ORIGINAL ARTICLE

Surgical versus endovascular intervention for vascular access thrombosis: a nationwide observational cohort study

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GRAPHICAL ABSTRACT

Surgical versus endovascular intervention for vascular access thrombosis: a nationwide observational cohort study

Background

There is no consensus whether arteriovenous (AV) access thrombosis in hemodialysis patients is best treated by surgical or endovascular intervention

Methods
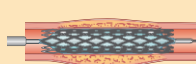
Swedish Renal Access registry, 2008–2020

AV access thrombosis, n = 904

Risk for access abandonment

AVF and AVG

Results

Access abandonment	Endovascular OR (95%CI)	Surgical intervention OR (95%CI)
30 days	1 (ref)	1.63 (1.11–2.33)
90 days	1 (ref)	1.44 (1.05–1.97)
1 year	1 (ref)	1.25 (0.94–1.66)

Adjusted odds ratio

No significant difference in time to next intervention or between subgroups

Conclusion

Endovascular intervention is associated with consistent short- and long-term access benefit in hemodialysis patients with AV access thrombosis.

NEPHROLOGY DIALYSIS TRANSPLANTATION

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KEY LEARNING POINTS

What is already known about this subject?

- In patients on haemodialysis, arteriovenous access thrombosis is a common complication.
- Surgical or endovascular intervention is used to declot the access and treat the underlying lesion, often a stenosis.
- While guidelines stress the importance of early thrombus removal, they offer no preference for the choice of intervention.

What this study adds?

- Our results demonstrate a consistent favour of endovascular intervention with a small, short- and long-term access benefit in all subgroups, which summarizes the results from previous more heterogenic studies.

What impact this may have on practice or policy?

- The availability of experienced radiologists at the local hospital level is important to optimize the care of vascular access thrombosis in patients on haemodialysis.

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ABSTRACT

Background. There is no consensus whether an arteriovenous (AV) access thrombosis is best treated by surgical or endovascular intervention. We compared the influence of surgical versus endovascular intervention for AV access thrombosis on access survival using real-life data from a national access registry.

Methods. We included patients from the Swedish Renal Access Registry (SRR-Access) with a working AV access undergoing surgical or endovascular intervention for their first thrombosis between 2008 and 2020. The primary outcome was the risk of access abandonment (secondary patency at 30, 60, 90 and 365 days). Secondary outcomes were time to next intervention and 30-day mortality. Access characteristics were obtained from the SRR-Access and patient characteristics were collected from the Swedish Renal Registry. Outcomes were assessed with multivariable logistic regression and Cox proportional hazards regression models adjusted for demographics, clinical and access-related variables.

Results. A total of 904 patients with AV access thrombosis (54% arteriovenous fistula, 35% upper arm access) were included, with a mean age of 62 years, 60% were women, 75% had hypertension and 33% had diabetes. Secondary patency was superior after endovascular intervention versus surgical (85% versus 77% at 30 days and 76% versus 69% at 90 days). The adjusted odds of access abandonment within 90 days and 1 year were higher in the surgical thrombectomy group {odds ratio (OR) 1.44 [95% confidence interval (CI) 1.05–1.97] and OR 1.25 (0.94–1.66), respectively}. Results were consistent in the long-term analysis. There was no significant difference in time to next intervention or mortality, and results were consistent within subgroups.

Conclusions. Endovascular intervention was associated with a small short- and long-term benefit as compared with open surgery in haemodialysis patients with AV access thrombosis.

Keywords: arteriovenous fistula, chronic haemodialysis, endovascular, thrombosis, vascular access

INTRODUCTION

The arteriovenous (AV) access is the lifeline of the haemodialysis (HD) patient. Long-term AV access patency depends on many factors, including access site and type, sex, age, diabetes, surgical skills and surveillance [1]. Complications are common, most frequently related to the development of stenoses and subsequent thromboses, where late thrombosis is the most common cause of AV access failure and abandonment [2, 3]. In addition, AV access thrombosis is also strongly associated with increased mortality [4].

The two different approaches to treat AV access thrombosis are surgical or endovascular intervention. Surgical thrombectomy procedures generally demand additional procedures such as revision of the anastomosis, patch plasty or interposition grafts. There are various endovascular techniques, including pharmacological or mechanical thrombolysis and adjunct procedures with different types of angioplasty balloons and stents. In principle, both surgical and endovascular interventions aim to declot the access and treat the underlying problem, most often a stenosis [2, 3]. The overall goal is to avoid the need for a central venous catheter for the next dialysis session and ultimately to increase the long-term patency of the access.

There is little recent evidence on which of the above-mentioned methods is preferred for treating AV access thrombosis, although technical advancements in interventional radiology have made endovascular procedures more favourable [2]. Randomized controlled trials are limited, only performed in AV grafts and published years before endovascular techniques expanded. Local preference and ability to perform the procedures, rather than clinical evidence, guide decision-making. Indeed, guidelines recommend the choice of AV access thrombosis intervention to be decided by local expertise based on assessment of the patient and the AV access [5, 6]. Whereas guidelines stress the importance of early thrombus removal in arteriovenous fistulas (AVFs) and treatment of the underlying lesion, they offer no preference for surgical or endovascular intervention with regard to AV grafts (AVGs) or AVFs.

