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Std. Num.:	08905096	Type:	Doc Del (Journal Article)
Publication:	Annals of Vascular Surgery	Copies:	1
Publisher:	Springer-Verlag	Urgency:	Normal
Vol(Iss) Pg:	() p.	Genre:	Journal Article
Date	prepub	Total Fee:	$64.26

Title: Factors Associated with Successful Thrombus Extraction with the AngioVac Device; An Institutional Experience

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Clinical Research

Factors Associated with Successful Thrombus Extraction with the AngioVac Device: An Institutional Experience

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Background: The AngioVac (AngioDynamics, Latham, NY) device utilizes a venovenous bypass circuit for percutaneous venous thrombectomy and has been applied in the setting of iliocaval thrombosis as well as right heart thrombus and pulmonary emboli. We describe our experience with the AngioVac device in 12 patients with a variety of indications with the goal of identifying factors correlating with successful thrombectomy.

Methods: From August 2013 to June 2015, 12 patients underwent AngioVac percutaneous thrombectomy at our institution. Preoperative, intraoperative, and postoperative data were retrospectively analyzed.

Results: Indications for thrombectomy included iliocaval thrombosis in 33% (4), right heart thrombus in 42% (5), and pulmonary embolus in 25% (3). We experienced a 58% complete success rate. Partial success was achieved in 17%, and no thrombus was extracted in 25%. Iliocaval and right heart thrombi were the most amenable to AngioVac thrombectomy with 100% (4/4) and 60% (3/5) complete success rates, respectively. Pulmonary embolus was the least amenable to thrombectomy with a 33% partial success rate (1/3) and 67% failure rate (2/3).

Conclusion: The AngioVac devices allow for percutaneous thrombectomy in the setting of iliocaval and right heart thrombus in patients for whom medical therapy fails or for those in whom surgical intervention is considered high risk. Pulmonary emboli are less amenable, likely due to limited steeribility of the device. Larger studies are needed to make more definitive conclusions, and newer iterations of the device will likely allow for improved outcomes.

INTRODUCTION

The AngioVac (AngioDynamics, Latham, NY) device utilizes a venovenous bypass circuit for percutaneous thrombectomy and has been applied in the setting of iliocaval and right heart thrombi, as well as pulmonary emboli.[1–23] While good outcomes have been seen with iliocaval and right heart thrombi,[1–20] anecdotal experience with pulmonary embolectomy has been less positive, although limited.[1,2,21] We describe our experience with the AngioVac device in 12 patients with a variety of indications with the aim of analyzing the indications, comorbid status, complications, and factors correlated with a successful outcome.

Conflict of interest: None.

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Ann Vasc Surg 2016; ■: 1–6
http://dx.doi.org/10.1016/j.avsg.2016.04.015

Manuscript received: September 29, 2015; manuscript accepted: April 12, 2016; published online: ■ ■ ■

