National Institute for Health and Care Excellence

Final

Abdominal aortic aneurysm: diagnosis and management

Evidence review Q: Permissive hypotension during transfer of people with ruptured abdominal aortic aneurysm to regional vascular services

NICE guideline NG156

Methods, evidence and recommendations

March 2020

Final

This evidence review was developed by the NICE Guideline Updates Team

Disclaimer

The recommendations in this guideline represent the view of NICE, arrived at after careful consideration of the evidence available. When exercising their judgement, professionals are expected to take this guideline fully into account, alongside the individual needs, preferences and values of their patients or service users. The recommendations in this guideline are not mandatory and the guideline does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of the individual patient, in consultation with the patient and/or their carer or guardian.

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Permissive hypotension during transfer of people with ruptured AAA to regional vascular services

Review question

Does permissive hypotension improve a person's chance of survival or improve the stability of their condition in the transfer of people with ruptured or symptomatic abdominal aortic aneurysms to a regional vascular service?

Introduction

This review question aims to determine if permissive hypotension improves a person's chance of survival or improve the stability of their condition in the transfer of people with ruptured or symptomatic abdominal aortic aneurysms to a regional vascular service.

Table 1: Inclusion criteria

Parameter	Inclusion criteria
Population	People with suspected or confirmed ruptured or symptomatic unruptured abdominal aortic aneurysms who need to be transferred to a regional vascular service
Intervention	Permissive / controlled hypotension or hypotensive resuscitation strategy
Comparator	Normotensive resuscitation strategy
Outcome	• Survival /mortality • Bleeding/need for transfusion • Myocardial infarction • Renal failure • Adverse effects of intervention – stroke, bowel ischaemia • Quality of life • Resource use, including of intensive care unit stay, and cost

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in Appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

A Cochrane systematic review (Moreno et al. 2016) that aimed to compare controlled hypotension and normotensive resuscitations strategies for people with ruptured AAA was identified as a potential source of randomised controlled trials (RCTs) relevant to this review question. Since the systematic review was published in 2016, the Cochrane Vascular Group worked in collaboration with the NICE Guideline Updates Team and performed update literature searches to facilitate identification of any RCTs published after publication of the systematic review by Moreno et al. (2014). All RCTs that met inclusion criteria outlined in table 1 were included.

Studies were excluded if they:

- were not in English
- were not full reports of the study (for example, published only as an abstract)
- were not peer-reviewed.

Clinical evidence

Included studies

The 2016 Cochrane systematic review did not identify any RCTs comparing controlled hypotension and normotensive resuscitations strategies in people with ruptured AAA. An update literature search performed by Cochrane, in August 2017, found 228 abstracts; none of which were considered relevant to this review question. Another update search was performed by Cochrane, in December 2017. This search identified 270 abstracts; none of which were considered relevant to this review question.

Excluded studies

No studies were retrieved for full-text review..

Economic evidence

Included studies

A literature search was conducted jointly for all review questions by applying standard health economic filters to a clinical search for AAA. This search returned a total of 5,173 citations. Following review of all titles and abstracts, no studies were identified as being potentially relevant to the review question. No full texts were retrieved, and no studies were included as economic evidence.

An update search was conducted in December 2017, to identify any relevant health economic analyses published during guideline development. The search found 814 abstracts; all of which were not considered relevant to this review question. As a result no additional studies were included.

Excluded studies

No studies were retrieved for full-text review.

Evidence statements

No evidence was identified for this review question.

Research recommendation

RR8. Does permissive hypotension improve survival or improve the stability of people undergoing repair of ruptured AAA?

The committee's discussion of the evidence

Interpreting the evidence

The outcomes that matter most

The committee considered that the outcome that matters most is mortality during transfer.

The quality of the evidence

The committee agreed that, although there was a lack of evidence on permissive hypotension during transfer of people with ruptured AAA, practical guidance was needed for clinicians who will be transferring people between hospitals. They agreed that the context of inter-hospital transfer was important as vascular specialists should be involved in the decision to commence permissive hypotensive resuscitation strategies.

