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Comparison of Results of Radiocephalic Arterio-Venous (RCAV) Fistulas for Long-Term Hemodialysis between Original Technique and Pongsapak Modified Technique

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Abstract

Background: **The radiocephalic arteriovenous fistula (RCAV) has been proved to be safe and effective vascular access for chronic hemodialysis. The incidence of fistula failure or complications is extremely low. The purpose of this study was to compare the effectiveness and complication rates between the original technique of radiocephalic arteriovenous fistula and the Pongsapak modified technique.**

Materials and Methods: **Radiocephalic arteriovenous fistulas were performed in 80 patients with chronic renal failure at Phrae Hospital from January 2002 to October 2005. Half of them (40/80) were performed using the original technique and the other half (40/80) with the Pongsapak modified technique. Demographic data, blood flow rate, duration of function, thrombotic complications, infection rates, number of operations and cost were analysed.**

Results: **The data were analyzed and compared using Mann-Whitney U test for two independent groups. The results of this study revealed that the Pongsapak modified technique was more effective with fewer complications compared with the original technique ($P < .01$). This modified technique gave satisfactory results not only by increasing the size of the fistula but also by decreasing visible scar by S-plasty incision at the wrist. Once established, the incidence of fistula failure and thrombosis has been extremely low and the incisional scar is less perceptible.**

Conclusions: **The Pongsapak modified technique of arteriovenous fistula at the wrist has proved to be a safe and effective means of gaining vascular access for chronic hemodialysis. The technique was well accepted by patients, physicians and dialysis personnel. The author recommends the use of Pongsapak modified technique for the creation of radiocephalic AV fistulas for long-term hemodialysis.**

Introduction

The two major problems of radiocephalic arteriovenous (AV) fistula include early thrombosis of the fistula and failure of the venous run off system to develop adequately. These complications not only cause fistula failure, but also more expenses and additional surgical interventions. Obstructed venous flow, nidus of thrombus formation, compression by surrounding swollen tissue or hematoma, the small size of the draining vein, calcified atherosclerotic vessel, decreased blood pressure, increasing blood viscosity, tension causing poor blood flow and excessive angulation, either single or in combination, are common causes of these problems. To overcome these problems, the technique of arteriovenous fistula has been modified.[1-7]

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In order to maintain successful long-term hemodialysis, the maintenance of patent vascular access capable of providing blood flow of at least 200 ml/min is essential.[8-10] The discovery of an indwelling Silastic-Teflon cannula by Quinton, et al[11] in 1962 provides a convenient means of gaining access to the blood vessel for repeated hemodialysis. Frequent clotting, infection, and restricted use of the operated extremity, however, are the major disadvantages of this technique, as pointed out by Ramirez et al in 1966.[12] For this reason, Brescia, et al 1966[11] advocated a surgically created subcutaneous arteriovenous fistula at the wrist as a substitute for the Silastic-Teflon cannula. In this type of fistula, a side-to-side arteriovenous anastomosis between the radial artery and an adjacent superficial vein is created and this technique has been subsequently used by others.[9,13-16] However, an anastomosis of end of vein to side of artery is a more preferable technique because of higher blood flow through the fistula and the preservation of radial artery preventing venous hypertension and steal phenomenon.[4,5,15,17-19] Although the initial failure rate of native arteriovenous fistula may be as high as 15-25 percent,[2,5] once the fistula has been established and successfully used for dialysis, the incidence of late failure is minimal, being less than 5 percent after six months of dialysis.[2,5] To date, many patients can be maintained on dialysis for more than five years with the same native arteriovenus fistula[2] and an effort is made to create an internal AV fistula in every patient expected to undergo long-term hemodialysis.