MATERIALS AND METHODS

Study population

Data were obtained from the Swedish Renal Access Registry (SRR-Access) and the Swedish Renal Registry (SRR). The SRR-Access includes information on vascular access creation, type

of access, complications and revision procedures. The SRR-Access started as a regional access registry in 2005, expanded to the national level in 2011 and was recently validated in a separate study [7]. The SRR is an ongoing national renal registry of nephrology-referred patients with chronic kidney disease (CKD) in Sweden [8, 9]. The data from the SRR-Access are interlinked with the SRR for information on the start of dialysis and transplantation. In this study we included prevalent patients on HD with a working AV access experiencing a vascular access thrombosis registered between 1 January 2008 and 20 April 2020. Registration of the events was made by dialysis nurses based on information provided by the access surgeon. Patients were informed and consented to participation in the registry. No additional individual consent is required for specific research projects. The study was approved by the ethical review board in Stockholm.

Exposure

We categorized exposure into either surgical or endovascular access intervention at the time of the first registered thrombotic event based on available information in the SRR-Access. Surgical access interventions were classified into thrombectomy (thrombectomy, thrombectomy + anastomosis revision or thrombectomy + patch plasty), hybrid/other [thrombectomy + intraoperative percutaneous transluminal angioplasty (PTA), thrombectomy + local thrombolysis or reported hybrid intervention] and other surgical interventions (ligation of venous side branches, flow-reducing intervention, patch plasty with vein or synthetic patch, interposition graft, interposition vein, transposition, vein patch, other anastomosis revision or anastomosis revision + ligation of venous side branches). We also identified whether the surgical intervention included any type of anastomosis revision in order to be able to study this adjunct procedure separately.

All types of endovascular procedures for AV access thrombosis were included. The different percutaneous endovascular interventions were mechanical or pharmacological thrombolysis with adjunct procedures [angioplasty with plain balloon, cutting balloon, drug-eluting balloon (DEB), stent, stent graft, drug-eluting stent (DES) and coiling of venous side branches].

Outcomes

The primary outcome was secondary patency after AV access declotting at 30, 60 and 90 days, 1 year and within 5 years. Secondary outcomes were primary patency and 30-day mortality after AV access declotting. Definitions of primary and secondary patency were according to the recommendations from the Society for Vascular Surgery [10]. Primary patency was defined as the time from intervention to the following intervention, and secondary patency was defined as the time to access abandonment, defined as the permanent cessation of using the access for dialysis [10].

Covariates

Patient characteristics (age, sex, primary kidney disease and comorbidity) and start date of first dialysis were collected from the SRR. Information regarding the type of AV access

was obtained from the SRR-Access. AV access types were categorized into arteriovenous graft (AVG) or AVF and further divided into upper arm (brachial-basilic AVF transpositioned in one or two stages, brachiocephalic AVF, AVG from axillary or brachial artery), forearm (radiocephalic AVF, ulnar AVF and AVG from radial artery) or other (atypical, not regular access solutions). Data were obtained regarding the number of previous interventions before the thrombosis occurred (any type of intervention, including surgical interventions such as anastomosis revisions or endovascular procedures to treat significant stenosis). The time from first cannulation to first thrombosis was calculated and categorized into quartiles. If the date of first cannulation was missing, it was replaced by the date of dialysis initiation.

Statistical analysis

Patient characteristics were described using means/medians for continuous variables according to their underlying distribution and proportions for categorical variables for each type of intervention for AV access thrombosis. The proportions of patients with a functional access and intervention-free survival at 0, 30, 60, 90 and 365 days post-intervention were computed. Logistic regression models adjusting for patient characteristics and access type were used to assess short-term primary and secondary patency at the predefined time intervals and 30-day mortality. Kaplan–Meier curves were produced for post-intervention secondary access patency until a maximum of 5 years, comparing patients with endovascular intervention with those with surgical intervention (both overall, for thrombectomy and hybrid interventions separately) using log-rank statistics. Primary and secondary patency were then assessed with Cox proportional hazards regression models adjusted for demographic, clinical and access-related variables. The unadjusted model included the time from intervention to access abandonment. We applied censoring at kidney transplantation or death, whichever came first. Model 1 is adjusted for age categories and sex. Model 2 additionally included diabetes, ischaemic heart disease and peripheral arterial disease. Model 3 additionally included time from first cannulation to thrombosis, number of interventions before thrombosis, access type and upper/forearm placement. As a next step, we stratified by age (<55, 55–65, 65–75 and >75 years), sex, type of AV access and comorbidity (diabetes, ischaemic heart disease, cerebral vascular or peripheral vascular disease, hypertension or malignancies).

