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ORIGINAL ARTICLE

Gianturco Z-stent placement for the treatment of chronic central venous occlusive disease: implantation of 208 stents in 137 symptomatic patients

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PURPOSE
To report the technical successes, adverse events, and long-term stent patency rates of Gianturco Z-stents for management of chronic central venous occlusive disease.

METHODS
Overall, 137 patients, with mean age 48.6±16.1 years (range, 16-89 years), underwent placement of Gianturco Z-stents for chronic central venous occlusions. Presenting symptoms included lower extremity edema (n=66, 48.2%), superior vena cava syndrome (n=30, 21.9%), unilateral upper extremity swelling (n=20, 14.6%), hemodialysis fistula or catheter dysfunction (n=11, 8.0%), ascites (n=8, 5.8%), and both ascites and lower extremity edema (n=2, 1.5%). Most common etiologies of central venous occlusion were prior central venous access placement (n=58, 42.3%), extrinsic compression (n=29, 21.2%), and post-surgical anastomotic stenosis (n=27, 19.7%). Number of stents placed, stent implantation location, stent sizes, technical successes, adverse events, need for re-intervention, follow-up evaluation, stent patencies, and mortality were recorded. Technical success was defined as recanalization and stent reconstruction with restoration of in-line venous flow. Adverse events were defined by the Society of Interventional Radiology Adverse Event Classification criteria. Primary and primary-assisted stent patencies were analyzed using Kaplan-Meier analysis.

RESULTS
In total, 208 Z-stents were placed. The three most common placement sites were the inferior vena cava (n=124, 59.6%), superior vena cava (n=44, 21.2%), and brachiocephalic veins (n=27, 13.0%). Technical success was achieved in 133 patients (97.1%). There were two (1.5%) severe adverse events (two cases of stent migration to the right atrium), one (0.7%) moderate adverse event, and one (0.7%) mild adverse event. Mean follow-up was 43.6±52.7 months. Estimated 1-, 3-, and 5-year primary stent patency was 84.2%, 84.2%, and 82.1%, respectively. Estimated 1-, 3-, and 5-year primary-assisted patency was 92.3%, 89.6%, and 89.6%, respectively. The 30- and 60- day mortality rates were 2.9% (n=4) and 5.1% (n=7), none of which were directly attributable to Z-stent placement.

CONCLUSION
Gianturco Z-stent placement is safe and effective for the treatment for chronic central venous occlusive disease with durable short- and long-term patencies.

Chronic central venous occlusive disease (central venous obstruction) arises most commonly as a sequela of deep vein thrombosis, implantable pacemaker wires, malignancy, indwelling central venous catheters, and post-surgical anastomotic strictures (1). Clinically, patients present with pain and edema in the involved extremity, or in the case of patients on chronic hemodialysis, elevated central venous pressures which may increase the risk of bleeding and access site pseudoaneurysms (1). Additionally, superior vena cava (SVC) syndrome may cause symptoms such as chest pain, swelling of the head and neck, and respiratory distress secondary to pleural effusions (2). Balloon angioplasty and stent placement is the standard of care for management of chronic venous occlusive disease (3).

Historically there have been limited commercially available stents designed for placement in the venous systems, and there are unique aspects of stent placement in the venous systems, including the need for more flexible, larger stents relative to arterial

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applications (4). However, several types of metallic stents have successfully been used for venous stent reconstruction procedures, with the Wallstent (Boston Scientific) being the most commonly used device (3). Gianturco Z-stents; however, have large diameters, high rigidity, high radial force (5, 6), and large interstices that prevent occlusion of venous tributaries and have been utilized in patients with venous disease due to malignant compression, anastomotic strictures, and for inferior vena cava (IVC) extension in patients requiring bilateral iliocaval stenting (5–9). There are several case series describing the use of Gianturco Z-stents for the treatment of venous disease, primarily focused on occlusion of the SVC (6, 7, 10, 11).

The purpose of this study was to report the technical successes, adverse events, and long-term stent patencies of Gianturco Z-stent placement for management of chronic central venous occlusive disease in 137 patients.

Methods

Patient selection

This retrospective study was conducted with Institutional Review Board approval (HUM00143526 and 18-3203), complied with the Health Insurance Portability and Accountability Act, and followed the Strengthening the Reporting of Observational Studies (STROBE) statement in its reporting (12). Informed consent was not required for this retrospective study. A retrospective search of the electronic medical record was performed from 12/31/1997 to 12/22/2017 (13). A search using the terms "Z-stent" and "Gianturco" yielded a total of 186 potential patients.

