HHS Public Access

Author manuscript

BJA Open. Author manuscript; available in PMC 2022 October 19.

Published in final edited form as:

BJA Open. 2022 September ; 3: . doi:10.1016/j.bjao.2022.100031.

Association between anaesthesia type and arteriovenous fistula maturation

Omar I. Ramadan[1,2], **Laura M. Dember**[3,4,5], **Grace J. Wang**[1,2], **Jia Hwei Ng**[6], **Mark P. Mantell**[1], **Mark D. Neuman**[2,7,*]

[1]Department of Surgery, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA

[2]Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA, USA

[3]Renal-Electrolyte and Hypertension Division, Department of Medicine, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA

[4]Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA

[5]Department of Biostatistics and University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA

[6]Division of Kidney Diseases and Hypertension, Department of Medicine, Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Great Neck, NY, USA

[7]Department of Anesthesiology and Critical Care, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA

Abstract

[*]Corresponding author. Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA, USA. mark.neuman@uphs.upenn.edu.

Authors' contributions

Conception and design: OR, LD, MN.
Acquisition, analysis, or interpretation of data: all authors.
Drafting and revision of the manuscript: all authors.
Statistical analysis: OR, LD, MN.
Obtained funding: OR, LD.
Administrative, technical, or material support: OR, MN.
Supervision: LD, GW, JN, MM, MN.
Approved the submitted version of the manuscript and agreed to be personally accountable for their own contributions and to ensure that questions related to the accuracy and integrity of the work are resolved and documented: all authors.

Declarations of interest

OR, LD, GW, JN, MM, and MN have no conflicts of interest involving the work under consideration for publication. LD has relevant financial activities outside the submitted work, including serving as a consultant for Merck, AstraZeneca, and Cara Therapeutics and compensation from the National Kidney Foundation for her role as Deputy Editor of the *American Journal of Kidney Diseases*. None of these financial relationships supported or affected the work under consideration in any way.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bjao.2022.100031.

Meeting Presentation: This study was presented as a virtual podium presentation in the Scientific Forum at the American College of Surgeons Clinical Congress 2021 on 24 October 2021.

Background: Whereas general anaesthesia is commonly used for haemodialysis fistula creation, regional or local anaesthesia has been posited to lead to better fistula maturation outcomes. We sought to measure the association between anaesthesia type and arteriovenous fistula maturation.

Methods: We performed a secondary analysis of data from the Hemodialysis Fistula Maturation study, a multicentre prospective cohort study of advanced chronic kidney disease patients who underwent single-stage upper extremity fistula creation between 2010 and 2013. We evaluated the relationship between anaesthesia type and unassisted (without maturation-facilitating interventions) or overall (unassisted or assisted) fistula maturation using multivariable logistic regression.

Results: Among 602 participants, 336 (55.8%) received regional/local anaesthesia and 266 (44.2%) received general anaesthesia. Unassisted maturation occurred in 164/309 patients (53.1%) after regional/local *vs* 91/226 patients (40.3%) after general anaesthesia (P=0.003). After adjustment for patient factors and fistula type, regional/local anaesthesia was associated with greater odds of unassisted maturation than general anaesthesia (odds ratio 1.72, 95% confidence interval 1.24–2.39; P=0.001). However, after further adjustment for clinical centre fixed effects, odds of unassisted maturation did not differ by anaesthesia type (odds ratio 1.03, 95% confidence interval 0.78–1.36; P=0.830). Similar findings were observed for overall maturation and composite endpoints accounting for potential survivorship bias.

Conclusions: Regional/local anaesthesia was associated with increased odds of fistula maturation when adjusting for patient factors and fistula type. However, this association did not persist after adjusting for centre fixed effects. Future research is needed to better understand the relationship between anaesthesia type and centre factors to optimise outcomes after fistula surgery.

