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Comparative outcomes of treated symptomatic versus non-treated asymptomatic high-grade central vein stenoses in the outflow of predominantly dialysis fistulas

Claude J. Renaud[1,5], Maud Francois[3], Alain Nony[4], Mahammed Fodil-Cherif[5] and Luc Turmel-Rodrigues[5]

[1]Division of Nephrology, University Medical Cluster, National University Health System, Singapore, Singapore, [2]Department of Nephrology–Haemodialysis, CHU Bretonneau, Tours, France, [3]Department of Nephrology–Haemodialysis, Centre Hospitalier, Bourges, France, [4]Department of Nephrology–Haemodialysis, Polyclinique, Blois, France and [5]Department of Vascular Radiology, Clinique St Gatien, Tours, France

Correspondence and offprint requests to: Claude J. Renaud; E-mail: claude_jeffrey_renaud@nuhs.edu.sg

Abstract

Background. Witholding treatment in asymptomatic/pauci-symptomatic high-grade central vein stenosis (CVS), i.e. those not causing debilitating painful extremity oedema, the benefits of which have been shown in only one study in grafts, is debatable. The aim of our study was to assess the short- and long-term benefits of such a strategy in mainly autogenous fistulas.

Methods. We retrospectively compared the outcomes of 53 untreated asymptomatic/pauci-symptomatic and 50

symptomatic high-grade CVS treated by dilation with or without stenting between January 1998 and August 2010 at a single center. Central vein and access patency was estimated by Kaplan–Meier analysis.

Results. Mean age, central catheter use and location of stenosis (brachiocephalic vein) in asymptomatic/pauci-symptomatic and symptomatic CVS were significantly different at 69 versus 75 years, 28 versus 48% and 74 versus 56%, respectively. Ninety percent of the cases had an autogenous fistula. The mean degree of stenosis was >80%. Fourty percent of asymptomatic/pauci-symptomatic CVS became severely symptomatic after 4 years. Primary central vein patency at 3, 12, 24 and 36 months in asymptomatic/pauci-symptomatic and symptomatic CVS were 87 ± 5 versus 82 ± 6, 77 ± 6 versus 55 ± 9, 71 ± 7 versus 35 ± 9 and 67 ± 7 versus 18 ± 9%, respectively (P = 0.002). Primary access circuit patency rate was not significantly different between the two groups with 66 ± 5 versus 50 ± 4% at 1 year. Secondary central vein and access circuit patency rates at 1 and 3 years were 100 and 93 ± 7 versus 89 ± 5 and 84 ± 7% (P = 0.014).

Conclusions. Withholding treatment in asymptomatic/pauci-symptomatic CVS in dialysis fistulas yielded significantly better short- and long-term central vein patency than treatment of symptomatic cases without detrimental effects on overall dialysis circuit.

Keywords: autogenous fistulas; central vein stenosis; outcomes; percutaneous transluminal angioplasty; vascular access

Introduction

There is growing awareness that the treatment of central vein stenosis (CVS) and occlusion in patients without debilitating extremity oedema may be detrimental given the poor long-term patency rates usually associated with treatment [1–3]. The National Kidney Foundation Kidney Dialysis Outcomes Quality Initiative 2006 guidelines [4], unlike its 1997 [5] and 2001 [6] editions, advocate percutaneous transluminal angioplasty (PTA) with or without stenting over surgery for treatment of CVS only when they are associated with symptoms. However, only one retrospective study in grafts supports this strategy [7]. It is not clear if asymptomatic or pauci-symptomatic high-grade CVS in patients with predominantly autogenous fistulas behave similarly.

As a result of our previous experience, our policy from 1998 was to treat CVS and occlusions only when they become severely symptomatic, i.e. causing handicapping or painful arm oedema. The purpose of this retrospective study was to evaluate the short- and long-term outcomes of this strategy.

Materials and methods

Patients and settings

No institutional review board approval was required for this retrospective study. All angiograms of consecutive end-stage kidney disease patients on three times a week haemodialysis seen at a large national referral vascular access center between 1 January 1998 and 31 August 2010 were reviewed and re-read by two authors (C.J.R. and L.T.R.), searching for CVS.