The committee noted that a recommendation in the clinical guideline on assessment and management of major trauma (NICE guideline NG39) recommended the use of restrictive approaches to volume resuscitation in this population. The committee recognised that populations experiencing haemorrhage after trauma and those experiencing haemorrhage due to ruptured AAA were likely to be demographically different (especially with respect to age). However, they agreed that the rationale underpinning the use of restrictive fluid rescuscitation in people after major trauma was applicable to people with ruptured AAA, as both groups experience profuse bleeding. As a result, the committee considered it reasonable to adapt the recommendation from NICE guideline NG39 so it can be used within the context of AAA.

Benefits and harms

The committee considered that the recommendation would prevent harm associated with overuse of resuscitative fluids during transfer of people to regional vascular services following AAA rupture. Excessive fluid resuscitation can dilute clotting factors, cause hypocalcaemia and reduce a patient's body temperature. The committee agreed that a potential benefit of a permissive hypotensive resuscitation strategy is that it can make surgery easier by reducing the size of haematomas. Furthermore, patients will retain the ability to form clots, making postoperative management easier.

Cost effectiveness and resource use

The committee considered that the recommendation is cost-neutral; it is unlikely to have an impact on costs and resources.

Other factors the committee took into account

The committee noted that there is no standard definition of permissive hypertension. As a result, there are varying interpretations of the meaning of permissive hypotension the techniques usd to perform it and the target parameters used to monitor it.

The committee also noted that local practice might vary depending on proximity to a regional vascular service, and the impact of long periods of volume restriction in people with ruptured AAA is not yet known. As a result, they drafted a research recommendation in this area.

Appendices

Appendix A – Review protocol

Review protocol for assessing the time period for transfer to regional vascular services

Review question 19	Does permissive hypotension improve a person's chance of survival or improve the stability of their condition in the transfer of people with ruptured or symptomatic abdominal aortic aneurysms to a regional vascular service?
Objectives	To determine if permissive hypotension improve a person's chance of survival or improve the stability of their condition in the transfer of people with ruptured or symptomatic abdominal aortic aneurysms to a regional vascular service?
Type of review	Intervention
Language	English only
Study design	Systematic reviews of study designs listed below Randomised controlled trials Quasi-randomised controlled trials
Status	Published papers only (full text) No date restrictions
Population	People with suspected or confirmed ruptured or symptomatic unruptured abdominal aortic aneurysms who need to be transferred to a regional vascular service
Intervention	Permissive / controlled hypotension or hypotensive resuscitation strategy
Comparator	Normotensive resuscitation strategy
Outcomes	Survival /mortality Bleeding/need for transfusion Myocardial infarction Renal failure Adverse effects of intervention – stroke, bowel ischaemia Quality of life Resource use, including of intensive care unit stay, and cost
Other criteria for inclusion / exclusion of studies	Exclusion: Non-English language Abstract/non-published Pharmacological interventions not available in the UK
Baseline characteristics to be extracted in evidence tables	Age Sex Size of aneurysm Comorbidities
Search strategies	See Appendix B
Review strategies	Appropriate NICE Methodology Checklists, depending on study designs, will be used as a guide to appraise the quality of individual studies. Moreno et al's Cochrane review (ongoing at the time of protocol development) comparing the effects of controlled (permissive) hypotension resuscitation and normotensive resuscitation strategies for people with ruptured AAA will be used as the evidence base for this part of the guidance Cochrane has agreed to share their excluded studies lists with NICE; the analyst will review this list for studies excluded due to an absence of outcomes of interest – any papers that report outcome data for the additional outcomes of interest specified by the Guideline Committee (adverse effects of intervention, quality of life, resource impact) will be used to supplement the Cochrane review

Review question 19	**Does permissive hypotension improve a person's chance of survival or improve the stability of their condition in the transfer of people with ruptured or symptomatic abdominal aortic aneurysms to a regional vascular service?**
	Data on all included studies will be extracted into evidence tables. Where statistically possible, a meta-analytic approach will be used to give an overall summary effect. All key findings from evidence will be presented in GRADE profiles and further summarised in evidence statements.
Key papers	Moreno DH, Cacione DG, Baptista-Silva JC. Controlled hypotension versus normotensive resuscitation strategy for people with ruptured abdominal aortic aneurysm. Cochrane Database Syst Rev. 2016 May 13;5:CD011664

