



# Success of Limb Salvage in Patients with Peripheral Artery Disease

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## INTRODUCTION

There are nearly 2 million people living with limb loss in the United States with the main cause of amputation being vascular disease (54%). Out this population, about half will die within 5 years, making the mortality rate of amputation higher than breast cancer, colon cancer, and prostate cancer. Furthermore, if the patient has diabetes, then up to 55% will require a contralateral amputation within 2-3 years. This highlights the importance of limb salvage procedures.

As a limb salvage procedure, transmetatarsal amputation (TMA) is an attractive option because of the potential for good functional outcomes and no requirements for bracing. However, there are no previous studies that evaluate limb salvage success rate with TMA.

Most TMA incisions cross through 3 angiosomes (dorsalis pedis artery, medial plantar artery, and lateral plantar artery). The dorsalis pedis artery supplies the dorsal skin flap while the posterior tibialis artery supplies the plantar flap. If there is only one patent vessel to the foot, then only the dorsal or plantar flap would receive direct blood flow to support wound healing. More importantly, if the patent single vessel was the peroneal artery, then the TMA site would be dependent on only collateral flow to heal the amputation site. We therefore hypothesize that limb salvage rates in patients undergoing transmetatarsal amputation with single-vessel runoff is lower than in patients with 2 or 3 vessel runoff, and that patients with single vessel peroneal artery runoff have lower limb salvage rates than those with single vessel anterior tibial or posterior tibial artery runoff.

## METHOD

This study was a retrospective review of all patients who presented to the Dallas VA Medical Center from 2010-2020, underwent a TMA, and had an angiogram or computed tomography angiography (CTA). Electronic medical records were used to extract the following data on the patients: laboratory data (white blood count (WBC), glycated hemoglobin (Hgb A1c), c-reactive protein (CRP), estimated glomerular filtration rate (ESR), albumin, and prealbumin), treatment characteristics, demographic/social data, and co-morbidities (congested heart disease, chronic kidney disease, coronary arterial disease, diabetes). Failure of TMA was defined as requiring a higher level of amputation (below-knee or above-knee amputation). Vitamin D deficiency was defined as < 30 ng/ml.

### Confounding variables:

Wound healing is multifactorial process and while perfusion to the foot is one of the most important factors, we will evaluate other important factors that may contribute to wound dehiscence, poor healing, re-infection and amputation. These factors include glycated hemoglobin, creatinine, estimated glomerular filtration rate, albumin, prealbumin, and vitamin D.

Data was compiled using Microsoft Excel (Microsoft Corporation, Redmond, WA). Continuous data are given as mean, median, 95% confidence intervals (CI) and standard deviation (±). A chi square test was used to compare dichotomous variables. A one-way Analysis of Variance (ANOVA) was used to evaluate continuous variables, and the Mann-Whitney U Test was used for non-parametric data. For all comparisons and modelling, the level of significance was set at P<0.05.

