Characteristics and outcomes of stent occlusion after iliocaval stenting

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ABSTRACT

Objective: With increasing use of iliocaval stenting, complications have become more noticeable. Stent occlusion is one such outcome that has not been studied in detail. Characteristics of stent occlusion in addition to outcomes after recanalization are presented.

Methods: An analysis of 3468 initial iliocaval stents placed during an 18-year period from 1997 to 2015 was performed. A total of 102 stent occlusions were identified, amounting to a 3% stent occlusion rate. Characteristics evaluated included onset after stent placement, techniques used for restoring patency, and their outcome. Kaplan-Meier analysis was used to assess stent patency. Regression analysis was used to evaluate risk factors for stent occlusion.

Results: Stent occlusions occurred at a median of 5.8 months after placement. The occluded stent could be reopened after a wide range of intervals, the longest being 14 years. The majority (69%) of occlusions were chronic (>30 days) and the remainder (31%) were acute; 77% of the occlusions occurred in post-thrombotic limbs. The most common technique used to recanalize the acutely occluded stent was pharmacomechanical thrombectomy, whereas wire recanalization with balloon angioplasty was the technique most used for chronic occlusions. Of the 102 occluded stents, patency was achieved in 75 of 88 (84%) attempts. After successful recanalization, the median primary patency was 7 ± 1.9 months, median primary assisted patency was 7.5 ± 3.5 months, and median secondary patency was 25 ± 8.3 months. Clinically, there was improvement in the visual analog scale pain scores from a median of 3.5 to 1 ($P < .01$), in the median grade of swelling from 2 to 1 ($P < .01$), and in the mean Venous Clinical Severity Score from 6.4 to 3.8 ($P < .01$) after recanalization. A 40% ulcer healing rate was noted after recanalization during a median follow-up period of 17 months. There were no significant adverse events or mortality. Regression analysis revealed stent placement for native vein occlusion as the only statistically significant predictor of stent occlusion.

Conclusions: Stent occlusion after iliocaval stenting is a rare occurrence. Recanalization of occluded stents can be performed with minimal morbidity even months to years after occlusion with good outcomes. Long-term patency of occluded stents that were recanalized is poor compared with patency of the initially placed stent. (J Vasc Surg: Venous and Lym Dis 2019;7:56-64.)

Keywords: Iliac vein stenting; Iliocaval stenting; Iliofemoral stenting; Iliac vein stent occlusion; Iliac vein stent thrombosis; Vein stent occlusion

Obstructive iliocaval lesions can result from thrombotic or nonthrombotic causes. Post-thrombotic syndrome (PTS) is the predominant cause, given the high incidence of deep venous thrombosis.[1] Nonthrombotic iliac vein lesions (NIVLs), variably known as May-Thurner syndrome, iliac vein compression syndrome, and Cockett syndrome, occur frequently in silent form in the general population but may become symptomatic with secondary events, such as trauma, infection, or secondary thrombosis of the obstructed segment.[2-5] Other less common causes of iliac obstruction include congenital venous anomalies, iatrogenic or other trauma, retroperitoneal fibrosis, and benign or malignant tumors. In most patients with obstructive iliac vein lesions, endovenous procedures have supplanted open surgery as the treatment of choice. The last two decades have witnessed a great increase in venous stent use for femoral-iliocaval disease.[6-14] The Wallstent (Boston Scientific, Marlborough, Mass) has been the most frequently used (off label); several dedicated venous stents are in development.[14-16] Complications of iliac-caval stenting have been described.[15] One aspect that has not been explored in detail is stent occlusion. Our study attempts to fill this gap by examining stent occlusion in terms of both characteristics and outcomes after secondary restoration of patency.

METHODS

A review of contemporaneously entered data into electronic medical records of femoral-iliocaval stents in 3468 limbs between 1997 and 2015 was performed. Both acute

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(<30 days) and chronic (>30 days) occlusions identified by venous duplex ultrasound during follow-up were included in the review. The stent occlusions were analyzed for characteristics including detection after stent placement, recanalization technique, and outcomes after recanalization. A subset of 455 consecutive limbs that underwent stent placement between 2011 and 2013 were analyzed using multivariable logistic regression to identify potential risk factors for stent occlusion. These risk factors included age, sex, PTS, thrombophilia (based on laboratory values), stenting for native vein occlusion, and in-stent restenosis (ISR). Operative reports of the secondary procedure were reviewed to identify inflow or outflow lesions that may have contributed to stent occlusion. Occurrence of major adverse events was also tracked.

