ORIGINAL ARTICLE

Application of Upper Extremity Radionuclide Venography as a Diagnostic Approach for Port-A Catheter Thrombosis

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Background: To investigate the role of upper extremity radionuclide venography as a potential diagnostic modality in the assessment of venous thrombosis associated with a Port-A catheter.

Methods: Fourteen symptomatic patients who had received Port-A catheter implantation were enrolled. A dynamic nuclear medicine flow study was performed with intravenous administration of Technetium-99m macroaggregated albumin to both upper extremities. Imaging patterns of the venous system were categorized as patency, partial obstruction, and total occlusion.

Results: The findings of the dynamic images clearly demonstrated clinical problems. Three patients were free of a definite venous flow change. Three patients had partial obstruction of venous return. A significant cut-off of venous return was demonstrated in 8 patients, and total occlusions were hence diagnosed. All patients underwent this procedure smoothly without any complication.

Conclusion: These results suggest that upper extremity radionuclide venography is an easily performed and effective method for diagnosing Port-A catheter thrombosis in clinical practice. [*J Chin Med Assoc* 2006;69(8):358–363]

Key Words: radionuclide angiography, thrombosis, upper extremity, vascular access port

Introduction

The care of cancer patients has been made much easier by the widespread use of a totally implantable venous access system (Port-A catheter) for chemotherapy. Major complications that may occur with Port-A catheters include thrombosis, infection, extravasation of the administered agents, fracture of the catheter, and migration of the catheter.[1,2] Even though Port-A catheter materials have improved greatly, the development of thromboses of the superior vena cava, subclavian vein, or axillary vein is still a serious problem. Clinical evidence of venous obstruction occurs in 3–40% of patients with central venous catheters.[3] Specifically, with a subclavian Port-A catheter, thrombotic occlusion occurs in up to 25% of patients.[4]

The major diagnostic procedures for catheter-associated thromboses are contrast or digital subtraction venography, Doppler ultrasonography, and computed tomography (CT). Although upper extremity radionuclide venography has been reported to be a valuable modality for venous thrombosis of the upper extremities,[5] the application of this simple procedure specifically for thrombosis associated with Port-A catheters has not been reported. We investigated the potential role of radionuclide venography with a dynamic flow study, in the clinical assessment of upper extremity venous return for patients with a Port-A catheter.

Methods

Between June 2004 and June 2005, a study with upper extremity radionuclide venography was conducted in cancer patients with a Port-A catheter at a regional teaching hospital. The patients included in this study

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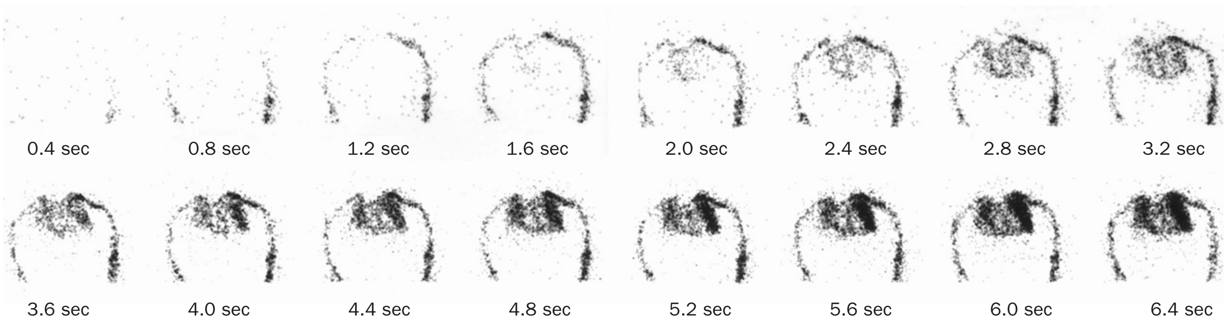

Figure 1. A Port-A catheter was implanted in a 73-year-old male with lung cancer for long-term therapy (patient 9). Upper extremity radionuclide venography was performed for the clinical complaint of swelling sensation in his left upper arm. Scintigraphic images clearly displayed the flow of radiotracer from the upper extremities, subclavian vein, superior vena cava, right heart, and then bilateral lung fields. No definite disruption of venous return was demonstrated. The scintigraphic result essentially excluded the possibility of venous obstruction in the upper extremities.