Keywords

anaesthesia type; arteriovenous fistula maturation; end-stage renal disease; general anaesthesia; haemodialysis; local anaesthesia; regional anaesthesia

More than 500 000 people in the USA and nearly 2 400 000 people across 56 countries receive maintenance haemodialysis to treat end-stage renal disease (ESRD)[1] and thus require vascular haemodialysis access. Arteriovenous fistulas are the preferred type of vascular access because of reduced risks of infection and thrombosis and lower overall costs compared with central venous catheters or synthetic arteriovenous grafts.[2] However, up to 60% of newly created arteriovenous fistulas fail to mature adequately for use, often as a result of insufficient vasodilation and wall remodelling after creation of the artery–vein anastomosis.[3] Failure of fistula maturation necessitates additional procedures to secure dialysis access, such as central venous catheter placement, fistula angioplasty, or fistula revision surgery, with associated morbidity, mortality, and cost.[4,5]

The type of anaesthesia used for arteriovenous fistula surgery has been hypothesised to influence fistula maturation. Unlike general anaesthesia, which is commonly used for fistula creation, regional and local anaesthesia deliver targeted anaesthesia to the operative limb (regional) or the operative site (local). Patients undergoing surgery with regional or local anaesthesia do not require intubation or mechanical ventilation and may have reduced needs for systemic sedative or analgesic medications, potentially decreasing the risk of

intraoperative haemodynamic changes and postoperative complications that could affect the likelihood of fistula maturation.[6-8] Additionally, regional anaesthesia causes a sympathetic nerve block that results in enhanced arterial flow and vasodilation starting immediately preoperatively until several hours postoperatively.[8,9] Despite the theoretical advantages of regional and local anaesthesia over general anaesthesia, prior analyses of relationships between anaesthesia type and fistula outcomes have generated conflicting results.[10-12] To this end, we conducted a secondary analysis of a large prospective multicentre observational study of patients undergoing arteriovenous fistula creation to measure the association between anaesthesia type and fistula maturation.

Methods

The University of Pennsylvania Institutional Review Board deemed this study (protocol number 844723) exempt from review and waived the requirement for participant informed consent. Hemodialysis Fistula Maturation (HFM) study data were used in compliance with an existing Data Use Agreement between the Cleveland Clinic Foundation and the University of Pennsylvania. Our study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines[13] (see Supplementary material: STROBE Statement) and was conducted in accordance with the Declaration of Helsinki.

Data source

The National Institute of Diabetes and Digestive and Kidney Diseases HFM study was a multicentre prospective cohort study of 602 patients who underwent single-stage upper extremity arteriovenous fistula creation at seven clinical centres in the USA between March 2010 and August 2013.[4,14,15] The seven centres were all academic vascular access referral institutions representing multiple geographic regions and diverse patient populations within the USA. Clinical decisions, such as fistula type and location, anaesthesia type, timing of and approach to cannulation, and fistula interventions, were made by the treating clinicians.[16] The surgical procedures were performed by vascular surgeons.[16] Data collection was performed monthly throughout the duration of follow-up, with more frequent data collection from initial cannulation of the fistula until the maturation outcome was ascertained.[16] Patients were followed until 3 months after fistula abandonment or the end of the study.[16]

Inclusion criteria

We studied all patients included in the HFM study. Eligibility criteria for the HFM study included: adults <80 yr old; life expectancy >9 months; chronic kidney disease or ESRD with preexisting or anticipated initiation of haemodialysis within 3 months of fistula surgery; and single-stage upper extremity fistula surgery.[16] Single-stage fistula surgeries included in the HFM study were radiocephalic, brachiocephalic, and one-stage brachiobasilic fistulas with simultaneous transposition of the basilic vein; two-stage procedures, such as two-stage basilic vein transpositions, were excluded.

