

# Impact of COVID-19 pandemic on hemodialysis access thrombosis

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## Abstract

**Background:** Delay in care of suspected stenosis or thrombosis can increase the chance of losing a functioning hemodialysis access. Access to care and resources were restricted during the COVID-19 pandemic. To evaluate the impact of the pandemic on arteriovenous fistula (AVF) and arteriovenous graft (AVG) procedures we have assessed the number and success of thrombectomies done before and during the COVID-19 pandemic.

**Methods:** We examined all AVF and AVG angiograms with and without interventions, including thrombectomies, performed at a single center during April 2017–March 2021 (pre-COVID-19 era) and April 2020–March 2021 (COVID-19 era).

**Results:** The proportion of procedures that were thrombectomies was higher during the COVID-19 era compared to the pre-COVID-19 era (13.3% vs 8.7%,  $p = 0.009$ ). The proportion of thrombectomy procedures was higher during COVID-19 for AVF (8.2% vs 3.0%,  $p < 0.001$ ) but there was no difference for AVG (26.5% vs 27%,  $p = 0.99$ ). There was a trend toward a higher likelihood of unsuccessful thrombectomy during COVID-19 (33.3% vs 20.4%,  $p = 0.08$ ).

**Conclusions:** More dialysis access thromboses and unsuccessful thrombectomies were noted during the COVID-19 pandemic. This difference could be due to a delay in patients getting procedures to maintain their dialysis accesses.

## Keywords

COVID-19, dialysis access, arteriovenous fistula, arteriovenous graft, thrombosis, thrombectomy, interventional nephrology

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## Introduction

In an effort to battle the coronavirus disease 19 (COVID-19) pandemic, hospitals canceled or postponed elective surgeries and non-essential procedures in order to preserve personal protective equipment, save hospital space to meet its accelerating patient admissions, and prevent medical personnel from exposure to the virus.<sup>1–3</sup> The American College of Surgeons<sup>4</sup> formulated the guidelines for triaging various surgeries and procedures based on three-tier classes following category criteria from the Centers for Medicare and Medicaid Services (CMS). Most of the conditions requiring procedures on hemodialysis access were categorized under tier 3, which was recommended not to postpone. Those tier 3 conditions included thrombosed or nonfunctional dialysis access, infected dialysis access, fistula revision for ulceration, renal failure with the need for dialysis access, and

tunneled dialysis catheter. AVF angiogram was listed under tier 2 meaning it could be postponed if possible.<sup>3,4</sup>

In the midst of the pandemic, patients expressed concerns and felt anxious about going to the hospital in fear of getting exposed to COVID-19.<sup>5</sup> Both patient and procedure facility factors may have led to a delay in referral for procedures. Delay in treating an access stenosis can lead to

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thrombosis and loss of hemodialysis access.<sup>6,7</sup> The Kidney Disease Outcomes Quality Initiative (KDOQI) recommended preemptive angioplasty to prevent thrombosis in individuals who show persistent clinical indication to prevent thrombosis.<sup>8</sup> Therefore, we hypothesized that there was an increased proportion of access thrombosis and unsuccessful thrombectomy during the COVID-19 pandemic.

## Methods

We compared procedures done prior to the COVID-19 pandemic with that during the pandemic at a hospital-based interventional nephrology practice. The study was approved by the University of Wisconsin Institutional Review Board (ID 2021-0645). The study was done in accordance with Helsinki Declaration as revised in 2013. Data were collected using electronic medical records. Thrombectomy procedures were performed at a university hospital and a community hospital by interventional nephrologists. Patients were referred from various dialysis centers as well as inpatient. Two different groups were designated: one as the pre-COVID-19 group who underwent procedures between April 1, 2017 and March 31, 2020 and the COVID-19 group between April 1, 2020 and March 31, 2021. These time periods were chosen because the hospital began to limit the number of elective procedures due to the pandemic from April 1, 2020. During the COVID-19 era, patients were required either a rapid COVID-19 test on the same day or obtain a COVID-19 PCR test 48 h prior to the procedure. Thrombectomies performed were either chemical, using instillation of tissue plasminogen activator and heparin, or mechanical, using circumferential aspiration thrombectomy (CAT) catheters. Unsuccessful thrombectomy was defined as failure to maintain patency of fistula or graft after the procedure and a tunneled dialysis catheter insertion within 48 h of the initial thrombectomy. Total procedures included angiogram of the AVF or AVG or intervention with either balloon angioplasty, stent placement or thrombectomy. Each group was broken down into AVF and AVG procedures. Total procedures did not include tunneled dialysis catheter placement, exchange or disruption of fibrin sheath in central venous catheter. Hypertension was not added in the baseline characteristics because of the high prevalence in end stage kidney disease requiring dialysis. Age of dialysis access in days was calculated from the day of the access creation surgery to the day of the thrombectomy.

