Repeated femoral vein puncturing for maintenance haemodialysis vascular access

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Abstract

Background. When access cannot be achieved using a native arteriovenous fistula or a synthetic prosthetic graft, central venous catheters are usually placed. This mode of access is short-lived, prone to infection, stenosis and thrombosis of central veins. To overcome access problems, we developed a new native vascular access (‘femoral vein access’) and devices. We report here on our experience with the availability, longevity, procedure and morbidity of haemodialysis (HD) using femoral vein access.

Methods. Repeated (three times a week) patient’s native femoral vein puncturing has been used as the vascular access (femoral vein access) for maintenance HD in 30 patients (mean age ± SD: 61.70 ± 15.27 years old; 18 female/12 male). The femoral vein was punctured beneath the inguinal ligament (on a length ranging from 30 to 100 mm) after disinfection and local anaesthesia. Long (effective length 56 mm) 19- and 18-gauge needles with four side holes were used for the femoral vein puncture as an arterial site of the extracorporeal circuit of HD and shorter (effective length 40 mm) similar gauge needles for the subcutaneous vein puncture used as the return site. The needle is inserted blind into the femoral vein after the femoral artery has been located by palpation and the perception of a pulse. Patients returned home the same day.

Results. The mean duration of HD treatment using femoral vein repeated puncture was 4.99 ± 3.42 years (up to 16.0 years). This represented a total experience of 23 369 femoral vein punctures. The mean blood flow achieved on dialysis was 165 ± 20 ml/min. The average Kt/V was 1.74 ± 0.48 per session.

Conclusions. The femoral vein repeated puncture technique has substantial advantages over venous catheters. It does not require surgery, while permitting adequate blood flow. This method can be used as a long-term (over 10 years) blood access. Apart from a few local haematomas, no serious complications have been observed. Moreover, it does not carry a heavy financial burden.

Keywords: adequate dialysis; haemodialysis; long survival; morbidity; native femoral vein puncture; vascular access

Introduction

The development of maintenance haemodialysis (HD) treatment was made possible only by the introduction of the external arteriovenous shunt by Quinton et al. [1] in 1960. Six years later, Brescia et al. [2] reported the technique of native arteriovenous fistula (AVF). Shortly thereafter, prosthetic subcutaneous interpositional bridge grafts were developed [3–6]. Since then, advances in permanent HD vascular access have been scarce [7] over the past three decades. During the same time, vascular access-associated morbidity and its related cost have tremendously increased [8–11].

Solving the vascular access problems is a crucial issue not only for patients, but also for dialysis staff, nephrologists and surgeons, as well as for financial providers.

About 20 years ago, we considered femoral vein puncture as a potential HD vascular access and tried initially to implement it for occasional use. Thereafter, we extended the experience to long-term HD treatment. For the sake of convenience we have called this use of the femoral vein by repeated puncture for HD ‘femoral vein access’. Our experience with the availability, longevity and morbidity of the femoral vein access in maintenance HD patients is reported in the present paper.

