POSTOPERATIVE ARTERIAL RELAXATION AND INTRAOPERATIVE VENOUS DILATION AS INTERCONNECTED PROGNOSTIC FACTORS FOR THE MATURATION OF ARTERIOVENOUS FISTULAS

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INTRODUCTION

The purpose of any arteriovenous anastomosis for hemodialysis access is the development of a functional fistula which is as close to the ideal as possible. As a definition, an adequate fistula is located at a depth of 6 mm from the skin surface, has a minimum diameter of 6 mm and can accommodate a blood flow higher than 600 ml/minute (1). A major limiting factor in achieving such a fistula is the caliber of the vessels to be anastomosed, not necessarily from a technical point of view but because there are certain limits below which the development of an adequate fistula is impossible. Parmar et al. (2) showed that 45.5% of the arteriovenous fistulas created by using an artery with a diameter < 1.5 mm had failed to mature within 12 weeks, compared to an artery > 1.5 mm where
maturation was reached in all cases. They also found statistically significant difference in blood flow rates if the artery before surgery was <1.5 mm (347 ml/minute) or >1.5 mm (521 ml/min). Regarding the vein diameter, Mendes et al. (3) reported that 16% of fistulas were adequate with a vein diameter of 2 mm or less, compared to 76% of those larger than 2 mm. Fila et al. (4) showed that when the initial vein diameter was less than 2 mm only 60.2% of the fistulas reached maturation. In this group of functional fistulas the intraoperative vein dilation leads to an average 75% increase while in the group of non-functional fistulas the average intraoperative distention of the vein was only 48%, showing that vein elasticity is also of great importance (4).

MATERIAL AND METHODS

The aim of the study was to evaluate if arterial relaxation immediately after surgery, arterial relaxation within the first 8 postoperative weeks and intraoperative vein dilation correlate with vein distention 8 weeks after surgery, as a measure of fistula maturation.

Between January and May 2015, a number of 19 patients underwent an arteriovenous fistula between the radial artery and the cephalic vein of the forearm at the Second Surgical Clinic of the Iasi Regional Cancer Institute.

Of the 19 study patients 12 (63.2%) were women and 7 (36.8%) men. The mean age of the patients was 55 ± 13.63 years, range 24-80 years. Eight patients (42.11%) had diabetes. Twelve patients (63.2%) were included in the group of patients with a normal, elastic artery and 7 (36.8%) in the group with calcified artery.

Inclusion criteria: patients with end-stage chronic kidney disease in which an arteriovenous fistula between the radial artery and the cephalic vein of the forearm was created. Exclusion criteria: patients with fistulas other than one between the radial artery and the cephalic vein of forearm; patients unwilling to participate in the study.

The patients enrolled in the study were assigned to 2 study groups according to the macroscopic appearance of the arterial wall during surgery: the first group included diabetic patients with calcified arteries that were practically non-distensible, transformed into a rigid tube; the second group included patients with a macroscopically normal artery.

Before surgery the blood pressure was measured in both arms and vein diameter was measured using ultrasound (5) at a point located 4 cm above the anastomosis so as not to compromise the wound dressing when measuring the vein after surgery. The initial measurement of vein diameter was performed without a tourniquet in order to assess its ability to distend. The diameter of the artery was also measured at 4 cm above the anastomosis. The measurements were taken preoperatively, one hour postoperatively, and 8 weeks after surgery (during the first dialysis appointment). Each measurement was performed 3 times and the average of these measurements was recorded.

All of the patients underwent an arteriovenous anastomosis in a side-to-end fashion between the radial artery and the cephalic vein of the forearm. The diameter of the venous side of the anastomosis was increased by up to 50% by using a longitudinal incision in the venous wall. That was the reason why in all cases the anastomosis diameter was 50% larger than the vein diameter before surgery. The vein was
dilated by injecting an isotonic saline solution while digitally compressing the vein. After surgery, all patients were advised to perform flexion exercises for 8 weeks.

