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Validation of the Global Limb Anatomical Staging System (GLASS) in first time lower extremity revascularisation in Chronic Limb Threatening Ischemia (CLTI)

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Abstract

Background: Chronic limb-threatening ischemia (CLTI) is a condition that has significant effects on morbidity, mortality, and public health. There are numerous ways to treat CLTI, including open and endovascular revascularization procedures. Global Limb Anatomic Staging System (GLASS) was developed in an effort to support revascularization decision-making. **Objectives:** To determine the immediate technical outcomes of pulsatile inline flow to the foot and investigate its correlation with pedal disease descriptors using the GLASS Staging system. **Material and methods:** This retrospective study conducted at Madras Medical College from January 2020 to March 2022 includes 200 consecutive patients diagnosed with CLTI who underwent first-time open or endovascular intervention. The angiographic images of the patients' limbs were reviewed and classified based on the GLASS Staging system, and each limb was categorized according to the Pedal disease descriptor. Difference in proportions were tested for statistical significance in difference using Chi square test. A p value <0.05 was considered statistically significant. **Results:** Among the participants, 71 received Endovascular intervention, with 18.3% classified as GLASS I, 43.7% as GLASS II, and 38.0% as GLASS III. On the other hand, 129 participants underwent Open-Bypass intervention, with 17.1% classified as GLASS I, 18.6% as GLASS II, and 64.3% as GLASS III. There was a statistically significant association between the pedal disease descriptor and GLASS staging. **Conclusion:** GLASS stage and pedal disease descriptor could be used to predict the establishment of pulsatile inline flow to foot. Higher the GLASS stage correlates with poor pedal disease descriptor.

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Introduction

Globally, peripheral artery disease (PAD) is a frequent condition. An estimated 202 million persons worldwide had PAD in 2010.[1] Nearly, 1% to 2% of patients with lower extremity PAD have chronic limb-threatening ischemia (CLTI), or chronic limb-threatening ischemia. 20% of people with CLTI will have an amputation, and 25% will pass away within a year.[2,3] In recent years, PAD has become more common, most likely as a result of the rising incidence of diabetes mellitus (DM) brought on by the ageing population.[4] As a result, CLTI is a condition that has significant effects on morbidity, mortality, and public health. There are numerous ways to treat CLTI, including open and endovascular revascularization procedures. In order to offer efficient, long-lasting treatment choices that will result in better outcomes, new solutions are required since the number of patients suffering from CLTI keeps rising. For many years, the decision to revascularize patients with CLTI had not been standardised; instead, it had been largely driven by the preferences and personal beliefs of experienced surgeons. Clinical trials that are now being conducted and recent ones are seeking to fill this evidence gap, and modern practise guidelines encourage increased standardisation in diagnosis and therapy.[5-7] Based on expert consensus and the best available data, the Global Limb Anatomic Staging System (GLASS) was developed in an effort to support revascularization decision-making.[8] For GLASS staging, the Femoropopliteal (FP) and Infrapopliteal (IP) segments must be scored separately. The preferred IP artery for revascularization in this situation is the Target Artery Pathway(TAP), which the observer must first identify. The surgeon establishes the TAP, which is then recognised either retroactively during a case, from operating notes, or on the basis of imaging data of the IP artery that was predominantly targeted for intervention. In the absence of this data, the TAP is chosen as the IP artery that seems to be the least damaged on imaging. It's also crucial to understand that GLASS was created with angiographic imaging in mind. Therefore, all imaging and scoring performed for this study are related to angiograms.[9,10] A TAP, which connects the groin to the foot, should be restored with a pulsatile in-line flow following successful revascularization, whether it be surgical or endovascular.

Aim:

The aim of this study was to validate the GLASS Staging system by assessing the immediate technical outcome of establishment of Pulsatile Inline flow across the various stages of GLASS.

Objective :

- To determine the immediate technical outcomes of pulsatile inline flow to the foot
- Investigate its correlation with pedal disease descriptors using the GLASS Staging system

Material and methods

The present study is a retrospective observational study conducted at Madras Medical College in Chennai from January 2019 to March 2021. The study focused on 200 consecutive patients diagnosed with Critical Limb Threatening Ischemia (CLTI) who underwent their first-time open or endovascular intervention during the specified study period. Data for the study were collected from the hospital's medical records and angiographic images. Patients who had incomplete medical records or missing angiographic images, as well as those who had previously undergone open or endovascular interventions for CLTI, were excluded from

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the study. The angiographic images of the patients' limbs were reviewed and classified based on the GLASS Staging system, which categorizes limbs into three stages: GLASS Stage I, II, or III, depending on the severity of ischemia. Additionally, each limb was categorized according to the Pedal disease descriptor, which classified them into P0 (Target artery crosses ankle into foot, with intact pedal arch), P1 (Artery crosses ankle into foot; absent or severely diseased pedal arch), or P2 (No target artery crossing ankle into foot). The collected data, including GLASS Staging and Pedal disease descriptors, were subjected to statistical analysis to explore the correlation between these two variables. The study adhered to ethical guidelines, ensuring patient confidentiality and data protection. Data entry was done using MS Excel 2016 and data analysis was done using IBM Statistical Package for Social Sciences (SPSS) version 26.0., Armonk, NY. Means and proportions were presented for continuous and categorical variables respectively. Difference in proportions were tested for statistical significance in difference using Chi square test. A p value <0.05 was considered statistically significant.