Subjects and methods

Patients

The use of the femoral vein access for maintenance HD treatment for more than 1 year was analysed in 30 patients
The selection of the 30 patients studied here was based upon those who had a long experience (>1 year) of HD using femoral vein access because they seemed to have a substantial advantage over the patients with a short one (<1 year) for demonstration of excellent long-term utility (availability, longevity and morbidity) of femoral vein access. Their clinical characteristics are shown in Table 1. Their age ranged from 25 to 89 years [61.70 ± 15.27 years (mean ± SD)]. Their dry weight (post-dialysis body weight) ranged from 34.0 to 71.8 kg (48.09 ± 10.53 kg). The causes of chronic renal failure were chronic glomerulonephritis (19 patients), nephrosclerosis (NS; three patients), diabetes mellitus (four patients), systemic lupus erythematosus (one patient), primary amyloidosis (one patient), haemolytic uraemic syndrome (one patient) and polycystic kidney disease (one patient). The total duration of HD ranged from 1.5 to 28.6 years (12.85 ± 8.58 years). The number of hours per dialysis session ranged from 4.0 to 6.1 h (5.29 ± 0.50 h). Twenty-six patients (86.7%) out of 30 had attempted intermittent longer HD [>5.0 h (5.42 ± 0.40 h) per session, three times weekly] so as to achieve better blood pressure control. However, the remaining four patients had not allowed it and their numbers of hours per dialysis session ranged from 4.0 to 4.8 h (4.49 ± 0.38 h). The methods of dialysis were HD (17 patients) and haemodiafiltration (13 patients). Native AVF was attempted from zero to 12 times (4.73 ± 3.26 times). Four expanded polytetra-fluoroethylene arteriovenous grafts (PTFE AV graft) [5] were inserted in three patients (cases 1, 7 and 27) before the initiation of femoral vein access. Twenty-six out of 30 patients have had a previous native AVF created and eventually used before the femoral vein access was implanted. Among the remaining four patients, two patients (cases 3 and 22) have undergone HD using the femoral vein access from the beginning of the HD treatment because of non-functioning fistulas. Two other patients (cases 28 and 30) with NS and advanced arteriosclerotic disease (AS) had no AVF creation attempt at all.

The indication for femoral vein access was access failure (AF) in 24 patients (failure of AVF or graft; 22 stenosis and two non-functioning), but it was also used as the primary access in two patients (cases 28 and 30) with severe AS. Four patients (cases 2, 9, 19 and 29) had used this access because their native AVFs had to be surgically closed to cure high output heart failure.

### Procedures, devices and measurements

The femoral vein puncture is usually performed under local anaesthesia with patients returning home the same day. We measured by ultrasonography the distance between skin and femoral veins of both thighs of 20 randomly selected maintenance HD patients. It ranges from 10.0 to 20.6 mm (14.54 ± 2.93 mm) on the right and from 10.0 to 18.0 mm
(13.88 ± 2.61 mm) on the left side. This, and the necessary angle for puncture was the basis for the needle length choice.

The femoral vein needles (Figure 1A and B) used for puncturing the femoral vein (i.e. for the 'arterial site' of the extracorporeal circuit) are 19- or 18-gauge needles (effective length 56 mm) with four side holes (Figure 1C). The same needles (but with an effective length of 40 mm) are used for the puncture of the subcutaneous vein used for returning the blood to the patient. We had developed initially a same size needle but with six holes instead of four to allow for a sufficient blood flow. It turned out after some trials that they were too weak (several needles kinked or bent), so we reduced the number of side holes in the needle.

Because of its stiffness and strength we chose Teflon rather than PVC as the material.

The needles we are using currently are 19G4HWKS, 18G4HWKS, 19G4HWS and 18G4HWS from Medikit® (Tokyo, Japan). Their cost (~$2 a piece) is not significantly different from standard HD needles.

The following information was collected for each patient at a dialysis session over 6 months: the number of dialysis hours per session, dry weight evaluation and femoral vein blood flow. The Kt/V index using Daugirdas’s formula [12] (the target Kt/V in Japanese HD patients is >1.6) was measured for each patient once over 6 months. Data are given as mean ± SD.

Fig. 1. (A) Needle for arterial site. (B) Needle for venous site. (C) Four side holes.
Femoral vein blood flow was mainly determined according to the recommendations of Japanese Society of Dialysis Therapy (JSDT) \[13\]. As of December 31, 1999, JSDT has advocated an appropriate blood flow for achieving significant better 1 year survival rates within the range of 2.5–3.0 ml/min/kg. If post-dialysis body weight (dry weight) is ~52.0 kg (average dry weight in Japanese dialysis patients) their femoral vein blood flows should be prescribed within the range of 130–156 ml/min; these are very low compared to those in other countries. However, in our longer term HD patients using femoral vein access, blood flow supply was usually sufficient within the range of 130–230 ml/min for achieving a Kt/V index >1.6.