Appendix B – Literature search strategies

Clinical search literature search strategy

Main searches

Bibliographic databases searched for the guideline

- Cumulative Index to Nursing and Allied Health Literature - CINAHL (EBSCO)
- Cochrane Database of Systematic Reviews – CDSR (Wiley)
- Cochrane Central Register of Controlled Trials – CENTRAL (Wiley)
- Database of Abstracts of Reviews of Effects – DARE (Wiley)
- Health Technology Assessment Database – HTA (Wiley)
- EMBASE (Ovid)
- MEDLINE (Ovid)
- MEDLINE Epub Ahead of Print (Ovid)
- MEDLINE In-Process (Ovid)

Identification of evidence for review questions

The searches were conducted between November 2015 and October 2017 for 31 review questions (RQ). In collaboration with Cochrane, the evidence for several review questions was identified by an update of an existing Cochrane review. Review questions in this category are indicated below. Where review questions had a broader scope, supplement searches were undertaken by NICE.

Searches were re-run in December 2017.

Where appropriate, study design filters (either designed in-house or by McMaster) were used to limit the retrieval to, for example, randomised controlled trials. Details of the study design filters used can be found in section 4.

Search strategy review question 19

Moreno DH, Cacione DG, Baptista-Silva JC. Controlled hypotension versus normotensive resuscitation strategy for people with ruptured abdominal aortic aneurysm. Cochrane Database Syst Rev. 2016 May 13;5:CD011664

Cochrane Register of Studies (CRS)Strategy, searched 12 April 2016 **Search Strategy:**
#1 MESH DESCRIPTOR Aortic Aneurysm EXPLODE ALL TREES #2 MESH DESCRIPTOR Aneurysm, Ruptured EXPLODE ALL TREES #3 (aneurysm* near4 (abdom* or thoracoabdom* or thoraco-abdom* or aort*)):TI,AB,KY #4 (aort* near3 (ballon* or dilat* or bulg*)):TI,AB,KY #5 AAA*:TI,AB,KY #6 MESH DESCRIPTOR Aorta, Abdominal EXPLODE ALL TREES WITH QUALIFIERS SU #7 #1 OR #2 OR #3 OR #4 OR #5 OR #6 #8 MESH DESCRIPTOR Fluid Therapy EXPLODE ALL TREES

Cochrane Register of Studies (CRS)Strategy, searched 12 April 2016 **Search Strategy:**
#9 MESH DESCRIPTOR Infusions, Intravenous EXPLODE ALL TREES #10 MESH DESCRIPTOR Lactic Acid EXPLODE ALL TREES #11 MESH DESCRIPTOR Glucose EXPLODE ALL TREES #12 MESH DESCRIPTOR Saline Solution, Hypertonic EXPLODE ALL TREES #13 MESH DESCRIPTOR Mannitol EXPLODE ALL TREES #14 MESH DESCRIPTOR Albumins EXPLODE ALL TREES #15 MESH DESCRIPTOR Dextrans EXPLODE ALL TREES #16 MESH DESCRIPTOR Isotonic Solutions EXPLODE ALL TREES #17 MESH DESCRIPTOR Plasma Substitutes EXPLODE ALL TREES #18 MESH DESCRIPTOR Osmotic Pressure EXPLODE ALL TREES #19 MESH DESCRIPTOR Hemodilution EXPLODE ALL TREES #20 MESH DESCRIPTOR Hemoglobins EXPLODE ALL TREES #21 MESH DESCRIPTOR Blood Pressure EXPLODE ALL TREES #22 MESH DESCRIPTOR Shock, Hemorrhagic #23 MESH DESCRIPTOR Resuscitation EXPLODE ALL TREES #24 MESH DESCRIPTOR Hypotension EXPLODE ALL TREES #25 MESH DESCRIPTOR Hydroxyethyl Starch Derivatives #26 starch:TI,AB,KY #27 hydroxyethyl*:TI,AB,KY #28 (haemoglobin or hemoglobin):TI,AB,KY #29 fluid:TI,AB,KY #30 (saline or NaCl):TI,AB,KY #31 dextran:TI,AB,KY #32 ringer:TI,AB,KY #33 lactate:TI,AB,KY #34 glucose:TI,AB,KY #35 gelatin:TI,AB,KY #36 (HES 130*):TI,AB,KY #37 voluven:TI,AB,KY #38 albumin:TI,AB,KY #39 mannitol:TI,AB,KY #40 HBOC-201:TI,AB,KY #41 (crystalloid or colloid):TI,AB,KY #42 isovol*:TI,AB,KY #43 normovol*:TI,AB,KY #44 electrolyte:TI,AB,KY #45 hypertonic:TI,AB,KY #46 (osmotic pressure):TI,AB,KY #47 (volume loading):TI,AB,KY #48 (volume expansion):TI,AB,KY #49 (volume substitution):TI,AB,KY #50 (haemodilution or hemodilution):TI,AB,KY #51 resuscitation:TI,AB,KY #52 hypotens*:TI,AB,KY #53 normotensive #54 (organ perfusion):TI,AB,KY

