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The Patency Rate of Endovascular Procedure in Patients with Superior Vena Cava Syndrome Caused by Intravenous Catheterization: A Case Series and Longitudinal Study

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Abstract

Introduction: Different methods have been well addressed in literature in terms of treating superior vena cava (SVC) syndrome; nevertheless, the patency of endovascular treatment has rarely been investigated in patients with SVC syndrome in patients with central venous access.

Objectives: The present study was performed to assess the patency rate of endovascular procedure in patients with SVC syndrome caused by intravenous catheterization.

Methods: The present case series and longitudinal study was conducted on patients with SVC syndrome in presence of central venous catheter who underwent venoplasty. Computed tomography (CT) venography was performed 1, 6 and 12 months after venoplasty. Facial swelling, facial discomfort, extremity edema, arteriovenous fistula (AVF) dysfunction, impairment in dialysis and SVC stenosis were measured at baseline and 1, 6 and 12 months after venoplasty.

Results: Out of 20 investigated patients, 11 (55%) were male. Significantly decreases were observed in the median grades of facial swelling and extremity edema in the follow-up (P<0.001). The decrease in facial discomfort was statistically insignificant (P=0.129), and the median grade of SVC stenosis significantly decreased from 1.5 to zero in the follow-up (P<0.001). A statistically-significant decrease was observed in AVF dysfunction (P=0.007), and impairment in dialysis significantly decreased after the intervention during the follow-up (P<0.001).

Conclusion: Findings of the present study revealed the appropriate patency rate of endovascular treatment in patients with SVC syndrome in presence of central venous catheter.

Key words: Catheterization, Central Venous; Endovascular Procedures; Superior Vena Cava Syndrome

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INTRODUCTION

The symptoms of superior vena cava (SVC) syndrome include obstruction of the SVC vein and swelling of the head, face, neck, arms and breasts. SVC syndrome may also cause cyanosis, plethora and distended subcutaneous veins. With an approximate annual incidence of 15000 cases, this syndrome is considered a rare condition in the US (1-7). Although the majority of the cases are secondary to underling malignant diseases, especially lung cancer, the other causes reported to contribute to disruption to SVC flow include mediastinal fibrosis, pacemaker lead implantation and central venous catheterization insertion (8-12). Different treatments proposed for SVC syndrome comprise percutaneous transluminal angioplasty, stent implantation, thrombolysis, mechanical thrombectomy and vein grafting (13-21).

Despite evaluating these methods in numerous studies, the patency rate of endovascular treatment has rarely been addressed in patients with SVC syndrome in presence of central venous access. The present study was performed to take a step towards improving the treatment of these patients.

Methods

Study design

The present case-series and longitudinal study was performed on patients presenting in 2018-19 to Imam Khomeini Hospital in Tehran, Iran. The study protocol was approved by Ethics Committee of Tehran University of Medical Sciences, Tehran, Iran. The study included patients who signed informed consent forms.

Study population

The eligible patients comprised those with SVC syndrome and AVF dysfunction (defined as high pressure of the venous structure or bleeding during dialysis or inappropriate dialysis as well as those with bleeding after dialysis catheter insertion, permcath malfunction). All the patients underwent venography; and venoplasty was performed in cases of occlusion and stenosis. The exclusion criteria comprised inability to follow up and SVC syndrome being caused by other conditions such as mediastinal fibrosis and lung cancer.

Intervention and outcome assessment

All the included patients who underwent venoplasty as a treatment for SVC syndrome were followed up by undergoing CT venography 1, 6 and 12 months after the intervention. As a general term covering any pains felt in the mouth, jaws and the face, facial pain or facial discomfort was measured with a numerical rating pain Scale (NRPS), with a zero score denoting the absence of pain, 1-3 represented as 1+, 4-6 as 2+ and 7-10 as 3+.

