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Long-Term Results of Endovascular Stent Placement in the Superior Caval Venous System

Tarek Smayra, Philippe Otal, Valérie Chabbert, Patricia Chemla, Marques Romero, Francis Joffre, Hervé Rousseau

Service Central de Radiologie, CHR Rangueil, 1, avenue Jean Poulhès, F-31403 Toulouse, France

Abstract

Purpose: To present the long-term results in superior caval stenting for symptomatic obstruction.
Methods: Forty-nine stents were placed in 30 patients: 16 (53%) with malignant lesions, five (17%) with benign lesions and nine (30%) hemodialysis patients. Self-expandable stents were deployed on a first-line basis. Patients were followed clinically as well as by various imaging techniques and survival analysis was performed.
Results: Stent deployment was possible in all cases. Reocclusion was seen in 13 patients, of whom eight belonged to the hemodialysis group. Primary and secondary patency rates for malignant, benign and hemodialysis patients were respectively 74%, 50% and 22%, and 74%, 75% and 56% at 1 year. We had 7% complications and one death from iatrogenic superior vena cava injury.
Conclusion: Primary stenting of superior caval obstruction is a first-choice treatment method achieving good mid-term patency. Patients with hemodialysis shunts must be closely monitored for early reintervention.

Key words: Vena cava, stenosis or obstruction—Vena cava, interventional procedure—Superior vena cava syndrome

Two types of lesions can obstruct the superior caval venous system. Malignant lesions are the most frequent and result from direct venous involvement by adjacent malignant tumor or nodes. Alternatively the obstructive lesion may be benign. Clinical manifestations of venous obstruction can be quite serious, requiring prompt palliative treatment. Different therapeutic methods are available, among which we believe that endovascular stent placement could be a good one. The objective of this paper is to the present long-term results of superior caval system stenting in a relatively large series from a single center.

Correspondence to: H. Rousseau; tel: +33 5 61 32 28 51, fax: +33 5 61 32 24 92, e-mail: ROUSSEAU.H@chu-toulouse.fr

Materials and Methods

Between 1987 and 1999, 49 stents were placed in 30 patients (17 men, 13 women) ranging in age between 29 and 86 years (mean 61 years). Nineteen were suffering from symptomatic obstruction of the superior vena cava (SVC) and 11 from an isolated obstructive lesion of its affluent venous trunks. The responsible lesion was malignant in 16 cases (53%), benign in five (17%) and secondary to hemodialysis arteriovenous fistula in nine (30%) patients. Among the patients with malignant lesions, five had squamous cell carcinoma of the lung, four had adenocarcinoma, three had small cell carcinoma, one had pleural mesothelioma, one had metastasis from bilateral breast cancer and two had lung cancers of unknown type. The benign lesions were post-surgical ($n = 2$), post-radiotherapy ($n = 2$) or the sequela of mediastinal fibrosis and upper limb thrombophlebitis ($n = 1$).

All the patients were clinically assessed before treatment for the presence of venous dilation ($n = 30$), facial edema ($n = 19$), laryngopharyngeal symptoms ($n = 5$) and neurologic signs ($n = 2$), according to the four classes described by Kishi et al. [1]. Prior to stenting, among the malignancy group patients, 11 (69%) had radiotherapy ($n = 3$), chemotherapy ($n = 2$) or both ($n = 6$), but symptoms either recurred or failed to respond. Bilateral upper extremity venograms allowed SVC obstruction to be graded according to Stanford's classification [2]. There were four lesions of type I, five of type II, six of type III and four of type IV. Isolated venous lesions with a patent SVC were classified as stenosis ($n = 7$) or occlusion ($n = 4$).