Pathology

Thrombotic and nonthrombotic causes were determined by prior history of iliocaval thrombosis, when present, combined with pathognomic venographic and intravascular ultrasound (IVUS) features that have been described in previous publications.[17,18]

Clinical and duplex ultrasound follow-up

Patients were observed after secondary intervention at 6 weeks, 3 months, and 6 months and yearly thereafter. The Venous Clinical Severity Score (VCSS) with visual analog scale (VAS) for pain (score 1-10) was employed. Swelling was objectively assessed using grades: grade 0, absent; grade 1, pitting, not obvious; grade 2, ankle edema; grade 3, gross swelling involving the leg up to the knee; and grade 4, swelling of the entire limb. Duplex ultrasound assessment of stent patency and estimation of luminal ISR were carried out at poststent day 1, at 2 to 4 weeks after intervention, and at subsequent clinical follow-up intervals thereafter. Significant residual or recurrent symptoms prompted more frequent stent surveillance; the time intervals were based on individualized clinical and duplex ultrasound findings. Once stent occlusion was identified by venous duplex ultrasound examination, it was confirmed by transfemoral or transpopliteal venography, depending on extent of occlusion, either previously or at time of secondary intervention, to ascertain extent and inflow/outflow detail.

Secondary intervention

Recanalization was pursued in the symptomatic patient presenting with stent occlusion. Endovascular intervention was performed under general anesthesia as the procedure can be prolonged and frequently painful during balloon dilation. No new temporary inferior vena cava filters were placed before recanalization of acute or chronic stent occlusions.

Acute stent occlusions. Acute occlusions were treated with pharmacomechanical thrombectomy (PMT) optionally followed by catheter-directed thrombolysis (CDT).

ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective cohort study
- **Take Home Message:** This was an 18-year, single-center, retrospective review of iliocaval stents and stent occlusions to determine risk factors for iliocaval stent occlusion, rate of successful recanalization of occluded iliocaval stents, and patency and clinical outcomes of recanalization of occluded iliocaval stents. Of 3468 iliocaval stents placed during an 18-year period from 1997 to 2015, there were 102 occlusions identified, with 77% occurring in post-thrombotic limbs. Re-establishment of patency was successful in 75 of 88 attempts (84%), with no mortality or major adverse events, with improvement in visual analog scale pain scores and Venous Clinical Severity Scores ($P < .01$), and with median primary patency of 7 ± 1.9 months and median secondary patency of 25 ± 8.3 months.
- **Recommendation:** If it is clinically indicated, the authors recommend that occluded iliocaval stents undergo an attempt at recanalization.

PMT was carried out using the Trellis-8 system (Covidien, Mansfield, Mass) and more recently the AngioJet peripheral thrombectomy catheter (Boston Scientific). Subsequently, balloon maceration (18×60-mm angioplasty balloon) was used to clear residual thrombus (Fig 1). Follow-up CDT using UniFuse infusion catheter (AngioDynamics, Latham, NY) was performed for 24 to 48 hours if PMT was unsuccessful in restoring in-line flow or if there was significant residual thrombus. IVUS provides a truer assessment of residual thrombus than venography.[17,18]

Chronic stent occlusions. The technique of stent recanalization of chronic occlusions is preferentially done through a midthigh femoral vein approach; the short entry to the lesion allows greater pushability of instruments.[19] Access of the profunda femoris vein or the popliteal vein was sometimes required, depending on inflow. The internal jugular vein approach with body floss technique, if required, was used when the antegrade approach failed.[20,21] Glidewire (0.035 inch) supported by angled-tip Glidecath (Terumo Medical Corp, Somerset, NJ) was primarily used to negotiate passage through the occluded stent. Quick-Cross support catheter (Spectranetics Corp, Colorado Springs, Colo) and the TriForce peripheral crossing set (Cook Medical, Bloomington, Ind) were supplementally used. When successful entry and passage through the occluded stent were not possible with these devices, laser or radiofrequency wires were used for recanalization.

