



# The trend of percutaneous and open surgical procedures for peripheral arteriovenous malformations in the National Health Service England

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## ABSTRACT

**Introduction** This study aimed to assess the trend of percutaneous and open surgical procedures for peripheral arteriovenous malformations (AVMs) performed in NHS hospitals in England between 2012 and 2018.

**Methods** Hospital Episode Statistics (HES) is a freely available data warehouse that represents the whole population of England served by the NHS. Data from the HES database was obtained and analysed for all hospital episodes between 2012 and 2018 for the total number and trend of 'primary diagnosis', and 'primary procedures and interventions' identified for peripheral AVMs.

**Results** Over the period studied, there was an increase in the total number of admissions for peripheral AVMs; total primary diagnosis increased from 2242 to 2857 per year. Open surgery remained more commonly performed than percutaneous procedures throughout the studied period. However, the overall percentage of primary procedures and interventions being percutaneous in this period increased from 29.8% to 41.0% per year. The increase in the number of percutaneous procedures per year seemed to occur in both children (from 43 to 124) and adults (from 408 to 492) over the course of the study period.

**Conclusions** This study concluded that open surgery remained the most commonly performed primary procedure for peripheral AVMs, although there was an increasing trend for percutaneous procedures in NHS hospitals in England. The increase in the number and percentage of percutaneous procedures for peripheral AVMs was likely to have significant resource implications for the provision of care for patients with peripheral AVMs in NHS hospitals.

## KEYWORDS

Vascular malformations – Arteriovenous malformations – Embolisation – Percutaneous – Surgery

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## Introduction

Vascular malformations are lesions derived from aberrant embryonic development of vascular channels and feature dysplastic abnormally formed vessels, affecting up to 1.5% of the population of all age groups.<sup>1,2</sup> Peripheral vascular malformations often refer to lesions outside the central nervous system; usually confined in the subcutaneous and muscular tissues of the extremities and torso.<sup>1–5</sup> When such lesions involve the arteries and veins, they are referred to as peripheral arteriovenous malformations (AVMs).

Interventional treatment options for peripheral AVMs include open surgery such as excision or debulking of the lesions, and percutaneous procedures including embolosclectherapy. Percutaneous procedures are

minimally invasive, hence may carry the advantage of improved functional outcome and reduced morbidity to the patients.<sup>4</sup> Furthermore, recent advances in the imaging and minimally invasive technology may contribute to a paradigm shift in the interventional treatment options for AVMs.<sup>5</sup> Therefore, it is important to assess the trends in the number of these procedures being performed as this may have significant implications for healthcare systems, including the NHS.

Hospital Episode Statistics (HES) is a freely available data warehouse that represents the whole population of England served by the NHS. It includes data on hospital admissions, outpatient appointments and the procedures or interventions performed during hospital admissions.<sup>6</sup> HES is a powerful epidemiological, socioeconomic and political tool used by the NHS, government, and other

organisations and individuals as a data source for various healthcare analyses. Therefore, HES data may have significant implications on the regulation of healthcare system locally and nationally.<sup>7,8</sup> HES data comes from the routine exchange of information between providers and commissioners of healthcare for NHS patients. The processing cycle and HES data quality are detailed on the NHS Digital website. Briefly, data collected by healthcare providers is submitted to the Secondary Uses Service which, at prearranged dates during the year, takes an extract from the database and sends it to HES for cleaning and validation before making the information available in the data warehouse. Data quality reports and checks are completed at various stages in the cleaning and processing cycle.<sup>6</sup>

This study aimed to assess trends in the number of percutaneous and open surgical procedures for peripheral AVMs carried out in NHS hospitals in England between 2012 and 2018 (7 years) based on publicly available HES data.

## Methods

The main diagnosis and the total number of primary procedures and interventions for peripheral AVMs for patients admitted to NHS hospitals from 2012 to 2018 were retrieved from the HES database via the NHS Digital website (<https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/hospital-episode-statistics>), and analysed.<sup>6</sup> During this period, the primary diagnoses were coded according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10), while primary procedures and interventions were recorded according to the Office of Population, Censuses and Surveys: Classification of interventions and procedures, 4th Revision (OPCS-4). The only ICD-10 code that represented the primary diagnosis of peripheral AVM was 'Q27.3 - arteriovenous malformation (peripheral)'. The OPCS-4 procedural codes used that represented interventions for peripheral AVMs, both percutaneous and open surgery, are shown in Table 1. The data collected were classified into and analysed as children (age <18 years old) and adults ( $\geq 18$  years), and all ages.