Recently, prosthetic vascular grafts have been used more frequently for arteriovenous fistula. However, the native arteriovenous fistula is more beneficial due to its lower cost, fewer complications, higher patency rates and easier self-care.[4,5,8,10,18,20] The radial arteriovenous fistula has proved to be a safe and effective means of gaining access to the circulation for maintenance of hemodialysis and it has been proved that the anastomosis between end of vein and side of artery is the best surgical technique.[2,4,5,7,10,18] The National Kidney Foundation Dialysis Outcomes Quality Initiative (K/DOQI) suggested that the first choice of arteriovenous fistula is radiocephalic fistula as it can be placed distally at the wrist. The proximal site can be saved for future use. It can be performed under local anesthesia and hospitalization can be avoided. The infection rate is lower than fistula using the synthetic grafts. The second choice is native brachiocephalic fistula. If the two native fistulas cannot be performed, arteriovenous graft or transposed native brachio-basilic fistula is an alternative.[17,18]

Since 2003, the number of patients with end-stage renal disease maintained on chronic hemodialysis had been increasing progressively in Phrae Hospital. These patients needed to have a patent and functioning access during hemodialysis. Two major problems of radiocephalic fistula include early thrombosis (non-functioning) and inadequate blood flow (access blood flow less than 200 cc/min). These complications led to unnecessary hospitalization, repeated surgical procedures and declining in patient morale. Subsequently, a modified technique was created to solve these problems.[6,7,12,16,21] In order to solve these problems the author had modified the technique. In this report, the author described a modified technique of AV fistula and compared the results and the advantages of the modified technique with the original technique.

Materials and Methods

From January 2002 to October 2005, 80 patients with end-stage chronic renal failure were admitted to Phrae Hospital for the creation of arteriovenous fistulas. Forty arteriovenous fistulas were created by original technique (from January 2002 to January 2003) and the remaining 40 by Pongsapak modified technique (from February 2003 to February 2004) by the author without selection criteria.

Demographic data including age, sex, technique of AV fistula, blood flow rate, access failure, patency rate, number of operations or revisions and cost were obtained (Table 1). Blood flow rate through created AV fistula that delivered blood flow rate less than 200 ml/min was considered inadequate. Access failure included fistulas that never functioned or that thrombosed, (ie. no thrill, no bruit) and those that continued to flow but veins did not dilate to a size adequate for convenient cannulation. Access failure would need replacement of a failed access by a new one. Early failures were failures within 30 days after surgery and late failures were failures after 30 days. Patency of arteriovenous fistulas was determined at 3, 6, 9, 12, and 18 months after surgery. The duration of patency was determined from the date of operation

Table 1 Demographic data of 80 patients

	Original Technique (N = 40) Frequency (%)	Pongsapak (N = 40) Frequency (%)	Total (N = 80) Frequency (%)
Age (years)			
26-40	4 (10.0)	5 (12.5)	9 (11.2)
41-55	13 (32.5)	11 (27.5)	24 (30.0)
56-70	20 (50.0)	15 (37.5)	35 (43.8)
71-85	3 (7.5)	9 (22.5)	12 (15.0)
	X = 58.0	X = 58.3	X = 58.2
	SD = 10.6	SD = 14.3	SD = 12.5
	Min = 72.0	Min = 26	Min = 26.0
	Max = 72.0	Max = 80	Max = 2.0
Sex			
Male	21 (52.5)	22 (55.0)	43 (53.8)
Female	19 (47.5)	18 (45.0)	37 (46.3)

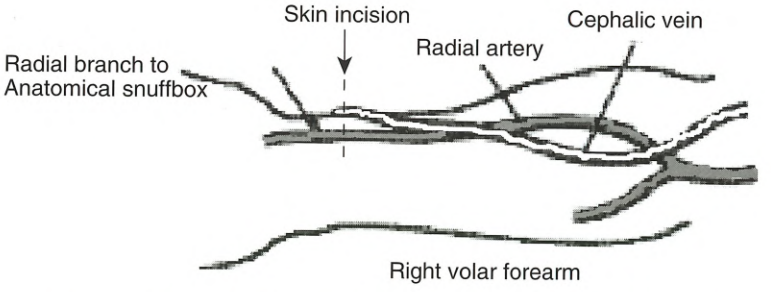

Figure 1 Diagram showing a longitudinal or transverse incision

until the decrease of blood flow to the point where hemodialysis was not possible or until the patients obtained transplantation. Patency rates of all vascular accesses were analyzed by life-table analysis.

