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RESEARCH PAPER

Skin Perfusion Pressure and Wound Closure Time in Lower Extremity Wounds

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Peripheral artery disease;
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Chronic wounds;
Skin perfusion pressure;
Diabetic foot ulcer

Abstract

INTRODUCTION: Peripheral Arterial Disease (PAD) affects approximately 8 million patients in the United States. We investigate the relationship of Skin Perfusion Pressure (SPP) and wound closure time in lower extremity wounds.

METHODS: We conducted a retrospective study of 1125 lower extremity wounds in 998 patients between June 2006 and October 2014 in our wound clinic. We analyzed the relationship between SPPand wound closure time. SPP was measured using a Laser Doppler instrument.

RESULTS: Patients with SPP values over 30 mmHg had shorter wound closure times, while patients with SPP values below 30 mmHg had a significantly longer wound closure time. Diabetic patients took longer to achieve wound closure compared to non-diabetics. No significant relationship was observed between SPP and wound closure time in relation to age or gender.

CONCLUSION: SPP is a useful tool in estimating time to wound closure and assessing the necessity of vascular interventions in lower extremity wounds.

Introduction

Since 2000, the prevalence of peripheral artery disease (PAD) has increased worldwide. PAD now affects approximately 8 million Americans.[1,2] Patients suffering from PAD are often subject to high morbidity and costly procedures, such as limb amputation and a myriad of endovascular therapies. Early detection and treatment of PAD has been shown to significantly increase both quality of life and life expectancy for patients.[3–6] Current non-invasive options used to diagnose PAD include the ankle-brachial index (ABI), toe-brachial index (TBI), pulse volume recording (PVR), transcutaneous oxygen monitoring (TCOM), and handheld Doppler waveform testing. There are limitations to each method, however.[7]

In recent years, the skin perfusion pressure (SPP) has shown to be a simple and reliable measurement for diagnosing PAD. Typically, an SPP value less than 50 mmHg is considered characteristic of PAD, while values less than 30 mmHG are associated not only with severe PAD but also critical limb ischemia (CLI).[4,8] In addition to diagnosing PAD and CLI, SPP has proven to be a beneficial tool in assessing the severity of lower limb ischemia and therefore, probability of wound closure and optimal degree of amputation.[9–12]

In this retrospective review of 1125 wounds in 998 patients, we investigate the relationship between SPP and the number of days required to achieve complete wound

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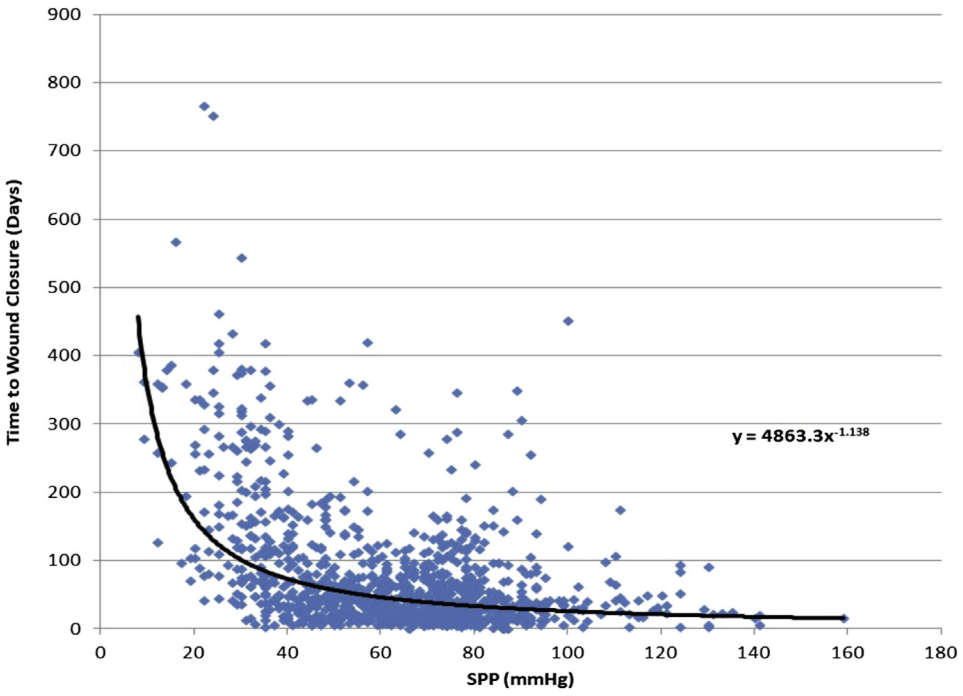

Figure 1 All wound data, n = 1125.

closure of the lower extremity. Results are compared across a series of demographic categories including age, sex and presence of diabetes. Additionally, we are able to support previously established evidence-based reports on the positive correlation among SPP and predictability of time to wound closure.