## Results

There were 1179 total procedures in the pre-COVID-19 group and 405 total procedures in the COVID-19 group. These included a total of 103 thrombectomies during the

pre-COVID-19 era and 54 thrombectomies during the COVID-19 era. Patients undergoing thrombectomy in the two eras were similar in terms of age, sex, and diabetes, but more patients had coronary artery disease and peripheral vascular disease during the pre-COVID-19 era than the COVID-19 era (36.9% vs 18.5%,  $p=0.02$  and 27.2% vs 7.4%,  $p=0.003$ , respectively). The proportion of patients with a prior stent placement was higher pre-COVID (43.2%) compared to during COVID (16.0%;  $p=0.001$ ). There was no difference, however, in the proportion of patients with central venous stenosis (34.1% vs 32.0%;  $p=0.83$ ). [Table 1]

The proportion of thrombectomy cases was greater in the COVID-19 group compared to the pre-COVID-19 group (13.3% vs 8.7%,  $p=0.009$ ). [Table 2; Figure 1] As shown in Figure 2, a larger proportion of these thrombectomy cases were unsuccessful in the COVID-19 group (33.3% vs 20.4%, unadjusted: OR=1.95, 95% CI=0.93–4.10,  $p=0.08$ , adjusted: OR=1.68, 95% CI=0.76–3.73,  $p=0.20$ ) but this difference was not statistically significant. A greater proportion of thrombectomies during COVID-19 compared to pre-COVID-19 was observed for AVF (8.2% vs 3.0%,  $p<0.001$ ) but not for AVG (26.5% vs 27.0%,  $p=0.99$ ). [Figure 1] After the adjustment, a proportion of unsuccessful thrombectomies was greater during COVID-19 for both AVF (41.7% vs 25.9%, OR=1.83, 95% CI=0.45–7.39,  $p=0.39$ ) and AVG (26.7% vs 18.4%, OR=1.14, 95% CI=0.39–3.38,  $p=0.81$ ), but neither difference was statistically significant (Table 3).

Sensitivity analyses limiting the pre-COVID-19 period to the most recent year (April 2019–March 2020) found similar results. (Table 4) The proportion of thrombectomies for AVF was greater during COVID-19 than in the year prior (8.2% vs 3.2%,  $p=0.009$ ).

## Discussion

We found that a higher proportion of AVF procedures were thrombectomies during COVID-19 period compared to pre-COVID-19 period. A higher proportion of these thrombectomies were unsuccessful, although this result did not reach statistical significance. No such differences were observed in AVG.

A similar study performed in the United Kingdom by Seet et al.<sup>9</sup> examined the vascular access salvage attempts, salvage success, 1 month patency and the use of tunneled dialysis catheter following unsuccessful salvage during COVID-19 pandemic in 2020 and a similar time period in the previous year. They found more cases of access thrombosis during COVID-19 pandemic but was not statistically significant. Salvage was attempted for 63% of thrombosed access during COVID-19 pandemic compared to 92% in 2019 ( $p=0.014$ ), and more patients ended up with tunneled dialysis catheter placement when more salvage was

