Reversed, Nonreversed Translocated, in Situ Vein Grafts in Arterial revascularization : Techniques, Versatility Durability, and Cumulative Results

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INTRODUCTION

Since Carrell and Guthrie used the reversed saphenous vein graft for arterial reconstruction in 1906,[1] this technique has undergone several technical modifications to earn its popularity and credibillty.[2-4] Vein preparation has also been refined to attain optimal preseveration of histocytologic integrity in order to improve graft patency.[6-12] Notwithstanding the periodical enthusiasm to substitute or prosthetic grafts,[16-18] or prosthetic graft with a venous cuff[13-15] for expedience, autogenous vein graft remains the preferred conduit and the gold standard in vascular bypass operations. Autogenous vein graft has been subjected to intense scrutiny for optimal morphologic preservation, and, identification of etiologic factores contributing to segmental fibrosclerosis and aneurysmic degeneration. The anatomic orientation of reversed versus noreversed vein graft has also been extensively evaluated for their role in long term graft function and patency.[22] Despite the initial nongermane attitude toward vein preparation, there is evidence to support the importance of the pH, osmolality, osmolarity and the duration of storage in media, in the preservation of the intefrity of cellular and extracellular elements of the vein grafts.[5,9,10,23,24,25] It is well established that durability and long term patency of a vein graft is frequently the by product of at least four vital elements: vein quality. Vein preparation, anatomic orientation and surgical technique.

Anatomy and Quality of Saphenous Vein

Basic morphologic disparity exists in groin and ankle saphenous vein. The former has more abundant intimal myobiasts and fibrocollagen than the ankle saphenous vein.

Consequently, the tensile strength is greater in the former.[26] Like any other veins, the nutrient supply to the vein wall is by way of arterial vasa vasorum derived from the adjacent arteries. Disruption of the blood supply of the arterial vasa, may have potential repercussion that not been well documented.

Arterial and venous vasa coexists in the vein wall with differing distribution patterns. Arterial vasa has a rhomboidal configuration the orients parallel to the axis of the vein. In contradistinction, the venous vasa has a circumferential configuration that embraces the vein (Figure 1-2). Venous vasa converge toward venous side branches to gain access to communicate with the lumen of the vein. Thus the venous vasa can readily become channels to deliver nutrients from the lumen of the vein wall via the ligated side branches once the vein becomes an arterial conduit.[26] Differing from prosthetic graft, saphenous vein has a spectrum of quality i.e. postphlebotic, segmental fibrotic, ectatic aneurysmic, ultrathin, nonuniform thickness, multiple stenosis and etc.

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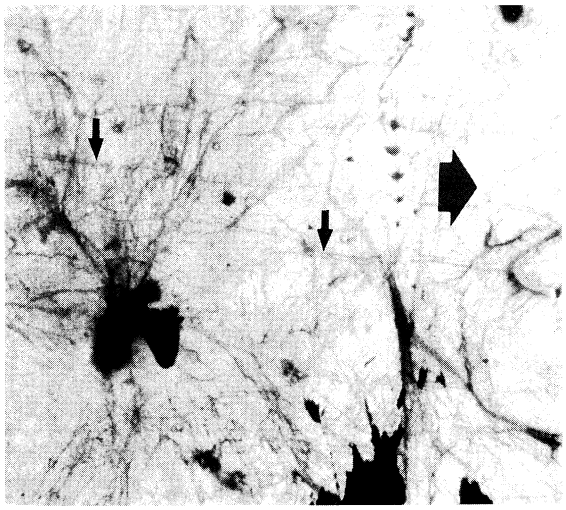

Figure 1. Arrows point to rhomboidal configuration of arterial vesa oriented along the axis of the vein (Large Arrow).

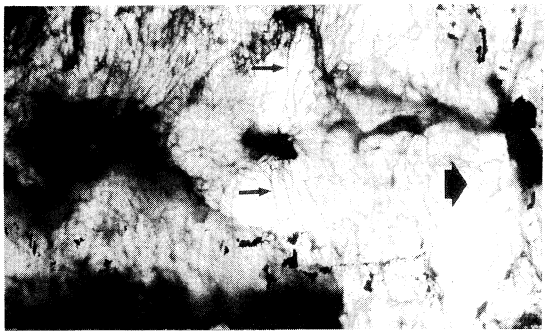

Figure 2. Arrows point to circumferential configuration of venous vasa embracion the long axis of the vein (Large Arrow).

