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Research Article

Site selection for vascular access creation in hemodialysis in end stage renal disease

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ABSTRACT

Background: Chronic kidney failure is characterized with progressive and irreversible diminishing of glomerular filtration rate. AVF has been unanimously considered the gold standard vascular access of choice for hemodialysis. Arterio-venous fistula (AVF) for hemodialysis should be created in patients with endogenous creatinine clearance < 20 mL/min/1,73m^2. Aim of current study was to choose the proper site for arteriovenous fistula creation with minimal complications.
Methods: It was a prospective study, carried out in the dept. of surgery from April 2008 to August 2013. A total of 140 patients were studied over the period. The fistulae were created using radial artery cephalic vein side to side and brachial artery cephalic vein side to side or end to side anastomosis. Statistical analysis used: Mean, Standard deviation, Standard error.
Results: A total 140 patients were studied, out of them 104 were males and 36 were females. The radiocephalic site was used for 82 (58.57%) patients and 58 (41.43%) patients were operated on brachiocephalic site. The mean inner diameter of radial artery, brachial artery and cephalic vein (intima to intima) at elbow and wrist were 21.49001 ± 0.901 (SE - 0.28492), 3.72533 ± 1.06837 (SE - 0.30841) and 0.68079 ± 0.49551 (SE - 0.116790) respectively. The mean flows velocity of brachial and radial artery were 76.10526 ± 4.54477 (SE - 1.04264) and 52.64286 ± 5.5968 (SE - 1.495810) respectively. The success rate of AV fistula on table was 97.85% (137 out of 140). The incidence of complication was 18.57%.
Conclusion: The site for fistula creation depends on the quality of the artery and vein. To achieve good success rates preoperative color Doppler is essential to evaluate the vessels. The complication rates can be minimised by following standard operating protocols.

Keywords: Chronic kidney disease, Arteriovenous fistula, Hemodialysis

INTRODUCTION

Chronic Kidney Disease (CKD) is a long term condition caused by damage to both kidneys. It is only relatively recently that the epidemiology of CKD has been studied in detail with the finding that it is more common than previously thought.[1] The average prevalence has been reported at 11% in USA and Europe (excluding those on dialysis or with a functioning transplant).[2] Diabetes mellitus, which is also becoming more common, is one cause of CKD.[3]

An international classification of CKD has identified five stages.[4] The primary goal of hemodialysis is to restore the intracellular and extracellular fluid environment that is characteristic of normal kidney function.[5]

The native arteriovenous fistula (AVF) for haemodialysis has been described as the Achilles heel but also the Cinderella of haemodialysis.[6] AVF has been the vascular access of choice for haemodialysis because of lower cost, morbidity and mortality.[7] Despite this, nearly two thirds of incident dialysis patients, even in the developed countries use a venous catheter to start with their haemodialysis and fewer than 15.0% begin dialysis with an AVF.[8] The study was conducted with the objectives to choose the proper site for formation of arteriovenous fistula, to find out the success rate at various sites and to study the complications and patency.

METHODS

It was a prospective study, carried out in the dept. of surgery from April 2008 to August 2013. Informed consent was obtained from all the patients and prior approval from institutional ethical committee was taken. A total of 140 patients were studied over the period. The fistulae were created using radial artery cephalic vein side to side and brachial artery cephalic vein side to side or end to side anastomosis on right or left hand.

Doppler studies were done before every procedure to demonstrate the velocity and diameter of vessels. Patients were followed up to one year.

RESULTS

A total 140 patients were studied, out of them 104 were males and 36 were females. The male to female ratio was 2.88. The mean age of presentation was 41.76 years. The youngest age of presentation was 22 years and oldest was 63 years.

The radiocephalic site was the most common site for anastomosis. This was the site for 82 (58.57%) patients and 58 (41.43%) patients were operated on brachiocephalic site. The various comorbidities associated with these patients were Diabetes Mellitus (35.71%), Hypertension (19.28%), hypertriglyceridemia (12.14%), myalgia and bodyaches (62.14%), hypocalcaemia (17.14%), hyperphosphatemia (12.85%).