Cochrane Register of Studies (CRS)Strategy, searched 12 April 2016 Search Strategy:
#55 (systolic blood pressure):TI,AB,KY #56 #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 #57 #7 AND #56

Health Economics literature search strategy

Sources searched to identify economic evaluations

- NHS Economic Evaluation Database – NHS EED (Wiley) last updated Dec 2014
- Health Technology Assessment Database – HTA (Wiley) last updated Oct 2016
- Embase (Ovid)
- MEDLINE (Ovid)
- MEDLINE In-Process (Ovid)

Search filters to retrieve economic evaluations and quality of life papers were appended to the population and intervention terms to identify relevant evidence. Searches were not undertaken for qualitative RQs. For social care topic questions additional terms were added. Searches were re-run in September 2017 where the filters were added to the population terms.

Health economics search strategy

Medline Strategy
Economic evaluations 1 Economics/ 2 exp "Costs and Cost Analysis"/ 3 Economics, Dental/ 4 exp Economics, Hospital/ 5 exp Economics, Medical/ 6 Economics, Nursing/ 7 Economics, Pharmaceutical/ 8 Budgets/ 9 exp Models, Economic/ 10 Markov Chains/ 11 Monte Carlo Method/ 12 Decision Trees/ 13 econom*.tw. 14 cba.tw. 15 cea.tw. 16 cua.tw. 17 markov*.tw. 18 (monte adj carlo).tw. 19 (decision adj3 (tree* or analys*)).tw. 20 (cost or costs or costing* or costly or costed).tw.