To test the robustness of our findings we performed several sensitivity analyses. First, we excluded individuals who had performed any type of anastomosis revision at the same time as the thrombectomy. Second, we stratified by prevalent and incident dialysis patients after 2008, excluded those where the date of first cannulation was missing and additionally performed analyses stratifying on the year of first cannulation/dialysis initiation. Last, we used the Fine and Gray models to account for the competing risk of death. Missingness for any of the included variables was very low (<10 individuals) and analyses were thus performed on complete cases. All analyses were performed using Stata 15 (StataCorp, College Station, TX, USA).
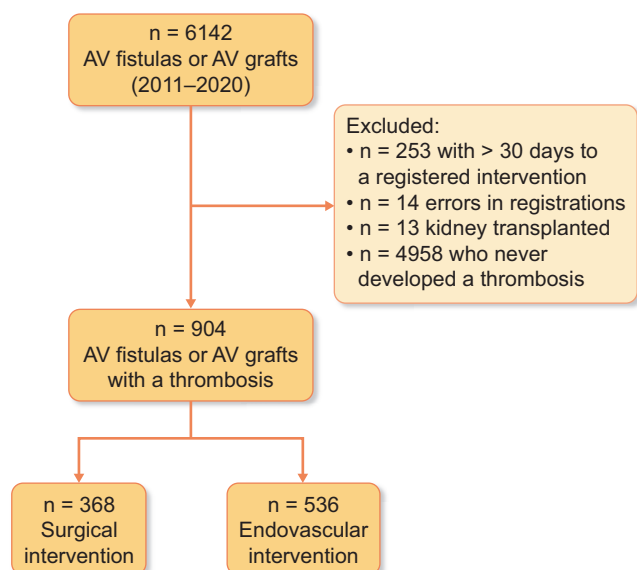
FIGURE 1: Study flow chart.

RESULTS

Of 6142 patients on HD with an AV access and registered in the SRR-Access, we included 904 patients who developed a vascular access thrombosis (Fig. 1). Of these patients, 368 (41%) underwent an endovascular intervention while 536 (59%) had an open surgical intervention (Table 1).

The median age was 65 years at the time of thrombosis and 60% were women. The endovascular intervention group had a history of more cardiovascular diseases (peripheral arterial, ischaemic heart or cerebrovascular disease) and diabetes mellitus, while malignancies and hypertension were more prevalent in the surgical intervention group. Diabetic nephropathy was the most common primary renal disease in both groups. Patients treated with an endovascular procedure had more AVFs (60% versus 49%) and more often an upper arm access (39% versus 32%).

In the group undergoing endovascular intervention, 41 (11%) had a stent inserted, 51 (14%) were treated with a cutting balloon, 12 (3%) were treated with DEB and in 3 patients (1%) venous side branches were coiled. Notably, despite being registered as a thrombosed access, information was missing if thrombolysis of the access was performed in 61% of the patients undergoing endovascular treatment. In patients treated with surgical intervention, 310 (58%) underwent surgical thrombectomy, 61 (11%) had anastomosis revision, 167 (31%) received hybrid interventions, 5 (1%) had a stent inserted, 9 (2%) were treated with a cutting balloon, 9 (2%) received thrombolysis and 1 (0.2%) was treated with DEB. In 59 (11%) of the patients undergoing surgical treatment for the thrombosed access, the thrombectomy method was not specified.

The median time from access creation to first thrombosis was 433 days [interquartile range (IQR) 169–1008] for the endovascular group compared with 448 days (IQR 178–1053) for the surgical group. The median time from first cannulation to access thrombosis was 63 days (IQR 18–159) for the endovascular group and 64 days (IQR 21–174) for the surgical group. The mean number of interventions before the thrombosis event was 2.3 [standard deviation (SD) 3.4] for the endovascular group and 2.1 (SD 3.4) for the surgical group. The median duration until the intervention was performed was <24 h in both the endovascular and the surgical group (IQR 0–1 day for both groups).

Short-term patency

There was no difference in the immediate success rate (time to abandonment <24 h) between surgical and endovascular intervention (91% for endovascular and 90% for surgical). The AV access secondary patency was consistently higher in patients treated with endovascular intervention versus surgical intervention over time: endovascular 85% versus surgical 77% (30 days), 80% versus 73% (60 days), 76% versus 69% (90 days) and 55% versus 50% (1 year) (Table 2). The overall intervention-free primary patency at 1 year was only 144 patients (16%). This primary intervention-free patency favoured endovascular procedures at 30 and 60 days but was similar at 90 days and 1 year. Compared with the endovascular group, the surgical intervention group showed a higher risk of access abandonment within the first 90 days {odds ratio [OR] 1.63 [95% confidence interval (CI) 1.11–2.33] at 30 days and OR 1.44 [95% CI 1.05–1.97] at 90 days}. There was no difference in primary intervention-free patency between the two types of intervention procedures (Table 2). When further categorizing the patients into those who underwent a surgical procedure with thrombectomy or hybrid procedures, we observed lower secondary patency for the surgical thrombectomy only compared with hybrid procedures (Supplementary data, Table S1). The adjusted OR for access abandonment within 30 days was 2.04 (95% CI 1.38–3.04) for surgical thrombectomy and 1.34 (0.82–2.17) for hybrid procedures (Supplementary data, Table S2) as compared with endovascular procedures. There was no statistically significant difference in primary patency during the first year for any of the procedures.