Methods

Medical records were obtained for the 998 patients (1125 lower extremity wounds) presenting to our wound clinic between June 2006 and October 2014 and reviewed retrospectively. The baseline SPP value taken upon each patient's initial visit was compared to his or her wound closure time in days thereafter. Treatment of these 998 patients and accompanying 1125 wounds of the lower extremity was based on a "best practice" model in an effort to achieve the fastest feasible wound closure time, simultaneously preserving maximal limb length. Patients were examined by clinicians, SPP values were measured and recorded (Sensilase, Vasemed), and sharp wound debridement was rendered. Moist wound dressings were applied at every visit. If infection was suspected or evident, wound cultures were obtained, and appropriate antibiotic therapy was administered. Most patients returned once a week for debridement, dressing changes, progress checks and infection evaluations.

Patients with SPP values below 30 mmHg were immediately referred to vascular specialists at Cedars-Sinai Medical Center for angiograms and vascular interventions. In patients with gangrenous tissues or osteomyelitis present, partial foot amputations were performed in the interest of timely wound closure. When required due to severe ischemia or infection, major limb amputations were performed. In some cases, advanced wound care modalities were initiated, and skin grafts and substitutes were used as indicated and when appropriate. Hyperbaric oxygen therapy was administered based on UHMS treatment indication: diabetic foot ulcer with Wagner Scale Grade 3 or higher, chronic osteomyelitis, radiation wound or failed skin flap and grafts. Negative pressure wound therapy was provided as indicated. Finally, platelet-derived growth factor gel was given in instances deemed appropriate.

Results

1125 wounds localized to the lower extremity in 998 patients (446 male, 552 female) with an average age of 79 years old (range 40–103 years old) are included in the data analysis. The average number of days to wound closure is

Table 1 Demographic Data by Group.

SPP Group	Male	Female	Diabetic	Non-Diabetic	Avg Age
≤30 mmHg	45	44	44	45	81.25
31–50 mmHg	124	145	134	135	79.97
>50 mmHg	277	363	248	392	77.83
Total	446	552	426	572	78.58

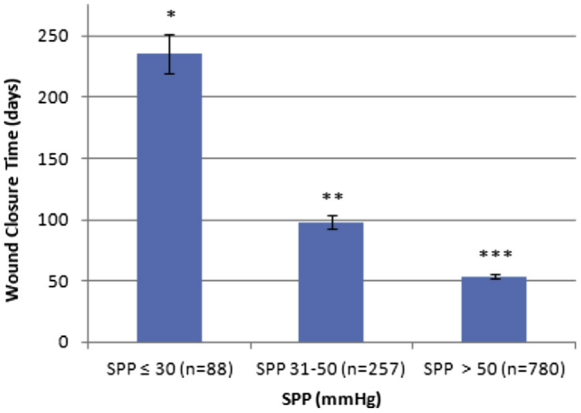

Figure 2 Average wound closure time was compared across 3 different ranges of SPP, SPP ≤ 30 mmHg (CLI), SPP 31–50 mmHg (PAD), and SPP > 50 mmHg (Non-PAD). 1-way. ANOVA and subsequent post hoc Tukey HSD analysis revealed all 3 means to be significantly different from each other ($F = 243.9$, $p < 0.001$). Bars are shown as ± SE.

78 days (range 4–766 days). The average SPP value is 63 mmHg (range 8–159 mmHg). Of the 998 patients examined, 426 (42.7%) patients had diagnosed diabetes, 879 (88.1%) patients were over the age of 65, and 552 patients were female (55.3%).

SPP values and wound closure time were compared for all 1125 wounds (Fig. 1). A significant correlation of reduced wound closure times with higher SPP values ($p < 0.001$) is observed. Furthermore, SPP values are grouped into 3 ranges: 30 mmHg or less (≤30 mmHg) representing severe PAD and CLI patients, between 31 mmHg and 50 mmHg (31–50 mmHg) representing mild and moderate PAD, and greater than 50 mmHg (>50 mmHg) representing non-PAD patients. Additional demographic data for each group can be found in Table 1. The average wound closure time for each of the 3 groups of 235 days, 98 days and 52 days, respectively (Fig. 2). Based on 1-way ANOVA and post-hoc analysis, all 3 groups are determined to be statistically significant.

