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Thoracic stent graft versus surgery for thoracic aneurysm (Review)

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[Intervention Review]

Thoracic stent graft versus surgery for thoracic aneurysm

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ABSTRACT

Background

Thoracic aortic aneurysm (TAA) is an uncommon disease with an incidence of 10.4 per 100,000 inhabitants. It occurs mainly in older individuals and is evenly distributed among both sexes. There are no signs or symptoms indicative of the presence of the disease. Progressive but unpredictable enlargement of the dilated aorta is the natural course of the disease and can lead to rupture. Open chest surgical repair using prosthetic graft interposition has been a conventional treatment for TAAs. Despite improvements in surgical procedures perioperative complications remain significant. The alternative option of thoracic endovascular aneurysm repair (TEVAR) is considered a less invasive and potentially safer technique, with lower morbidity and mortality compared with conventional treatment. Evidence is needed to support the use of TEVAR for these patients, rather than open surgery. This is an update of the review first published in 2009.

Objectives

This review aimed to assess the efficacy of TEVAR versus conventional open surgery in patients with thoracic aortic aneurysms.

Search methods

For this update the Cochrane Vascular Information Specialist searched the Specialised Register (last searched January 2016) and CENTRAL (2015, Issue 12).

Selection criteria

Randomised controlled trials in which patients with TAAs were randomly assigned to TEVAR or open surgical repair.

Data collection and analysis

Two review authors independently identified and evaluated potential trials for eligibility. Excluded studies were further checked by another author. We did not perform any statistical analyses as no randomised controlled trials were identified.

Main results

We did not find any published or unpublished randomised controlled trials comparing TEVAR with conventional open surgical repair for the treatment of thoracic aortic aneurysms.

Authors' conclusions

Stent grafting of the thoracic aorta is technically feasible and non-randomised studies suggest reduction of early outcomes such as paraplegia, mortality and hospital stay. High quality randomised controlled trials assessing all clinically relevant outcomes including open-conversion, aneurysm exclusion, endoleaks, and late mortality are needed.

PLAIN LANGUAGE SUMMARY

Thoracic endoscopic stent graft versus open surgery for thoracic aneurysm

Background

An aneurysm is a localised dilation or widening of an artery. Thoracic aneurysm is a relatively infrequent disease that affects both older men and women. The cause of thoracic aneurysm is unknown but the aneurysms generally do not cause symptoms. They are, however, likely to increase in size. Patients who do not receive surgical treatment at the time of diagnosis have a greater chance of dying from rupture of the aneurysm. Aneurysms greater than 5 cm carry a higher risk of bursting. Surgical repair of aneurysms requires general anaesthesia and opening of the chest wall to place an artificial graft in the area of the diseased vessel. This is associated with procedure-related deaths and complications such as paraplegia, stroke, and renal failure and excludes some patients because of age and accompanying illnesses. Endovascular repair is a recently introduced, minimally invasive technique in which a stent is delivered through a blood vessel and fixed to the aneurysm. A seal forms between the stent and the vessel wall so that blood does not flow between the two. We searched for evidence of the effectiveness of endovascular repair compared with open surgical repair for thoracic aneurysms.

Key results

No randomised controlled trials were found in the medical literature (current until January 2016). Reports from non-randomised studies suggest that endovascular repair is technically feasible and may reduce early negative outcomes including death and paraplegia. However, stent devices have late complications that are uncommon to open surgery (for example, development of leaks, graft migration, need for re-intervention) and patients receiving stents may require frequent surveillance with computed tomography (CT) scans.

Quality of the evidence

In the absence of studies eligible for inclusion in the review it was not possible to assess the quality of the evidence.