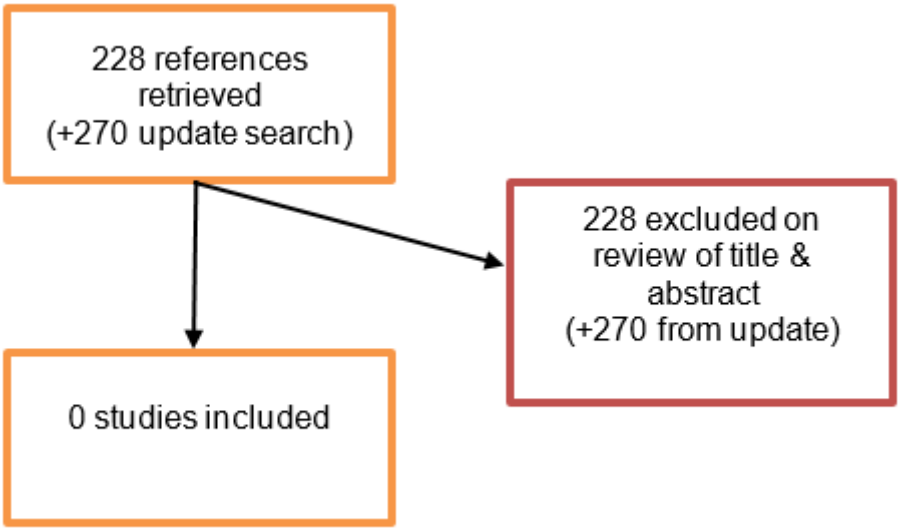
Medline Strategy

21 (price* or pricing*).tw.
22 budget*.tw.
23 expenditure*.tw.
24 (value adj3 (money or monetary)).tw.
25 (pharmacoeconomic* or (pharmaco adj economic*)).tw.
26 or/1-25

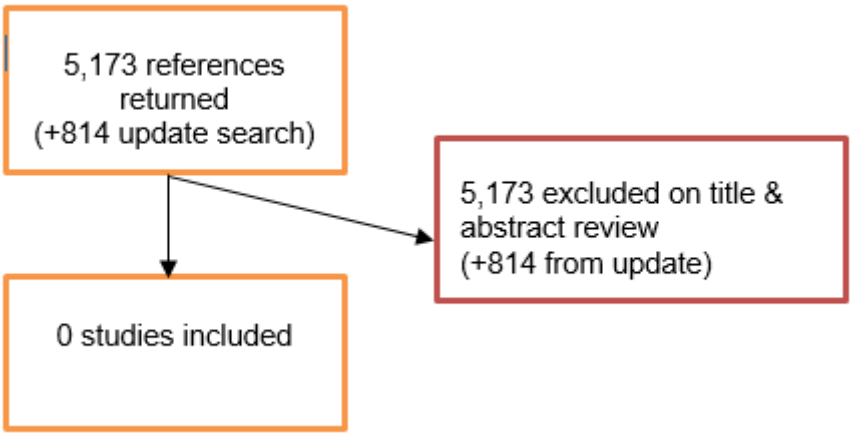
Quality of life
1 "Quality of Life"/
2 quality of life.tw.
3 "Value of Life"/
4 Quality-Adjusted Life Years/
5 quality adjusted life.tw.
6 (qaly* or qald* or qale* or qtime*).tw.
7 disability adjusted life.tw.
8 daly*.tw.
9 Health Status Indicators/
10 (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw.
11 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw.
12 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw.
13 (sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw.
14 (sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw.
15 (euroqol or euro qol or eq5d or eq 5d).tw.
16 (qol or hql or hqol or hrqol).tw.
17 (hye or hyes).tw.
18 health* year* equivalent*.tw.
19 utilit*.tw.
20 (hui or hui1 or hui2 or hui3).tw.
21 disutili*.tw.
22 rosser.tw.
23 quality of wellbeing.tw.
24 quality of well-being.tw.
25 qwb.tw.
26 willingness to pay.tw.
27 standard gamble*.tw.
28 time trade off.tw.
29 time tradeoff.tw.
30 tto.tw.
31 or/1-30

Appendix C – Clinical evidence study selection

The flow charts for individual questions are presented using the format below.



Appendix D – Economic evidence study selection



Appendix E – Excluded studies

Clinical studies

No full text papers were retrieved. All studies were excluded at review of titles and abstracts.

Economic studies

No full text papers were retrieved. All studies were excluded at review of titles and abstracts.

Appendix F – Research recommendation

Research recommendation	Does permissive hypotension improve survival or improve the stability of people undergoing repair of ruptured AAA?
Population	People with a ruptured AAA in whom surgery is planned
Intervention(s)	Permissive/controlled hypotension or hypotensive resuscitation strategy; performed during transfer or upon arrival at a regional vascular service
Comparator(s)	Normotensive resuscitation strategy
Outcomes	• Survival /mortality • Bleeding/need for transfusion • Myocardial infarction • Renal failure • Adverse effects of intervention – stroke, bowel ischaemia • Quality of life • Resource use, including of intensive care unit stay, and cost
Study design	Randomised controlled trial