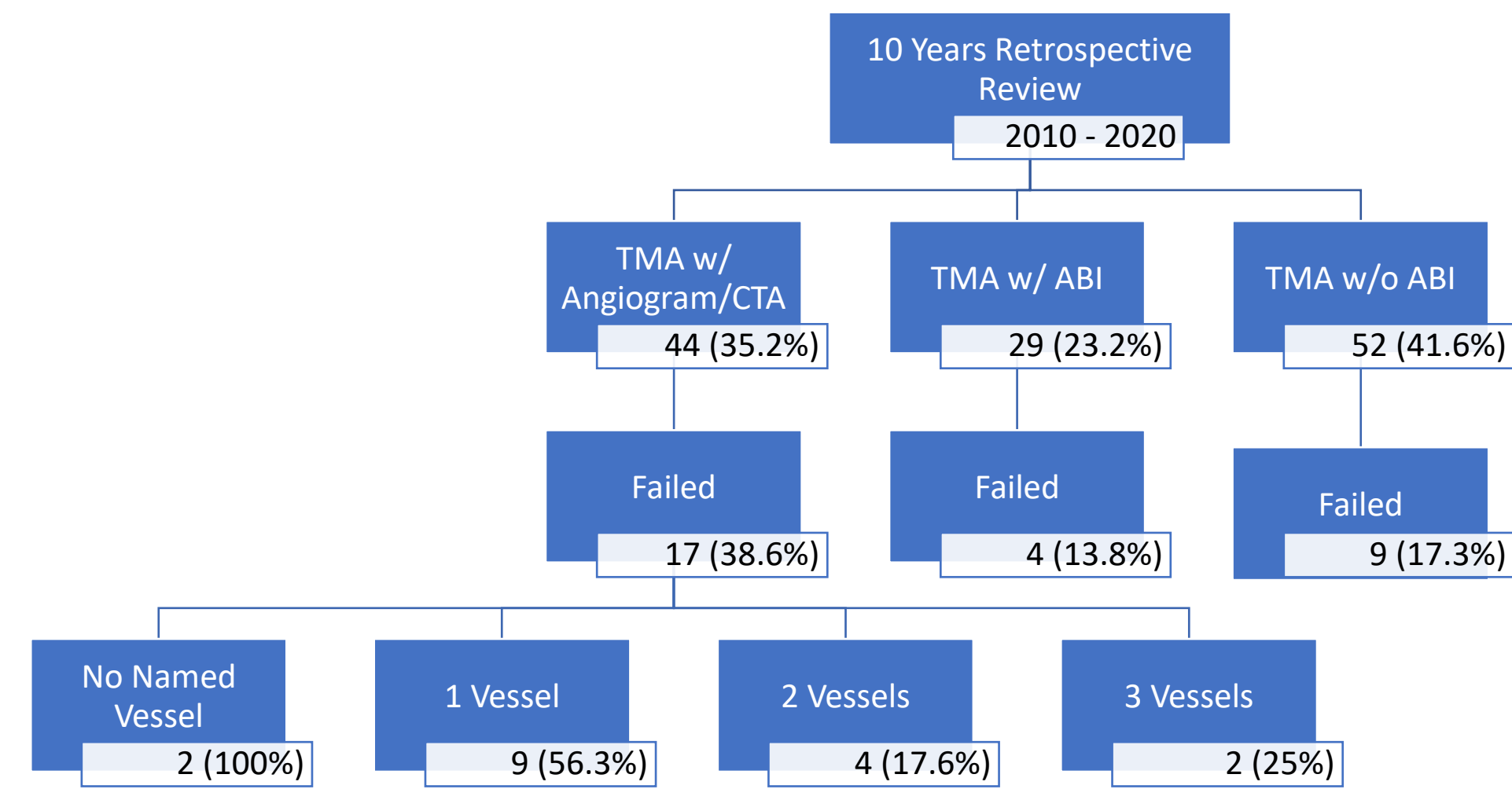


Fig. 1: Breakdown of patients with TMA outcome between 2010-2020.