Outcomes

Our primary outcome was unassisted fistula maturation, which was also the primary outcome for the HFM study.[16] In the HFM study, fistula maturation was defined using rigorous, standardised, and clinically meaningful criteria developed by a multidisciplinary team of surgeons and nephrologists, which required that patients have their fistula accessed with two needles for ≥75% of dialysis sessions during a 4-week period with evidence of adequate dialysis.[16] Patients had to satisfy these criteria either within 9 months of fistula creation or within 8 weeks of initial cannulation for dialysis if this occurred >9 months after surgery. If maturation criteria were met without maturation-facilitating endovascular or surgical procedures, this was defined as unassisted fistula maturation. We defined overall fistula maturation, a secondary outcome, as maturation that was either unassisted or occurred after a maturation-facilitating intervention. To account for potential survivorship bias, we assessed the following additional exploratory outcomes: (1) death before maturation; (2) a composite of death before maturation or failure to attain unassisted maturation by the end of follow-up; and (3) a composite of death before maturation or failure to attain overall maturation by the end of follow-up. We also compared intraoperative factors by anaesthesia type, including intraoperative medications administered (heparin, protamine, topical vasodilators, topical thrombin); surgery duration in minutes; presence of a palpable thrill at the completion of surgery as determined by the surgeon; and the surgeon's prediction of successful maturation at the completion of surgery (ascertained by the surgeon's response at the end of the procedure to the prompt, 'Surgeon's predictor of success,' with one of the following answers: 'unlikely,' 'marginal,' or 'likely').

Independent variables

Our adjusted analyses incorporated the following patient factors, measured preoperatively, that have previously been shown to be associated with fistula maturation outcomes or that differed by anaesthesia type: sex, age (as a linear term), race (Black or non-Black), ethnicity (Hispanic or non-Hispanic), insurance status (uninsured or insured), ESRD aetiology, diabetes, heart disease (including congestive heart failure, myocardial infarction, angina, cardiac arrhythmias, coronary artery bypass graft surgery, and percutaneous coronary intervention), body mass index (as a linear term), current smoking status, current dialysis use, antiplatelet or anticoagulant use, albumin (as a linear term), and haemoglobin (as a linear term). As previous studies have suggested that maturation rates vary by fistula type–highest for brachiobasilic fistulas and lowest for radiocephalic fistulas[15,17,18]–we controlled for type of fistula created (radiocephalic, brachiocephalic, or brachiobasilic). We conducted an exploratory analysis that also controlled for history of prior arteriovenous fistula or graft surgery among patients for whom this information was available (approximately two-thirds of the study sample).

Statistical analyses

The study outcomes and overall analytic approach were defined in a pre-specified statistical analysis plan that was finalised before beginning our analyses (see Supplementary material: Pre-specified Statistical Analysis Plan). For our primary analyses, we followed past observational studies in this area[11,12,19] by combining patients who received regional or

local anaesthesia into a single group. Additionally, since recent prospective literature[10] has suggested potential differences in outcomes between patients receiving local *vs* regional anaesthesia, a secondary analysis compared regional and local anaesthesia individually with general anaesthesia. Our main analyses included only participants for whom the outcome of fistula maturation was ascertained (i.e. complete case analysis). We compared baseline and intraoperative characteristics using Pearson's χ^2 tests and *t*-tests. We tested the association between anaesthesia type and fistula maturation outcomes using multivariable logistic regression adjusted for (1) patient factors only and (2) patient factors plus clinical centre fixed effects. We added the fixed effects adjustment to assess whether centre-level factors were contributing to the association between anaesthesia type and fistula maturation.[20] To do this, we included a categorical variable in the regression identifying the clinical centre at which the fistula surgery occurred. In an additional exploratory analysis, we instead adjusted for clinical centre using a three-level categorical variable that categorised centres by their proportion of fistula surgeries performed under regional or local anaesthesia relative to general anaesthesia: low (<33.3% regional/local anaesthesia), medium (33.3–66.6%), or high (>66.6%) (Supplementary Table S1). We also calculated variance inflation factors for all models to rule out multicollinearity. All models used heteroscedasticity-robust standard errors that accounted for clustering by clinical centre. A two-sided *P*-value <0.05 was defined as statistically significant. All statistical analyses were performed using Stata 16.1 software (StataCorp LLC, College Station, TX, USA).