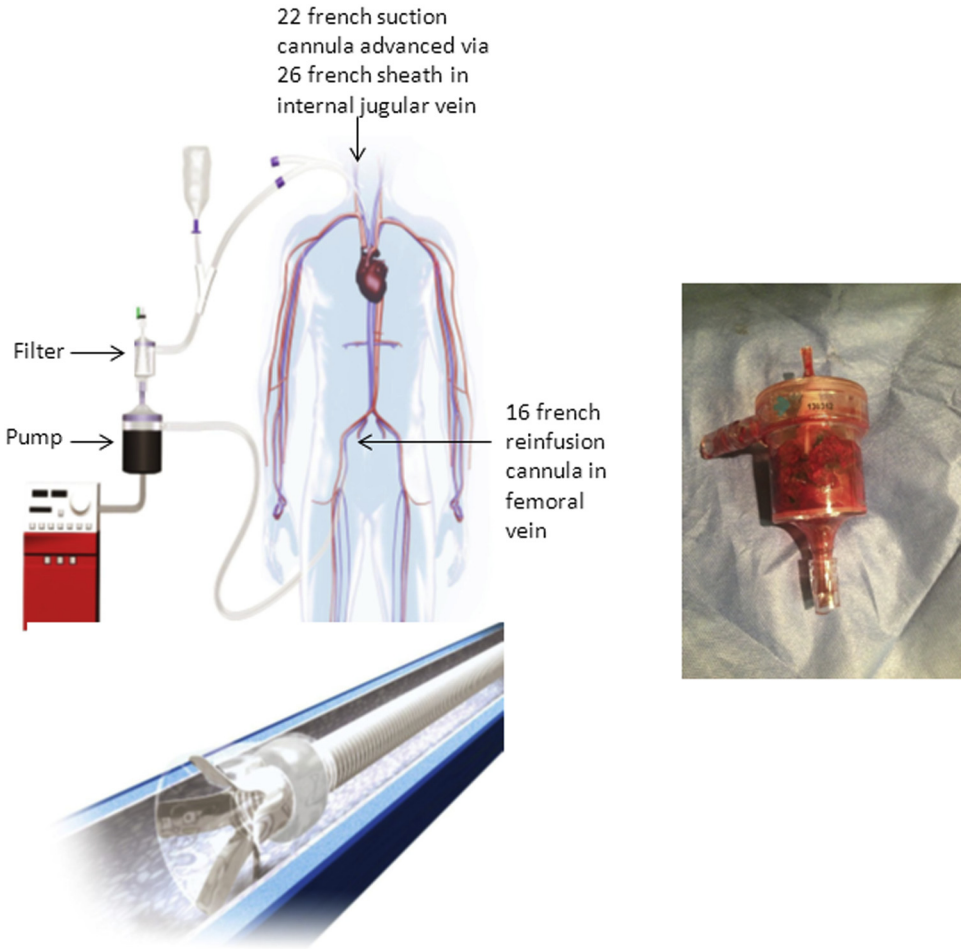

Fig. 1. The AngioVac system consists of an aspiration cannula, a return cannula, and a filter and utilizes a venovenous bypass circuit to achieve thrombus extraction.

METHODS

From August 2013 to June 2015, 12 patients underwent AngioVac percutaneous thrombectomy at our institution. Demographics, preoperative characteristics, indication for intervention, procedural details, and outcomes were retrospectively analyzed. Continuous variables were expressed as the mean with standard deviation. Categorical values were expressed as a percentage and compared using the chi-squared test.

All procedures were performed in the operating room or interventional radiology suite under general anesthesia. Standard monitoring lines included a central venous line, arterial line, and foley catheter. Thrombus was identified by venography, transesophageal echocardiography, or both. Systemic heparinization to an activated clotting time > 250 sec was achieved. Depending on the clinical scenario, either the femoral vein or the internal jugular vein was accessed and, after serial dilations, a 26-French GORE DrySeal Sheath was placed under fluoroscopic guidance. The 22-French aspiration cannula was then advanced under fluoroscopic guidance, aided by transesophageal echocardiography if thrombus was intracardiac. A return cannula, usually a 16- or 18-French FemFlex cannula, was placed in either the remaining femoral or the internal jugular vein. The AngioVac circuit was connected and flow was commenced at 2—3 L/min, usually requiring 3000—4000 rpm. The presence of chattering would signal the engagement of thrombus with interruption of flow. The filter was inspected periodically for thrombus and repeat venography or assessment with transesophageal echocardiography was performed to verify resolution of thrombus (Fig. 1). Cannulae were removed and hemostasis achieved with deep 0-Prolene purse-string sutures and manual compression. Reversal with protamine is not warranted. The patient was extubated if possible in the operating room.

Table I. Patient characteristics

AGE/Gender	Presentation	Diagnosis	Comorbidities	Acuity	26F Cannula	Success
45/Male	Fever	Right heart thrombus	ESRD, prior CABG, infected dialysis catheter, *Staphylococcus bacteremia*	Chronic	LFV	No
60/Male	Renal failure	Iliocaval thrombus	Migrated IVCf thrombosis, DVT, CVA, acute renal failure	Acute	RFV, RIJ	Yes
56/Female	Pedal edema	Iliocaval thrombus	Stage 4 endometrial cancer	Chronic	LFV	Yes
29/Male	Dizziness	Right heart thrombus	Stage 4 testicular cancer	Acute	RFV	Yes
53/Female	Dyspnea, palpitations	Right heart thrombus	Lymphoma, factor V Leiden, chemotherapy infusion catheter thrombus	Chronic	RFV, RIJ	Partial
56/Female	Chest pain	Iliocaval thrombus	Migrated IVCf thrombosis, obesity, COPD, pulmonary hypertension, acute renal failure	Acute	RFV	Yes
74/Female	Pedal edema	Iliocaval thrombus	IVCf thrombosis s/p pulmonary embolectomy	Chronic	RIJ	Yes
45/Male	Dyspnea, chest pain	Pulmonary embolus		Acute	RFV	No
45/Male	Dyspnea	Pulmonary embolus	DVT, metastatic pancreatic cancer	Chronic	RFV	No
81/Female	Dyspnea	Pulmonary embolus	DVT	Chronic	RIJ	Partial
67/Female	None	Iliocaval/right heart thrombus	Metastatic breast cancer	Acute	RIJ	Yes
45/Male	Fever, tachycardia, hypoxia, stroke	Right heart thrombus	DVT, thrombus in transit, NICM, EF, 20% AF, CVA, chronic renal insufficiency	Acute	RFV	Yes

