

Arterial Reconstruction and Bypass Repair for Diabetic Ischemic- Gangrenous Foot Ulcers; Long Lasting Implicative way for Level Salvage

Seyed Mansour Alamshah*, Seyed Masoud Moosavi, Iraj Nazari, Hossain Minaee, Sohail Noroozi and Ahmad Sadeghpour

Department of Vascular, Trauma and Transplantation Surgery. Golestan Hospital, Ahwaz Jundishapour University of Medical Science. Ahwaz- Iran.

*Corresponding Author E-mail : mansourseyedalam@gmail.com

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Limb salvage is the gold aim of attempting any curative procedure for diabetic foot preservation. Arterial reconstruction may be better practical remedy among all other practical preserving protocols for diabetic feet. This retrospective cohort clinical study reflects 5 years experiences in revascularization of ischemic diabetic feet. Patients with Ischemic and non-healed wounds who had received vascular reconstructions are recruited and investigated through their file information. Doppler and angiography reports with recorded Blood Dropping Time index (BDT: time of edge bleeding during cutting until a drop formation) for patients during debridement had been considered. Feasible reconstruction was performed in deferent ways and grafts accompanied by toe pressure in some cases. BDT have compared before and after vascular reconstruction in patients that had been measured and recorded. From different 158 cases, 41 patients (28 male, 13 female) of ischemic, gangrenous diabetic foot wounds were found who had been revascularized by grafting or endartrectomies. They had been admitted 4 -22 days (mean= 8.5 days) with >10 years diabetic history. Mean complete improvement time was 34.53 days after surgery. Mean BDT was about 71 seconds before repair and average 8.46 seconds after vascular repair (P=00.002). Detected Toe pressure in 11 cases was <30 mmHg and Toe-Brachial indexes were <0.6. Patency of Dacron was 13 months versus 22-61 months for autogenous vein bypasses for femoro-popliteal and 9-16 months for popliteo-tibial. Revascularization in arterial occlusions or severe stenosis of diabetic feet with threatening ischemia might be feasible and efficient and still may account the best way for long standing management especially by autogenous vein utility in which seems to be effective and more economical in comparisons.

Keywords: Arteria Bypass; Diabetic Foot Ischemia; Limb Salvage; Revascularization.

Diabetic wounds are imposed, common, unpredictable refractory lesions which mostly involve the feet in all patients and always lead to amputations. These progressive ulcers need to be attended by an accurate educational planning to protect diabetics from their complications. As

postulated by fundamental review of diabetic foot infection and ulceration, multidisciplinary approach directed at controlling hyperglycemia, administration of systemic antibiotics and local wound management to prevent dissemination of infection is mandatory¹. These have to be

accompanied by surgical debridement with or without minor amputations and/or drainage as the preliminary step^{1,2}. Assessment and controlling the limb arterial circulation along with required vascular reconstruction in order to limb protection is an important covering modality that can provide a safe range of assurance in wound management⁶. This is because of simultaneous existence of arterial disease with diabetic foot ulcers that confer a poor long-term prognosis for the limb and life surveillance. Thus apparently, ischemic diabetic limbs have more amputation rate⁷. In this circumstance, anticipation and differentiation of ischemia in diabetic feet especially pulseless foot is crucial, because not to miss un-circulated limb. On the other hand, pure neuropathic ulcers even plantar types usually do not need any vascular intervention and tend to heal fairly. Therefore, ischemia should work-up strongly according to available procedures to be focused on circulatory and mapping modalities. Today, a new spectrum of circulation assessment is considered beyond the CT angiography and trans-cutaneous oxygen pressure or toe pressure for ischemic diabetic feet. Angiosome directed perfusion and Radiotracer imaging⁸ are the examples. Although, in spite of progression in para-clinical foot circulatory evaluations still, clinical assessments and approved academic classifications are presumed that work better⁹. Besides, regarding to the established limb threatening ischemia in diabetic foot, ankle brachial index (ABI) or any preliminary work-up are neither mandatory nor worthy. Conventional angiography is now more accepted for main evaluation while simultaneously provides the possibility of any intra-vascular interventions as angioplasties lead to limb salvage. Apart from reconstruction surgery, long effectiveness of angioplasty is doubtful and usually timely confined and more than 70% recurrence with needed re-PTA is reported¹⁰. Having all techniques be performed, presumably justified direct surgical approach provides a long standing and succeeding key remedy to protect limbs for salvage. This paper is reporting our results of surgical approaches for complicated and established ischemic diabetic feet.

