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ORIGINAL ARTICLE

Tunneled catheters placed in bone marrow transplant patients: radiological and clinical follow-up results

Muharrem Parlak, Tanzer Sancak, Mutlu Arat, Sadık Bilgiç, Umman Sanlıdilek

PURPOSE
To present the radiological and clinical follow-up results of 75 bone marrow transplant patients who underwent fluoroscopy-guided tunneled catheter placement between June 2001 and June 2004.

MATERIALS AND METHODS
Tunneled catheters were placed in 75 bone marrow transplant patients with fluoroscopic guidance. The left subclavian vein was used in 67 patients, whereas the right side was used in 9.

RESULTS
The first attempt of catheter insertion was failed in 3 patients who then underwent contralateral catheter placement. No complications were noted during or immediately after the procedures. Late complications included 8 cases of infection, 2 cases of fibrin sheath formation, and 1 case of persistent hiccups, which began at the time of catheter insertion. Inadvertent catheter removal was noted in 4 cases.

CONCLUSION
Fluoroscopy-guided central venous catheterization should be preferred over the anatomical landmark technique due to its higher technical success rate, shorter procedure time, and lower complication rate. When placing a central venous catheter, multiple factors should be considered, such as catheter type, number of lumens, duration and frequency of pertinent treatments, and patient needs. The procedural and early post-procedural complications were mostly related to the placement technique; however, the late complications could have been prevented by nurse care and patient education.

Key words: • central venous catheterisation • bone marrow transplantation • infection

From the Departments of Radiology (M.P., T.S., ✉ *sancaki@yahoo.com,* S.B., U.S.) and Hematology (M.A.) Ankara University School of Medicine, Ankara, Turkey.

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Central venous catheters (CVCs) are widely used in many centers for hemodialysis, oncological chemotherapy, blood sampling, total parenteral nutrition, bone marrow transplantation, central venous pressure follow-up, and oxygen saturation measurements in internal jugular veins (1). New applications are added to this list every day. CVC applications are increasing along with the expanding related fields and thus, the rate of dysfunctions and complications are increasing as well. The number of people who had CVC was close to 3 million in 1989 and over 5 million in 1996 (2).

Worldwide, CVCs are routinely implanted by interventional radiologists. Additionally, patients with CVCs that were implanted by other specialists are referred to interventional radiology departments due to malfunctions and complications. CVC applications occupy an important place in interventional radiology; therefore, the radiological implantation technique, procedural complications, and ways to reduce and treat these complications should be well known.

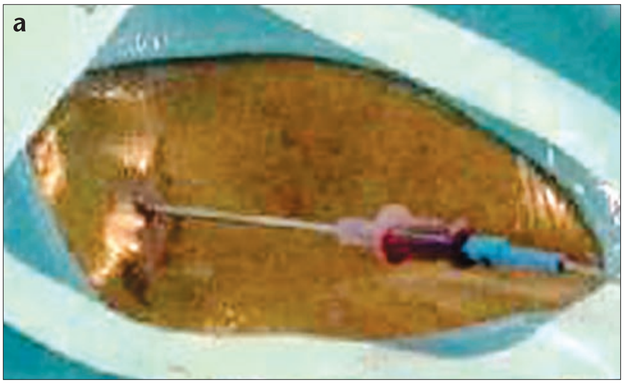
Patients scheduled for bone marrow transplantation (BMT) form a special patient population. In this patient group, CVC supplies a safe venous route for intensive chemotherapy, which prevents extravasation from peripheral veins causing skin necrosis and burns. There are many more benefits, including multiple antibiotic therapy applications to control serious systemic infections as a result of chemotherapy-induced immunosuppression, fluid-electrolyte treatments, blood and related product administration as a result of bone marrow suppression, and frequent blood sampling for the follow-up of potential complications of chemotherapy. Other advantages of CVC consist of being an ideal route for parenteral nutrition in patients who cannot adequately feed via an oral route, preventing pain and psychological/physical trauma related to frequent venous cannulation, preventing potential complications during stem cell collection and transplantation, and facilitating a more convenient, routine lifestyle for patients, both while they are sick and recovering at home (3).

On the other hand, there are numerous complications associated with CVCs during and after their administration. These complications can seriously affect BMT patients` morbidity and mortality.

In this study, procedural and post-procedural complication rates were calculated for semi-permanent catheters placed in the angio unit with imaging guidance. The complication rates of the imaging-guided catheter placement were reported and discussed comparing them with the complications rates of the anatomical landmark techniques in the literature (4, 5).