The procedure was done in a sterile dedicated angiography suite, under local anesthesia in the majority of the patients. A few requested general anesthesia because of low pain tolerance. Transcatheter thrombolysis was done prior to stent placement in two patients only, where the superior caval system was extensively occluded. We used a short-term protocol consisting of 100 000 IU of urokinase (Sanofi-Winthrop, Gentilly, France) given at the rate

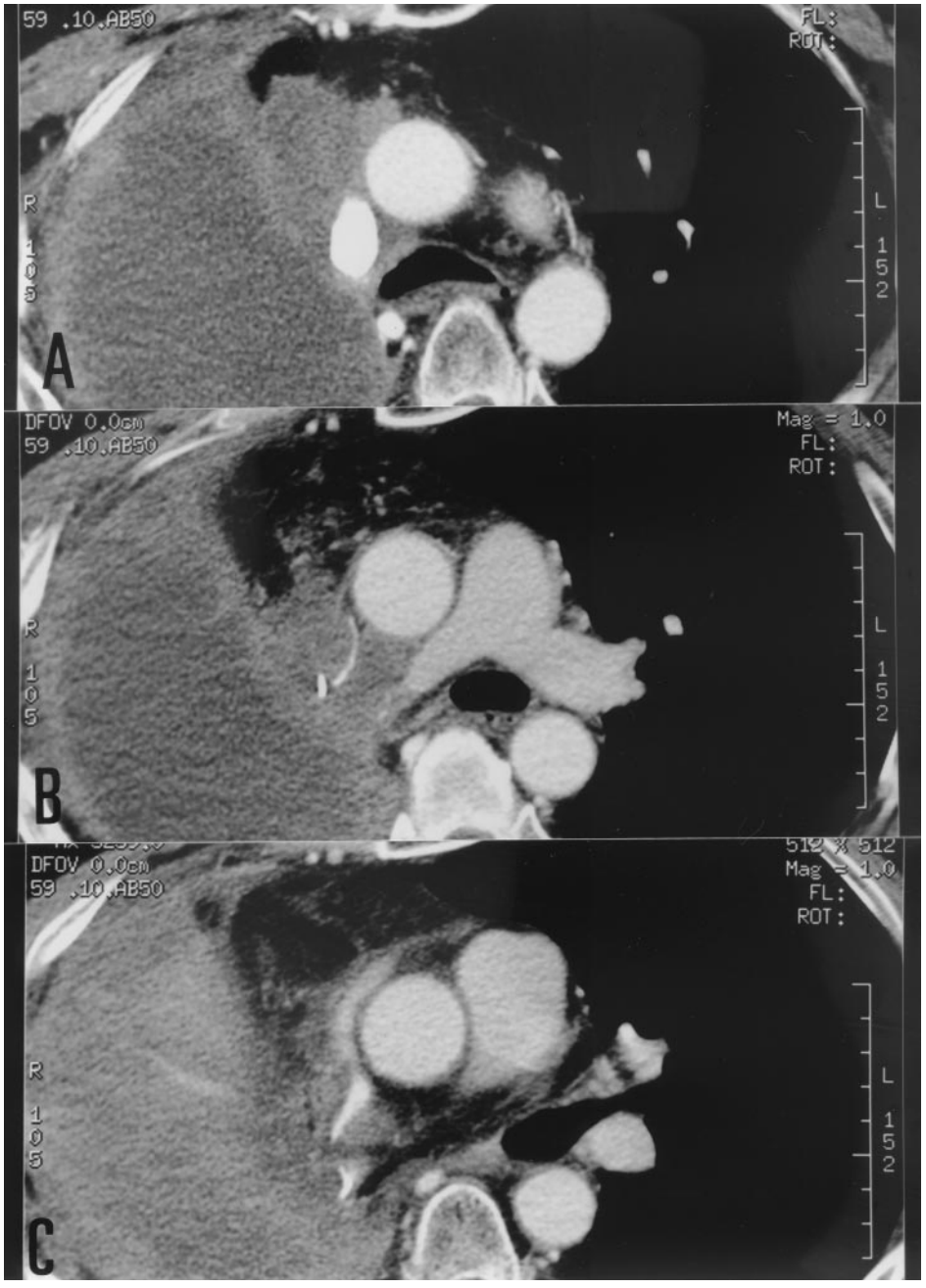

Fig. 1 A–C. A 50-year-old man with right pneumonectomy for lung cancer of unknown type, presenting with superior vena cava encasement by tumor invasion seen on 5 mm enhanced CT scans above (**A**), at (**B**) and below (**C**) the pulmonary artery division.

of 4000 IU per minute. In one patient, mechanical thrombectomy of the occluded right innominate venous trunk was performed using the Hydrolyser catheter (Cordis, Roden, The Netherlands).