## Statistical analysis

The data retrieved from the HES database were analysed with Microsoft Excel - Office 365 (Microsoft Corporation, Redmond, WA). Data were presented as frequency per year according to our classified age groups.

## Results

### Admissions for a primary diagnosis of peripheral AVM

Figure 1 shows the total number of admissions per year to NHS hospitals with peripheral AVM as the primary diagnosis from 2012 to 2018 (range 2,242–2,857). During this period, there was an increasing trend in the number

**Table 1** OPCS-4 codes used in this study to represent primary procedures for peripheral arteriovenous malformations

Percutaneous procedures	
OPCS-4 codes	Procedures
L75.3	Embolisation of arteriovenous abnormality NEC
L75.4	Percutaneous transluminal embolisation of arteriovenous malformation NEC
L75.5	Percutaneous transluminal venous embolisation of arteriovenous malformation
L75.6	Percutaneous transluminal arterial and venous embolisation of arteriovenous malformation
Open surgery	
OPCS-4 codes	Procedures
L75.1	Excision of congenital arteriovenous malformation
L75.8	Other specified other arteriovenous operations
OPCS-4 = Office of population censuses and surveys classification of interventions and procedures, 4th revision	

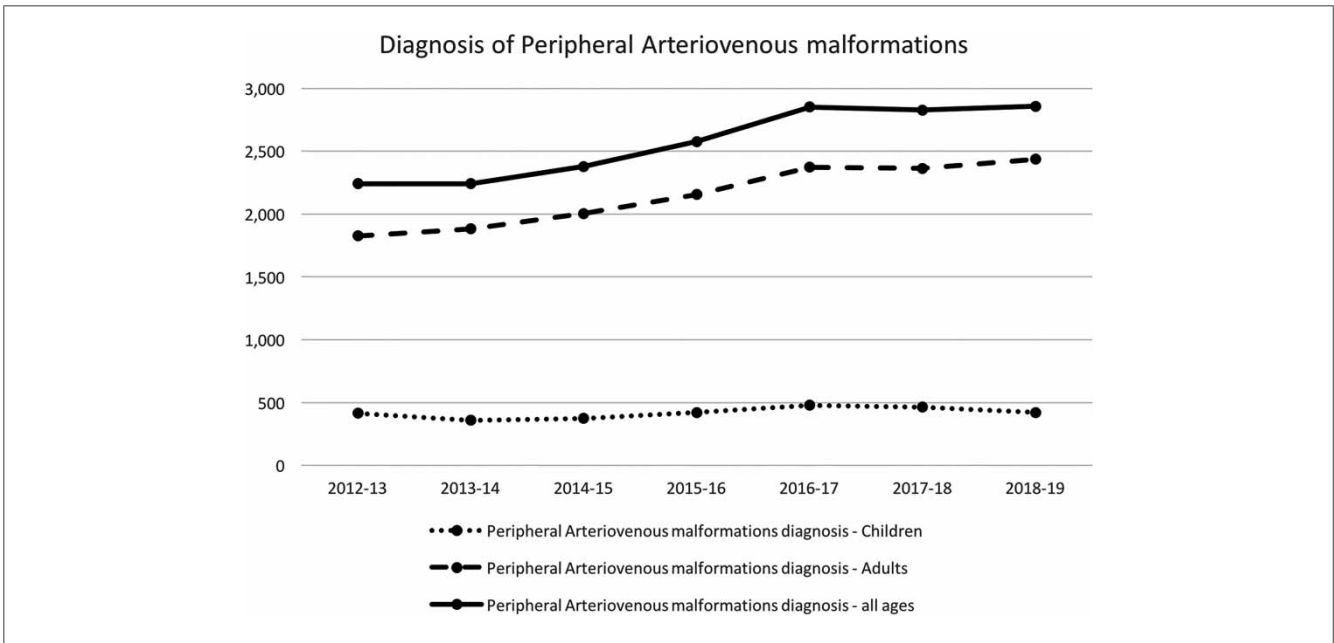
of overall admissions with a primary diagnosis of peripheral AVM. However, when the primary diagnosis of peripheral AVM was assessed based on the two age groups, increase in number of admissions was only apparent in adults but not in children.