The statistical analysis of the data was performed using IBM SPSS version 17.0 for Windows. The statistical tests performed were the student t-test in order to check for statistically significant differences between groups and linear regression in order to assess whether or not immediate arterial and venous dilation can be used to predict the fistula outcome. For this study, a 5% significance level was considered satisfactory.

RESULTS

We compared the percentage of arterial and venous distention immediately after surgery and at 8 weeks after surgery and the percentage of the vein dilation at 8 weeks after surgery, between the patients with a macroscopically calcified radial artery and those with a macroscopically normal artery, as assessed during surgery.

The mean arterial distention 1 hour after surgery in calcified artery patients was 2.28 ± 3.23% compared with 37.52 ± 12.75% in normal artery patients. When assessed at 8 weeks after the procedure, the mean arterial distention in the calcified artery group was 9.36 ± 9.36%, while in the normal artery group it was 97.25 ± 47.18%.

As to vein distention we found that intraoperative distention in the calcified artery group was 202.24 ± 105.69%, while in the normal artery patients it was 117.99 ± 112.19%. The venous distention 8 weeks after surgery in the calcified artery group was 31.85 ± 5.44% and 95 ± 44.11% in the normal artery group.

We then analyzed the differences between these diameter variations from a statistical point of view using an independent samples t-student test. We found that the difference between the calcified artery and normal artery groups was statistically significant for all diameter variations with p<0.001 for arterial distention at 1 hour and 8 weeks after surgery, and p=0.002 for venous distention 8 weeks after surgery.

As a final step in our analysis we performed a linear regression analysis of arterial distention 1 hour after surgery and venous distention 8 weeks after surgery and we came to the conclusion that arterial distention immediately after surgery and therefore the presence of arterial calcifications can be used to predict whether or not a good fistula can be achieve at a 1% statistical significance level (p<0.001, r-square 0.72). However, when comparing intraoperative venous distention and venous distention 8 weeks postoperatively we found that intraoperative venous dilation is a less effective predictor of fistula outcome (p=0.021, r-square 0.24).

DISCUSSION

Determining whether a fistula is adequately matured or not is very important and hemodialysis nurses can do that. In more and more studies their experience has been considered the best tool for fistula assessment, before even measuring the flow through the fistula. The clinical criteria followed are: a superficial vein, with a diameter adequate for the puncture, with a uniform thrill and a length of minimum 10 cm available for puncture (6).

Once the fistula is opened during the procedure, the wall of the vein withstands a higher pressure than the venous pressure which causes structural alterations of the wall. Depending on the capacity of the wall to distend the vein lumen it thickens by
hypertrophy of smooth muscle cells. Thus, the venous wall becomes resistant to repeated punctures and extrinsic compression (7).

When the vascular clamp is removed from the artery after the anastomosis is completed there is a rapid redistribution of the blood flow in the region depending on pressure gradients and flow resistance. The overall resistance downstream to the artery anastomosed to the vein decreases. The flow thus increases through a constant section of the artery and the speed of the flow and the shearing stress are also increased leading to a progressive dilation of the artery (8).

The mechanism through which the arterial wall becomes increasingly rigid and thus reduces the vascular compliance required to maintain adequate flows through the fistula are not entirely known. They may include fluid overload, arterial calcification, inflammation, activation of the sympathetic and rennin–angiotensin system, increased lipid oxidation, nitric oxide anomalies (9). The increased arterial wall rigidity has direct implications on fistula outcome because given the inadequate blood flow through the fistula hemodialysis is not effective. An example is the diabetic patient in which the accelerated atherosclerosis transforms the artery into a rigid tube unable to relax and increase the blood flow (10).

A key role in arterial wall relaxation is played by the nitric oxide. Its synthesis is increased by the alterations in local blood flow, as shown by many studies (10, 11, 12). It is also responsible for the activation of metalloproteinases in the extracellular matrix of the cells within the vascular wall. These lead to the destruction and reorganization of the cellular matrix that could explain the changes occurring in the vascular wall (13).