Potential criterion	Explanation
Importance to patients, service users or the population	The historical approach of managing people with major bleeding events after major trauma has involved early and aggressive fluid administration.This approach can dislodge blood clots that help stem bleeding, cause dilution coagulopathy, and result in hypothermia. In order to avoid these complications, clinicans have started performing permissive hypotension: an approach that restricts the amount of fluid resuscitation administered while maintaining blood pressure in a lower than normal range if there is still active bleeding during the acute period of injury. The technique has been shown to improve outcomes of people with severe penetrating trauma (notably penetrating torso injuries), and it is possible that it may also improve outcomes of people with ruptured AAA.
Relevance to NICE guidance	Medium priority: in the absence of evidence, the committee chose to draft recommendations by adopting and adapting recommendations from NICE guidance on management of major trauma (NICE guideline NG39). Research specific to people with rupture AAA would clarify the role of permissive hypotension and allow for AAA-specific recommendations to be possible in future guideline updates.
Current evidence base	No evidence was found that assessed the efficacy of permissive hypotension for increasing the chances of survival of people with ruptured AAA.
Equality	No specific equality concerns are relevant to this research recommendation.
Feasibility	There is a sufficiently large and well defined population available that multicentre randomised controlled trials in this area should be feasible.

Appendix G – Glossary

Abdominal Aortic Aneurysm (AAA)

A localised bulge in the abdominal aorta (the major blood vessel that supplies blood to the lower half of the body including the abdomen, pelvis and lower limbs) caused by weakening of the aortic wall. It is defined as an aortic diameter greater than 3 cm or a diameter more than 50% larger than the normal width of a healthy aorta. The clinical relevance of AAA is that the condition may lead to a life threatening rupture of the affected artery. Abdominal aortic aneurysms are generally characterised by their shape, size and cause:

- Infrarenal AAA: an aneurysm located in the lower segment of the abdominal aorta below the kidneys.
- Juxtarenal AAA: a type of infrarenal aneurysm that extends to, and sometimes, includes the lower margin of renal artery origins.
- Suprarenal AAA: an aneurysm involving the aorta below the diaphragm and above the renal arteries involving some or all of the visceral aortic segment and hence the origins of the renal, superior mesenteric, and celiac arteries, it may extend down to the aortic bifurcation.

Abdominal compartment syndrome

Abdominal compartment syndrome occurs when the pressure within the abdominal cavity increases above 20 mm Hg (intra-abdominal hypertension). In the context of a ruptured AAA this is due to the mass effect of a volume of blood within or behind the abdominal cavity. The increased abdominal pressure reduces blood flow to abdominal organs and impairs pulmonary, cardiovascular, renal, and gastro-intestinal function. This can cause multiple organ dysfunction and eventually lead to death.

Cardiopulmonary exercise testing

Cardiopulmonary Exercise Testing (CPET, sometimes also called CPX testing) is a non-invasive approach used to assess how the body performs before and during exercise. During CPET, the patient performs exercise on a stationary bicycle while breathing through a mouthpiece. Each breath is measured to assess the performance of the lungs and cardiovascular system. A heart tracing device (Electrocardiogram) will also record the hearts electrical activity before, during and after exercise.

Device migration

Migration can occur after device implantation when there is any movement or displacement of a stent-graft from its original position relative to the aorta or renal arteries. The risk of migration increases with time and can result in the loss of device fixation. Device migration may not need further treatment but should be monitored as it can lead to complications such as aneurysm rupture or endoleak.

Endoleak

An endoleak is the persistence of blood flow outside an endovascular stent - graft but within the aneurysm sac in which the graft is placed.

- Type I – Perigraft (at the proximal or distal seal zones): This form of endoleak is caused by blood flowing into the aneurysm because of an incomplete or ineffective seal at either end of an endograft. The blood flow creates pressure within the sac and significantly increases the risk of sac enlargement and rupture. As a result, Type I endoleaks typically require urgent attention.

- Type II – Retrograde or collateral (mesenteric, lumbar, renal accessory): These endoleaks are the most common type of endoleak. They occur when blood bleeds into the sac from small side branches of the aorta. They are generally considered benign because they are usually at low pressure and tend to resolve spontaneously over time without any need for intervention. Treatment of the endoleak is indicated if the aneurysm sac continues to expand.