Histomorphologic integrity in association with vein graft preparation

Extensive investigations have been focused on the subject of vein preparation for decades. Pertinent data emerged from these studies are as follows:-

1. Short storage in cold neutral pH media containing colloid offers good morphologic preservation[7,10,11,22,26]
2. Mechanical distention induces extracellular matrix production by vascular myoblast[10,28,29]
3. Reendothelialization is to be expected, whereas myoblast damage is often irreverseable and is responsible for the development of medial fibroplasia[5,24,26,30]
4. Arterialization of the optimally prepared vein will produce a myofibrous coduit by increasing myoblasts population in the vein wall as opposed to fibrocollagenous conduit by increasing fibrocollagen content in the vein grafts[10,24,25,26]

Anatomic orientation of vein graft

1. Reversed saphenous vein
2. In situ saphenous vein
3. Nonreversed translocated saphenous vein

These three techniques have been used in various types of bypass procedures with good and durable results even with follow up in excess of > 20 years. The surgical technique and vein graft orientation can certainly influence the durability and patency of a vein graft without taking the quality of the vein per se into consideration.[31,32,33,34]

Reversed Saphenous Vein Graft

This time-honored grand old technique has earned its reputation to be considered as the gold standard. Among the recognized short- comings of the reversed saphenous vein graft is having to anastomose the norrowest and thinest popliteal portion of the reversed saphenous vein to a thick and perhaps calcified common femoral artery in femoropopliteal bypass. Because of the size and thickness mismatch between vein and artery. Vein graft can collapse leading to compromised inflow that can contribute to early graft occlusion. Linton vein patch to the donor common femoral of external iliac artery is designed specifically to neutralize the size and thickness mismatch that exists between the vein graft and the artery. Anastomosing a thicker proximal saphenous vein to a 1-2 mm tibial or peroneal artery in the distal anastomosis can also present problems in size and thickness discrepancy. Evidence also ex-

ists in thrombi and leukocytes sequestered in valve cuspe of reversed vein graft.[35] Whether adversed sequelae emerged from this incidental observation in reversed vein graft has not been reported.

In situ vein Graft

A technique initiated by Hall[31] and popularized by Leather et al[32,36-38] has gained a great deal of attention and enthusiasm. It is now widely used in crural bypass. Conceptually, it is a very appealing techinque in matching the wider portion of the saphenous vein to the tivial vessel. The disadvantages of the in situ techniques resides in (1) missed side branches to droduce arteriovenous fistula (AVF), (2) inadequate proximal reach precludes anastomosing the groin saphenous vein to a noncalcified, external iliac or even common iliac artery when the common femoral arterey is not a desirable donor artery (3) the overlying skin incision breakdown can jeopardize the vein graft patency, (4) inadvertent tearing of side branches during valvulotomy can produce long-lasting adverse consequences, (5) obturator valvulotme has the tendency to excessively disrupt and damage the endotibial lining to produce a thrombogenic surface. (6) focal fibrotic vein segment is often missed or cannot be replaced without disrupting the continuity of the vein graft. The segmental fibrosis often becomes the future site of stenosis/occlusion. Angioscopically guided side branch occlusion with coils though conceptually appealing, a prospective randomized study has not shown the anticipated benefit.[39]

Nonreversed translocated saphenous vein (NTSV)

This technique was developed out of frustration while using the in situ technique in 8/1982. By preserving the concept of proper size matching of the in situ technique, and yet maintains the freedom of selection the optimal donor artery, preserve the option of anatomic placement of vein graft in the subsartorial or extraanatomic routing, NTSU has become a more versatile bypass graft. NTSV has also lent itself to composite sequential bypass of varying configurations. (Figure 3) It is also possible to perform carotid to radial artery bypass for subclavian-axillary-brachial arteries occlusion from failures of previous arterial reconstructions.[40-41] (Figure 4) A good caliber and uniform composite vein graft can also be created in NTSV by replacing the unacceptable fibrostenotic segments. (Figure 5)