Statistical comparisons between the two techniques were obtained using Mann-Whitney U test for two independent variables (spss version 13.0) or by the student's t -test, whatever appropriate.

Technique of creation of AV fistula

Original technique of Brescia-Cimino radio-cephalic arteriovenous fistula The original technique is the autogenous side-to-side radiocephalic AV fistula. The end vein to side artery is the best technique that produces adequate blood flow with least complications for long-term hemodialysis. The usual vessels chosen for end vein to side artery are distal cephalic vein and radial artery in the non-dominant forearm just above the wrist.

The operations were performed under local anesthesia. A 4-5 cm incision was made longitudinally

Figure 2 A longitudinal or transverse skin incision

or transversely over the area of the radial pulse. A fistula was created between the radial artery at the wrist and the adjacent cephalic vein. A longitudinal incision 0.5-1.0 cm was made in the corresponding lateral surface of the artery.[17,19,20,22] The slanting segment of the adjacent vein was then anastomosed end-to-side to the artery by continuous suture to prevent subsequent enlargement of the fistula (Figure 1-3).[9]

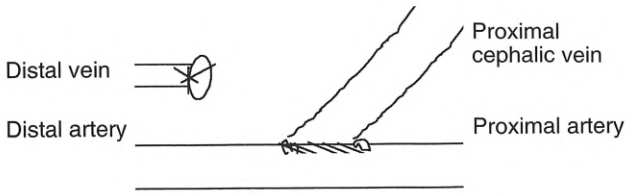

Figure 3 End vein to side artery with 6-0 prolene running suture

The Pongsapak modified technique This technique was modified from the original technique. A skin incision in the shape of S-plasty was made over the radial pulse and cephalic vein. An oval shape excision, 0.5 cm long and 0.3 - 0.4 cm wide (1/3 width of diameter of artery), was made over the lateral side of the radial artery. The slanting segment of adjacent cephalic vein was anastomosed end to the side hole of the artery with interrupted 6-0 prolene suture (Figure 4-7). The accuracy of suture placement was clearly improved by the use of magnifying glasses or surgical loupes.

Results

Patient age ranged from 26-80 years, with mean age of 58 years. Almost half of the patients (39/80) were over fifty years old. This reflects the broadened indications for long-term dialysis. There were 45 males and 35 females with male to female ratio of 4.5:3.5. A-V fistulas using the original and the Pongsapak modified technique were performed in 40 patients each. (Table 1)

Access blood flow: The success (providing access blood flow of at least 200 ml/min) of the original technique was detected in 15 of 40 created fistulas (success ratio of 3:8). The success of the Pongsapak modified technique was detected in all 40 created fistulas (success ratio of 1:1)

Initial flow rate: The initial flow rate through radiocephalic fistula was measured after the fistula matured (a period of 3-6 weeks) and hemodialysis was begun, usually at 1 month, by using dialyzer flow meter. With the original technique, blood flow varied from 0 (non-functioning fistula or thrombosis) to 350 ml/min (average 238 ml/min); whereas with the Pongsapak modified technique, blood flow varied from 330-400 ml/min (average 375 ml/min). Blood flow through the fistula was obviously higher with the Pongsapak modified technique ($P < .01$) (Table 2).

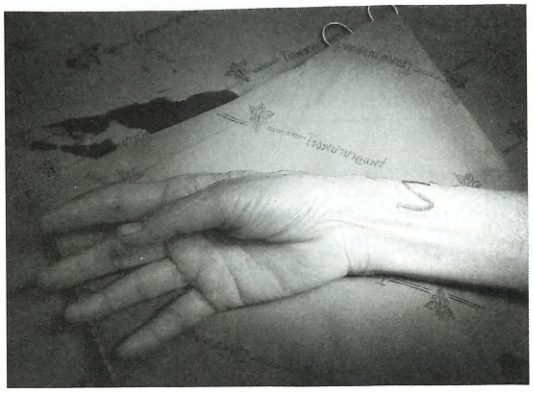

Figure 4 S-plasty skin incision over the radial pulse and cephalic vein

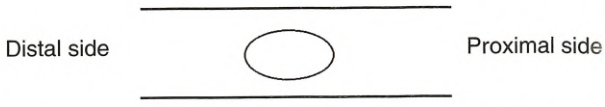

Figure 5 An oval shape hole, 0.5 cm long and 0.3 - 0.4 cm wide (1/3 width of diameter of artery), over the lateral side of radial artery

