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# What are the Observed Procedural Costs of Vascular Access Surgery? Protocol for a Systematic Review

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| Complete List of Authors: | Edgar, Ben; Queen Elizabeth University Hospital Campus, Renal Transplant and Vascular Access Surgery; University of Glasgow, School of Cardiovascular and Metabolic Health  
Jones, Catrin; Queen Elizabeth University Hospital, Renal Transplant and Vascular Access Surgery; University of Glasgow, School of Health and Wellbeing  
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What are the Observed Procedural Costs of Vascular Access Surgery?
Protocol for a Systematic Review

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Author Contributions:
B.E. conceived the idea and B.E. and D.B.K. drafted the manuscript. B.E. and D.B.K. contributed to the development of the selection criteria. B.E., C.J. and D.B.K. developed the search strategy and the data collection and management strategy. E.A., K.S, A.J., L.G., P.T., R.K., and C.S. reviewed the protocol and offered revisions. All authors approved the protocol prior to submission.

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Conflicts of Interest:
All authors declare no conflict of interest.

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Abstract

Introduction
A central component in the introduction of a novel surgical procedure or technique is an evaluation of its cost-efficiency when compared to a benchmark standard of care. Accurate assessment of costs is thus essential in ensuring appropriate allocation of resources within a healthcare system. The treatment of kidney failure requires a significant volume of resources, and vascular access provision is the main modifiable cost. The costs of providing this service are obscured by generic NHS reference costs which lack adequate granularity to allow meaningful comparisons between treatments. The aim of this systematic review will be to assess the reporting of procedural costs in all published economic analyses of vascular access surgery and perform a comparison of the reported procedural costs involved in arteriovenous fistula (AVF) and arteriovenous graft (AVG) creation. This will provide an estimate as to the accuracy of the NHS Reference costs in this field.

Methods and Analysis
The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines will be followed. A systematic search will be performed of the MEDLINE, Embase and Cochrane databases to identify relevant literature. Studies will be selected by title and abstract review, followed by a full-text review using inclusion and exclusion criteria. Data collected will pertain to procedural costs of AVG and AVG creation. Costs will be adjusted to a common currency using a GDP deflator index and conversion rates based on purchasing power parities for GDP. Comparison with NHS reference costs will indicate their reliability for use in future economic analyses in this field.

Ethics and Dissemination
Ethical approval is not required as it is a protocol for a systematic review. Findings will be disseminated through peer-reviewed publications and conference presentations.

Strengths and Limitations of this Study

- This is the first systematic review of the procedural costings of Vascular Access Surgery using standardised methodology.
- Findings from this review will indicate whether NHS reference costs can reliably be used as a marker of procedural cost in vascular access surgery for future economic analyses.
- The analysis will focus on direct procedural costs, rather than pre- or post-procedural costs and non-medical expenses that may constitute a significant proportion of the cost to be considered in any future economic analysis.
- Conclusions will be drawn from a UK perspective and any conclusions may not be directly applicable to international practice.
**Introduction**

A central component in the introduction of a novel surgical procedure or technique is an evaluation of its cost-efficiency when compared to a benchmark standard of care. Accurate assessment of costs is thus essential in ensuring appropriate allocation of resources within a healthcare system. Healthcare costs are a function of resources consumed and the unit costs associated with those resources.

The economics of costing are complex, and various methods exist with varying degrees of specificity at an individual level. ‘Gross-costing’ defines the cost of a resource at a highly aggregated level by bundling items e.g. the average cost per hospital day, which reduces the workload of cost-estimation whilst sacrificing specificity in the resulting cost-estimate. ‘Micro-costing’ involves the direct enumeration and costing of every input consumed in the treatment of a particular patient, producing a more specific estimate of cost but is a labour-intensive process. In addition, there are two approaches to determining the resource allocation of non-itemised aspects. The ‘top-down’ approach to costing assigns total costs for a healthcare system to individual units, for example dividing the annual operating theatre budget by the number of procedures performed to estimate an average cost-per-procedure, which lacks specificity of procedural costs. The ‘bottom-up’ approach identifies the resource use for each individual patient, providing more specific cost estimates, but requires significant investigator effort and is dependent on similar procedures consuming similar resources. There is no standardised, universal method of health-economic analysis performed, with most approaches falling somewhere on a spectrum between ‘top-down gross-costing’ and ‘bottom-up micro-costing’. For example, NHS-England employs ‘top-down gross-costing’ methodology to estimate resource use per healthcare resource group (HRG). These costs represent the average cost per inpatient episode for bundled groups of conditions or procedures, such as ‘Peripheral Vascular Disorders’ or ‘Complex Abdominal Procedures’. Such generalisations preclude the use of these reference costs in making meaningful comparisons between different surgical procedures within the same procedure group.