exhibited 1 or more of the following: a decreased Port-A catheter flow rate; difficulty with infusing solutions; superior vena cava syndrome; ipsilateral pain, edema, or venous engorgement. Patients with upper extremity thrombophlebitis, varicose veins, and/or receiving anticoagulation therapy were excluded from this study. All patients were investigated in the same department. Since radionuclide venography displays higher sensitivity and specificity compared to magnetic resonance imaging (MRI) or venography for detecting upper extremity and catheter-related thromboses,[6,7] our hospital policy allows the use of radionuclide venography for evaluating the possibility of thrombosis in these patients. Therefore, ultrasonography, MRI, or contrast venography was not performed concurrently with this study. The Ethics Committee on Human Studies at our hospital approved the study, and this investigation was conducted according to the guidelines of the Declaration of Helsinki.

No specific preparation for enrolled patients was required prior to this examination. The blood flows in the deep venous system from the upper extremities to the heart were evaluated noninvasively using radionuclide venography. All images were acquired using dual-head gamma camera analysis (DST-XLi, General Electric Medical Systems, Buc, France) equipped with large-field-of-view, low-energy, general-all-purpose collimators with a 20% energy window centered at 140 KeV. With the patient supine, an intravenous line was applied to a superficial dorsal vein of the Port-A catheter ipsilateral hand through a 23-gauge 3/4-inch butterfly needle. A 3-way stopcock was attached to the tubing system. A superficial dorsal vein in the contralateral hand was accessed as well to determine the patency of the superior vena cava. The contralateral injection of radiotracer also helped to assess the venous anatomy on that side in case the Port-A catheter was to be replaced. At the beginning of this procedure, 185 MBq (5 mCi) Technetium-99m macroaggregated albumin (Tc-99m MAA) was administrated as a bolus injection simultaneously to both sites followed by 10 mL of normal saline flush to each stopcock. Concurrently with the radiotracer injection, we acquired dynamic images on a workstation computer at a rate of 0.4 seconds/frame for 300 seconds. The region of interest selected was from the lower neck over the anterior chest and shoulders to the lung base, with the heart in the lower 1-third of the field of view. The images were visually interpreted for the deep venous flow from the upper extremities bilaterally to the heart by an experienced nuclear medicine physician who was not aware of the patients' clinical conditions. The ipsilateral flow was compared with the contralateral flow. Scintigraphic diagnosis was made by the imaging patterns. Three major categories were accepted as a diagnosis due to the Port-A catheter.

1. Patency of venous return: symmetric, smooth, and continuous flow in the deep venous system from the upper extremities to the heart. No remarkable delayed passage or stasis of the radiotracer found (Figure 1).
2. Partial obstruction of venous return: images showed significant delayed dissipation of radiotracer in comparison with the contralateral site even though the radiotracer was subsequently cleared (Figure 2).
3. Total occlusion of venous return: truncated venous return of the deep venous system at the ipsilateral site (Figure 3) or retrograde flow to the jugular vein (Figure 4) was demonstrated.

Results

A total of 14 cancer patients (11 males and 3 females, aged 58.3 ± 3.8, range 34–78 years) with a Port-A