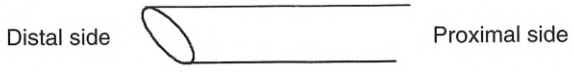

Figure 6 The slanting segment of cephalic vein

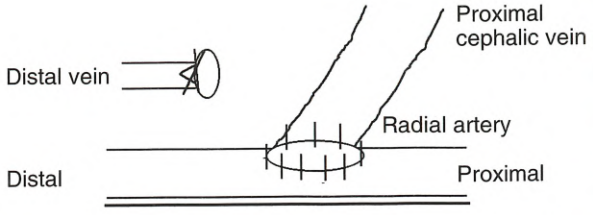

Figure 7 The slanting segment of adjacent cephalic vein anastomosed end to side hole of the artery with interrupted 6-0 Prolene suture

There were five fistulas with early thrombosis and five with inadequate blood flow with the original technique whereas there was none with the Pongsapak modified technique (Table 3).

Late fistula flow rate (6 months after surgery): The flow was at least 400 ml/min in all functioning AV fistula with both the original and the Pongsapak modified technique. These data suggested that flow would increase with time as the artery and vein dilated. As time passed, the anastomosed veins became even

Table 2 Comparison of access blood flow between the original and the Pongsapak modified technique

Technique	No. of patients	$\bar{X}$	SD	Min.	Max.	t	Sig.
Original	40	238.75	111.00	0.00	300	8.80	0.001
Pongsapak	40	375.00	18.26	330.00	400		

Table 3 Comparison of surgical failures between the original and the Pongsapak modified technique

Surgical failure	Original Technique (N = 40) Frequency (%)	Pongsapak (N = 40) Frequency (%)	Total (N = 80) Frequency (%)
Non- functioning	5 (12.5)	0 (0.0)	5 (6.3)
Inadequate flow	5 (12.5)	0 (0.0)	5 (6.3)
Adequate flow	30 (75)	40 (100.0)	70 (87.5)

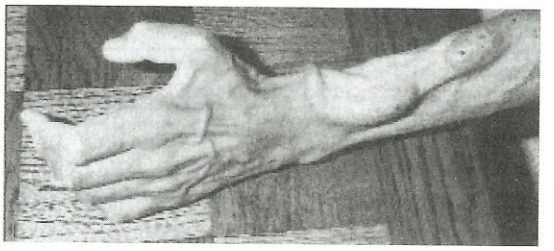

Figure 8 Arterialization of arteriovenous fistula

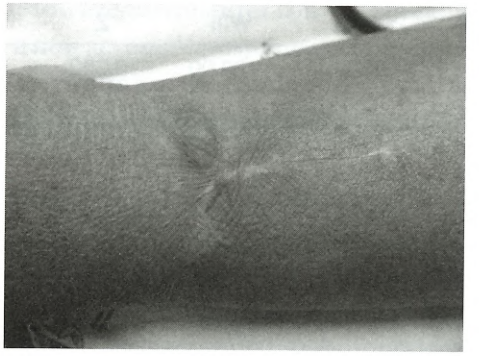

Figure 9 Marked hypertrophic and painful scars after transverse and/or longitudinal incisions