Long-term patency

The median follow-up time was 1.1 years (IQR 0.2–2.9). Patients with an AVF, forearm access, younger age and fewer previous interventions all had a longer time to access abandonment after their first thrombosis. As with the short-term analysis, the secondary patency within 5 years was superior if the thrombosis was treated by endovascular intervention (Fig. 2). In the fully adjusted Cox regression model, the hazard ratio (HR) was 1.20 (95% CI 1.01–1.42) for surgical versus endovascular intervention (Table 3). There was no significant difference in primary patency if the surgical procedure was categorized into a surgical thrombectomy only or a hybrid procedure (Table 3, Supplementary data, Figure S1).

Table 1. Baseline characteristics overall and by undertaken procedures

Characteristics	Endovascular (n = 368)	Surgical (n = 536)	Overall (N = 904)
Sex (female), n (%)	224 (60.9)	321 (59.9)	545 (60.3)
Age (years), mean (IQR)	64.8 (52.2–74.0)	64.8 (52.5–73.7)	64.8 (52.3–73.7)
<55	108 (29.4)	162 (30.2)	270 (29.9)
55–64	78 (21.2)	109 (20.3)	187 (20.7)
65–74	96 (26.1)	151 (28.2)	247 (27.3)
>75	86 (23.4)	114 (21.3)	200 (22.1)
Primary renal diagnosis, n (%)			
Diabetic nephropathy	106 (28.8)	122 (22.8)	228 (25.2)
Other specified diseases	76 (20.7)	125 (23.3)	201 (22.2)
Glomerulonephritis	67 (18.2)	72 (13.4)	139 (15.4)
Hypertension	42 (11.4)	76 (14.2)	118 (13.1)
Adult polycystic kidney disease	27 (7.34)	61 (11.3)	88 (9.7)
Pyelonephritis	19 (5.2)	27 (5.0)	46 (5.1)
Unknown	31 (8.4)	53 (9.9)	84 (9.3)
Comorbidity, n (%)			
Diabetes	127 (34.6)	170 (31.7)	297 (32.9)
Ischaemic heart disease	73 (19.9)	85 (15.9)	158 (17.5)
Cerebrovascular disease	33 (9.0)	36 (6.7)	69 (7.6)
Peripheral vascular disease	30 (8.2)	35 (6.5)	65 (7.2)
Hypertension	264 (71.9)	413 (77.1)	677 (75.0)
Malignancy	34 (9.2)	68 (12.7)	102 (11.3)
Access type and location, n (%)			
Fistula	221 (60.4)	258 (48.8)	479 (53.6)
Graft	145 (39.6)	271 (51.2)	416 (46.5)
Upper arm	143 (39.1)	168 (31.8)	311 (34.8)
Forearm	214 (58.5)	339 (64.1)	553 (61.8)
Other location	9 (2.5)	22 (4.2)	31 (3.5)
Type of intervention, n (%)			
Surgical thrombectomy	n/a	310 (57.8)	310 (57.8)
Hybrid interventions	n/a	167 (31.2)	167 (31.2)
Unknown method of thrombectomy	223 (60.6)	59 (11.0)	282 (31.2)
Anastomosis revision	n/a	61 (11.4)	61 (11.4)
Any stent	41 (11.1)	5 (0.9)	46 (5.1)
Cutting balloon	51 (13.9)	9 (1.7)	60 (6.6)
Thrombolysis registered	145 (39.4)	9 (1.7)	154 (17.0)
Drug eluting balloon	12 (3.3)	1 (0.2)	13 (1.4)
Coiling of venous side branches	3 (0.8)	0	3 (0.3)
First cannulation year, n (%)			
<2011	74 (20.1)	113 (21.1)	187 (20.7)
2011–12	79 (21.5)	114 (21.3)	193 (21.4)
2013–14	49 (13.3)	93 (17.4)	142 (15.7)
2015–17	55 (15.0)	94 (17.5)	149 (16.5)
>2017	111 (30.2)	122 (22.8)	233 (25.8)
Access age at thrombosis (days), mean (IQR)	433 (169–1008)	448 (178–1053)	442 (174–1039)

n/a, not applicable.

Subanalyses and sensitivity analyses

The results were consistent between most of the predefined subgroups. There was no significant interaction with sex, time on dialysis before thrombosis, comorbidity (diabetes, ischaemic heart or peripheral artery disease) or type of access (AVG or AVF) (Fig. 3).

However, there was a significant interaction with access location overall; endovascular procedures were favoured in fore and upper arm AV accesses, while interventions in other AV access locations favoured surgery. However, the total number of accesses in the upper arm and other locations was smaller, which made the confidence interval wider, crossing 1 and therefore not statistically significant for those two groups. We did not observe an interaction for the year of intervention or year of first cannulation, but in the most recent accesses and interventions (first cannulation >2017, intervention

2018–20), the results favoured endovascular intervention more strongly and were statistically significant (Supplementary data, Table S3). In the sensitivity analyses of time to access abandonment, including a restricted analysis of those with a verified declotting method, the results pointed in the same direction (favouring endovascular procedures), although the difference in some of the analyses decreased, the confidence interval widened and they were no longer statistically significant (Supplementary data, Table S3 and Figure S2).