BACKGROUND

Description of the condition

Aneurysms are usually defined as a permanent localised dilation of an artery where the diameter is at least 50% greater than the expected normal size of the artery. The majority of aortic aneurysms are localised in the abdominal aorta, but the thoracic part of the aorta is not immune to vascular degeneration. Thoracic aortic aneurysms (TAAs) are usually associated with atherosclerosis. Due to the uncommon nature of the disease the data on natural history, prevalence, and mortality are limited and sometimes differ. A study published in 1982 reported an incidence of TAAs of 5.9 per 100,000 in a stable community over 30 years of observation (Bickerstaff 1982), while another survey documented an incidence of 10.4 per 100,000 from 1980 to 1994 (Clouse 1998). The two-fold increase in the incidence of TAAs may be attributed to the advent of more sophisticated diagnostic instruments, such as computed tomography (CT), or the result of an aging population. However, according to some reports, TAAs occur mainly in older individuals and, contrary to abdominal aortic aneurysms which affect mainly males, the incidence of TAAs is evenly distributed among both sexes (Bickerstaff 1982; Clouse 1998).

Given the silent nature of TAAs it is difficult to identify signs and symptoms that warn of the presence of the disease. Most of the time such aneurysms are diagnosed by chance. When the diagnosis is made, identification of factors that might help us to recognise patients who are in most need of treatment, or who are at high risk of rupture, is necessary. While age, the presence of hypertension, chronic obstructive pulmonary disease, and renal failure have been identified as risk factors associated with aneurysmal disease and its rupture, the diameter of the aneurysm is the most important predictor to be considered when evaluating patients with TAAs (Griepp 1999). A number of retrospective studies have documented that the size of the aortic aneurysm is the major factor predicting rupture. Although small aneurysms may rupture, risk of rupture and mortality related to rupture become significant when the diameter of the affected aorta exceeds 5 cm (Cambria 1995; Coady 1997; Lobato 1998; Perko 1995). The five-year mortality rate of aneurysms exceeding 6 cm varies from 38% to 64% (Coady 1997; Joyce 1964). In addition, the rate of increase in the size of aortic aneurysms is part of the natural course of the disease and is an another indicator that predicts rupture. Indeed, TAAs may have an expansion rate of between 0.2 cm and 0.4 cm per year. Growth rate is directly related to the initial size of the diseased aorta (Cambria 1995; Coady 1997; Hirose 1993). Some authors estimate that each 1 cm increase in the size of the thoracic aneurysm is translated into a further increase in the probability of rupture by a factor of 1.9, compared with a factor of 1.5 observed for abdominal aneurysms (Juvonen 1997).

Data from several retrospective surveys indicate that for patients who did not receive surgery at the time of diagnosis, rupture was the most common cause of death, with death rates ranging from 42% to 74% (Bickerstaff 1982; Crawford 1986; Perko 1995). The five-year survival rate was 39% for patients with TAAs and 23% for those with thoracoabdominal aneurysm (Perko 1995). When rupture occurs, patients mostly die within six hours and, although 46% of patients arrive alive at the hospital, the overall mortality rate of ruptured TAAs reaches 97% (Johansson 1995).

Description of the intervention

The high mortality of aneurysmal disease has lead many to suggest surgical repair of the dilated aorta, even though the anatomical morphology of the thoracic aorta together with the characteristics of patients affected by TAAs pose a considerable challenge to surgeons. Open surgical repair using prosthetic graft interposition is the conventional treatment for TAAs mainly because of its feasibility and effectiveness in excluding the degenerated aorta from the systemic circulation. Open surgical repair of TAAs is associated with significant perioperative complications including 30-day mortality and paraplegia, with rates of 4.8% and 4.6% respectively. Stroke and renal failure are also important complications to be considered (Coselli 2000; Deeb 1995; LeMaire 2003). Despite noteworthy improvements in surgical procedures with extracorporeal circulation for peripheral organ preservation, the development of different techniques for spinal cord protection, together with the refinement of prosthetic grafts for aortic repair, morbidity and mortality rates remain high (Hamerlijnck 1989; Huynh 2002; Thurnher 2002).