Results

Of the 602 patients in the HFM study, 336 (55.8%) underwent either regional or local anaesthesia–including 133 (22.1%) regional and 203 (33.7%) local–and 266 (44.2%) underwent general anaesthesia (Table 1). The groups were similar with respect to age and race. Regional or local anaesthesia patients were more likely to be male, Hispanic, uninsured, and diabetic. Other comorbidities, current smoking status, and antiplatelet or anticoagulant use were similar between the groups. Regional or local anaesthesia patients also had lower preoperative albumin and haemoglobin concentrations than general anaesthesia patients. Nearly two-thirds of patients in both groups had maintenance dialysis initiated before surgery. General anaesthesia patients were more likely than regional or local anaesthesia patients to have had a prior arteriovenous fistula or graft surgery. The majority of regional or local anaesthesia patients had either radiocephalic (*n*=124, 36.9%) or brachiocephalic (*n*=164, 48.8%) fistulas, compared with 48 (14.3%) who had brachiobasilic fistulas. In contrast, general anaesthesia patients had brachiocephalic (*n*=111, 41.7%) or brachiobasilic (*n*=107, 40.2%) fistulas more frequently than radiocephalic (*n*=48, 18.0%) fistulas. Of the seven clinical centres, two performed <33.3% of their fistula surgeries under regional or local anaesthesia, three performed between 33.3% and 66.6% under regional or local anaesthesia, and two performed >66.6% under regional or local anaesthesia (Supplementary Table S1). Similar patterns were observed in the baseline characteristics of the analytic (535 patients) and excluded (67 patients) cohorts (Supplementary Table S2).

Use of intraoperative intravenous heparin (not including heparinised saline) and protamine was more common in general anaesthesia cases (Table 2). Surgery duration–from incision to dressing application–was shorter in regional or local anaesthesia cases than general

anaesthesia cases (regional or local anaesthesia 88.0 min, standard deviation [SD] 48.2 minutes *vs* general anaesthesia 104.2 min, SD 34.0 min; $P<0.001$). Finally, surgeons more often predicted 'likely' success in regional or local anaesthesia cases (regional or local anaesthesia 82.0% *vs* general anaesthesia 73.6%; $P=0.013$).

Unassisted and overall fistula maturation were both more frequent among patients who had received regional or local anaesthesia *vs* general anaesthesia on unadjusted analysis (unassisted: regional or local 53.1%, 95% confidence interval [CI] 47.5–58.6% *vs* general anaesthesia 40.3%, 95% CI 34.1–46.8; $P=0.003$; overall: regional or local 78.6%, 95% CI 73.7–82.9% *vs* general anaesthesia 67.7%, 95% CI 61.3–73.5%; $P=0.004$) (Table 3). After adjusting for patient characteristics and fistula type, the odds of both unassisted and overall maturation were higher for patients who received regional or local anaesthesia compared with general anaesthesia (unassisted maturation: odds ratio [OR] 1.72, 95% CI 1.24–2.39; $P=0.001$; overall maturation: OR 1.55, 95% CI 1.03–2.33; $P=0.038$). These results were similar when history of previous arteriovenous fistula or graft surgery was incorporated into the models, although only 338/535 (63.2%) patients were included in this exploratory analysis as a result of missing information.

In models that controlled for patient factors and clinical centre fixed effects, anaesthesia type was no longer associated with either unassisted or overall maturation (unassisted maturation, regional or local *vs* general anaesthesia: OR 1.03, 95% CI 0.78–1.36; $P=0.830$; overall maturation, regional or local *vs* general anaesthesia: OR 1.01, 95% CI 0.57–1.80; $P=0.968$) (Table 3). Results were similar when an alternate variable for centre was used that categorised centres by their relative volume of regional or local anaesthesia to general anaesthesia (Supplementary Table S3). Findings were also qualitatively similar for composite outcomes that accounted for death (Supplementary Table S4).

In exploratory analyses that compared regional and local anaesthesia separately with general anaesthesia, the odds of unassisted and overall maturation were greater for local than for general anaesthesia after adjustment for patient factors and fistula type (unassisted maturation: OR 2.10, 95% CI 1.39–3.19; $P<0.001$; overall maturation: OR 2.04, 95% CI 1.34–3.09; $P=0.001$), but did not differ for patients receiving regional relative to general anaesthesia (unassisted maturation: OR 1.29, 95% CI 0.73–2.28; $P=0.374$; overall maturation: OR 1.11, 95% CI 0.58–2.10; $P=0.756$) (Supplementary Table S5). Because of sample size limitations within certain centres, we did not adjust for clinical centre when evaluating regional and local anaesthesia separately. The full models and their coefficients are reported in Supplementary Table S6a-p.