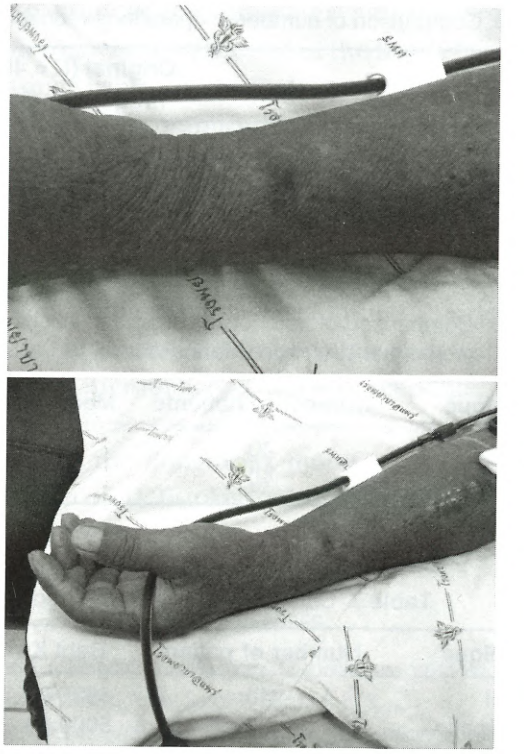

Figure 10 Minimal scar by S-plasty incision

more prominent with thickened wall, making venipuncture easier. This çarterializationé is caused by prolonged exposure of veins to arterial pressure and flow. (Figure 8)

Marked hypertrophic and painful scars occurred after transverse and/or longitudinal skin incision. Minimal scars occurred after S-plasty incision (Figure 9-10).

Early failure: Early failure was found with the original technique but not with the Pongsapak modified technique. Most failures (25% or 10/40) occurred during the first month after surgery. Generally, it was necessary to replace a failed original fistula either with a newly created fistula at a more proximal location or with synthetic graft.

After completion of the operation, a strong thrill should be palpable in the arterialized vein. A pulsating vein without thrill usually indicates insufficient flow.

Patency of fistula: Patients' follow-up period ranged from 3 to 18 months. (Table 4, Figure 11)

Table 4 The cumulative patency rates in 80 radiocephalic fistulas

Time of follow up (months)	Patency of fistula (%)	
	Original technique (n = 40)	Modified technique (n = 40)
0 (1 wk)	90	100
1	75	100
3	75	100
6	75	100
9	75	100
12	70	100
15	65	97.5
18	60	95

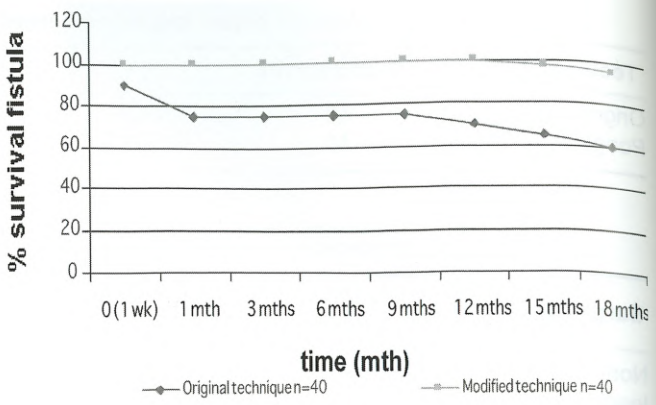

Figure 11 Patency rates in 80 radiocephalic fistulas

Table 5 Comparison of number of operations required between the original technique and the Pongsapak modified technique.

Number of operations	Original (N = 40) Frequency (%)	Pongsapak (N = 40) Frequency (%)	Total (N = 80) Frequency (%)
1	30 (75.5)	40 (100.0)	70 (87.5)
2	7 (17.5)	0 (0.0)	7 (8.8)
3	3 (7.5)	0 (0.0)	3 (3.8)

Table 6 Comparison of number of surgical revisions between the original technique and the Pongsapak modified technique. Wilcoxon (Mann-Whitney)

Technique	Number of patients	Mean of rank	Sum of rank	Mann	Will	Z	Sig
Original	40	35.50	1420.00	600.00	1420.00	-3.352	0.001
Pongsapak's	40	45.50	1820.00				

Table 7 Comparison of cost between the original technique and the Pongsapak modified technique

Technique	Number of patient	Baht X	SD	Min.	Max.	t	Sig.
Original	40	6625.00	3677.52	5000.00	15000.00	3.34	.001
Pongsapak	40	5000.00	0.00	5000.00	5000.00		

Analysis of patency of fistula revealed that the lower patency rate of the fistula using original technique was from early failure (<30 days). There was no difference in patency rates in late failure (>30 days).