METHODS

We retrospectively studied all the referred and surgically treated ischemic diabetic patients

from the November 2012 until December 2017 (5 years) in our department of Golestan hospital affiliated to Ahwaz Jundishapour University of medical science, Ahwaz-Iran. Our included patients for study were all who had established diabetic limb threatening ischemic, non-healed wound, infected or gangrenous foot and those in whom angioplasty despite the distal runoff was not successful because of hard arterial occlusions. All had been operated surgically and repaired by multiple vascular techniques. Non-ischemic neuropathic diabetic wounds and all patients who were candidate non-surgically and usually had successful angioplasty were not included. Patients are selected depending on mentioned criteria and their file information and other follow up sheets of the vascular clinic. The aim of the study was to find their outcome according to the surgical vascular repairs and following limb salvages and considering survival along with success in treatment of ischemic diabetic feet. Of note, we had invented and institute a routinely considered experimental predictor and conditional foundation based on our internal pilot study for assessment of the clinical degree of ischemia outcome in distal cut-edge of ischemic wounds that toe pressure measurement is not feasible. That is an "observational index" which is institutionalized and has named as "Blood Dropping Time" (BDT). That was defined in seconds and is the duration of cut-edge bleeding for a drop formation to be freely drop from the incision of debrided or amputated peri-gangrene or peri-wound skin while the extremity being held in about 20 degrees up (from the zero point) for interfering of hyperemic venous and ischemic static situations. We believe that this index is directly related to the severity of microangiopathy in diabetic wounds; compatible with Toe pressure and clinically reflects the foot circulatory angiosomes; along with the outcome of the wound which determines necessity of the next approach and also assigns on table. In normal interpretation (two palpable and acceptable pulses), index has found as 1-3 seconds maximum. In mild to moderate reduced circulation (one Palpable pulse), about 7-10, and moderate to severe (no pulse, delayed capillary filling of 3-5 seconds) 12-17 seconds and severe (no pulses, no capillary filling, tip of the toes cyanosis), =30 seconds or further "no dropping- no circulation" situation (Table,1). The extremities for arterial

Table 1. Defined explanation of Blood Dropping Time foundation (BDT) used for determining the wound suggesting outcome.

Foot status Classification	Pulses	Clinical signs Capillary filling	Foot appearance	BDT (mean) in seconds	Predicted wound outcome, and approach
Normal Mild to Moderate	+DP*, +PT** one Pulse +DP or PT	≤1 second ≤3 seconds	Warm reddish pink Less warm Purple	1 - 3 s maximum 7 -10 s	Complete wound healing. Suturing. Delayed healing, ± dehiscence or infection. Open wound.
Moderate to severe	No pulses	Delayed capillary filling of ≥ 3-5 seconds No capillary filling	Cool Bluish purple	12 -17 s	Non-healing wound progresses to gangrene. Vascular intervention.
Severe	No pulse		Cold Bleach/pale foot or mottled forefoot with Toes tip cyanosis	≥ 30 s	Gangrenous non-healing wound. Vascular intervention + high amputation
No circulation	No pulse	No capillary feeding	Dead Gangrene	No bleeding	High amputation

*Dorsalis Pedis pulse. **Posterior Tibialis pulse

repair had been explored and possible technical repair such as endarterectomy with vein or ePTFE patches or bypass grafting by Dacron tube in thigh or saphenous vein according to feasibility in calves, had been performed. The sum of reported and achieved BDT seconds pre and post operation was compared and analyzed P value calculated via T test by SSPS software, version 14.