### Percutaneous versus open surgical procedures for peripheral AVM

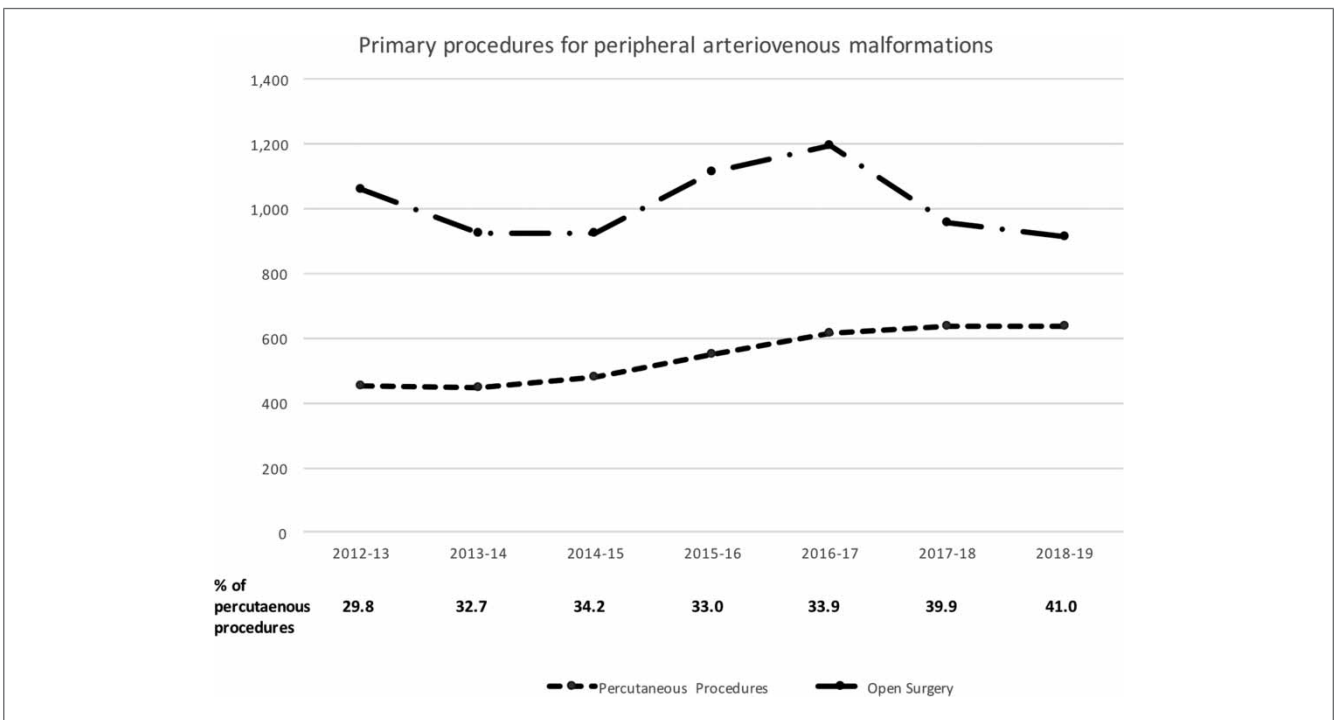
Figure 2 shows the total number of admissions per year for percutaneous intervention (range 447–636) and open surgery (range 914–1,195) as primary procedures and interventions for peripheral AVMs from 2012 to 2018. During this period, there were more open surgery than percutaneous procedures performed for peripheral AVMs per year. However, the number of percutaneous procedures but not open surgery appeared to rise steadily over this period, as reflected by the increase in the percentage of the primary procedures being percutaneous from 29.8% in 2012–2013 to 41.0% in 2018–2019.

Figure 3 shows increasing trends in the total number of admission per year of children (range 37–124) and adults (range 408–531) with percutaneous interventions performed as the primary procedures and interventions for peripheral AVM from 2012 to 2018. In both children and adults, there appeared to be a steady rise in percutaneous interventions performed as primary procedure for peripheral AVM during this period.