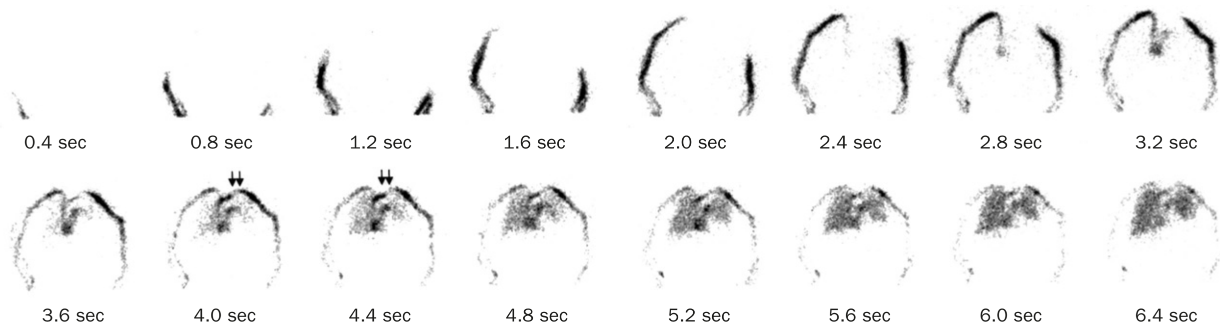

Figure 2. This was a 55-year-old male with oral cancer (patient 2). Upper extremity radionuclide venography was performed for the clinical complaint of swelling sensation in his left upper arm. In comparison with the venous return of the right site, the radiotracer from the left upper arm showed a significant delay. A section with diminished radioactivity was found in the left subclavian vein (arrows). However, continuous flow could be found. This finding was suggestive of a partial obstruction of venous return caused by compression of the Port-A catheter.

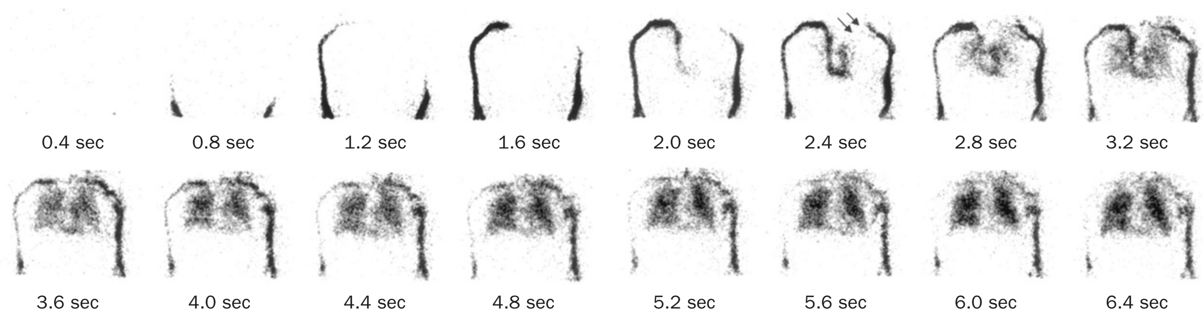

Figure 3. A 71-year-old male with bladder cancer received Port-A catheter implantation for long-term chemotherapy (patient 13). Upper extremity radionuclide venography was carried out for edema of the upper arm. Major cut-off sign was demonstrated in the left subclavian vein (arrows). This finding indicated total occlusion of the left subclavian vein. Local background activity around the left supraclavical area was elevated, which was suggestive of microcirculation.

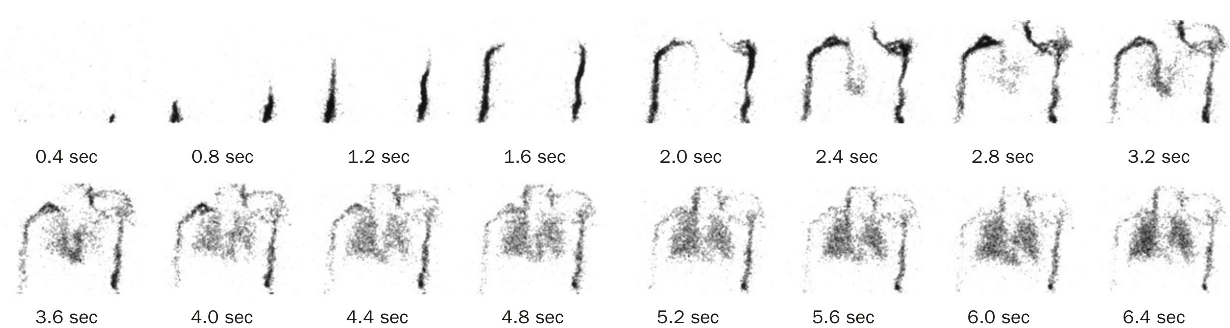

Figure 4. Upper extremity radionuclide venography was performed in a 69-year-old male with colon cancer (patient 11). In addition to the major cut-off sign of venous return in the left subclavian vein, obvious regurgitation of radiotracer in the jugular veins was also demonstrated. About 6–8 frames later (2.4–3.2 seconds), radiotracer flow was found in the counter site of neck. This finding exhibited total occlusion of the left subclavian vein. Venous return was retrogradely forced to the left jugular vein, passing the skull base area, joining the right jugular vein and returning to the superior vena cava.