RESULTS

From our files there were 158 cases of diabetic foot ulcers had been referred for treatment. From all, 96 cases had treated with out-patient medical and some supporting interventional therapy. 49 patients had been admitted for debridement and amputation with good capillary filling but severe infectious gangrene wounds that were excluded from the study. 41 cases (28 male, mean age=56 and 13 female, mean age= 62.4) who had been admitted (4 -22, mean= 8.5 days) for ischemic non-neuropathic diabetic ulcers were eligible and considered for study that all had Doppler reports had revealed very low damped distal circulation, some with ABI =0.5 and toe pressure in 11 cases <30 mmHg and Toe –Brachial indexes were <0.6. Conventional or CT angiography reports had revealed occlusion and good or relative runoff as the indication for surgery. Arterial repair was performed in all while all had more than 10 years diabetic involvement (9 cases >20). All the patients had angiography which revealed main arterial (iliac, femoral, popliteal and distal anterior/posterior tibial) occlusions. The most complain was infected gangrenous toes with or without ischemic forefoot or plantar gangrene. Mean BDT was about 71 seconds before repair and salvaging amputation while, its average became 8.46 seconds after vascular repair (paired T test, t=3.836 for 95% confidence) (P=00.002). There were eleven cases of femoro-popliteal bypass, had repaired by saphenous vein conduit in 9, one composite graft (Dacron – vein) and one Dacron graft repair. Seven femoro-popliteal endarterectomy and patch, four popliteo-tibial reconstruction bypass by autogenous vein, five ilio-femoral endarterectomy and patch, eleven popliteal endarterectomy with vein patch repair and three non-reparable femoral-popliteal-distal explore due to severe arterial calcification (Table, 2). Annual patency of Dacron

Table 2. Vascular reconstruction procedures and used kinds of conduits

Type of vascular repair	Synthetic Prosthesis	Vein Autogenous	Compound* Prosthesis	No, Total
Ilio-femoral Endartrectomy + Patch	3 (ePTFE)	2	0	5
Femoro-Popliteal Endartrectomy + Patch	2 (ePTFE)	5	0	7
Femoro-Popliteal Bypass	1 (Dacron)	9	1	11
Popliteal- Tibial Endartrectomy + Patch	0	11	0	11
Popliteal-Tibial Bypass	0	4	0	4
Non – repairable Explore	–	–	–	3

* Dacron-vein compound grafting.

was 13 months versus autogenous vein bypasses for femoro-popliteal were 22-61 months and for popliteo-tibial were 9-16 months. Result for control of the mean time of complete improvement of ulcers was 34.53 days after surgery and mean granulation tissue coverage was 11 days. Complete recovery was ended to different feet amputations (single toe/ transmetatarsal forefoot/ Chopart technique) in all cases and ischemia was controlled. Two previous counterpart amputations, one chronic renal failure and one death after reconstruction due to hypotension and MI had mentioned in our cases. Antibiotic protocol was intravenous Ciprofloxacin+Clindamycin, Levofloxacin+Meropenem or combination of ceftizoxim or ceftazidim and amikacin had followed by oral administration. All the patients had supported by intravenous heparin (FH) for 3-5 days and oral administration of aspirin+warfarin or Aspirin+Clopidogrel tablets at least for three months. All the patients with circulated limbs and pretty good to good capillary filling had been able to walk on their feet with or without supports and walkers with acceptable complete healing after discharge.

DISCUSSION

It is now well accepted that diabetic foot management is not pure medical. In fact, diabetes involving team especially physicians require potential cognition for on time primary applications of interventional or surgical remedy based on the prompt decision making, followed and supported by simultaneous medical and antibiotic therapy. Believe in the strategy of surgical intervention as the first plan for infection control and then assessment

of the limb ischemia have to be settled for diabetic feet to achieve sustained healing and maximum limb salvage.^{2- 4,6} Apart from standard clinical evaluations, two points are addressed crucial for this high risk population. First, timely diagnosis and being assured of arterial perfusion to the foot by an expert and if be needed, an angiography^{4,6,7,11}; second, possible revascularization simultaneously, otherwise in the beginning of the treatment.^{5,6,11} Literary, the knowledge in presence of arterial disease confers an overall poor prognosis in diabetics for both life and limbs.⁷ But, in spite of low cumulative limb salvage rate, high neuropathy score, raise in the thought of unsuccessful distal limb vascular repair for handling of diabetic feet; usually, all the applicable arterial reconstructive procedures towards aorto-tibial direction can be effective as compared to non-diabetics, especially in pedal bypass repair which is a safe method with good long term outcome.^{4,5,11,13-18} Therefore, diabetic foot ischemia and wounds knowledge ought to be enough understood and be well directed towards promising outcome by fulfilling a cost-effective and efficient vascular interventional or surgical treatment whenever is feasible. Of course, based on a long time admission of diabetics beside multiple successive procedures pertained to their healing prospect with ischemia, individual cost accounting of limb preservation may not be usually economical. Especially with vascular interventions and surgery expenses are being issued. Nevertheless now, even in spite of expensive vascular surgery on diabetics compared to the last decade; believing in Panayiotopoulos *et al.*¹⁹ who had claimed in the year 1970 that femoro-distal reconstruction surgery in both diabetic and non-diabetic patients may be cheaper option than multiple primary amputation