Unilateral brachial access was sufficient in cases of unilateral venous lesions. Bilateral access was used when bilateral innominate lesions were present. A femoral approach was necessary when lesion catheterization via brachial access failed. In some cases, due to the large sheaths required for stent placement, femoral access was used even when the guidewire could cross the venous lesion via the brachial access; in this case, a pull-push technique was used by pulling the guidewire inserted from the brachial approach to the femoral side with a snare (Amplatz "Goose Neck", Microvena, White Bear Lake, USA) and reversing it using a multipurpose catheter (Cordis, Roden, The Netherlands).

Three kinds of self-expandable stent were used depending on their availability at the time of the procedure: 26 Memotherm (Bard, Galway, Ireland), 22 Wallstent (Schneider, Bülach, Switzerland) and one Symphony (Boston Scientific, Paris, France). Their diameter was chosen to be slightly larger than the underlying normal vein and ranged between 10 and 14 mm. Their length was between 30 and 80 mm, allowing the entire venous lesion to be covered (Figs. 1, 2).

When no blood clots were found on the initial venogram, we performed a low-pressure dilation with a slightly smaller balloon at the stenosis in order to assess its toughness, and reused the same balloon after stent deployment to achieve better but not complete initial stent expansion. The reasons for this approach will be discussed later. In two patients, existing central venous catheters were