Main points

- Overall 137 patients, with mean age 48.6±16.1 years (range, 16–89 years), underwent placement of Gianturco Z-stents for chronic central venous occlusions.
- Presenting symptoms included lower extremity edema (n=66, 48.2%), superior vena cava syndrome (n=30, 21.9%), unilateral upper extremity swelling (n=20, 14.6%), hemodialysis fistula or catheter dysfunction (n=11, 8.0%), ascites (n=8, 5.8%), and both ascites and lower extremity edema (n=2, 1.5%).
- Most common etiologies of central venous occlusion were prior central venous access placement (n=58, 42.3%), extrinsic compression (n=29, 21.2%), and post-surgical anastomotic stenosis (n=27, 19.7%).
- The three most common placement sites were the inferior vena cava (n=124, 59.6%), superior vena cava (n=44, 21.2%), and brachiocephalic veins (n=27, 13.0%).
- Estimated 1-, 3-, and 5-year primary stent patency was 84.2%, 84.2%, and 82.1%, respectively. Estimated 1-, 3-, and 5-year primary-assisted patency was 92.3%, 89.6%, and 89.6%, respectively.

Inclusion and exclusion criteria

After manual review, 137 patients (73.7%) underwent Z-stent placement for chronic central venous occlusive disease and were included in the study. The remaining 49 patients (26.3%) were excluded based on the following criteria: Z-stent placed in the arterial vasculature (n=27, 14.5%), Z-stent placed at an outside facility (n=19, 10.2%), Z-stent placed in the esophagus or duodenum (n=2, 1.1%), or Z-stent placed in the iliac vein only (n=1, 0.5%), as described in Fig. 1.

Patient demographics and comorbidities

Of the patients, 70 (51%) were male. Mean age of the cohort was 48.6±16.1 years (range, 16–89 years). The most common comorbidities included end-stage renal disease (n=52, 37.9%), malignancy (n=32, 23.3%), hereditary thrombophilia (n=6, 4.4%), and lupus (n=4, 2.9%).

Presenting symptoms

Presenting symptoms included unilateral or bilateral lower extremity edema (n=66, 48.2%), SVC syndrome (a clinical diagnosis rendered when there was bilateral upper extremity swelling or respiratory distress due to venous occlusion) (n=30, 21.9%), unilateral upper extremity swelling (n=20, 14.6%), hemodialysis fistula or catheter dysfunction (n=11, 8.0%), ascites (n=8, 5.8%), and both ascites and lower extremity edema (n=2, 1.5%).

Etiology of central venous occlusive disease

The most common etiology of chronic venous occlusion was from catheter placement for central venous access (n=58, 42.3%), followed by extrinsic compression (n=29, 21.2%), post-surgical anastomotic stenosis (n=27, 19.7%), chronic deep venous thrombosis (n=19, 13.9%), and IVC atresia (n=4, 2.9%), with complete description in Table 1.

Description of stenoses and occlusions

Of the 137 locations of chronic central venous occlusive disease (central venous obstruction), 86 (62.8%) were stenoses and 41 (29.9%) were total occlusions. Of the lesions, 61 (44.5%) were located in the thoracic central veins and were classified per the Society of Interventional Radiology Reporting Standards for Thoracic Central Vein Obstruction as: Type 1C (n=8, 5.8%), Type 2B (n=19, 13.9%), or Type 4 (n=34, 24.8%) (14). Of the occlusions, 76 (55.5%) were located in the IVC. A complete description of sites of venous occlusive disease is presented in Table 2.

Recanalization and stent reconstruction techniques

Each patient was evaluated by an attending interventional radiologist in the clinic or in the hospital. Procedures were performed under conscious sedation with intravenous midazolam and fentanyl (n=76, 55.5%) or general anesthesia (n=61, 44.5%).