AF, atrial fibrillation; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; DVT, deep vein thrombosis; EF, ejection fraction; ESRD, end-stage renal disease; FV, femoral vein; IJ, internal jugular vein; IVCf, inferior vena cava filter; L, left; NICM, nonischemic cardiomyopathy; R, right.

RESULTS

From August 2013 to June 2015, 12 patients underwent AngioVac percutaneous thrombectomy at our institution. Average age was 55 ± 14 years and 50% (6/6) of the patients were female. Indications for thrombectomy were iliocaval thrombosis in 33% (4), right heart thrombus in 42% (5), and pulmonary embolus in 25% (3). Metastatic cancer was the likely underlying etiology of a prothrombotic state 33% of patients (4), while 8% (1) had a documented hypercoagulable state (factor V Leiden deficiency). Active bacteremia was demonstrated in 8% of the patients (1). Catheter/wire-associated thrombus was present in 25% of the patients (3). Two patients presented with inferior vena cava filter thrombosis associated with suprarenal migration of the filter. In both cases, the AngioVac device was used to successfully extract all thrombus such that the filters could be removed. In one patient a filter was replaced, and in the other it was not. Details are listed in Table I.

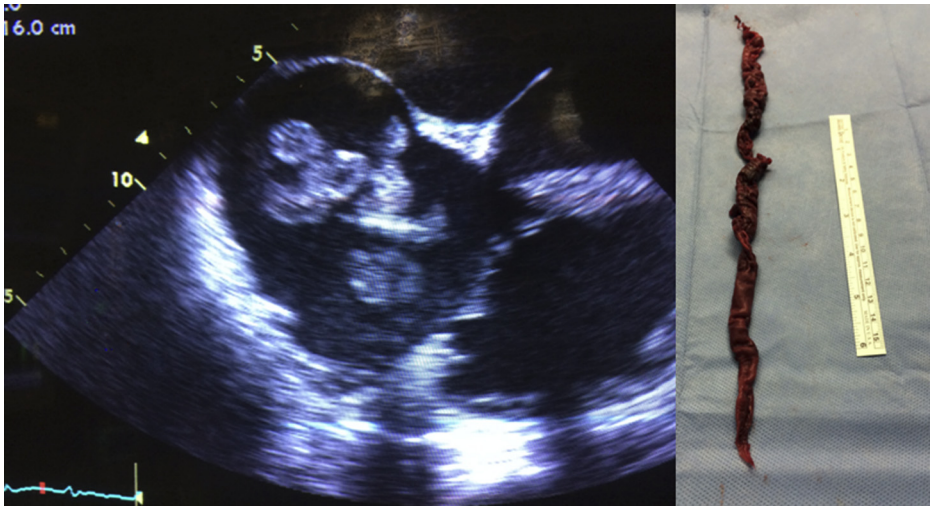

Fig. 2. A large intracardiac thrombus as visualized by transesophageal echocardiography was successfully removed using the AngioVac device.

The venous system was most frequently accessed via a femoral approach for placement of the 26-French sheath through which the 22-French aspiration cannula is advanced (75%; 9). The right internal jugular vein was cannulated in all other cases (25%; 3), and in 2 of those 3 was chosen due to the presence of an inferior vena cava filter and/or extensive iliocaval thrombosis precluding access from below. In no case was a venous cutdown required. In one case of a patient with deep vein thrombosis and thrombus in transit in the right atrium entangled on an implantable cardioverter defibrillator wire, thrombus was engaged with the aspiration cannula and pulled back into the 26-French sheath. Upon removal of the sheath, intact whole thrombus was manually extracted via the skin puncture site (Fig. 2).

We experienced a 58% (7) success rate, with success defined as complete extraction of all thrombus. Partial success was achieved in 17% (2) and no thrombus was extracted in 25% (3). Iliocaval and right heart thrombi were the most amenable to AngioVac thrombectomy with 100% (4/4) and 60% (3/5) complete success rates, respectively. Pulmonary embolus was the least amenable to thrombectomy with a 33% partial success rate (1/3) and 67% failure rate (2/3). There were no complications related to device use. One patient developed respiratory failure post procedure necessitating prolonged intubation and another developed pneumonia.