Inclusion/exclusion criteria

All patients with high-grade CVS, defined as >50% stenosis of the subclavian, brachiocephalic trunk or superior vena cava mandatorily associated with reflux into upstream collaterals were included in the study except if CVS had been previously treated in another institution or before January 1998. Patients fulfilling these criteria of high-grade CVS were then split into two groups: Group A if the CVS was considered 'symptomatic' and treated at the time of the first angiogram and Group B if the CVS was considered 'asymptomatic or pauci-symptomatic' and left untreated at the time of the first angiogram.

Symptomatic CVS (Group A) was treated at the time of first angiogram only in cases of painful, distressing or severe arm oedema impairing everyday life use of the limb. Such oedema did not prevent the regular use of the vascular access but the pain and impaired arm function prompted the patients to seek redress. The vein or graft lying beneath the skin remained always accessible to needles. We excluded one case of CVS with no extremity swelling which was treated because of evidence of reflux into the intracranial veins in order to prevent development of intracranial hypertension as has been previously reported [8–11].

Asymptomatic CVS (Group B) was not treated at the time of the first angiogram because they were not the cause of access dysfunction for which angiography was indicated. They were incidentally detected during systematic angiographic evaluation of the outflow. For example, CVS was not a cause of low flow (<500 or 600 mL/min in fistulas and grafts, respectively), difficulties in cannulation, prolonged bleeding times, hand ischemia, re-circulation (>15%), ineffective dialysis ($KT/V < 1.2$) or access thrombosis. Such clinical abnormalities were always explained by concomitant peripheral stenoses and were solved after treatment of these peripheral stenoses. Pauci-symptomatic CVS stenoses (also Group B) were eventually the cause of moderate hand/forearm oedema or increase in venous pressure (dynamic venous pressure >120 mmHg) with no consequence on the quality of life and dialysis, the reason why they were also left untreated. As previously mentioned, this approach resulted from our previous clinical experience and was one rationale for this study.

Data collection

Clinical data were collected on the patients' age, sex, race, date of haemodialysis initiation and access creation type and location of vascular access, diabetes mellitus status, history of and current use of central haemodialysis catheters and cardiac rhythm management devices (CRMDs, i.e. pacemakers and defibrillators). We re-assessed all selected lesions for degree of stenosis (referenced to the adjacent upstream normal vein), total occlusion and thrombi embolization to the level of the stenosis (logjamming). Data on stenosis and symptom evolution with or without treatment were obtained from clinical notes and serial angiograms performed only in cases of recurrence of clinical abnormalities.

Procedures/technique

Central venography was performed using 10 mL of iodinated contrast material and digital subtraction acquisitions with image processing at three frames per second. A ≥50% stenotic lesion of the central veins with filling of collaterals veins and/or 'logjamming' with concomitant painful severe extremity oedema was an indication for PTA. These symptomatic central lesions were accessed and crossed through an antegrade cannulation of the vascular access. Three cases were approached from the femoral vein.

Angioplasty balloons 9–16 mm in size and with rated burst pressure 16–30 atmospheres were selected—Blue-Max and XXL (Boston Scientific, Natick, MA) (1998–2002) and Atlas and Conquest (Bard Peripheral Vascular Inc., Tempe, AZ) (2002–10). Stents 12–16 mm in size were placed only if PTA was unsatisfactory due to flow-limiting elastic recoil, failure of sufficient disappearance of collaterals or stenosis re-occurrence within 3 months after a previous PTA. Stents used were 1 Wallstent (Boston Scientific), 1 Wallgraft (Boston Scientific), 23 Smartstents (Cordis) and 4 Fluency (Bard Peripheral Vascular; Angiomed GmbH, Karlsruhe, Germany). Stent size used was based on the largest balloon used (usually 1–2 mm above balloon diameter). Three cases with logjamming underwent declotting by a method previously described, using a 45-cm 9F sheath pushed in contact with the thrombus [12]. All procedures were conducted as day cases under inhalational conscious sedation using a 50% nitrous oxide per 50% oxygen gas mixture by face mask under routine cardiac and oxygen saturation monitoring, except for four patients who received intravenous Sulfentanyl, Propofol and/or Midazolam. No patient received any form of anticoagulation

(except during haemodialysis and thromboaspiration) as an attempt to treat the oedema prior to angiography/dilation.