DISCUSSION

In this contemporary, large, nationwide study of patients on HD experiencing AV access thrombosis, endovascular interventions were associated with better short- and long-term post-intervention secondary patency as

U.H. Lundström *et al.*

Table 2. Short-term AV access patency after surgical versus endovascular intervention (reference category) for AV access thrombosis

Patency	Endovascular, n (%)	Surgical, n (%)	Adjusted OR[a] (95% CI)
Access patency			
1 day	334 (90.8)	483 (90.1)	1.12 (0.71–1.78)
30 days	311 (84.5)	415 (77.4)	1.63 (1.11–2.33)
60 days	293 (79.6)	393 (73.3)	1.44 (1.04–1.99)
90 days	281 (76.4)	372 (69.4)	1.44 (1.05–1.97)
1 year	203 (55.2)	269 (50.2)	1.25 (0.94–1.66)
Intervention-free patency			
30 days	228 (62.0)	308 (57.5)	1.20 (0.91–1.58)
60 days	184 (50.0)	254 (47.4)	1.10 (0.84–1.44)
90 days	152 (41.3)	221 (41.2)	0.99 (0.75–1.31)
1 year	60 (16.3)	84 (15.8)	1.08 (0.74–1.58)

[a]Adjusted for age, sex, diabetes, peripheral arterial disease, previous myocardial infarction, fistula or graft, upper/lower arm, time to first thrombosis and number of previous interventions.
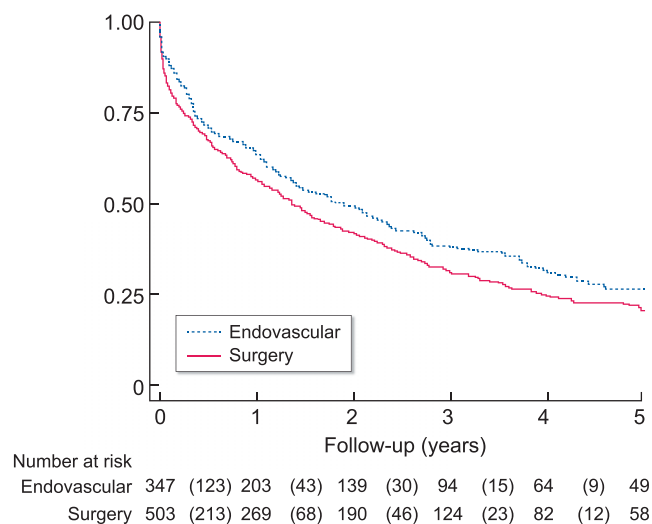
FIGURE 2: Time to access abandonment after an AV access thrombosis treated with surgery or endovascular intervention.

Table 3. Risk of long-term dialysis access closure following surgical thrombectomy compared with endovascular intervention (reference category) after access thrombosis

Model	HR (95% CI) for surgical intervention	P-value
Unadjusted	1.21 (1.03–1.44)	0.02
Model 1[a]	1.22 (1.03–1.44)	0.02
Model 2[b]	1.22 (1.04–1.45)	0.02
Model 3[c]	1.20 (1.01–1.42)	0.04

[a]Model 1: adjusted for age categories and sex.
[b]Model 2: adjusted for Model 1 + diabetes, ischaemic heart disease and peripheral arterial disease.
[c]Model 3: adjusted for Model 2 + time from first cannulation to thrombosis, number of interventions before thrombosis, access type and upper/lower arm.

compared with surgical thrombectomy. In contrast, primary patency between the two groups was similar. Our results were consistent through predefined strata, including both AVGs and AVFs. Although the absolute difference in results (7% difference in access abandonment after 3 months, 5% after 1 year) was rather small, they support the increased use of endovascular techniques as a complement to surgical interventions and further stress the importance of making endovascular procedures and skills more available.

We are not aware of previous studies evaluating this research question in routine care settings and regard our results as novel. This is a registry-based study on a real-life cohort, including both AVGs and AVFs, undergoing contemporary endovascular interventions. Although previous studies are heterogeneous in the way they define endovascular procedures [11], both immediate and long-term success rates have been observed to improve over time [12]. The technical advances in endovascular procedures in recent years, allowing both visualization and treatment of the underlying lesion, may have resulted in better outcomes as compared with older techniques [2, 13].