**Table 1.** Baseline characteristics and demographics in thrombectomies.

	Pre-COVID-19 (4/1/2017–3/31/2020)	COVID-19 (4/1/2020–3/31/2021)	p value
	AVG & AVF	AVG & AVF	
Total number of cases	103	54	-
Age (mean)	62.6	60.6	0.35
Male	51 (49.5%)	25 (46.3%)	-
Female	52 (50.5%)	29 (53.7%)	0.70
African American	44 (42.7%)	16 (29.6%)	0.11
Type 1 or 2 diabetes	67 (65%)	38 (70.4%)	0.50
CAD	38 (36.9%)	10 (18.5%)	0.02
CHF with EF ≤40%	11 (11.4%)	2 (3.7%)	0.13
PVD	28 (27.2%)	4 (7.4%)	0.003
Median number of prior interventions preceding 1 year**	2 (Interquartile range: 1,3)	1 (Interquartile range: 0,3)	0.19
Proportion of prior stent(s) placement	43.2%	16.0%	0.001
Proportion of central venous stenosis	34.1%	32.0%	0.83
Access vintage (years)			
Mean	2.4 (2.2)*	2.0 (1.9)*	0.29
Unknown	20	6	

AVG: arteriovenous graft; AVF: arteriovenous fistula; CAD: coronary artery disease; CHF: congestive heart failure; EF: ejection fraction; PVD: peripheral vascular disease

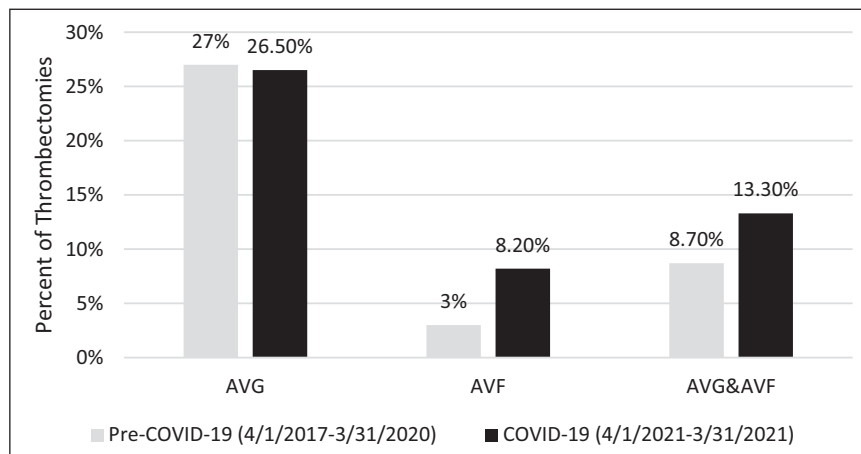
\*After excluding a total of 26 unknown age of access in both the pre-COVID-19 and COVID-19 groups in AVG & AVF

\*\*Procedures including angioplasty, stent placement, and thrombectomy of AVF and AVG

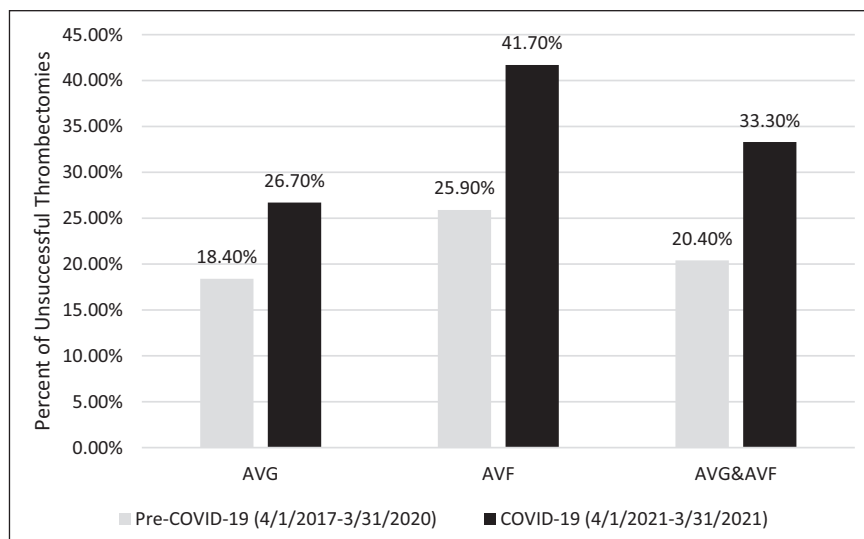
**Table 2.** Results.