Results

Among the participants, 23.0% fell in the age range of 50-54, 15.5% were aged 55-59, 18.5% belonged to the 60-64 age group, 20.0% were in the 65-69 age range, and the same percentage (23.0%) comprised individuals aged 70 and above. Males accounted for 81.5% of the total participants, while females represented 18.5%. Among the participants, 17.5% were classified as GLASS I, 27.5% as GLASS II, and the largest group, comprising 55.0%, were categorized as GLASS III. The Pedal descriptor '0' was assigned to 15.0% of the participants, '1' to 52.0%, and '2' to 33.0%. (Table 1)

Among the participants, 71 received Endovascular intervention, with 18.3% classified as GLASS I, 43.7% as GLASS II, and 38.0% as GLASS III. On the other hand, 129 participants underwent Open-Bypass intervention, with 17.1% classified as GLASS I, 18.6% as GLASS II, and 64.3% as GLASS III. Among the participants, 30 were classified as P0, with 63.3% of them falling into GLASS I, 23.3% in GLASS II, and 13.3% in GLASS III. For P1, 104 participants were identified, with 14.4% classified as GLASS I, 35.6% as GLASS II, and 50.0% as GLASS III. As for P2, there were 66 participants, with 1.5% in GLASS I, 16.7% in GLASS II, and the majority 81.8% falling into GLASS III. There was a statistically significant association between the pedal disease descriptor and GLASS classification (p value <0.01). (Table 2)

Table 3 describes about the relationship between various GLASS Stages and Immediate Technical Outcomes. In patients with GLASS 1 , the immediate technical outcome was achieved in 91.42% of the patients, in GLASS 2 ,76.36% and in GLASS 3 only in 33.63 % of patients the immediate technical outcome was achieved.

The relationship of Pedal disease descriptor and GLASS staging is shown in Table 4 and 5. It is seen that Higher GLASS staging is associated with Higher Pedal descriptor levels and poor achievement of Inline flow to the foot.

Table 1: Distribution of study patients based on baseline characteristics (n=200)

Parameter	**Frequency**	**Percentage**
Age (in years)		
50-54	46	23.0
55-59	31	15.5
60-64	37	18.5
65-69	40	20.0
70 and above	46	23.0
Sex		

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Males	163	81.5
Females	37	18.5
GLASS Classification		
GLASS I	35	17.5
GLASS II	55	27.5
GLASS III	110	55.0
Pedal disease descriptor		
0	30	15.0
1	104	52.0
2	66	33.0
Total	**200**	**100.0**

Table 2. Association between, GLASS classification, type of intervention and pedal modifier (n=200)

Characteristic	**GLASS Classification**			**Total** n(%)	**p value***
	GLASS I n(%)	**GLASS II** n(%)	**GLASS III** n(%)		
Type of intervention					
Endovascular	13(18.3)	31(43.7)	27(38.0)	71(100.0)	<0.001
Open- Byepass	22(17.1)	24(18.6)	83(64.3)	129(100.0)	
Pedal disease descriptor					
P0	19(63.3)	7(23.3)	4(13.3)	30(100.0)	<0.001
P1	15(14.4)	37(35.6)	52(50.0)	104(100.0)	
P2	1(1.5)	11(16.7)	54(81.8)	66(100.0)	

** Chi square test was applied*

Table 3: Correlation of GLASS Stages and Technical Outcomes
GLASS Stage I:

	Number of patients	**Pulsatile inline outflow**	**Immediate technical outcome**
Bypass	22	21	95.40%
Endovascular	13	11	84.60%
Total	**35**	**32**	**91.42%**

Table 3 (A)
GLASS Stage II:

	Number of patients	**Pulsatile Inline Outflow**	**Immediate Technical Outcome**
Bypass	24	21	87.50%
Endovascular	31	21	67.70%
Total	**55**	**42**	**76.36%**

Table 3 (B)
GLASS Stage III:

	Number of patients	**Pulsatile Inline Outfow**	**Immediate Technical Outcome**
Bypass	83	32	38.55%
Endovascular	27	05	18.50%

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Total	**110**	**37**	**33.63%**

Table 3 (C)

Table 4: Correlation of pedal disease descriptor and GLASS Staging:

Number of Patients		**Pedal disease descriptor**		
		P0	**P1**	**P2**
GLASS I	35	19	15	01
GLASS II	55	07	37	11
GLASS III	110	04	52	54

	Number of Patients	**Pulsatile Inline Outflow**	**Immediate Technical Outcome**
P0	30	26	86.66%
P1	104	83	79.80%
P2	66	02	3.03%