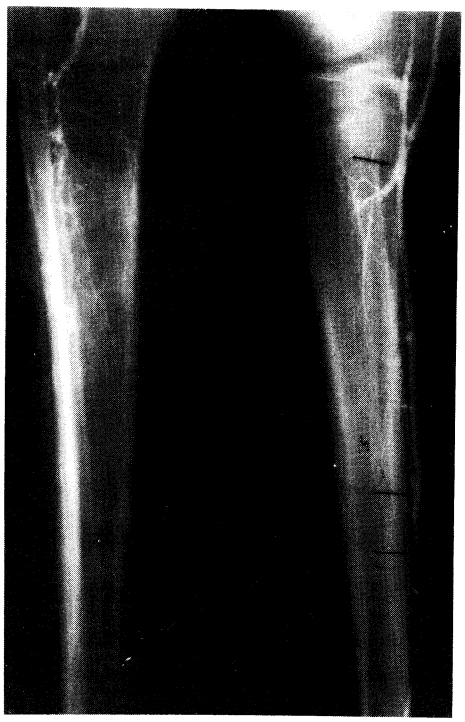

Figure 3. Composite sequential bypass of nonreversed saphenous vein to popliteal and peroneal artery. Single arrow denotes side to side anastomosis to popliteal artery. Double arrows signify the length of distal end to side anastomosis to the peroneal artery.

Surgical Technique: Of Nonreversed Sapheous Vein Graft

Similar to reversed vein graft the saphenous vein, lesser saphenous vein or arm vein is excised. Side branches are tied with 4.0 silk prior to division. The vein graft is immediately immersed in papaverine solution (60 mg/100cc plasmalyted). The lumen is flushed with the same to evacuate residual blood. Care is taken not to skeletonize the vein for preservation of vasa vasorum contained in the adventitia and perigraft connective tissue. Under sys-

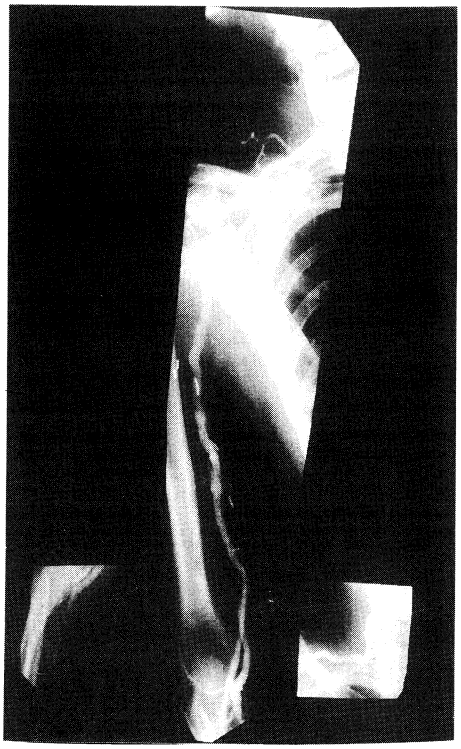

Figure 4. Carotid To radial artery bypass using saphenous veins from both thighs in a nonreversed fashion to provide adequate length for the bypass. Insets depict end to side anastomosis to carotid artery and end to side anastomosis to radial artery.

