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Original Article

Diabetic patients with inadequate flow of the posterior tibial artery and in dialysis are not good candidates for Syme amputation

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Abstract

Objective: There is a renewed interest in Syme amputation (SA) as it is considered a "lower limb salvage" procedure. The aim of this study was to describe the characteristics and evolution of diabetic patients who underwent SA to search for factors that would affect the outcome by comparing a group of patients who had a successful amputation against those who required a major amputation.

Methods: Seventeen diabetic patients submitted to non-traumatic SA between 2008 and 2016 were analyzed retrospectively.

Results: Eight patients required a higher level of amputation. In this group, six patients continued with the posterior tibial artery (PTA) occluded despite the revascularization, and seven were on dialysis. When assessing the permeability of PTA and dialysis as predictors of failure, they multiplied the risk by 20 (cOR of 24 and 21, respectively). However, after adjusting for both factors, there was only clinical significance.

Conclusion: SA in diabetic patients may be an alternative in those with a preserved heel pad tissue vascularization and permeable posterior tibial artery at the time of surgery. Patients on dialysis are likely to fail with this level of amputation.

Level of Evidence IV; Therapeutic Studies; Retrospective Cohort Study.

Keywords: Diabetes; Ischemia; Amputation; Tibial artery, posterior.

Introduction

Amputation is one of the most feared consequences in patients who have diabetes[1,2]. Peripheral vascular disease and diabetic neuropathy are the main risk factors for developing diabetic foot. The risk of developing foot ulceration in diabetic patients is higher than 25%[3], and in these patients, amputation occurs 10-30 more often than in the general population[1,2]. Therefore, there is a renewed interest in Syme amputation (SA) as it is considered a "lower limb salvage" procedure that would avoid a higher level of amputation[4–8]. If the ankle-level amputation fails, patients can proceed to the more proximal amputation without jeopardizing their chances for success[8].

This amputation through the ankle was described by James Syme in 1842 and popularized by Wagner in diabetic patients[9,10]. Harris stressed the importance of preserving the posterior tibial artery (PTA) indemnity during dissection, which is the one that primarily irrigates the heel pad[11,12]. For a time, diabetes and peripheral vascular disease were considered a contraindication for this surgical technique[13]. However, it has been shown that it can be performed in diabetic patients with an ankle-arm index greater than 0.5[14] and with the advent of new revascularization techniques of the lower limb, SA is possible in this group of patients[15].

The advantages of performing amputation through the ankle are the ability to temporarily bear weight on the stump

Study performed at the Hospital Italiano de Buenos Aires, Foot and Ankle Orthopaedics Department, Buenos Aires, Argentina.

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without the need for a prosthesis, better preservation of the body image, better proprioceptive feedback about the "foot position," granting gait stability[7], and lower incidence of skin complications[16,17]. In addition, it is a safer surgery than other major amputations. Finally, it presents a minimal increase in metabolic cost when walking to normal gait with infrapatellar or supracondylar level[18,19].

The aim of this study is to describe the characteristics and evolution of diabetic patients who underwent SA to search for factors that would affect the outcome of this procedure by comparing a group of patients who had a successful amputation against those who required a major amputation.

Methods

The study was approved by the institution's ethics committee, and the medical records of the adult patients diagnosed with Diabetes Mellitus[20] submitted to non–traumatic SA between 2008 and 2016 were analyzed retrospectively. All these patients had no chance of more distal foot amputation due to tissue damage.

Patients younger than 18 years old, with a history of traumatic SA, incomplete records, and postoperative follow-up under 12 months were excluded.

Demographic data, uncontrolled Diabetes Mellitus (glycosylated hemoglobin HbA1c >7%)[20], serum albumin (<2.5g/Dl)[14], comorbidities (dialysis, history of smoking, dyslipidemia, insulin dependence, and obesity), preoperative vascular status and level change of the amputation were analyzed. It was considered successful SA, a patient who evolved favorably and did not require a major level of amputation.

Patients were divided into two groups: patients who evolved favorably and remained at the SA level (Successful SA group) and patients in whom SA failed and required a major level of amputation (Unsuccessful SA group).