There is scarce evidence from interventional studies to guide the decision of surgical or endovascular intervention in patients with AV access thrombosis. Guidelines stress the importance of early thrombus removal in AVFs and treatment of the underlying lesion, and immediate treatment (<6 h) has been associated with improved outcomes both for AVGs and AVFs [14]. However, they offer no preference for surgical or endovascular intervention with regard to AVGs or AVFs [6]. In the recently published European Renal Best Practice guidelines, only one randomized controlled study fulfilled the inclusion criteria [15]: Uflacker et al. [5] conducted this study in 1994–97, randomizing 174 patients with thrombosed AVGs to conventional surgical thrombectomy or endovascular procedure with mechanical thrombolysis, and reported no difference in immediate success rate [15]. The first meta-analysis from 2002 on thrombosed AVGs included seven randomized studies and 479 patients and concluded that surgical thrombectomy with revision was superior to endovascular procedures, including mechanical or pharmaco-mechanical thrombolysis [11]. A systematic review of observational and randomized studies noted similar outcomes for pharmaco-mechanical thrombolysis to surgical thrombectomy in AVGs, with comparable short-term success rates for endovascular intervention to surgical revision of the underlying lesion [16]. Two later meta-analyses on AVGs also yielded similar results comparing the two modalities, although surgical intervention was associated with superior long-term results [17, 18]. Most of the previous observational studies comparing surgical with endovascular interventions were single-centre retrospective cohort studies with divergent results [19, 20]. Thus older trials suggest surgery is superior in AVGs, while newer studies
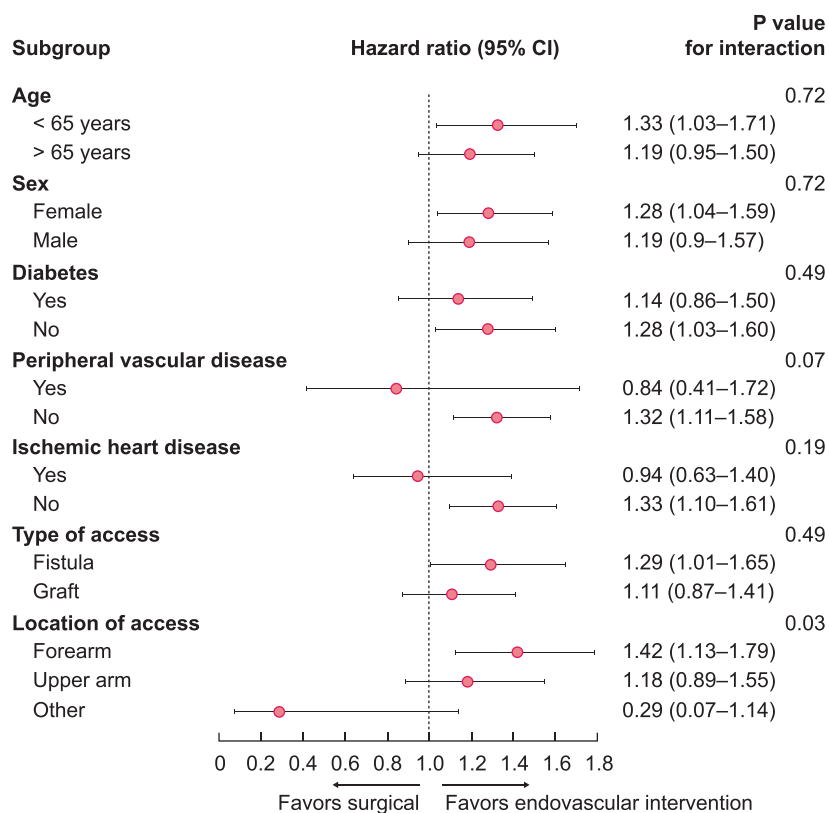
Subgroup	Hazard ratio (95% CI)	P value for interaction
Age		0.72
< 65 years		1.33 (1.03–1.71)
> 65 years		1.19 (0.95–1.50)
Sex		0.72
Female		1.28 (1.04–1.59)
Male		1.19 (0.9–1.57)
Diabetes		0.49
Yes		1.14 (0.86–1.50)
No		1.28 (1.03–1.60)
Peripheral vascular disease		0.07
Yes		0.84 (0.41–1.72)
No		1.32 (1.11–1.58)
Ischemic heart disease		0.19
Yes		0.94 (0.63–1.40)
No		1.33 (1.10–1.61)
Type of access		0.49
Fistula		1.29 (1.01–1.65)
Graft		1.11 (0.87–1.41)
Location of access		0.03
Forearm		1.42 (1.13–1.79)
Upper arm		1.18 (0.89–1.55)
Other		0.29 (0.07–1.14)

0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8

← Favors surgical   Favors endovascular intervention →

FIGURE 3: Risk for access abandonment in subgroups. Model adjusted for age, sex, diabetes, peripheral arterial disease, myocardial infarction, fistula or graft, upper/lower arm, time to first thrombosis and number of previous interventions.

indicate improved endovascular outcomes [18]. To conclude, our study demonstrates a consistent favour of endovascular intervention in all subgroups and our ability to compare results from different subgroups head to head summarizes the results from previous more heterogenic studies.

Ideally an AV access thrombosis should be treated immediately with a rapid, effective and safe intervention that salvages the access for continued dialysis. A favourable immediate success rate further minimizes the risk and morbidity from multiple procedures [11]. In a recent study on surgical thrombectomy, the immediate success rate, defined as patients able to use the access for dialysis right after the procedure, was 70%, in contrast with the immediate success rate of 90% following open surgical intervention in our study. Another important consideration is safety. Surgery could, apart from the surgical trauma, involve general anesthesia, which might be associated with adverse events, and the bleeding risk could also differ between the two interventions. In our study we had no information on bleeding events, but we observed no difference in the 30-day mortality between the two treatment options. Our findings also suggest that younger patients, AVF (versus AVG) and forearm access (versus other locations) were associated with superior access survival, regardless of the treatment method of the thrombosis. This contrasts with a previous small study where upper arm AVF was associated with superior 1-year secondary patency. However,

94% of their forearm AVFs did not undergo anastomotic revision [21].

