

# Correlation between the Intraoperative Blood Flow and the Early Patency of Radiocephalic Fistula\*

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수술직 후 동정맥루 혈류량과 동정맥루 초기 개통성과의 상관관계에 관한 연구

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**배 경** : 만성신부전 환자들의 혈액투석을 위한 요골동정맥루의 초기 개통성에 영향을 미치는 여러 요인들이 알려져 있으나 아직까지 수술직 후 동정맥루의 예후를 예측할 수 있는 방법은 적다. 따라서 이 연구의 목적은 수술직 후 동정맥루의 혈류량과 동정맥루의 초기 개통성과의 상관관계를 알아봄으로써 수술직 후 동정맥루의 혈류량이 동정맥루의 성패를 가늠할 수 있는 한 지표로의 사용 가능성을 알아보는 것이다.

**방 법** : 1998년 3월부터 1999년 10월까지 38명의 환자에 있어서 45개의 요골동정맥루를 만들었다. 수술직 후 혈류량은 동정맥루 완성 10분후에 측정하였다. 환자들은 동정맥루가 막히거나 첫 혈액투석 후 3개월까지 추적검사하였으며 수술직 후 혈류량, 나이, 성, 당뇨병 유무, 두정맥 직경, 동정맥루의 미세진동의 유무 등이 동정맥루의 초기 개통성에 영향을 미치는 가를 알아보았다.

**결 과** : 수술직 후 동정맥루의 혈류량은 50ml/min에서 500ml/min이었으며 평균 혈류량은  $195.9 \pm 16.7$  ml/min 이었다. 여러 가지 요인들 중 초기 개통성에 영향을 미치는 인자는 수술직 후 혈류량이었으며 특히 혈류량이 150ml/min 이하인 경우 통계학적으로 유의하게 초기 개통성이 낮았다. 또한 혈류량이 70ml/min 이하인 경우 모든 경우에서 한달이내에 동정맥루가 막혔다.

**결 론** : 수술직 후 동정맥루의 혈류량은 동정맥루의 초기 개통성을 예측할 수 있는 중요한 지표중의 하나로 사용할 수 있으며 특히 혈류량이 70ml/min 이하인 경우에는 혈류량이 낮은 이유를 찾아보아 교정해 주거나 다른 곳에 만들어 주는 것이 좋을 것으로 생각된다.

**중심 단어** : 동정맥루 · 수술직 후 혈류량 · 초기 개통성.

## Introduction

Since its first introduction by Brescia, et al in 1966<sup>1)</sup>,

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the radiocephalic(Cimino) fistula has been the most popular method for vascular access for hemodialysis because of its less complications, easy construction, convenience, and relatively good early and late patency rate compared to those with the synthetic graft<sup>2,3,5)</sup>.

However, there have been no reliable intra-operative parameters to estimate the outcomes of the fistula, so that the operators have difficulties in predicting or deciding to change to another surgical modalities after completion of the vascular anastomosis.

The intra-operative decision for successful radiocephalic fistula was made according to the following intra-operative parameters such as palpable thrill on the fistula, appropriate size of the vein, and audible bruit. But we have experienced many early failures in patients with all of the above criteria, which make us to find some other objective and accurate intra-operative parameters to predict the outcomes of radiocephalic fistula.

We studied the correlation between intra-operative blood flow and early outcomes of radiocephalic fistula by measuring the blood flow of the fistula after completion of the vascular anastomosis. The purpose of this study was to investigate the correlation between intra-operative blood flow and early patency of radiocephalic fistula.

## Materials and Methods

Between March 1998 and October 1999, 45 radiocephalic arteriovenous fistulas were constructed in 38 patients by single surgeon. The fistulas with synthetic grafts, brachial artery or leg fistulas were excluded in this study. There were 25 men and 20 women with a mean age of  $54.3 \pm 1.9$  years (ranged 29–78).

The operations were performed under local anesthesia and with loupe ( $\times 3.5$ ). After isolation of cephalic vein and radial artery with transverse incision on the wrist, we measured blood flow of radial artery and internal diameter of cephalic vein with Hegar dilator. The inclusion criteria for choosing radiocephalic fistula were well palpable cephalic vein prior to operation, no difference of blood pressure between both arms, more than 1mm in internal diameter of the cephalic vein and no venous obstruction with probing to elbow. The vascular anastomosis was done with end to side fashion using continuous suture with 7–0 polypropylene. All patients were received

prophylactic antibiotics and intravenous injection of 5,000IU heparin before clamping radial artery. None of the patients were received anticoagulation postoperatively.