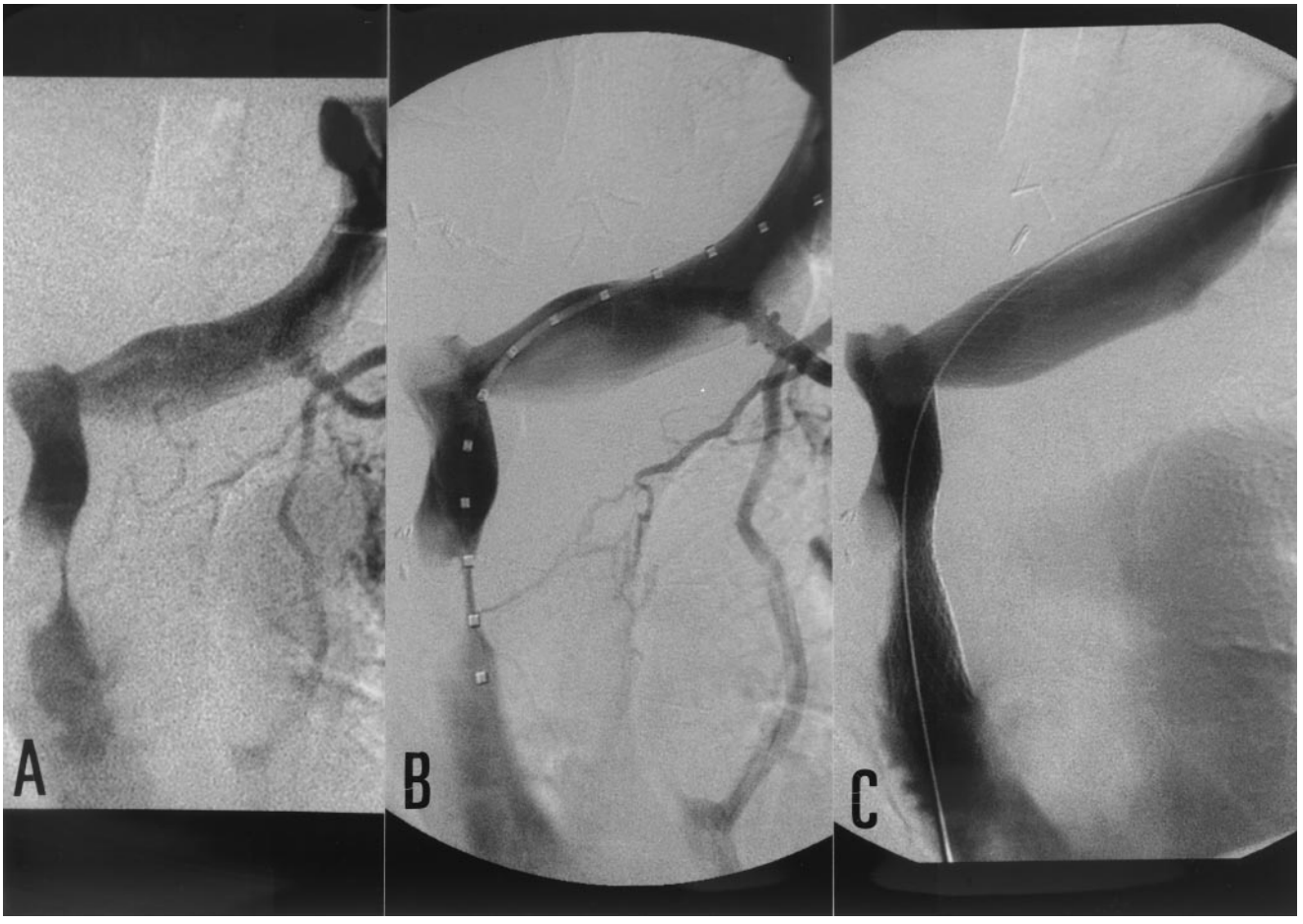

Fig. 2 A–C. Same patient as in Fig. 11, on venography done through a left brachial access. The extremely tight stenosis (**A**) was catheterized (**B**) using a graded pigtail catheter, allowing precise stenosis measurements. A 14 × 80 mm Memotherm stent was deployed to relieve the stenosis (**C**).

pulled by means of a snare (Amplatz "Goose Neck", Microvena, White Bear Lake, USA) before inserting the stent, then repositioned at the end of the procedure inside the device. In some of the malignancy group patients, bilateral brachiocephalic system stenting was deemed necessary. This was done by deploying parallel stents via bilateral brachial access (Fig. 3). More than one stent were used in 14 patients, either because SVC confluence reconstruction was necessary or because the lesion was too long to be completely covered with only one device. Patients received about 5000 IU of heparin during the procedure. Broad-spectrum antibiotics were administered when it was considered there was a high risk of infection, mainly in hemodialysis patients.

The follow-up of each patient was done clinically by the referring physician, as well as through Doppler ultrasonography, computed tomography, magnetic resonance imaging or venography when necessary. Additional interventions such as balloon angioplasty, stenting or transcatheter fibrinolysis were done in cases of stent failure. Global mean follow-up was 10 months (range 1–51 months). The malignant, benign and hemodialysis groups have a mean follow-up of 6, 15 and 13 months respectively. At the latest follow-up 17 patients were still alive with patent stents.

Primary patency is defined as patency since stent deployment without a further procedure to maintain or regain patency. Secondary patency is the patency obtained after performing every possible procedure to keep the vessels patent. Kaplan-Meier survival analysis was done using TIGRE software (Gustave-Roussy Institute) to calculate primary and secondary patency rates, and to perform survival comparison tests (log-rank).

Results

It was possible to cross the lesions and deploy the stents in all patients. A total of 49 stents were placed in the 30 patients of our series. There were 26 Memotherm stents, 22 Wallstents and one Symphony stent. Clinical relief was noted in all patients following stent deployment after a delay of a few minutes to a few days. Regarding early complications of the procedure, one patient died immediately after stent deployment despite active resuscitation measures, following cardiac tamponade caused by iatrogenic SVC perforation. In another patient, a 10 mm diameter Wallstent had migrated on the fourth day of its placement and was found in the pulmonary artery. It was successfully retrieved through an iliac venotomy and a 12 mm diameter Wallstent was placed instead.