Study end points and definitions

Results for all treated cases were standardized to current Society of Interventional Radiology (SIR) guidelines [13]. Technical failure was defined as an inability to cross and dilate the lesion with <30% residual stenosis at the time of the primary procedure. The disappearance of reflux into upstream collaterals after dilation or stent placement was the best indicator of technical success but some degree of residual reflux was almost the rule, especially in high-flow fistulas, and insufficient decrease in reflux was an indication for stent placement. Clinical success, defined as the disappearance of extremity swelling and uninterrupted use of the access for haemodialysis, was eventually the sole reliable criterion of success. This clinical success, complete disappearance of the oedema, was assessed clinically by the attending nephrologists in the days following treatment.

All complications that occurred within 30 days were considered procedure related and were reported also as per SIR guidelines. The primary central vein patency was defined as the time interval between a successful initial PTA or stent and the first repeat intervention on the central vein in the case of symptomatic CVS or the time interval between diagnosis of stenosis and eventual onset of severe extremity swelling in asymptomatic/pauci-symptomatic cases. Secondary central vein patency was defined as the time interval between the diagnosis of CVS and the date of access abandonment whatever the cause (including recurrence of arm oedema with failure of CVS re-opening), surgical ligation, death, transplant or loss to follow-up, regardless of the number of subsequent procedures performed to treat CVS recurrent stenoses. Access circuit primary patency was defined as the time interval of uninterrupted use of the access for haemodialysis between the diagnosis of CVS, treated or untreated, and the first intervention for access dysfunction or symptomatic oedema. Access circuit secondary patency was defined as the time interval between the diagnosis of CVS and access abandonment whatever the cause, surgical ligation, death, transplant or loss to follow-up, regardless of the number of subsequent procedures performed to treat CVS or recurrent peripheral stenoses.

Statistical analysis

Primary and secondary central vein patency rate was estimated using Kaplan–Meier survival techniques and the difference was compared by log-rank test. The accesses primary and secondary patency rates were also assessed to rule out any confounding effect on central vein patency rates and *vice versa*. Discrete variables were expressed as percentage and continuous variables as means and SDs or range. Clinical variables were analyzed to assess for associations with outcomes using the Student's *t*-test, Pearson chi-square test, Wilcoxon rank sum test and Fisher exact test.

The level of significance was set as $P < 0.05$. All analyses were conducted using SPSS version 17 for Windows (SPSS Inc., Chicago, IL).

Results

Patients

Fifty-three asymptomatic/pauci-symptomatic (Group B) and 50 symptomatic CVS (Group A) were identified in 53 and 49 patients, respectively. Fifty-three percent of Group B was pauci-symptomatic. The rest had been referred for (i) difficult access cannulation (15%); (ii) low flow access (11%); (iii) immature fistulas (9%); (iv) thrombosed access (9%) and (v) extremity/hand pain (2%). The patients' clinical features are shown in Table 1. One patient in Group A had a left and right brachiocephalic vein stenosis angioplastied at a different time period and each side was treated as one case. Of note, there were statistically significant differences in the mean patient age, previous haemodialysis catheter exposure and location of the central stenosis between patients presenting with asymptomatic/pauci-symptomatic and symptomatic CVS. Ipsilateral forearm and upper arm fistulas constituted >90% of the accesses evaluated in both groups. The mean baseline stenosis and the number of cases with complete occlusion of the brachiocephalic vein were not significantly different.

Technical and clinical success

PTA failed in four patients and residual stenosis of >30% without flow limitation was seen in six patients giving an overall technical success rate of 80%. Seventy-two percent (five of seven) of occlusions were crossed and successfully treated. Fifteen of the 46 PTAs performed were followed by stent placement (14 Smartstents and 1 Wallstent) to improve on flow-limiting recoils (8 cases), failure of sufficient disappearance of collaterals (6 cases) or to trap residual thrombi post-thromboaspiration (1 case). Mean post-procedure stenosis was 17% (range, 0–50%). All extremity oedema disappeared after dilation/stenting within 48 h resulting in a clinical success rate of 92% (46 of 50). There were no immediate complications recorded during the treatment procedures. Two patients had fluid overload within hours of successful treatment and hence required in-center haemodialysis. This complication was likely due to underlying poor cardiac function as has recently been reported [14]. This never recurred after we decided to refer all patients for immediate haemodialysis after successful re-opening of CVS. Two deaths occurred within 30 days of the procedures. They were cardiac related and had no obvious link with the re-opening of the central vein obstruction.