Discussion

Failure of fistula maturation occurs frequently and necessitates multiple invasive procedures and prolonged use of central venous catheters with associated morbidity and mortality.[4] Hence, interventions that improve maturation rates may also offer patient-centred benefits. In our secondary analysis of the multicentre prospective HFM study, we found that regional or local anaesthesia for single-stage arteriovenous fistula surgery was associated with significantly increased odds of fistula maturation relative to general anaesthesia after

controlling for patient factors and fistula type. However, in models that also incorporated a within-centre comparison to account for potential confounding because of centre characteristics, we no longer found an association between anaesthesia type and fistula maturation outcomes. Our findings suggest that such centre factors–such as variations in surgeon, anaesthesiologist, or centre-level expertise in regional or local anaesthesia, clinical practice patterns, or dialysis unit practices–may contribute to differences in outcomes between regional or local anaesthesia and general anaesthesia observed in prior retrospective studies.[11,21]

Our results contained several other interesting findings. When we compared all three anaesthesia types, separating regional and local anaesthesia, we found that local anaesthesia was associated with improved outcomes relative to general anaesthesia when adjusting for patient factors while regional anaesthesia was not significantly different from general anaesthesia, perhaps because of sample size limitations. We also observed that both regional or local and general anaesthesia were commonly used for brachiocephalic fistula creation. However, regional or local anaesthesia was rarely used for brachiobasilic fistulas whereas general anaesthesia was seldom used for radiocephalic fistulas. These practice patterns may reflect differences in anaesthesia requirements based on the size and location of the surgical incisions. Additionally, surgeons predicted ‘likely’ fistula maturation success more frequently after procedures performed under regional or local compared with general anaesthesia. This qualitative assessment may suggest that the regional or local anaesthesia procedures were on average less complex than general anaesthesia ones, for example because of fistula type or anatomic factors such as vein or artery size.

Prior literature, derived largely from retrospective or singlecentre data, has been mixed regarding the effect of regional or local anaesthesia relative to general anaesthesia on fistula outcomes. For instance, one retrospective analysis of a national surgical database found no meaningful outcome differences between regional or local anaesthesia and general anaesthesia,[12] whereas two others suggested superior outcomes for regional or local anaesthesia.[11,21] Similarly, an 84-patient single-centre prospective cohort study found no differences in outcomes[19] whereas a 123-patient single-centre retrospective cohort study instead reported improved maturation outcomes after regional anaesthesia.[22] However, all of the aforementioned studies adjusted for patient factors only.[11,12,19,21,22]

Our analysis of the association between anaesthesia type and fistula maturation builds on and extends prior work in two important ways. First, we harnessed a highly granular dataset derived from a large multicentre prospective cohort study to address this question. The HFM study sample was geographically and demographically diverse, and detailed information was recorded about patient characteristics and perioperative courses, allowing us to create rigorous multivariable regression models. Patients were followed closely postoperatively, and the HFM study used meticulous, standardised protocols for ascertaining outcomes–particularly fistula maturation outcomes–in a clinically relevant manner. Second, in addition to the standard patient factors and fistula type adjustments, we also adjusted for clinical centre fixed effects, allowing for a within-centre comparison. Importantly, while we found an association between anaesthesia type and fistula maturation outcomes with adjustment for patient factors and fistula type, these associations were not robust

to further adjustment for clinical centre. This suggests that centre factors may play a consequential role in contributing to associations between anaesthesia type and fistula maturation outcomes. Experience is necessary to perform regional anaesthesia well[23]; thus, one possible explanation is heterogenous centre-level expertise in regional or local anaesthesia, wherein centres (and their surgeons and anaesthesiologists) that routinely use regional or local anaesthesia may be more likely to realise its potential benefits for fistula maturation. As a result of the relatively small number of centres included in the HFM study, we were not able to fully examine this in the present work.