It is now recognised that a significant volume of healthcare resources required in the treatment of kidney failure is in providing vascular access provision, and this is the main modifiable cost. However, the costs of providing Vascular Access surgery are over-simplified and may not reflect the true cost of the service. For example, the two main surgical procedures (arteriovenous fistula- “AVF”, and arteriovenous graft- “AVG”) are defined by the same reference cost (YQ42Z – *Open Arteriovenous Fistula, Graft or Shunt Procedures*), allowing no distinction between their costs.

The aim of this systematic review will be to assess the reporting of procedural costs in all published economic analyses of vascular access surgery, and a comparison of the reported procedural costs involved in arteriovenous fistula and arteriovenous graft creation. This will provide an estimate as to the accuracy of the NHS Reference costs in this field.
Methods and Analysis

This systematic review will be conducted and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.\(^9,10\)

Objectives
To conduct a systematic review of the procedural costs of arteriovenous fistula and arteriovenous graft creation in the published literature.

Review Questions
This systematic review will address the following research question: What are the reported procedural costs of vascular access surgery, and how do they compare to the NHS Reference Costs?

Criteria for considering studies
Inclusion Criteria
Costing studies published in English, with full text available, reporting procedural costs for AVF or AVG creation for the purpose of vascular access for haemodialysis were included.

Exclusion Criteria
Studies which do not report procedural costs of vascular access creation or only report non-surgical costs were excluded. Studies reporting annualised costs per access type or the costs of dialysis provision without specific reporting of procedural costs were excluded as it is not possible to compare procedural costs in this context. Studies only reporting surgical revision or the cost of vascular access maintenance without reporting procedural costs of the index surgery were excluded.

Type of Outcome
The outcomes of interest will be the procedural costs of AVF and AVG creation.

Information sources and search strategy
A systematic search will be performed on the MEDLINE, Embase and Cochrane databases to identify studies published in English from January 1\(^{st}\), 2000, to July 31\(^{st}\), 2023. The search strategy will include keywords to describe healthcare economic evaluations, combined with Medical Subject Heading terms relating to vascular access surgery for haemodialysis. This will be supplemented by a manual search of reference lists from the identified studies, review articles and systematic reviews.

NHS reference costs will be obtained from the most recent version of the National Schedule of NHS Costs and pertain to the total unit cost for currency code ‘YQ42Z – Open Arteriovenous Fistula, Graft or Shunt Procedures’\(^7\).

Selection of studies for inclusion
Titles and abstracts identified using the search strategy will be screened independently by two reviewers (BE/CJ) to identify appropriate studies for eligibility assessment. Reasons for exclusion of studies will be collected during abstract screening. Full text articles of
potentially suitable studies will be retrieved and independently assessed for eligibility by the same reviewers. Screening conflicts will be resolved by a third independent reviewer (DBK).

Data Collection and management
Included studies will be extracted for information relating to study design, country, price year, costing method and/or source of cost data, vascular access procedures studied, and cost per procedure. Data will be extracted into a standardised proforma using Microsoft Excel (Version 16.76 © 2023 Microsoft Corporation).

When more than one variation of a procedure is reported e.g. brachiocephalic fistula and radiocephalic fistula, or when the procedure is compared between certain groups e.g. incident or prevalent haemodialysis patients, a procedural average will be calculated for the purposes of reporting costs.

When the price year is not reported, it will be assumed to be the same as year of publication. If procedural costing data has been adopted from government-derived costing schedules, the year of schedule publication will be used.

To allow meaningful comparison over time and geography, costs will be adjusted from original price year to target price year using a Gross Domestic Product deflator index, and converted to US Dollars using conversion rates based on purchasing power parities for GDP. The target year (2021) is selected to match the most recently published NHS Reference Costs.

Data Analysis and Quality Assessment
Normality of data will be assessed using the Shapiro-Wilk’s test. Continuous variables will be analysed using the independent students’ t-test or Mann-Whitney U test as appropriate, and multi-set comparisons performed using ANOVA or Kruskal-Wallis tests. Continuous variables will be reported as mean with standard deviation if normally distributed, or median with interquartile range in the case of non-normality. Data analysis will be performed using RStudio (Version 2023.03.0+386 © 2022 Posit Software, PBC).