How the intervention might work

In view of these complexities, and the fact that many high risk patients were regularly excluded from open surgical repair, a less invasive and potentially safer technique became imperative. Thus an alternative for open surgical repair for aortic aneurysm has become the performance of endovascular repair using stent grafts. The aim of this technique is to reach the target site by performing an access through a remote vessel to deliver the stent, secure endograft fixation, and allow the formation of a haemostatic seal between the graft and the vessel wall. The endovascular repair (EVAR) technique has been successfully used in the treatment of abdominal aortic aneurysms and with respect to conventional open surgical repair has been shown to reduce early post-operative complications and death (Greenhalgh 2004; Prinssen 2004). The success of the stent-graft placement performed in abdominal aortic aneurysms prompted experts to translate the technique to thoracic aneurysm repair. Dake was the first to report the use of stent graft in 13 patients with TAAs with positive outcomes over 11 months of observation (Dake 1994).

Identification of the best vascular access through which to deliver the stent is important, as well as performing imaging studies that help assess the best site for the insertion of the stent-graft delivery system. Non-surgical repair may be an attractive therapeutic option for patients with TAAs. According to some authors the morbidity and mortality associated with EVAR of thoracic aneurysm (TEVAR) appear to be less than with conventional treatment. In addition, while mid-term survival seems satisfactory in patients receiving endovascular treatment the long-term outcomes for high risk patients are disappointing, probably due to co-existing disease (Demers 2004; Ehrlich 1998; Greenberg 2000; Marcheix 2006; Mitchell 1999).

Why it is important to do this review

Thus, convincing evidence that TEVAR is better than open surgical treatment for TAAs is needed. Potential advantages of TEVAR include reduction in the rate of paraplegia; reduced time under anaesthesia; avoidance of arterial cross-clamping, renal failure, and cardiovascular complications; reduced length of hospital stay,

and particularly a reduction in the length of stay in an intensive care unit.

OBJECTIVES

This review aimed to assess the efficacy of thoracic endovascular aneurysm repair (TEVAR) versus conventional open surgery in patients with thoracic aortic aneurysms (TAA).

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs) evaluating TEVAR compared with conventional open surgical repair.

Types of participants

All asymptomatic patients in whom a thoracic aortic aneurysm was diagnosed by computed tomography (CT), magnetic resonance angiography (MRA), or conventional angiography. Only studies reporting the size of TAAs were eligible for consideration.

Mycotic aneurysms (aneurysms caused by an infection of the arterial wall or when a pre-existing aneurysm has become secondarily infected), acute or chronic dissections, and all patients with connective tissue disorders were excluded.

Types of interventions

All types of endovascular devices were considered when compared with conventional open surgical treatment.

Types of outcome measures

Primary outcomes

- short-term mortality rates (30 days, or in hospital, i.e. procedure related);
- aneurysm exclusion (no flow in the aneurysmal sac or extravasations (discharge of blood from a vessel to the tissues) beyond the sac) on follow-up imaging 30 days after the procedure;
- major complications (haemorrhage, open conversion, myocardial infarction, stroke, renal failure, respiratory failure, spinal chord ischaemia, bowel ischaemia, lower limb ischaemia).

Secondary outcomes

- minor complications;
- long-term complications and mortality (re-intervention rates for problems related to the TAA or its treatment were sought where possible, as was cause of death with or without re-intervention, i.e. device related);
- quality of life (based on validated questionnaires).

Search methods for identification of studies

Electronic searches

For this update the Cochrane Vascular Information Specialist (CIS) searched the Specialised Register (January 2016). In addition the CIS searched the Cochrane Register of Studies (CRS) http://www.metaxis.com/CRSWeb/Index.asp (CENTRAL (2015, Issue 12)).

See Appendix 1 for details of the search strategy used to search the CRS. The Specialised Register is maintained by the CIS and is constructed from weekly electronic searches of MEDLINE, EMBASE, CINAHL, AMED, and through handsearching relevant journals. The full list of the databases, journals and conference proceedings which have been searched, as well as the search strategies used are described in the Specialised Register section of the Cochrane Vascular module in the*Cochrane Library* (www.cochranelibrary.com).