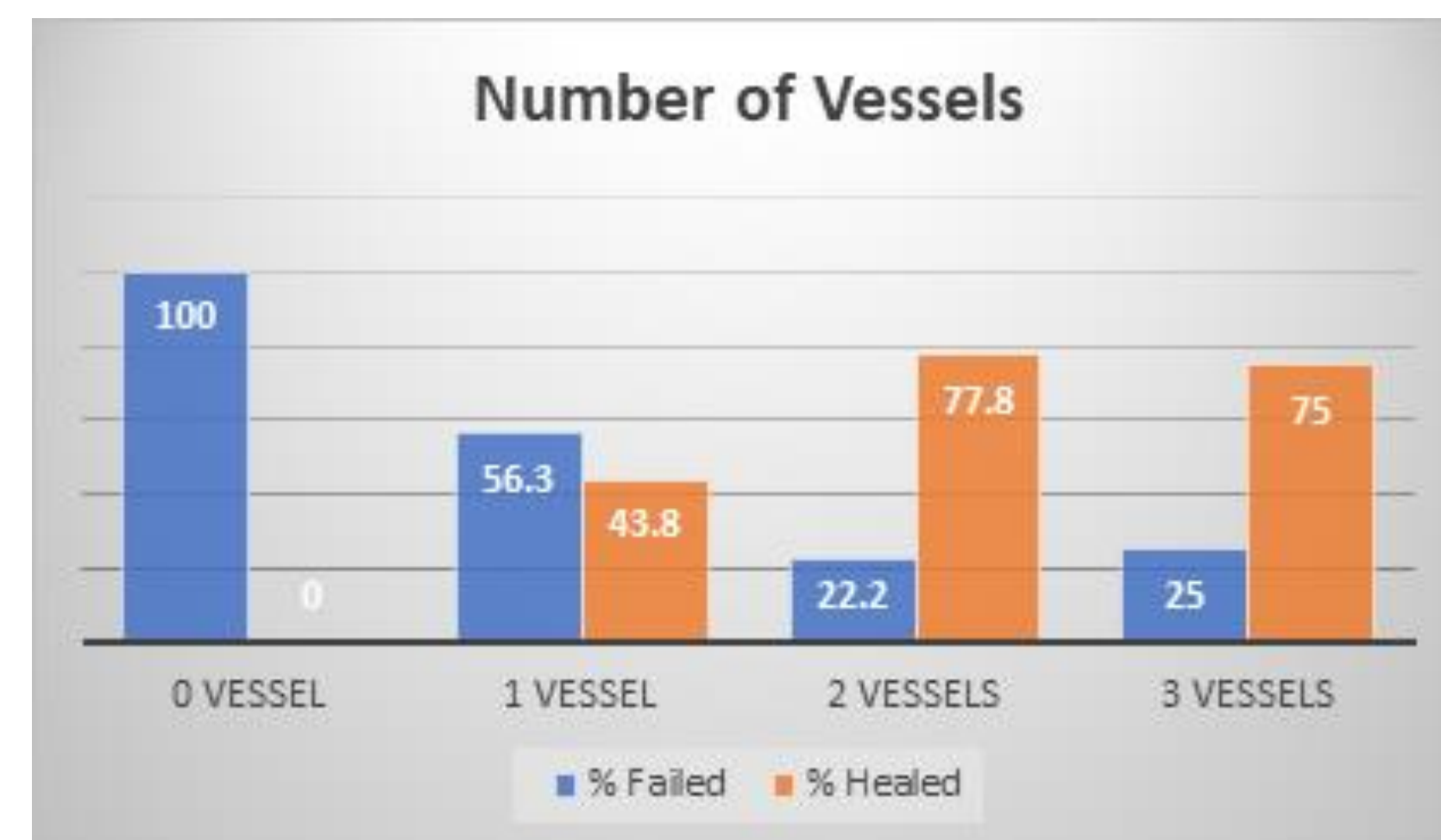


Fig 2: Number of vessel runoff to the foot and the outcome

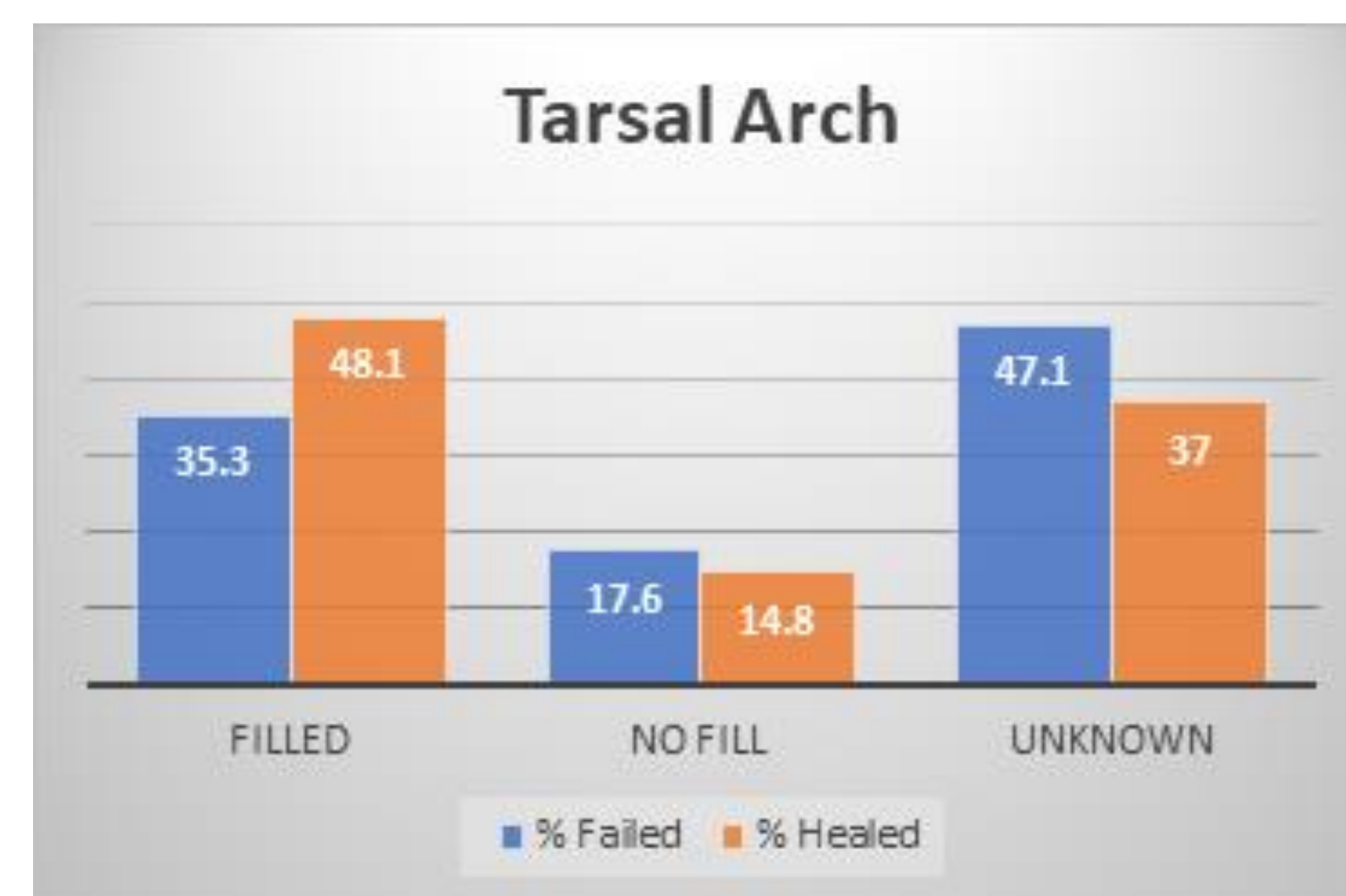


Fig 3: Patients with tarsal arch filled and outcome

	Failed TMA	Healed TMA	95% CI	OR	p-value
n (Total = 44)	17 (38.6)	27 (61.4)			
Male	17 (100)	27 (100)			
Diabetes Mellitus	11 (64.7)	24 (88.9)	.05 – 1.09	.23	.53
Chronic Kidney Disease	5 (29.4)	8 (26.6)	.26 – 3.74	.99	.99
On Hemodialysis	3 (17.6)	6 (22.2)	.16 – 3.51	.75	.71
Heart Disease	8 (47.1)	14 (51.9)	.24 – 2.78	.83	.76
Labs					
White Blood Count	11.6, 10.7 (5.2)	11.9, 11 (4.8)	10.28 – 13.22		.85
Erythrocyte Sedimentation Rate	67.3, 61 (32.8)	61, 65 (30.6)	56.18 – 80.98		.85
C-Reactive Protein	9.4, 9.3 (8.1)	6.8, 5.3 (5.0)	5.72 – 10.06		.26
