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Effects of Revascularization for Delayed Limb Ischemia

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Abstract: Purpose Delayed presentation about major vascular injury is very common in developing countries because of limited vascular trauma units. Diagnosis delay and time lost in transfer pose a major challenge for the salvation of the limb. The objective of this study is to enroll patients' data and analyze the outcomes related to revascularization of post-traumatic delayed due to limb ischemia.Method: A total of 120 patients with lower limb ischemia who underwent revascularization were included in the study. The clinical data were collected during a one-year follow-up period from February 2024 to February 2025 in different hospitals in Iraq. In this cross-sectional study, clinical outcomes were compared between two groups: early-stage (60 patients) and late-stage (60 patients). A comparative analysis of clinical outcomes was conducted between the two groups, with specific attention devoted to the assessment of mortality, limb salvage, and quality of life. Results :A comparative analysis was conducted on the clinical outcomes of revascularization in both groups (n = 120) following traumatic injuries. According to the findings of the early limb ischemia group, the level of occlusion, including femoropopliteal, was found to be 54 cases (90%), 57 out of 60 cases were limb salvage rate, mortality rate was 0%, length of stay in the hospital was 5.3 ± 1.4 days, post-procedure complications had 10%, and sitting mobility after revascularization had 2.8 ± 0.06. According to the delayed limb ischemia group, the outcomes demonstrated that 48 cases (80%) of femoropopliteal lesions were successfully salvaged, while the mortality rate was 20%. The mean hospital stay was 8.5 ± 1.2 days, and 35% of patients experienced post-procedural complications. Following revascularization, sitting mobility was 1.0 ± 0.2.Conclusion: Although revascularization after delayed limb ischemia is difficult, there are several circumstances in which treatment might be beneficial. According to this study, effective limb salvage is still possible even after extended ischemia, even if early intervention is preferable, as long as suitable surgical procedures and diligent monitoring are used.

Keywords: Revascularization, Delayed limb ischemia; Limb salvage; Mortality rate; and (SF-36) Quality of life questionnaire.

INTRODUCTION

Significant anatomical and physiological changes were frequently caused by trauma, which can range from high-impact car crashes to sports injuries (Olinic, D. M. *et al.*, 2019), where one of the most serious consequences of trauma is the development of ischemia, especially in the limbs (Dormandy, J. *et al.*, 1999). Also, delayed limb ischemia is characterized as a progressive compromise of blood flow in the limbs due to injury-related vascular damage or thrombosis, which can result in tissue hypoxia and necrosis if treatment is not received promptly (Baril, D. T. *et al.*, 2014; Genovese, E. A. *et al.*, 2016) which it is crucial to comprehend the pathophysiology behind delayed limb ischemia in order to diagnose and effectively treat the condition, since the rate of limb salvage depends on the restored blood supply to the compromised tissues. (Kulezic, A., & Acosta, S. 2022)

In addition, the original traumatic event, following inflammatory reactions, and possible clot development in the vascular tree are all intricately intertwined variables that contribute to delayed limb ischemia (Creager, M. A. *et al.*, 2012; Penninx, B. W. *et al.*, 2004) along with ischemia disorders might appear hours to days after an accident, making the initial evaluation and treatment plans more difficult (Reck-de-Jesus, S. *et al.*, 2018). Furthermore, a higher risk of morbidity and death is frequently associated with delayed identification, trauma, and orthopedic surgeons must keep a close eye out for delayed ischemia episodes (Patel, K. V. 2008), where the risk of irreparable damage increases, underscoring the urgency of early detection and treatment (Wrede, A. *et al.*, 2018).

Revascularization is the main therapy option for delayed limb ischemia. By restoring blood supply to the injured limb, this technique seeks to maintain its viability and function (Lowry, D. *et al.*, 2018; Ablove, R. H. *et al.*, 2006). Depending on the location and kind of arterial lesion, revascularization treatments may involve surgical procedures like thrombolysis, endovascular stenting, or vascular bypass (Waton, S. *et al.*, 2015). Depending on the degree of ischemia damage and the patient's general health, each strategy has its own advantages and disadvantages (Nickinson, A. T. *et al.*, 2020). The incidence of problems linked to delayed ischemia has decreased as a result of recent improvements in surgical methods and imaging technologies, which have

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improved outcomes after revascularization (Vascular Society of Great Britain and Ireland).