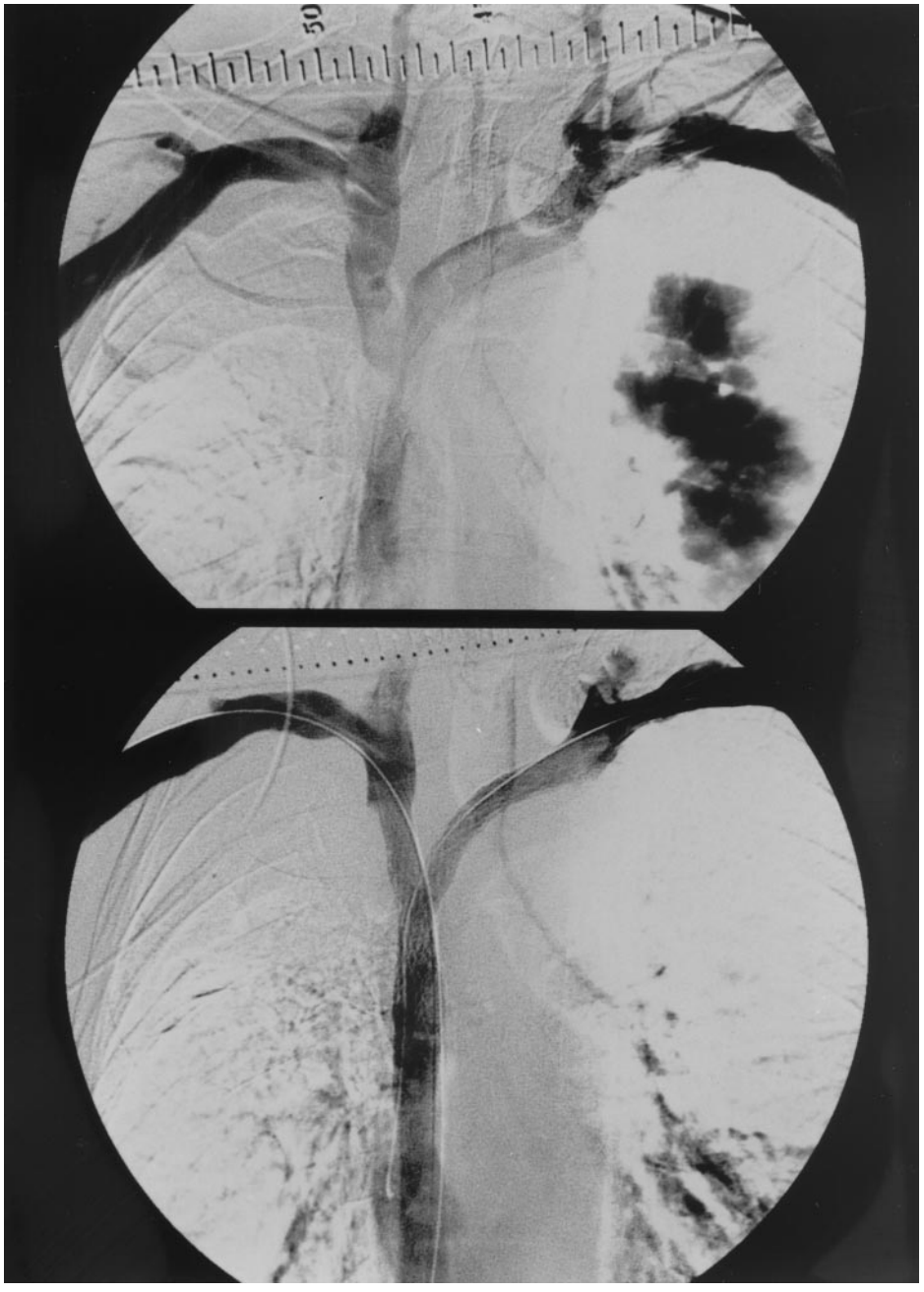

Fig. 3. Above: Superior vena cava tight anteroposterior stenosis resulting from squamous cell carcinoma of the lung and requiring bilateral stenting for confluence reconstruction. Below: Three 10 mm diameter Memotherm stents were deployed via bilateral venous brachial access.

Stent dysfunction requiring reintervention was found in 13 patients (43%). They were managed as follows: Five patients had restenosis treated with balloon angioplasty, which was successful in four cases. In the fifth patient, balloon angioplasty failed and the patient died 1 month later from lung adenocarcinoma with hepatic metastasis. Two patients had a second stenting, both from the hemodialysis group, after presenting with acute occlusion of their Wallstents. The first was treated with a Passager stent (Boston Scientific, Ireland) in the subclavian vein, covering two adjacent Wallstents and achieving good angiographic results. But the arteriovenous fistula was closed because of poor hemodialysis results and another hemodialysis access was constructed on the opposite side. The second patient was treated with a Wallstent placed inside the original one, achieving good venous patency. Of the six other patients, two were lost to follow-up and were not treated, one had his ipsilateral hemodialysis arteriovenous fistula removed, and the three others had anticoagulation treatment, which was successful in only one.