and admissions, seems to be justified. In regards, overall now, it was also the same as before in our patients. Exceptionally, in recruited patients for non-surgical-interventional modalities, based on their financial issues and their recovery expenses; we have found them being considered neither economical nor acceptable due to tandem vascular interventions based on their established ischemia and delay for surgery and country economical situation. In support, since it has been found that if autogenous vein has being utilized, because of its good patency, the age, sex, diabetes and the condition of the out flow artery do not influence outcome in arterial reconstruction of distal foot; even if, we do not know how good the off-loading is or in the absence of pedal arteries on angiogram.^{4,15,}

²⁰ Therefore, the trend has been persuaded toward vascular surgery reconstruction by venous conduits in order to achieve long relief in comparison with angioplasty and non-surgical interventions. In this regards, sum of annual patency in our bypassed cases considering accompanied interfering clinical complexes of diabetes, confirm preferred utilizing of autogenous vein tubes. Meanwhile, our results also have shown 92.3% success with vascular repair based on obtained statistic index for BDT which was implicative for a lot of vascular reconstruction control in our ischemic diabetic patients and could be impressive for feasible healing results with aimed salvaging extremities; “the fact that encourages the surgeons to use economical arterial reconstruction strategy for threatening ischemia that superimpose diabetic feet” and conclusively before any attempt for decision making in diabetic foot.²¹ Otherwise then, should switch to essential medical managements with consecutive amputations. In this relation, some complementary medical therapy such as iloprost infusion in selected cases has been shown that provide high distal flow with complete healing of wounds.²² Besides now, iloprost have shown to be a predictor of successful surgical revascularization²³ that can be used bi-directional in order to treat the foot medically or evaluate possibility of surgical successes for future applying. Consequently, we claim that total advantages of ilio-distal vascular repairs as the most required procedures suggested in resistant limb threatening ischemia in diabetic feet ulcers are provided as:

- Very better infection control.

- Suitable ground for fast granulation coverage.
- Shorten and limiting healing tim.
- Limits amputation levels and spare the ideal length of limb salvage.
- Better reconstructive skin coverage (grafts, flaps).
- Possible and certain walking by patient’s own feet.

Therefore, it also seems determining of the circulatory status of diabetic feet as the first consideration has to be professionally legislated, considering the probable preference of economical acceptance of revascularization in compare to angioplasty or stentings.

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REFERENCES

1. Younes NA, Bakri FG. Diabetic foot infection. *Saudi Med J*; **27**(5):596-603 (2006).
2. Shigematsu K, Shigematsu H. Surgical management of the diabetic foot. *Clin Calcium*; **13**(9):1179-84 (2003).
3. Lioupis C. The role of distal arterial reconstruction in patients with diabetic foot ischemia. *Int J Low Extrem Wounds*; **4**(1):45-9 (2005).
4. Andros G. Diagnostic and therapeutic arterial interventions in the ulcerated diabetic foot. *Diabetes Metab Res Rev*; **20** Suppl 1:S29-33 (2004).
5. Shor NA, Chumak IuF, Reuka VP, Zhukov OA. Restorative operations on main vessels for diabetic angiopathy of lower extremities with purulent- necrotic complications. *Klin Khir*; **(9)**:20-2 (2003).
6. Sumpio BE, Lee T, Blume PA. Vascular evaluation and arterial reconstruction of the diabetic foot. *Clin Podiatr Med Surg*; **20**(4):689-708 (2003).
7. Campbell WB, Ponette D, Sugiono M. Long-term results following operation for diabetic foot problems: arterial disease confers a poor prognosis. *Eur J Vasc Endovasc Surg*; **19**(2):174-7 (2000).
8. Alvelo JL, Papademetris X, Mena-Hurtado C, Jeon S, Sumpio BE, Sinusas AJ, Stacy MR. Radiotracer imaging allows for noninvasive detection and quantification of abnormalities in angiosome foot perfusion in diabetic patients with critical limb ischemia and nonhealing wounds. *Circ Cardiovasc Imaging*. 2018 may; **11**(5):e006932. Doi:10.1161/CIRCIMAGING.117.006932.
9. Weaver ML, Hicks CW, Canner JK, Sherman