Our findings should be interpreted in the context of limitations. Although we controlled for an array of patient factors, fistula type, and centre fixed effects, we cannot rule out confounding as a result of other characteristics (e.g. severity of comorbidities or size of the vessels used for fistula creation) or confounding by indication. Further, sample size considerations precluded us from adjusting for centre fixed effects when comparing regional anaesthesia and local anaesthesia separately with general anaesthesia. We also observed several differences in intraoperative factors between anaesthesia groups. Whereas these were not adjusted for in our analysis as they occurred after exposure to anaesthesia, future studies may consider their potential role in influencing fistula surgery outcomes with differing types of anaesthesia. In addition, the HFM study was conducted between 2010 and 2013, and practice patterns or surgeon or anaesthesiologist expertise may have changed since then; however, we assess any such changes to be marginal and outweighed by the high-quality nature of the HFM data. Finally, the HFM study only included single-stage fistula surgeries, and as such our findings may not apply to two-stage procedures.

In conclusion, we found that regional or local anaesthesia was associated with improved odds of arteriovenous fistula maturation after adjusting for patient factors and fistula type. However, we did not observe an association between anaesthesia type and fistula maturation after also adjusting for clinical centre fixed effects. In this context, our analyses highlight the importance of considering centre factors when exploring the association between anaesthesia type and fistula maturation. Future research may consider whether and how fistula maturation outcomes with regional or local anaesthesia – relative to general anaesthesia – vary across surgeons or anaesthesiologists, who may have different levels of expertise, or institutions, which may range in their availability of standardised regional or local anaesthesia protocols and procedures.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

We thank the members of the HFM Study Group.

Funding

The National Institutes of Health (T32HL098054 to OR), Agency for Healthcare Research and Quality (AHRQ) National Research Service Award (5T32HS026116 to OR), and National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) (U01DK082232 to LD). Neither the National Institutes of Health, AHRQ, nor NIDDK were involved in our study design, collection, analysis, or interpretation of data, writing the report, or

the decision to submit the report for publication. The Hemodialysis Fistula Maturation (HFM) study was funded by NIDDK (U01DK066597, U01DK082179, U01DK082189, U01DK082218, U01DK082222, U01DK082236, U01DK082232, U01DK082240). NIDDK was involved in the HFM study design, collection, analysis, and interpretation of data.