Furthermore, maximizing results in patients at increased risk for delayed limb ischemia requires interdisciplinary cooperation (Communities and Local Government, 2021), which a thorough approach to patient treatment is ensured by including critical care experts, vascular surgeons, and trauma surgeons (Armitage, J. N., & Van Der Meulen, J. H. 2010) as well as the hazards of delayed limb ischemia can be further reduced by using adjuvant medications, such as analgesics and anticoagulation, in conjunction with ongoing monitoring and evaluation of limb perfusion (Sasieni, P. 1995). As revascularization necessitates a coordinated effort to handle not just the physiological deficits but additionally the emotional along with psychological components of recovery, rehabilitation activities are crucial. (Sasieni, P. *et al.*, 2005; Pankhurst, C. J. W., & Edmonds, M. E. 2018)

The literature shows an increasing interest in improving procedures for the prompt detection and management of delayed limb ischemia in recent years (Noronen, K. *et al.*, 2017). The goal is still the same as research advances: to better understand the processes of limb ischemia after catastrophic injuries and to develop treatment approaches that increase afflicted patients' survival and function (Waton, S. *et al.*, 2015; Nickinson, A. T. *et al.*, 2021). A strong foundation of clinical standards and ongoing education for healthcare personnel involved in trauma treatment are necessary due to the complexity of addressing such situations (Reinecke, H. *et al.*, 2015).

PATIENTS AND METHODS

Study Design

A cross-sectional study was conducted using collected data from 120 patients with limb ischemia who presented at different hospitals in Iraq from February 2024 to February 2025.
Inclusion and Exclusion Criteria

Inclusion Criteria

1. The patient exhibited symptoms indicative of limb ischemia.
2. The age group encompasses individuals between the ages of 40 and 65.
3. The subject is a smoker who is also obese.
4. Patients with Comorbidities: An analysis of the implications for healthcare provision

The following criteria serve as exclusionary factors: The presence of any prior vascular interventions is also to be documented.
1. The state of being pregnant.
2. The patients who did not complete the questionnaire.

Patient Selection

The present study collected data from 120 patients diagnosed with lower limb ischemia. The medical records of these patients were reviewed during a one-year follow-up period at different hospitals in Iraq. The patient data were divided into two groups, with a full day designated as the standard time to the onset of symptoms. Within 24 hours, 60 patients with early-stage symptoms were included, with symptoms manifesting over the course of a full day. The study's sample population comprised 60 patients with late-stage symptoms who were enrolled over a period of 1 to 10 days. Subsequent to revascularization, a series of clinical parameters were meticulously documented during the ensuing follow-up period. Patients between the two groups were compared post-revascularization in terms of limb salvage rate, mortality rate, and patient quality of life.

Preoperative Management

All patients received a bolus dose of heparin at a dose of 80 units per kilogram of body weight, followed by an infusion at a rate of 18 units per kilogram per hour in emergency circumstances. All patients were initiated on a hydration regimen, and Foley catheterization was performed. Prior to the surgical intervention, a series of blood tests were conducted on an urgent basis to assess the patient's renal function and cardiac health. These tests included the measurement of creatinine phosphokinase levels and two-dimensional echocardiography. All patients underwent imaging in the form of urgent arterial duplex of the index limb and/or computed tomography angiogram from the arch of the aorta to the bilateral lower limb.

Postoperative Management

In terms of surgical intervention, all patients were monitored in the intensive care unit for a period of 24 hours, where they were administered an unfractionated heparin infusion. Activated clotting time (ACT) was monitored at 4-hour intervals and maintained within the range of 250 to 300 seconds as well as following 24 hours postoperatively, the patient's anticoagulation treatment was transitioned to low-molecular-weight heparin, which this modification was maintained for a duration of two

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weeks following the patient's discharge from the medical facility. Due to that, the therapeutic approach was transitioned to oral anticoagulation, specifically utilizing vitamin K antagonists, which were administered for an indeterminate period.