Procedure for insertion and removal of needle

For femoral vein puncture and during the session the patient is lying in bed. Before femoral vein puncture is performed, the subcutaneous venipuncture used as venous return of the HD circuit is performed as usual, and the catheter lumen is flushed with saline to avoid clotting during the femoral vein puncturing.

The operator of the venipuncture of the femoral vein must be an experienced doctor or nurse. Approximately 90% of medical staff in Japan are right-handed. The right-handed sticker must stand on the right side of the patients to stick both the right and the left femoral vein. Left-handed stickers are better positioned standing on the left side of the patient to stick both left and right femoral veins.

The puncture site is located 30–100 mm below the inguinal ligament. As much as possible a different site is stuck at each dialysis session to avoid local skin thickening and scar tissue formation.

The anatomical relationships between femoral arteries and femoral veins in both thighs must be examined by ultrasonography in each patient initially before starting to use repeated femoral vein punctures and at any time in maintenance treatment when experiencing difficulties in puncturing.

For femoral vein puncture, the angle between needle and skin is between 10° and 50°.

After skin disinfection using the same aseptic technique as for a native AVF (in our case we use povidone-iodine and alcohol antiseptic solutions), ~1.0 ml of 1.0% lidocaine hydrochloride is infiltrated in the skin of the chosen site (only one patient dialysing by this technique for 16 years does not use local anaesthesia before the needle is inserted).

The 19- or 18-gauge needle for the femoral vein puncture is inserted blind along and just inside the pulsating femoral artery (Figure 2A).

In the very rare cases of inadvertent puncture of the femoral artery, the needle is withdrawn and a firm but non-occlusive compression is applied for 10–15 min before a new attempt to puncture the vein is performed.

Fig. 2. Scene of vein puncture. (A) Start of puncturing. (B) The catheter is placed in the lumen of the femoral vein. (C) The catheter is connected with a connecting line to the extracorporeal arterial circuit. (D) The HD is started.
When the catheter is placed in the vascular lumen (Figure 2B) the metallic mandril of the catheter is carefully and slowly withdrawn. The catheter lumen in the femoral vein is filled with venous blood by venous pressure, then quickly connected with a connecting line to the extracorporeal arterial circuit (Figure 2C) without saline-flushing. Thereafter, the blood pump is turned on and HD is started (Figure 2D).

At completion of the HD session, the needles are taken out and a gentle compression of ~10 min is applied on the skin puncture area including the zone where the vein itself has been stuck.

In our unit, all patients are dialysed for three sessions every week. The dialysis time per session ranges from 4.0 to 6.1 h.

Results

Results of femoral vein access in 30 patients are shown in Table 2. The duration of HD treatment using the femoral vein access ranged from 1.2 to 16.0 years (4.99 ± 3.42 years). The number of femoral vein punctures ranged from 187 to 2496 per patient (778.96 ± 533.70 per patient). The overall experience we report represents a total of 23,369 femoral vein punctures. Blood flow achieved through the femoral vein ranged from 130 to 230 ml/min (165 ± 20 ml/min). Twenty-eight patients (93.3%; cases 2–22 and 24–30) out of 30 had regularly used 19-gauge needles for repeated femoral vein puncture providing 161 ± 3 ml/min of blood flow while the remaining two (6.7%; cases 1 and 23) had regularly used 18-gauge needles for repeated femoral vein puncture, also providing 221 ± 5 ml/min of blood flow. The Kt/V index ranged from 0.79 to 2.49 (1.74 ± 0.48). Two patients (cases 6 and 15) had a Kt/V index < 1.0 in spite of intermittent longer HD.

Case 6 (male; Kt/V index = 0.79) had a substantial residual renal function (daily urine volume = 300–500 ml). Case 15 (female; Kt/V index = 0.98) had, accompanied with advanced liver cirrhosis with massive ascites, giant splenomegaly and hypotension (systolic blood pressure < 100 mmHg). Her pre-dialysis blood urea nitrogen levels were prone to low values (39.5–55.0 mg/dl).