Materials and methods

The study included 75 patients who were prepared for BMT and were evaluated for semi-permanent CVC implantation in the angio unit be-



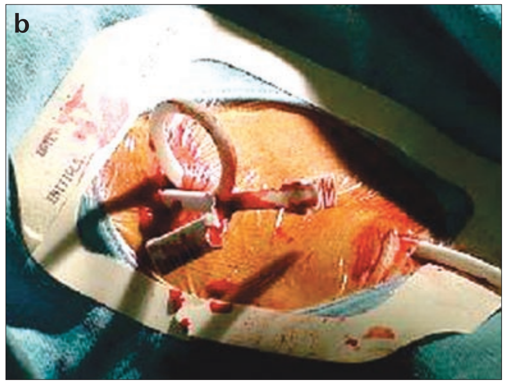


Figure 1. a-c. Following sterilization of the area, the right subclavian vein was punctured using a single wall needle, and the guidewire was advanced to the superior vena cava **(a)**. The catheter passing through the tunnel and the peel-away sheath was seen **(b)**. The catheter was fixed to the skin after placement **(c)**.

tween June 2001 and June 2004. There were 47 (62%) males and 28 (38%) females (age range: 16–58 years). All patients were under follow-up for hematological diseases. Allogenic BMT was performed on 57 (76%) patients and autologous BMT was performed on 18 patients (Table 1).

Patients were interviewed to determine the presence of risk factors for potential complications of CVC implantation. In this interview, radiotherapy to the chest area in 1 patient, previous 3 catheterization in 1 patient and difficult catheterization history due to narrowing of superior vena cavae in 1 patient was recorded. Minimum platelet count required on the day of procedure was 50,000 µl. For the patients with platelet counts below this level, platelet suspensions were given using an IV route on the contralateral arm. The venous entry site was determined to be the subclavian vein by the concensus of hematology and radiology departments.

CVCs were implanted in the angio unit with the fluoroscopic guidance by a Siemens Multistar T.O.P. device. When necessary, patients were evaluated by ultrasonography (US) with a Toshiba SSA 270 A using 3.75 MHz convex and 7 MHz linear array probes.

Care was taken to maintain sterile conditions before the procedure and all interventions were performed wearing sterile surgical gowns and gloves. Patients were placed on the fluoroscopy table in a supine position with both arms aside. Shoulders were slightly elevated to prevent clavicle compression of the subclavian vein. The head was tilted to the other side and the area of intervention was located with fluoroscopic guidance. After sterilization of the area, local anesthesia was administered. A standard angiography needle was used for venous puncture. After venous blood came through the needle, a 0.035-inch J-ended guide wire was advanced 15 to 20 cm with fluoroscopic guidance (Fig. 1a). A small skin incision was made to facilitate the catheter passage and serial dilatations were performed. Next, a small incision was made at least 10 cm from the entry site to form the tunnel tract. A subcutaneous tract of at least 10 cm was created using a trocar. After applying local anesthesia to the tunnel entry and the tract, serial dilatations were performed to widen the tunnel tract. The catheter (11F, double lumen Bio-Cath set, MedCOMP, Harleysville, PA, USA) was then passed through the tunnel by attaching it to the trocar. With fluoroscopic guidance, a 12F peel-away sheath was advanced over a guidewire and the catheter was pushed and placed through the sheath (Fig. 1b). When the catheter was located at the atriocaval junction, the peel away sheath was removed. The catheter cuff was embedded into the tunnel entry (Fig. 1c). The venotomy site and tunnel entry were sutured with 3.0 atraumatic sutures. Images were obtained after each procedure in order to exclude the possibility of pneumothorax. The catheter was flushed with a low-dose heparin-saline solution. Technical success rate, procedure times, and complications were all noted, and follow-up forms were prepared to record any late complications.

Results

The technical success rate was 100%. The left subclavian vein was used in 67 out of 75 cases and the right side was used in 8 patients. Only one catheter set was used for each patient. Three failed initial attempts were followed by contralateral side attempts. Tips of the catheters were positioned 1–2 cm within the atrium. Each procedure took approximately 15 to 20 min. No procedural or early post-procedural complications were noted. Persistent hiccups occurred in only 1 case, upon catheter insertion. Late complications included 8 cases of infection, 4 cases of inadvertent catheter removal, and 2 cases of fibrin sheath formation (Table 2). Catheters were removed for patients with infection and hiccups. Fibrin sheath was diagnosed by contrast material injection under fluoroscopy, and several treatments including mechanical stripping, exchange over a guidewire, and thrombolytic dwell were recommended, as reported in the literature (6); however, catheter removal was performed instead, based on the request of the hematology department.

Subclavian catheters remained in place between 26 days and 7 months. Follow-ups were performed for at least 10 months for all patients (Table 3). Three patients were excluded from the long-term evaluations due to limited follow-up. Twenty-five patients died during follow-up due to reasons unrelated to their catheters.