- Type III – Midgraft (fabric tear, graft dislocation, graft disintegration): These endoleaks occur when blood flows into the aneurysm sac through defects in the endograft (such as graft fractures, misaligned graft joints and holes in the graft fabric). Similarly to Type I endoleak, a Type III endoleak results in systemic blood pressure within the aneurysm sac that increases the risk of rupture. Therefore, Type III endoleaks typically require urgent attention.

- Type IV– Graft porosity: These endoleaks often occur soon after AAA repair and are associated with the porosity of certain graft materials. They are caused by blood flowing through the graft fabric into the aneurysm sac. They do not usually require treatment and tend to resolve within a few days of graft placement.

- Type V – Endotension: A Type V endoleak is a phenomenon in which there is continued sac expansion without radiographic evidence of a leak site. It is a poorly understood abnormality. One theory that it is caused by pulsation of the graft wall, with transmission of the pulse wave through the aneurysm sac to the native aneurysm wall. Alternatively it may be due to intermittent leaks which are not apparent at imaging. It can be difficult to identify and treat any cause.

Endovascular aneurysm repair

Endovascular aneurysm repair (EVAR) is a technique that involves placing a stent –graft prosthesis within an aneurysm. The stent-graft is inserted through a small incision in the femoral artery in the groin, then delivered to the site of the aneurysm using catheters and guidewires and placed in position under X-ray guidance.

- Conventional EVAR refers to placement of an endovascular stent graft in an AAA where the anatomy of the aneurysm is such that the ‘instructions for use’ of that particular device are adhered to. Instructions for use define tolerances for AAA anatomy that the device manufacturer considers appropriate for that device. Common limitations on AAA anatomy are infrarenal neck length (usually >10mm), diameter (usually ≤30mm) and neck angle relative to the main body of the AAA

- Complex EVAR refers to a number of endovascular strategies that have been developed to address the challenges of aortic proximal neck fixation associated with complicated aneurysm anatomies like those seen in juxtarenal and suprarenal AAAs.

These strategies include using conventional infrarenal aortic stent grafts outside their 'instructions for use', using physician-modified endografts, utilisation of customised fenestrated endografts, and employing snorkel or chimney approaches with parallel covered stents.

Goal directed therapy

Goal directed therapy refers to a method of fluid administration that relies on minimally invasive cardiac output monitoring to tailor fluid administration to a maximal cardiac output or other reliable markers of cardiac function such as stroke volume variation or pulse pressure variation.

Post processing technique

For the purpose of this review, a post-processing technique refers to a software package that is used to augment imaging obtained from CT scans, (which are conventionally presented as axial images), to provide additional 2- or 3-dimensional imaging and data relating to an aneurysm's, size, position and anatomy.

Permissive hypotension

Permissive hypotension (also known as hypotensive resuscitation and restrictive volume resuscitation) is a method of fluid administration commonly used in people with haemorrhage after trauma. The basic principle of the technique is to maintain haemostasis (the stopping of blood flow) by keeping a person's blood pressure within a lower than normal range. In theory, a lower blood pressure means that blood loss will be slower, and more easily controlled by the pressure of internal self-tamponade and clot formation.

Remote ischemic preconditioning

Remote ischemic preconditioning is a procedure that aims to reduce damage (ischaemic injury) that may occur from a restriction in the blood supply to tissues during surgery. The technique aims to trigger the body's natural protective functions. It is sometimes performed before surgery and involves repeated, temporary cessation of blood flow to a limb to create ischemia (lack of oxygen and glucose) in the tissue. In theory, this "conditioning" activates physiological pathways that render the heart muscle resistant to subsequent prolonged periods of ischaemia.

Tranexamic acid

Tranexamic acid is an antifibrinolytic agent (medication that promotes blood clotting) that can be used to prevent, stop or reduce unwanted bleeding. It is often used to reduce the need for blood transfusion in adults having surgery, in trauma and in massive obstetric haemorrhage.