Vascular access for hemodialysis: creation, functioning, and complications (Data of the Hospital of Kaunas University of Medicine)

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Key words: *chronic renal failure; vascular access; hemodialysis; vascular mapping; fistula maturation.*

Summary. *Background. There are no data about arteriovenous fistulas (AVF) formation, survival, and complications rate in patients with end-stage renal failure in Lithuania.*

Material and methods. We analyzed the data of patients (N=272) with end-stage renal failure, dialyzed at the Hospital of Kaunas University of Medicine from January 1, 2000, until March 30, 2010, and identified 368 cases of AVF creation. The patients were divided into two groups: group 1 included the patients with an AVF that functioned for <15 months (n=138) and group 2 included patients with an AVF that functioned for ≥15 months (n=171).

Results and conclusions. Less than half (47%) of the patients started planned hemodialysis and 51% of the patients started hemodialysis urgently. The mean time of AVF functioning was 15.43±8.67 months. Age, gender, the kidney disease, and time of AVF maturation had no influence on AVF functioning time. AVFs of the patients who started planned hemodialysis functioned longer as compared to AVFs of the patients who started hemodialysis urgently (P<0.05). Hospitalization time of the patients who started hemodialysis urgently was longer as compared that of the patients who had a matured AVF (37.63±20.55 days vs. 16.54±9.43 days). The first vascular access had better survival than repeated access. AVF survival in patients with ischemic brain vascular disease was worse than in patients without this comorbidity.

Introduction

Hemodialysis (HD) is the dominant form of renal replacement therapy for the patients with end-stage renal disease and requires complication-free access to the peripheral blood circulation. Hence, the establishment and maintenance of vascular access (VA) is pivotal and has long been labeled the "Achilles' heel" of HD due to its vital role in the delivery of dialysis (1).

VA for HD can be achieved by three ways: native arteriovenous fistula (AVF), arteriovenous graft (AVG), usually polytetrafluoroethylene, or cuffed central venous catheter (CVC). The main role of the cuffed CVC is as a bridge until either an AVF or an AVG can be constructed or as permanent access in the patient who has exhausted all other VA possibilities (2).

It is well established that AVF is the top priority among the VA methods. This access type is beneficial for superior patency rate, lower infection risk, lower costs, and lower mortality risk if compared to either AVG or CVC. All clinical practice guidelines (NKF-K/DOQI, of USA, Canada, and Australia) indicate that an AVF is the VA of first choice for HD patients (2).

A native AVF is the golden standard of VA for HD, but there are a number of these access-specific problems. The AVF is usually created through the surgical anastomosis of the radial (wrist) or brachial (elbow and upper arm) artery to the cephalic vein. Two major complications of AVF include an initial failure to mature (primary nonfunctional) and a later venous stenosis followed by thrombosis (2, 3). The data analysis of AVF survival that was performed at the time of the NKF-K/DOQI suggested a primary patency of 85% for AVF at 1 year and 75% at 2 years. These data exclude the AVF that did not mature adequately to support HD. Primary nonfunctioning or rates of failure to mature up to 50% have been reported by some centers, particularly when an aggressive AVF placement policy is enforced (1).

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There have been no data on AVF formation, survival and complications rates in Lithuania until now. For this reason, we decided to investigate the data obtained from our patients who were dialyzed and now are on HD in our dialysis center. Parameters that may have an influence on VA functioning time and development of complications were analyzed.

Material and methods

Since January 1, 2000, until March 30, 2010, 311 patients with chronic renal failure were dialyzed at the Hospital of Kaunas University of Medicine. The data of 271 patients were available. Baseline demographic information was entered into a computerized database, including age, gender, cause of renal failure, and comorbidities. The causes of end-stage renal failure (ESRF) were analyzed according to the reason of the disease: renal causes (pyelonephritis, glomerulonephritis, polycystosis of the kidney) and vascular causes (primary arterial hypertension, diabetes as the main reason of the ESRF). Comorbidities were defined as follows: coronary artery disease (diagnosis of ischemic heart disease documented in the medical records); peripheral vascular disease (a history of lower extremity revascularization, or amputation of a digit or extremity, or history of claudication and ischemic extremity changes or gangrene); cerebrovascular disease (a stroke or transient ischemic attack documented in the medical records, or clinical signs and symptoms of chronic brain ischemia, when the diagnosis was documented in the medical records); diabetes (if a patient had ever required hypoglycemic agents or insulin, and the diagnosis was documented in the medical records, but diabetes was not the main reason of chronic renal failure). We analyzed the data of the start of HD (planned through a matured AVF or urgent through a temporary CVC; duration of hospitalization and waiting time for AVF creation; frequency of vascular mapping before VA creation). VA characteristics that were analyzed included access type and anatomic location. HD patients were divided into the groups according to AVF functioning time: group 1 included the patients with an AVF that functioned for <15 months (n=138) and group 2 included patients with an AVF that functioned for ≥15 months (n=171).