Searching other resources

The reference lists of all relevant studies found were screened.

Data collection and analysis

Selection of studies

Two authors (IA and RC) assessed all studies identified from the literature search. Disagreements were resolved through discussion with the review team and the agreed arbitrator (AM).

Data extraction and management

Where eligible studies were identified, we planned for two review authors (IA and CR) to independently extract data. We planned to use a standard data extraction form to extract the following information: characteristics of the study (design, method of randomisation, blinding of outcome evaluators, and balance of prognostic factors (age, sex, size of the aneurysm)); participants; interventions; outcomes (types of outcome measures, adverse events). We planned to contact the authors of trials when these information were incomplete. We planned to resolve any disagreement by discussion.

Assessment of risk of bias in included studies

For the assessment of study quality, we planned to use the risk of bias approach for Cochrane reviews (Higgins 2011) based on the assessment of the following domains of each included study: sequence generation, allocation concealment, blinding of participants, personnel and outcome assessors, incomplete outcome data, selective reporting bias, and other potential sources of bias (Higgins 2011).

We planned for two authors to independently evaluate the risk of bias of the included studies. Any disagreements were to be resolved by discussion or by a third review author.

Measures of treatment effect

We planned to carry-out meta-analyses of primary and secondary outcomes. For the analysis of dichotomous outcomes, we planned to use risk ratios with 95% confidence intervals (CI); for the analysis of continuous outcomes, we planned to use the mean difference (MD) or standardised mean difference (SMD) and 95% CI.

Unit of analysis issues

The unit of analysis was planned to be each participant recruited into the trials.

Dealing with missing data

In the event of missing data, we planned to contact the corresponding authors to try to obtain the relevant information.

We will not use any imputation methods. We preferred the intention-to-treat data where this approach was available. Where intention-to-treat data are not available, we planned to conduct analyses using data of available cases.

Assessment of heterogeneity

We planned to consider whether the clinical and methodological characteristics of the studies were sufficiently homogeneous to pool data in a meta-analysis. We planned to quantify inconsistency among the pooled estimates using the I^2 statistic.

We planned to consider a Chi^2 test with a P value of 0.10 to be significant, and interpret the I^2 statistic as: 0% to 40% unimportant heterogeneity; 30% to 60% moderate heterogeneity; 50% to 90% substantial heterogeneity; and 75% to 100% considerable heterogeneity.

Assessment of reporting biases

Where there are more than 10 studies that can be combined into a meta-analysis, we planned to use a funnel plot to examine for small-study effects, which may indicate publication bias.

Data synthesis

We planned to use the fixed-effect model to pool the data for each outcome. Where important or substantial heterogeneity (for example I^2 greater than 50%) was detected, we planned to meta-analyse data of the treatment effect using a random-effects model (with two or more studies).

Subgroup analysis and investigation of heterogeneity

Where sufficient data are available, we plan to perform subgroup analyses based on several participant characteristics such as sex, the size of the aneurysm, its anatomical localisation (ascending, descending, or thoracoabdominal) and condition of patients (high risk versus low risk), and characteristics of the intervention (such as fenestrated or branched endografts bifurcated stent graft).

Sensitivity analysis

Where a sufficient number of studies was available, we planned to perform sensitivity analyses to assess the consistency and robustness of the results of the meta-analyses based on the following scenarios: including only studies with low risk of selection bias (sequence generation and allocation concealment) (Wood 2008); including only trials with low risk of detection bias (blinding of outcome assessor) (Savovic 2012); including only trials with low risk of attrition of bias; including only trials that did not deviate from intention-to-treat analysis (Abraha 2015).

