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Venous Access Devices Utilized in Association with Intensive Cancer Chemotherapy

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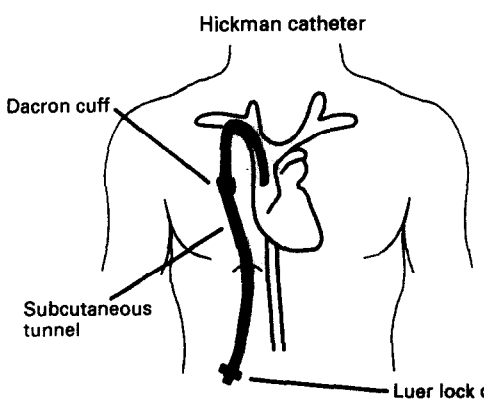
Abstract—*Consistent and reliable venous access is a major component of the management of patients with cancer undergoing chemotherapy. Venous access devices such as the long-term right atrial catheter and the subcutaneous port have become a major aspect of the supportive care of such individuals, with resultant advantages which have improved their quality of life. Yet, the occurrence of infectious and non-infectious complications restricts the usefulness of these devices and warrants a standardized approach to device placement, patient education and the management of such complications. Infectious complications, including exit site and tunnel infections, as well as bacteremias requiring catheter removal occur at a rate of approximately two episodes for every* 1000 *catheter days, while non-infectious complications occur more frequently. Uniform patient education and catheter care, as well as placement by a single consistent surgeon will decrease the frequency of complications, improve the longevity and function of these venous access devices, while minimizing the associated morbidity.*

RELIABLE VASCULAR ACCESS has become a necessity for the patient with cancer undergoing chemotherapy. Inadequate venous access requires the patient to undergo repetitive painful venipunctures which frequently results in frustration and loss of valuable time for the technicians, nurses and physicians responsible for placing such lines. Routine vascular access devices are associated with vein sclerosis and phlebitis, risk of infiltration and infection, and may result in inadequate delivery of nutritional, antimicrobial and antineoplastic therapy. These standardly utilized techniques include the steel needle (butterfly) and central venous catheters. The steel needle is characterized by low infection rates but has limited infusion capacity and is associated with a marked increase in complications should these catheters be left in place for greater than 72 h [1]. Consequently, this technique requires the need for frequent and repetitive venipunctures. The use of central lines, while potentially increasing the available functions, has the risk of complications which include pneumothorax, vascular injury, brachial plexus injury, sepsis and even death [2]. Therefore, a venous access device with low risk, catheter longevity and ease of access is highly desirable. During the past 10 years such devices have become available and are now widely used [3, 4]. These include the long-term right atrial catheter (Hickman, Broviac, etc.) with a variable number of lumens, or the subcutaneous port (mediport, portacath, etc.) with inherently more limited access. The long-term right atrial catheter which measures approximately 90 cm in length has a dacron felt cuff 30 cm from the end of the catheter. This cuff, when the catheter is inserted subcutaneously, is positioned about 2 cm above the skin exit site (Fig. 1). The single lumen Broviac catheter has a smaller internal catheter diameter than the single lumen Hickman catheter. The increased lumen size makes the Hickman catheter more functional not only for drug and fluid administration, but also for blood withdrawal. The double or triple lumen catheter is, in effect, the melding together of more than one of the larger or smaller catheters to



Modified from Broviac *et al. Surg Gynecol Obstet* **1973, 136, 602.**

Fig. 1.

increase the available venous access. These catheters and also the subcutaneous ports have become very popular over the past decade because of their obvious advantages, which include: the ability to infuse a wide range of intravenous solutions, blood products, antimicrobial and chemotherapeutic agents; phlebotomy and the administration of hyperalimentation. The long-term right atrial catheter has the added advantage of being able to be utilized for large volume hemopheresis such as is necessary for platelet collection and also for central venous monitoring. These devices have obvious advantages and yet infectious and non-infectious complications do occur. This review outlines, in general terms, the approach at the University of Maryland Cancer Center to the placement and the management of such complications.