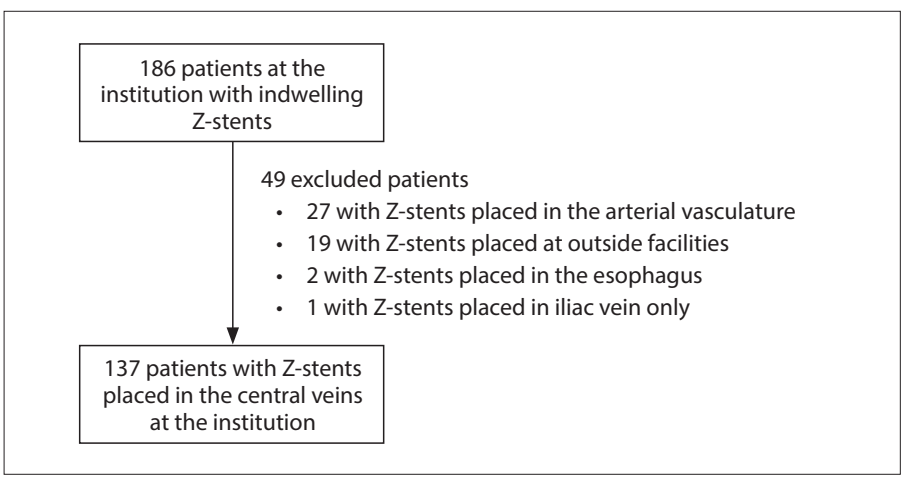

Figure 1. Flow diagram demonstrating inclusion and exclusion criteria.

Table 1. Etiology of chronic venous occlusive disease

Etiology of occlusion and stenosis	n (%)
Prior central line placement	58 (42.3)
Extrinsic compression	29 (21.2)
Compression of IVC by tumor	18 (13.1)
Compression of SVC by tumor	9 (6.6)
Fibrosing mediastinitis	2 (1.5)
Post-surgical anastomotic stenosis	27 (19.7)
Liver transplant	25 (18.2)
Cardiac transplant	1 (0.7)
Hepatectomy	1 (0.7)
Deep venous thrombosis	19 (13.9)
IVC atresia	4 (2.9)

IVC, inferior vena cava; SVC, superior vena cava.

Table 2. List of sites of venous occlusive disease

Location	n (%)
Thoracic central veins	61 (44.5)
Type 1C	8 (5.8)
Type 2B	19 (13.9)
Type 4	34 (24.8)
IVC	76 (55.5)
Suprahepatic/infra-atrial	13 (9.5)
Intrahepatic	34 (24.8)
Infrahepatic/suprarenal	12 (8.8)
Pararenal/renal vein confluence	13 (9.5)
Infrarenal	13 (9.5)

IVC, inferior vena cava.
Venous occlusive disease involving the thoracic central veins are classified per the Society of Interventional Radiology Reporting Standards for Thoracic Central Vein Venous obstruction (14).
Non-thoracic central vein venous occlusive disease are reported by each obstructed location, and the number of obstructed IVC segments exceeds the total number of IVC venous occlusions as some patients had multiple involved segments.

Venous recanalization and stent reconstruction procedures from chronic venous occlusive disease have been previously described (15-18). Representative clinical cases are shown in Figs. 2 and 3. Blunt recanalization was performed using a vertebral-tip catheter (Terumo) and a straight stiff glidewire (Terumo). If blunt recanalization attempts were unsuccessful, sharp recanalization was attempted using an 18-gauge BRK trans-septal needle (St. Jude Medical) and loop snare or AMPLATZER vascular plug (St. Jude Medical). Once the obstruction was traversed, intraluminal position was confirmed using contrast venography (n=137, 100%) and intravascular ultrasound (Volcano Corporation) (n=42, 30.7%). After intravascular location was confirmed, the 16 F Z-stent sheath (Cook Medical) was inserted over the guidewire and positioned beyond the target lesion. The Gianturco Z-stent (Cook Medical) was inserted through the sheath and then deployed with the "pusher" across the area of venous occlusion. Additional Z-stents were deployed, as required, with 25%–50% overlap with the adjacent stent, until the entire venous lesion was covered. Patients were then heparinized, with a targeted activated clotting time >250 s, and were opened using sequential angioplasty with 32 or 46 mm CODA balloon (Cook Medical) based on intra-procedural venography and intravascular ultrasound to prevent oversizing. Completion venography and intravascular ultrasound evaluation were performed after stent placement. Of note, no stents were placed across the costoclavicular junction.