Statistical data analysis. Baseline characteristics of patients were summarized, with categorical variables compared using the χ^2 test. Data were presented as mean±SD or percentage. Comparisons between the groups were made using the Student's *t* test and Mann-Whitney *U* test for continuous variables, and the chi-square and Fisher's exact tests for categorical variables. Cumulative survival of VA was estimated using the Kaplan-Meier method. Statistical analysis was performed with SPSS 17.0 software. A *P* value of less than 0.05 was considered significant.

Results

Demographic characteristics of the patients who were on chronic HD and dialyzed through an AVF are represented in Table 1. There were 368 cases of VA creation: 271 were the first VA and 97 were repeated (63 of the second, 24 of the third, and 8 of the fourth access).

Vascular mapping was done in 14.7% of cases before the first, in 20.6% of cases before the second, in 41.6% of cases before the third, and in 62.5% of cases before the fourth VA creation.

The mean maturation time of AVF was more than 2 weeks (19.67±16.52 days) in our center.

The mean time of VA functioning was 15.43±8.67 months. No significant differences were found regarding gender, age, main renal disease, maturation time, or localization of AVF between two patients groups according to AFV functioning time (<15 or ≥15 months) (Table 2). More than half (51%) of patients studied started HD urgently through a CVC (83 patients in the group 1 and 80 in the group 2) and 47% (52 patients in the group 1 and 89 in the group 2) started planned HD through a matured AVF; data about HD start in 2% of patients were missing (2 pa-

Table 1. Characteristics of patients (n=271) who were hemodialyzed through native arteriovenous fistula

Variables	Value (%)
Gender:	
male	56%
female	44%
Age:	
<50 yr	24%
≥50 yr	76%
The main kidney disease:	
renal cause of ESRD	52.6%
vascular cause of ESRD	34.6%
other reason of ESRD	12.8%
Comorbidity:	
ischemic heart disease	50.7%
cerebrovascular disease	2.95%
peripheral vascular disease	4.05%
diabetes (not as reason of ESRD)	2.9%
Diabetes (as the reason of ESRD)	17.3%
Hemodialysis start:	
planned	47%
urgent	51%
no information	2%

tients in the group 1 and 3 in the group 2). Significantly shorter time of VA functioning was documented in patients who started HD urgently through a CVC as compared to the patients who started planned HD through a matured AVF (11.25±6.27 months vs. 8.56±4.72 months, $P<0.05$). Urgent HD was associated with longer hospital stay. The data on hospital stay of the patients who started planned and urgent HD are represented in Table 2.

Kaplan-Meier survival curves showed that survival of the first AVF was better than that of repeated AVF (Fig. 1).

The mean waiting time of AVF creation was 4.1±3.77 days.

AVF survival in patients with ischemic brain vascular disease (IBVD) was worse than in patients without this comorbidity (Fig. 2). In addition, we did not find any data that coronary artery disease or peripheral vascular disease shortens time of AVF functioning.

Table 2. Characteristics of hemodialysis patients groups according to arteriovenous fistula (AVF) functioning time (group 1 – <15, group 2 – ≥15 months)

Characteristic	Group 1 (n=138)	Group 2 (n=171)	*P*
Gender:			
male	80	98	NS
female	58	73	NS
Age, mean±SD, years	62.71±14.61	56.98±16.71	NS
Hemodialysis start			
planned	52	89	<0.05
urgent	83	80	NS
AVF maturation time, days	25.63±23.78	30.0±30.16	NS
Vascular access localization			
radiocephalic	97	136	NS
high radiocephalic	17	21	NS
brachiocephalic	16	12	NS
The cause of ESRD			
renal	71	95	NS
vascular	51	57	NS
The first AVF/second AVF, %	64.49/35.5	74.85/25.14	<0.05