References

1. United States Renal Data System. USRDS annual data report: Epidemiology of kidney disease in the United States. Available from: https://adr.usrds.org/2021/end-stage-renal-disease; 2021
2. Thamer M, Lee TC, Wasse H, et al. Medicare costs associated with arteriovenous fistulas among US hemodialysis patients. Am J Kidney Dis 2018; 72: 10–8 [PubMed: 29602630]
3. Dember LM, Beck GJ, Allon M, et al. Effect of clopidogrel on early failure of arteriovenous fistulas for hemodialysis: a randomized controlled trial. JAMA 2008; 299: 2164–71 [PubMed: 18477783]
4. Huber TS, Berceli SA, Scali ST, et al. Arteriovenous fistula maturation, functional patency, and intervention rates. JAMA Surg 2021; 156: 1111–8 [PubMed: 34550312]
5. Viecelli AK, O'Lone E, Sautenet B, et al. Vascular access outcomes reported in maintenance hemodialysis trials: a systematic review. Am J Kidney Dis 2018; 71: 382–91 [PubMed: 29203125]
6. Howell SJ, Sear YM, Yeates D, Goldacre M, Sear JW, Foéx P. Risk factors for cardiovascular death after elective surgery under general anaesthesia. Br J Anaesth 1998; 80: 14–9 [PubMed: 9505771]
7. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation 1999; 100: 1043–9 [PubMed: 10477528]
8. Mouquet C, Bitker MO, Bailliart O, et al. Anesthesia for creation of a forearm fistula in patients with endstage renal failure. Anesthesiology 1989; 70: 909–14 [PubMed: 2729630]
9. Shemesh D, Olsha O, Orkin D, et al. Sympathectomy-like effects of brachial plexus block in arteriovenous access surgery. Ultrasound Med Biol 2006; 32: 817–22 [PubMed: 16785004]
10. Aitken E, Jackson A, Kearns R, et al. Effect of regional versus local anaesthesia on outcome after arteriovenous fistula creation: a randomised controlled trial. Lancet 2016; 388: 1067–74 [PubMed: 27492881]
11. Levin SR, Farber A, Malas MB, et al. Association of anesthesia type with outcomes after outpatient brachiocephalic arteriovenous fistula creation. Ann Vasc Surg 2020; 68: 67–75 [PubMed: 32504791]
12. Beaulieu RJ, Locham S, Nejim B, Dakour-Aridi H, Woo K, Malas MB. General anesthesia is associated with reduced early failure among patients undergoing hemodialysis access. J Vasc Surg 2019; 69: 890–7. e5 [PubMed: 30798844]
13. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 2007; 370: 1453–7 [PubMed: 18064739]
14. Huber TS, Larive B, Imrey PB, et al. Access-related hand ischemia and the hemodialysis fistula maturation study. J Vasc Surg 2016; 64: 1050–1058.e1 [PubMed: 27478007]
15. Chemla ES, Morsy MA. Is basilic vein transposition a real alternative to an arteriovenous bypass graft? A prospective study. Semin Dial 2008; 21: 352–6 [PubMed: 18564966]
16. Dember LM, Imrey PB, Beck GJ, et al. Objectives and design of the hemodialysis fistula maturation study. Am J Kidney Dis 2014; 63: 104–12 [PubMed: 23992885]
17. Maya ID, O'Neal JC, Young CJ, Barker-Finkel J, Allon M. Outcomes of brachiocephalic fistulas, transposed brachiobasilic fistulas, and upper arm grafts. Clin J Am Soc Nephrol 2009; 4: 86–92 [PubMed: 18945990]
18. Hakaim AG, Nalbandian M, Scott T. Superior maturation and patency of primary brachiocephalic and transposed basilic vein arteriovenous fistulae in patients with diabetes. J Vasc Surg 1998; 27: 154–7 [PubMed: 9474093]
19. Elsharawy MA, Al-Metwalli R. Does regional anesthesia influence early outcome of upper arm arteriovenous fistula? Saudi J Kidney Dis Transpl 2010; 21: 1048–52 [PubMed: 21060172]
20. Allison PD. Linear fixed effects models. In: Fixed effects regression models, vols. 7–27. Thousand Oaks, CA: SAGE Publications, Inc.; 2009

21. Cole NM, Vlassakov K, Brovman EY, Heydarpour M, Urman RD. Regional anesthesia for arteriovenous fistula surgery may reduce hospital length of stay and reoperation rates. Vasc Endovascular Surg 2018; 52: 418–26 [PubMed: 29706126]

22. Hu RT, Story DA, Chuen J, Mount PF. Impact of anaesthesia on outcomes after radiocephalic arteriovenous fistula creation. Anaesth Intensive Care 2015; 43: 414–5 [PubMed: 25943616]

23. Smith AF, Pope C, Goodwin D, Mort M. What defines expertise in regional anaesthesia? An observational analysis of practice. Br J Anaesth 2006; 97: 401–7 [PubMed: 16835256]

Table 1

Baseline characteristics.

	General anaesthesia, no. (%)	**Regional/local anaesthesia, no. (%)**	***P*-value**
	***n*=266 (44.2)**	***n*=336 (55.8)**	
Age (yr), median (iqr)	55 (47–65)	56 (47–63.5)	0.790
Male	175 (65.8)	248 (73.8)	0.033
Black	127 (48.3)	137 (41.4)	0.093
Hispanic	26 (9.8)	53 (15.9)	0.029
Uninsured[a]	7 (2.7)	21 (6.3)	0.006
Currently on dialysis	171 (64.3)	207 (61.6)	0.500
Prior AV fistula/AV graft	79 (44.9)	51 (24.5)	<0.001
Cause of ESRD			
Diabetic nephropathy	73 (27.4)	119 (35.4)	<0.001
Hypertensive nephropathy	49 (18.4)	96 (28.6)	
Glomerulonephritis	25 (9.4)	27 (8.0)	
Other	44 (16.5)	58 (17.3)	
Unspecified	75 (28.2)	36 (10.7)	
Comorbidities			
Diabetes	142 (53.4)	211 (62.8)	0.020
Heart disease [b]	113 (42.5)	147 (43.8)	0.750
Hypertension	253 (95.1)	328 (97.6)	0.096
Bmi (kg/m^2), mean (SD)	30.5 (7.5)	30.4 (7.6)	0.780
Prior kidney transplant	11 (4.1)	14 (4.2)	0.980
Hypercoagulable state	11 (4.1)	19 (5.7)	0.390
Current smoker	51 (19.3)	54 (16.2)	0.320
Antithrombotic [c]	148 (55.8)	193 (57.4)	0.700
Albumin (g/dl)	3.7 (0.6)	3.5 (0.6)	<0.001
Haemoglobin (g/dl)	10.7 (1.7)	10.4 (1.6)	0.030
AV fistula type			
Radiocephalic	48 (18.0)	124 (36.9)	<0.001