Table 3. Stent location

Location	n (%)
Superior vena cava	44 (21.2)
Brachiocephalic veins	27 (13.0)
Right	15 (7.2)
Left	12 (5.8)
Subclavian veins	13 (6.3)
Right	6 (2.9)
Left	7 (3.4)
IVC	124 (59.6)
Suprahepatic/infra-atrial	18 (8.7)
Intrahepatic	53 (25.5)
Infrahepatic/suprarenal	16 (7.7)
Pararenal/renal vein confluence	13 (6.3)
Infrarenal	24 (11.5)
Total	208

As many patients had multiple stents, the number of stents is greater than the number of patients.

Post-procedural anticoagulation and antiplatelet agents

Patients were initiated on enoxaparin 1 mg/kg twice daily and transitioned to warfarin, either at the 2-week clinic follow-up, or in-hospital if the patient had a prolonged post-procedural hospitalization. Patients were also discharged on antiplatelet therapy consisting of clopidogrel 300 mg loading dose, then 75 mg daily, and aspirin 81 mg daily. Warfarin was continued for at least 1 year. Clopidogrel was discontinued 2 months after the procedure and restarted only if future stent placement was required. Aspirin was prescribed indefinitely as long as there was no contraindication.

Defined and recorded variables

Recorded variables included number of stents placed, stent implantation location, stent sizes, technical successes, adverse events, need for re-intervention, follow-up evaluation, stent patencies, and mortality.

Technical success was defined as successful recanalization with balloon angioplasty, stent placement, and restoration of in-line venous flow, with less than a 20% residual stenosis, as described previously (19). Adverse events were prospectively recorded and retrospectively classified according to the Society of Interventional Radiology Adverse Event Classification System (20). Primary, primary-assisted, and secondary patency were assessed as described previously by either contrast-enhanced computed tomography (CT) or catheter-based venography (19, 21). A stent was defined as having primary-assisted patency if it required intervention to maintain patency, but was not abandoned (19, 21). Patients were instructed to follow-up with contrast-enhanced CT every 3 months after the procedure. Structured clinical follow-up notes were not reliably documented for review.

Statistical analysis

Statistical analysis was completed with SPSS 25 (IBM Corp.), with $p < 0.05$ denoting statistical significance. Calculation of duration of primary and primary-assisted patency, as well as 1-, 3-, and 5-year primary and primary-assisted patency rates were performed using Kaplan-Meier analysis. Central tendency measures were not reported as the last observation was censored, and 50% survival was not reached due to high patency rates.

Results

Successful recanalization was achieved in 137 patients (100%), with sharp recanalization required in 15 patients (10.9%). Overall, 208 Z-stents were placed, most commonly in the IVC (n=124, 59.6%), SVC (n=44, 21.2%), and brachiocephalic veins (n=27, 13.0%), with full description of stent locations in Table 3. The most commonly deployed Z-stent diameter was 20 mm (n=118, 56.7%) followed by 25 mm (n=53,

Table 4. Stent size by location	
Location	n (%)
IVC	
15 mm	4 (3.2)
20 mm	76 (61.3)
25 mm	40 (32.3)
30 mm	4 (3.2)
SVC	
15 mm	7 (15.9)
20 mm	28 (63.6)
25 mm	7 (15.9)
30 mm	2 (4.5)
Brachiocephalic vein	
15 mm	13 (48.1)
20 mm	8 (29.6)
25 mm	6 (22.2)
Subclavian vein	
15 mm	7 (53.8)
20 mm	6 (46.2)

25.5%), 15 mm (n=31, 14.9%), and 30 mm (n=6, 2.9%), with full description of stent sizes by location in Table 4.

Technical success was obtained in 133 of 137 patients (97.1%), with technical success in all 61 obstructions of the thoracic central veins (100%) and 72 of 76 obstructions of the IVC (94.7%). In one patient with post-liver transplant IVC stenosis, the Z-stent failed to expand fully and a Wallstent was subsequently placed, which achieved full expansion. The remaining three technical failures were due to moderate or severe adverse events which are detailed below.

Per the Society of Interventional Radiology Adverse Event Classification System (20), there were two (1.5%) severe adverse events, one (0.7%) moderate adverse event, and one (0.7%) mild adverse event.

One severe adverse event occurred when the Z-stent migrated from the intra-hepatic IVC to the right atrium and was removed with an endobronchial forceps (Lymol Medical). The patient underwent placement of a Z-stent 9 days later.

The other severe adverse event occurred when the Z-stent migrated from the intra-hepatic IVC into the right atrium and required open cardiac surgery to retrieve the stent. The patient recovered uneventfully from this surgery without long-term sequela.