Table 1 shows the patency rates after endovascular treatment of superior caval system obstruction. Figs. 4 and 5 represent the cumulative survival for stent primary and secondary patency respectively, in the malignant and hemodialysis groups. The 1-year primary patency rates for the malignant and hemodialysis patients are respectively 74%

Table 1. Patency after stent deployment

Etiology	Primary patency		Secondary patency	
	Failures (n)	Patency rate (%)	Failures (n)	Patency rate (%)
Malignant ($n = 16$)	2	87.5	2	87.5
Benign ($n = 5$)	3	40	1	80
Hemodialysis ($n = 9$)	8	11.1	4	55.6
Total ($n = 30$)	13	56.7	7	76.7

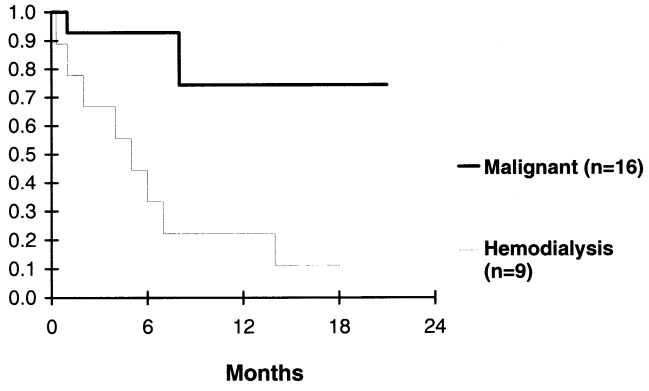

Fig. 4. Kaplan-Meier cumulative survival plot for stent primary patency in the malignant and hemodialysis groups.

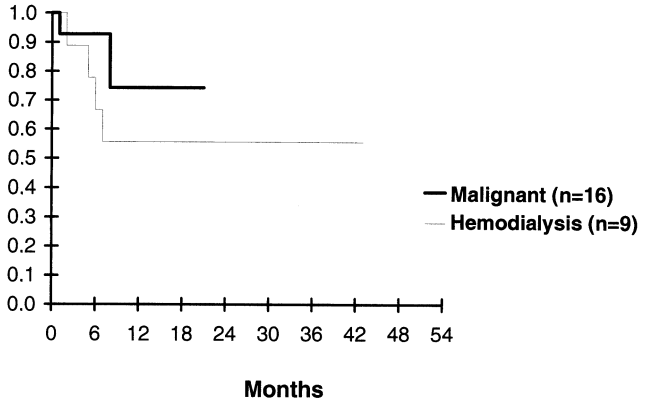

Fig. 5. Kaplan-Meier cumulative survival plot for stent secondary patency in the malignant and hemodialysis groups.

and 22%, and the secondary patency rates for the same groups are 74% and 56% respectively. A log-rank test showed a significant difference between the two groups only for primary patency rate ($p = 0.035$). Patients with benign lesions were not included in this analysis because of the small number of subjects; they had 1-year primary and secondary patency rates of 50% and 75% respectively.

Discussion

Endovascular stenting of symptomatic malignant or benign obstructive SVC lesions is an effective mid-term therapeutic solution. Malignant disease is the most frequent cause of superior caval system obstruction and in the majority of cases (80%) lung cancer is incriminated. Benign causes are becoming more and more frequent with the increasing placement of indwelling central venous catheters [3]. According to Denny et al. central venous catheters cause venous obstructive lesions by means of venous compression, chemical trauma from infused drugs through the catheter and mechanical trauma resulting from inadequate catheter placement [4]. Benign stenosis can also result from hemodialysis, post-radiotherapy or post-surgical mediastinal fibrosis, thrombophlebitis and any obstruction not caused by malignant tumor invasion. According to Parish et al., benign causes represent only 3–25% of superior vena cava syndromes, but unlike malignant lesions, where patient survival is already compromised (about 7 months), the most important factor in treatment choice is achieving good long-term patency [4].