catheter were enrolled. The basic and resulting characteristics of enrolled patients are presented in Table 1. A diagnosis of patency of venous return was found in 3 patients (21%). A decreased flow rate with a diagnosis of partial obstruction of venous return was found in 3 patients (21%). Significant cut-off or truncated venous return was demonstrated in 8 patients (57%) who were diagnosed as having total occlusion of venous return. In the subgroup with total occlusion of venous return, patients were grouped according to

Table 1. Baseline characteristics and observational results of study patients

	Gender	Age (yr)	Cancer	Location*	Scintigraphic diagnosis	Comments
1	Male	44	Oral cancer	Right subclavian vein	Partial obstruction	
2	Male	55	Oral cancer	Left subclavian vein	Partial obstruction	
3	Female	64	Ovarian cancer	Left subclavian vein	Total occlusion	Collateral circulation
4	Male	35	Esophageal cancer	Right subclavian vein	Patency	
5	Male	44	Esophageal cancer	Right subclavian vein	Total occlusion	Retrograde flow to jugular veins
6	Male	53	Esophageal cancer	Left subclavian vein	Total occlusion	Venous shunt to pulmonary vessels
7	Male	61	Lung cancer	Left subclavian vein	Total occlusion	Collateral circulation
8	Male	65	Lung cancer	Left subclavian vein	Total occlusion	Collateral circulation
9	Male	73	Lung cancer	Left subclavian vein	Patency	
10	Male	78	Lung cancer	Left subclavian vein	Partial obstruction	
11	Male	69	Colon cancer	Left subclavian vein	Total occlusion	Collateral circulation Retrograde flow to jugular veins
12	Female	70	Colon cancer	Left subclavian vein	Total occlusion	Collateral circulation
13	Male	71	Bladder cancer	Left subclavian vein	Total occlusion	
14	Female	34	Lymphoma	Right subclavian vein	Patency	

**Location, site of the Port-A catheter implantation.*

the type of abnormal flow. Evidence of collateral circulation was demonstrated in 5 patients. Retrograde flow in the ipsilateral jugular vein that forced the radiotracer to bypass the skull base, move to the contralateral jugular vein, the superior vena cava, and finally enter the right heart was found in 2 patients. Another patient presented a cut-off of the left subclavian vein and showed venous shunt flow directly to the pulmonary vessels. All patients underwent the procedure smoothly, and no complication occurred as a result of the procedure.

Discussion

A number of different types of devices and sites for the implantation of venous access systems have been increasingly utilized in various conditions in daily practice. Tunneled percutaneous placement of silicone rubber-cuffed catheters inserted through a subclavian vein is commonly used even though ventricular tachycardia secondary to fracture and embolization of the Port-A catheter has been occasionally portrayed as a serious complication.[8] Frequent use of central venous access systems to manage regimens for cancer patients has increased the incidence of catheter-associated deep venous thrombosis.[9] Furthermore, pulmonary embolism was reported in 2.5% of patients with subclavian vein thrombosis.[10] Potential risk factors associated with thrombosis formation include catheter positioning, size of the catheter, and specific site of catheter insertion.[11]

As thrombus forms, treatment options may vary, including supportive therapy, anticoagulation, catheter-directed thrombolysis, surgical intervention to remove intravascular clots, or revise the anatomy of the costoclavicular space. Some of the published literature suggest that whenever an indwelling central venous catheter is indicated, an appropriate pharmacologic agent should be initiated (i.e., low-molecular-weight heparin, a low dose of unfractionated heparin or warfarin) to prevent the possibility of a coagulation problem. Indeed, starting aggressive treatment as early as possible is practicable, for active patients may decrease patients' long-term morbidity. Therefore, the key point in this discussion relates to how rapidly and accurately a clinical diagnosis can be made.