During long-term follow-up, 54.6% of patients remitted, 34.7% died, 4.1% recurred, 1.3% partially remitted, 1.3% were stable, and 1.3% had refractory disease.

Discussion

In the past, CVCs were made of polyethylene and were intended for short-term use. Currently, catheter technology has reached the point where there are many types of catheters available for many different kinds of patient needs. Modern catheters are made of silicone and polyurethane, not polyethylene, and are associated with a lower risk of infection and thrombosis (1, 5). The 11F catheters used in our patients were soft, radio-opaque silicone catheters. As a result of the improvement in radiological imaging quality and radiologists' increasing experience with central venous interventions, CVC implantation is now becoming a routine procedure for interventional radiologists, whereas it was traditionally performed by surgeons in operation rooms or in emergency situations.

There are numerous complications associated with the use of CVCs. Among those, procedural ones appear during the early phase, along with significant changes in the clinical picture of patients; therefore, they can be easily recognized. Minor procedural complications include failed venous puncture and catheter malposition. Major procedural complications include hematoma, hemopneumothorax, air embolism, and arterial or neural injury. Post-procedural complications include infectious and thrombotic complications, catheter kink, migration, "pinch off" syndrome, catheter rupture, and cardiac complications. The most important late phase com-

Table 1. Number of patients who underwent catheter placement according to primary diseases and bone marrow transplantation types

Primary disease	Total	Allogenic BMT	Autologous BMT
AML	23	21	2
CML	17	17	-
MM	10	2	8
ALL	6	6	-
NHL	5	-	5
HD	4	2	2
MDS	4	4	-
RCC	2	2	-
PrMF	2	2	-
Amyloidosis	1	-	1
PHL	1	1	-
Total	75	57	18

AML: acute myelocytic leukemia, CML: chronic myelocytic leukemia, MM: multiple myeloma, ALL: acute lymphoblastic leukemia, BMT: bone marrow transplantation, NHL: non-Hodgkin's lymphoma, HD: Hodgkin's disease, MDS: myelodysplastic syndrome, RCC: renal cell cancer, PrMF: primary myelofibrosis, PHL: primary hepatic lymphoma.

Table 2. Catheter complications

Catheter complications	Number of cases (%)	Catheter time (day)
Spontaneous removal	4 (5.3%)	(15, 56, 60, 120)
Infection	8 (10.6%)	(26, 28, 33, 75, 90, 92, 150, 210)
Hiccups	1 (1.3%)	(30)
Fibrin sheath	2 (2.6%)	(28, 60)
Total	15 (20%)	

Table 3. Follow-up results according to primary disease

Disease	Number of cases	Number of deaths	Living cases
AML	23	5	1 refractory, 17 remission
CML	17	4	3 recurrence, 10 remission
MM	10 (1 lost to follow up)	4	1 stable, 1 partial remission, 3 remission
ALL	6	4	2 remission
NHL	5 (1 lost to follow-up)	1	3 remission
HD	4	1	3 remission
MDS	4	3	1 remission
RCC	2	2	-
PrMF	2	-	2 remission
Amyloidosis	1 (1 lost to follow-up)	-	No follow up
PHL	1	1	-
Total	75 (3 lost to follow-up)	25	41 remission, 3 recurrence

AML: acute myelocytic leukemia, CML: chronic myelocytic leukemia, MM: multiple myeloma, ALL: acute lymphoblastic leukemia, NHL: non-Hodgkin's lymphoma, HD: Hodgkin's disease, MDS: myelodysplastic syndrome, RCC: renal cell cancer, PrMF: primary myelofibrosis, PHL: primary hepatic lymphoma.

plications are infections, which can be masked by the patient's primary disease and can remain un-recognized for a long time (6–9).

Appropriate vein selection for CVC, good evaluation of patient needs, and an experienced team to implant the catheter can help to reduce the complication rate. When deciding the site of CVC, multiple factors should be considered, such as catheter type, the number of lumens needed, and the duration and frequency of pertinent treatments, together with patient needs.

In the anatomical landmark technique, technical success is directly related to a patent, and a good caliber vessel being in the expected position. Especially in patients with known venous access problems, the advantages of radiological imaging and catheter guidewire technology provide radiologists alternative possibilities. There are many studies in the literature showing the safety and cost-effectiveness of radiological venous access under fluoroscopic and sonographic guidance (9, 10).

Subclavian vein stenosis and/or occlusion secondary to temporary or permanent catheters, especially in hemodialysis patients, are reported in the literature (11). However, due to the relatively infrequent catheterization needs and short duration of catheterization of our patients compared to dialysis patients, and considering our patients` psychological status, subclavian veins were determined to be the choice of access by the decision of 2 clinics.