Glycated Hemoglobin (%)	7.4, 6.8 (2.3)	7.3, 7.1 (1.4)	6.84 – 7.91		.86
Albumin	2.8, 2.6 (0.7)	2.7, 2.7 (0.5)	2.57 – 2.91		.78
Pre-Albumin	10.9, 9 (3.3)	11.8, 10.5 (5.1)	9.06 – 13.60		.72
Vitamin D Deficiency	9 (52.9)	7 (25.9)	.89 – 11.6	3.21	.70
Runoff Vessels (AT, PT, Peroneal)					
Zero / Unnamed Vessel	2 (100)	0			
One	9 (56.3)	7 (43.8)	.89 – 11.6	3.21	.07
Two	4 (17.6)	14 (77.8)	.07 – 1.10	.29	.06
Three	2 (25)	6 (75)	.08 – 2.64	.47	.38
Tarsal Arch Filled					
Yes	6 (35.3)	13 (48.1)	.17 – 2.05	.59	.40
No	3 (17.6)	4 (14.8)	.24 – 6.34	1.23	.80
Unknown	8 (47.1)	10 (37.0)	.44 – 5.18	1.51	.51
Pedal Arch Filled					
Yes	3 (17.6)	7 (25.9)	.13 – 2.79	.61	.52
No	7 (41.2)	13 (48.1)	.22 – 2.57	.75	.65
Unknown	7 (41.2)	7 (25.9)	.55 – 7.29	2	.29