The accurate diagnosis of catheter-associated deep venous thrombosis can, at times, be rather difficult. The diagnosis is usually based on a patient's clinical history and the results of Doppler ultrasonography or contrast venography. However, for patients with symptomatic venous thrombosis, Doppler ultrasonography would appear to have a lower accuracy as regards diagnosis than does contrast venography. CT or MRI may be effective for the diagnosis of catheter-associated deep venous thrombosis,[7] but these diagnostic modalities are typically expensive as a routine diagnostic tool. Contrast venography also has several dangerous complications such as extravasation of the contrast medium,[12] anaphylactoid reactions,[13] and contrast-induced nephropathy.[14] *In vitro*-labeled platelet scintigraphy provides direct evidence of active or acute thrombosis.[15] Unfortunately, this technique requires a labor-intensive, lengthy labeling process and has a high number of false-negative results in patients receiving heparin therapy.

Radionuclide venography using Tc-99m MAA is limited in that it relies on alterations in the normal venous anatomy. Therefore, it provides indirect evidence of deep vein thrombosis and cannot differentiate between acute and chronic deep venous thrombosis. Nevertheless, upper extremity radionuclide venography using Tc-99m MAA remains a practical and noninvasive imaging procedure for patients with Port-A catheter thrombosis.[16]

In most of the published studies, venous thrombosis was investigated by contrast or digital subtraction venography and Doppler ultrasonography. Celiker et al[17] examined the role of radionuclide venography in the diagnosis of abnormal subclavian venous flow due to permanent pacemaker leads. Their findings demonstrated radionuclide venography imaging patterns similar to ours, even though the emphasis was on the effect of the body diameter of the leads and silicone-insulated leads. Another significant difference between our studies is that Celiker et al used Tc-99m pertechnetate for the radiotracer and we used Tc-99m MAA. A nuclear medicine flow study using isotope-labeled particles (Tc-99m MAA) can be used effectively to clearly demonstrate venous return from the upper extremities, subclavian veins, superior vena cava, right heart, and subsequent distribution to both lung fields. As a consequence of one of the physical properties, Tc-99m MAA will be trapped within the capillary beds of the lungs, allowing a clear resultant diagnostic image without interruption by arterial radioactivity. In addition, the lung perfusion scan derived from the supplemental benefit of Tc-99m MAA could be acquired to verify the possibility of pulmonary embolism.[18] Although we did not acquire images of lung perfusion scintigraphy in the current stage, further studies to enroll more cancer patients with Port-A catheters could be designed to validate our observational findings using upper extremity radionuclide venography and lung perfusion scintigraphy concurrently.

According to the diagnostic criteria for deep venous thrombosis using radionuclide venography, the rapid cut-off phenomenon of radiotracer flow is one of the major signs of thrombosis formation. Other significant signs, the development of collateral circulation and retrograde flow, may provide further information, which could be helpful for the accurate diagnosis of deep venous thrombosis. A comparison of blood flow in bilateral upper extremities is necessary for the accurate diagnosis of deep venous thrombosis using radionuclide venography. A resultant picture of the significantly delayed passage of radiotracer and the reduced clarity of its presence in the venous system without truncation are considered to be partial obstruction of the venous system. A normal picture for upper extremity radionuclide venography should reveal bilateral, symmetric, rapid, and smooth radiolabeled radiotracer flow from the upper extremities to the central venous system.

Upper extremity radionuclide venography is a cost-effective imaging examination. Its nominal cost for a patient in Taiwan is almost 1-third to half that of contrast venography. Radionuclide venography is also simple and safer in terms of mortality and morbidity. Another attraction for scintigraphy is its lower radiation burden for both operators and patients. The whole-body dose is 0.015 rad/mCi.[17] The radiation dose is a significant point if it is necessary to repeat the procedure. Mild or even moderate stenosis, if expected to exist on one side, could be missed. However, if our technique using a large-field-of-view gamma camera is applied, the detection of this degree of stenosis is possible by comparing with the normal flow on the other side.[6,19]

In conclusion, upper extremity radionuclide venography may be used as a noninvasive and cost-effective method, which is easily and safely performed with low radiation exposure (total dosage less than 10 mCi) to show the venous flow abnormalities in patients with Port-A catheters. In particular, physicians who are not specialists in medical imaging can easily interpret the scintigraphic results of radionuclide venography. The results of this investigation are helpful as a clinically effective diagnostic approach to the presence of Port-A catheter thrombosis. Therefore, we suggest that radionuclide venography be routinely recommended for diagnosing Port-A catheter thrombosis.

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