Four patients (cases 27, 28, 29 and 30) out of 30 died. The causes of death were severe cardiac valvular disease (case 27, tricuspid regurgitation and case 28, aortic stenosis associated with mitral regurgitation) and sepsis due to pneumonia (cases 29 and 30). In these four patients, HD using femoral vein access was maintained until just before the death. No one died as a result of morbid conditions related to femoral vein access.

The complications related to the femoral vein access were few. In three patients (cases 1, 7 and 25), local haematoma made it impossible to carry out HD using femoral vein access on the same side for more than 2 weeks. Case 1 had experienced local haematoma once (one time in 1310 punctures, 0.076%). He complained of severe pain in the inserted site soon after the puncturing and his systolic blood pressure (70 mmHg) reduced transiently due to bleeding [RBC = 226 × 10⁹/μl (before; 270 × 10⁹/μl)]. As soon as possible the needle inserted was taken out and plasma expander was infused. After these treatments the pain disappeared and his blood pressure returned to normal without aggravation of anaemia. He was hospitalized one night for observation of suspected bleeding. Case 7 had suffered from local haematoma once (one time in 842 punctures, 0.119%) and was hospitalized for 6 days, while case 25 had experienced it twice (two times in 749 punctures, 0.267%) and was hospitalized for 4 and 3 days, respectively. Blood pressure reduction due to bleeding was not observed in cases 7 and 25. In all four bleeding episodes among three patients, blood transfusion was not done. It occurred as a whole only four times (0.017%) in 23,369 punctures. A few infections consisting of local skin inflammation and eventual discharge of a drop of pus, which responded well to oral minocycline hydrochloride (minomycin) treatment, were observed in only three patients [case 1, two times (0.153%) in 1310 punctures; case 11, six times (2.400%) in 250 punctures; and case 13, 10 times (1.425%) in 702 punctures] during the study period. It occurred as a whole 18 times (0.077%) in 23,369 punctures. Neither abscess nor bacteriaemia was ever observed. No patient was hospitalized for the treatment of local skin infections in inserted sites or had died as a result of such infections.

Traumatic AVF had been experienced only once. The patient (case 29) had initially complained of severe pain at insertion. The needle was immediately removed and the contralateral femoral vein was stuck for the dialysis. The occurrence of a traumatic AVF was confirmed by ultrasonography. The pain at the inserted site disappeared within a week after the onset, but a superficial loud bruit in the same site persisted. No symptom of high cardiac output was associated. The AVF between the deep femoral artery and the femoral vein needed to be closed surgically. He entered the hospital for 15 days in order to ease the pain and to be operated for traumatic AVF. This occurred once (0.004%) in 23,369 punctures.

Discussion

HD access-related morbidity (native AVF and grafts) and its associated cost have been increasing every year [8–10]. In addition to their huge financial impact, the frequency and unpredictability of HD vascular AF is an enormous frustration for the patient, dialysis staff, the nephrologist and surgeon [10]. Because of the impact of these circumstances on HD patients worldwide, considerable investigative efforts have been expended in the search for major breakthroughs in vascular access devices. Deep vein catheters have been the most frequent response to these problems. However, they lead to many complications including infection, central vein stenosis or thrombosis, and ultimately to increased mortality [14–17]. These important drawbacks are not balanced or justified by a substantial functional survival [18–20].
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**Table 2.** Results of 30 patients with femoral vein access
According to ultrasound surveillance, the femoral vein in a pre-dialysis patient usually has a voluminous size. Twenty years ago, we considered femoral vein repeated puncture as a possible HD vascular access. We tried to develop needles specifically for the femoral vein puncture. The prevalence of HD using femoral vein access in our unit was 15.4% of patients (16/104) on May 31, 1997 and 5 years later, it increased to 17.6% of patients (35/199). In the early period, after the initiation of HD treatment using femoral vein access, we frequently tried to create the traditional vascular accesses, either native or synthetic (a straight or loop graft), but after a substantial period of time with successful HD using femoral vein access, we do not use them, except native AVF.

