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REVIEW ARTICLE

Risk factors for reamputation in chronic limb-threatening ischemia: a scoping review

José M. Vilas-Boas, Rita Piedade, Emílio Silva, Tiago C. Pereira, Tiago Moura, Diogo D. Monteiro, Joana Ferreira, Armando Mansilha

Department of Angiology and Vascular Surgery, ULS São João, Porto, Portugal
Department of Surgery and Physiology, Faculty of Medicine, Porto University, Porto, Portugal

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ABSTRACT

INTRODUCTION: After an initial amputation, up to 47% of patients with chronic limb-threatening ischemia (CLTI) experience reamputation, with debilitating consequences for patients and high healthcare costs. Identifying reamputation rates and risk factors is crucial to optimizing initial amputation-level decision-making. This review updates current evidence on reamputation rates and identifies key risk factors in patients with CLTI.

METHODS: A comprehensive review of the PubMed database was conducted to identify studies reporting reamputation rates and predictors in patients with CLTI. Keywords included: “reamputation”, “risk factors”, “CLTI”, “Critical limb ischemia - CLI”, and “dysvascular”. We included seven retrospective cohort studies.

RESULTS: Reamputation rates ranged from 10% to 41%. Reamputation incidence varied widely by study population, follow-up duration, and initial amputation level. This review identified key predictors of reamputation, including diabetes mellitus, renal insufficiency (especially end-stage renal disease and hemodialysis), prior revascularization, severe atherosclerotic disease, and more distal initial amputation levels. Additional risk factors identified in specific cohorts included older age, male sex, abnormal ankle-brachial index, ischemic pain, non-ambulatory status, and systemic inflammatory markers. Mortality after initial lower-extremity amputation remained high, though it was not consistently associated with reamputation.

CONCLUSION: Reamputation remains prevalent among CLTI patients. Early identification of high-risk individuals may support more appropriate surgical decision-making. Significant heterogeneity across studied populations underscores the need for future research using local data and developing context-specific predictive models.

Keywords: Reamputation; Risk factors; Chronic limb-threatening ischemia; Predictive models.

INTRODUCTION

Chronic limb-threatening ischemia (CLTI), the most severe form of peripheral arterial disease (PAD), is associated with high rates of amputation, mortality, and functional decline.[1] Amputation remains a common and necessary intervention in CLTI, not only when revascularization fails or is not feasible, but also when revascularization is successful yet complicated by severe infection. However, even after an initial amputation, a substantial proportion of patients undergo reamputation because of poor wound healing or infection.[2,3]

Reamputation profoundly affects rehabilitation, quality of life, and functional independence. Patients

Corresponding Author:
José Miguel Vilas Boas | jmvilasboas98@gmail.com
Department of Angiology and Vascular Surgery, Unidade Local de Saúde de São João, Alameda Prof. Hernâni Monteiro, 4200-319 Porto, Portugal

requiring further reamputation often experience prolonged hospitalizations, repeated admissions, delayed prosthetic fitting, and increased mortality.[4-7] Failure of initial wound healing prolongs wound care and delays return to functional mobility.[8-10] Each subsequent procedure exposes patients to additional perioperative risks and resets the wound-healing process, prolonging the time to definitive prosthesis provision and functional recovery.[8-10] O'Brien et al. found that early amputation failures were associated with a twofold increase in the length of postoperative hospitalization, resulting in decreased mobility and physical condition.[6,11] Moreover, multiple reinterventions impose a substantial psychological and physical burden on patients and elevate healthcare costs.[7,12,13] Therefore, identifying patients at increased risk for reamputation is crucial for optimizing surgical planning and long-term care.

This review updates current evidence on reamputation rates and identifies and explains key predictors of reamputation in patients with CLTI.

METHODS

We searched the PubMed database for articles published through March 2025 that reported reamputation rates and risk factors in patients with CLTI. The query was as follows: “reamputation” AND “risk factors” AND (“CLTI” OR “CLI” OR “dysvascular”).

The literature search was limited to articles published in English and Portuguese.

We selected studies based on study design, sample size, and recency. We also retrieved articles from additional sources through cross-referencing. All included studies were retrospective or prospective observational clinical studies or systematic reviews. The primary objectives were to evaluate reamputation rates, identify patient- and limb-specific risk factors for reamputation, and evaluate the impact of reamputation on mortality.

Reamputation was defined as a subsequent ipsilateral soft-tissue revision (i.e., surgical debridement of non-healing tissue) or an amputation at the same or a more proximal level (i.e., with shortening of bone length) after an initial toe, transmetatarsal (TM), below-knee (BK), or above-knee (AK) amputation.