All venous access attempts were successful and we believe that the main reason underlying this was the pre-evaluation. All cases were interviewed about possible previous catheterizations and venograms were obtained if necessary. Technical failure rates are reported to be 8.9% and 1.4% in the surgical and radiological literature, respectively (6). The first attempt venous puncture success rate under imaging guidance is around 87.4%, and 54% with the anatomical landmark technique (6), whereas in the present study the rate was 93%.

The rate of minor complications in radiological series is around 4%, and up to 58% in surgical series. The procedure time is around 20 min in radiological series and up to 1 hour in surgical series (12). Our series had similar procedure times as reported in the radiological literature. No complications were noted during or immediately after the procedures, except one case that developed hiccups. As a result, our minor complication rate was calculated to be 1.3%.

The second most common complication seen with the anatomical landmark technique is arterial puncture, with a reported incidence of 5%-10% (13). We did not observe any such complication in our patients.

Moreover, pneumothorax was not seen in our series. It occurs at the rate of 0%–6% in the surgical literature and 1%–3.3% in the radiological literature (13, 14).

The CVC tip position is recommended to be at the atriocaval junction, or 0.5–1 cm within the right atrium. A CVC tip left at the subclavian vein is associated with a high risk of venous thrombosis. Tip position further in the heart chambers can cause valve damage, endocardial trauma, sterile or septic vegetation, cardiac arrhythmia, and even cardiac perforation. In the present study there was no catheter malposition, which has a reported incidence rate of up to 32% without imaging guidance (13, 15).

The occurrence of peri-catheter thrombosis in our series was 2.6%, which is 10% and 4% in the surgical and radiological literature, respectively (16).

Central vein thrombosis is reported to be seen in 5%–16% and 0%–3% of cases by the non-radiological and radiological literature, respectively (13). No central vein thrombosis was noted in the current series.

We had 8 cases (10.6%) of infection, while the reported incidence of infection is 10%–20% and 3%–7% in surgical and radiological literature, respectively (12, 16).

In comparison to the surgical series reported in the literature, our complication rate was significantly lower. Our complication rate was also lower than the rate reported radiological series using fluoroscopic guidance. Although the infection rate was lower than the rate in surgical series report, it was higher than the rate in radiological series. Considering the immunocompromised status of our patients, our higher infection rate is plausible. The rate of infection and the causative pathogens in our cases were also consistent with the literature (11–17).

Inadvertent catheter removal was noted in 4 (5.3%) of our patients. This could have been due to inadequate patient adaptation to the catheter, weakening of the subcutaneous fat-fibrous tissue, or significant loss of weight due to the malignancy and chemotherapy.

A review of the literature showed that catheter placement under imaging guidance is more appropriate due to its cost-effectiveness, safety, and speed (9). It should be kept in mind that this procedure requires teamwork. Increasing patient numbers and continuous follow-up in larger series can help ensure that catheterizations in future BMT patients are safer and more effective.

Since fluoroscopic-guidance in central venous catheterization decreases the procedure time and complication rate, resulting in a high technical success, it should be preferred over the anatomical landmark technique. Patient and nurse education can help decrease the incidence of late complications.

Moreover, intervening to prevent potential complications and solving problems has become routine practice for interventional radiologists (6). The most prevalent catheter-related problems, such as catheter dislocations, malpositions, and migrations can be corrected with snare catheters with fluoroscopic guidance. Furthermore, catheter fractures and remnants during removal can also be managed using suitable catheters under fluoroscopic guidance. Fibrin sheath formation triggers catheter dysfunction and thus infection (6). When fibrin sheath formation is suspected, contrast injection should be made through the catheter ports and thrombolytic treatment should be given if thrombus is detected within the catheter. One should not forget that these catheters can be exchanged over a guidewire and mechanical fibrin sheath stripping can be performed safely. Venous thrombus at the catheter entry vein can be treated medically using heparin derivatives in addition to arm elevation. Catheters should be removed if necessary and in cases of a continuing thrombus, thrombolytic treatment should be administered. Catheters should be removed as soon as possible in cases of catheter infection. Since the treatment protocol of BMT patients takes a long time, an infected CVC should be removed, preferably after obtaining a new temporary or permanent access for the ongoing therapy.

The procedural and early post-procedural complications are mostly related to the implantation technique. Better education for CVC implant techniques and sonographic- or fluoroscopic- guidance will decrease the complication rate significantly. Improvements in catheter technology brought lower thrombosis and infection rates. Improvements in radiological imaging modalities and increasing experience of radiologists in the implantation of CVCs also decreased the complication rates.

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