Laser or radiofrequency wire recanalization. Laser recanalization is accomplished using either the 2.3-mm

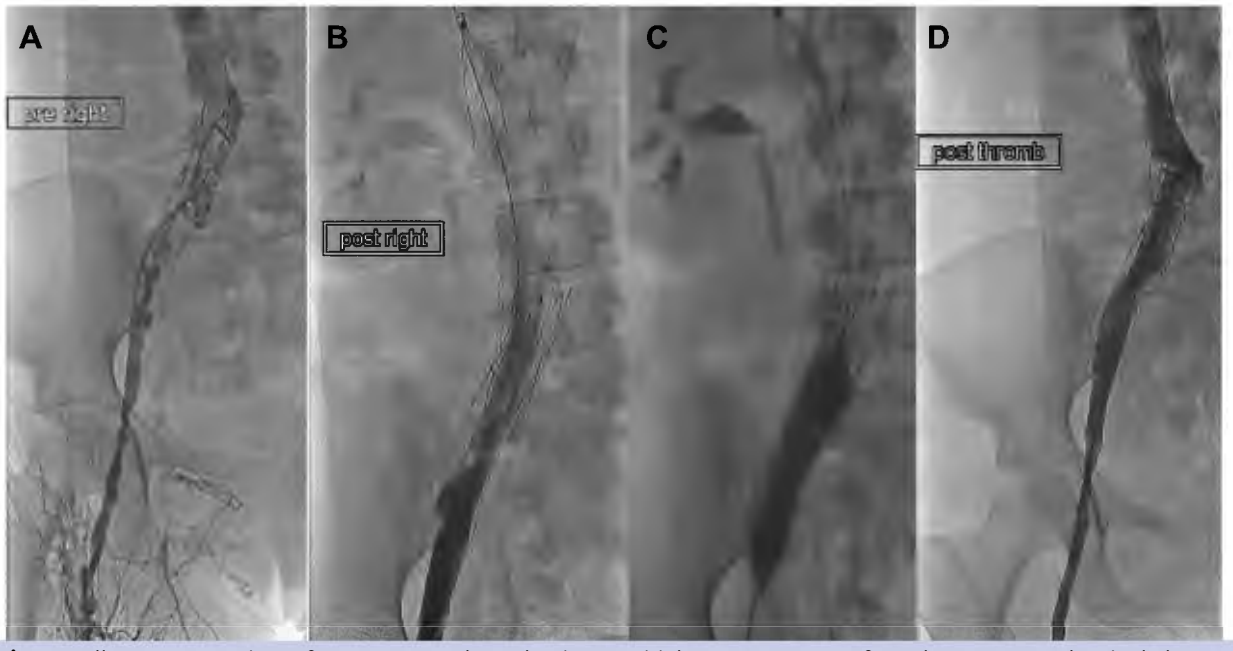

Fig 1. Balloon maceration of acute stent thrombosis. **A,** Initial venogram. **B,** After pharmacomechanical thrombectomy (PMT): persistent thrombus burden. **C,** Angioplasty using 18- × 60-mm balloon. **D,** Completion venogram.

or 2.5-mm Turbo-Elite laser atherectomy catheter (Spectranetics Corp). The antegrade or retrograde approach can be used, and the laser catheter is advanced over a 3.5-cm flexible-tip Amplatz Super Stiff polytetrafluoroethylene-coated guidewire (Boston Scientific). The Glidewire is subject to damage with this device and should not be used. If one is sure of the location of the catheter within the stent (IVUS or multiplane fluoroscopy), it can be advanced bareback, provided one does not go outside the stent. Fig 2 depicts use of the laser catheter.

Commercially available radiofrequency wire can also be used for stent recanalization when standard techniques do not work. Our experience has been with the 0.035-inch 250-cm PowerWire (Baylis Medical, Mississauga, Ontario, Canada). The PowerWire radiofrequency guidewire delivers radiofrequency power in a monopolar mode between its distal electrode and an external disposable indifferent patch. The key is to ensure that the wire is within the confines of the stent before and during progression and not passed through the stent interstices.

Once wire recanalization was complete, angioplasty was carried out using large-caliber (≥18-mm) high-pressure (14-16 atm) Atlas balloons (Bard Peripheral Vascular, Tempe, Ariz) until appropriate luminal areas were attained.[22] This can be done in a single step, saving supplies if the thrombus is soft. With harder lesions, sequentially larger balloons had to be employed (particularly after laser or radiofrequency recanalization) because of "watermelon seeding" of the large-caliber balloon. Angioplasty was carried out caudal to cranial (femoral access) or cranial to caudal (jugular access) to enable easier retrieval of the angioplasty balloon should it disrupt. Stent extension was carried out if needed to ensure adequate inflow and outflow, with landing zones determined by IVUS related to adjacent bone landmarks. Gianturco-Rösch Z stents (Z stent; Cook Medical) are generally used for upper extensions into the cava and Wallstents for others. The technique of using the Wallstent-Z stent combination has been described previously.[23] The inguinal ligament is often an area of compression requiring stent extension across the ligament.[24] Completion IVUS interrogation (Visions PV .035; Philips Volcano, San Diego, Calif) was then performed to ensure adequacy of planimetric measurements of the stent luminal areas of the common femoral vein, external iliac vein, and common iliac vein; 125 mm^2, 150 mm^2, and 200 mm^2 were used as normal luminal area cutoffs in the common femoral vein, external iliac vein, and common iliac vein stent segments, respectively.[22] Any residual narrowing on IVUS was overcome by repeated dilation using sustained inflation or, if necessary, a larger caliber angioplasty balloon (20-24 mm). Completion venography was subsequently performed. The 11F sheath was then withdrawn to just outside the vein, and a Surgicel Fibrillar patch (Ethicon, Somerville, NJ) was introduced through the sheath into the track to aid in local hemostasis. Manual pressure was maintained to complement the hemostatic effect. A compressive dressing was finally applied over the access site.