We considered only clinically relevant reamputations, representing an unplanned and undesirable outcome. Studies reporting staged minor amputations performed primarily for infection control and ultimately achieving limb salvage (e.g., sequential toe amputations leading to transmetatarsal amputation) were excluded. However, we retained one study because it included toe amputations for infection control unless a more proximal amputation had been planned a priori, aligning with the definition of an unplanned, clinically significant reamputation. We considered reamputation clinically significant regardless of whether it occurred early (during the index hospitalization or within 30 days) or later during follow-up. In both scenarios, the residual limb had not yet achieved durable healing, and the patient remained at risk of reintervention and was unable to progress to rehabilitation. Therefore, we accepted all time points reported in the included studies, provided reamputation was an unplanned/undesirable procedure.

We excluded studies not focused on CLTI patients, abstracts only, studies with incomplete data, letters, or nonclinical studies.

RESULTS

We retrieved 93 articles; after removing duplicates, 85 remained. After reviewing all titles and abstracts, 11 full-text articles were read, and a total of 7 articles were selected for analysis. The papers reviewed were published between 2017 and 2024 and were all retrospective cohort observational studies. Three were from Europe, three from the United States of America, and one from Japan. This review included 27592 patients. Table 1 summarizes the results.

Reamputation rates

Reamputation after lower-extremity amputation remains common across diverse patient populations, particularly among those with CLTI. Reported rates of ipsilateral reamputation ranged from 10% to 41%, varying widely by study population, follow-up duration, and initial amputation level (Table 1).

Risk factors for reamputation

Several patient- and disease-related factors were consistently linked to higher reamputation risk. Across multiple studies, diabetes mellitus, renal impairment, the initial amputation level, and prior revascularization emerged as key predictors. Diabetes is linked to impaired wound healing and stump infection, often resulting in reamputation across cohorts.[15] Geurts et al. identified diabetes mellitus as a primary independent risk factor for ipsilateral reamputation within 1 year after initial amputation ($p < 0.01$).[9] Similarly, Norvell et al. found that among patients undergoing TM amputations, diabetes markedly increased the hazard of reamputation (HR 1.9; 95% CI 1.4-2.5). When diabetes coexisted with an abnormal ankle-brachial index (ABI), the risk was even higher (HR 2.4; 95% CI 1.8-3.2).[10] Czerniecki et al. included diabetes in their final predictive model for reamputation within 12 months, confirming its importance as a risk factor.[8] Endoh et al. reported that insulin use was independently associated with a higher risk of in-hospital reamputation (OR 1.38; 95% CI 1.24–1.53).[14]

Likewise, renal insufficiency, particularly end-stage renal disease (ESRD) and hemodialysis dependence, emerged as a consistently significant risk factor for reamputation across the reviewed studies.8[8,10,14] Renal dysfunction impairs wound healing and tissue oxygenation, increases susceptibility to infection, and is associated with worse outcomes after lower-extremity amputation due to the systemic illness burden.16 In Norvell et al.'s cohort, TM amputees with renal failure had a 1.7-fold higher risk of reamputation (95% CI 1.3–2.1), underscoring the need for caution when performing TM amputation in high-risk renal patients.10 Endo et al. identified hemodialysis as the strongest independent predictor, with a 2.1-fold increased risk of early in-hospital reamputation (95% CI 1.87–2.35).[14]

Table 1. Summary of main results of studies reporting rates and risk factors for reamputation after initial dysvascular amputation, included in this review.

Author/ year of publication	Year of publication	n	Results	
			Rates	Key predictors
Endoh et al.[14]	2017	13774	The overall in-hospital reamputation rate was 10.1% for patients who initially underwent foot or transtibial amputation.	Higher age (OR 1.03; 95% CI 1.03–1.04), male sex (OR 1.14; 95% CI 1.03–1.26), use of insulin (OR 1.38; 95% CI 1.24–1.53), hemodialysis (OR 2.10; 95% CI 1.87–2.35), higher number of comorbidities (OR 1.50; 95% CI 1.27–1.76).
Fard et al.[6]	2019	382	Twenty-six percent underwent ipsilateral reamputation within 12 months after initial major amputation.	No significant risk factors were found.
Czerniecki et al.[8]	2019	5260	The overall 12-month reamputation rate was 24.4%. Crude reamputation risks were 40.3%, 25.9% and 9.7% in the transmetatarsal, below-knee and above-knee groups, respectively.	Included eleven predictors in a reamputation predictive model (good model calibration with goodness-of-fit testing [p=0.918], good discrimination [AUC 0.72] and a discrimination slope of 11.2%): amputation level, sex, smoking, alcohol, rest pain, use of outpatient anticoagulants, diabetes, chronic obstructive pulmonary disease, white blood cell count, kidney failure and prior revascularization.
Norvell et al.[10]	2020	7187	Risk of requiring at least one reamputation was 41% (transmetatarsal), 25% (below-knee), and 9% (above-knee) within 12 months of first dysvascular amputation.	After any level amputation: chronic obstructive pulmonary disease (HR 1.2; 95% CI 1.0–1.4), elevated white blood cell count (HR 1.7; 95% CI 1.5-1.8), abnormal ABI (HR 1.2; 95% CI 1.0–1.3), history of revascularization (HR 1.1; 95% CI 1.0–1.3), alcohol misuse (HR 1.2; 95% CI 1.1–1.5). After transmetatarsal: diabetes (HR 1.7; 95% CI 1.3–2.3), kidney failure (HR 1.7; 95% CI 1.3–2.1). After below-knee: smoking (HR 1.4; 95% CI 1.2–1.6).
Torbjörnsson et al.[2]	2021	288	Fifty (17.4%) patients had a reamputation during the 11-year follow-up after initial major amputation	Ischemic pain as an indication for primary amputation (HR 3.55; 95% CI 1.55-8.17).
Geurts et al.[9]	2024	516	The 12-month reamputation rate was 19.4% after initial major amputation	Diabetes (OR 1.42), lipid-lowering drug usage (OR 1.80), lower level of amputation (OR 0.48).
Guerra et al.[5]	2024	182	Risk of requiring at least one reamputation was 22% (toe), 30% (transmetatarsal), 8% (below-knee), and 3.6% (above-knee) for a median follow-up time of 285 days	Lower level of amputation (OR 1.64; 95% CI 1.51-5.23), non-ambulatory status (OR 6.74; 95% CI 1.74-26.18), toe pressure <30 mmHg (OR 4.89; 95% CI 1.52-15.78), abnormal ankle waveform (OR 3.12; 95% CI 1.30-7.46), prior revascularization (OR 2.19; 95% CI 0.88-5.49).

