The prognostic role of finger pressures and access flows in hemodialysis patients

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Chapter 11

Impact
Scientific contribution

Aim of the present thesis was to study the potential of both finger pressures using plethysmography as well as the role of access flow ($Q_a$) regarding a number of crucial outcome parameters in hemodialysis (HD) patients. At the start of this thesis, we hypothesized that plethysmography could play an important role as a prognostic tool. Plethysmography is a simple, cost-friendly and non-invasive bedside modality for determining blood pressure of the digits of the hand. We were convinced that, by using digital plethysmography prior to AVA construction, we would be able to detect any possible (latent) loss of blood pressure along the arm-hand axis potentially reflecting degree of atherosclerosis. We hypothesized that a lowered blood pressure at the hand has important prognostic modalities determining, in part, the onset of hand ischemia after AVA construction (hemodialysis access induced distal ischemia, HAIDI). Moreover, it was anticipated that plethysmography of the digits could predict access patency, and possibly even patient survival.

In chapters 2, 3, 4, 5 and 6, scientific evidence is provided confirming the prognostic value of finger pressures regarding these issues. Our results were published in 4 highly rated peer-reviewed journals and presented at several (inter)national conferences. The study unveiling the association between an abnormal digital brachial index and diminished access patency was selected in the top 5% global abstracts at the 2020 European Society of Vascular Surgery (ESVS) Annual conference.

The exact role of access flow volume ($Q_a$) measurements in the management of HD patients is also ill-defined. Although an association between $Q_a$ and high-output cardiac failure and cardiac death was previously suggested, international guidelines are still struggling with an evidence-based role of a measurement of $Q_a$ with respect to cardiovascular survival. Although it is long known that an elbow-based AVA generates higher $Q_a$ levels compared to a wrist-based AVA, any possible impact on mortality rates of different types of AVA's was unknown. Chapter 7 indicates that advanced statistical methods are very valuable for analyzing the complex associations between $Q_a$ and long-term survival of a HD population. Since single “actual” $Q_a$ may fluctuate substantially over the course of a year, these values were not found to have any prognostic value. However, it is essential to consider 3-month-trends in $Q_a$ as a factor predicting survival. Chapter 8 reported that patients having an elbow-based AVA sustain a 3 times higher risk
of cardiovascular death compared to patients with a wrist-based AVA. The studies reported in chapter 7 and 8 were published in two high impact factor journals (Nephrology Dialysis & Transplantation, impact factor 6.0; European Journal of Vascular & Endovascular Surgery, no. 1 journal in Vascular Surgery, impact factor 7.1) and were also presented at (inter)national conferences.

Studies of the present thesis have changed our view on the role of these novel risk factors in the long term management of HD patients. This thesis will certainly stimulate follow-up studies confirming the prognostic value of finger pressures and longitudinal analysis of $Q_a$ the management of HD patients.

Social impact for the hemodialysis population

Chronic kidney disease (CKD) is an important contributor to public health problems and has a significant impact on mortality and morbidity of patient populations. Costs for treatment of CKD have increased drastically since the 1960s following introduction of a wide range of live-saving therapies for patients with end-stage renal disease (ESRD). At present, the prevalence of patients receiving renal replacement therapy (RRT) worldwide is approximately 2.5 million, whereas this number is expected to have doubled by the end of 2030. Several national screening programs have shown that more than 10% of the ‘healthy’ adults display markers reflecting CKD with even higher percentages in octogenarian populations. Causes for CKD are diverse, but cardiovascular disease, diabetes and hypertension are labelled as the most important causes.

Hemodialysis (HD) is the most prevalent type of RRT, and a native arteriovenous access (AVA) is univocally the preferred type of HD access. Although ESRD patients may benefit from HD in terms of prolonged long-term survival, complications associated with the presence of the AVA are numerous. In addition, incidence rates of adverse outcomes are rising due to growing numbers of frail and elderly patients requiring HD. The primary patency rate of an AVA two years after construction is just 51%, whereas the secondary patency rate is 64%. These data indicate that the course after AVA construction is seldomly uncomplicated. Besides poor patency rates, survival rates of the average HD population are even lower compared to populations of patients suffering from several different types of solid-organ cancers. For instance, approximately half of all HD patients are dead after 5 years, mostly due to cardiovascular disease. Therefore, identifying risk factors, both modifiable as well as unmodifiable, are crucial for quality of life and survival of HD patients.
Our studies have shown that patients with abnormal digital brachial index (DBI) values have a primary access patency rate as low as 25%, whereas patients with normal DBI values display a two times higher rates (49%). Patients presenting with abnormal DBI values conferred a two times higher risk of cardiovascular mortality as compared to patients with normal DBI values. A preoperative DBI obtained by digital plethysmography may therefore identify high-risk patients possibly burdened with cardiovascular disease. These conclusions highlight the necessity of developing screening and intervention programs to improve AVA outcomes, ideally incorporating digital plethysmography following validation in future studies.

Hand ischemia in the presence of an AVA (hemodialysis access-induced distal ischemia, HAIDI) is a dreadful complication with a serious impact on quality of life. Previous studies reported percentages up to 20%, whereas up to 80% of seemingly asymptomatic patients reported one or more symptoms associated with hand ischemia (coldness, pain, cramps etc.). Around 5% of all HD patients require invasive treatment for hand ischemia at one point in their life. A tool that accurately predicts HAIDI was never identified. Our studies are the first to show that an Allen Test under plethysmographic control, prior to AVA construction, has a potential to accurately predict the onset of HAIDI. With this information, vascular surgeons can counsel their patients on risk of HAIDI once a certain type of AVA is preferred. Conversely, alternative types of HD treatment with a lower or negligible risk of complications including HAIDI may be advised if this newly identified risk factor is present.

When the condition of distal arm arteries is too poor for a wrist-AVA, an elbow-AVA is often preferred. However, possible hemodynamic consequences are often not considered. In the long term however, patients survival has more priority than AVA patency. Based on our study results demonstrating that a wrist-AVA is associated with a superior survival, it may seem prudent to initiate a preoperative program focusing on improving circumstances for successful wrist AVA construction including lower arm training and radial artery preservation, next to forearm vein preservation. Furthermore, strict surveillance of trends rather than actual $Q_a$ deserves careful consideration in future HD management.

In conclusion, studies of this thesis may aid professionals in optimizing a tailored management of patients who are scheduled to undergo renal replacement therapy, especially regarding the prediction of morbidity and mortality associated with the presence of their life-saving vascular access.