Anticoagulation

Enoxaparin (40 mg) was given preoperatively. Bivalirudin 75 mg (more effective thrombin inhibition in our

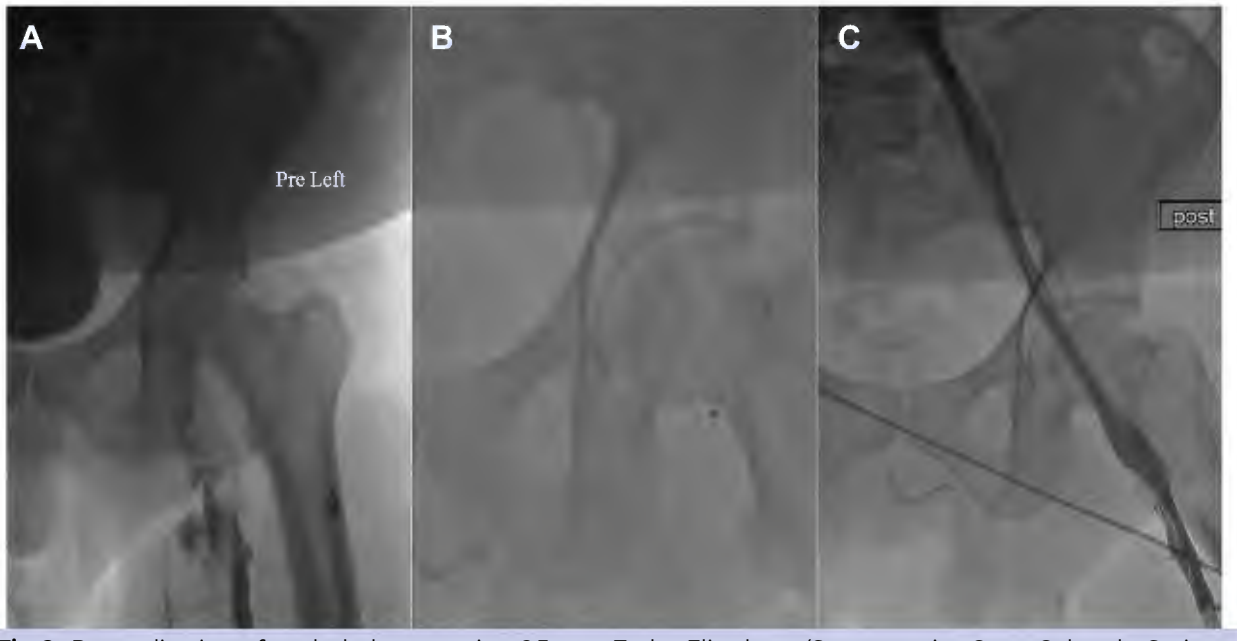

Fig 2. Recanalization of occluded stent using 2.3-mm Turbo-Elite laser (Spectranetics Corp, Colorado Springs, Colo). **A,** Initial venogram demonstrating occluded stent. **B,** Laser recanalization being performed through internal jugular approach (radiopaque tip gives distal location). **C,** Venogram after recanalization.

experience) was given intravenously in the operating room before the start of the procedure. Long-term anticoagulation, typically direct-acting oral anticoagulants, were instituted in recanalized patients. Aspirin 81 mg and cilostazol 50 mg twice daily were optionally added. Cilostazol suppresses neointimal hyperplasia.[25-28] The time for re-endothelialization after venous trauma is approximately 6 weeks.[29]

Informed consent was obtained from treated patients. Institutional Review Board permission was obtained for publication of this analysis.