Upper extremity edema defined as the accumulation of fluids causing swelling in tissues perfused by the peripheral vascular system was evaluated as follows:

- Grade 0: Slight pitting, unnoticed changes in the extremity shape, a depth of indentation of 0-1/4" (<6 mm) and rapid disappearance of the symptoms
- Grade 1: No marked changes in the extremity shape, a depth of indentation of 1/4 -1/2" (6-12 mm) and disappearance in 10-15 seconds
- Grade 2: Noticeably deep pitting, swollen extremity, a depth of pitting of 1/2-1" (1-2.5 cm) and a 1-2 minute duration of the symptoms
- Grade 3: Very swollen and distorted extremity, a depth of pitting of over 1" (>2.5 cm) and a 2-5 minute duration of the symptoms

The narrowing or blockage of the SVC known as SVC obstruction was investigated using a five-point scale as follows:

- Grade 0: SVC narrowing without clinical evidence of SVC syndrome
- Grade 1: mild-to-moderate SVC narrowing without collaterals
- Grade 2: severe SVC narrowing above the azygos vein serving as partial collateral
- Grade 3: SVC obstruction below the azygos vein
- Grade 4: SVC obstruction at the azygos arch

In case of AVF dysfunction, the AVF flow was measured before and after the treatment using a Doppler ultrasound. The success criteria comprised improvements in the head and facial swelling, the AVF function and SVC vein stenosis after CT venography during the follow-up (21-24).

Data collection

The data were collected using a checklist consisting of demographic and baseline information about underlying diseases and symptoms. The demographic information comprised name, age, gender, the habitual history, including smoking, drug abuse and alcohol consumption, underlying diseases such as heart, pulmonary and kidney diseases and cancers and the symptoms before and after the treatment, i.e. facial and extremity swelling and facial discomfort. The patients completed the checklist in two stages, i.e. before and after the treatment, and the symptoms after the treatment were compared with those before the treatment to evaluate the patency. The clinical symptoms of the patients recorded by the researchers included the head and facial swelling, upper extremity edema, facial discomfort, fistula failure, dialysis disorder and SVC stenosis.

Statistical analysis

The data were analyzed in SPSS-22 using descriptive and analytical methods. The categorical variables were expressed as frequency and relative frequency and the numerical variables as mean±standard deviation (SD) and median with an interquartile range (IQR). The Chi-squared test was used to analyze the trend of distribution changes at four follow-up time points, i.e. baseline and three times after the intervention. The Friedman test was also used to numerically test the scores of the variables during the follow-up. Moreover, the Shapiro-Wilk test and graphical methods were used to investigate the distribution normality of the variables. $P<0.05$ was set as the level of statistical significance.

RESULTS

The present study investigated 11 (55%) males and 9 (45%) females. Permcath malfunction was observed in 11 (55%) cases, port dysfunction in 7 (35%) and AVF dysfunction in 2 (10%). Clinical symptoms at baseline and follow-up in the patients undergoing venoplasty are reported in table 1. The frequency of grades 1-3 of facial swelling observed at baseline in 60.0% of the patients decreased after the intervention and reached 15% after 12 months. The median grade of facial swelling significantly decreased in the follow-up ($P<0.001$). The frequency increase in grade 0 from 40% to 85% ($P=0.005$), the decrease in grade 2 from 5% to 0% ($P=0.008$) and the decrease in grade 3 from 3% to

Table 1: Clinical symptoms at baseline and follow-up in the patients undergoing venoplasty

