. At

baseline, 3 patients (11.5%) had clinical evidence of paralysis, and 1 patient (3.8%) had sternotomy. Hypertension presented in 14 patients (53.8%), chronic obstructive pulmonary disease in 3 (11.5%), chronic renal failure in 4 (15.4%), and previous stroke in 7 (26.9%). Preoperative neurologic symptoms presented in 4 patients (15.4%).

Other issues: Authors recognised that some potentially severe complications exist related to device insertion, despite a simple device implantation procedure. Iatrogenic aortic injury or device insertion into the FL was a theoretical possibility and would lead to severe complication. To mitigate this risk, the device could be placed over a transesophageal/intravascular ultrasound/fluoroscopyguided guidewire. However, none of the patients experienced this complication.

Key efficacy findings

Number of patients analysed: 26

Procedural data:

- Successful AMDS implantation: 100% (n=26)
- DHCA duration (minutes): 34.0 (range 26.5 to 42.5)
- Arterial cannulation and cerebral perfusion:
  - through the right axillary artery: 91.3%
  - through the femoral artery: 8.7%
- Median cerebral perfusion duration (minutes): 32.0 (21.5 to 40.5)
- Median deep hypothermic circulatory arrest duration (minutes): 34.0 (IQR 26.5 to 42.5)
- Median AMDS implantation time (minutes): 3.0 (2.0 to 5.5)
- Median length of stay (days):
  - Intensive care unit: 9.0 (5.8 to 13.3)
  - Hospital: 14.0 (9.0 to 19.5)

Summary of vessel malperfusions

Malperfusion	Total	Resolved	Percentage
Coronary artery	1	1	100%
Innominate artery	6	6	100%
Right common carotid artery	6	5	83.8%
Left common carotid artery	7	7	100%
Left subclavian artery	2	2	100%
Right subclavian artery	1	1	100%
Spinal cord	3	3	100%
Celiac artery	6	6	100%

Superior mesenteric artery	8	7	87.5%
Right renal	6	6	100%
Left renal	10	9	90%
Left lower extremity	7	7	100%
Right lower extremity	3	3	100%
Total	66	63	95.5%

Reintervention: n=3

One patient had successful left renal artery stenting for static malperfusion during the index hospitalisation. Another patient had successful superior mesenteric artery stenting for residual static malperfusion. The third patient presented to the hospital after more than 24 hours of chest pain, anuria, and bilateral lower extremity pain, pulselessness, and inability to move the left lower extremity. The CT scan confirmed the diagnosis of acute aortic dissection with complete TL collapse immediately below the superior mesenteric artery, with malperfusion to bilateral kidneys and lower limbs. The patient regained femoral pulses bilaterally after AMDS implantation, but as a result of his late presentation, received bilateral femoral artery patch angioplasties and left lower extremity fasciotomy.

Key safety findings

30-day mortality: 7.7% (n=2) One patient died of multiorgan failure on postoperative day 4, and life-sustaining therapy was withdrawn from another patient after a severe stroke.

New neurologic deficit identified postoperatively: 7.7% (n=2) At 30 days, 6 patients (23.1%) were diagnosed with a neurologic injury postoperatively. Of these patients, 4 patients (66.7%) presented with neurologic symptoms before the intervention. A new neurologic deficit was identified postoperatively in 2 patients without neurologic symptoms preoperatively.

Acute renal failure: 19.2% (n=5)

Dialysis: 19.2% (n=5)

No aortic injury associated with device implantation and new aortic arch branch vessel compromise.

No device-related deaths or reinterventions were reported during the follow-up period.

Study 3 Montagner M (2021)

Study details

Study type	Case series (retrospective)
Country	Germany (single centre)
Recruitment period	2018 to 2020
Study population and number	n=16 Patients with ATAD I and affected SAVs
Age and sex	Mean 61 years; 68% (11/16) male
Patient selection criteria	Inclusion criteria: patients had operation and AMDS implantation for ATAD I; at least 1 SAV affected, based on preoperative CT scans.
Technique	Hemiarch procedure with adjunct AMDS implantation
Follow-up	Perioperative period
Conflict of interest/source of funding	Two authors received travel grants and speaker fees from Ascyrus Medical (Boca Raton, FL, USA).