Table 1: Laboratory values between patients who had angiogram and/or CTA. DM = Diabetes Mellitus; 95% CI = 95% Confidence Interval; OR = Odd Ratio; Descriptive variables are represented as N (%); Continuous variables are represented as mean, median (standard deviation); AT = Anterior Tibial Artery; PT = Posterior Tibial Arter

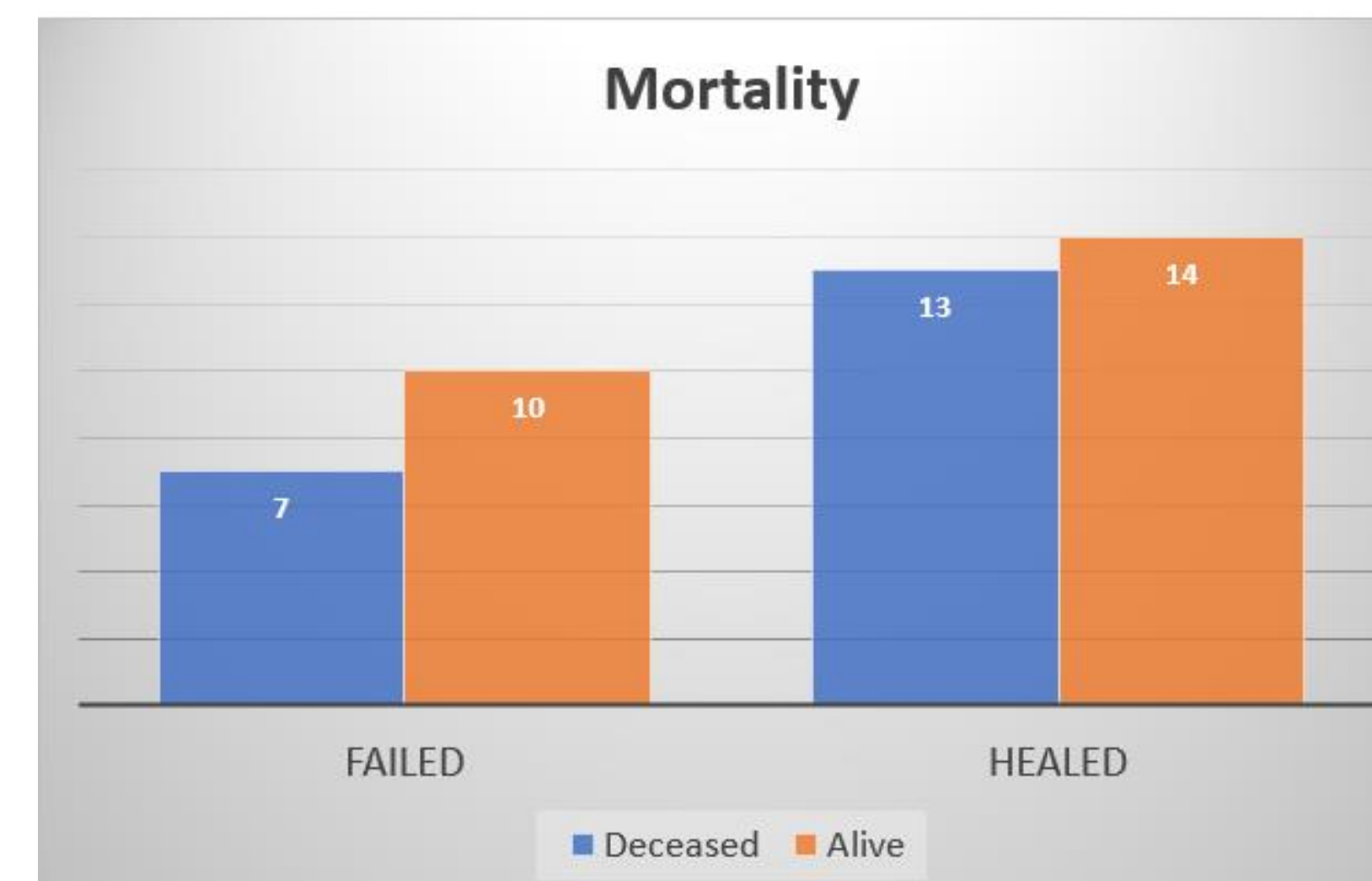


Fig 6: Overall survival rate of patient with TMA and had angiogram/CTA.