Follow-up

A total of 133 (mean 2.55) angiograms were performed in Group B; 42/53 had follow-up angiograms. One hundred and twenty-seven (mean 2.5) angiograms were performed in Group A; 24/50 had follow-up imaging. Follow-up was not significantly different in the two groups (Table 1). Table 2 summarizes the outcomes at the end of the follow-up.

Central vein patency

The primary central vein patency is shown in Table 3 and Figure 1. Asymptomatic/pauci-symptomatic CVS had significantly superior primary central vein patency rate than treated symptomatic CVS (log-rank test, $P = 0.002$). At the end of follow-up, 21 (40%) had developed symptoms, providing a 60% primary patency rate at 4 years. The mean time between CVS diagnosis and first PTA was 18.6 (range, 0.6–72.4) months. They also demonstrated a higher secondary central vein patency rate than treated CVS ($P = 0.014$) as shown in Table 3 and Figure 2. Treated CVS required an additional 56 PTAs, 15 stent placements and 2 thromboaspirations resulting in an average 2.56 central procedures per case per follow-up. One patient had a combination of 7 PTAs, another 13 PTAs, while 5 had a second stent and one a third stent. No significant difference was observed between the primary and secondary central vein patency rate of stenoses, which received PTA only or a combination of PTA and stent at first treatment ($P = 0.217$).

Access patency

Primary access circuit patency in patients with asymptomatic/pauci-symptomatic and symptomatic CVS was similar

Table 1. Patient demographics and clinical characteristics

Characteristics	Asymptomatic/ pauci-symptomatic	Symptomatic	P
Patients (*n*)	53	49[a]	
CVS (*n*)	53	50	
Mean age in years (range)	69 ± 14 (24–89)	75±10 (47–92)	0.021
Male–female ratio in %	68:32	58:42	0.21
Diabetes mellitus (%)	20 (37)	15 (30)	0.179
Prior central catheter use (%)	14 (26)	24 (48)	0.044
CRMD use (%)	9 (17)	10 (20)	0.424
Number of venograms	133	127	
Mean number of venograms per patient (range)	2.6 (1–13)	2.5 (1–18)	
Follow-up in months (range)	23.8 (0.6–138.2)	22.4 (0.6–84.7)	0.215
Type of vascular access (%)			
Forearm fistula	39 (74)	36 (71)	
Upper arm fistula	9 (17)	8 (16)	0.305
Forearm graft	0	3 (6)	
Upper arm graft	5 (9)	3 (6)	
Mean access age in months (range)	33 ± 34 (1–155)	38 ± 40 (0.23–190)	0.49
Location of CVS (%)			
Brachiocephalic vein	39 (74)	23 (46)	
Subclavian vein	14 (26)	26 (54)	0.05
Superior vena cava	0	0	
Mean baseline stenosis in % (range)	82 ± 13 (50–100)	82 ± 12 (60–100)	0.889
Logjamming (%)	3 (5)	4 (6)	
Total occlusion (%)	10 (19)	7 (14)	0.363

[a]One patient in the symptomatic group underwent bilateral central vein angioplasty during the course of follow-up.

(Table 3 and Figure 3). Secondary access circuit patency was in essence similar to secondary central vein patency by definition. In patients with asymptomatic/pauci-symptomatic CVS, this was maintained at 100% till 24 months follow-up when one access was ligated for distal ischemia resulting in a 94% patency from that point (Table 3 and Figure 2). Accesses with treated symptomatic CVS had a more modest secondary patency. The difference between the two survival outcomes was significant (P = 0.014).

Table 2. Clinical outcomes of all followed up central vein stenoses[a]

Event at end of follow-up	Asymptomatic CVS	Symptomatic CVS
Functional asymptomatic access (%)	17 (32)	16 (32)
Ligated access (%)	1 (2)[b]	6 (12)[c]
Transplant (%)	2 (3)	3 (6)
Loss to follow-up (%)	0	3 (6)
Death (%)	12 (23)	22 (44)
Developed symptoms (%)	21 (40)	NA

[a]NA, not applicable.
[b]One distal ischemia.
[c]Three failed angioplasties, one CVS recurrence and two distal ischemia.