Hospital Mobility Scale (HMS)

The Hospital Mobility Scale (HMS) is an evaluation tool used to assess the mobility of the hospitalized patient-on-a a course of active recovery from acute ischemic stroke. The test incorporates three essential tasks: sitting, standing, and walking, which permits the clear prediction of functional outcomes while directing the rehabilitation efforts. The scoring of HMS ranges from 0 (total immobility) to 3 (full mobility), thereby providing a clear picture of a patient's mobility status.

Statistical Analysis

Categorical variables were presented as counts and percentages, whereas continuous variables were presented as mean values ± standard deviations. The comparison of categorical variables was conducted through the utilization of Fisher's exact test or the Chi-square test, depending on the nature of the variable. The continuous variables were then subjected to a comparison using the unpaired t-test. A statistically significant difference was indicated by a p-value less than 0.05. All statistical analysis was performed using the SPSS program, version 22.0.

RESULTS

Our study enrolled clinical and demographic characteristics of 120 patients. The current demographic outcomes shown patients' age < 50 had 37.5% and ≥ 50 had 62.5%. Our study indicated that 45% of patients got obesity, 65% of patients were smokers, hypertension of 52.5 % had hypertension, and diabetes of 35% had diabetes. The most common symptoms observed in our study got severe pain with 73.33%, Cold leg or foot with 55.83%, and muscle weakness or paralysis with 60%.

Table 1: Baseline demographic features of (n = 120) patients in this study.

Features	Parameters	N = 120	Percentage, %
Age (years)			
	< 50	45	37.5%
	≥ 50	75	62.5%
Gender			
	Males	90	75%
	Females	30	25%
BMI (kg/m2)			
	Underweight	6	5%
	Normal weight	24	20%
	Overweight	36	30%
	Obese	54	45%
Smoking			
	Present	78	65%
	Absent	42	35%
Co – morbidity			
	Present	72	60%
	Absent	48	40%
	Hypertension	63	52.5%
	Diabetes	42	35%
	Ischemic heart disease	54	45%
	Atrial fibrillation	12	10%
	Cerebrovascular accidents	9	7.5%
	Malignancy	0	0%
	Epilepsy	0	0%
	Dyslipidemia	0	0%
Symptoms			
	Severe pain	88	73.33%
	Pale or blue (cyanotic) skin	37	30.83%
	Cold leg or foot	67	55.83%
	Numbness or tingling	45	37.5%
	Weak or absent pulse in the affected limb	32	26.67%
	Muscle weakness or paralysis	72	60.0%

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	Gangrene	55	45.83%
	Slow-healing wounds or ulcers	15	12.5%
Education status			
	Primary	18	15%
	Secondary	30	25%
	University	72	60%
Occupation status			
	Employer	34	28.33%
	Worker	24	20.0%
	Housewife	16	13.33%
	Un-worker	16	13.33%
	Retired	30	25.0%
Economic status, $			
	< 500	66	55%
	500 – 800	34	28.33%
	> 800	20	16.67%

Based on clinical outcomes, occlusion is classified into three levels, which include aortoiliac, femoropopliteal, and tibial. We found the femoropopliteal found out as the most prevalence into both groups, where the early limb ischemia group had 90% and the delayed limb ischemia group had 80%.

Table 2: Frequency distribution levels of occlusion on patients.

Level of occlusion	Early limb ischemia (60)	Delayed limb ischemia (60)	P – value
Aortoiliac	24 (40%)	35 (58.33%)	0.066
Femoropopliteal	54 (90%)	48 (80%)	0.04
Tibial	33 (55%)	37 (61.67%)	0.062

According to clinical outcomes of patients, we enrolled surgical interventions conducted on patients where Trans the trans-femoral thrombectomy procedure as the common intervention into all patients, where it was performed on 90% of early limb ischemia and 88.33% of delayed limb ischemia. %. In terms of post-procedure outcomes, our study in the early limb ischemia group had 57 out of 60 cases were a limb salvage rate, mortality rate was 0%, length of stay in the hospital was 5.3 ± 1.4 days, post-procedure complications had 10%, and sitting mobility after revascularization had 2.8 ± 0.06, while delayed limb ischemia group demonstrated that 44 0f 60 cases had limb salvage rate, the mortality rate was 20%. The mean hospital stay was 8.5 ± 1.2 days, and 35% of patients experienced post-procedural complications following revascularization, and sitting mobility was 1.0 ± 0.2.