With respect to the indications, AVF (native or graft) failure has been the most frequent condition leading to the use of femoral vein puncture. Only in two cases with advanced arteriosclerosis no attempt was made to create AVF.

Femoral vein puncture is very similar to femoral vein cannulation with a catheter for HD as described first by Shaldon et al. [21] in the early 1960s. According to Uldall [22] femoral vein cannulation is the method of choice for most emergencies in end-stage renal disease patients with pulmonary oedema and other serious pulmonary diseases. Furthermore, it is also reported in the literature [22] that the most common complication of femoral vein cannulation for HD is traumatic AVF. It is important to note the rarity of this complication in our experience. It occurred only once (0.004%) in 23,369 punctures.

Of the morbidity associated with the femoral vein access, only local haematoma formations in inserted sites related to the blind venipunctures by inexperienced dialysis staff are the most problematic. However, the femoral vein punctures performed by experienced dialysis staff in our unit were quite safe for usual maintenance HD without even local haematoma formation. We believe that this is due to the use of small size needles (19- and 18-gauge) and the care taken in the puncture performed by experienced personnel. Local minor infections were also of note and their incidence was obviously higher than that of local haematomas. However, local minor infections were only observed in three patients with a high susceptibility to infections, presumably due to low immunity; these scarcely disturbed the maintenance HD using femoral vein access because the infections were easily cured within a short period of time by oral administration of antibiotics and the contralateral femoral vein was also available for puncturing. Further, local minor infections did not extend to bacteriaemia and sepsis, presumably due to highly skilled puncturing, minimal skin injury as a result of the use of small sized needles, careful procedures for disinfection of inserted sites both before and after the puncturing, and the very short stay of the needle in the femoral vein compared to that of deep vein catheters.

To sum up, the incidence of femoral vein access problems was 0.017% (four times in three patients per 23,396 punctures) for local haematomas, 0.077% (18 times in three patients per 23,396 punctures) for local minor infections and 0.004% (one time in one patient per 23,369 punctures) for traumatic AVF. Of hospitalization related to femoral vein access problems, local minor haematomas needed 14 days, local minor infections zero and traumatic AVF 15 days. Total hospital days associated with femoral vein access problems were 29 days (0.053%) out of 54,750 days.

Thus, the effect of long-term repeated femoral vein access has been almost innocuous. From this point of view, it compares favourably with deep vein catheter use.

With regard to longevity and availability of the femoral vein access, the longest duration of HD using this access was 16.0 years (total HD duration 26.6 years) in a female patient (case 18) who has never been hospitalized for any trouble related to the femoral vein access. In other words, this represents 2,496 consecutive punctures without any morbidity event.

The procedures related to the femoral vein puncture are very simple and easy except for the need of technical skill. The only particular devices for the venipuncture using this access are special needles.

Femoral vein access can be extended worldwide to a patient population of different body size suffering from access troubles. In the case of a femoral vein blood flow of 130–230 ml/min, this may be sufficiently provided by the use of 19- and 18-gauge needles for femoral vein puncture. When more than 230 ml/min of femoral vein blood flow is required, larger and longer needles (17- or 16-gauge needles) for femoral vein puncture may need to be developed.

Progress in the skill of femoral vein puncturing is of the utmost importance for both patients and staff because highly skilled puncturing will greatly lessen the femoral vein access-associated morbidities such as local haematomas and pain at insertion, resulting in a patient’s acceptance of the technique.

In conclusion, the femoral vein access has some extremely appealing advantages: (i) it does not need surgery; (ii) it provides a sufficient blood flow; (iii) it allows for long-term HD (over 5 years in 12 patients); (iv) local haematoma formations in inserted sites are the main drawback but may only occur in 0.017% of punctures, and additionally, local minor infections in inserted sites must be paid a considerable attention but may only occur in 0.077% of punctures; (v) it is not expensive, and turns out to be a financially worthy maintenance dialysis blood access technique.

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