Statistical analysis

All statistical analysis was performed using SPSS Statistics version 24 (IBM Corp, Armonk, NY). Clinical outcomes including pain, swelling, and VCSS were compared before and after intervention using the paired *t*-test. Patency was assessed using the Kaplan-Meier analysis. *P* value ≤.05 was considered significant. Multivariable logistic regression was used to evaluate the impact of six risk factors previously noted on stent occlusion. Some numbers vary slightly from aggregate case material because of missing data. This is reflected in specific number values shown in context.

RESULTS

Characteristics of stent occlusion. Of the 3468 stented limbs, stent occlusions occurred in 102 limbs (95 patients) for a stent occlusion rate of 3%. Of these, 36 were men and 59 women. Among those with stent occlusions, there was a preponderance of left-sided stents (75%). Thrombophilia was present in 38 of 95 patients (40%; of these, 3/38 patients had discontinued anticoagulation). Clinical, Etiology, Anatomy, and Pathophysiology (CEAP) classification scores ranged from 3 to 6 (Table I). Of the 68 limbs that underwent recanalization for which data were available, 27 limbs had occlusion of the entire stent column, whereas the remainder had only segmental occlusion (upper segment, 8; middle segment, 7; and lower segment, 26). Fourteen (15%) patients had undergone bilateral stenting. Of these, five (36%) had bilateral stent occlusions, the remainder unilateral occlusion. Of the five bilateral stent occlusions, four had undergone the fenestrum technique and one had the combination Z stent-Wallstent technique.[23,30] The fenestrum technique involves using large-caliber balloons (>18 mm) to enlarge the interstice of the Wallstent that covers the contralateral common iliac vein outflow. This enlarged interstice (fenestrum) is then stented to provide an outflow channel for the common iliac vein.

Table I. Baseline Clinical, Etiology, Anatomy, and Pathophysiology (*CEAP*) clinical scores

CEAP class	No. (%)
3	38 (52)
4	9 (12)
5	9 (12)
6	18 (24)
Total	74[a]

[a]Patients for whom data were available.

Table II. Clinical scores before and after intervention

Variable	Preintervention score	Postintervention score	*P* value
VAS (pain)	3.5	1.0	<.01
Swelling	2	1	<.01
VCSS	6.4	3.8	<.01

VAS, Visual analog scale; *VCSS*, Venous Clinical Severity Score.

Stent occlusion occurred a median of 5.8 months after stenting (1 day-14.4 years). The nature of the occlusion was acute (≤30 days since stent placement) in 32 limbs (31%) and chronic in 70 limbs (69%). Follow-up CDT using UniFuse infusion catheter was performed in 27 of 32 limbs (84%). Pathologic change of the original lesion was post-thrombotic in 77% and NIVL in 23% of the limbs; 56% had undergone stenting with recanalization of chronic total occlusion (CTO) of the native vein, and 44% had stent correction of only stenotic lesions (31% PTS, 13% NIVL). Of the 33 limbs in which the operative report characterized flow pathologic changes, 26 (78%) had compromised inflow that led to the occlusion, whereas seven had compromised outflow. Of the 32 limbs with acute occlusion, 20 (63%) had compromised inflow.

Procedural success of recanalization. Recanalization was successful in 84% of attempts (75/88 limbs). Intervention was not attempted in 14 patients/limbs because of absent or minimal symptoms or the patient's choice. There were 74 stents reopened <3 months of known occlusion, and 1 was reopened between 3 and 12 months.

Clinical outcomes after recanalization. The median follow-up period was 17 months. There were no significant adverse events and no mortality. There was no clinically evident pulmonary embolism, including in patients who underwent balloon maceration of