Variable	Baseline	1st month	6th month	12th month	P-value*
Facial swelling					
Grade 0 (%)	8 (40.0)	16 (80.0)	15 (75.0)	17 (85.0)	8.05 (0.005)
Grade 1 (%)	4 (20.0)	2 (10.0)	4 (20.0)	3 (15.0)	0.02 (0.892)
Grade 2 (%)	5 (25.0)	1 (5.0)	1 (5.0)	0 (0.0)	7.04 (0.008)
Grade 3 (%)	3 (15.0)	1 (5.0)	0 (0.0)	0 (0.0)	5.26 (0.022)
Mean (SD)	1.2 (1.1)	0.35 (0.81)	0.30 (0.57)	0.15 (0.37)	
Median (IQR)	1.0 (2.0)	0.0 (0.0)	0.0 (0.75)	0.0 (0.0)	23.20 (<0.001)
Extremity edema					
Grade 0 (%)	9 (45.0)	16 (80.0)	16 (80.0)	18 (90.0)	9.41 (0.002)
Grade 1 (%)	2 (10.0)	2 (10.0)	3 (15.0)	2 (10.0)	0.03 (0.874)
Grade 2 (%)	6 (30.0)	1 (5.0)	1 (5.0)	0 (0.0)	9.00 (0.003)
Grade 3 (%)	3 (15.0)	1 (5.0)	0 (0.0)	0 (0.0)	5.26 (0.022)
Mean (SD)	1.2 (1.2)	0.35 (0.81)	0.25 (0.55)	0.10 (0.31)	
Median (IQR)	1.0 (2.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	25.38 (<0.001)
SVC stenosis					
Grade 0 (%)	0 (0.0)	15 (75.0)	14 (70.0)	17 (85.0)	25.58 (<0.001)
Grade 1 (%)	10 (50.0)	3 (15.0)	4 (20.0)	3 (15.0)	5.33 (0.021)
Grade 2 (%)	7 (35.0)	2 (10.0)	2 (10.0)	0 (0.0)	9.30 (0.002)
Grade 3 (%)	3 (15.0)	0 (0.0)	0 (0.0)	0 (0.0)	5.61 (0.018)
Mean (SD)	1.7 (0.75)	0.45 (0.94)	0.40 (0.68)	0.15 (0.37)	
Median (IQR)	1.5 (1.0)	0.0 (0.75)	0.0 (1.0)	0.0 (0.0)	42.82 (<0.001)
Facial discomfort					
Negative (%)	16 (80.0)	20 (100)	19 (95.0)	19 (95.0)	2.31 (0.129)
Positive (%)	4 (20.0)	0 (0.0)	1 (5.0)	1 (5.0)	
AVF dysfunction					
Negative (%)	16 (80.0)	19 (95.0)	20 (100)	20 (100)	7.21 (0.007)
Positive (%)	4 (20.0)	1 (5.0)	0 (0.0)	0 (0.0)	
Dialysis impairment					
Negative (%)	7 (35.0)	17 (85.0)	19 (95.0)	19 (95.0)	20.70 (<0.001)
Positive (%)	13 (65.0)	3 (15.0)	1 (5.0)	1 (5.0)	

SVC: superior vena cava; AVF: arteriovenous fistula
*The p-values calculated using Chi-square test

0% (P=0.022) were statistically significant. Similarly, significant decreases (P<0.001) were observed in all grades of extremity edema from 55% to 10% after 12 months of the follow-up compared to before the follow-up. Grades 1-3 of facial swelling at baseline associated with SVC stenosis decreased in all the patients after the intervention and reached 25% after one month of the follow-up, 30% after six months and 15% after 12 months. The median grade of SVC stenosis also significantly decreased from 1.5 to zero during the follow-up (P<0.001), and the frequency increase in grade 0 from 0% to 85% (P<0.001) and the decrease in grades 1-3 were statistically significant (P<0.05) (table 1). The decreases in the frequency of facial discomfort from 20% at baseline to 0% one month after the intervention, 5% six months after and 0% twelve months after were statistically insignificant (P=0.129). The decreases in the frequency of AVF dysfunction from 20% at baseline to 5% one month after the intervention, 0% six months after and 0% twelve months after were statistically significant (P=0.007). The frequency of impairment in dialysis also significantly decreased from 13 (65%) at baseline to 5% during the follow-up (P<0.001) (table 1).

Discussion

Quick and effective alleviation of the symptoms rather than a long-term recovery constitutes the main objective of treating SVC syndrome. Conventionally, most patients with SVC syndrome associated with malignant diseases have been treated with either or both radiation therapy and chemotherapy. Venous congestion and partial remission normally do not disappear sooner than 3-7 days of performing radiation therapy. Satisfactory responses can be observed in approximately 46%-70% of the patients during the first two weeks. Steroids and anticoagulant therapy are also used in this regard. Endovascular stents have been successfully used recently to relieve the symptoms. Rapid and sustained therapeutic responses were reported in 75%-95% of the patients (9-10). Managing the benign causes associated with intravascular devices include removing the device, thrombolytic therapy, anti-coagulant administration, endovascular stenting, conservative management or a combination of these measures (11-12).