The patient's vascular status was first evaluated with a preoperatively eco doppler with ankle-arm index measurement. Then they were also evaluated by the cardiovascular surgery service. After, bthrough digital angiography, they examined not only PTA the PTA condition and the vascularization of heel pad tissue. If this vascularization was not enough, patients were revascularized before amputation to achieve satisfactory revascularization of the heel pad due to the irrigation of PTA or collateral vessels like the calcaneal branch of the peroneal artery[21] (Figure 1). So, when either branch supplying the heel was intact and clinically had the same temperature as the contralateral heel pad with no infection signs and skin lesions, SA was indicated. Data were collected from electronic medical records.

Statistics Analysis

Continuous variables are presented as absolute number and percentage. Continuous variables that assume a normal distribution are presented as means and standard deviation. Otherwise, they are expressed as median and interquartile range (IQR).

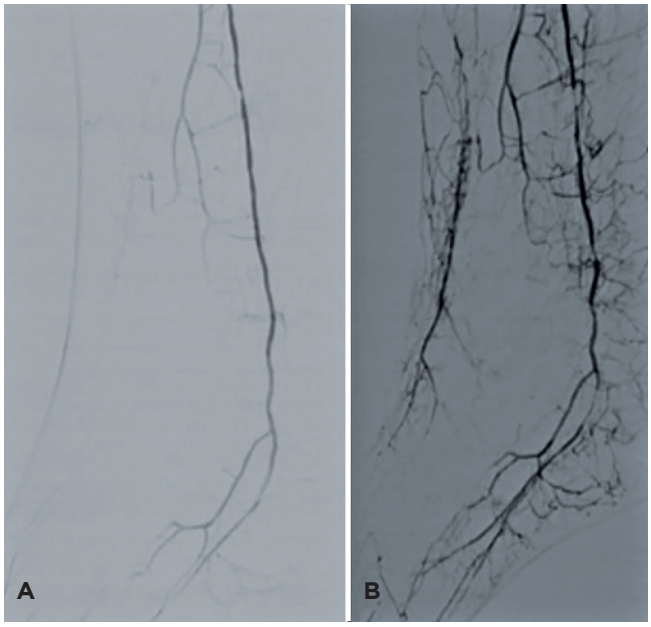

Figure 1. (A) Pre and (B) post revascularization angiography of the PTA.

Categorical variables were reported with their absolute number and percentage. In case of categorical variables, the chi-square test was used.

A logistic regression model evaluated the risk factors associated with unsuccessful SA. The crude and adjusted odds ratios (OR) are presented with their confidence interval and p-value. The statistically significant p-value was set at <0.05. The variables selected for the multivariate analysis were those clinically or statistically significant. STATA software version 13 was used for data analysis (StataCorp LP College Station, Texas, USA).

Results

Eighteen SA were performed in diabetic patients between 2008 and 2016, 17 complied with inclusion criteria, and one was lost in the follow-up. The median follow-up was 14 months (IQR: 19-33), 16 patients were male, and one was a female. The median age was 57 years *(*IQR 44-64*)* (Table 1).

The main cause of amputation was ischemia. Ten patients had PTA occlusion before amputation. After digital angiography, cardiovascular surgeons considered that eight of them required a revascularization procedure before the amputation. Finally, three had successful revascularization of PTA, and five achieved satisfactory heel pad revascularization by collateral vessels. Nine out of 17 patients had a successful SA (not requiring a higher level of amputation), and eight evolved unfavorably. Seven of the last group required an infrapatellar and one supracondylar amputation (Figure 2).

Out of the nine patients who evolved favorably, eight had permeable posterior tibial at the time of SA. Permeability of

Table 1. Patients demographic data and associated risk factors

	Total n = 17	Successful n = 9	Not successful n = 8	p-value
Age, median (IQR), years	57 (44-64)	64 (49-70)	52 (43-58)	0.067
Male Sex, n (%)	16 (94)	9 (100)	7 (87)	0.470
Ischemia, n (%)	10 (58.8)	4 (44)	6 (75)	0.334
Dialysis, n (%)	8 (50)	1 (12.5)	7 (87.5)	0.003
Insulin-dependent, n (%)	14 (82.4)	6 (66.7)	8 (100)	0.072
Ever-smoke, n (%)	8 (50)	3 (37)	5 (62.5)	0.317
Contralateral amputation n (%)	2 (12%)	0	2 (25%)	0.110
Dyslipidemia, n (%)	9 (56.3)	5 (62.5)	4 (50)	0.614
Obesity, n (%)	4 (25)	2 (25)	2 (25)	1
Preoperative Glycosylated Hemoglobin, mean/average (SD), gr/dL	7.24 (6.5-7.95)	6.9 (6.6-7.5)	7.6 (6.4-9.3)	0.340
Preoperative Albumin, median (IQR), gr/dL	2,8 (2.6-3.1)	3.1 (2.6-3.3)	2.7 (2.49-2.85)	0.147
Permeable PTA n (%)	10 (58.8)	8 (88.9)	2 (25)	**< 0.001**

IQR: interquartile range, SD: standard deviation, PTA: posterior tibial artery, Boldface indicates statistical significance (p<0.05).