Discussion

For many years, nephrologists have been working to early detect kidney diseases and renal failure. Every year, the number of patients who start planned HD through a matured AVF is growing (4). Discovered dependence in VA functioning time and planned start of HD shows an importance of this work. It is not the only reason why the patient must be timely referred to nephrologists. Some investigators have shown that the initial placement of a catheter instead of the timely

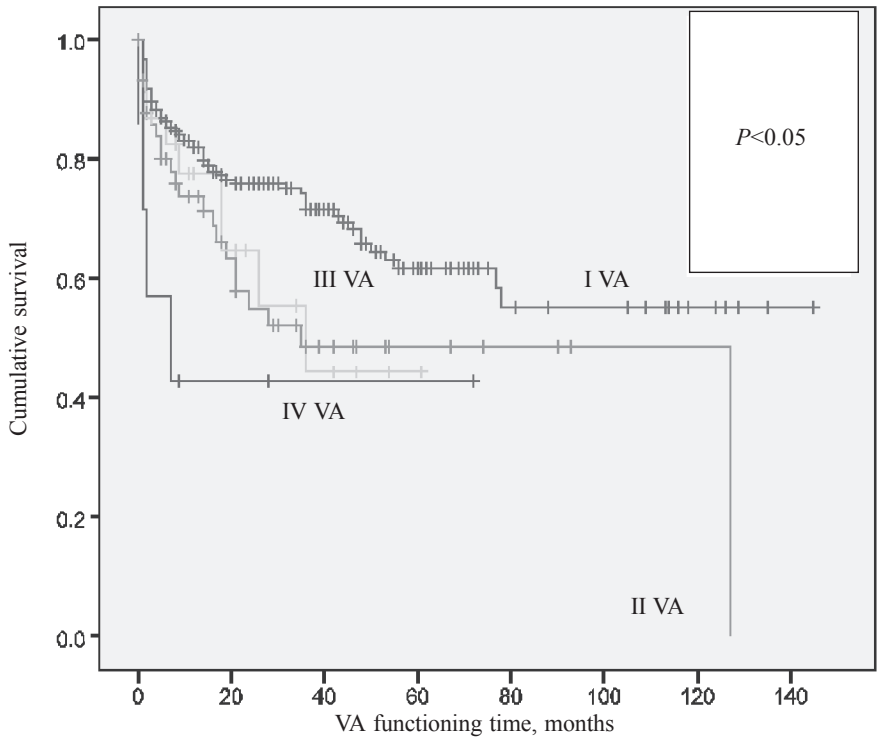

Fig. 1. Survival of the first (n=271) and repeated (n=97) vascular access (VA) of hemodialysis patients