	Total procedures*	Non-thrombectomies	Thrombectomies	
			N (%)	p value
Total				
Total Pre-COVID-19 4/1/2017–3/31/2020	1179	1076	103 (8.7)	0.009
COVID-19 4/1/2020–3/31/2021	405	351	54 (13.3)	AVG
Total Pre-COVID-19 4/1/2017–3/31/2020	282	206	76 (27.0)	0.99
COVID-19; 4/1/2020–3/31/2021	113	83	30 (26.5)	AVF
Total Pre-COVID-19 4/1/2017–3/31/2020	897	870	27 (3.0)	<0.001
COVID-19 4/1/2020–3/31/2021	292	268	24 (8.2)	

\*Total number of AVF/AVG angiograms and/or angioplasty and/or stent placement or thrombectomy.



**Figure 1.** Incidence of thrombectomies in total procedures.



**Figure 2.** The proportion of unsuccessful thrombectomies.

**Table 3.** Association of COVID-19 (vs pre-COVID) for unsuccessful thrombectomies.

	Odds ratio	95% Confidence interval	p value
<b>Total</b>			
Unadjusted	1.95	0.93–4.10	0.08
Stepwise adjustment*	1.84	0.86–2.93	0.12
Fully adjusted <sup>§</sup>	1.68	0.76–3.73	0.20
<b>AVF</b>			
Unadjusted	2.04	0.63–6.66	0.24
Stepwise adjustment*	2.07	0.60–7.15	0.25
Fully adjusted <sup>§</sup>	1.83	0.45–7.39	0.39
<b>AVG</b>			
Unadjusted	1.61	0.60–4.36	0.35
Stepwise adjustment*	1.30	0.47–3.62	0.61
Fully adjusted <sup>§</sup>	1.14	0.39–3.38	0.81

\*Both forward and backward stepwise resulted in adjustment for age and sex.

<sup>§</sup>Adjusted for age, sex, AA, DM, CAD, CHF, PVD, AVG (not for age of access).

not attempted. The proposed reason was the reduced number of surgical interventions during the COVID-19 surge.<sup>9</sup>

Stenosis and neo-intimal hyperplasia cause venous stasis which leads to thrombosis.<sup>10</sup> Risk factors for access thrombosis include advanced age, smaller vein, and medical comorbidities including diabetes, hypertension, coronary artery disease, heart failure, and peripheral vascular disease.<sup>10–15</sup> Intradialytic hypotension has shown to be associated with AVF thrombosis but not in AVG.<sup>16</sup> COVID-19 infection is a hypercoagulable condition and causes both arterial and venous thrombosis.<sup>17</sup> One explanation for the higher AVF thrombosis incidence rate in COVID-19 group could be the delay in intervention for stenosis diagnosis and management. Prompt monitoring and surveillance of dialysis access can detect stenosis and prevent AVF thrombosis.<sup>10,18–20</sup> Multiple studies have shown that proper maintenance and monitoring with intervention could reduce the rate of thrombosis up to 30%–80%.<sup>21–23</sup>

The longer the delay in addressing the thrombosis, the more is the risk of permanent access failure.<sup>10,21–24</sup> Fistula thrombectomy should ideally be performed within 48 h of thrombosis while graft thrombectomy must be completed no later than 1 week, but ideally in 48 h.<sup>10,24</sup> The greater proportion of thrombectomies may be due to the fact that thrombectomy does not get delayed because it is an emergency as patient cannot dialyze if access is thrombosed. Patients' fear of contracting COVID-19 virus could have contributed to seeking medical care in a timely fashion. Prior studies found that 40.9% of adults did not seek proper medical care and 12% opted not to get urgent or emergency care for fear of COVID-19.<sup>5,25</sup> Our own patients have expressed concern during the dialysis rounds when angiogram was offered to evaluate the access based on abnormal physical exam finding. Our patients were able to be scheduled for the outpatient procedures including angiograms and thrombectomy if indicated, but it might have