## RESULT

Over 10 years, a total of 125 TMA were performed at the institution. Forty-four patients (35.2%) had an angiogram/CTA peri-operative; 29 patients (23.2%) had an ankle-brachial index (ABI) done peri-operative; and 52 patients (41.6%) had no pre-operative vascular study. [Fig 1] Thus, 44 patients were included in the analysis, of which there were 17 TMA failures (38.6%).

Unfortunately, 18 (40.9%) patients had unknown tarsal arch fill and 14 (31.8%) patients had unknown pedal arch fill. This was due to the retrospective nature of the study. There was no statistical significant between the two groups (healed vs failure) in term of their tarsal and pedal arch fill. [Fig 3 and 4]

The most common co-morbidities for the entire cohort were diabetes mellitus, heart disease (coronary arterial disease, congested heart failure), kidney disease, and vitamin D deficiency. When comparing co-morbidities in patients with failed vs. successful TMA, there was no statistically significant difference between the two groups. Similarly, there was no significant difference in WBC, Hgb A1c, ESR, CRP, albumin, and pre-albumin between patients who had failed vs. successful TMA. [Table 1]

The most common indication for amputation was gangrene, osteomyelitis, and infection, in respective order. [Fig 5] The mortality rate is a 51.9% in patients with successful outcome, and 58.8% in patients with failed outcome. [Fig 6]

Of the 17 patients with failed TMA, 2 (11.8%) patients had no patent vessel runoff to the foot, 9 (52.9%) patients had one patent vessel, 4 (23.5%) patients had two patent vessels, and 2 (11.8%) patients had three patent vessels to the foot. [Fig 2]