Discussion

There is a clear consensus that central vein stenoses and occlusions developing in the outflow of dialysis accesses have to be treated when they cause handicapping arm oedema and that failure in re-opening the central drainage results in the access being ligated or embolized as the only way to treat the oedema. It is probably useful to emphasize from our experience that even severe arm oedema never precluded the regular use of the vascular access, which lies beneath the skin and remained accessible for effective dialysis. Such stenoses are frequently the consequence of previous central vein catheterization for urgent dialysis, intensive care venous access and placement of CRMDs. This is the reason why upper limb venography is recommended in these patients prior to surgical creation of any vascular access [2, 3, 15]. However, the present study confirms that central stenoses can also develop spontaneously since 63% (65 of 103) of the cases had no history of previous central vein catheterization. In contrast, central vein stenoses and occlusions can be qualified asymptomatic when they are incidentally diagnosed during angiography performed for abnormalities due to a peripheral stenosis or pauci-symptomatic when they cause simple increase in peripheral venous pressures, prolonged bleeding or transient mild arm swelling. The angiographic severity of the central stenosis is not a sufficient explanation for the development of arm oedema since apparently moderate central stenoses can be symptomatic and conversely complete occlusions can remain symptom free. There exists an obvious balance between access flow and the development of collaterals. Hemodynamic pressure studies in grafts have shown that less intra-access pressure is generated by CVS than peripheral stenosis despite more severe lesions in the former due to the greater ability at collateralization by central veins and their greater caliber and capacitance [16]. Poorly developed collaterals might be unable to divert low-flow fistulas, whereas huge collaterals can compensate high flows. Collaterals also have more time to enlarge and compensate fistula flow when the central obstruction develops progressively. It can also be hypothetized that stenoses can then develop on collaterals and explain why initially asymptomatic stenoses suddenly cause arm oedema. It has also

Table 3. Patency rates in central vein and entire access circuit (estimated percentage cumulative patency ± percentage SE)

Follow-up in months	3	6	12	24	36	P
Primary central vein patency						
Asymptomatic CVS	87 ± 5	77 ± 6	77 ± 6	71 ± 7	67 ± 7	0.002
Symptomatic CVS	82 ± 7	68 ± 6	55 ± 4	35 ± 9	18 ± 9	
Primary access patency						
Asymptomatic CVS	83 ± 5	72 ± 7	66 ± 5	44 ± 8	30 ± 1	0.695
Symptomatic CVS	81 ± 6	68 ± 6	50 ± 4	35 ± 9	17 ± 11	
Secondary central and access patency						
Asymptomatic CVS	100	100	100	93 ± 7	93 ± 7	0.014
Symptomatic CVS	92 ± 4	92 ± 4	89 ± 5	89 ± 5	84 ± 7	