Due to variations in study designs (all study types are eligible) and the primary outcome of interest (direct procedural costs), no appropriate quality assurance checklist has been identified. Quality assurance will therefore be performed by the reviewers based on the following criteria:

1. Is there a clear description of the procedure performed and does it fit the procedures eligible for inclusion?
2. Is there a clear description of the cost definitions (procedural costs vs. total hospital costs)?
3. Is the study sample representative for the patient population studied?

Outcomes and Prioritisation
The primary outcome of interest is the procedural costs of AVF and AVG creation in 2021 US Dollars. Secondary outcomes include comparison with the NHS reference costs for these
procedures, and whether reported costs are significantly different based on study design and country.

**Patient and public involvement**
No patients or members of the public were involved in the design of this study.

**Ethics and Dissemination**
Ethical approval if not required as it is a protocol for a systematic review of peer-reviewed published literature. Findings will be disseminated through peer-reviewed publications and conference presentations.

**Discussion**
Although bottom-up micro-costing is recognised as the ideal way to produce accurate costs at a patient-specific level, it is rarely done perhaps due to the time required to perform accurately. Consequently, top-down gross-costing methodology is often employed but this is less transparent and less reliable.\(^\text{12}\)

There has been longstanding debate over the two main surgical methods of providing vascular access for haemodialysis: Arteriovenous fistula (AVF) and Arteriovenous grafts (AVG). Since the inception of AVG as a novel technique, there has been greater emphasis upon the assessment of outcomes rather than cost. Economic analysis has played a role in only one randomised trial in this field\(^\text{13}\), which based procedural costs upon NHS reference costs in absence of a suitable alternative. Such an approach may allow a meaningful comparison of periprocedural care, but accurate costs of an intervention at the micro-level are required in order perform accurate economic analysis and provide a comprehensive view of outcomes alongside the cost at which they are achievable\(^\text{8,14}\).

This study will assess the methodology employed in performing health-economic evaluations of AVF and AVG in the literature and assess the prevalence of micro-costing methodology within these studies. Comparison against the NHS reference costs for these procedures - the contemporary benchmark used to cost procedures in UK practice – will assess their reliability for use in future cost-efficiency analyses of vascular access modalities.

Several limitations to this review are recognised. The analysis will focus on direct procedural costs, rather than pre- or post-procedural costs and non-medical expense, which constitute a significant proportion of the cost to be considered in any future economic analysis. The objective, however, is to differentiate between procedural costs, as these appear more highly aggregated than those for periprocedural care. Second, by comparing against NHS reference costs, we approach this study from a UK perspective and any conclusions drawn may not be directly applicable to international practice. Third, there is potential for national tariffs used to cost procedures to be used as incentives to practitioners to target specific interventions, such as providing cost-savings to centres achieving high rates of dialysis via native AVF. This may obscure the true procedural costs if cost data is sourced from national tariffs, as it may reflect a higher commissioner-to-institution reimbursement rather than a higher true procedural cost. Finally, we anticipate that in certain studies, costs (the true cost to the hospital) will be reported as charges i.e. the price paid by patients, government or third-party payers, and that the two are not directly interchangeable. However, without
transparent data on the variability between costs and charges it is not possible to determine its impact on the results of this review.
References


Search Strategy – MEDLINE (ALL) (OVID) 30/08/2023 = 938 results

1. exp "Costs and Cost Analysis"/
2. exp health care costs/
3. exp health expenditures/
4. exp hospital costs/
5. exp economics/
6. ('cost$' or 'cost$ study').ab,hw,kf,kw,ot,sh,tw.
7. (microcost or micro-cost or microcosting or micro-costing).ab,hw,kf,kw,ot,sh,tw.
8. Cost-Benefit Analysis/ or Cost-Effectiveness Analysis/
9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10. exp Vascular Surgery/
11. exp Blood Vessel prosthesis implantation/
12. exp Arteriovenous shunt, surgical/
13. exp blood vessel prosthesis/
14. exp Vascular Surgical Procedures/
15. vascular access.ab,hw,kf,kw,ot,sh,tw.
16. dialysis access.ab,hw,kf,kw,ot,sh,tw.
17. 10 or 11 or 12 or 13 or 14 or 15 or 16
18. arteriovenous fistula.ab,hw,kf,kw,ot,sh,tw.
19. hemodialysis.ab,hw,kf,kw,ot,sh,tw.
20. haemodialysis.ab,hw,kf,kw,ot,sh,tw.
21. arteriovenous graft.ab,hw,kf,kw,ot,sh,tw.
22. AV fistula.ab,hw,kf,kw,ot,sh,tw.
23. AV graft.ab,hw,kf,kw,ot,sh,tw.
24. 18 or 19 or 20 or 21 or 22 or 23
25. 17 and 24
26. 9 and 25
27. exp animals/ not humans.sh.
28. 26 not 27
Search Strategy – COCHRANE DATABASE 30/08/2023 = 64 results