Two patients had partial success in thrombus removal. One patient with factor V Leiden deficiency and lymphoma developed right atrial thrombus associated with her chemotherapy catheter. AngioVac thrombectomy was successful in removing the catheter-associated thrombus but thrombus attached to the right atrial wall could not be removed despite attempts via both the femoral and internal jugular vein. She eventually required sternotomy for open thrombectomy. A second patient with pulmonary emboli, dyspnea, and right heart strain underwent AngioVac thrombectomy with partial thrombus extraction. She was treated with long-term anticoagulation and still has mild dyspnea on long-term follow-up.

In no case of pulmonary embolism was thrombus extraction completely successful. In all cases of pulmonary embolism, thrombus was present in the main and right and left pulmonary arteries. The main pulmonary artery was accessed with the device in all cases, although the distal right and left pulmonary arteries were not. One patient developed respiratory failure requiring prolonged intubation after failed AngioVac thrombectomy for pulmonary embolism. Snaring was used intraoperatively to assist in thrombus dislodgement without success.

When analyzed based on time from onset of symptoms and initial diagnosis, patients undergoing AngioVac thrombectomy in the acute setting (within 30 days of symptom onset or diagnosis) had an 83% (5/6) success rate, with one failure occurring in a patient with pulmonary embolus. Patients presenting with chronic thrombus (after 30 days of symptom onset or diagnosis) had a 33% (2/6) success rate. Of those patients with metastatic cancer, thrombectomy was successful in 75% (3/4); the one unsuccessful case was again for pulmonary

embolus. See Appendix for a detailed description of patients.

DISCUSSION

In our experience, the AngioVac device has been an excellent resource in patients with iliocaval or right heart thrombi. While surgical thrombectomy has been the standard of care for the latter, in patients at high risk for surgery, AngioVac thrombectomy had 60% complete success rate and 20% partial success rate. In patients with iliocaval thrombosis, surgery is less commonly employed, with anticoagulation and percutaneous thrombolysis the mainstay of treatment. In these patients, AngioVac thrombectomy had a 100% success rate, with 2 patients with thrombosed IVC filters undergoing IVC filter thrombectomy and removal. Outcomes in pulmonary embolectomy were clearly inferior, with no cases of complete thrombus extraction.

Failure of AngioVac thrombectomy is likely multifactorial, including factors such as thrombus shape, size, location, and composition. Iliocaval thrombus and thrombus in transit are most amenable to extraction, likely due to their easy accessibility and serpiginous shape which conforms to the aspiration cannula. Even if too large to completely aspirate into the bypass circuit and filter, thrombus may be aspirated into the sheath and manually extracted via venotomy/skin puncture site.

Right heart thrombus, if bulky, may be less amenable to percutaneous extraction. In this scenario, thrombus age likely correlates with the ability to fragment and extract thrombus. AngioVac thrombectomy in the acute setting demonstrated an 83% success rate, with one failure occurring in a patient with pulmonary embolus, compared with a 33% success rate in the chronic setting. When only patients with iliocaval or right heart thrombus are included (thereby excluding confounding factors in pulmonary thrombectomy), success rates for acute thrombus were 100% (5/5), compared with 50% (2/4) for chronic thrombus. In the case of chronic thrombus that is difficult to fragment or dislodge, adjuncts such as snaring may be of assistance.

Our lower success rate seen with the AngioVac device in the setting of pulmonary embolus is similar to that described by the literature, and is likely secondary to difficulty maneuvering the large 22-French cannula into the pulmonary artery branches.[1,2,21] This aspiration cannula is relatively inflexible and does not easily track over a guidewire. Furthermore, we observed that the reduction in vessel caliber associated with attempted entry into the right and left main pulmonary arteries results in lower device flows and likely less efficient thrombus aspiration. Newer iterations of the device will likely allow for improved steeribility. Because of the large size of the aspiration cannula, great care must also be taken to avoid injury to the tricuspid subvalvular apparatus.

CONCLUSION

In conclusion, AngioVac thrombectomy may offer an excellent alternative to medical therapy or other percutaneous approaches or surgery in high risk patients with iliocaval or right heart thrombus, achieving success rates of approximately 80% in this small series. Pulmonary emboli appear to be less amenable, likely secondary to limited steeribility. Newer iterations of the device will likely address this issue. Our series, although small, is one of the largest reported in the literature. Larger studies are needed to make more definitive conclusions.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.avsg.2016.04.015.

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