Summary of findings

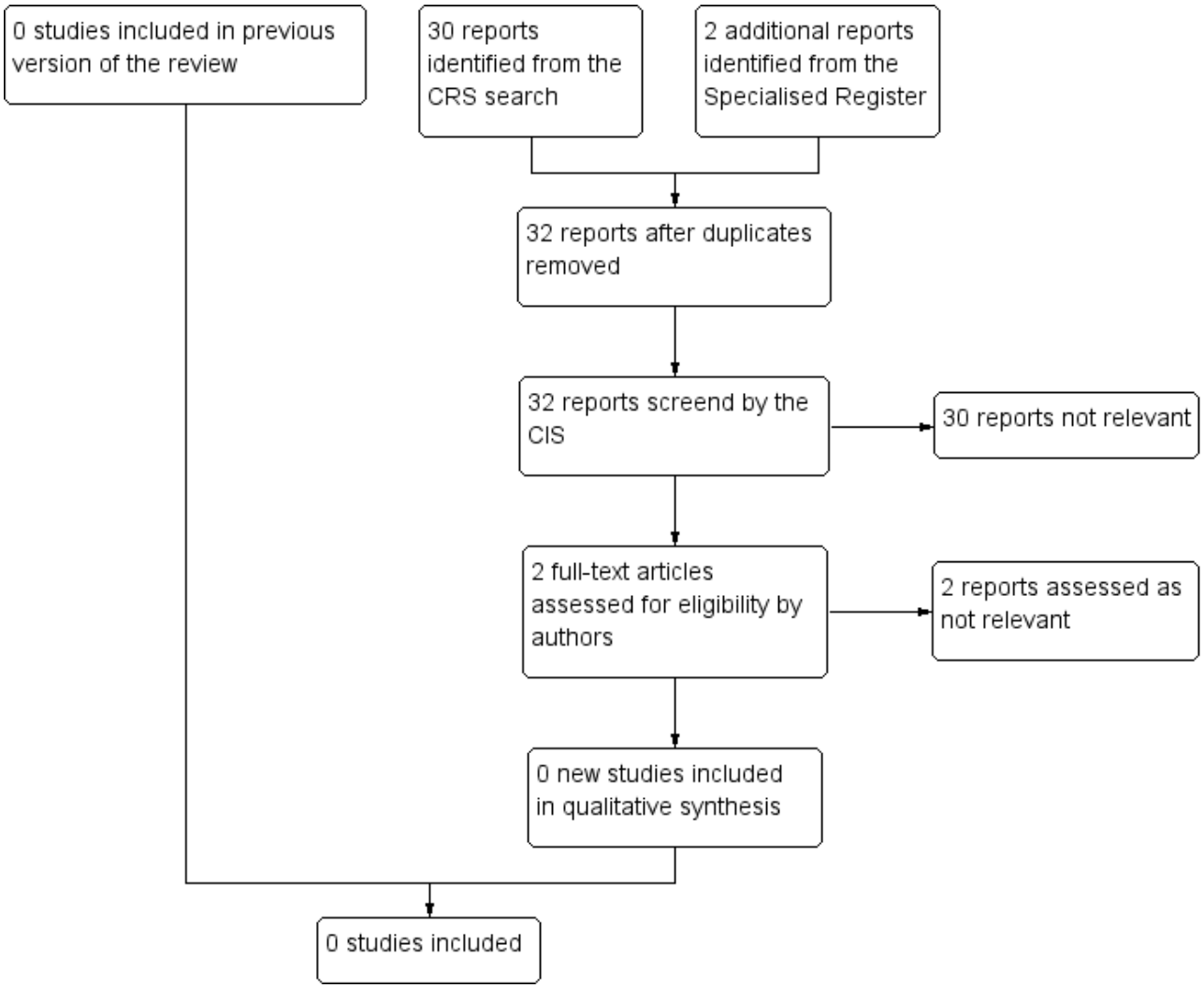
We planned to present the main findings of the review results concerning the quality of evidence, the magnitude of effect of the interventions examined, and the sum of available data on the primary outcomes (Types of outcome measures) in a 'Summary of findings' table, according to the GRADE principles as described by Higgins 2011 and Atkins 2004. Since we planned to assess different comparisons of interventions, we planned to develop a 'Summary of findings' table for each comparison using the GRADEpro software (GRADEproGDT), to assist in the preparation of the 'Summary of findings' table.