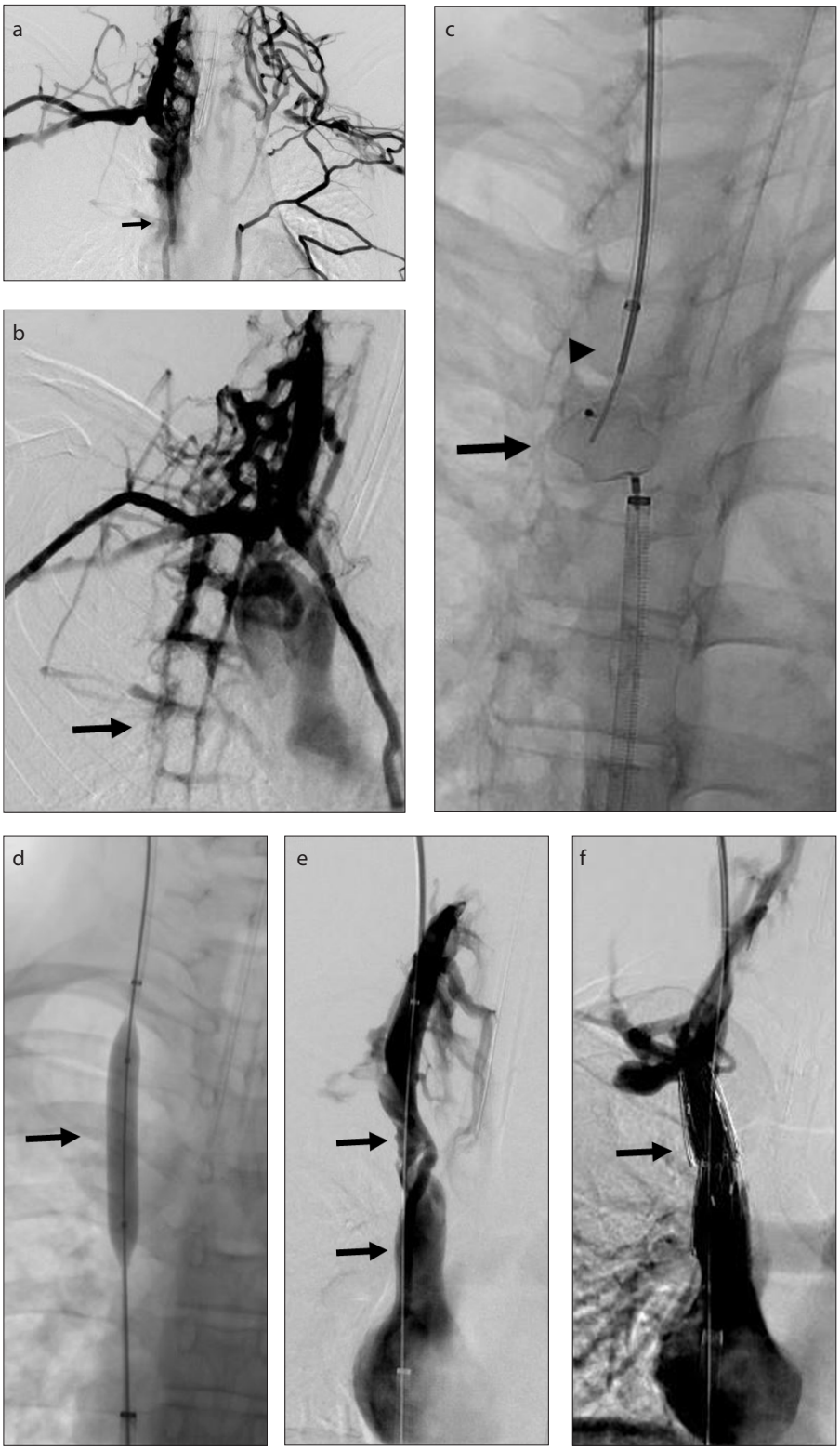

Figure 2. a–f. A 19-year-old male with history of acute myelogenous leukemia and multiple central venous catheters presented with chronic neck and face swelling. Digital subtraction venography **(a)** demonstrates chronic occlusion of the right brachiocephalic vein and superior vena cava (SVC, *arrow*) with collateral vein formation. Additional delayed image **(b)** demonstrates further filling of the extensive venous collaterals with persistent occlusion on the SVC *(arrow)*. Image **(c)** shows the patient undergoing sharp recanalization with a BRK needle *(arrowhead)* and AMPLAZER plug target *(arrow)*. Image **(d)** shows angioplasty of the SVC with an 8 mm balloon *(arrow)*. The SVC was patent on post-dilation venography (**e,** *arrows*). In image **(f)**, a 15 mm × 5 cm Gianturco Z-stent *(arrow)* was placed and balloon-dilated to 12 mm. There was no evidence of adverse events on completion venography.