Fig. 4: Patients with pedal arch filled and outcome

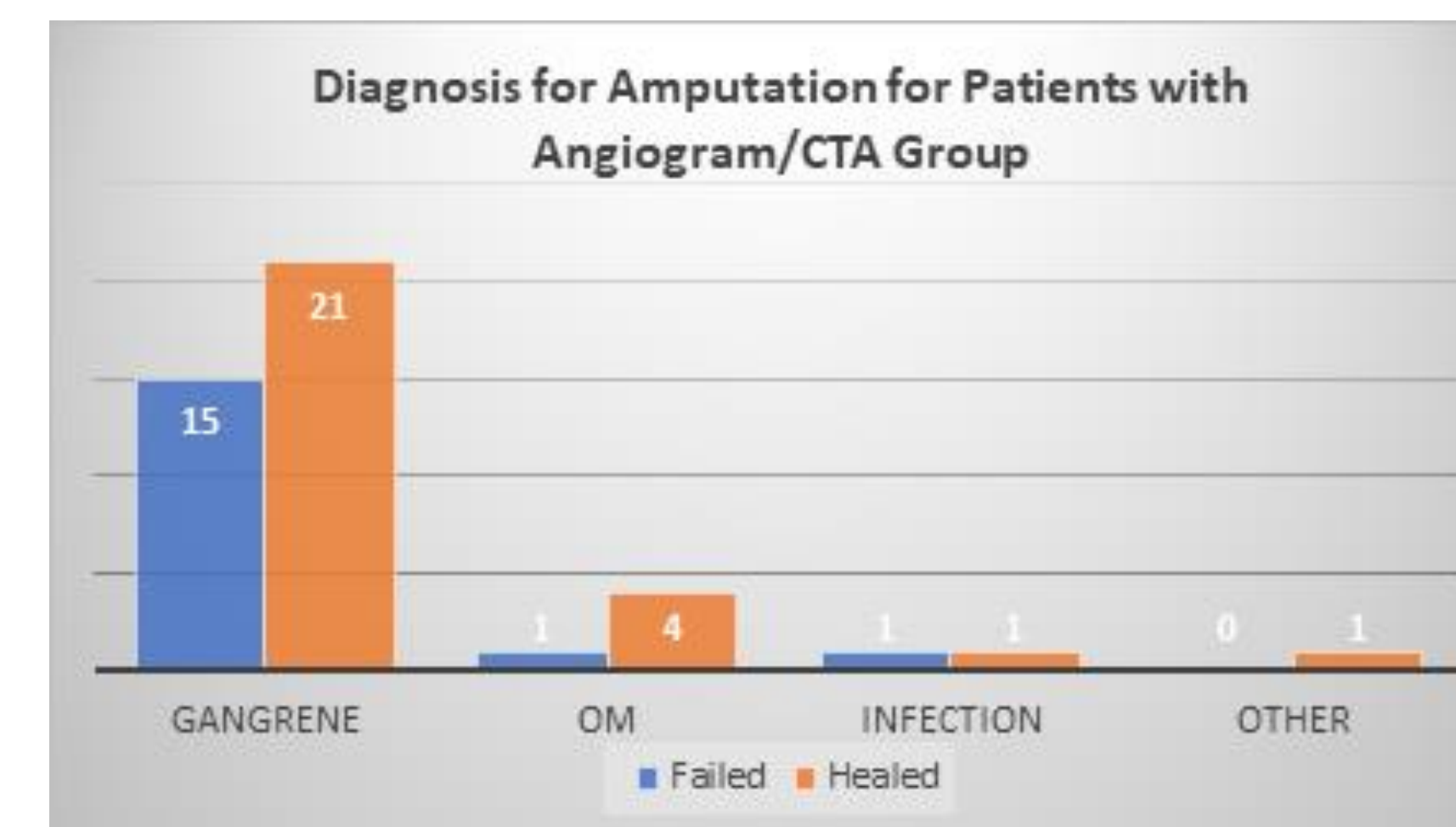


Fig 5: Diagnosis for TMA in for cohort with angiogram/CTA

## DISCUSSION

Previous studies mainly evaluated limb salvage in term of critical limb ischemia. However, there is no previous study that evaluates limb salvage success rate with TMA. This is the first study to our knowledge that evaluate success rate of TMA in patient with peripheral arterial disease (PAD).

This study is interesting as it offered perspective into success and failure rate of patients with PAD with known number of vessels runoff to the foot. The data showed that there was no statistical difference between the two groups in term of co-morbidities, infection, and diagnosis. Thus, making the reason for success or failure of TMA to be mainly based on the patient's vascular status. The data in this study showed no difference in the limb salvage rate with regard to the presence or absence of tarsal and pedal arch filled. However, this is most likely due to the low subject number; thus, affecting the power analysis. The number of tarsal and pedal arch fill were too under power to confidently draw any conclusion from it. The authors hypothesize that if pedal/tarsal arch filled is present, then the success rate will further increase as it will allow more perfusion to the soft tissue in the area.

Anecdotally, we have treated people with single vessel runoff to the foot and we have seen mixed results, with the majority resulted in surgical site dehiscence and requiring long-term local wound care. Some patients eventually ended up with a lower extremity amputation. If we can predict the success rate of limb salvage prior to surgery and educate the patient on the success rate of their procedure, then we can prevent those unnecessary procedure that has high likelihood of failure and spare the patient from the extensive process of local wound care that would ultimately result in a more proximal amputation. This prediction will help save the healthcare system on unnecessary expenditure of resources (operating room time, procedures, wound care supplies and products, skin grafts, home health, office visits, and hospital readmission for infection).

There are several limitations to this study. The first limitation is the retrospective nature of the study. The retrospective study often limited what data were available to be gathered for analysis. Not all patient with angiogram or CTA has a visible foot to be evaluated for presence of tarsal or pedal arch filled. Furthermore, since this was a 10-years study, multiple providers from different services have evaluated to the patient and performed the TMA. Majority of the of the time, a Podiatrist was not involved in the care until more recently. Selection bias may also be presents as this study was conducted at a Veterans Affairs hospital; thus, it only offers care to veterans. Some veterans lived far away and may not be able to come to the hospital for care as frequently as other veterans who live closer.

## CONCLUSION

In summary, if the patient has no named vessel runoff to the foot, then the success rate is extremely low. If there is only one vessel runoff to the foot, then the patient has a 56.3% chance of failure that will result in a more proximal amputation. Two or more vessels runoff in the foot yielded over a 75% success rate in limb salvage with a TMA. Finally, the authors believe that presence of tarsal and pedal Arch filled will have a positive impact on healing and limb salvage.