ID    Search
#1    MeSH descriptor: [Costs and Cost Analysis] explode all trees
#2    MeSH descriptor: [Health Care Economics and Organizations] explode all trees
#3    MeSH descriptor: [Health Care Quality, Access, and Evaluation] explode all trees
#4    MeSH descriptor: [Economics] explode all trees
#5    ('cost$' or 'cost$ study'):ti,ab,kw
#6    (microcost or micro-cost or microcosting or micro-costing):ab,ti,kw
#7    cost near/3 analysis:ti,ab
#8    #1 or #2 or #3 or #4
#9    #5 or #6 or #7
#10   #8 AND #9
#11   MeSH descriptor: [Vascular Surgical Procedures] explode all trees
#12   MeSH descriptor: [Blood Vessel Prosthesis] explode all trees
#13   MeSH descriptor: [Blood Vessel Prosthesis Implantation] explode all trees
#14   MeSH descriptor: [Arteriovenous Shunt, Surgical] explode all trees
#15   "vascular access":ab,ti,kw
#16   "dialysis access":ab,ti,kw
#17   #11 or #12 or #13 or #14 or #15 or #16
#18   arteriovenous fistula:ab,ti,kw
#19   AV fistula:ab,ti,kw
#20   arteriovenous graft:ab,ti,kw
#21   AV graft:ab,ti,kw
#22   hemodialysis:ab,ti,kw
#23   #18 or #19 or #20 or #21 or #22
#24   #17 and #23
#25   #10 and #24
# Reporting checklist for protocol of a systematic review and meta analysis.

Based on the PRISMA-P guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the PRISMA-Preporting guidelines, and cite them as:


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<td>Identification</td>
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<td>Update</td>
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<td>Registration</td>
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<td>Authors</td>
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<tr>
<td>Contact</td>
<td>#3a Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author</td>
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For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml
Contribution  #3b  Describe contributions of protocol authors and identify the guarantor of the review

Amendments  

#4  If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments

Support  

Sources  #5a  Indicate sources of financial or other support for the review

Sponsor  #5b  Provide name for the review funder and / or sponsor

Role of sponsor or funder  #5c  Describe roles of funder(s), sponsor(s), and / or institution(s), if any, in developing the protocol

Introduction  

Rationale  #6  Describe the rationale for the review in the context of what is already known

Objectives  #7  Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)

Methods  

Eligibility criteria  #8  Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review

Information sources  #9  Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage
Search strategy #10 Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated

Study records - data management #11a Describe the mechanism(s) that will be used to manage records and data throughout the review

Study records - selection process #11b State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)

Study records - data collection process #11c Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators

Data items #12 List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications

Outcomes and prioritization #13 List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale

Risk of bias in individual studies #14 Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis

Data synthesis #15a Describe criteria under which study data will be quantitatively synthesised

Data synthesis #15b If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I², Kendall’s τ)

Data synthesis #15c Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)
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<td>Confidence in cumulative evidence</td>
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None The PRISMA-P elaboration and explanation paper is distributed under the terms of the Creative Commons Attribution License CC-BY. This checklist can be completed online using [https://www.goodreports.org/](https://www.goodreports.org/), a tool made by the EQUATOR Network in collaboration with Penelope.ai
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| <b>Primary Subject Heading</b>: | Surgery |
| Secondary Subject Heading: | Health economics, Renal medicine |
| Keywords: | HEALTH ECONOMICS, Dialysis < Nephrology, Systematic Review, Transplant surgery < Surgery, Vascular surgery < Surgery, VASCULAR SURGERY |
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B. Edgar\textsuperscript{1,2}, C. Jones\textsuperscript{1,3}, E. Aitken\textsuperscript{1,2}, K. Stevenson\textsuperscript{1}, A. Jackson\textsuperscript{1}, L. Gaianu\textsuperscript{4}, P. Thomson\textsuperscript{5}, R. Kasthuri\textsuperscript{6}, C. Stove\textsuperscript{6}, D.B. Kingsmore\textsuperscript{1,2,7}

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Tel: 0141 201 1100
Abstract

Introduction
A central component in the introduction of a novel surgical procedure or technique is an evaluation of its cost-efficiency when compared to a benchmark standard of care. Accurate assessment of costs is thus essential in ensuring appropriate allocation of resources within a healthcare system. The treatment of kidney failure requires a significant volume of resources, and vascular access provision is the main modifiable cost. The costs of providing this service are obscured by generic NHS reference costs, which lack adequate granularity to allow meaningful comparisons between treatments. The aim of this systematic review will be to assess the reporting of procedural costs in all published economic analyses of vascular access surgery and perform a comparison of the reported procedural costs involved in arteriovenous fistula (AVF) and arteriovenous graft (AVG) creation. This will provide an estimate as to the accuracy of the NHS reference costs in this field.