- RL, Hines KF, Mathioudakis N, Abularrage CJ. The society for vascular surgery wound, ischemia, and foot infection (Wlfi) classification system predicts wound healing better than direct angiosome perfusion in diabetic foot wounds. *J Vasc Surg.*; **68**(5):1473-1481. Doi: 10.1016/j.jvs.2018.01.060. Epub 2018 May 24 (2018).
10. Meloni M, Izzo V, Giurato L, Del Giudice C, Da Ros V, Cervelli V, Gandini R, Uccioli L. Recurrence of critical limb ischemia after endovascular intervention in patients with diabetic foot ulcers. *Adv Wound Care (New Rachele)*; **7**(6):171-176 (2018). Doi: 10.1089/wound.2017.0778.
 11. Petrasovic M, Belacek J, Holoman M. Pedal bypass in the treatment of arterial occlusive disease of the lower extremities in diabetics. *Bratisl Lek Listy*. **100**(6):312-6 (1999). Slovak.
 12. Toursarkissian B, D'Ayala M, Stefanidis D, Shireman PK, Harrison A, Schoolfield J, Sykes MT. Angiographic scoring of vascular occlusive disease in the diabetic foot: relevance to bypass graft patency and limb salvage. *J Vasc Surg.* **35**(3):494-500 (2002).
 13. Calle-Pascual AL, Duran A, Diaz A, Monux G, Serrano FJ, de la Torre NG, Moraga I, Calle JR, Charro A, Maranes JP. Comparison of peripheral arterial reconstruction in diabetic and non-diabetic patients: a prospective clinic-based study. *Diabetes Res Clin Pract.* **53**(2):129-36 (2001).
 14. Debus ES, Timmermann W, Sailer M, Schmidt K, Reith HB, Franke S. Arterial reconstruction in arteriopathic diabetic perforating ulcer- is it effective? Revascularization in diabetes mellitus and peripheral arterial occlusive disease. *Zentralbl Chir.*; **124** Suppl 1:36-9 (1999).
 15. Staffa R, Leybold J, Kriz Z. Pedal bypass for limb salvage. *Acta Chir belg.*; **105**(5):491-6 (2005).
 16. Vermassen FE, van Landuyt K. Combined vascular reconstruction and free flap transfer in diabetic arterial disease. *Diabetes Metab Res Rev*; **16** Suppl 1:S33-6 (2000).
 17. Holstein PE, Sorensen S. Limb salvage experience in a multidisciplinary diabetic foot unit. *Diabetes Care.* **22** Suppl 2:B97-103 (1999).
 18. Albrektsen SB, Henriksen BM, Holstein PE. Minor amputations on the feet after revascularization for gangrene. A consecutive series of 95 limbs. *Acta Orthop Scand.* **68**(3):291-3 (1997).
 19. Panayiotopoulos YP, Tyrrell MR, Arnold FJ, Korzon-Burakowska A, Amiel SA, Taylor PR. Results and cost analysis of distal [crural/pedal] arterial revascularisation for limb salvage in diabetic and non-diabetic patients. *Diabet Med* **14**(3):214-20 (1997).
 20. Luther M, Lepantalo M. Luther M, Lepantalo M. Arterial reconstruction to the foot arteries—a viable option? *Eur J Surg.*; **163**(9):659-65 (1997).
 21. Niagu C, Buzea A, Agache A, Geogerscu D, Patrascu T. Surgical revascularization in chronic limb-threatening ischemia in diabetic patients. *Chirurgia (Bucur)*; **113**(5):668-677 (2018). Doi: 10.21614/chirurgia.1135.668.
 22. Miranda F, La Spada M, Baccellieri D, Stilo F, Benedetto F, Spinelli F. Iloprost infusion in diabetic patients with peripheral arterial occlusive disease and foot ulcers. *Chir Ital.*; **57**(6):731-5 (2005).
 23. Izzo V, Meloni M, Giurato L, Uccioli L. The prostacyclin analogue iloprost as an early predictor of successful revascularization in diabetic patients affected by critical limb ischemia and foot ulcers. *Cardiovasc Revasc Med* (2018). pii:S1553-8389(18)30397-X. doi: 10.1016/j.carrev.2018.08.021. [Epub ahead of print]