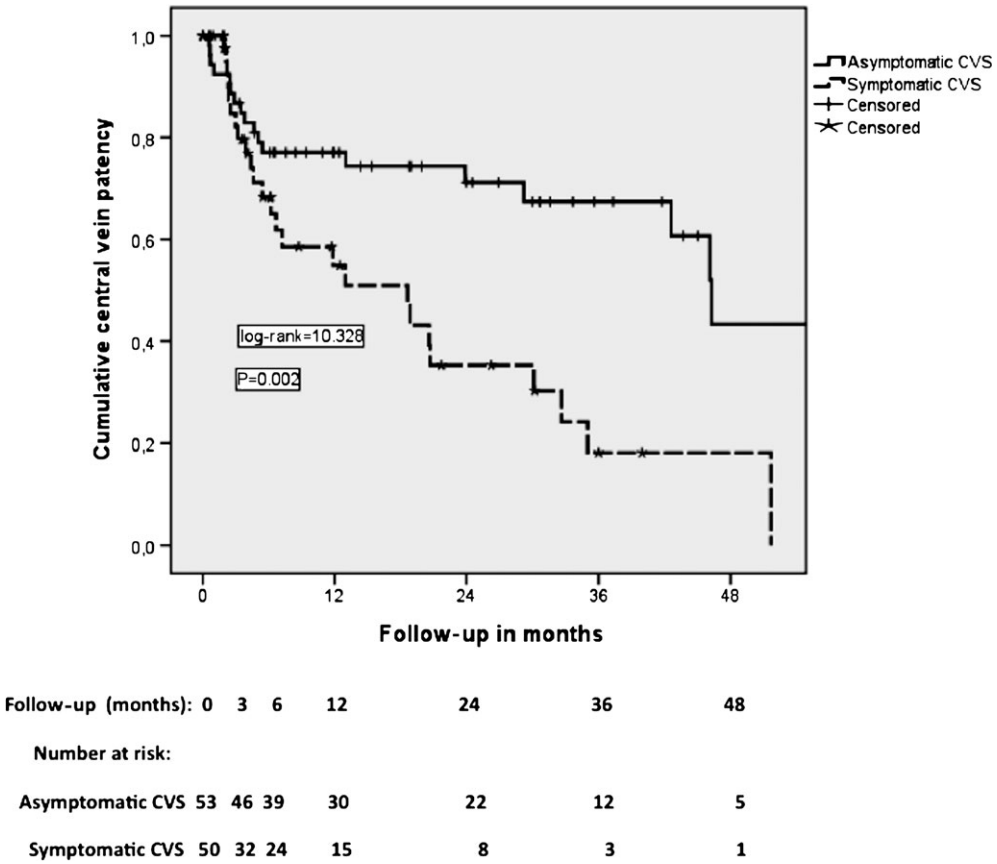
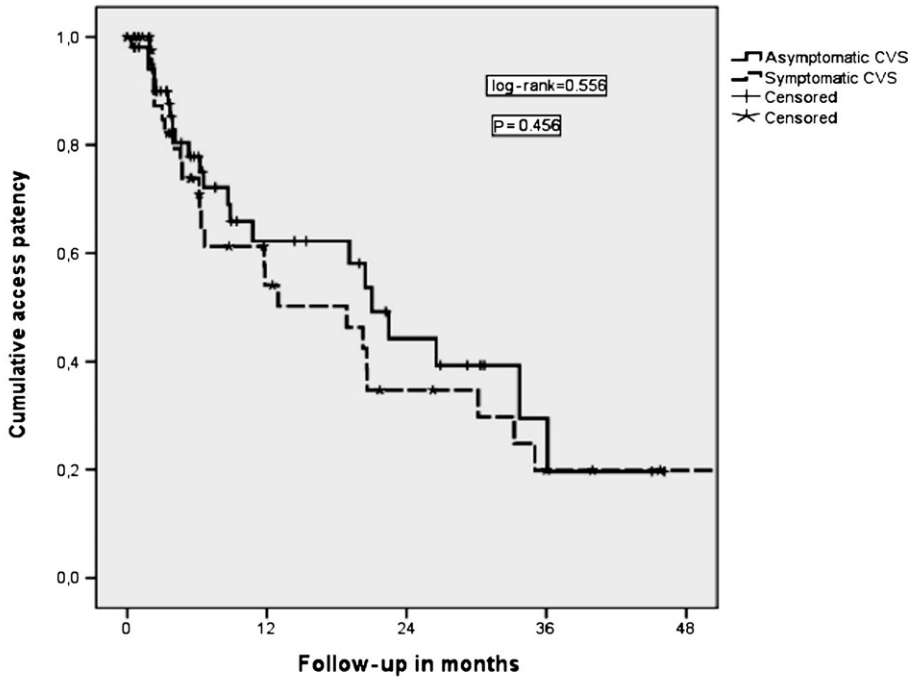


Fig. 1. Kaplan–Meier analysis of central vein primary patency of asymptomatic and treated symptomatic central vein stenoses.

incidentally happened that PTA of peripheral stenoses in accesses with asymptomatic or pauci-symptomatic CVS triggered hand oedema within 2 weeks after PTA, necessitating secondary CVS treatment. Collaterals are therefore protective rather than merely indicative of severe stenosis, except when there is significant reflux into the jugular veins, a phenomenon associated with pseudotumor cerebri-like manifestations in adults and children [8–11]. It is also well known that stenosis grading is challenging in dialysis accesses since the reference vessel diameter can be difficult or impossible to determine. In particular, the subclavian vein shows physiological narrowing at the level of the thoracic outlet a fact known for over half a century [17]. On this basis, all data about spontaneous improvement or regression of stenoses with time that are based on purely angiographic data need to be interpreted with caution. This is the reason why we considered that the diagnosis of significant CVS should be mainly based on the evidence of reflux in upstream collaterals and angiographic stenosis progression was not included as an outcome measure in our study.

Little is known about the natural history of asymptomatic/pauci-symptomatic severe CVS. Although they may increase venous pressure in haemodialysis circuits, it has never been proven that they are a cause of access thrombosis. It is well known nonetheless that once treatment is initiated, non-withstanding the patients' symptoms status, this is beneficial only in the short-term and patency rates are generally poorer than those seen in dilated peripheral venous stenoses



Follow-up (months):	0	3	6	12	24	36	48
Number at risk:							
Asymptomatic CVS	53	52	28	18	10	4	0
Symptomatic CVS	50	40	25	15	8	3	1

Fig. 2. Kaplan–Meier analysis of primary access circuit patency from diagnosis of asymptomatic or treatment of symptomatic central vein stenoses.