	General anaesthesia, no. (%)	Regional/local anaesthesia, no. (%)	*P*-value
	***n*=266 (44.2)**	***n*=336 (55.8)**	
Brachiocephalic	111 (41.7)	164 (48.8)	
Brachiobasilic	107 (40.2)	48 (14.3)	

AV, arteriovenous; ESRD, end-stage renal disease; IQR, inter-quartile range; sd, standard deviation.

[a] Uninsured is defined as absence of health insurance coverage.

[b] History of heart disease includes history of congestive heart failure, myocardial infarction, angina, cardiac arrhythmias, coronary artery bypass graft surgery, and percutaneous coronary intervention.

[c] Preoperative antithrombotic use, including antiplatelets and anticoagulants.

Table 2

Intraoperative factors.

	General anaesthesia, no. (%) ***n*=266 (44.2)**	**Regional/local anaesthesia, no. (%)** ***n*=336 (55.8)**	***P*-value**
Intraoperative medications			
Heparin [a]	188 (70.7)	159 (47.3)	<0.001
Protamine	127 (47.7)	48 (14.3)	<0.001
Topical vasodilators	25 (9.4)	32 (9.5)	0.960
Topical thrombin	74 (27.8)	69 (20.5)	0.037
Surgery duration (min), mean (SD) [b]	104.2 (48.2)	88.0 (34.0)	<0.001
Palpable thrill [c]	257 (97.0)	328 (98.5)	0.210
Surgeon prediction of likely success [d]	195 (73.6)	274 (82.0)	0.013

SD, standard deviation.

[a]Not including heparinised saline.

[b]From incision to dressing application.

[c]As determined by the surgeon at the end of the procedure.

[d]Likely success was ascertained by the surgeon's response at the end of the procedure to the prompt, 'Surgeon's predictor of success,' with the following options: 'Unlikely,' 'Marginal,' and 'Likely.' We considered 'Unlikely' and 'Marginal' to be a prediction of unlikely success and 'Likely' to be a prediction of likely success.

BJA Open. Author manuscript; available in PMC 2022 October 19.

Table 3

Fistula maturation outcomes by anaesthesia type.

	No. (%) of Patients			Unadjusted		Adjusted for patient factors and fistula type [a]		Adjusted for patient factors, fistula type, and centre ID [b]	
	General anaesthesia (*n*=226)	Regional/local anaesthesia (*n*=309)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Unassisted maturation	91 (40.3)	164 (53.1)	0.003	1.68 (1.19–2.37)	0.003	1.72 (1.24–2.39)	0.001	1.03 (0.78–1.36)	0.830
Overall maturation	153 (67.7)	243 (78.6)	0.004	1.76 (1.19–2.59)	0.005	1.55 (1.02–2.33)	0.038	1.01 (0.59–1.80)	0.968

CI, confidence interval; ESRD, end-stage renal disease; ID, identification; OR, odds ratio.

[a]Multivariable adjustment for: male sex, age, Black race, Hispanic ethnicity, uninsured status, ESRD aetiology, diabetes history, heart disease history, body mass index, current smoking status, current dialysis use, current use of antiplatelets or anticoagulants, preoperative albumin, preoperative haemoglobin, and fistula type.

[b]Multivariable adjustment with an additional variable identifying the clinical centre at which the fistula surgery occurred.