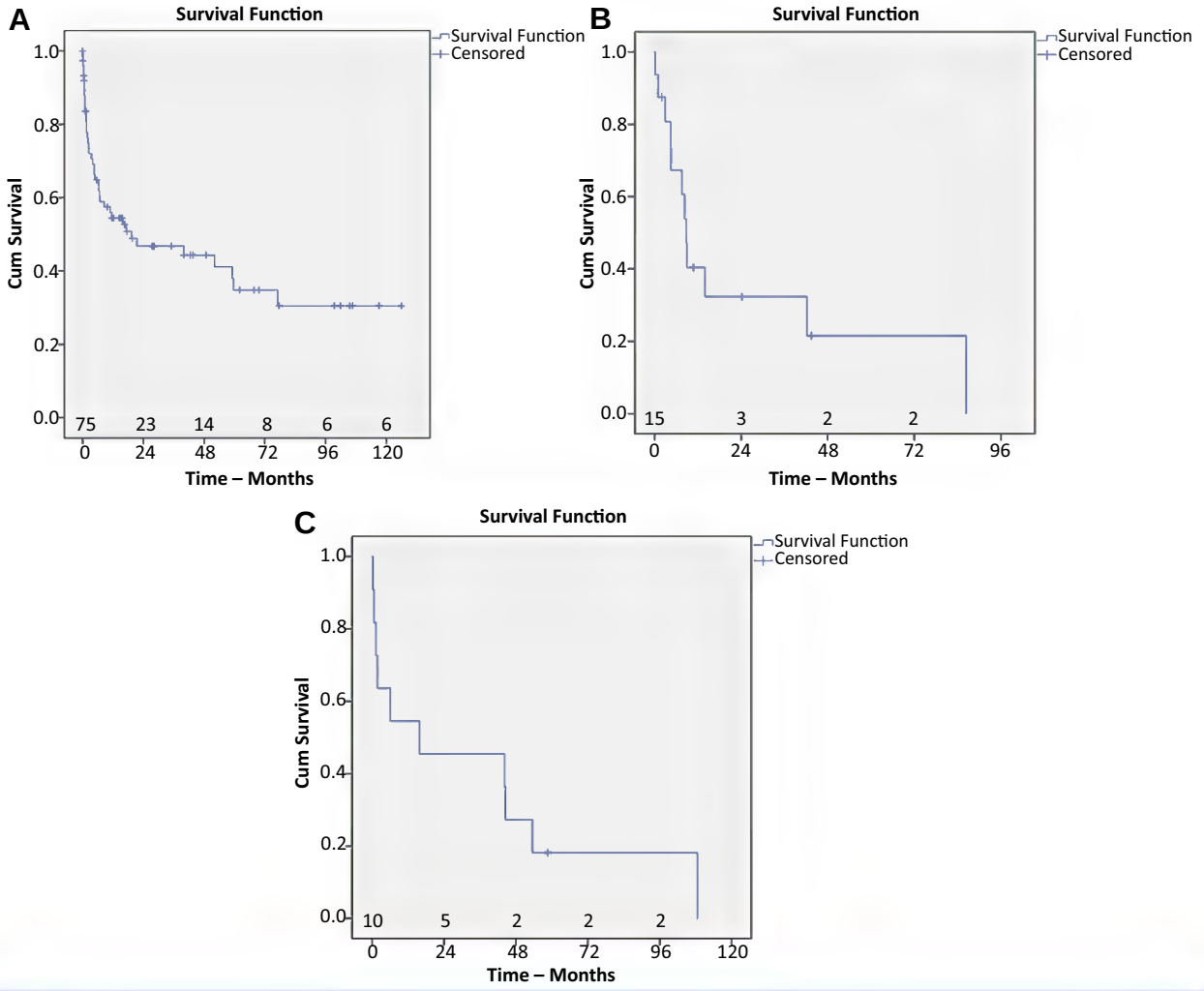

Fig 3. Primary **(A)**, primary assisted **(B)**, and secondary **(C)** patencies after recanalization of occluded femoral-iliocaval stent column.

thrombus. The median VAS pain scores improved from 3.5 to 1 ($P < .01$). The median grade of swelling improved from 2 to 1 ($P < .01$). The median VCSS improved from 6.4 to 3.8 ($P < .01$; Table II); 9 of 13 (70%) ulcers healed.

Patency of reopened stents. After successful recanalization of the occluded stent, the median primary patency was 7 ± 1.9 months, median primary assisted patency was 7.5 ± 3.5 months, and median secondary patency was 25 ± 8.3 months (Fig 3). Recurrent stent thrombosis occurred in 10 of 75 successful recanalizations, accounting for a rethrombosis rate of 12.4%. Median time to rethrombosis was 328 days.

Risk factors for stent occlusion. Of the six variables evaluated as potential risk factors for stent occlusion (Table III), native vein occlusion was the only statistically significant predictor (odds ratio [OR], 388; $P < .01$). The wide confidence interval (22-6939) is reflective of the small number of such events. Of the 75 limbs in which successful recanalization was possible, 24 (32%) required stent extension caudally. This high number of caudal stent extensions in both acute and chronic occlusions suggests that missed lesions or intrinsically poor inflow is potentially a major cause of stent occlusions.