RESULTS

Description of studies

See Figure 1.

Figure 1. Study flow diagram.



Results of the search

No studies were identified that met any of the inclusion criteria. A number of case series, cohort studies, and controlled studies with historic controls were found. These were excluded because of lack of randomisation (*see* Characteristics of excluded studies).

Risk of bias in included studies

It was not possible to review methodological quality in the absence of studies eligible for inclusion in the review.

Effects of interventions

No published or unpublished randomised controlled trials were found comparing thoracic endovascular aneurysm repair (TEVAR) with conventional open surgical repair for the treatment of thoracic aortic aneurysms (TAAs).

DISCUSSION

Summary of main results

Thoracic surgery for the treatment of aneurysms is performed in a complex setting and entails general anaesthesia, thoracotomy with extensive surgical resection, left lung collapse, and aortic cross-clamping. As a result, important postoperative complications such as haemorrhage, spinal cord injury, stroke, and renal insufficiency must be considered. Distal aortic perfusion, cerebrospinal drainage, and intercostal artery implantation are some of the advances made to avoid complications associated with thoracic surgery but morbidity remains high. Moreover, factors such as the age of the patient and the presence of serious co-morbidities such as coronary heart disease, chronic lung disease, diabetes, and hypertension may exclude a number of patients from receiving surgical treatment.

The advent of endovascular stent interposition, first described by Parodi (Parodi 1991) for abdominal aneurysm and later by Dake (Dake 1994) for the thoracic tract, has generated great interest among thoracic surgeons. This is mainly because an endovascular stent is considered a minimally invasive device and therefore, a good alternative for patients affected by thoracic aortic aneurysms (TAAs) who are not suitable for open surgical treatment.

This review documents that there are no published or pending randomised controlled trials that compare thoracic endovascular aneurysm repair (TEVAR) with open surgical treatment for

patients with TAAs, assessing early and late mortality and major complications. Most of the current information relating to endovascular intervention comes from reports of case series, observational studies, or registry data with differing presentations.

Overall completeness and applicability of evidence

There is currently no evidence from randomised controlled trials.

Quality of the evidence

It was not possible to review methodological quality or the quality of the evidence in the absence of studies eligible for inclusion in the review.

Potential biases in the review process

Potential biases in the review process were minimised by performing extensive literature search.

Agreements and disagreements with other studies or reviews

Although no RCTs comparing TEVAR with open surgical treatment for patients with TAAs were identified, at least two controlled clinical trials can be mentioned. The first study, published in 2002, compared 19 patients who received endovascular stents with an historic cohort of 10 patients who received open surgical repair. Endovascular deployment was successful in all but one patient and early outcomes such as mean length of intensive care unit stay and hospital stay were better in the TEVAR group. The study, however, was not randomised and follow up was limited (Najibi 2002).

The second trial, published in 2005, started as a prospective non-randomised multicenter phase II study. Promising results in terms of technical success and positive early outcomes prompted the FDA to approve the Gore TAG thoracic endoprosthesis (Makaroun 2005). At a later stage the study became a controlled trial in which the data of the 142 patients were compared with 94 controls (Bavaria 2007). According to the final analysis of the trial, mortality at 30 days was better in the endograft group, as well as other outcomes such as paraplegia and the length of hospital stay. However, the two-year survival rate was similar in the two groups. The significant limitations of the trial were that it was not a randomised trial; at least half of the control group was historical, which may augment further the selection bias; and symptomatic aneurysms were significantly higher in the open surgical cohort (38% versus 21%). In addition, data on aortic characteristics were unavailable in many of the control patients and the follow up was limited to two years, within which time 17% of the patients had exclusion of their aneurysm of a size greater than 0.5 cm, and at least 17% of the patients were lost to follow up (Bavaria 2007).