Analysis

Study design issues: This study investigated the effects of AMDS implants on TL perfusion in patients presenting with acute type A aortic dissection and affected SAVs. Acute preoperative neurological symptoms were classified only if present on admission to hospital. Postoperatively, the presence and quality of neurological symptoms were assessed for all patients by discriminating between loss of function (0 points out of 5 at neurological examination, Medical Research Council Muscle Scale) and impaired function (1 to 4 out of 5). Duration was divided into transient (symptom improves or recovers within days after surgery) and permanent (no recovery observed perioperatively).

Study population issues: The most stenotic portion of a diseased branch was defined as ‘dissected’ in cases of dissection without perfusion impairment, as ‘subtotally occluded’ in cases of 75% to 99% stenosis and as ‘totally occluded’ in cases with 100% stenosis.

At baseline, 1 patient (6.25%) was admitted in cardiogenic shock because of a massive pericardial effusion and with acute left-sided hemiparesis (PENN class Abc). The average German Registry for acute aortic dissection type A score was 20.47% (SD: 6.8%). Six patients (37.5%) presented with acute neurological symptoms: 5 of them had a left-sided hemiparesis, and 1 patient had isolated left leg paresis. Among these patients, preoperative CT scans showed involvement of 2 supra-aortic branches in 50% of cases, and 67% had at least 1 subtotally occluded vessel.

Other issues: There were a few limitations in addition to the retrospective nature and the small sample size. The analysis refers to the perioperative course only, so longer follow-up period was needed to provide valuable information regarding positive vascular remodelling. The collected quantitative measurements were derived from the CT scan, which is known to provide a static flow pattern only. A dynamic analysis using carotid Doppler might have been a more precise tool to assess cerebral perfusion. Due to the lack of availability of

dynamic measurements for most patients, authors were not able to provide meaningful results regarding this topic.

Key efficacy findings

Number of patients analysed: 16

Intraoperative data:

- Pain-to-cut time (time between onset of symptoms and the operation): 398±268 minutes
- Operation time: 370±114 minutes
- Aortic valve surgery:
    - Repair: 68.75% (n=11)
    - Biological replacement: 25% (n=4)
    - Mechanical replacement: 6.25% (n=1)
- Root operation:
    - Reconstruction: 56.25% (n=9)
    - Bentall: 31.25% (n=5)
    - David: 12.85% (n=2)
- AMDS sizing:
    - 40 tubular: 25% (n=4)
    - 40 to 30 tapered: 18.75% (n=3)
    - 55 tubular: 6.25% (n=1)
    - 55-40 tapered: 50% (n=8)
- Revision for bleeding: 12.5% (n=2)

Perioperative data:

- Length of stay in the intensive care unit: 11±8 days
- Ventilation time: 5±6 days
- Open chest therapy: 6.5% (n=1)
- Reintubation: 12.5% (n=2)
- Tracheotomy: 12.5% (n=2)
- Delirium: 37.5% (n=6)
- Postoperative low cardiac output syndrome: 6.25% (n=1)

Centre-line-based measurements of dissected SAVs and descending aorta before and after surgery, mean±SD, % (n)

Assessment of dissected vessels	Preoperative, n=16	Postoperative, n=16
Innominate artery		
Dissected	75% (n=12)	68.75% (n=11)
Subtotal occlusion	25% (n=4)	6.25% (n=1)
Total occlusion	0	0
TL diameter (mm)	9.15±1.81	11.51±2.42
TL area (mm^2)	68.04±25.16	108.22±44.92
FL diameter (mm)	13.67±1.93	10.18±6.25
FL area (mm^2)	149.60±41.78	110.53±80.03
Total area (mm^2)	214.82±54.11	221.42±78.00
Measurement landmark (mm)	18.82±6.93	20.16±8.34
Right common carotid		
Dissected	25% (n=4)	18.75% (n=3)
Subtotal occlusion	37.5% (n=6)	18.75% (n=3)
Total occlusion	18.75% (n=3)	0
TL diameter (mm)	4.24±2.34	5.98±2.06
TL area (mm^2)	18.21±13.66	31.25±15.87
FL diameter (mm)	7.04±3.57	3.21±4.56
FL area (mm^2)	48.42±28.59	23.48±34.97
Total area (mm^2)	67.12±20.35	54.84±25.82
Measurement landmark (mm)	30.74±21.17	28.46±17.20
Left common carotid		
Dissected	25% (n=4)	25% (n=4)
Subtotal occlusion	12.5% (n=2)	0
Total occlusion	6.25% (n=1)	0
TL diameter (mm)	5.91±2.12	7.51±1.49
TL area (mm^2)	30.92±15.60	45.92±18.39
FL diameter (mm)	3.89±4.40	2.37±4.01
FL area (mm^2)	26.37±33.09	16.28±30.51
Total area (mm^2)	57.13±22.84	62.60±31.87
Measurement landmark (mm)	40.30±29.62	35.49±20.00
Proximal-descending aorta		
TL diameter (mm)	18.34±4.42	23.91±3.86
TL area (mm^2)	278.59±130.33	460.13±144.61

