CLINICAL STUDY

Iliac Vein Stent Placement: Acute Venographic Changes and Relevance to Venous Biomechanics

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ABSTRACT

Purpose: To describe acute venographic changes of external iliac vein (EIV) after ipsilateral common iliac vein (CIV) stent placement.

Materials and Methods: Retrospective review was performed of 17 cases with placement of a single CIV stent. Central CIV stent diameter and minimal ipsilateral EIV diameter were measured on venogram; vein diameter was measured at the same 2 anatomic locations on venogram obtained before intervention. Relative CIV diameter increase was defined as the ratio of change in central CIV diameter after stent placement to CIV diameter before intervention. Relative EIV diameter reduction was defined as the ratio of change in diameter of EIV after stent deployment in CIV to EIV diameter before intervention. Diameters before and after intervention were compared using a 2-tailed, paired sample *t* test. Pearson coefficient was calculated for correlations.

Results: There was a significant reduction of EIV diameter after ipsilateral CIV stent placement compared with before stent placement (mean 9.3 mm ± 3.1 vs 11.9 mm ± 3.8; $P < .01$); mean decrease in EIV diameter was 21.7% ± 15.8. There was a correlation between relative CIV diameter increase and relative EIV diameter reduction ($r = .8917$).

Conclusions: Significant venographic narrowing of the EIV occurs after placement of an adjacent CIV stent, and the degree of narrowing is associated with the relative increase in CIV diameter. These findings may be explained by the inherent anisotropic elasticity of veins. Further study is warranted to guide future venous interventions.

ABBREVIATIONS

CIV = common iliac vein, EIV = external iliac vein

The pathophysiology of postthrombotic syndrome is not completely understood, but prior studies have suggested that the 2 main contributing factors are venous outflow obstruction owing to narrowing related to chronic venous fibrosis and incompetency of the venous valves (1–7). In patients with venous outflow obstruction owing to postthrombotic chronic fibrosis, treatment with venous stent placement has been shown to improve flow with clinical relief (8). However, the biomechanics of venous stent placement has not been previously studied, and many stents in clinical use now were initially designed for use in the arteries or outside the vascular system.

The anisotropic elasticity of veins has been previously described, quantified, and modeled and may be a crucial characteristic to understand for effective stent outcome in the veins (9–11). Anisotropic elasticity refers to the nonuniform mechanical responses of the vein depending on the direction in which stress is applied. Specifically, a prior ex vivo study has demonstrated that veins are less extensible in the longitudinal direction relative to the circumferential direction compared with arteries (11). However, the relevance of these properties to venous interventions has not been previously studied. Until the biomechanical properties of veins are directly studied and characterized in

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relation to stent placement, the response of veins after stent placement in clinical practice may provide some insight. The purpose of this study was to describe and characterize the venographic changes of the external iliac vein (EIV) after adjacent common iliac vein (CIV) stent placement to better understand the biomechanics of veins during stent placement.

MATERIALS AND METHODS

Imaging Analysis

All cases of CIV stent placement over a 9-year period were retrospectively reviewed after obtaining institutional board review approval; 86 cases with venous stent placement were screened for inclusion. Patients with placement of a single stent centered in the CIV with single plane venograms obtained before and after intervention from the EIV to the inferior vena cava were included in the analysis (n = 17). Cases with placement of a second stent extending to the inguinal ligament were excluded. Imaging analysis was performed by a single interventional radiologist (R.A.A.). The venogram obtained after intervention was reviewed, and the final intraluminal diameter of the stent was measured in the midstent location. The minimal ipsilateral EIV diameter (not including the stent) was also measured on the venogram obtained after intervention. Using bony landmarks on the unsubtracted venograms, the vein diameter at the same 2 anatomic locations in the CIV and EIV were measured on the venogram obtained before intervention for comparison. The relative EIV diameter reduction was defined as the ratio of change in diameter of EIV after stent placement in the CIV to EIV diameter before intervention. The relative CIV diameter increase was defined as the ratio of change in central CIV diameter after stent placement to CIV diameter before intervention. Stent oversizing was defined as the relative difference of the nominal stent diameter to the diameter of the vein at the peripheral stent edge before intervention (ie, the adjacent "normal" vein diameter).

Procedural Details

Mean patient age was 50.1 years ± 16.0 (14 women and 3 men). Indications for intervention were acute iliac deep venous thrombosis (n = 11), chronic postthrombotic syndrome with iliac vein involvement (n = 5), and incidental iliac vein occlusion requiring access for right heart catheterization (n = 1). All patients with acute iliac venous thrombosis underwent catheter-directed thrombolysis before stent placement (n = 11). Venous access sites for stent deployment included the common femoral (n = 15) and popliteal (n = 2) veins. All stents were self-expanding and included WALLSTENT (Boston Scientific, Marlborough, Massachusetts) (n = 10), Zilver (Cook, Inc, Bloomington, Indiana) (n = 5), and S.M.A.R.T. (Cordis Corp, Milpitas, California) (n = 2) stents. The EIV was venographically normal in caliber and contour in 82.4% (14 of 17) of cases; 11.8% (2 of 17) of cases had mild narrowing of the EIV treated with venoplasty alone, and 5.9% (1 of 17) of cases had minimal synechiae without significant narrowing not requiring treatment. The median stent diameter was 14 mm (range, 12–20 mm), and the median stent length was 80 mm (range, 60–94 mm). Of cases, 94.1% (16/17) were supplemented with venoplasty within the stent after deployment with an average balloon diameter 1.8 mm ± 1.4 (range, 0–4 mm) less than the nominal stent diameter. Anticoagulation was continued or initiated in 100% of patients after stent placement with warfarin (Coumadin; Bristol-Myers Squibb, New York, New York) (n = 8), enoxaparin (n = 3), rivaroxaban (n = 4), or apixaban (n = 2). Antiplatelet medications were continued or started in 47.1% (8 of 17) of patients with aspirin and/or clopidogrel.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel (Microsoft Corp, Redmond, Washington). Diameters before and after intervention were compared using a 2-tailed, paired sample *t* test. The Pearson coefficient was calculated for correlations. Statistical significance was assessed with an α level of .05.

RESULTS

There was a statistically significant reduction of EIV diameter after ipsilateral CIV stent placement compared with before stent placement, with an average decrease in EIV diameter of 2.6 mm ± 2.0 (mean 9.3 mm ± 3.1 vs 11.9 mm ± 3.8; $P < .01$). The mean decrease in relative EIV diameter after stent placement was 21.7% ± 15.8%. Figures 1a, b and 2a, b show 2 cases examples demonstrating the reduction in EIV diameter after adjacent CIV stent placement. EIV narrowing occurred at a mean distance of 25.1 mm ± 14.4 peripheral to the CIV stent edge and 46.2 mm ± 34.6 central to the inguinal ligament. There was a correlation between the relative CIV diameter increase and the relative EIV diameter reduction (r = .8917) (Fig 3). However, there was no correlation between stent oversizing and relative EIV diameter reduction (r = .1936).

DISCUSSION

This study characterizes and quantifies the observation of venographic narrowing of the EIV after stent placement in the ipsilateral CIV. This finding may explain biomechanical properties of veins that could adversely impact the placement of venous stents. Prior studies have demonstrated the anisotropic elasticity of veins, with veins being less extensible in the longitudinal direction