Despite the reported early advantages, stent devices for thoracic aneurysm have late complications that are uncommon with open surgery. Such complications include endoleaks, graft migration, stent fractures, and aneurysm-related death. Type I or attachment site endoleak is the most frequent complication and its incidence may reach 30% of cases (Neuhauser 2005). Usually Type I endoleaks require additional stent-graft deployment for sealing or spot coiling, but sometimes such endoleaks may close spontaneously due to the formation of spontaneous thrombosis of the aortic false lumen and not require any further treatment. While resolution may occur within one week to eight months, endoleaks may progress with dilatation of the false lumen necessitating close follow up, supplementary procedures, or even open surgical treatment.

The available controlled clinical trials on TEVAR efficacy had promising results in terms of early mortality and reduction in postoperative complications but they failed to give generalisable conclusions, not only because of their internal low methodological quality but also in that high risk patients were not the target population. This reduces the original expectation that stent grafts could be an alternative for patients excluded from open surgical treatment because of their high risk status. The recent report of the Society of Thoracic Surgeons in fact states that the indication for stent grafting of a thoracic aortic aneurysm should be based on a predicted operative risk that is clearly lower than the risk of either conventional open repair or optimal medical management (Svensson 2008). To this it must be added that patients who receive TEVAR will be in need of frequent surveillance CT scans after the intervention is performed and at a later stage they will probably need surgical re-intervention.

Although graft stenting for TAAs is technically feasible and may reduce the number and of severity of early outcomes, high quality randomised controlled trials assessing all clinically relevant outcomes, including early and late mortality, open conversion, aneurysm exclusion, endoleaks, are needed.

AUTHORS' CONCLUSIONS

Implications for practice

Technically, endovascular repair of thoracic aneurysms may be a good alternative to open surgical repair. However, its benefit cannot be established as there are no published randomised controlled trials. The available information comes from non-randomised studies, which show benefit in terms of early mortality and complications such as paraplegia. Although such evidence may suggest that endovascular repair can be appropriate in selected patients, high quality studies are needed to produce generalisable conclusions.

Implications for research

High quality randomised controlled trials evaluating thoracic endovascular aneurysm repair (TEVAR) for thoracic aortic aneurysms are needed. These prospective trials should have adequate follow up, enough to evaluate the durability of endovascular treatment in terms of endoleak rate, re-intervention rate, open-conversion rate, and rupture-free survival. In addition, clinically relevant outcomes including early and late mortality, major complications, and hospital and intensive care unit stay must be considered. However, it would probably be extremely difficult to perform a randomised trial given the current stage of surgical endovascular practice.

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CHARACTERISTICS OF STUDIES

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Appoo 2006	Case series of 99 patients with descending thoracic aneurysms treated with first or second generation endografts (1999 - 2005)
Azizzadeh 2003	Case-control study. Analysis of 18 patients with delayed neurologic deficit after open cardiovascular surgery for thoracoabdominal or thoracic aortic repair
Bavaria 2007	Multicentre non-randomised controlled trial of 140 consecutive patients with descending thoracic aneurysms treated with EVAR compared with 94 retrospective case series treated with open cardiovascular surgery for thoracoabdominal or thoracic aortic repair
Cambria 2002	Retrospective data on 28 patients treated with EVAR for thoracoabdominal aneurysm
Dake 1998	Prospective uncontrolled clinical trial of 103 patients treated with EVAR for thoracoabdominal aneurysms

Study	Reason for exclusion
Fattori 2006	Register data of 457 consecutive patients (113 emergency and 334 elective cases) who received an endovascular Talent device
Hassoun 2005	Ongoing, prospective non-randomised phase II trial
Hassoun 2006	Retrospective clinical trial involving 139 patients who underwent endovascular descending thoracic aortic repair
Ince 2003	Retrospective analysis of six patients treated with EVAR for aortic aneurysm after previous coarctation surgery
Makaroun 2005	Prospective non-randomised uncontrolled trial of 139 patients treated with Gore-TAG device
Mitchell 1999	Prospective consecutive treatment of 103 patients with home-made first-generation device
Najibi 2002	Non-randomised controlled trial of 19 patients receiving endovascular treatment and 10 historic controls receiving open surgical repair
Wheatley 2006	Non-randomised multi-institutional analysis of 158 consecutive patients treated with Gore-TAG device