FL diameter (mm)	24.30±3.34	16.36±8.45
FL area (mm^2)	471.88±134.24	262.81±150.36
Total area (mm^2)	749.75±175.57	728.00±193.56
Measurement landmark (mm)	105.56±13.79	105.56±13.79
Mid-descending aorta		
TL diameter (mm)	16.13±2.96	19.43±2.82
TL area (mm^2)	211.31±80.47	303.00±85.55
FL diameter (mm)	22.12±3.24	19.34±6.42
FL area (mm^2)	392.06±117.40	324.13±158.53
Total area (mm^2)	602.13±166.26	621.63±193.72
Measurement landmark (mm)	220.31±28.44	220.31±28.44

In 87.5% of patients, elimination of antegrade FL perfusion in the aortic arch was achieved, with partial or full FL thrombosis of the descending aorta in 68.75% of patients.

Paired t-test comparison of indexed TL area in the SAVs and descending aorta after an AMDS implant

Indexed TL areas, mean±SD	**Preoperative**	**postoperative**	**P value**
Indexed innominate artery TL (%)	32±9	55±28	0.002
Indexed right common carotid artery TL (%)	34±33	72±40	0.01
Indexed left common carotid artery TL (%)	64±40	83±29	0.13
Indexed proximal-descending TL (%)	36.53±12.49	64.31±18.91	<0.001
Indexed mid-descending TL (%)	35.09±8.66	50.74±16.41	0.002

Key safety findings

Full AMDS expansion was confirmed in all patients postoperatively, without any device-related complications.

Perioperative data:

- Dialysis: 12.5% (n=2)
- Postoperative neurological deficit: 50% (n=8)

  Among the 6 patients with preoperative acute deficits, 5 (83%) had the deficits also after surgery and 1 recovered completely. Three new postoperative neurological deficits were diagnosed: 1 patient had an occluded right common carotid and a subtotally occluded left common carotid artery preoperatively, and 2 presented with subtotal occlusion of the right or left common carotid. Neurological deficits were transient in 5 patients (62.5%), and 6 patients (75%) were classified as impaired function.

- Neurological deficit duration
  - Transient: 62.5% (n=5)

    - Permanent: 37.5% (n=3)
- Neurological deficit quality:
    - Impaired function: 75% (n=6)
    - Loss of function: 25% (n=2)
- Postoperative CT-diagnosed stroke: 37.5% (n=6)
- 30-day mortality: 18.75% (n=3)

Validity and generalisability of the studies

- Studies were done in Canada and Germany. There was no data related to the UK context.
- The total sample was small. Bozso (2021) had the longest follow-up period (median 631 days; outcomes were reported at 1 year after operation), and Montagner (2021) had the shortest follow-up duration (perioperative period). Therefore, studies in larger cohorts with longer follow-up were lacking.
- All patients had ATAD I but there was variation in the inclusion criteria, such as patients with ATAD I complicated by malperfusion or patients presenting with ATAD I and affected SAVs.
- One device (AMDS) was used, and its insertion was done during hemiarch repair in all patients but one (who had total arch replacement).

Existing assessments of this procedure

There were no published assessments from other organisations identified at the time of the literature search.

Related NICE guidance

Below is a list of NICE guidance related to this procedure.