Intra-operative blood flow measurements were made 10 minutes after completion of the vascular anastomoses. 3–4mm of handheld flow probes (Transonic System Inc, USA) were placed around the venous outflow tract and direct measurements of flow (in mL/min) were recorded. A flow probe fitted snugly around the vessel was chosen and positioned not to interfere with the blood flow. The flowprobes were calibrated for usage each time according to the manufacturers recommendations. Repeated measurements were made until a consistent result was obtained.

Patients were followed until failure of fistulas (no audible bruit, palpable thrill or not acceptable flow for hemodialysis 1 month after operation), or 3 months after first hemodialysis with these fistulas. Early patency defined as maintaining appropriate flow for hemodialysis at 3 months after hemodialysis.

### 1. Statistical analysis

Data are expressed as mean  $\pm$  standard error. Continuous variables were analyzed by Wilcoxon rank sum test and discrete variables were compared with chi square test using SAS system program (SAS Institute Inc®, USA).

## Results

Forty-five radiocephalic arteriovenous fistulas were constructed in thirty-eight patients. The mean age was  $54.3 \pm 1.9$  years (range, 29–78) and there were 25 men (56%). The demographics and the value of various observations of patients are shown in Table 1.

There were 11 cases of early failure and the overall early patency rate was 75.6% (34/45), and the clinical characteristics of those patients were shown in Table 2.

Effects of variables on early patency were as follows (Table 1) ;

Age, sex, presence of diabetes and palpable thrill were not related to early patency ( $p > 0.05$ ). The mean

size of cephalic vein was  $2.7 \pm 0.1$ mm(range, 1.0–5.0 mm) and not related to early patency.( $p > 0.05$ ) The mean flow of radial artery was  $20.5 \pm 1.2$ mL/min (ranged 7–40mL/min) and not related to early patency, too( $p > 0.05$ ).

Flow of fistula was the only related variable to early patency with mean flow  $195.9 \pm 16.7$ mL/min(range, 50–500mL/min,  $p = 0.002$ ). Fistulas with flow less than 150ml/min(10 of 18, 40%) revealed higher failure rate than those of flow more than 150ml/min(1 of 27, 16%)( $p < 0.01$ , Table 3), and all of the patients with flow less than 70ml/min failed in maintaining patency within a month(5 of 5).

There was no case of complications such as infection, heart failure, swelling of upper extremity and aneurysm formation.

## Discussion

The number of patients with end-stage renal disea-

se who are cling to chronic hemodialysis is increasing progressively, which makes surgeons be demanded to maintain a patent and functioning access to the circulation. The radio-cephalic(Cimino) fistula has been the procedure of choice for vascular access because of less complications and simple procedure<sup>9</sup>, and the parameters that affect the short-term and long-term outcomes of this fistula have been reported. Variable patency rates at 24 months according to the operator were reported by Prischl and colleagues<sup>9</sup>, which ranged from 13 to 62%. Women were revealed the another risk factor by many researchers<sup>7,8</sup> and these poor results partly came from their smaller vessels<sup>9</sup>. Diabetes were also demonstrated a risk factor for poor outcomes in several studies.<sup>19,11</sup> Hicks, et al<sup>12</sup> reported that these poorer results might be explained by increased arterial disease or even impaired venous endothelial function. Cinat et al<sup>13</sup> reported that older patients had better primary patency rates, and this might be explained by more aggressive vascular and

**Table 1.** Demographics and clinical characteristics in 45 radiocephalic fistula

Variables	Value	p-value
Age	$54.3 \pm 1.9$ years(29 – 78)	ns
Sex(M:F)	25 : 20	ns
Diabetes(present : none)	16 : 29	ns
Flow(radial artery)	$20.5 \pm 1.2$ ml/min(7 – 40)	ns
Size(cephalic vein)	$2.7 \pm 0.1$ mm(1.5 – 5)	ns
Thrill(Present:none)	44 : 1	ns
flow(fistula)	$195.9 \pm 16.7$ ml/min(50 – 500)	$p < 0.01$

**Table 2.** Clinical characteristics of 11 patients of failed fistula

	Age	Sex	Diabetes	Thrill	Vein*	Artery**	Fistula***
1	72	F	+	+	1.5	25	55
2	44	M	-	+	2.5	24	149
3	44	M	+	+	2	35	70
4	41	F	+	-	1.5	18	70
5	70	M	+	+	2	12	75
6	41	M	-	+	3.5	40	145
7	78	F	-	+	1.5	10	157
8	46	M	+	+	3	25	140
9	39	M	-	+	1.5	18	150
10	55	M	-	+	3	36	55
11	69	M	-	+	4	24	137

\* : size of the cephalic vein

\*\* : flow of the radial artery

\*\*\* : flow of the radiocephalic fistula

**Table 3.** Intra-operative blood flow and early failure

Blood flow	Early failure	p-value
≤150ml/min	10/18(55.6%)	p<0.01
>150ml/min	1/27( 3.7%)	

systemic disease predisposing to early graft thrombosis and decreased graft patency in younger patients with early-onset renal failure. However, we did not find any correlation between early patency of fistula and these parameters(presence of diabetes, old age, sex, and size of cephalic vein). This was probably because we evaluated early patency only, and we think that similar results may be expected with longer follow up.