The parameters analyzed in our study were the intraoperative venous dilation, the postoperative arterial dilation measured 1 hour after the procedure and the arterial and venous dilations 8 weeks postoperatively. The choice of these parameters was based on physiological reasons, as we believed they all play a role in achieving an adequate venous distention: the intraoperative venous dilation is a measure of vein elasticity; the venous distention between the measurement performed 1 hour after procedure and 8 weeks after surgery is due to hemodynamic factors and vein elasticity; the arterial distention between the preoperative measurement and the measurement 1 hour after the procedure evaluates the immediate capacity of the artery to relax after the decrease in the resistance distal to the fistula; arterial distention 8 weeks after the procedure shows how well the artery has accommodated to the new hemodynamic conditions in order to increase the flow through the fistula.

In our study, in the patients with calcified arteries the differences between the diameter of the artery before the procedure and 1 hour after the procedure were, as expected, quite small, due to the fact that the calcified artery is basically a rigid tube. However, in the group of patients with macroscopically normal arteries, there was a significant increase in the diameter of the artery after surgery, but the increase was extremely variable, depending on each patient’s hemodynamic condition, as shown by the large standard deviation.

The venous dilation was considered of great importance in our study because the vein size at 8 weeks after the procedure is very important in determining whether the fistula had adequately matured or not. It is for this reason that we tried to assess.
whether arterial distention immediately after surgery and arterial distention 8 weeks after surgery can be used to predict adequate fistula maturation, assessed in our study by the distention of fistula between the measurement performed 1 hour after surgery and 8 weeks after surgery. We found that both the immediate and late arterial distention are a good predictor of late venous distention, and even better than the intraoperative venous distention. This shows that an artery capable to relax in order to increase the flow through the fistula is essential for an adequate maturation of the fistula.

An adequate increase in the diameter of the vein or artery alone does not independently result in a patent fistula.

If the vein is elastic and dilates well during the procedure it does not mean that it will produce a good fistula unless the artery is able to relax and increase the blood flow.

At the same time a healthy, non-calcified artery can in time progressively dilate a vein that appeared to be unable to dilate during the procedure. Arterial relaxation happens immediately in normal arteries and our study shows it can be used as a prognostic tool of adequate fistula maturation.

CONCLUSIONS

We have shown that good immediate arterial distention also means an adequate, matured fistula 8 weeks after the procedure. At the same time the immediate venous distention is also a prognostic factor of an adequate fistula and we believe that together the elasticity and compliance of the arterial and venous walls are inextricably linked in determining the outcome of a fistula.

REFERENCES

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**SELENIUM SUPPLEMENTATION VIA BRAZIL NUT IMPROVES THYROID HORMONE LEVELS IN HEMODIALYSIS PATIENTS: A PILOT STUDY**

Hemodialysis (HD) for patients known with renal failure is associated with low levels of total and free T3 (triiodothyronine). This fact that can be explained partially by a selenium (Se) deficit that is also a common feature for HD. Selenium is an essential micronutrient important for the thyroid hormone metabolism. This study aimed to investigate the effect of selenium supplementation via Brazil nut (rich in Se) on thyroid hormone levels on HD patients. Forty patients with HD received for 3 months one nut daily that contained in average 58.1 mg Se. All patients presented at baseline a Se deficit, low T3. After the intervention, Se, FT4 (free thyroxine) and GPx (glutathione peroxidase) activity plasma levels arised significantly increased (p < 0.05), while the TSH levels were reduced but not significantly. In conclusion, by increasing Se levels an improvement in thyroid hormone levels in HD patients is obtained (Stockler-Pinto M B, Carrero J J, Carvalho L et al Effect of selenium supplementation via Brazil nut (Bertholletia excelsa, HBK) on thyroid hormones levels in hemodialysis patients: a pilot study. *Nutr Hosp.* 2015;32(4):1808-1812).

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