Colour Doppler studies were performed in all the patients to know the diameter and flow of vessels. The mean inner diameter of radial artery, brachial artery and cephalic vein (intima to intima) at elbow and wrist were 21.49001 ± 0.901 (SE - 0.28492), 3.72533 ± 1.06837 (SE - 0.30841) and 0.68079 ± 0.49551 (SE - 0.116790) respectively. The mean flows velocity of brachial and radial artery were 76.10526 ± 4.54477 (SE - 1.04264) and 52.64286 ± 5.5968 (SE - 1.495810) respectively.

The success rate of AV fistula on table was 97.85% (137 out of 140). All brachiocephalic anastomosis were functioning on table. The success rate of radiocephalic was 96.34%. The technique for anastomosis was same in all the cases. The success rate at these two sites and at different follow up visits are given in Table 1.

The rate of complications was more at wrist region or for radiocephalic site. In the series overall complications were seen in 26 (18.57 %) patients. Infection and wound gaps were more at wrist as compared to elbow. Number of patients suffered from various complications at two sites has enumerated in Table 2. Bleeding from the anastomotic site because of infection was more commonly seen at wrist in three (2.14 %) patients which corresponded to 11.53% of the overall complications. It is the most dangerous complication and is associated with greater morbidity and mortality. Edema and ecchymosis around the operated site were seen in 17 (65.38%). The wound infection was present in five (3.57%) patients, all at wrist region. In presence of infection, the underlying fistula became non-functioning. It was associated with the surrounding hematoma. Infection treated with antibiotics and regular dressings. In all the patients, fistula was created at new site. Bleeding from operation site was present in three (2.14%) patients. The source of bleeding was the anastomotic site. Two of these three were associated with the wound gaping without infection as discharge was sterile for bacterial growth and one was associated with skin necrosis, surrounding hematoma.

Table 1: Success rates at two sites on table and at follow ups.

	Brachiocephalic	Radiocephalic
On table	100% (58/58)	96.34% (79/82)
At 1 month	100% (58/58)	92. 68 % (76/82)
At 6 month	100% (58/58)	90.24 % (74/82)
At 1 year	98.27% (57/58)	85.36 % (70/82)

Table 2: Various complications at wrist and elbow.

Complications	Total n = 140	At Wrist n=82	At Elbow n=58
Infection and wound gape	5 (3.57%)	5 (100%)	0
Bleeding from operation site	3 (2.14%)	3 (100%)	0
Edema of the hand	9 (6.42%)	5 (55.56%)	4 (44.445%)
Ecchymosis around the operated site	8 (5.71%)	4 (50%)	4 (50%)
Pseudoaneurysm	1 (0.71%)	1 (100%)	0

Pseudoaneurysm developed in one (0.71%) patient. Angiography demonstrated leak from arterial side. On

exploration, a small rent in the artery could be identified and repaired with nonabsorbable monofilament sutures and surrounding hematoma was evacuated.

DISCUSSION

As compared to central venous catheter, use of AVF in hemodialysis is associated with higher blood flow rate and lower rate of infection, thrombosis, septicemia, central venous stenosis and mortality.[9] AVF has been unanimously considered the gold standard vascular access of choice for hemodialysis. Whenever appropriate, an AVF must be created one to four months prior to the scheduled start of dialysis if the creatinine clearance is less than or equal to 25 ml/min and/or the serum creatinine is over four mg/dl.[10] Hemodialysis performed via a catheter is also associated with an increased risk of mortality. Polkinghorne et al reported two to three fold increase in the risk of death in the first six months in patients receiving hemodialysis via a catheter when compared to the AVF.[9] In a dialysis morbidity and mortality study, Dhingra et al. reported an increased mortality risk of 54.0% among diabetic and 70.0% among nondiabetic patients who were using a catheter as compared to those who were using an AVF.[11] In a nationwide Choice for Healthy Outcomes in Caring for End stage renal disease (CHOICE) study, Astor et al. reported 47.0% higher risk of death in incident hemodialysis patients who were using a catheter as compared to AVF.[12]

Chronic kidney failure is characterized with progressive and irreversible diminishing of glomerular filtration rate (GFR).[1-4] When glomerular filtration rate falls below 20 mL/min/1.73 m^2, and serum creatinine concentration rises above 220 mmol/L, chronic kidney failure progressively advances, leading to irreversible renal parenchyma disorder and finally, to an end stage renal disease . In patients with diagnosed chronic kidney failure cephalic veins should be preserved for arterio-venous fistula (AVF) creation.[13] If hemodialysis planned, vascular access should be created when endogenous creatinine clearance - C_{cr} <20 mL/min/1.73 m^2, and regular hemodialysis treatment should be started when C_{cr}<10 mL/min/1.73 m^2. Dialysis should start earlier if there is hypervolemia (C_{cr} = 15-20 mL/min /1.73 m^2).[14]