Methods and analysis
The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines will be followed. A systematic search will be performed of the MEDLINE, Embase and Cochrane databases to identify full-text economic analyses of vascular access for haemodialysis in which the procedural cost of AVF or AVG creation are reported. Publications in English from January 1st, 2000, to August 30th, 2023, will be eligible for inclusion. Studies will be selected by title and abstract review, followed by a full-text review using inclusion and exclusion criteria. Studies not reporting the procedural costs of surgery will be excluded. Data collected will pertain to procedural costs of AVF and AVG creation. Costs will be adjusted to a common currency using a GDP deflator index and conversion rates based on purchasing power parities for GDP. Comparison with NHS reference costs will indicate their reliability for use in future economic analyses in this field.

Ethics and dissemination
Ethical approval is not required for this systematic review. Findings will be disseminated through peer-reviewed publications and conference presentations.

Study registration
PROSPERO, CRD42023458779.

Strengths and limitations of this study
- This systematic review of the procedural costings of vascular access surgery will use standardised and reproducible methodology.
- Findings from this review will indicate whether NHS reference costs can reliably be used as a marker of procedural cost in vascular access surgery for future economic analyses.
- The analysis will focus on direct procedural costs, excluding pre- or post-procedural costs and non-medical expenses that may constitute a significant proportion of the cost to be considered in any future economic analysis.
- Conclusions will be drawn from a UK perspective and any conclusions may not be directly applicable to international practice.
INTRODUCTION

A central component in the introduction of a novel surgical procedure or technique is an evaluation of its cost-efficiency when compared to a benchmark standard of care[1]. Accurate assessment of costs is thus essential in ensuring appropriate allocation of resources within a healthcare system [2-4]. Healthcare costs are a function of resources consumed and the unit costs associated with those resources.

The economics of costing are complex, and various methods exist with varying degrees of specificity at an individual level. ‘Gross-costing’ defines the cost of a resource at a highly aggregated level by bundling items e.g. the average cost per hospital day, which reduces the workload of cost-estimation whilst sacrificing specificity in the resulting cost-estimate.

‘Micro-costing’ involves the direct enumeration and costing of every input consumed in the treatment of a particular patient, producing a more specific estimate of cost but is a labour-intensive process. In addition, there are two approaches to determining the resource allocation of non-itemised aspects. The ‘top-down’ approach to costing assigns total costs for a healthcare system to individual units, for example dividing the annual operating theatre budget by the number of procedures performed to estimate an average cost-per-procedure, which lacks specificity of procedural costs. The ‘bottom-up’ approach identifies the resource use for each individual patient, providing more specific cost estimates, but requires significant investigator effort and is dependent on similar procedures consuming similar resources [5,6]. There is no standardised, universal method of health-economic analysis performed, with most approaches falling somewhere on a spectrum between ‘top-down gross-costing’ and ‘bottom-up micro-costing’. For example, NHS-England employs ‘top-down gross-costing’ methodology to estimate resource use per healthcare resource group (HRG). These costs represent the average cost per inpatient episode for bundled groups of conditions or procedures, such as ‘Peripheral Vascular Disorders’ or ‘Complex Abdominal Procedures’. Such generalisations preclude the use of these reference costs in making meaningful comparisons between different surgical procedures within the same procedure group[7].

It is now recognised that a significant volume of healthcare resources required in the treatment of kidney failure is in providing vascular access provision, and this is the main modifiable cost[8]. However, the costs of providing Vascular Access surgery are oversimplified and may not reflect the true cost of the service. For example, the two main surgical procedures (arteriovenous fistula- “AVF”, and arteriovenous graft- “AVG”) are defined by the same reference cost (YQ42Z – Open Arteriovenous Fistula, Graft or Shunt Procedures), allowing no distinction between their costs.

The aim of this systematic review will be to assess the reporting of procedural costs in all published economic analyses of vascular access surgery, and a comparison of the reported procedural costs involved in arteriovenous fistula and arteriovenous graft creation. This will provide an estimate as to the accuracy of the NHS Reference costs in this field.
METHODS AND ANALYSIS

This systematic review will be reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [9,10].

Objectives
To conduct a systematic review of the procedural costs of arteriovenous fistula and arteriovenous graft creation in the published literature.