**Table 4.** Sub-analysis of results by year.

	Total procedures*	Non-thrombectomies	Thrombectomies	% Thrombectomies	Thrombectomies	% Thrombectomies	Thrombectomies	P value†	Unsuccessful thrombectomies	% Unsuccessful	p value‡
Total											
4/1/2017–3/31/2018	391	368	23	5.9					2	8.7	
4/1/2018–3/31/2019	390	354	36	9.2					7	19.4	
4/1/2019–3/31/2020	398	354	44	11.1				0.33	12	27.3	0.66
Total Pre-COVID-19	1179	1076	103	8.7				0.009	21	20.4	0.08
COVID-19 Group 4/1/2020–3/31/2021	405	351	54	13.3					18	33.3	
AVG											
4/1/2017–3/31/2018	82	64	18	22.0					1	5.6	
4/1/2018–3/31/2019	85	62	23	27.1					3	13.0	
4/1/2019–3/31/2020	115	80	35	30.4				0.56	10	28.6	0.99
Total Pre-COVID-19	282	206	76	27.0				0.99	14	18.4	0.43
COVID-19 Group 4/1/2020–3/31/2021	113	83	30	26.5					8	26.7	
AVF											
4/1/2017–3/31/2018	309	304	5	1.6					1	20.0	
4/1/2018–3/31/2019	305	292	13	4.3					4	30.8	
4/1/2019–3/31/2020	283	274	9	3.2				0.009	2	22.2	0.30
Total Pre-COVID-19	897	870	27	3.0				<0.001	7	25.9	0.23
COVID-19 Group 4/1/2020–3/31/2021	292	268	24	8.2					10	41.7	

\*Total number of AVF/AVG angiograms and/or angioplasty and/or stent placement or thrombectomy.

†Versus COVID-19 period.

taken longer time to schedule because of hesitancy in fear of contracting COVID-19 and due to requirement for a COVID-19 test prior to the procedure.

The COVID-19 pandemic has impacted the health care in various ways. The average new subjects' enrollment for clinical trials since the pandemic is around 70% of the pre-pandemic enrollments, and some trials have been halted the trials which has increased costs.<sup>26</sup> There was a reduction of 84% in urgent referral from primary care to specialist for suspected cancer patients in United Kingdom which predicted that a delay of 1 month is estimated to cause loss of 1412 lives and 25,812 life-years.<sup>27</sup> One international multi-center prospective observational study revealed higher in-hospital mortality after vascular interventions during COVID-19 pandemic than pre-pandemic period. One of the explanations was the increase in threshold for operating aneurysm to  $\geq 6.5$  cm from  $\geq 5.5$  cm in usual practice due to limited capacity in the operating room.<sup>28</sup> An observational study revealed a large diameter of aneurysm  $\geq 6.5$  cm to have significantly high risk of 1 year mortality.<sup>29</sup>

Our study has several limitations. This study has a relatively small sample size in a single center. We do not know if other office-based practice or ambulatory surgical center were similarly affected by COVID-19 pandemic. The small sample size also limits precision of our estimates. There was no known change in referring dialysis units because of COVID-19 but we do not have the access to all the units to find out if the number of referrals changed and if there was a change of access monitoring policy. Despite requiring patients to get COVID tested, we do not have the complete data on the results since the most tests were performed locally rather than at our institution. Consequently, we cannot ascertain if COVID-19 infection itself caused more thrombosis. Since we do not have the data from the referring units, there is no quantification of how many days an access was dysfunctional before it thrombosed and if there was a delay in care. The difference in the prevalence of risk factors for thrombectomies between eras could not be determined, as we only have information on those with an event. More specific variables for example, the number of days from identification of access dysfunction to actual procedure, presence of vascular calcification, pseudoaneurysm, aneurysm, and ultrafiltration rate may need to be assessed in the future to expand the study and thoroughly investigate the etiology of more AVF thrombosis in the time of COVID-19 pandemic.

## Conclusion

There was an increase in proportion of fistula thrombectomies compared to other procedures during the COVID-19 pandemic. Thrombectomy success rates may also have decreased. Although there is no specific reason behind these findings, we could speculate a delay in the treatment of preceding fistula stenosis due to patient hesitancy.

## Author's contributions

MC: study design, data acquisition, data analysis, data interpretation, draft manuscript, and preparation

BA: data analysis, statistical analysis, draft revision

AG: study design, data analysis, data interpretation, draft revision, supervision, mentorship

ZJ, RP, MK, MRC: manuscript review

MC, ZJ, RP, MK, MRC, BA, AG take responsibility that this study has been reported honestly, accurately and transparently, and accept accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

## IRB

University of Wisconsin Institutional Review Board  
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## Declaration of conflicting interests

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