There have recently been many reports about the good correlation between the blood flow and the outcomes of fistula<sup>13-17</sup>. However the blood flow measurements in those studies were done with color flow duplex imaging postoperatively unlike our intraoperative study with transit-time ultrasonography. Although these parameters may be useful in assessing and counseling patients with end-stage renal failure, these parameters are not helpful for operators in predicting intra-operatively whether this fistula will maintain its patency or not.

Flow measurement with transit-time ultrasonography has several advantages compared to color flow duplex imaging. It is not dependent on the angle of insonation, is diameter independent, and less affected by flow profile<sup>5</sup>. And it measure flow directly, without any need for additional calculations related to cross-sectional area, so the results are immediately available, easily interpretable, and more accurate than can be achieved with conventional ultrasonogram<sup>5</sup>.

Wong, et al<sup>9</sup> reported about the blood flow measurement intraoperatively in radiocephalic fistula. However, they concluded that the intra-operative fistula blood flow did not correlate with the outcomes of the operation. They used color flow duplex ultrasound and they reported that their results of no correlation between intra-operative blood flow and outcomes of fistula had came from vascular spasm caus-

ed by manipulation. We performed operation with caution in vascular manipulation to avoid spasm, used papaverine solution, and measured 10 minutes after completion of vascular anastomosis. We think that such methods may avoid vascular spasm that interferes with accurate measurement of blood flow especially in the radial artery.

Johnson, et al<sup>5</sup> used first intraoperative transit-time ultrasonography for measurement of blood flow in various vascular access procedure. They reported that radiocephalic fistula with flow rate less than 170mL/min was at risk for early failure and should be watched carefully or allowed to mature longer than 4 to 6 weeks. And they recommended that radiocephalic fistula with flow rates below 100mL/min should be immediately abandoned in favor of alternative sites unless intraoperative angiography reveals a correctable lesion. These results corresponded with our results in this study(The exact value difference of 170mL/min and 150mL/min in this study is within the limit of standard error of flowmeter and probe).

We found that thrill on the fistula that had been the major intra-operative hallmark for the patency of fistula, was not correlate with early patency. In fact we experienced thrill even in the flow less than 40 mL/min. The thrill on the fistula should not be the hallmark for patency of the fistula because the thrill varied with examiners and may be the representative of a turbulent flow from errors in vascular anastomosis. We found also that the flow rate of the radial artery was not correlated with flow rate or early patency of fistula. This finding may represent that the flow rate and early patency of the fistula depended mainly on the distal venous run-off, not on the arterial inflow.

We had a limitation in this study. We did not evaluate the late patency. However, the fistula that maintained flow at 3 months after first hemodialysis could show a good late patency rate because the failure of the radiocephalic fistula occurred mainly during the first month<sup>18</sup>.

## Summary

### Background :

There have been many parameters that determined the results of radiocephalic fistula. However, few reliable intraoperative parameters have been suggested until now. The purpose of this study was to find the correlation between intra-operative blood flow and early patency of radiocephalic fistula.

### Methods :

Between March 1998 and October 1999, 45 radiocephalic arteriovenous fistulas were constructed in 38 patients. Intra-operative blood flow measurements were made 10 minutes after completion of the vascular anastomoses with 3–4mm handheld flow probes. Patients were followed until failure of fistula or 3 months after first hemodialysis with these fistulas. Intraoperative blood flow as well as age, sex, presence of diabetes, size of cephalic vein, thrill on the fistula and flow of radial artery were correlated with early patency.

### Results :

The mean intraoperative blood flow was  $195.9 \pm 16.7$  mL/min ranged from 50 to 500 mL/min, and it was the only significant parameter that determined early patency of radiocephalic fistula. Fistulas with flow less than 150ml/min (10 of 18) revealed higher failure rate than those of flow more than 150ml/min (1 of 27), which was statistically significant ( $p < 0.01$ ). All of the patients with flow less than 70ml/min (5 of 5) failed in maintaining patency within a month. However, the other variables were not correlated with early patency.

### Conclusion :

In conclusion intra-operative blood flow measurements can be performed with ease and intraoperative blood flow in radiocephalic fistula is well correlated with early patency of the fistula. And we recommend that radio-cephalic fistula of flow less than 150mL/min should be observed carefully and that of flow less than 70mL/min must be abandoned intraoperatively.

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