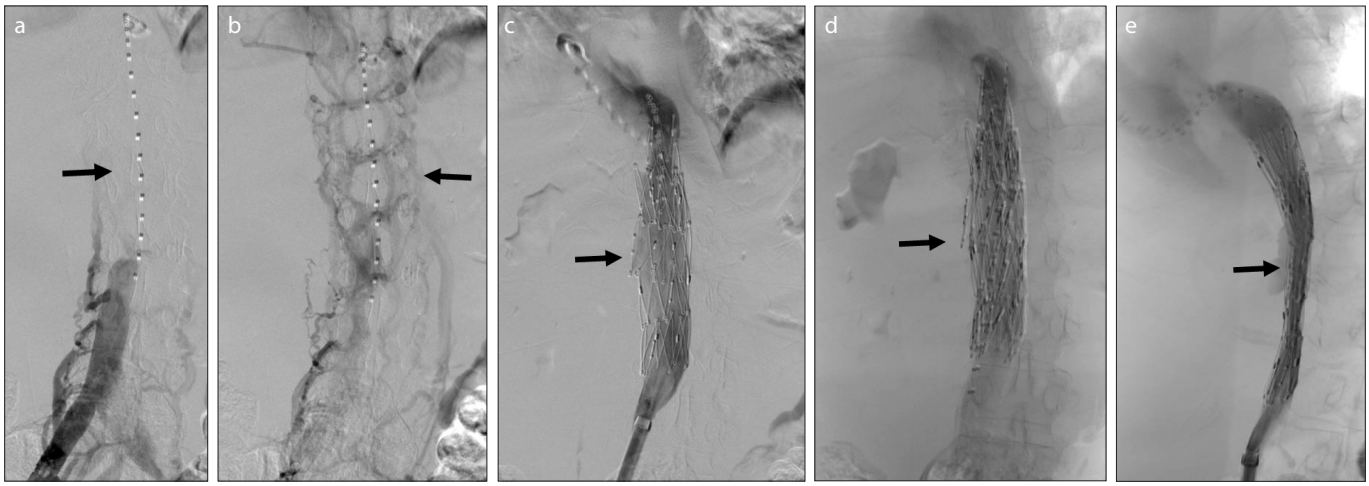

Figure 3. a–e. A 63-year-old woman with history of metastatic salivary gland carcinoma with bi-lobar hepatic metastases and extrinsic compression of the intrahepatic and suprarenal inferior vena cava (IVC) presented with chronic bilateral lower extremity edema. Digital subtraction venography **(a)**, from a right groin approach, shows chronic occlusion of the IVC *(black arrow)* with collateral vessel formation. Delayed image **(b)** demonstrates numerous retroperitoneal collateral veins *(black arrow)*. In images **(c–e)**, stent reconstruction of the IVC was performed using a total of five, 25 mm × 5 cm Gianturco Z-stents *(black arrows)* which were post-dilated to 18 mm. Digital subtraction venography, in frontal **(d)** and lateral **(e)** planes show a widely-patent IVC stent reconstruction *(black arrows)*.

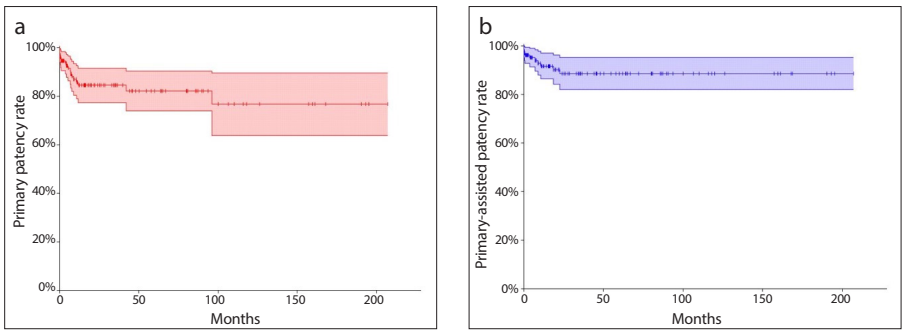

Figure 4. a, b. Kaplan-Meier curve **(a)** demonstrates primary patency of the indwelling Z-stents. Kaplan-Meier curve **(b)** shows primary-assisted patency of the indwelling Z-stents.