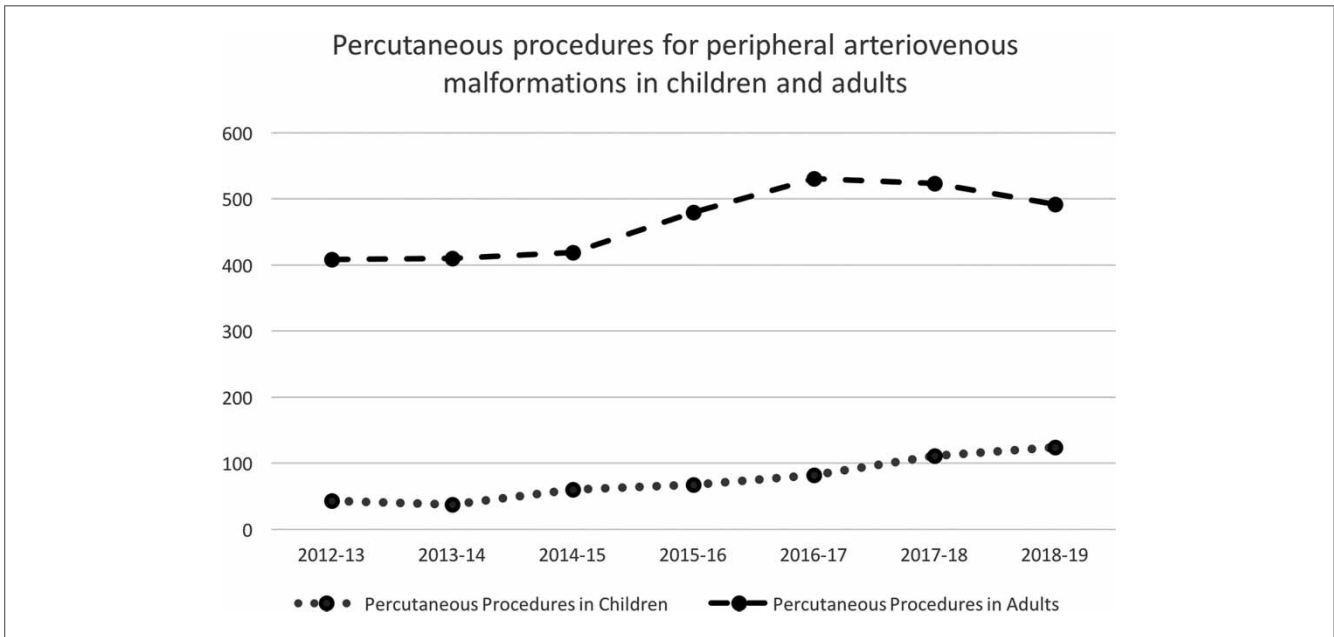
Figure 4 shows the trends in the total number of admissions per year of children (range 179–359) and adults (range 675–881), with open surgery performed as the primary procedures and interventions for peripheral AVM from 2012 to 2018. Unlike for percutaneous



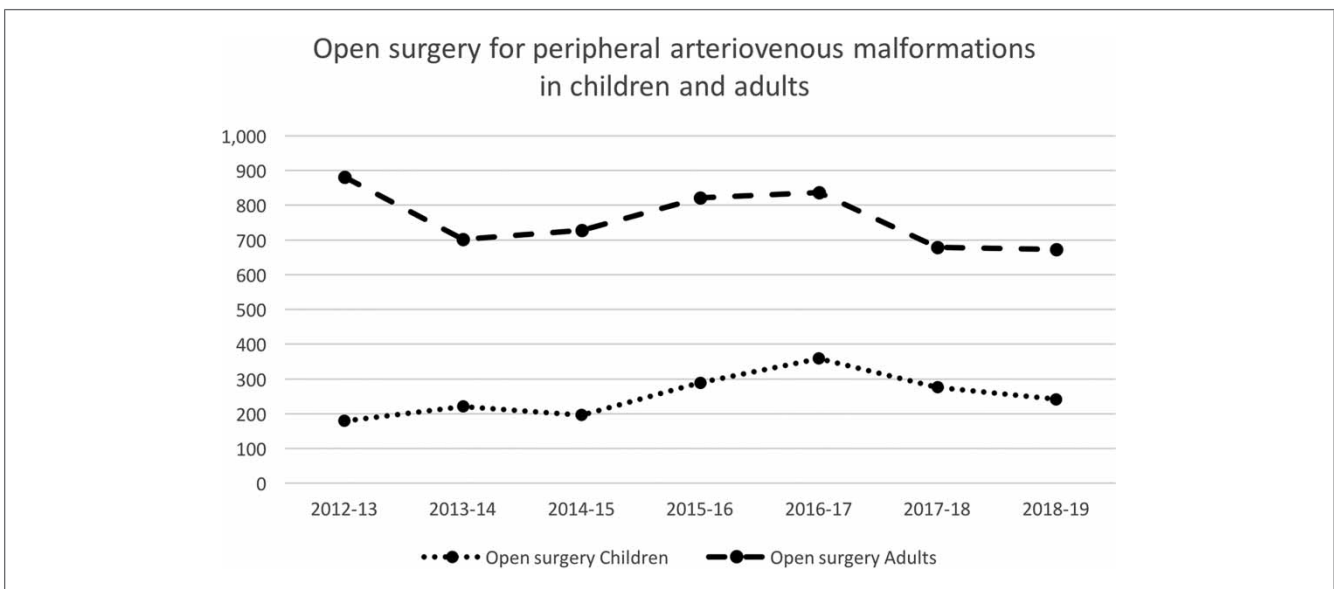
**Figure 1** The total number of admissions per year of children, adults and all ages to NHS hospitals with peripheral arteriovenous malformations (ICD-10 code: Q27.3) as the main diagnosis from 2012 to 2018. ICD-10 = International statistical classification of diseases and related health problems, 10th revision.