The results of our study were thus consistently in favour of endovascular interventions regardless of whether patients treated with surgical thrombectomy underwent simultaneous revision of the anastomosis or other hybrid interventions. The difference in time to access abandonment between the procedures diminished in those who underwent hybrid interventions adjunct to the surgery, which may indicate that surgery could be complimented with endovascular interventions to improve patency. It has been argued that studies with superior outcomes from open surgical interventions tend to include more complete revisional access surgery than salvage or rescue procedures of the vascular access, which reduces comparability [2]. A large Japanese study on 879 interventions for thrombosed AV accesses, both AVGs and AVFs, compared three groups: endovascular intervention or surgical thrombectomy, followed by either surgical revision of the access or balloon angioplasty (in our study, equivalent to 'hybrid intervention'). Similar to our results, they found comparable patencies for endovascular and surgical intervention followed by balloon angioplasty [22]. A British study of 155 thrombosed AV accesses in the same three groups found better success rates for endovascular interventions, yet surgical revision had superior intervention-free survival and less need for additional

procedures to remain patent [23]. Another Swedish regional study of 131 patients showed better results for endovascular catheter-directed thrombolysis compared with open surgical thrombectomy. Whereas catheter-directed thrombolysis yielded more adjunct procedures, open thrombectomy had an increased risk of rethrombosis or other access-related events [24].

Our study has several strengths. It is a representative Swedish sample of well-characterized patients undergoing routine nephrologist care with prospective recruitment to the registry and detailed characterization of dialysis access, both AVGs and AVFs. Compared with previous studies, which tend to be single-centre data collections with few participants, our study allowed for subgroup analyses on access type, location and different interventions. We have no loss to follow-up and longer observation times as compared with previous studies. Since centres may differ in experience and preference of the procedures, our results from a whole national dialysis population improve comparability. Our study also includes more contemporary procedures, acknowledging that endovascular methods have improved over time [12]. In this regard, although we could not find a significant interaction with the year of intervention, we specifically noted improved patencies following endovascular procedures in patients in our study initiating HD after 2016 (Supplementary data, Table S3). We were able to adjust for confounders such as age, sex, diabetes, peripheral arterial disease, myocardial infarction, AVG or AVF, upper or forearm and time to first thrombosis together with the number of previous interventions, all of which have been less often accounted for in earlier studies.

Like all observational studies, our study also has limitations. We do not have information on bleeding complications in relation to specific interventions and the use of certain medications, such as platelet inhibitors. We lack information on the underlying causes concerning why endovascular or surgical intervention was chosen, although we believe factors related to local routines may have contributed. While the treatment decision is often made by the access surgeon in collaboration with the nephrologist, the availability of access surgeons or experienced interventional radiologists may differ at the local hospital level. However, we do not believe there were systematic differences in skills between those performing surgery or endovascular procedures, and since clinics likely would chose the technique they were most experienced with, this would diminish any difference observed between the groups. Nevertheless, in order to account for possible selection bias, we adjusted for several confounders that may have contributed to the choice of treatment, such as previous interventions, age, sex and type of access. We missed data on whether mechanical or pharmacological thrombolysis were used in the accesses undergoing endovascular intervention, and in as many as 60% of the endovascular procedures, information regarding the declotting method was missing. Although all the patients were registered as access thrombosis, it is not compulsory to register thrombectomy or thrombolysis in the SRR-Access, which may have led to some misclassification. One concern is that inequality in registration rates across the country would affect its use in clinical studies. However, a recent study assessing the

external and internal validation showed a 95% match between the registry and medical records in the SRR-Access [7].

In summary, in this nationwide, observational study, we found that endovascular interventions were associated with a small benefit in access survival compared with open surgery in HD patients with AV access thrombosis. However, a well-designed and powered randomized controlled trial in both AVGs and AVFs is needed in order to safely guide clinical decisions.

SUPPLEMENTARY DATA

Supplementary data are available at *ndt* online.

AUTHORS' CONTRIBUTIONS

All authors have made substantial contributions to the conception, design, interpretation of data and results, critical revision of the manuscript and intellectual content. U.H.L. and M.E. were responsible for the acquisition of data, statistical analysis and drafting the manuscript. All authors gave final approval of the version to be published and agreed to take responsibility for the content.

CONFLICT OF INTEREST STATEMENT

Outside the submitted work, U.H.L. reports speaker and consultancy engagements from Baxter Healthcare. M.E. reports speaker engagements from Astellas Pharma, AstraZeneca, Vifor Pharma and Fresenius; advisory board engagements from Astellas Pharma, AstraZeneca and Vifor Pharma and receipt of institutional grants outside of this study from Astellas Pharma and AstraZeneca. G.W. reports speaker engagements from WL Gore. U.H. reports speaker engagements from WL Gore. J.J.C. reports speaker engagements from AstraZeneca, Vifor Pharma, Fresenius, Kabi, Baxter Healthcare and Abbott; advisory board engagements from AstraZeneca, Baxter Healthcare and Bayer and receipt of institutional grants outside of this study from Astellas, Vifor Pharma, MSD and AstraZeneca. The results presented in this article have not been previously published in whole or part, except in abstract format.

DATA AVAILABILITY STATEMENT

The data in this article cannot be shared on a public repository due to privacy reasons. Data can be made available upon reasonable request to the main author after ethical review permission or through application to the SRR (www.snronline.se).