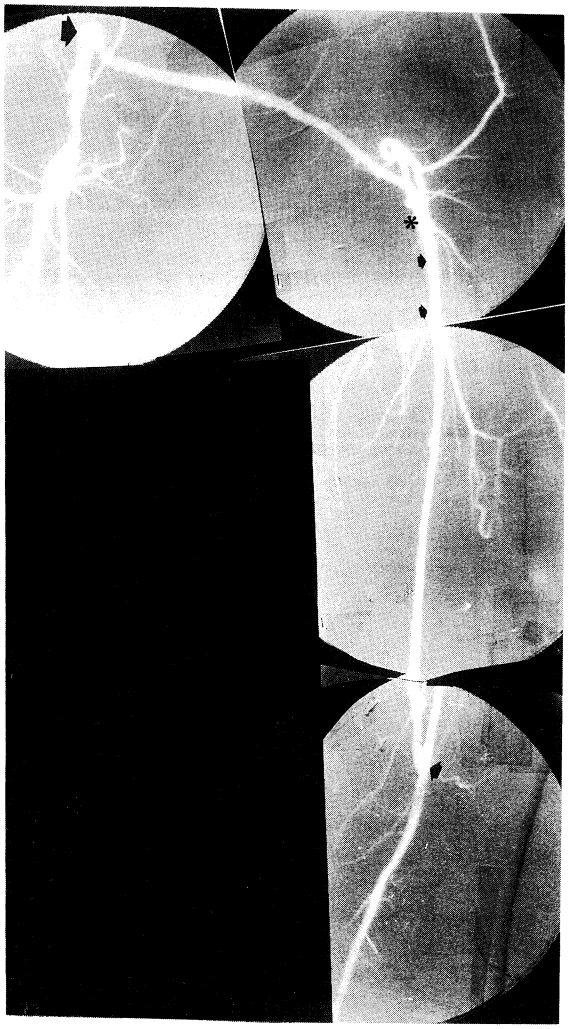

Figure 5. Transpubic femoro-profudofemoral-posterior tibial sequential bypass using a comosite vein graft of greater and lesser saphenous veins for limb salvage to heal gangrene toes. Solid arrow in right groin indicated origin of nonreversed translocated vein graft. Asteric indicatied greated-lesser saphenous vein splicing. Solid arrows denoted is do to side anasomosis with deep femoral artery and distal anastomosis to the popliteal artery.

temic Heparinization (5,000 u) the proximal vein is spatulated (2-3 cm) for end to side anastomisis with 5.0 Prolene Suture. With the vein graft distended by the arterial blood, modified Mill's Valvulotome is introduced at the distal vein graft to incise the valve cusps. Dragging the valvulotome along the vein wall should be avoided to prevent unintentionl damage to the vein. An atramatic bulldog clamp is used to occlude the valvulotomized vein graft distally. In doing so arterial blood emerge through the side branches that communicate with the vein vasa will continue to perfuse the vein wall without interruption. The vein graft can reach the receipient artery by

anatomic or extraanatomic routing. (Figure 6)[6-7] A long distal anastomosis (>2 cm) is preferred to avoid turbulant flow and to reduce the high shear injury to the floor of the artery. (Figure 7)[8-9] Option of bypassing to the lateral planta artery from the popliteal artery a fete that is beyond the scope of in situ technique. (Figure 8) Simililarly, lateral routing for popliteal dorsalis bypass (Figure 9) or femoral dorsalis bypass (Figure10) offer a short and direct access to the dorsalis pedis artery for expediancy. Parashutting technique is employed for the toe anastomisis to assure predcise precise suture placement and reduce suture tearing of vein at the toe created by a tie.

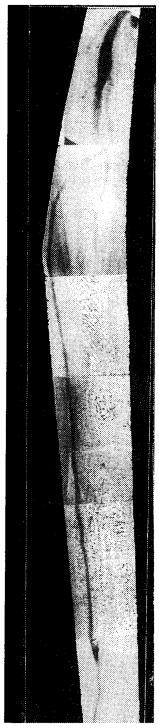

Figure 6. Subtraction angiogram demonstrating femoro-anterior tibial bypass routing laterally to transverse through the grove between tibia and fibular head. The nonreversed saphenous vein graft was placed in the subcutaneous tunnel. Note the long distal end to side anastomosis.

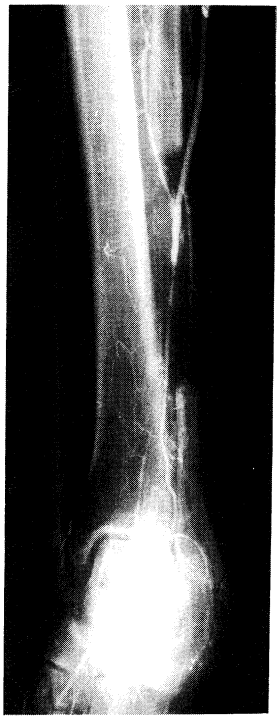

Figure 7. Postoperative arteriogram demonstrated femoral artery bypass. The latter was accessed by partial fibularectomy. The nonreversed vein graph was routed laterraly in a subculaneous tunnel that traversed through the grove between the tibia and fibular head. Note the long distal end to side anastomosis (Arrows).

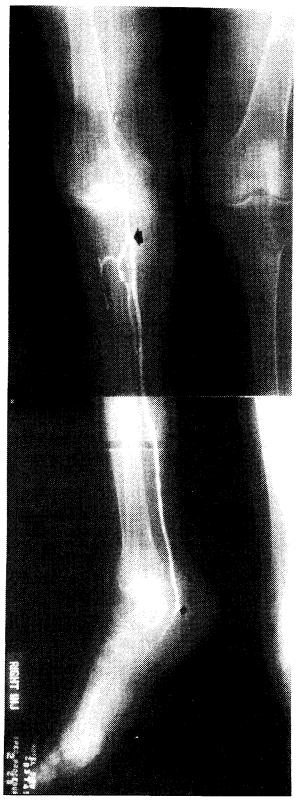

Figure 8. Postoperative arteriogram of popliteal to lateral plantar artery bypass to heal gangrene toes.