Kee et al. reported benign diseases in 13 out of 51 patients undergoing stenting, primary clinical patency in 10 (77%) out of the 13 and secondary

clinical patency in 11 (85%) during a 1-27 month follow-up with a median duration of 17 months. Moreover, four patients did not return for the follow-up. They also reported periprocedural mortality and morbidity respectively as 3% and 10%, and found catheter-directed thrombolysis and endovascular stenting to be safe and effective treatments for SVC syndrome (13). Lanciego et al. found Wallstent vascular endoprosthesis to be an early effective treatment in lowering the morbidity and complications and relieving the symptoms of SVC syndrome from neoplastic origin. Wallstent endoprosthesis was therefore proposed as the first choice for managing SVC syndrome (14). Kalra et al. found endovascular treatment to be effective in the short term, and reported the need for repeated interventions. They reported that this procedure had no negative effects on future surgical reconstruction, which made it a rational and primary intervention in the selected patients. The patients who failed to respond to endovascular treatment were also identified as candidates for open surgical reconstruction (15). Despite reporting the same clinical and technical success as that of unilateral Wallstent placement, Dinkel et al. found bilateral Wallstent placement to be associated with a lower patency and more complications (16). Given the immediate and relatively stable relief of the symptoms caused by endovascular stenting, Kim et al. found this technique to be the first choice of treating and alleviating the symptoms of SVC syndrome (9). In 2018, Hooker et al. found both surgical and endovascular treatments to often require secondary interventions for maintaining patency, and percutaneous treatment to be associated with fewer sequelas. They also found the treatment of benign SVC syndrome to be a safe, effective and reasonable primary method (18). Given the high risks of the surgical correction of SVC syndrome, the focus has shifted to endovascular management over the past few decades. In the US, uncovered balloon-expandable stents, including Z stents, Palmaz stents and Wallstent® (Boston Scientific), are the main stents in use. The typical complications of SVC stenting include thrombosis, stent migration, hemopericardium and transient chest pain. Using uncovered stents or covered stents with uncovered margins has lowered the incidence of stent migration. In case SVC stenosis is at the confluence of the 2 veins, covered stents are yet associated with higher risks of stent migration and obstruction of unilateral azygos and brachiocephalic veins (19-20). Gustavo found stents to be transiently beneficial for most patients with peripheral or central upper-extremity symptomatic venous obstruction. Re-interventions and regular follow-up were required for maintaining patency and clinical success. The clinical success of the stents used for central venous lesions is lower than that of the stents used for peripheral venous lesions (21). The objectives of treating malignant SVC-related syndromes include alleviating the symptoms and treating the underlying diseases. Successfully managing the underlying etiology depends on the type and degree of spread of the disease and the overall prognosis, which is tightly related to the histology and whether or not previous treatments have been performed. All these factors affect the selection of treatment methods. A major finding of the present study was that recurrence was more frequent in the cases whose venoplasty was not optimal. Stenting during the follow up was also associated with lower recurrence rates, especially in the cases with suboptimal results. Given the risk of recurrence, optimal results are recommended that be obtained by closely observing the patients and taking diagnostic and therapeutic measures in case of a significant clinical suspicion.

Imaging techniques play a key role in diagnosing and treating different conditions that affect SVC. Indirect radiographic symptoms of the chest, including mediastinal widening and mediastinal masses, can suggest malignancy arising from the lung, pleura or trachea. These radiographs can also be used to evaluate the position of central venous catheters in certain benign cases. CT scans and MRI can also be used to show the level and extent of venous obstruction, map the route of venous drainage and identify the underlying etiology. Venography is normally required as part of interventions for acute thrombotic SVC syndrome to evaluate the location and extent of SVC obstruction and collateral drainage (5-7).

Limitations

Due to low prevalence of SVC syndrome conducting clinical trial has considerable difficulties and most of performed surveys have same methods. Therefore, the results cannot be generalized with proper confidence and still need to be assessed.

Conclusions

Findings of the present study revealed the appropriate patency rate of endovascular treatment in patients with SVC syndrome in presence of central venous catheter.

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AUTHORS' CONTRIBUTION

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CONFLICT OF INTEREST

None declared.

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