Patients with diabetes mellitus (DM) exhibit a significantly longer time to lower extremity wound closure in relation to SPP when compared to non-diabetic (non-DM) patients (Fig. 3, $p < 0.001$). The average SPP value for DM when compared to non-DM patients are 63.7 mmHg and 62.1 mmHg, respectively. Such does not reveal a statistical significance ($p > 0.05$). There is no significant difference noted in wound closure time related to SPP values observed with respect to gender (Fig. 4, $p > 0.05$). Finally, no statistical significance was observed in time to wound closure of the lower extremity and accompanying SPP when comparing patients aged 65 years or older and patients younger than 65 years (Fig. 5, $p > 0.05$).

Discussion

Peripheral artery disease can result in a range of serious potentially fatal complications. Our study aims to establish

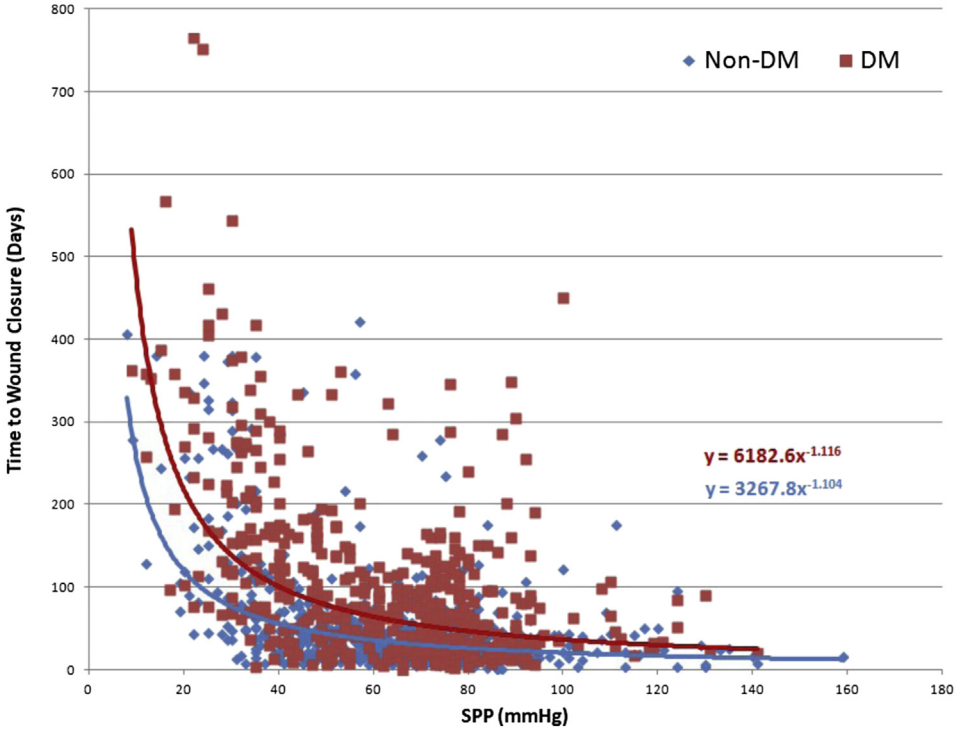

Figure 3 DM patients (n = 426) VS non-DM patients (n = 572).