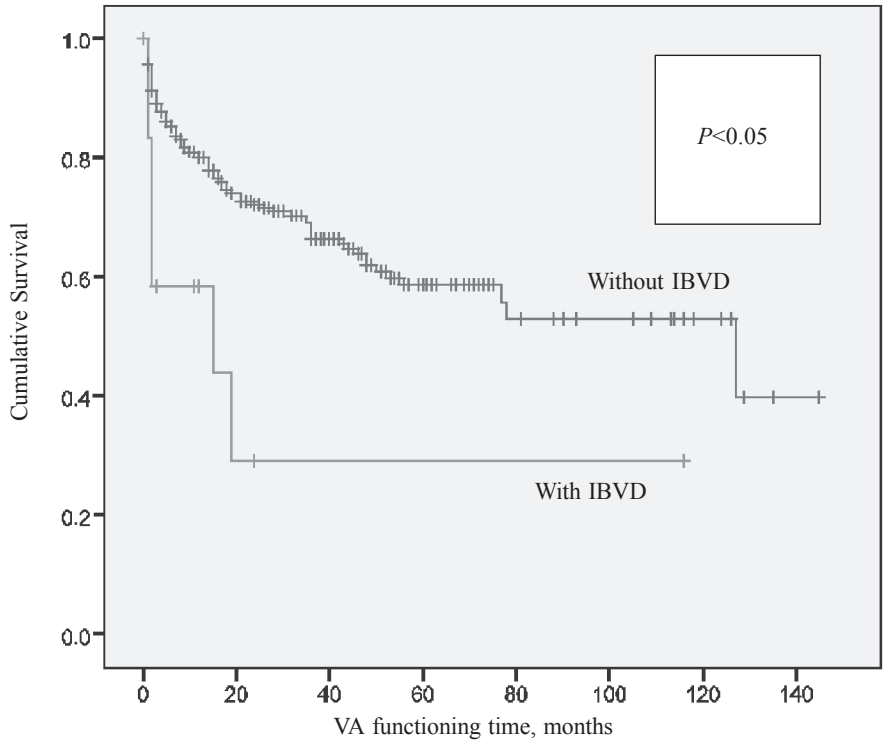

Fig. 2. Survival of vascular access (VA) in hemodialysis patients with ischemic brain vascular disease (IBVD) and without this comorbidity

construction of a VA, late referral to nephrologists, and unplanned dialysis increase morbidity and mortality in chronic HD patients (5). Ortega et al. reported that HD through the CVC increased the risk of death from all causes, not just infection-related mortality. They indicated that there exist a relationship between timely creation of AVF and morbidity and mortality: a greater number of hospitalizations and a longer stay being associated with the use of catheters, which entail complications and translate into increase of costs (5). Our results showed that more than half of our patients started HD urgently through a CVC and hospitalization time of these patients was much longer than that of the patients who started HD through a matured AVF.

Vascular mapping before access creation is strongly recommended according to many European and USA authors (6). It is well known that there are more AVG than AVF created as a primary VA in the United States. A large study of routine preoperative mapping in the University of Alabama at Birmingham (USA), involving more than 500 patients, demonstrated a dramatic increased in the construction of AVF as opposed to AVG, while maintaining the likelihood that the AVF will be usable for HD. These improvements in outcomes were likely due to identification of suitable veins by ultrasound that were not apparent on physical examination (6, 7). Therefore, variations in gender and age distribution of HD patients at different facilities may result in substantial differences in the proportion of patients dialyzed with an AVF, even when there is a concerted effort to place more AVFs and preoperative vascular mapping is used routinely (8). For two years, we have been performing vascular mapping for every patient before a new VA creation. Some years ago, this procedure was applied in complicated cases only when it was necessary to create the third or the fourth AVF. The available data are insufficient for discussion about the influence of vascular mapping on VA survival, but it is clear that this method is very important for a successful creation of the repeated AVF.

Failure of AVF maturation, also known as primary AVF failure, ranges from 9 to 70%, depending on HD center (9). Patients with a nonmatured AVF require placement of temporary dialysis catheter and aggressive interventional strategy to develop AVF functionality. Despite such efforts, a substantial proportion of marginal AVFs never mature adequately to be used for HD. The clinical consequence of immature AVFs includes prolonged dependence on "bridging catheters" with all of the attendant complications and need for further attempts at permanent VA surgery. Even in programs that use routine preoperative vascular mapping to guide the surgeon's choice of VA type

and location, primary failure still occurs in a subset of patients (10). The fact that only 14.6% of VA created in our centra were nonmatured shows professional experience of our surgeons and availability of introduction of vascular mapping.

According to the data available from the Dialysis Outcomes and Practice Patterns Study (DOPPS) and the Italian multi-center study, longer maturation time appears to be associated with a lower risk of failure of the first AVF (10). The finding that first cannulation 2 weeks after AVF creation is not associated with worse AVF survival, as it was thought some years ago, should not be used to recommend that all AVFs can be cannulated 2–4 weeks after creation (9). Nephrologists may be able to select appropriate patients and perform AVF cannulation in an early stage in a way that is not detrimental to AVF survival (9, 11). The mean maturation time of AVF was more than 2 weeks (19.67±16.52 days) in our center. We did not find any influence of maturation time on time of VA functioning. If compared to the data of 2005–2006 obtained in our center, AVF maturation time became longer (it was 14.78±4.87 days in 2005–2006) (12). We have data about VA creation collected within January 1, 2000, and January 1, 2003, in our HD center. In that time, AVF maturation time was shorter, often less than 14 days. We established that shorter maturation time of a new VA was associated with more frequent early thrombotic complications: the mean time of success AVF was 15.45±2.56 days and 12.5±2.42 days in the early thrombotic group ($P<0.05$) (13).