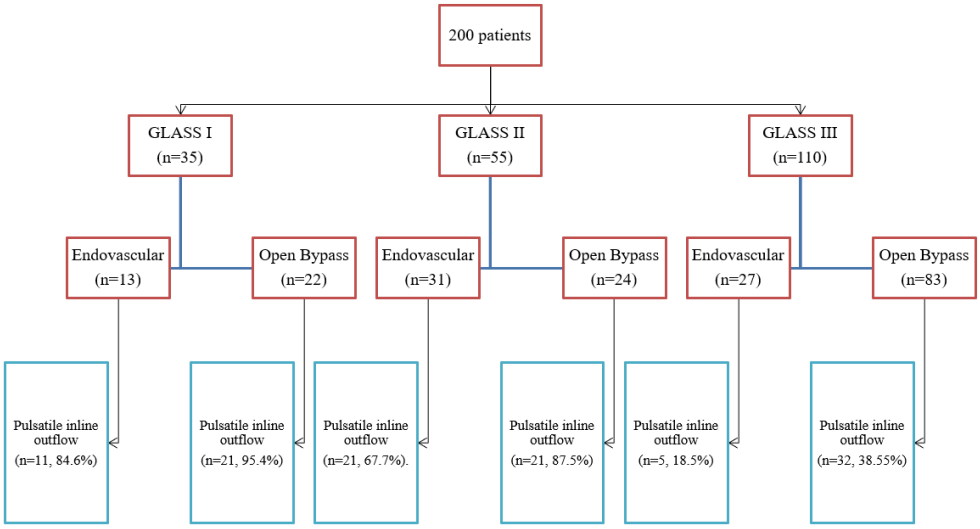

Figure 1: Schematic representation of study outcomes based on GLASS classification

Discussion

Recently, it has been demonstrated that the novel risk stratification measure, GLASS correlates with composite outcomes following open and endovascular treatments in patients with infra inguinal CLTI.[11-13] GLASS and other anatomic scoring systems were developed recently in an effort to give patients and doctors prognostic estimations of success in response to increased demand in a personalised approach to lower extremity revascularization. While the majority of the early scoring methods were restricted to the femoropopliteal segment, more recent research indicates that individuals with CLTI frequently have tibial and pedal illness, particularly those with non-compressible arteries like those with diabetes. The GLASS stages are intended to characterise the complexity of a preferred target arterial path and to assist evidence-based revascularization in patients with CLTI. They were created as a clinically focused framework for identifying patterns of arterial disease in these patients.[9] The present study aimed to assess immediate technical outcomes of pulsatile inline flow to the foot and its correlation with pedal disease descriptors using the GLASS Staging system. It involved 200 participants, with 23.0% aged 50-54, 15.5% aged 55-59, 18.5% aged 60-64,

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20.0% aged 65-69, and 23.0% aged 70 and above. Males constituted 81.5% of participants. GLASS classification revealed 17.5% as GLASS I, 27.5% as GLASS II, and 55.0% as GLASS III. Pedal disease descriptors distribution: 15.0% had '0', 52.0% had '1', and 33.0% had '2'. Statistically significant associations were found between intervention type and GLASS classification ($p<0.001$). Endovascular intervention was given to 71 participants with varied GLASS classifications, while 129 underwent Open-Bypass intervention, mostly GLASS III. Pedal disease descriptors were significantly associated with GLASS classification ($p<0.01$).

Since the GLASS was first suggested in the 2019 GVG, its performance has been examined in a number of research works.[11-15] Kodama et al[11] conducted a study exploring GLASS in patients with femoropopliteal disease and reported a significant relationship between GLASS and immediate technical failure in endovascular treatment. They found that GLASS was significantly related to amputation-free survival, limb salvage, and freedom from major amputation or limb event in the endovascular cohort, but not in the bypass surgery patients. Shirasu et al[16] conducted a systematic review and meta-analysis, which reported that immediate technical failure after endovascular treatment increased with advancing GLASS stage. Additionally, limb-based patency after endovascular treatment was significantly different between GLASS 1,2 and GLASS 3, suggesting the importance of GLASS staging in predicting outcomes. Some of the possible limitations of this study include retrospective design, single center study, a relatively smaller sample size, and lack of long term follow up.

Conclusion

In this single-institution retrospective review of consecutive first-time lower extremity endovascular or open revascularization procedures ,we found that in the Global Vascular Guidelines GLASS Anatomic inline flow to foot, Increasing the GLASS stages was associated with higher degree of Infra Malleolar disease, as specified by the GLASS pedal descriptor. Higher GLASS stages were also associated with higher rates of immediate technical failure following intervention. GLASS stage and pedal disease descriptor can be used to predict the establishment of pulsatile inline flow to foot. Higher the GLASS stage correlates with poor pedal disease descriptor. Further research, including larger multicentre studies with longer follow-up durations, is needed to validate and expand upon these findings. The clinical implications of GLASS classification in guiding personalized lower extremity revascularization strategies should be explored to improve treatment decision-making and patient outcomes.

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