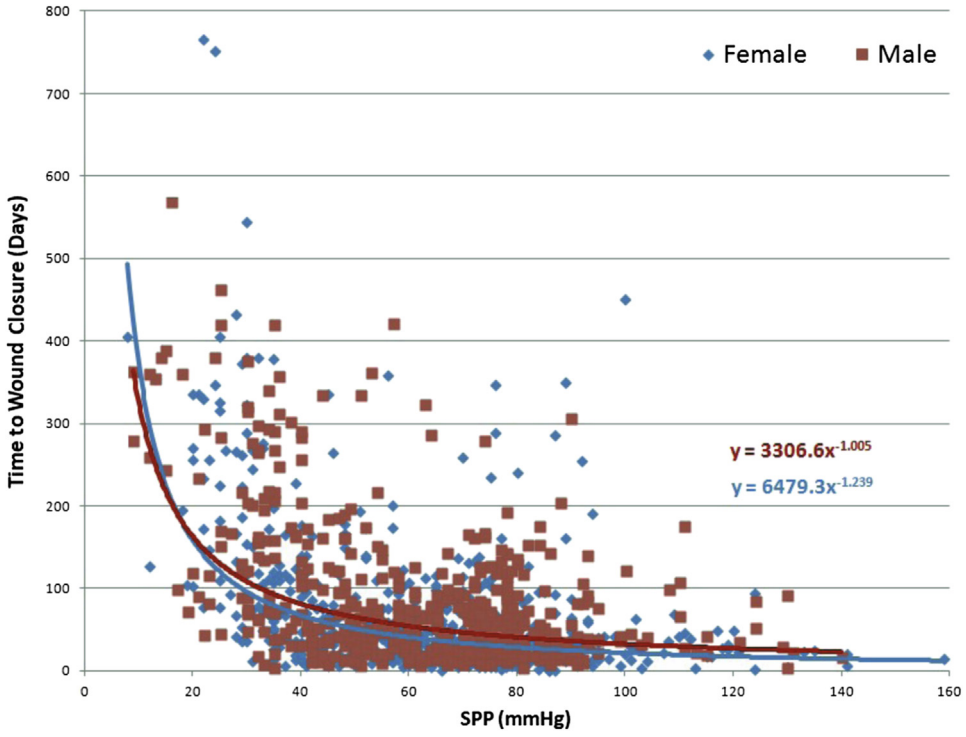

Figure 4 Male (n = 446) vs Female patients (n = 552).

a relationship between SPP values and time to closure of wounds localized to the lower extremity.

According to our data, there appears to be a positive correlation among SPP values and predicted time to wound closure. SPP values greater than 50 mmHg result in a more brief time to wound closure, whereas SPP values at or below 30 mmHg, indicative of severe PAD and critical limb ischemia (CLI), predict a much longer time to wound

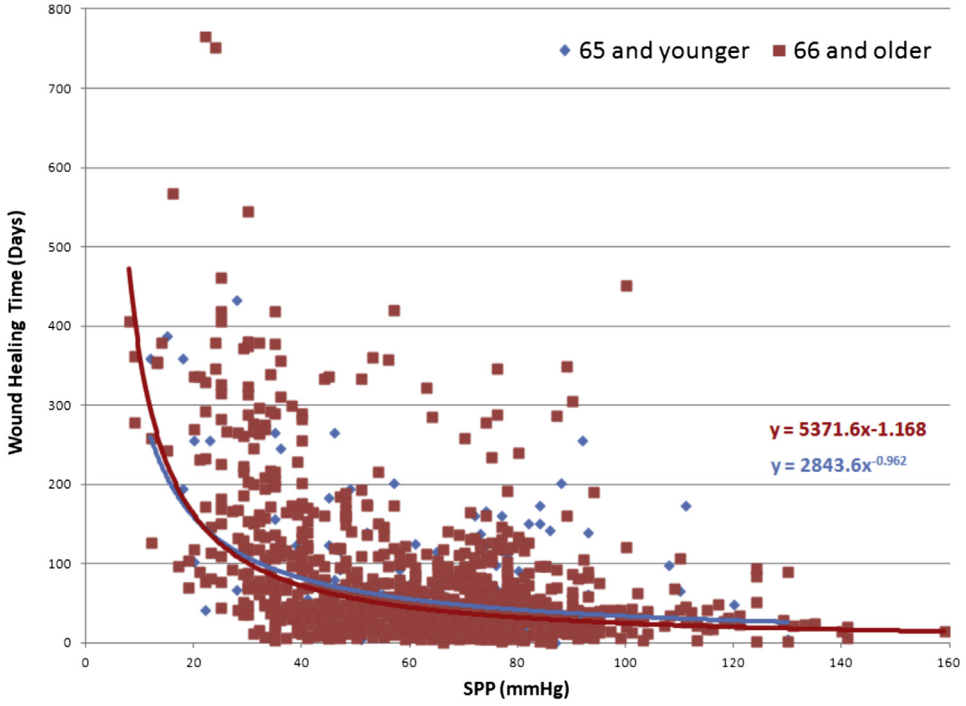

Figure 5 Age: Patients ≤65 (n = 119) vs > 65 years (n = 879).

closure. Despite efforts in which PAD and CLI patients are provided with expedited vascular interventions, patients presenting with SPP at or below 30 mmHg take significantly more time to heal.