Table 5. Description of primary and primary-assisted patency by location of occlusion, with 1, 3, and 5-year estimated patency

	Thoracic (%)	Non-thoracic (%)	Malignant (%)	Non-malignant (%)
Primary patency				
1-year	79.2	88.9	74.4	87.3
3-year	79.2	88.9	74.4	87.3
5-year	73.2	88.9	55.2	87.3
Primary-assisted patency				
1-year	90.4	92.6	86.9	93.0
3-year	83.7	92.6	86.9	89.4
5-year	83.7	92.6	86.9	89.4

A moderate adverse event occurred when acute thrombus formed along the freshly placed stent in the intrahepatic IVC. Balloon maceration was attempted and was unsuccessful. The patient then underwent overnight thrombolysis, which resolved the thrombus. The patient has been symptom-free for 7 years.

Patency data is shown in Fig. 4 and Table 5. Mean follow-up was 43.6±52.7 months (range, 1–207 months). Estimated 1-, 3-, and 5-year primary patency was 84.2%, 84.2%, and 82.1%, respectively.

A re-intervention was required in 22 patients (16.1%) at a mean of 12.0±23.0 months (range, 0–96 months): 11 patients with thoracic reconstructions (18.3%) and 11 patients with non-thoracic reconstructions (14.5%) required a re-intervention; 20 patients with benign obstructions (18.2%) and 2 patients with malignant obstructions (7.4%) required a re-intervention. The most common procedure performed at the re-intervention was recanalization and additional stent placement (n=13, 9.5%), followed by thrombolysis (n=5, 3.6%), and balloon angioplasty (n=4, 2.9%).

A second re-intervention was required in 6 patients (4.4%) at a mean of 22.4±16.3 months (range, 5.2–43.2 months): 2 patients with thoracic reconstructions (3.3%) and 4 patients with non-thoracic reconstructions (5.3%) required a second re-intervention; 6 patients with benign obstructions (5.5%) and 0 patients with malignant obstructions (0%) required a second re-intervention. The most common procedure performed at the second re-intervention was thrombolysis (n=3, 2.2%), followed by additional stent placement (n=2, 1.5%), and balloon angioplasty (n=1, 0.7%).

Estimated 1-, 3-, and 5-year primary-assisted patency was 92.3%, 89.6%, and 89.6%, respectively.

No stents were abandoned during the course of follow-up, so secondary patency was 100% at all follow-up intervals.

As of final follow-up evaluation, 30 patients (21.9%) were deceased. The 30- and 60-day mortality rates were 2.9% (n=4) and 5.1% (n=7), none of which were directly attributable to Z-stent placement.

Discussion

This study, which is the largest to date and with the longest follow-up evaluation, demonstrates the efficacy and safety of Gianturco Z-stent placement for the treatment for chronic central venous occlusive disease, with a technical success rate of 97.1% and an excellent patency rate at 5 years. Moderate or severe adverse events occurred in 2.2% of patients.

Balloon angioplasty and stent placement is the standard of care for the treatment of venous occlusive disease (3). Although Wallstents are frequently used for treatment of venous occlusive disease, Z-stents have been shown to have utility in several series for the treatment of caval thromboses due to malignant compression, strictures, or bilateral iliac venous obstructions due to their large diameters, high radial forces, and large interstices (6, 7, 10, 11). For the treatment of malignant obstruction of the SVC, Gaines et al. (7) reported a technical success of 90%, with primary patency of 65% and secondary patency of 75% at a mean follow-up of 5 months in 20 patients with SVC syndrome treated with Z-stents (7). Similarly, Rosch et al. (10) reported a technical success rate of 100% and secondary patency of 95% at final follow-up of less than one year in 22 patients with SVC syndrome treated with Z-stents (10). Treatment of malignant IVC syndrome was reported by Brountzos et al. (11), who treated 45 patients with Z-stents with technical success of 100% and primary and secondary patency of 59% and 100% at a mean follow-up of 18 months (11). Also, Furui et al. (22) treated 39 patients with IVC obstruction, achieving clinical success in 90%, but only with a mean clinical follow-up of 2.9 months (22). Weeks et al. (23) placed Z-stents in 9 patients with post-transplant IVC anastomotic strictures, with no evidence of recurrent clinical or venographic evidence of recurrent caval stenosis at a mean follow-up of 16 months (23). Petersen et al. (9) treated 19 patients with benign non-dialysis-related SVC or IVC venous occlusive disease with Z-stents, with primary patency of 83% and secondary patency of 100% at a mean follow-up of 38 months (9). This series presents much longer follow-up than prior Z-stent series, with higher 5-year primary and primary-assisted patency rates, thus supporting the long-term efficacy of Z-stent placement for the treatment of central venous occlusive disease.