We did not find any patient-dependent factor, which would have had an influence on AVF survival. Konner et al. found out that in age groups the lowest primary unassisted access survival was observed among female nondiabetic patients (51 and 63% for ages <65 and 65+ at two years, respectively). For ages under 65 years, male nondiabetic patients showed the best primary access survival (75% at two years). For patients aged 65 and older, the best primary unassisted access survival was observed among male diabetic patients (81% at 1 year, and 72% at 2 years) (8). We observed that survival of the first AVF according to the Kaplan-Meier curves was much better than that of the repeated AVF. The reasons of this difference are unclear. German nephrologists reported that the degree of VA calcification after 3 years on HD was much higher than on start of HD (14). We had no such data for our study patients. We can only presume that better survival of the first AVF might be associated with lesser degree of vascular calcification at the initiation of HD.

Conclusions

1. More than half of studied patients with end-stage renal failure were referred to nephrologists too late, and they started hemodialysis urgently through a central venous catheter.
2. Hospital stay in cases of urgent start of hemodialysis was longer as compared to a planned creation of an arteriovenous fistula.
3. Age, gender, the main kidney disease, localization, and maturation time of vascular access did not have any influence on time of vascular access functioning. AVF functioning time was statistically significantly associated with the start of hemodialysis (the number of patients with planned hemodialysis start was higher in the group with longer AVF functioning time).
4. Survival of the first vascular access was better than that of the repeatedly created access. Survival of the arteriovenous fistula in patients with ischemic brain vascular disease was worse than in patients without this comorbidity.

Kraujagyslinės jungtys hemodializei: formavimas, funkcionavimas ir komplikacijos (Kauno medicinos universiteto klinikų duomenys)

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Raktažodžiai: lėtinis inkstų funkcijos nepakankamumas, kraujagyslinė jungtis, hemodializė, doplerografija, jungties brandinimas.

Santrauka. *Įvadas.* Iki šiol neanalizuoti duomenys apie arterioveninių jungčių, skirtų hemodializės procedūrai atlikti galutiniu inkstų funkcijos nepakankamumu sergantiems pacientams, formavimą, funkcionavimą bei jų komplikacijų dažnį Lietuvoje.

Metodika. Išanalizuoti duomenys pacientų, sirgusių galutiniu inkstų funkcijos nepakankamumu ir gydytų planinėmis hemodializėmis (HD) Kauno medicinos universiteto klinikų Hemodializės centre 2000 m. sausio 1 d. – 2010 m. kovo 30 d. (N=272), kuriems buvo suformuotos 368 arterioveninės jungtys. Pacientai, buvo suskirstyti į dvi grupes. I grupėje – pacientai, kuriems arterioveninė jungtis funkcionavo <15 mėn. (n=138); II – pacientai, kuriems arterioveninė jungtis funkcionavo ≥15 mėn. (n=171).

Rezultatai ir išvados. 47 proc. tirtų pacientų gydymas hemodializėmis, pradėtas planingai; per subrendusią arterioveninę jungtį 51 proc. pacientų pradėtas skubiai, per centrinės venos kateterį. Vidutinė arterioveninės jungties funkcionavimo trukmė – 15.43±8.67 mėn. Pacientų amžius, lytis, inkstų liga ir arterioveninės jungties brandinimo trukmė neturėjo įtakos aterioveninės jungties funkcionavimo trukmei. Pacientams, kuriems gydymas planinėmis HD buvo pradėtas planingai, arterioveninė jungtis funkcionavo ilgiau, nei pacientams, kuriems HD buvo pradėtos per centrinės venos kateterį (p<0,05). Išanalizavus pacientų hospitalizacijos trukmę, pradedant gydymą planinėmis HD, rasta, kad hospitalizacijos trukmė, pradėjus HD skubiai, per centrinės venos kateterį, yra statistiškai patikimai ilgesnė (37,63±20,55 dienos), palyginus su HD, kurios pradėtos per subrendusią arterioveninę jungtį (16,54±9,43 dienos). Pirmosios arterioveninės jugties išgyvenamumas yra geresnis, palyginus su pakartotinai suformuotomis jungtimis. Pacientams, sergantiems išemine smegenų liga, arterioveninė jungtis fukcionavo trumpiau nei pacientams, neturintiems minėtos patologijos. Išeminė širdies liga ir periferinių kraujagyslių patologija didelės įtakos arterioveninių jungčių išgyvenamumui neturėjo.

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