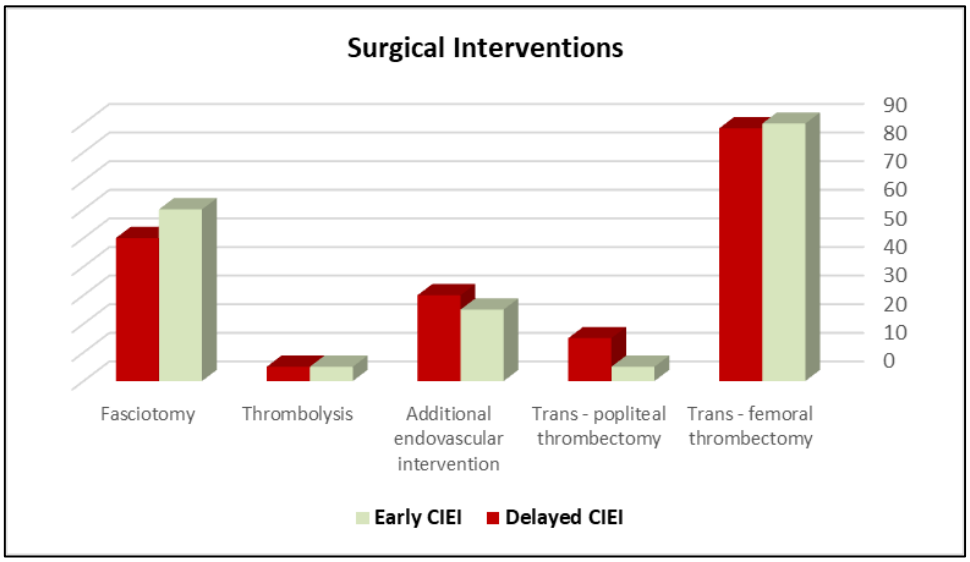

Figure 1: Identifying surgical interventions at patients.

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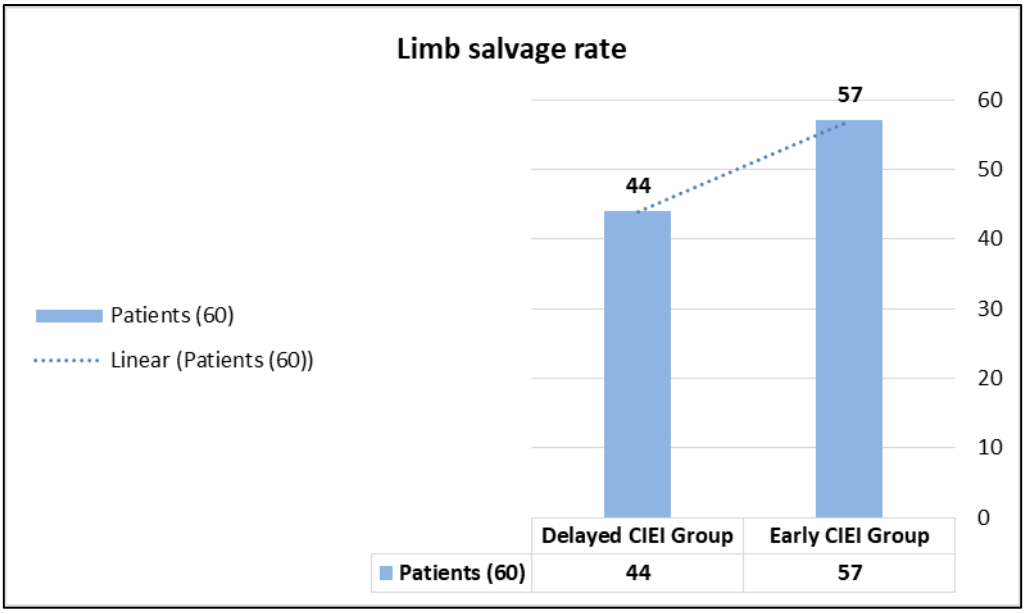

Figure 2: Determining post-procedure limb salvage rate at patients.

Table 3: Postoperative outcomes, including mortality rate, length of stay, complications, and functional recovery.