The primary alternatives to Z-stent placement, at the present time, are Wallstents, which have been extensively studied. Trerotola et al. (24) compared the use of Z-stents and Wallstents across the venous anastomosis in an animal model of hemodialysis grafts, finding increased duration of patency and less intimal hyperplasia in the Z-stent group, which was attributed to the larger interstices of the Z-stent (24). Clinically, Hennequin et al. (25) placed Wallstents in 15 patients with malignant SVC syndrome, with stent thrombosis in only one patient at a mean follow-up of 4.1 months (25). Similarly, de Gregorio Ariza et al. (26) treated 82 patients with SVC syndrome (83% of which were due to a malignancy) with stents (93% with Wallstents) and found primary patency in 87% and primary-assisted patency in 96% at a mean follow-up of 15 months. Their results were comparable to that seen in this series, though this series has significantly longer follow-up. Treatment of five patients with Wallstents for IVC venous occlusive disease due to lower extremity hemodialysis access was reported by Chang et al. (27), with a mean primary patency of 133 days and assisted patency of 781 days.

One disadvantage of Z-stents is that their larger diameter demands larger sheaths, and thus, larger access vessels relative to Wallstents that are available in various sizes and smaller stents, facilitating easier deployment in angulated vessels (23). Additionally, while the presence of external barbs in Z-stents creates more resistance to migration, and allows multiple overlapping Z-stents to be placed to increase stability within long, concentric stenoses (7), they may contribute to an increased inflammatory response relative to Wallstents (24).

There are several additional stents which may be used for central venous occlusive disease, but either have limited clinical availability or are not able to be applied to all locations of central venous occlusive disease. Polytetrafluoroethylene covered stents have demonstrated primary patency rates of 97%–100% at 1 month and 94%–100% at 1 year in the treatment of obstruction of the SVC, but have limited clinical availability in the United States (28, 29). The 11 mm diameter Viabahn endoprostheses (Gore Medical) is approved for over-dilation up to a diameter of 16 mm and and thus could be used for obstruction of the SVC, but not obstruction of the IVC (8). Newer dedicated venous stents such as Venovo and Vici are now on the market.

Moderate or severe adverse events occurred in three patients (2.2%) in this study. The two cases of stent migration to the right atrium likely resulted from under-sizing of the stent. Migration has been previously reported in several other series (22, 30, 31). Prior comparative studies of endovascular treatment of central venous occlusive disease also report rates of moderate or severe adverse events less than 5% (6, 7, 9–11, 22, 28). Notably, though relatively large CODA balloon sizes were employed for dilation, balloons were not fully expanded and dilation was monitored with intravascular ultrasound to prevent complications of over-sizing.

There are several limitations to the present study. First, this was a retrospective study. Non-standardized procedural and clinical protocols may have introduced measurement bias. Second, the decision to pursue Z-stent placement was based on operator preference, which may have introduced selection bias. Third, this study encompassed a range of underlying etiologies, which introduces variability in the initial intervention and length of follow-up evaluation. Fourth, these procedures were completed when no dedicated venous stents were available. Comparison of these results to large studies of new stents is recommended (4). Finally, as all procedures were performed at a tertiary medical center, long-term reported follow-up may be under-reported, potentially causing an under-estimation of delayed complications and an over-estimation of sustained stent patency rates.

In conclusion, Gianturco Z-stent placement for the treatment of chronic central venous occlusive disease demonstrates high technical success, a low rate of adverse events, and excellent short- and long-term patency rates.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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