DISCUSSION

Stent occlusions are rare overall. Femoral-iliocaval stent thrombosis is a rare occurrence, with description of its characteristics and outcomes being scant in the literature.[7-9,20,31] Factors associated with femoral-iliocaval stent occlusion considered in a previous publication included native CTO vs stenosis (OR, 9; $P < .001$) and stent extension into the common femoral vein (OR, 3.5; $P = .001$).[7,32] Subsequent studies have clarified the safety of stenting across the inguinal ligament when required.[24,33] In our study, only stenting in the setting of native vein occlusion was found to be a statistically significant predictor of stent occlusion.

Stent occlusion mainly involves PTS limbs. Stent occlusion occurs predominantly in stents placed for post-thrombotic etiology (~77%). Occlusion in stented patients with NIVLs is rare.[7] However, PTS was not found to be a statistically significant predictor of stent occlusion (Table III).

Table III. Results of multivariable logistic regression analysis of risk factors for stent occlusion

Variable	OR	95% CI		*P* value
		Lower	Upper	
Sex, female	2.7	0.3	20.7	.4
Age ≥50 years	2.4	0.2	27.9	.5
PTS	1.7	0.1	31.7	.7
Native vein occlusion	387.7	21.7	6939.3	<.01
Thrombophilia	3.7	0.6	25.4	.2
ISR	0.3	0.01	7.5	.4

CI, Confidence interval; *ISR*, in-stent restenosis; *OR*, odds ratio; *PTS*, post-thrombotic syndrome.

Stent occlusions predominantly occur after CTO recanalization. Stents placed for stenotic lesions tend to have a better outcome than those placed for CTO lesions (Table III).[7,19] CTO recanalization is a statistically significant predictor for stent occlusion (Table III). This highlights the importance of closer follow-up in such patients compared with stents placed for stenotic lesions.

Acute vs chronic thrombosis. The majority of the stent occlusions (69%) were chronic (>30 days). Technical inadequacies such as poor inflow or outflow and understenting or shelving may not necessarily be manifested within the first 30 days and explain this finding. In our experience, the major cause of acute stent occlusions is missed lesions at inflow and innately poor inflow due to post-thrombotic involvement of feeder veins.[34] There is not a satisfactory way to assess inflow or outflow, particularly inflow. Venographic anatomy is a poor guide as inflow can improve once a low-resistance pathway is opened and the collaterals are decommissioned. Lesions at the lower end of the stent can be missed on venography. IVUS is more reliable in this regard. Contrast material washout has been used to assess adequacy of stent flow. This has a mixed record in our experience. The large sheath in the femoral vein often impedes inflow. About half the stents we considered threatened have managed to remain patent. Considering the overall low rate of occlusions, it seems the best option is to stent marginal cases and to monitor outcome. If the stent occludes, specific causative lesions become apparent that can be identified and corrected during secondary intervention. A more proactive approach is to perform endovenectomy or adjunctive arteriovenous fistula.[35-39] The comparative utility of these procedures is not known. They carry the risk of adding these procedures in some patients who may not need them. In addition, outcomes after recanalization of inferior vena cava occlusions have been reported to be better than those for iliac vein lesions alone.[19,40-42] This is possibly due to continued flow from the contralateral limb that keeps the caval segment of the stent open. In our study, no difference in patency was noted after recanalization between acute and chronic stent occlusions.

Progression of ISR to stent occlusion is rare. Multivariable logistic regression did not reveal ISR as a predictor for stent occlusion. In our experience, most patients with ISR >50% remain patent, and the ISR shows little evidence of progression during years of follow-up. In fact, on long-term follow-up, our experience has been that <10% go on to develop stent occlusion. In this series, of the 24 patients with stent occlusion for whom we had data, only 5 (21%) had ISR >50% (median ISR was 38%).

Table IV. Patency after femoral-iliocaval stenting (60 months)

Variable	Initial stent, % (for stenotic lesion)	Recanalized native vein, %	Recanalized stent, %
Primary	72	33	35
Primary assisted	92	55	25
Secondary	95	65	18

So, a high-grade ISR in itself would not merit intervention in the absence of worsening symptoms. However, once diagnosis of stent occlusion has been made, intervention should be offered to all symptomatic patients (most are).

Thrombophilia is not a major cause of stent occlusion. Incidence of thrombophilia was 33% in our cohort. However, it was not found to be a significant predictor for stent occlusions, a finding reflected in worldwide experience.[15] Most stent occlusions appear to be related to other factors.