LONG-TERM INDWELLING RIGHT ATRIAL CATHETERS

Long-term right atrial catheters have been utilized at our center since November, 1978. These catheters have been placed in individuals primarily with hematologic malignancies and frequently in individuals with significant degrees of granulocytopenia and thrombocytopenia. We have attempted to place catheters into patients who were intellectually and physically competent, but for those individuals where these characteristics were not present, we have required at least a single family member who could maintain responsibility for the venous access device. Insertion through the early years of catheter placement was performed by a single surgeon, although more recently a rotating group of surgeons have utilized a uniform technique. We have strongly recommended that catheters be positioned utilizing fluoroscopic guidance. Initial patient education has been performed by a single nurse and, while patients have been hospitalized, the catheter maintenance has been performed by our nursing staff. We have routinely allowed for unlimited access, based exclusively on specific patient needs. Catheter care has been performed daily with cleansing and swabbing of the exit site with a povidone iodine solution and then the placement of a non-occlusive dressing. Catheter patency has been maintained by at least once a day flushing of 2.5–3.0 ml of a 100 unit/ml heparin solution. Further catheter flushing is repeated following each episode of blood withdrawal or when blood product infusions are completed. Utilizing these techniques, these long-term indwelling catheters have functioned superbly with full withdrawal and infusion function maintained for the life span of the catheter for 75% of the devices placed. Catheters in general have been left in place until the therapeutic plan for the patient has been completed, a complication has occurred requiring catheter removal, the patient has requested removal, or the patient has died from underlying disease. While the advantages of these catheters are obvious, a group of complications have occurred including infectious and non-infectious problems. The infectious complications include exit site and tunnel infections as well as catheter associated bacteremias, while the non-infectious complications included hemorrhage, migration, accidental removal, thrombosis, and lumen fracture, loss of function and the potential for psychologic stress associated with alterations in body image. The rate of infectious complications for these devices has been previously reported to occur approximately two per 1000 catheter days, while non-infectious complications are almost one and a half times as frequent [5].

INFECTIOUS COMPLICATIONS

Exit site infection

The first and most common infectious complication is that of the exit site infection. These infections are defined as the development of erythema, tenderness, induration, purulence or a combination of these signs and symptoms at the catheter exit site with extension if present to, but not beyond, the subcutaneous dacron cuff. This is an area approximately 2–3 cm from the point where the catheter exits from the skin (Fig. 1). Exit site infections may develop at any time throughout the life of the catheter, although they are more frequent during periods of neutropenia. These infections are caused by gram-positive pathogens with associated bacteremia unusual. With the exception of exit site infections due to fungal organisms, it has been our experience that the catheter does not need to be removed when an exit site infection develops but rather systemic antimicrobial therapy directed at

Table 1. *Management of complications of venous access devices*

Infectious complications
1. *Exit site infections* — antimicrobial therapy alone
(Exception — requiring catheter removal)
Fungal (*Candida* species, *Aspergillus*, etc.)
2. *Tunnel infections* — antimicrobial therapy plus catheter removal
3. *Bacteremias* — antimicrobial therapy alone
(Exception — requiring catheter removal)
Fungal (*Candida* species, etc.),
Bacillus species, JK Corynebacteria
Non-infectious complications
Guidelines
A. Placement platelet count ≥50,000/μl
B. Avoid placement during periods of disseminated intravascular coagulopathy
C. Single surgeon

the etiologic organism is almost universally effective (Table 1). Exit site infections, however, due to fungal organisms have been a bit more resistant and while rare in occurrence, frequently do require catheter removal.

Tunnel infection

The second infection is that of tunnel infection. These are defined as the development of erythema, tenderness, induration and, occasionally purulence along the subcutaneous tract or tunnel. The tunnel extends from the the level of the dacron cuff to the point where the catheter enters into the vein (Fig. 1). These infections are substantially different from exit site infections. With few exceptions these rarely originate as exit site infections. Tunnel infections again have frequently occurred during periods of neutropenia, are frequently associated with septicemia. Gram-positive organisms are the most likely pathogen. Management of tunnel infections must include appropriate antimicrobial therapy and catheter removal. Our experience has shown a high incidence of failure when catheters are left in place and tunnel infections have been treated with antimicrobial therapy alone. It is now our routine recommendation that, in the presence of a tunnel infection, the catheter should be immediately removed with continuation of antimicrobial therapy for 10–14 days. A new catheter can then be placed at a later date in a new location (Table 1).