Number of operations or surgical revisions: the study revealed that multiple surgical interventions were required in 10 of 40 fistula using the original technique versus in none of 40 patients using the Pongsapak modified technique ($P < 0.01$) (Table 5-6).

Cost: it was shown that a higher cost was found in the original technique because of multiple surgical revisions but no revision was needed in the Pongsapak modified technique ($p < .01$).

Discussion

The number of patients with end-stage renal disease maintained on chronic hemodialysis has been increasing progressively.[4] The increasing prevalence of diabetic and elderly patients among the new hemodialysis patients is a recent worldwide trend.[8]

The arterioveous fistula must be regarded as the

link to the life of hemodialysis. Any complications are, therefore, potentially life threatening. Careful attention to surgical details and the recognition and prevention of problems leading to fistula failure contribute to the quality and longevity of patients with chronic uremia.[2]

Clotting in the vein precipitated by venous punctures occurs frequently at the start, but its incidence decreases with time as the fistula enlarges and the operator acquires more experience. Delayed thrombosis can occur because of extensive thrombosis in the vein secondary to repeated punctures.[2]

The most important parameter in assessing the viability of an arteriovenous fistula is the presence of a palpable thrill and audible bruit. When present, prior to or immediately after skin closure, the fistula will probably function. If such a thrill or bruit is not present, the fistula may fail. For this reason, the causes of absent thrill/bruit must be identified and corrected before the patient leaves the operating room.[2,5,21]

The author's experience with original radio-cephalic fistula has been similar to that reported by others which showed a high early (<30 days) failure rate.[2,5,9] Late failure (>30 days) is rare. Early access failures, including those that continue to flow but do not dilate to a size adequate for convenient cannulation, require a new access. Vasospasm is a common cause of immediate clotting of the fistula and should be treated vigorously by locally administered xylocaine.[4]

Choosing a technique for the creation of an AV fistula for long-term hemodialysis that is easy, inexpensive, with adequate access blood flow and high patency rate and without complications is difficult. Therefore, a study comparing the original technique with the Pongsapak modified technique for creation of an AV fistula for long-term hemodialysis was carried out at Phrae Hospital. A better patency rate was obtained in the modified technique at short-term, but the long-term patency rates of both techniques were not different. Major problems of original technique were lower blood flow and non-functioning fistulas caused by narrowing and thrombosis in fistulas. Another problem was the scar along the longitudinal or transverse incision at the wrist.

Pongsapak modified technique: advantages of the Pongsapak modified technique resulted from the creation of an oval hole of the artery, forcing blood flow through the anastomosis and thus decreasing clot formation at the anastomotic site so early thrombosis was unlikely to develop and the fistula had adequate blood flow. The S-plasty skin incision provided better exposure of the operative field. The S-plasty skin incision also decreased scar formation as it could break up the straight linear scar, relaxed tension and created realignment of the displaced tissue.[23] Infection did not develop in the original technique nor the Pongsapak modified technique, which was similar to other reports.[2,4,24] In the original technique, early thrombosis and inadequate blood flow were main reasons for operative revisions which resulted in more time consuming process and higher cost. AV anastomosis by interrupted sutures avoided narrowing and decreased blood flow at the anastomotic site. Pongsapak modified technique gave satisfactory results not only by increasing the size of the fistula but also by decreasing visible scar by S-plasty skin incision at the wrist with fewer complications. The technique had been well accepted by patients, physicians and dialysis personnel.

Pongsapak modified technique has proved to be a safe and effective means of gaining vascular access for chronic hemodialysis. Once established, the incidence of fistula failure and thrombosis has been extremely low and the incisional scar is less perceptible.

From these reasons, the author would like to recommend the Pongsapak modified technique for the creation of AV fistulas for long-term hemodialysis.

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