Whatever is its cause, SVC syndrome can sometimes be very severe, depending on collateral venous system development and notably the azygous system [3], and may require urgent treatment. Management of these patients can be done in various ways. Anticoagulation alone is not efficient but may be used in association with other treatment modalities [3]. Thrombolysis can be effective in 88% of cases if done before the fifth day of occlusion, but in only 25% of cases when the delay is longer than 5 days; it is an insufficient technique in subacute and chronic occlusions [5]. Furthermore thrombolysis alone can be efficient only in the absence of underlying stenosis [6]. Percutaneous transluminal angioplasty (PTA) has a high rate of early restenosis and even of primary failure because of the fibrous and elastic nature of venous lesions [3, 6]. It can be very useful before stenting by allowing the stent to cross relatively tight lesions. In the case of malignant lesions, radiotherapy and chemotherapy can be tried alone or in combination in the hope of relieving clinical symptoms. In the case of a chemosensitive malignancy (small cell carcinoma, lymphoma), chemotherapy may give good results in about 60% of cases, but can take many weeks to achieve significant clinical relief, has many side effects and usually fails in the course of the next year [3, 7]. Radiotherapy gives a complete response in 15–60% of cases. However, post-radiotherapy edema is responsible for early aggravation of symptoms and the radiotherapy may take up to 3 months to obtain a clinically significant response; it is also less effective than stenting [3, 6–9].

Surgical treatment in superior caval system obstruction consists of bypassing the stenosis using a polytetrafluoroethylene (PTFE) tube or an autologous spiral saphenous vein graft. It is a major operation requiring median sternotomy and, even though it yields good patency rates, is not justified in malignancy patients with a poor prognosis when a less invasive alternative such as endovascular treatment is possible [4, 6, 10]. Many authors recommend performing a surgical bypass in benign Stanford types III and IV cases and stenting all the rest on a first-line basis and promptly [7, 10].

Different kinds of stents have been used in these lesions. The first one to be placed in the SVC was a Gianturco Z-stent, by Charnsangavej et al. in 1986 [11]. The Gianturco Z-stent has a large diameter that makes it well adapted to lesions of the SVC [12]. But a large introducing system is necessary, and migration and even fracture of this stent were reported; also its large strut interspaces allow early restenosis from tumor regrowth. The Wallstent is a self-expandable stent with a low initial radial strength that increases progressively as the Wallstent becomes fixed in the vessel [13]. This stent also has good flexibility and fair radio-opacity. Its major disadvantage relates to its largely unpredictable shortening while expanding, and the fact that it may even shorten further in the few days following its deployment and uncover the obstructive lesion [4, 14]. Oudkerk et al. [15] compared Gianturco Z-stents and Wallstents in 30 patients with malignant stenosis of the SVC and found a significantly higher early occlusion rate with Wallstents. However, the use of Wallstents has been advocated in benign SVC obstructions [4]. The Memotherm stent which is also a self-expandable stent, relies for its self-expansion on nitinol. Nitinol is a thermal memory alloy that assumes a predetermined shape at a set temperature (30 °C). It is, however, a much easier and more precise stent to deploy than the Wallstent despite its rather poor radio-opacity [13]. Symphony stents have a good radial strength, low radio-opacity and seem suitable for stenosis and short occlusions [13]. We had to use a Symphony stent in the subclavian vein of a hemodialysis patient because it was the only available device, and only once because it has large struts and required PTA three times for recurrence due to intimal hyperplasia. At the latest follow-up it was patent but broken, as a result of costoclavicular compression.