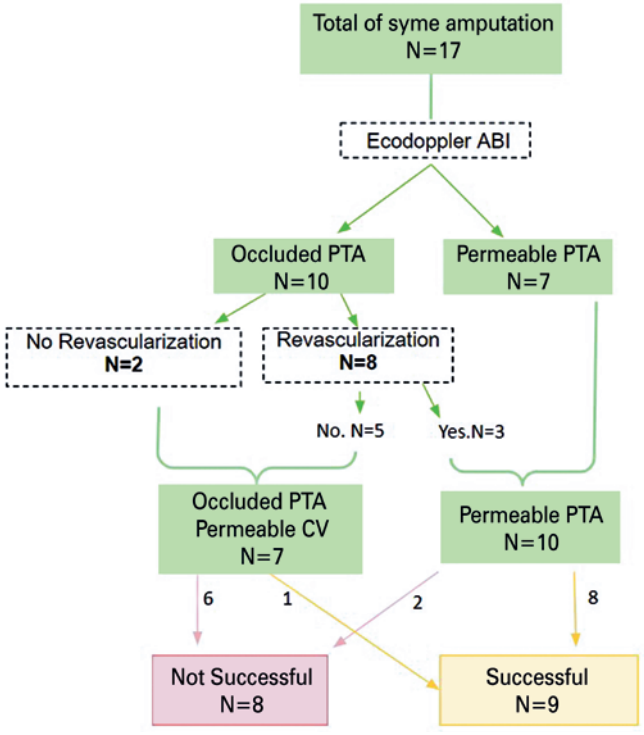

Figure 2. Treatment flowchart and evolution of the patients. ABI: ankle brachial index; PTA: posterior tibial artery; CV: collateral vessels.

the PTA was statistically significant (p=<0.001). Two patients who evolved unfavorably despite having a permeable PTA failed due to infectious compromise of residual tibial. Clinically there were no signs of infection in the ankle, but as a protocol procedure, the remaining bone samples were taken for culture and histopathology. Despite removing the compromised tissue and performing the amputation with healthy tissue, a multiresistant bacteria was found in the remaining tibia bone samples. After evaluating the risks and benefits with the infection committee, amputation was decided at a higher level.

Analyzing other factors that would interfere in the stump evolution, only a history of dialysis gave a statistically significant result (p=0.003). Seven out of eight patients who required a higher level of amputation were on dialysis; all required insulin. On the other hand, for oneonly one patient was on dialysis for those who evolved favorably.

When assessing the permeability of the PTA and dialysis as predictors of failure of this level of amputation, these factors multiplied the risk by 20 (cOR of 24 and 21, respectively). However, after adjusting for both factors, there was only clinical significance (Table 2). Furthermore, no relationship was found between other factors and the evolution of SA in our series.

Discussion

The level of SA offers many advantages to diabetic patients over major amputations, including less metabolic expenditure[18,19], better proprioception, and easy gait adaptation[7,16]. A high percentage of revision at major levels was observed; patients must be adequately selected for this level of amputation. It is important to preserve the flow indemnity through the PTA for the survival of the heel flap and the wound closure of the residual limb or stump.

With the advent of revascularization procedures, major amputation rates have been reduced in diabetic patients. The success of peripheral bypass[22] and percutaneous peripheral angioplasty contributes to "lower limb salvage" procedures[23]. It has been demonstrated that SA is an acceptable option in

Table 2. Univariate and multivariable analysis for permeability of the PTA and dialysis as predictors of failure

	OR	95 % CI	p-value	aOR	95 % CI	p-value
Permeable PTA	24	1.74-330.8	**0.02**	11	0.58-206.8	0.11
Dialysis	21	1.5-293.3	**0.02**	11	0.58-206.8	0.11

OR: crude Odds Ratio; aOR: adjusted Odds Ratio in multivariable analysis; CI, confidence interval; PTA: posterior tibial artery. Boldface indicates statistical significance (p<0.05).

diabetic dysvascular patients who underwent a preoperative revascularization procedure[5,24]. In our series, initially, ten patients had their PTA occluded, eight were revascularized, three the PTA became permeable, and five patients achieved a satisfactory heel pad revascularization due to collateral vessels. Regarding the patients who evolved favorably, eight out of nine had permeable posterior tibial at the time of amputation. As for the two patients who evolved unfavorably despite having a permeable PTA, they failed due to infectious compromise of residual tibial.