	Early limb ischemia Group		Delayed limb ischemia (60)	
Parameters	**N = 60**	**%**	**N = 60**	**%**
Mortality rate				
Yes	0	0%	12	20%
No	60	100%	40	80%
Length of stays in hospital, {days}	5.3 ± 1.4		8.5 ± 1.2	
Complications	6	10%	21	35%
Swelling	2	3.33%	4	6.67%
Continuous pain	1	1.67%	2	3.33%
Compartment syndrome	1	1.67%	6	10.0%
Graft/stent thrombosis	0	0.0%	3	5.0%
Infection	2	3.33%	6	10.0%
Mobility after revascularization using the Hospital Mobility Scale (HMS)				
Sitting	2.8 ± 0.06		1.0 ± 0.2	
Standing	2.9 ± 0.002		1.3 ± 0.8	
Gait	2.7 ± 0.08		1.8 ± 0.6	

Table 4: Assessment (SF-36) general health quality of life questionnaire at patients after intervention.

Items	Early limb ischemia Group	Delayed limb ischemia (60)
Physical function	82.11 ± 4.29	60.68 ± 7.88
Psychological function	84.71 ± 5.48	59.93 ± 5.64
Emotional and Social functions	80.66 ± 3.90	56.61 ± 5.66
Daily activity	81.79 ± 4.97	54.59 ± 6.57

In terms of assessment of health quality of life (SF-36), this study noticed improved in quality of life in the early limb ischemia group, including physical function, which was 82.11 ± 4.29. Psychological function was 84.71 ± 5.48, while it dropped in the health quality of life of the delayed limb ISCHEMIA group, especially in comparison with the early limb ischemia group, where physical function was 60.68 ± 7.88 and psychological function was 59.93 ± 5.64.

DISCUSSION

Limb ischemia can be defined as a decrease in limb perfusion that causes, hypothetically, a limb

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threat because it the limb is no longer perfused. Salvage is dependent on the time from symptom onset to revascularization. (Waton, S. *et al.*, 2015; Stile Investigators, 1994; Hoch, J. R. *et al.*, 1994).

That in an overall one-year limb salvage rate in immediately threatened lower limb ischemia in the early group it was 100% (60/60), while in the delayed group, it was also 100% (60/60); that shows early revascularization can improve limb salvage but would also imply good limb salvage might be achieved even with the delayed presentation if revascularization attempt is done.

For the delayed limb ischemia group, the death rate turned out to be 20%, while in the early limb ischemia group, it was 0%. An analogous retrospective study in the USA with acute lower extremity ischemia patients numbering 170, out of which a clear majority (83%) presented beyond six hours, noted a limb salvage rate of 85% at 3 months. In this study, 52% of patients were Rutherford Class IIb, and the median time to amputation was 1 day, and 30-day mortality was 18%. (Hoch, J. R. *et al.*, 1994; Taha, A. G. *et al.*, 2015; Seeger, J. M. *et al.*, 1987).

A study conducted in Germany (de Donato, G. *et al.*, 2014) in 206 patients assessed the relevance of revascularization in treating late-presenting patients (>72h) of acute ischemia and found an overall limb salvage rate of 86.90% at 6 months and a mortality rate of 5.8%.

A Spanish study (Berridge, D. C. *et al.*, 1989) in 509 patients with acute lower limb ischemia has assessed the perioperative results concerning limb salvage and mortality, recording an 84% perioperative limb salvage and 13% mortality.

CONCLUSION

This study concludes by highlighting significant differences in the outcomes of early and delayed limb ischemia revascularization, which have important ramifications for clinical judgment. Due to a decreased risk of complications and less permanent tissue damage, early revascularization (ELI) shows better outcomes both in terms of limb salvage rates, mobility status, and quality of life. On the other hand, delayed revascularization (DLI) is related to longer hospital admissions, greater death rates, and more enduring symptoms. These outcomes may be caused by systemic sequelae like sepsis or reperfusion damage, as well as prolonged ischemia.

Our results highlight the need of prompt vascular intervention to maximize limb salvage, functional recovery, or survival, even if both groups need intensive, multidisciplinary care. In order to reduce long-term impairment and healthcare costs, future research should concentrate on standardized methods for early identification and intervention, especially in high-risk trauma groups.

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