[18]. There is therefore a need for painful re-dilatations, stent placements and eventual access loss by ligation or embolization according to all publications [1–3, 18]. KDOQI [4] might need to clarify on the indications for PTA in CVS since practice pattern difference still exists as evidenced by two recent large series where on one hand, only 40% of 69 treated cases had arm oedema [19] and in the other, where all of the 55 treated cases had symptoms [20].

It is safe to leave asymptomatic/pauci-symptomatic stenoses untreated. We showed that 60% remained symptom free at 4 years and that this conservative approach did not lead to detrimental outcomes in the entire access primary and secondary patency rates. Our results confirm the findings of two previous studies on the natural history of asymptomatic CVS. Hernandez prospectively showed that high-grade catheter-induced subclavian vein stenosis with thrombosis self-resolved in 50% of cases by 3 months without treatment [21]. Levit *et al.* [7] looking at a cohort of 24 patients with asymptomatic CVS showed that 66% of the stenoses did not worsen over a follow-up of up to 99 days. However, Levit compared treated and untreated asymptomatic stenoses, whereas we compared treated symptomatic to untreated asymptomatic/pauci-symptomatic stenoses. Levit's series also had a smaller sample size and a shorter follow-up. The severity of the stenoses was likely lesser that ours since not all stenoses showed concomitant reflux in collaterals; and some of our asymptomatic stenoses became symptomatic with time, whereas this did not occur in Levit's series. Our cohort had predominantly forearm autogenous fistulas compared to Levit's sole inclusion of upper arm prosthetic grafts. There exists little data on the impact of access type and location on the behavior of asymptomatic CVS though Rajan *et al.* [22] described in two separate publications that symptomatic CVS is more common in patients with upper arm than forearm fistulas, which is not surprising since upper arm fistulas have higher flow rates and that CVS in patients with prosthetic grafts tend to have poorer survival post treatment than those with fistulas [23], which is usual in all studies comparing prosthetic grafts to autogenous fistulas in the long term.

Our results also indicate that the use of PTA and stents to treat CVS even at an advanced symptomatic stage does not generate worst outcomes to what has been previously reported on CVS treated much earlier. Our technical success rate was 80% and is in agreement with published rates of 70–100% [23–26]. Technical success rate in occlusions is much lower at a reported 50% success rate [18] and our rate of 72% confirms this. Published central vein primary patency rates are variable: 67–100% at 3 months [27, 28], 33–89% at 6 months [20, 29–31], 17–70% at 12 months [32, 33] and 0–50% at 24 months [26, 29, 32]. Similarly reported secondary patency rates are 55–100% at 6 months [28, 30, 32],