Interventional procedures

- Endovascular stent–graft placement in thoracic aortic aneurysms and dissections. NICE interventional procedures guidance 127 (2005). Available from https://www.nice.org.uk/guidance/ipg127

Medical technologies

- E-vita open plus for treating complex aneurysms and dissections of the thoracic aorta. NICE Medical technologies guidance 16 (2013, updated 2018). Available from https://www.nice.org.uk/guidance/mtg16

Additional information considered by IPAC

Professional experts' opinions

Expert advice was sought from consultants who have been nominated or ratified by their professional Society or Royal College. The advice received is their individual opinion and is not intended to represent the view of the society. The advice provided by professional experts, in the form of the completed questionnaires, is normally published in full on the NICE website during public consultation, except in circumstances but not limited to, where comments are considered voluminous, or publication would be unlawful or inappropriate.

Two professional expert questionnaires for aortic remodelling hybrid stent insertion during surgical repair of an acute type A aortic dissection were submitted and can be found on the NICE website.

Patient organisation opinions

One patient organisation submission for aortic remodelling hybrid stent insertion during surgical repair of an acute type A aortic dissection was received and can be found on the NICE website.

Patient commentators' opinions

NICE's Public Involvement Programme was unable to gather patient commentary for this procedure.

Company engagement

A structured information request was sent to 3 companies who manufacture a potentially relevant device for use in this procedure. NICE received 1 completed submission. This was considered by the IP team and any relevant points have been taken into consideration when preparing this overview.

Issues for consideration by IPAC

Ongoing trials

- Dissected aorta repair through stent implantation (DARTS): A feasibility study NCT03035643; Single group assignment; Canada; estimated enrolment n=30; estimated study completion date, February 2024.

- Dissected aorta repair through stent implantation (DARTS): A feasibility, safety and performance trial NCT03397251; single group assignment; Germany; estimated enrolment n=40; estimated study completion date, October 2023.

- Dissected aorta repair through stent implantation (DARTS): A post-market registry NCT03894033; observational (patient registry): Germany; estimated enrolment n=100; estimated study completion date, February 2024.

- A prospective, single arm, multi-center clinical investigation to evaluate the safety and effectiveness of AMDS in the treatment of acute DeBakey type I dissection: PERSEVERE NCT05174767; single group assignment; estimated enrolment n=93; estimated completion date, March 2028

References

1. Bozso SJ, Nagendran J, Chu MWA et al. (2021) Midterm outcomes of the dissected aorta repair through stent implantation trial. The Annals of thoracic surgery 111(2): 463-70
2. Bozso SJ, Nagendran J, Chu MWA et al. (2019) Single-stage management of dynamic malperfusion using a novel arch remodeling hybrid graft. The Annals of thoracic surgery 108(6): 1768-75
3. Montagner M, Kofler M, Heck R et al. (2021) Initial experience with the new type A arch dissection stent: restoration of supra-aortic vessel perfusion. Interactive Cardiovascular and Thoracic Surgery 33(2): 276-83

Literature search strategy

Databases	Date searched	Version/files
Cochrane Database of Systematic Reviews – CDSR (Cochrane Library)	15/03/2022	Issue 3 of 12, March 2022
Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library)	15/03/2022	Issue 2 of 12, February 2022
International HTA database (INAHTA)	15/03/2022	-
MEDLINE (Ovid)	15/03/2022	1946 to March 14, 2022
MEDLINE In-Process (Ovid)	15/03/2022	1946 to March 14, 2022
MEDLINE Epubs ahead of print (Ovid)	15/03/2022	1946 to March 14, 2022
EMBASE (Ovid)	15/03/2022	1974 to 2022 March 14
EMBASE Conference (Ovid)	15/03/2022	1974 to 2022 March 14

Trial sources searched 2020

- Clinicaltrials.gov
- ISRCTN
- WHO International Clinical Trials Registry

Websites searched 2020

- National Institute for Health and Care Excellence (NICE)
- NHS England
- Food and Drug Administration (FDA) - MAUDE database
- Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP – S)
- Australia and New Zealand Horizon Scanning Network (ANZHSN)
- General internet search