Fate of the reopened stent. Patients experience symptom improvement after secondary recanalization per VAS pain scores, grade of swelling, and VCSS, all statistically significant, underscoring the benefit of reopening of occluded stents. An attempt at reopening of occluded stents is worthwhile regardless of the time lapse after stent occlusion as shown in this study. However, patency after such stent recanalization is worse than that after initial stenting, as shown in Table IV.[7,19] Patients should be counseled accordingly. Unfortunately, current analysis does not illuminate what can be done proactively to prevent stent occlusions.

CONCLUSIONS

Stent occlusion after femoral-iliocaval stenting is a rare occurrence. Recanalization of occluded stents can be performed with minimal morbidity even months to years after occlusion. Long-term outcomes in these reopened stents are, however, less satisfactory than after initial stenting.

AUTHOR CONTRIBUTIONS

Conception and design: AJ, SR
Analysis and interpretation: AJ, WC, AK, SR
Data collection: AJ, WC, AK
Writing the article: AJ, WC, AK, SR
Critical revision of the article: AJ, SR
Final approval of the article: AJ, WC, AK, SR
Statistical analysis: AJ, WC, AK
Obtained funding: AJ
Overall responsibility: AJ

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DISCUSSION

Dr Peter Gloviczki (*Rochester, Minn*). I enjoyed very much, Dr Jayaraj, your presentation. It's a fantastic experience and obviously a very low rate of stent occlusion. Could you tell us about what factors affect stent occlusion. Is it the size of the stent, is it the poor inflow, or maybe other factors? That's my first question.

The second is: Could you suggest to us a technique how to reopen a chronically reoccluded iliac or iliofemoral venous stent.

Dr Arjun Jayaraj. Thank you, Dr Gloviczki. To answer your first question, there are many variables that play into occlusion of a venous stent. Stent size is one, and it is important to size the stents appropriately before placement. Intravascular ultrasound can be very helpful in this regard. We use luminal areas as opposed to the luminal diameter to determine necessity of intervention. We use cutoffs of 125, 150, and 200 mm for normal luminal areas for the common femoral, external iliac, and common iliac veins, respectively. Any area below the aforementioned values in a symptomatic patient merits intervention.

Other factors that govern stent occlusion include inflow into the stent and the outflow from the stent, besides development and extent of in-stent restenosis and stent compression. Stent compression is unique to venous disease and denotes development of fibrotic tissue around the stent. Risk factors for development and prevention have yet to be understood. In-stent restenosis is another problem. We typically have used cilostazol in our patient population to reduce the incidence of in-stent restenosis based on protective literature in other vascular beds.

Treatment of patients who develop either of the two—strength compression or in-stent restenosis—is

hyperdilation, dilating the stent with a balloon of caliber larger than the size of the stent. The overwhelming majority of these patients respond well to the same.

To answer your second question regarding recanalization, our workhorse for recanalization is the 0.035 Glidewire and 0.035 Glidecath. In excess of 95% of cases, we are able to get through with just the two. Rarely, we have to use the Quick-Cross or a TriForce catheter. Once one gets wire recanalization across the occluded stent, angioplasty is pursued with a large-caliber balloon, typically an 18-mm one.

Dr Mark Meissner (*Seattle, Wash*). Very nice presentation, Dr Jayaraj. I have two questions for you. The first is that you reported pharmacomechanical thrombolysis to be the most common intervention. How many of these required restenting in addition to balloon angioplasty? and did those patients fare worse?

And second, how does your group follow iliac venous stents? Do you image them with duplex and do you have any parameters that would suggest impending stent failure? It's my impression that although we follow these very closely with ultrasound, we rarely find any harbingers of stent failure before such an event.

Dr Jayaraj. Thank you, Dr Meissner. To answer your first question, typically if the stent is undersized, usually those patients are referred from elsewhere. We have to fracture the stent, and we typically do it using a large-caliber balloon and then reline the whole venous segment.

Now, if the stents are of adequate caliber, then we recanalize the stented vein, as I previously described. Oftentimes it's necessary to extend the stent stack down to the femoral confluence so that you have good inflow. Sometimes you pick up outflow lesions that you did not notice initially, in which case you have to extend the stent proximally. But for an adequately sized stent that is placed in a venous segment, we don't reline the whole stented segment.

With regard to your second question regarding follow-up, if they are initial stent patients, they typically get seen with a duplex study the day after the operation and subsequently at 2 and 4 weeks. Thereafter, a follow-up is actually determined by what the extent of disease is in those stents. Sometimes we follow them every 4 to 6 weeks. If they are stable for the first couple of duplexes, then we phase them out to every 3 months or so.

For our recanalization patients, be it occluded native vein recanalization or stented vein recanalization, we follow them more closely using the protocol previously noted.