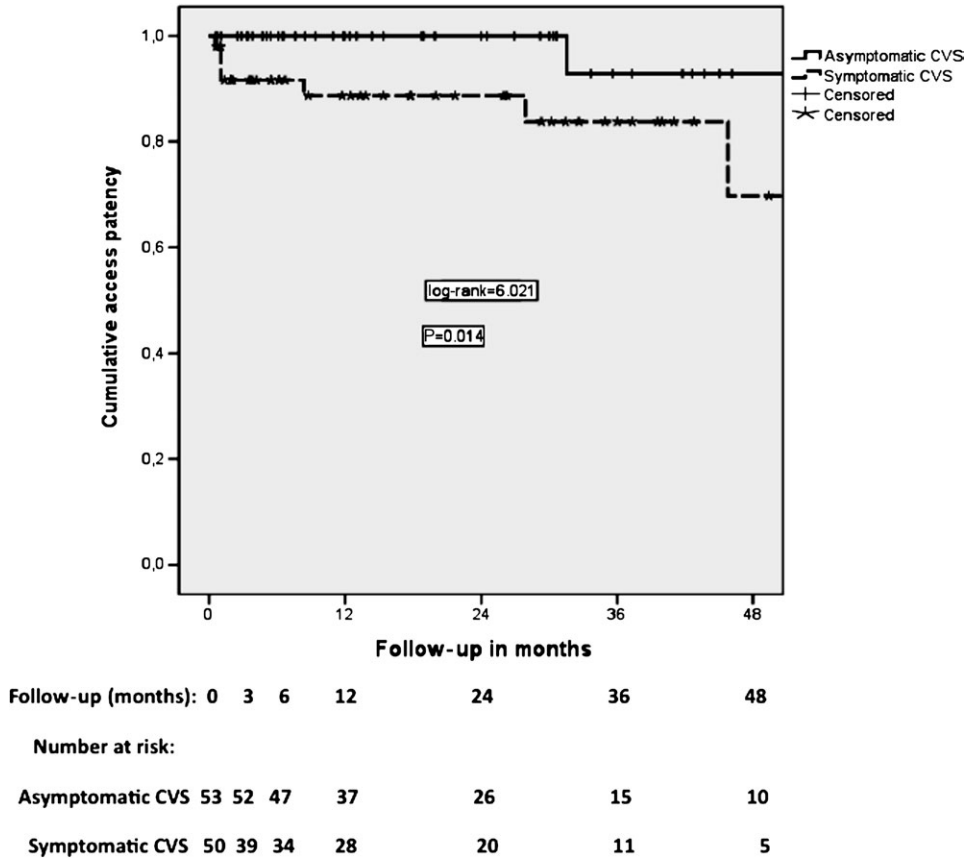


Fig. 3. Kaplan–Meier analysis of secondary patency of central vein and entire access circuit of cases with asymptomatic and treated symptomatic central vein stenoses.

46–100% at 12 months [28, 33] and 22–84% [29, 31] at 24 months. This wide variance in patency rates reflects the heterogeneity of the cases treated, sample size of the cohorts and differences in the definition of symptomatic CVS, outcomes definition and treatment algorithm used. It is not easy to compare our primary and secondary patency rates after treatment (with and without stent) to those in the literature since we had a majority of autogenous fistulas while demographic data of patients were not always provided in previous publications. However, our primary and secondary patency rates of roughly 50 and 90% at 1 year for both CVS and entire circuit are globally encouraging. Long-term primary and secondary central vein patency rates beyond 24 months are generally poor with large SEs and are thus not usually reported. Our 36-month secondary central patency of 84% is an apparent improvement over what has been described by Kim *et al.* [34] who reported a rate of 33% in a cohort of 44 patients in whom only 86% had extremity oedema. Long-term primary patency rate, however, was comparable at 18–20%.

Our study has limitations. It is retrospective and shares all the drawbacks of this approach. Ninety-five percent of the patients were of Caucasian race and hence most of these recommendations may not be applicable to other races. A comparison of re-circulation and access flow between the two groups would have more clearly addressed the concerns of dialysis inadequacy and thrombosis risk in untreated cases. However, this would have been confounded in cases presenting with concomitant peripheral stenoses, which also have an impact on access flow and thrombosis risk. Patency rate measurement beyond 12 months, in some cases, had SE measurements >10% of the percentage cumulative patency, hence negatively affecting the validity of the long-term outcomes. The majority of published CVS studies with long-term outcomes have similar shortcomings [19, 29, 30, 34]. Inclusion of two lesions from the same patient treated at different time interval as separate cases was appropriate given the underlying accesses and stenoses were different and the superior vena cava was not involved. Inclusion of CVS on both sides has been the rule in previous series [7, 26, 29].

There were some differences between the two groups, namely patient age, catheter use and location of the stenosis. Older patients are more likely to have symptomatic CVS given that the stenoses probably started much earlier, allowing sufficient time for the beneficial effects of the collaterals to wear off through either stenosis or occlusion. The association between catheter use and symptomatic CVS is well known [18]. Asymptomatic CVS is associated more with brachiocephalic rather than subclavian stenoses as a result of the higher density of collaterals found upstream of the more central brachiocephalic stenoses, allowing more effective blood flow diversion and hence lesser likelihood of generating extremity oedema.

We can conclude that withholding treatment in asymptomatic/pauci-symptomatic high-grade CVS leads to significantly better central vein patency rate than that seen in treated symptomatic cases. This approach does not shorten

overall access survival in patients with autogenous fistulas. We confirm that CVS should therefore be treated only in cases of major clinical problem: painful handicapping arm oedema and probably in prevention of intracranial hypertension, in the rare cases when collaterals run through the brain.

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Conflict of interest statement. None declared.

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