**Figure 2** The total number and percentage of admissions per year of all ages to NHS hospitals with the primary procedures and interventions being percutaneous interventions (OPCS-4 codes: L75.3, L75.4, L75.5 and L75.6) and open surgery (OPCS-4 codes: L75.1 and L75.8) for peripheral arteriovenous malformations from 2012 to 2018. OPCS-4 = Office of Population, Censuses and Surveys: Classification of interventions and procedures, 4th Revision.



**Figure 3** The total number of admissions of children and adults per year to the NHS hospitals with the primary procedures and interventions being percutaneous interventions (OPCS-4 codes: L75.3, L75.4, L75.5 and L75.6) for peripheral arteriovenous malformations from 2012 to 2018. OPCS-4 = Office of Population, Censuses and Surveys: Classification of interventions and procedures, 4th Revision.



**Figure 4** The total number of admissions of children and adults per year to the NHS hospitals with the primary procedures and interventions being open surgery (OPCS-4 codes: L75.1 and L75.8) for peripheral arteriovenous malformations from 2012 to 2018. OPCS-4 = Office of Population, Censuses and Surveys: Classification of interventions and procedures, 4th revision.

procedures, there was no obvious trend in the number of open surgical procedures performed as the primary procedure for peripheral AVM, both in children and adults, during this period.

### Discussion

Patients with peripheral AVMs suffer from a variety of symptoms and signs including pain and discomfort,

disfigurement and deformity, swelling, overgrowth of tissues, bleeding, ulceration, organ ischaemia and congestive cardiac failure.<sup>1-3,9,10</sup> Interventional therapies in the form of open surgery, percutaneous procedures, and hybrid treatments are indicated in symptomatic patients.<sup>3,9,10</sup> Open surgery includes excision and debulking of lesions with or without plastic reconstructive procedures, ligation of vessels and amputation.<sup>4,9,10</sup> Meanwhile, percutaneous procedures for peripheral AVM include embolosclectherapy with coils and sclerosants.<sup>5,9,10</sup> Not uncommonly, hybrid interventions of open and percutaneous procedures are also used to treat peripheral AVMs.<sup>5,9,10</sup>

This study found a rising trend in the total number of primary diagnosis of peripheral AVM in the NHS England between 2012 and 2018, particularly in adults. Possible reasons explaining this trend included a real rise in its incidence, advances in the diagnostic skills and technology, increase in doctor, patient and public awareness, elevation in the number of specialist centres and improved accuracy in coding of the diagnosis.

An increasing trend in the percentage of primary procedures and interventions performed for peripheral AVMs being percutaneous procedures was found in this study. This might reflect a shift in preference to the former due to its minimal invasiveness, advances in the percutaneous intervention technologies including imaging, coils and sclerosants, and improved understanding of the pathophysiology of the peripheral AVMs such as targeting its 'nidus'.<sup>5,11</sup> This is not surprising because embolosclectherapy, a percutaneous procedure, has increasingly being regarded as the treatment of choice for most peripheral AVMs in recent literature.<sup>5,11,12</sup> A similar increasing trend in percutaneous embolisation procedures has been reported in a study that reviewed a single institution's 21-year experience of treating brain cavernous malformations, AVMs and aneurysms despite the authors recognising that open surgery, in this case microsurgery, still played important roles.<sup>15</sup>

Not uncommonly, percutaneous therapy might require multiple treatments to achieve desirable outcomes,<sup>5,9-11</sup> thereby increasing the number of these procedures recorded in the HES. Furthermore, many large and/or complex AVMs which were previously not considered amenable to surgery are now offered percutaneous or hybrid procedures to manage symptoms.<sup>5,11</sup> Hybrid procedures combine both percutaneous intervention and open surgery; either in the same sitting or more often, as two interventions a few days apart.<sup>5,11</sup> The percutaneous intervention aims to reduce the blood flow, hence lowering the risk of bleeding for the subsequent open surgery. Since there are no separate OPCS-4 codes for hybrid procedures, we suspect that the hybrid procedures are likely to have been coded as either open surgery, which would be the primary intervention if there was only one hospital episode, or as both percutaneous procedure and open surgery if they were carried out in separate admissions.