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

Literature search strategy

Number	Search term
1	Aneurysm, Dissecting/
2	DeBakey.tw.
3	((aneurysm* or acute aort*) adj4 (dissect* or tear* or cut* or split*)).tw.
4	ATAAD.tw.
5	AAD.tw.
6	or/1-5
7	Self Expandable Metallic Stents/
8	((self expand* or self-expand*) adj4 metal* stent*).tw.
9	AMDS.tw.
10	(aortic arch adj4 (remodel* or stent* or graft*)).tw.
11	(aortic* adj4 (prosthes* or Implant*)).tw.
12	or/7-11
13	6 and 12
14	"Ascyrus Medical Dissection Stent".tw.
15	13 or 14
16	Animals/ not Humans/
17	15 not 16
18	limit 17 to english language

Appendix

The following table outlines the studies that are considered potentially relevant to the IP overview but were not included in the summary of the key evidence. It is by no means an exhaustive list of potentially relevant studies.

Additional papers identified

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
Bozso SJ, Nagendran J, MacArthur, RGG et al. (2019) Dissected aorta repair through stent implantation trial: Canadian results. The Journal of thoracic and cardiovascular surgery 157(5): 1763-71	Single-arm trial n=16 Follow-up: mean 130 days (SD 94)	Preliminary results suggest that the AMDS is a safe, feasible and reproducible adjunct to current surgical approaches for ATAD I repair. Further, the AMDS manages malperfusion and promotes early positive remodelling in the aortic arch and distal dissected segments, with favourable FL closure rates at follow-up. Ongoing follow-up will provide additional insight into the long-term effects of the AMDS.	This study reported the initial experience with the AMDS and its sample was included in Bozso (2021) which reported the acute and midterm outcomes of the DARTS trial (n=46, follow up, median 631 days).
Elbatarny M, Youssef A, Bozso SJ et al. (2020) Repair of acute type A dissection with distal malperfusion using a novel hybrid arch device. Multimed Man Cardiothorac Surg.	Case report n=1	The use of the AMDS uncovered aortic stent represents an attractive novel solution for patients with acute type A aortic dissection. Advantages include the ability to seal the distal anastomosis, depressurise the FL, and address distal malperfusion, without arch vessel intervention	Tutorial with limited efficacy outcomes reported for the single case.

		or risk of spinal cord ischemia. The simplicity of the technique makes it a viable option for widespread adoption. However, further study is required to clarify the exact role of the AMDS device in the armamentarium of treatment options for patients with acute type A aortic dissection.	
Greason KL (2018) Did the investigators hit the aortic dissection bullseye with DARTS? The journal of thoracic and cardiovascular surgery	Review	Dissected aorta repair through stent implantation represents a paradigm change in the management of acute ascending aortic dissection.	Review article
Luthra S and Tsang GM (2021) Concurrent stabilisation of “downstream” aorta during acute type A aortic dissection repair. J Thorac Cardiovasc Surg: 1-3	Review	The dissected aorta repair through stent implantation trial reported malperfusion-related mortality of 7.7%, malperfusion resolution in 95.5%, paralysis in 0%, new postoperative stroke in 6.5%, and aortic arch remodelling in 100%. However, the number of patients is small and follow-up is short.	Review article
Montagner M, Heck R, Kofler M et al. (2020) New hybrid prosthesis for acute type a aortic dissection. Surgical Technology International 36: 1-5	Review	The AMDS seems to achieve effective sealing of the FL at the distal anastomosis and rapid expansion of the TL, thereby depressurising the FL and increasing TL perfusion. Without adding significant time or complexity to the	Review article

		standard procedure, the AMDS could provide effective and reliable management of malperfusions, induce positive aortic remodelling and reduce reintervention rates. However, this hope has to be proven once long-term data become available.	
Waterford SD, Moon CJ and Moon MR (2019) Arch stenting in type A aortic dissection: tread lightly. Ann Thorac Surg 108: 1593-5	Review	This article does not highlight the greatest promise of the AMDS device: false lumen remodelling with a potential for decreased intervention on the distal aorta at long-term follow-up. For the time being, type A aortic dissection repair with ascending aortic or hemiarch replacement remains the best operation for restoration of true lumen flow.	Review article