Catheter associated bacteremias

It has been the experience of most investigators that when one is assessing the occurrence of bacteremias in a population largely dominated by patients who are undergoing intense chemotherapy and who experience significant neutropenia, that the majority of bacteremias and fungemias will not be catheter related. The techniques for identifying true catheter associated infections are limited and with the exception of those bacteremias or fungemias associated with an exit site or a tunnel infection, the only reproducible technique for incriminating the catheter as the source for bacteremia is to utilize comparative peripheral and catheter blood culture colony counts. Nonetheless, in patients with catheters in place, many bacteremias will occur. The management of these infections at the University of Maryland Cancer Center has shown that the majority of bacteremias can be managed with effective antimicrobial therapy while leaving the catheter in place. Our own experience however, suggests that bacteremias due to *Bacillus* species and JK Corynebacteria or fungemias (*Candida* species, etc.) follow a much different pattern. The majority of these infections are unresponsive to antimicrobial therapy alone. Our present approach is, with the exception of *Bacillus* species, multiresistant JK Corynebacteria and fungemias, to initiate appropriate antimicrobial therapy and only in the setting in which the blood cultures remain persistently positive beyond 24–48 h without another identifiable source, to remove the catheter (Table 1). The exception to this rule has been those previously identified organisms (*Bacillus* species, multiresistant JK Corynebacteria and fungemias) where, along with appropriate antimicrobial therapy, the catheter is removed at the first notification that the blood cultures are positive.

Press *et al.* have assessed factors which appear to be significant and related to the development of infectious complications for patients with long-term indwelling right atrial catheters [5]. These factors include: recent chemotherapy within the past 2 weeks, granulocytopenia and catheter thrombosis. Factors such as fever on the day of catheter insertion, infection at a distant site on the day of insertion, granulocytopenia on the day of insertion, antimicrobial prophylactic therapy or the use of double lumen catheters were not associated in their series with an increased risk of infection. Our own analysis, however, suggests that double lumen catheters, the presence of neutropenia and obesity (defined as greater than 125% above ideal body weight) do increase the relative risk for developing catheter related infectious complications.

NON-INFECTIOUS COMPLICATIONS

The major emphasis of catheter related complications has focused upon the infectious complications. However, our own experience has suggested that non-infectious complications occur at a greater frequency and have a higher associated risk of catheter removal (Table 1). The risk of hemorrhage can be minimized by placing catheters only in individuals with platelet counts which can be maintained above a level of 50,000 platelets/μl and avoiding catheter placement during periods in which disseminated intravascular coagulopathy may be occurring. Catheter associated vascular thrombosis routinely requires catheter removal. Our own experience suggests that relatively short courses of anticoagulation following catheter removal (7–14 days) are usually effective and that long-term anticoagulation is frequently unnecessary. In general, our own experience suggests that other non-infectious complications can be minimized by utilizing single lumen rather than double lumen catheters and avoiding where possible the placement of catheters in individuals who are obese. Most important is the use of one specific surgeon for catheter placement. The expertise which can be

brought to this procedure by an individual who places these catheters in immunocompromised patients on a routine basis can significantly decrease catheter associated morbidity while improving catheter function.

SUBCUTANEOUS PORTS

The use of subcutaneous venous ports has been promoted primarily because of the advantage of improved cosmetic appearance and a potential decrease in the risk of infection. In large part, venous ports have been associated with the disadvantages of a limited capacity for infusion, an increased risk of extravasation and associated discomfort with repetitive accessing of the subcutaneous port through the overlying skin. Careful studies comparing long-term right atrial catheters and subcutaneous ports in patient populations at equal risk of infection are only now being performed. Our own preference certainly for individuals with hematologic malignancies undergoing cyclic chemotherapy or marrow transplantation is for a long-term right atrial catheter with multiple lumens. The management of infectious and non-infectious complications for subcutaneous ports is very similar to those recommendations for long term indwelling catheters.

SUMMARY

The use of venous access devices such as the long-term right atrial catheter or subcutaneous port has now become an accepted component of the management of patients with cancer undergoing cyclic chemotherapy. These devices provide obvious advantages and improvements both for the patient and the medical personnel caring for such individuals. These devices should only be placed in individuals who can receive the maximum benefits from such venous access devices and meticulous care of these catheters should be employed. In general, the majority of exit site infections can be treated with antibiotic therapy alone, while tunnel infections should incorporate antimicrobial therapy plus catheter removal. The majority of catheter associated bacteremias and fungemias are not primarily catheter related and can be managed with appropriate microbial therapy, although we recommend initial catheter removal when the positive blood cultures include organisms such as *Candida, Bacillus* species, multi-resistant JK Corynebacteria or any bacteremia which persists beyond 24–48 h when there is no other identifiable focus. Non-infectious complications can be minimized by a single skilled surgeon and the appropriate use of platelet support prior to catheter placement.

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