On the other hand, the renal function was described as a predictor of transmetatarsal amputation (TMA) failure before[25], Syme procedure could be considered a minor amputation. In our series, seven patients out of eight with a non-successful SA were on dialysis. Ahn et al.[25] included 2018 patients submitted to TMA as the primary procedure to assess the relationship of renal function with TMA failure. Seventy-two patients failed and underwent major amputations. They found out that when evaluating risk for major amputation, the adjusted ORs for end-stage renal disease (ESRD) and dialysis was 2.28 (95% CI=1.27, 3.96) and 1.94 (95% CI=1.11, 3.28), respectively. ESRD negatively impacts morbidity, mortality, and survival rates after lower extremity amputation[26].

It is also important to control blood glucose levels for the evolution of the residual limb wound. Hyperglycemia disables macrophages and lymphocytes, which participate in the healing process[27]. In addition, higher levels of postoperative infection have been observed in patients with uncontrolled diabetes[28,29]. A reasonable glycosylated hemoglobin for adult patients is lower than 7%. Less stringent levels, lower than 8%, can be appropriate for patients with multiple comorbidities or long-standing diagnoses in which the objective is difficult to reach despite care education, adequate blood glucose monitoring, and effective doses of glucose-lowering medication and insulin[20]. In our series, patients who required a major level of amputation had preoperative glycosylated hemoglobin of 7.6gr/dL, and the successful patients had 6.9gr/dL; this difference is not statistically significant.

Overall, it is accepted that for the healing of successful wound normalization of serum albumin, a minimum of 3.0g/dl is required as tissue nutrition parameter[30,31]. Pinzur et al.[14] have established that a higher rate of wound healing has been achieved with adequate vascular flow and albumin higher than 2.5g/dl. They report a success of 88% with this level of amputation. In our series, the percentage of SA success was lower (53%), despite the albumin blood level being higher than 2.5g/dl. We believe that the lower percentage of success was related to vascularization of the heel flap and higher morbidity; most patients were on dialysis at the time of surgery. Even though age has been described as a predictor of failure, especially older than 65 years[13], in our series, the group that evolved favorably had a median age of 64 (IQR 25-75 49-70), and the one that required a level revision was of 52 (IQR 43-58).

One of the limitations of our study is the small and retrospective sample. Another one is the little published literature, which analyzes after the revascularization procedure not only the permeability of the PTA but the heel pad vascularization status at the time of amputation. We also found a few publications about the relationship between dialysis and not successful minor amputation.

Conclusion

Syme amputation in diabetic patients may be an alternative in those with a preserved heel pad tissue vascularization due to a permeable posterior tibial artery at the time of surgery. However, patients on dialysis are likely to fail with this level of amputation. There is no relationship between other factors and the evolution of amputation in our series.

Authors' contributions: Each author contributed individually and significantly to the development of this article: VMC *(https://orcid.org/0000-0002-8115-6300) Conceived and planned the activities that led to the study, approved the final version; ACP *(http://orcid.org/0000-0001-7308-3693) Conceived and planned the activities that led to the study, approved the final version; MGSA *(https://orcid.org/0000-0002-5127-5827) Performed the surgeries, interpreted the results of the study, approved the final version; SC *(http://orcid.org/0000-0001-8144-3994) Data collection, interpreted the results of the study, participated in the review process and approved the final version; DSV* (http://orcid.org/0000-0001-5742-1226) Data collection, interpreted the results of the study, participated in the review process and approved the final version; LAC *(http://orcid.org/0000-0003-2333-5834) Data collection, interpreted the results of the study, participated in the review process and approved the final; PS *(http://orcid.org/0000-0001-8714-299X) Performed the surgeries, interpreted the results of the study, and approved the final version; MC *(http://orcid.org/0000-0002-1251-4936) Performed the surgeries, interpreted the results of the study, and approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

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