Many authors prefer to use self-expandable stents rather than balloon-mounted ones in venous lesions because they have a larger diameter and are also more flexible and thus more suitable in the presence of respiratory movements with less risk of migration. In addition venous diameter can become greater after patency is regained and balloon-mounted stents that lack self-expansion can easily migrate for this reason. This is why stents are chosen with a larger diameter than the involved vein. In addition, our technique is to use a slightly smaller caliber balloon than the nominal diameter of the oversized stent in order to reduce venous rupture and postprocedureal pain, since the stent is allowed to expand in a progressive manner. The nitinol Memotherm stent, although more fragile, is more adapted to this principle of progressive expansion than the Wallstent, which shortens while expanding and might uncover the lesion or migrate. We compared the primary and secondary patency rates of the Wallstent and Memotherm stent using survival analysis and a log-rank test. No significant difference in patency was shown. The use of covered stent-grafts in superior caval venous obstructions was not deemed necessary [7].

Up to 37% of superior vena cava syndromes are associated with thrombosis [7]. Thrombolysis, performed medically or mechanically before stenting, has the benefit of revealing the underlying stenosis and allowing a more targeted stenting, thus diminishing the cost by reducing the number and size of the stents necessary, which additionally represent thrombogenic foreign objects [6, 8]. However, because of potential bleeding complications we perform thrombolysis only when the superior vena cava system is extensively occluded and no focal lesion can be revealed. On the other hand, we do not routinely perform PTA prior to stent deployment because we believe that immediate stenting helps in preventing distant embolic events by trapping the clots between the stent and the venous wall. Despite bilateral upper extremity venous lesions, many authors advocate performing unilateral stenting only for malignant diseases [7, 16]. We agree with this if well-developed venous collaterals connecting the right and left side are present on venography. When occlusion seems extensive with poor collateralization, as in Stanford IV lesions, bilateral stenting is necessary to relieve the symptoms. On the other hand, subclavian lesion stenting must be carefully evaluated because of the risk of stent damage from costoclavicular compression.

In cases where central venous catheters were present, they were pulled distally and then replaced through the deployed stent. This easy maneuver [7, 17, 18] allows catheters to be kept in place that otherwise would have to be completely removed before the procedure.

We do not believe, like many authors [4], that a transstenotic pressure gradient measurement is a useful criterion in the management of these lesions, notably because the venous circulation, in contrast to the arterial circulation, depends on many different factors (heart pump, respiratory mechanics, gravity, muscle contraction, etc.) which give it an irregular flow pattern and highly variable and thus unreliable pressure curves. Therefore demonstrating good blood flow through the superior caval system with markedly reduced collateral circulation on post-stenting venography represents a good criterion of immediate technical success.

A technical success of 90–100% in stenting these lesions is generally found in the literature. Patency rates appears to be the same whether dealing with totally occluded or only stenotic lesions [8]. Our patency rates correspond to those found in the literature, where primary patency rates vary between 77% and 85% and secondary patency rates between 85% and 91% for a follow-up of up to 17 months [3, 6–8]. But special consideration must be given to our nine hemodialysis patients. Eight of them presented with primary stent failure about 5 months after deployment. It is well known that central venous stenoses or occlusions in hemodialysis patients are due to the high flow situation in contrast to the low flow normally seen in veins [16]. This results in chronic intimal injury with intimal hyperplasia occurring mainly at sites of turbulence. Even after stenting these diseased areas, restenosis is always induced by its persistent primary cause, i.e., a high flow situation. This explains the low primary patency rate in hemodialysis patients and the necessity of repeated interventions to maintain venous patency. Some

authors even advocate avoiding first-line stenting of hemodialysis-induced lesions, given that a 60–80% restenosis rate, usually between 4 and 12 months after stenting, is almost the rule [19]. Other authors perform close monitoring of stented hemodialysis lesions in order to perform early PTA and maintain patency [16].

The overall complication rate in stenting of SVC syndrome is almost 19% [7, 8]. Most of the complications are procedure-related, such as hemorrhage after thrombolysis and anticoagulation, migration, shortening or thrombosis of stents. Less frequent are pulmonary embolism caused by endovascular maneuvers, iatrogenic venous lesions, dysphonia, lymphedema, etc. [3, 7]. In our series of 30 patients the complication rate was only about 7% including one immediate death and one stent migration successfully retrieved. In addition we found a Symphony stent fracture in the subclavian vein with no hemodynamic impact. Given these results, we think that superior caval system stenoses other than in hemodialysis patients must be treated by primary stenting. In hemodialysis patients, when stenting is necessary, close follow-up is strongly advised.

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