Review questions
This systematic review will address the following research question: What are the reported procedural costs of vascular access surgery, and how do they compare to the NHS Reference Costs?

Criteria for considering studies
Inclusion criteria
Costing studies published in English, with full text available, reporting procedural costs for AVF or AVG creation for the purpose of vascular access for haemodialysis were included.

Exclusion criteria
Studies which do not report procedural costs of vascular access creation or only report non-surgical costs were excluded. Studies reporting annualised costs per access type or the costs of dialysis provision without specific reporting of procedural costs were excluded as it is not possible to compare procedural costs in this context. Studies only reporting surgical revision or the cost of vascular access maintenance without reporting procedural costs of the index surgery were excluded.

Type of outcome
The outcomes of interest will be the procedural costs of AVF and AVG creation.

Information sources and search strategy
A systematic search will be performed on the MEDLINE, Embase and Cochrane databases to identify studies published in English from January 1st, 2000, to August 30th, 2023. The search strategy will include keywords to describe healthcare economic evaluations, combined with Medical Subject Heading terms relating to vascular access surgery for haemodialysis (Supplementary appendix). This will be supplemented by a manual search of reference lists from the identified studies, review articles and systematic reviews, and any relevant grey literature will be reviewed if referenced.

Converting health service costs over space and time relies on several assumptions, for instance that underlying technical or relative factor prices remain constant. The search window was selected to minimise potential inaccuracies arising from converting prices in earlier studies.[11]

NHS reference costs will be obtained from the most recent version of the National Schedule of NHS Costs and pertain to the total unit cost for currency code ‘YQ42Z – Open Arteriovenous Fistula, Graft or Shunt Procedures’ [7].
Selection of studies for inclusion
Titles and abstracts identified using the search strategy will be screened independently by
two reviewers (BE/CJ) to identify appropriate studies for eligibility assessment. Reasons for
exclusion of studies will be collected during abstract screening. Full text articles of
potentially suitable studies will be retrieved and independently assessed for eligibility by the
same reviewers. Screening conflicts will be resolved by a third independent reviewer (DBK).

Data collection and management
Included studies will be extracted for information relating to study design, country, price
year, costing method and/or source of cost data, vascular access procedures studied, and
cost per procedure. Data will be extracted into a standardised proforma using Microsoft
Excel (Version 16.76 © 2023 Microsoft Corporation).

When more than one variation of a procedure is reported e.g. brachiocephalic fistula and
radiocephalic fistula, or when the procedure is compared between certain groups e.g.
incident or prevalent haemodialysis patients, a procedural average will be calculated for the
purposes of reporting costs.

When the price year is not reported, it will be assumed to be the same as year of
publication. If procedural costing data has been adopted from government-derived costing
schedules, the year of schedule publication will be used.

To allow meaningful comparison over time and geography, costs will be adjusted from
original price year to target price year using a Gross Domestic Product deflator index, and
converted to US Dollars using conversion rates based on purchasing power parities for GDP
[12]. The target year (2021) is selected to match the most recently published NHS Reference
Costs.

Data analysis and quality assessment
Normality of data will be assessed using the Shapiro-Wilk’s test. Continuous variables will be
analysed using the independent students’ t-test or Mann-Whitney U test as appropriate,
and multi-set comparisons performed using ANOVA or Kruskal-Wallis tests. Continuous
variables will be reported as mean with standard deviation if normally distributed, or
median with interquartile range in the case of non-normality. Data analysis will be
performed using RStudio (Version 2023.03.0+386 © 2022 Posit Software, PBC).

Due to variations in study designs (all study types are eligible) and the primary outcome of
interest (direct procedural costs), no appropriate quality assurance checklist has been
identified. Quality assurance will therefore be performed by the reviewers based on the
following criteria:

1. Is there a clear description of the procedure performed and does it fit the
   procedures eligible for inclusion?
2. Is there a clear description of the cost definitions (procedural costs vs. total hospital
   costs)?
3. Is the study sample representative for the patient population studied?
Outcomes and prioritisation
The primary outcome of interest is the procedural costs of AVF and AVG creation in 2021 US Dollars. Secondary outcomes include comparison with the NHS reference costs for these procedures, and whether reported costs are significantly different based on study design and country.

Patient and public involvement
None.

ETHICS AND DISSEMINATION
Ethical approval is not required for this systematic review of peer-reviewed published literature. The study will be reported in accordance with PRISMA guidelines[9,10]. Findings will be disseminated through peer-reviewed publications and conference presentations.