Open surgery and percutaneous procedures, as well as hybrids vary in many aspects,<sup>5,11</sup> and require different

expertise, facilities and resources. A multidisciplinary approach is therefore vital for optimal outcome for these patients.<sup>14</sup> However, data on the primary specialist, and the type of centres such as single specialty versus multidisciplinary, or nonspecialist versus specialist carrying out these interventions, are not readily available in the HES database used in this study. The facilities and equipment setup are different; eg percutaneous procedures require catheter laboratory equipped with radiological imaging such as fluoroscopy and ultrasonography, whereas open surgery requires an operating theatre. A hybrid vascular theatre would allow both types of procedures to be carried out simultaneously. Furthermore, these procedures also differ in terms of their hospital length of stay and complication profile. All these factors are important for healthcare costs and resource planning. For example, using data from the National Inpatient Sample, which was a publicly available all-payer inpatient healthcare database designed to produce US regional and national estimates of inpatient utilisation, access, charges, quality and outcomes, Yue and colleagues evaluated the hospital complications and costs specific to spinal AVMs associated with laminectomy (open surgery) and embolisation (percutaneous procedure) in the US from 2002 to 2014; the complications from the former being more costly than the latter.<sup>15</sup> Therefore, understanding the trends of percutaneous procedures and open surgery for peripheral AVMs, as reported in this study, would clearly help healthcare resource planning.

There were several limitations of this study. First, the quality of HES data relies on the accuracy of the coding and reporting processes in the NHS organisations involved. There are processes in place to clean and validate the data provided to HES, and quality reports checks, as detailed on the NHS Digital website.<sup>6-8</sup> Procedures undertaken in the independent sector, not funded by the NHS, would not have been captured although the numbers for these were likely to be relatively small. Second, the diagnosis and procedure classification codes available and used in HES, ie, ICD-10 and OPCS-4, respectively, are often too nonspecific and overlap with one another.<sup>6-8</sup> It is very likely that many peripheral low-flow vascular malformations such as venous and lymphatic malformations, and vascular tumours would have been coded as AVMs in the HES, both in terms of diagnosis and procedures, since both terms are often inaccurately used interchangeably. Furthermore, there might also be overlap between central and peripheral AVMs, particularly in the codes used in OPCS-4. Finally, patients who were diagnosed and managed conservatively as outpatients without needing admission and/or intervention were likely not to be coded in the HES hospital admission main diagnosis data used in this study, leading to an underestimation of the numbers. Finally, some clinically useful information that might help improve our understanding of the trends of open surgery and percutaneous intervention which included baseline data of the patients such as comorbidities, and the size, type and anatomical location of the AVMs, the number of 'episodes' or procedures

performed per patient over a period of time, and type of anaesthesia used were not readily and freely available in the HES public domain. Despite these limitations, understanding the trends in the diagnosis and procedural treatment for peripheral AVMs using HES is important and useful since this data source is often used by the NHS, government and many other organisations for future healthcare analyses and planning including for resources. These limitations also highlight the need for more precise and specific diagnostic and procedure codes for peripheral AVMs than those used in HES to reflect changes in our current practice. Moreover, a national registry is clearly needed to analyse, improve and standardise the care of patients with peripheral AVMs.

## Conclusion

This study concluded that open surgery remained the most commonly performed primary procedure and intervention for peripheral AVMs although there was an increasing trend towards percutaneous procedures in NHS hospitals in England during the study period. The increase in the number and percentage of percutaneous procedures for peripheral AVMs was likely to have significant implications for the provision of care and resources for patients with peripheral AVMs in the NHS. Therefore, further studies are needed to assess the clinical outcomes and cost-effectiveness of these procedures. In addition, more precise and specific diagnostic and procedure codes for peripheral AVMs than those used by the HES are needed to reflect the current practice.

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