Furthermore, a significant difference among DM patients and non-DM patients is observed. DM patients take more time to achieve wound closure at any given SPP value when compared to that of non-DM patients. DM patients' complications include impaired collagen deposition, immunocompromise, nephropathy and neuropathy. Effective offloading of these neuropathic ulcers is a constant challenge. Due to the aforementioned factors, DM patients heal more slowly and ultimately required higher SPP values than non-DM patients, with respect to healing comparable ulcers. Specific values between DM and non-DM patients would require additional studies to more clearly elucidate potential treatment guidelines.

When analyzing patient demographics, gender and age do not appear to be a factor affecting correlation between SPP values and time to wound closure. No significant difference is observed in time to wound closure among males and females. Additionally, despite the established PAD risk factor of age greater than 65 years, no statistical significance is observed in the rate of wound closure in patients divided among these age groups.[13] Such would indicate that SPP is an invaluable indicator of wound closure, irrespective of age or sex of the patient. Our results support similar trend findings on the utility and predictive potential of using SPP such as those reported in the meta-analysis conducted by Pan et al.[14]

It is worth noting that additional factors such as wound type, wound size, metabolic status and interventions and treatments performed which may act as potential confounders in our data set require additional studies and analysis to further elucidate their impact regarding SPP as a predictive tool. These factors may have accounted for some of the variation seen in our data set but overall, the data presented suggests a strong correlation in favor of SPP as a predictive tool in wound healing time.

Conclusion

Our data suggests a strong, positive correlation among SPP measurements and time to wound closure of the lower extremity. SPP values are an excellent asset in predicting healing time and assessing the necessity of vascular interventions in lower extremity wounds.

Disclosures

None of the authors have any financial interest in any of the products, devices or drugs mentioned in this paper. This research project was self-funded by the authors.

References

1. Adera H, et al: Prediction of amputation wound healing with skin perfusion pressure. J Vasc Surg. 1995;21(5):823–828.
2. "Peripheral Artery Disease (PAD) Fact Sheet." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention; 16 June 2016. Web. 09 May 2017.
3. Bhatt D, et al: International prevalence, recognition and treatment of cardiovascular risk factors in outpatients with atherothrombosis. JAMA. 2006;295(2):180–189.
4. Castronuovo J, et al: Skin perfusion pressure measurement is valuable in the diagnosis of critical limb ischemia. J Vasc Surg. 1997;26(4):629–637.
5. Criqui M, et al: Mortality over a period of 10 years in patients with peripheral artery disease. N Engl J Med. 1992;326(6):381–386.
6. Hirsch A, et al: Peripheral arterial disease detection, awareness and treatment in primary care. JAMA. 2001;286:1317–1324.
7. Yamada, et al: Clinical reliability and utility of skin perfusion pressure measurement in ischemic limbs – comparison with other noninvasive diagnostic methods. J Vasc Surg. 2008;47:318–323.
8. Okamoto K, Oka M, Maesato K, et al: Peripheral arterial occlusive disease is more prevalent in patients with hemodialysis: a comparison with the findings of multidetector-row computed tomography. Am J Kidney Dis. 2006;48(2):269–276.
9. Kawarada O, et al: Assessment of macro and microcirculation in contemporary critical limb ischemia. Cathet Cardiovasc Interv. 2011;78(7):1051–1058.
10. Suzuki K et al. "Skin perfusion pressure and wound closure time." DFCON 2011 Poster Presentation. Diabetic Foot Global Conference 2011. Hollywood, CA.
11. Tsai F, et al: Skin perfusion pressure of the foot is a good substitute for toe pressure in the assessment of limb ischemia. J Vasc Surg. 2000;32:32–36.
12. Tsuji, et al: Importance of skin perfusion pressure in the treatment of critical limb ischemia. Wounds. 2008;20(4):95–100.
13. Hirsch AT, Haskal ZJ, Hertzer NR, et al: ACC/AHA 2005 practice guidelines for the management of patients with peripheral artery disease (lower extremity, renal, mesenteric, and abdominal aortic). Circulation. 2006;113:e454–e463.
14. Pan X, You C, Chen G, et al: Skin perfusion pressure for the prediction of wound healing in critical limb ischemia: a meta-analysis. Biomed Rep. 2018;8:330–334.