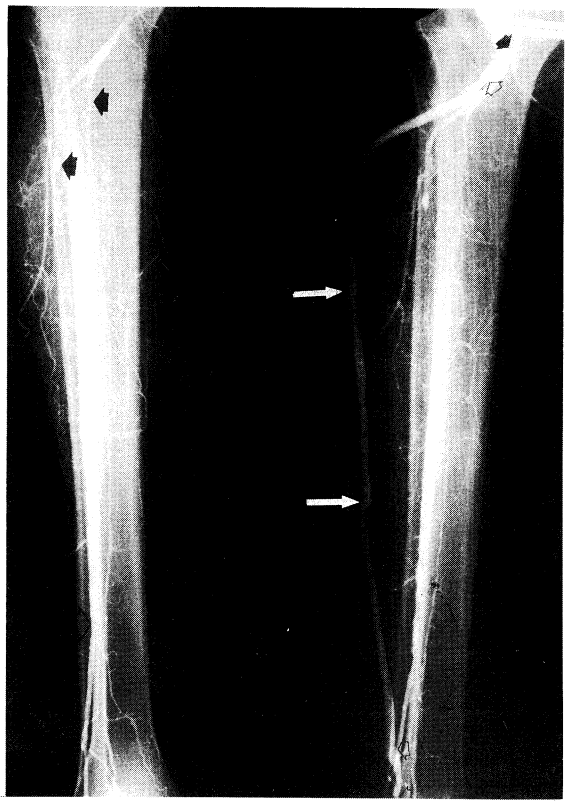

Figure 9. Postoperative arteriogram depicting infragrnu popliteal to dersalis bypass using nonreversed vein graft with lateral routing behind the fivula (Arrow).

Comments

The objectives of an optimal arterial bypass are successful organ revascularization and preservation, no postoperative complications that requires additional corrective procedures, durability of the bypass graft with long term patency, and expediency of the operation.

Comparing the suitability of the three techniques in arterial bypass using reversed, in situ and nonreversed translocated vein grafts has often elicit emotional and passionate discussion. Vehement disagreements often occur when the inventors of the procedures are involved. In the hands of good technical surgeons and quality vein optimal results can be achieved in any of these three techniques with recognized descrepancy in long term results (Table 1) under these circumstances, expediency of the procedure, good donor and recipient artery may be the sole determinant factors that can tilt the balance and be the scientific discrimination factors for the three techniques.

Reversed saphenous vein remains the expedient procedure when a good and uniform caliber vein is available and Linton vein patch is not needed to compensate for the compliance and diameter mismatch. However size mismatch coupled with calcified and thickened femoral artery in femoral-tibial bypass remain a hazard in reversed vein graft. NTSV graft provides the combined versatility and advantages of the reversed and in situ techniques. The advantage of minimizing size mismatch, no limitation of proximal reach and the option of subsatorial or

Table 1. Comparsion of vein grafts cumulative patency using life table analysis.

Series	Tech.	No.	Type Bypass	Vear Follow up	Patency Primary	Secondary
Shah, Etal, 1988	**In situ**	681	INFRA POP	5	75%	
Harris, Etal, 1987	**In situ**	98	FEM-POP	3	68%	
	Revers	102		5	77%	
Harris, Etal, (3 centers) 1993	**In situ**	82	FEM-TIB / PER	3	-	68%
	Revers	80				66%
Taylor,* Etal 1987	Reversed	110	INFRA POP	5	85%	> 10% endarterectomy of donor artery
Sottiurai* 1993	Nonreversed	135	BK FEM-POP	5	86.6%	-
	Translocated	130	FEM-TIB / PER	5	82.3%	84.4%

*Splicing of lesser, greater saphenous vein, or arm vein as indicated to produce a respectable vein graft.

anatomic placement of the NTSV graft denote additional attractive features surpassing the reversed and in situ vein grafts.