REFERENCES

1. Huijbregts HJ, Bots ML, Wittens CH *et al.* Hemodialysis arteriovenous fistula patency revisited: results of a prospective, multicenter initiative. *Clin J Am Soc Nephrol* 2008; 3: 714–719

2. Inston N, Al Shakarchi J, Khawaja A *et al.* Maintaining patency of vascular access for haemodialysis. *Cardiovasc Eng Technol* 2017; 8: 240–243

3. Pirozzi N, Garcia-Medina J, Hanoy M. Stenosis complicating vascular access for hemodialysis: indications for treatment. *J Vasc Access* 2014; 15: 76–82

4. Girerd S, Girerd N, Boffa JJ *et al.* Arteriovenous fistula thrombosis is associated with increased all-cause and cardiovascular mortality in haemodialysis patients from the AURORA trial. *Clin Kidney J* 2020; 13: 116–122

5. Gallieni M, Hollenbeck M, Inston N *et al.* Clinical practice guideline on peri- and postoperative care of arteriovenous fistulas and grafts for haemodialysis in adults. *Nephrol Dial Transplant* 2019; 34 (Suppl 2): ii1–ii42

6. Schmidli J, Widmer MK, Basile C *et al.* Editor's choice – Vascular Access: 2018 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2018; 55: 757–818

7. Welander G, Sigvant B. Validating vascular access data in the Swedish Renal Registry SRR. *J Vasc Access* 2020; 22: 629–634

8. Swartling O, Rydell H, Stendahl M *et al.* CKD progression and mortality among men and women: a nationwide study in Sweden. *Am J Kidney Dis* 2021; 78: 190–199

9. https://www.medscinet.net/snr/rapporterdocs/SNR_arsrapport%202021_webversion.pdf. (10 September 2021, date last accessed)

10. Sidawy AN, Gray R, Besarab A *et al.* Recommended standards for reports dealing with arteriovenous hemodialysis accesses. *J Vasc Surg*, 2002; 35: 603–610

11. Green LD, Lee DS, Kucey DS. A metaanalysis comparing surgical thrombectomy, mechanical thrombectomy, and pharmacomechanical thrombolysis for thrombosed dialysis grafts. *J Vasc Surg* 2002; 36: 939–945

12. Kitrou PM, Katsanos K, Papadimatos P *et al.* A survival guide for endovascular declotting in dialysis access: procedures, devices, and a statistical analysis of 3,000 cases. *Expert Rev Med Devices*, 2018; 15: 283–291

13. Kitrou P, Papasotiriou M, Katsanos K *et al.* Recent developments in endovascular interventions to sustain vascular access patency in haemodialysis patients. *Nephrol Dial Transplant* 2019; 34: 1994–2001

14. Sadaghianloo N, Jean-Baptiste E, Gaid H *et al.* Early surgical thrombectomy improves salvage of thrombosed vascular accesses. *J Vasc Surg* 2014; 59: 1377–1384.e2

15. Uflacker R, Rajagopalan PR, Selby JB *et al.* Thrombosed dialysis access grafts: randomized comparison of the Amplatz thrombectomy device and surgical thromboembolectomy. *Eur Radiol* 2004; 14: 2009–14

16. Tordoir JH, Bode AS, Peppelenbosch N *et al.* Surgical or endovascular repair of thrombosed dialysis vascular access: is there any evidence? *J Vasc Surg* 2009; 50: 953–956

17. Kuhan G, Antoniou GA, Nikam M *et al.* A meta-analysis of randomized trials comparing surgery versus endovascular therapy for thrombosed arteriovenous fistulas and grafts in hemodialysis. *Cardiovasc Intervent Radiol* 2013; 36: 699–705

18. Chan N, Wee I, Soong TK *et al.* A systematic review and meta-analysis of surgical versus endovascular thrombectomy of thrombosed arteriovenous grafts in hemodialysis patients. *J Vasc Surg* 2019; 69: 1976–88.e7

19. Morosetti M, Meloni C, Gandini R *et al.* Surgery versus interventional radiology in the management of thrombosed vascular access for hemodialysis. *J Vasc Access* 2002; 3: 97–100

20. Aitken E, Kasthuri R, Kingsmore D. A comparison of outcome from surgical and endovascular salvage procedures for occluded arteriovenous fistulae. *J Vasc Access*, 2012; 13: 536; author reply, 537

21. Ghaffarian AA, Al-Dulaimi R, Kraiss LW *et al.* Clinical effectiveness of open thrombectomy for thrombosed autogenous arteriovenous fistulas and grafts. *J Vasc Surg* 2018; 68: 189–196

22. Ito Y, Sato T, Okada R *et al.* Comparison of clinical effectiveness between surgical and endovascular treatment for thrombotic obstruction in hemodialysis access. *J Vasc Access* 2011; 12: 63–66

23. Lambert G, Freedman J, Jaffe S *et al.* Comparison of surgical and radiological interventions for thrombosed arteriovenous access. *J Vasc Access* 2018; 19: 555–560

24. Koraen-Smith L, Krasun M, Bottai M *et al.* Haemodialysis access thrombosis: outcomes after surgical thrombectomy versus catheter-directed thrombolytic infusion. *J Vasc Access* 2018; 19: 535–541