DISCUSSION
Although bottom-up micro-costing is recognised as the ideal way to produce accurate costs at a patient-specific level, it is rarely done perhaps due to the time required to perform accurately. Consequently, top-down gross-costing methodology is often employed but this is less transparent and less reliable.[13]

There has been longstanding debate over the two main surgical methods of providing vascular access for haemodialysis: Arteriovenous fistula (AVF) and Arteriovenous grafts (AVG). Since the inception of AVG as a novel technique, there has been greater emphasis upon the assessment of outcomes rather than cost. Economic analysis has played a role in only one randomised trial in this field, which based procedural costs upon NHS reference costs in absence of a suitable alternative [14]. Such an approach may allow a meaningful comparison of periprocedural care, but accurate costs of an intervention at the micro-level are required in order perform accurate economic analysis and provide a comprehensive view of outcomes alongside the cost at which they are achievable[8,15].

This study will assess the methodology employed in performing health-economic evaluations of AVF and AVG in the literature and assess the prevalence of micro-costing methodology within these studies. Comparison against the NHS reference costs for these procedures - the contemporary benchmark used to cost procedures in UK practice – will assess their reliability for use in future cost-efficiency analyses of vascular access modalities.

Several limitations to this review are recognised. The analysis will focus on direct procedural costs, rather than pre- or post-procedural costs and non-medical expense, which constitute a significant proportion of the cost to be considered in any future economic analysis. The objective, however, is to differentiate between procedural costs, as these appear more highly aggregated than those for periprocedural care. Second, by comparing against NHS reference costs, we approach this study from a UK perspective and any conclusions drawn may not be directly applicable to international practice. Third, there is potential for national tariffs used to cost procedures to be used as incentives to practitioners to target specific interventions, such as providing cost-savings to centres achieving high rates of dialysis via native AVF. This may obscure the true procedural costs if cost data is sourced from national
tariffs, as it may reflect a higher commissioner-to-institution reimbursement rather than a higher true procedural cost. Finally, we anticipate that in certain studies, costs (the true cost to the hospital) will be reported as charges i.e. the price paid by patients, government or third-party payers, and that the two are not directly interchangeable. However, without transparent data on the variability between costs and charges it is not possible to determine its impact on the results of this review.

**Contributors**

B.E. conceived the idea and B.E. and D.B.K. drafted the manuscript. B.E. and D.B.K. contributed to the development of the selection criteria. B.E., C.J, and D.B.K. developed the search strategy and the data collection and management strategy. E.A., K.S, A.J., L.G., P.T., R.K., and C.S. reviewed the protocol and offered revisions. All authors approved the protocol prior to submission.

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**Competing interests**

All authors declare no competing interests.

**References**


Search Strategy – MEDLINE (ALL) (OVID) 30/08/2023 = 938 results

1. exp "Costs and Cost Analysis"/
2. exp health care costs/
3. exp health expenditures/
4. exp hospital costs/
5. exp economics/
6. ('cost$' or 'cost$ study').ab,hw,kf,kw,ot,sh,V,tw.
7. (microcost or micro-cost or microcosting or micro-costing).ab,hw,kf,kw,ot,sh,titw.
8. Cost-Benefit Analysis/ or Cost-Effectiveness Analysis/
9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10. exp Vascular Surgery/
11. exp Blood Vessel prosthesis implantation/
12. exp Arteriovenous shunt, surgical/
13. exp blood vessel prosthesis/
14. exp Vascular Surgical Procedures/
15. vascular access.ab,hw,kf,kw,ot,sh,titw.
16. dialysis access.ab,hw,kf,kw,ot,sh,titw.
17. 10 or 11 or 12 or 13 or 14 or 15 or 16
18. arteriovenous fistula.ab,hw,kf,kw,ot,sh,titw.
19. hemodialysis.ab,hw,kf,kw,ot,sh,titw.
20. haemodialysis.ab,hw,kf,kw,ot,sh,titw.
21. arteriovenous graft.ab,hw,kf,kw,ot,sh,titw.
22. AV fistula.ab,hw,kf,kw,ot,sh,titw.
23. AV graft.ab,hw,kf,kw,ot,sh,titw.
24. 18 or 19 or 20 or 21 or 22 or 23
25. 17 and 24
26. 9 and 25
27. exp animals/ not humans.sh.
28. 26 not 27
Search Strategy – COCHRANE DATABASE 30/08/2023 = 64 results