The inherent disadvantage of in situ vein graft are limitations of proximal reach to a more suitable donor artery. Missed side branch leading to AVF, incomplete valvulotomy, potential tearing of side branches and the unrecognized fibrotic segment of the vein. Some of these potential complications is recognizable in NTSV technique during valvulotomy under direct vision. The highly emphasized preservation of arterial vasa vasorum for uninterupted arterial supply to the in situ vein graft to preserve the integrity of the vein has been proven more theoretical than pragmatic. (Figure 2) The demonstration of arterial and venous vasa in canine vein forms the basis to suggest that nutrients can reach the vein wall by way of venous vasa network following conversion of a vein to an arterial conduit.[40]

Comparison of long term patency without taking the recognized complications into consideration (AVF, valvulotome tearing of vein wall, missed valve, skin incision breakdown)NTSV and reversed saphenous vein unequivocally fares better than in situ vein grafts in that respect.[39,40,42]

Multiple prospective randomized studies have been reported in favor of reversed vein graft than in situ vein graft in patency and complication.[43-44] Documentation has also been made that the closed in situ technique is preferred to open technique with respect to incision complication and duration of the operation.[39] There was also doubt in the procedure in its early stage.[45]

The subject of preferred technique in arterial bypass using reversed, in situ or nonreversed transtocated vein remins personal, subjective and confidence in the technique. It is not because there is a shortage of data to compare and recognize the superiority of these modalities but rather the bias and passion that overide the facts. Some sugeons consider it a mission to carry the argument to the next millenium to expound their prejudice, preference and belief in the superiority of their own technique over others irrespective of the comparative data available in the literature. The NTV is less publicized despite its highly respectable results, versatility and long term patency that surpass the other techniques documented in the literature.[33,40] (Table) As a subsequence to the original publication in 1985 detailing the nonreversed tranlocated saphenous vein technique

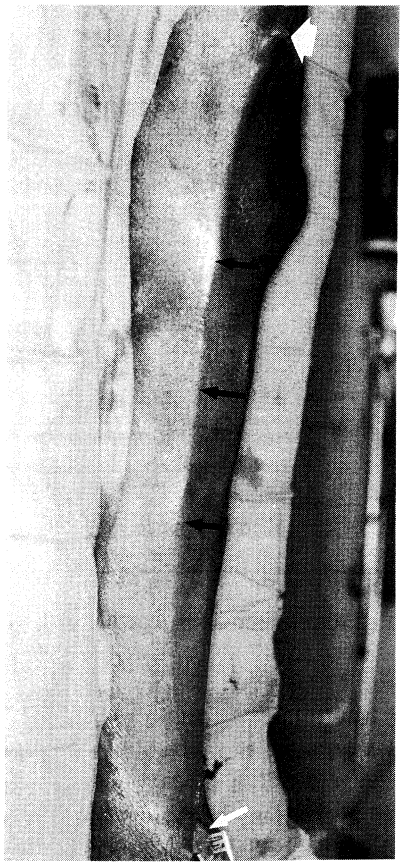

Figure 10. Intraoperative photograph displaying lateral routing of femoro0dorsalis bypass with nonreversed vein graft: obliquely across the thigh. Traversed between fibular head and tibial condyle to reach the dorsalis pedis. A counter incision above the knee was needed to complete the tunneling (Arrow) small arrow denoted the subcutaneous course of the bypass.

that was initiated in August 1982.[35,45-47] The most desirable scientific approach is a prospective randomized trial of the three techniques. However there is no need and justification to carry this issue to that extreme due to the costliness of the trial, the limited benefits and the unsurmontable prejudices exist on the subject.

The ultimate goals of an arterial bypass shared by most surgeons are as follows:-

1. Technically easy and simple
2. Good long term patency with minimal revision to maintain long term primary patency
3. Uniform caliber vein graft without focal stricture either primary or sevondary
4. No restriction in selection of optimal donor and recipient arteries for anastomosis
5. Minimal injury to the vein graft that affects immediate and long term patency ie.
   a. Improper vein preparation
   b. Iatrogenic vein injury – valvulotome injury, improper side branch ligation.

CONCLUSIONS

Factors that influence vein graft patency are:-

1. Adequate diameter of the vein graft
2. Absence of segmental fibrotic stricture
3. Proper vein preparation with short storage time
4. Techniques of grafting

The undeniable fact remains that reversed, in situ and nonreversed translocated vein grafting are established sound surgical techniques. Nonreversed vein graft surpasses reversed vein graft in obviating the size/thickness mismatch and supercedes in situ vein graft in the option of donor artery selection and the luxury in fibrotic vein segment excision in order to produce and uniform vein graft.

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