APPENDICES

Appendix 1. CRS search strategy

Search run on Tue Jan 19 2016		
#1	MESH DESCRIPTOR Aortic Aneurysm, Thoracic EXPLODE ALL TREES	52
#2	MESH DESCRIPTOR Aorta, Thoracic	139
#3	(thorac* near aneurysm):TI,AB,KY	68
#4	(thoracic near3 (balloon* or dilat* or bulg*)):TI,AB,KY	7
#5	TAA:TI,AB,KY	134
#6	#1 OR #2 OR #3 OR #4 OR #5	343
#7	MESH DESCRIPTOR Angioplasty EXPLODE ALL TREES	4101
#8	(angioplas* or percutan* or PTA or venoplasty):TI,AB,KY	12137
#9	(recanali* or revascular*):TI,AB,KY	6550
#10	dilat*:TI,AB,KY	6912
#11	(balloon or baloon):TI,AB,KY	6481

(Continued)

#12	MESH DESCRIPTOR Endovascular Procedures	168
#13	endovascular:TI,AB,KY	1171
#14	MESH DESCRIPTOR Blood Vessel Prosthesis EXPLODE ALL TREES	406
#15	MESH DESCRIPTOR Blood Vessel Prosthesis Implantation EXPLODE ALL TREES	389
#16	MESH DESCRIPTOR Stents EXPLODE ALL TREES	3123
#17	endoluminal:TI,AB,KY	124
#18	(stent*):TI,AB,KY	6755
#19	(endostent*):TI,AB,KY	1
#20	(graft*):TI,AB,KY	15917
#21	(endograft*):TI,AB,KY	57
#22	(endoprosthe*):TI,AB,KY	230
#23	(EVAR):TI,AB,KY	98
#24	(EVRAR):TI,AB,KY	0
#25	(TEVAR):TI,AB,KY	24
#26	#7 OR #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	40372
#27	#6 AND #26	80
#28	* NOT SR-PVD:CC AND 28/03/2013 TO 29/02/2016:DL	240623
#31	#27 AND #28	30

WHAT'S NEW

Date	Event	Description
19 January 2016	New citation required but conclusions have not changed	Searches of CENTRAL and Specialised Register were rerun. No randomised controlled studies were found. Minor edits made. Conclusions not changed.
19 January 2016	New search has been performed	Searches of CENTRAL and Specialised Register were rerun. No randomised controlled studies were found.

HISTORY

Protocol first published: Issue 4, 2007
Review first published: Issue 1, 2009

Date	Event	Description
29 September 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

Dr Iosief Abraha: selected and assessed trials for possible inclusion; and wrote the majority of the text of this review
Dr Carlo Romagnoli: prepared the abstract and approved the final version
Dr Roberto Cirocchi: selected and assessed trials for possible inclusion; and approved the final version
Dr Alessandro Montedori: resolved any differences in the assessment of trials, helped in writing the 'Description of studies', wrote the 'Plain language summary'; and approved the final version

DECLARATIONS OF INTEREST

Dr Iosief Abraha: none known
Dr Carlo Romagnoli: none known
Dr Roberto Cirocchi: none known
Dr Alessandro Montedori: none known

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

- Chief Scientist Office, Scottish Government Health Directorates, The Scottish Government, UK.

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

Economic analysis was removed as a secondary outcome for this 2016 update as Cochrane Vascular does not have the expertise to carry out complete economic evaluations. Economic data available from studies identified for future updates will be included in the discussion section.

INDEX TERMS

Medical Subject Headings (MeSH)

*Stents; Aortic Aneurysm, Thoracic [*surgery]; Endovascular Procedures [*methods]; Postoperative Complications [prevention & control]

MeSH check words

Humans