Before vascular access creation it is mandatory to take anamnestic data (data about previous central venous dialysis catheter, diabetes mellitus, peripheral arterial and venous diseases, trauma and surgical interventions at upper limbs, anticoagulant therapy and coagulation disorders and previous vascular access), per-form physical examination of upper limb vessels, Allen test, upper limb vessels color Doppler evaluation and echocardiography. Preoperative evaluation of arteries and veins should be performed first in patient's non-dominant arm.[15-18]

In evaluation of radial artery, for preoperative assessment of arterio-venous fistula creation, one should examine: inner diameter of radial artery, morphology of the wall, thickness of intima-media, atherosclerotic plaques, and presence of calcifications, velocity and flow through radial artery, as well as response of radial artery to reactive hyperemia. Distal radial artery diameter measurement is performed in longitudinal scan, in distal forearm, just above the wrist. Inner diameter of radial artery less than two mm and flow velocity >50 cm/s and blood flow through the radial artery >40 mL/min maintain adequate maturing of distal radio-cephalic AVF.[19,20] Measurement of diameter of radial artery in systole and diastole enable assessment of its pulsatility.[21,22] Evaluation of venous system includes examination of cephalic vein in the forearm. Cephalic vein is traced downstream (proximally) all way down till the confluence with deep venous system. Diameter of Cephalic vein >2.5 mm enables adequate maturation of AVF with good outcomes. Minimal diameter of 2.5 mm with cuff indicates good outcome of AVF. Inner diameter of cephalic vein >2.5 mm and flow through the subclavian vein above 400 mL/min enable adequate maturation of distal radio-cephalic AVF.[23]

In the study the incidence of complication was 18.57%. It was more at wrist than elbow region. The variety of acute and/ or chronic complications can be observed. Immediately after surgery, hemorrhage, low venous flow or hematoma may occur. At a later stage, there may be complications, such as infections, the development of an aneurysm and/or false aneurysm, stenosis of fistula vein, congestive heart failure, steal syndrome, ischemic neuropathy and thrombosis of fistula.

The incidence of infection is accounts for up to 20% in AVF which is lower than arteriovenous grafts. Most AVF infections involve perivascular cellulitis, which manifests as localized erythema and edema and is usually easily treated. Much more serious is an infection associated with anatomical abnormalities, such as aneurysms, hematomas or abscesses, which require surgical excision and drainage.[24]

The causes of fistula failure at a later stage include infections, aneurysm or pseudoaneurysm or fistula vein stenosis. Thrombosis is a crucial cause of AVF failure. It usually occurs near a stenosis in the area of anastomosis or fistula vein. Uremic factors such as homocysteine or endogenous inhibitors of Nitrous Oxide synthase (asymmetric dimethylarginine) may be implicated as the toxic products to the vascular endothelium causing thrombosis[25]. The risk of thrombosis increases with the degree of stenosis. National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines define significant stenosis of the vessel lumen as a reduction by more than 50%. Clinical suspicion of stenosis is confirmed by the presence of several factors: reduced quality of dialysis, problems with puncture, such as prolonged bleeding after

AVF puncture pain in the area of the fistula or increased venous pressure. An important cause of complications in hemodialysis patients is an increased thrombotic tendency, causing many fatalities involving ischemic heart disease or stroke, but in 17-25% of cases the reason for hospitalization is AVF thrombosis.[26,27] The most common cause of vascular access thrombosis is venous neointimal proliferation. This causes vascular stenosis, leading to fistula thrombosis.[27] Neointimal hyperplasia is characterized by the proliferation of smooth muscle cells under the influence of basic fibroblast- and platelet-derived growth factors.

The smooth muscle cell layer penetrates through the internal elastic lamina, migrates into the intima, and secretes matrix proliferous substances, such as collagen, elastin and proteoglycans. During migration of smooth muscle cells into the intima, they are transformed from a contractile into a secretory type that produces a basic substance causing intimal fibrosis.[28]

The site for fistula creation depends on the quality of the artery and vein. To achieve good success rates preoperative color Doppler is essential to evaluate the vessels. The complication rates can be minimised by following standard operating protocols.

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