ID   Search
#1   MeSH descriptor: [Costs and Cost Analysis] explode all trees
#2   MeSH descriptor: [Health Care Economics and Organizations] explode all trees
#3   MeSH descriptor: [Health Care Quality, Access, and Evaluation] explode all trees
#4   MeSH descriptor: [Economics] explode all trees
#5   ('cost$' or 'cost$ study'):ti,ab,kw
#6   (microcost or micro-cost or microcosting or micro-costing):ab,ti,kw
#7   cost near/3 analysis:ti,ab
#8   #1 or #2 or #3 or #4
#9   #5 or #6 or #7
#10  #8 AND #9
#11  MeSH descriptor: [Vascular Surgical Procedures] explode all trees
#12  MeSH descriptor: [Blood Vessel Prosthesis] explode all trees
#13  MeSH descriptor: [Blood Vessel Prosthesis Implantation] explode all trees
#14  MeSH descriptor: [Arteriovenous Shunt, Surgical] explode all trees
#15  "vascular access":ab,ti,kw
#16  "dialysis access":ab,ti,kw
#17  #11 or #12 or #13 or #14 or #15 or #16
#18  arteriovenous fistula:ab,ti,kw
#19  AV fistula:ab,ti,kw
#20  arteriovenous graft:ab,ti,kw
#21  AV graft:ab,ti,kw
#22  hemodialysis:ab,ti,kw
#23  #18 or #19 or #20 or #21 or #22
#24  #17 and #23
#25  #10 and #24
Search Strategy – Embase 1947-Present (ALL) (OVID) 30/08/2023 = 119 results

1. exp "Costs and Cost Analysis"/
2. exp health care costs/
3. exp health expenditures/
4. exp hospital costs/
5. exp economics/
6. ('cost$' or 'cost$ study').ab,hw,kf,kw,ot,sh,tw.
7. (microcost or micro-cost or microcosting or micro-costing).ab,hw,kf,kw,ot,sh,ti,tw.
8. Cost-Benefit Analysis/ or Cost-Effectiveness Analysis/
9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10. exp Vascular Surgery/
11. exp Blood Vessel prosthesis implantation/
12. exp Arteriovenous shunt, surgical/
13. exp blood vessel prosthesis/
14. exp Vascular Surgical Procedures/
15. vascular access.ab,hw,kf,kw,ot,sh,ti,tw.
16. dialysis access.ab,hw,kf,kw,ot,sh,ti,tw.
17. 10 or 11 or 12 or 13 or 14 or 15 or 16
18. arteriovenous fistula.ab,hw,kf,kw,ot,sh,ti,tw.
19. hemodialysis.ab,hw,kf,kw,ot,sh,ti,tw.
20. haemodialysis.ab,hw,kf,kw,ot,sh,ti,tw.
21. arteriovenous graft.ab,hw,kf,kw,ot,sh,ti,tw.
22. AV fistula.ab,hw,kf,kw,ot,sh,ti,tw.
23. AV graft.ab,hw,kf,kw,ot,sh,ti,tw.
24. 18 or 19 or 20 or 21 or 22 or 23
25. 17 and 24
26. 9 and 25
27. exp animals/ not humans.sh.
28. 26 not 27
# Reporting checklist for protocol of a systematic review and meta analysis.

Based on the PRISMA-P guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the PRISMA-Preporting guidelines, and cite them as:


<table>
<thead>
<tr>
<th>Reporting Item</th>
<th>Page Number</th>
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<tr>
<td><strong>Title</strong></td>
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<tr>
<td>Identification</td>
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<td><strong>Registration</strong></td>
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<td>Contact</td>
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<td>Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author</td>
</tr>
<tr>
<td>Contribution #3b</td>
<td>Describe contributions of protocol authors and identify the guarantor of the review</td>
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<td>Amendments #4</td>
<td>If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments</td>
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<td>Support Sources #5a</td>
<td>Indicate sources of financial or other support for the review</td>
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<td>Sponsor #5b</td>
<td>Provide name for the review funder and / or sponsor</td>
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<td>Role of sponsor or funder #5c</td>
<td>Describe roles of funder(s), sponsor(s), and / or institution(s), if any, in developing the protocol</td>
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<td>Introduction Rationale #6</td>
<td>Describe the rationale for the review in the context of what is already known</td>
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<td>Objectives #7</td>
<td>Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)</td>
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<td>Methods Eligibility criteria #8</td>
<td>Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review</td>
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<td>Information sources #9</td>
<td>Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage</td>
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<td>Search strategy</td>
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<td>Study records - data management</td>
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<td>Outcomes and prioritization</td>
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<td>Risk of bias in individual studies</td>
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<td>Data synthesis</td>
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Data synthesis  #15d  If quantitative synthesis is not appropriate, describe the type of summary planned  n/a

Meta-bias(es)  #16  Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)  n/a

Confidence in cumulative evidence  #17  Describe how the strength of the body of evidence will be assessed (such as GRADE)  n/a

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