Five studies found that distal amputations are more likely to require reamputation due to healing failure.[15,8-10,14] Norvell et al. and Czerniecki et al. found significant differences in 12-month reamputation rates among TM (41%), BK (25%), and AK (9%) amputees.[8,10] In the Geurts et al. cohort, the level of initial amputation independently predicted reamputation, with an OR of 0.48 ($p < 0.01$).[9] Guerra et. al found that TM amputees had a 1.64-fold increased risk of reamputation when compared to patients submitted to more proximal amputations (95% CI 0.51 – 5.23).[5] These findings underscore the heightened risk of reamputation following distal amputations.

While revascularization is a cornerstone of limb salvage in CLTI,[1] three studies found that limbs with prior ipsilateral revascularization before initial amputation were at higher risk of reamputation, with a hazard ratio of up to 1.4x (95% CI 1.2 – 1.6).[5,8,10] These studies included only technically successful endovascular or open procedures. These results warrant careful interpretation. Previous revascularization is considered a proxy for severe limb ischemia and failed limb salvage efforts. Rather than being harmful, it often reflects advanced arterial disease that continues to compromise limb perfusion even after the intervention. Moreover, surgeon bias at the time of revascularization may lower the threshold for considering revascularized limbs for salvage.[5]

When considering hemodynamic testing at the time of initial amputation, Norvell et al. and Guerra et al. identified ABI <0.9 (HR 1.2; 95% CI 1.0 - 1.3) and toe pressure <30 mmHg (OR 4.89; 95% CI 1.52 – 15.78) as significant predictors of reamputation, underscoring the role of ischemia in wound healing.[5,10]

Other risk factors were described, though consistency between studies was lower. Endoh et al. identified older age and male sex as independent predictors of reamputation and in-hospital death.[14] Older patients are frailer and typically undergo more proximal amputations, with a lower incidence of failed wound healing (as previously described). However, even after adjusting for amputation level, older age remained a predictor of in-hospital reamputation or death (OR 1.03; 95% CI 1.03 – 1.04). Death may confound this analysis, which may help explain these results.[13] Other studies have failed to demonstrate an association between age and reamputation.

Norvell et al. also identified chronic obstructive pulmonary disease, leukocytosis, and alcohol misuse as predictors of ipsilateral reamputation.[10] Guerra et al. highlighted non-ambulatory status as a predictor of a more proximal reamputation in patients with CLTI.[5] Furthermore, ischemic pain as an indication for initial amputation was associated with a 4-fold increased risk of reamputation in a Swedish cohort (95% CI 1.55 - 8.17).[2]

Mortality

Mortality after lower-extremity amputation remains alarmingly high, particularly among frail and elderly populations.[2] Endoh et al. reported an in-hospital mortality rate of 10.8%, a finding echoed by Fard et al., who documented 30-day and 1-year mortality rates of 14% and 34%, respectively.[6,14]

Interestingly, reamputation was not consistently associated with increased mortality. Guerra et al. found no significant difference in 1-year mortality between patients who underwent higher-level reamputation and those who did not (17.7% vs. 17.2%).[5] The same results were reported by Geurtz et al. (23% reamputation vs. 27% non-reamputation).[9]

DISCUSSION

This scoping review identified key risk factors for reamputation, most consistently including diabetes mellitus, renal impairment, and the initial amputation level. However, studies of reamputation in patients with CLTI show considerable clinical heterogeneity and methodological variability. Although studies identified several patient- and disease-specific predictors, reported rates and risk estimates varied widely. These discrepancies may reflect differences in outcome definitions, follow-up duration, initial amputation-level classification, and statistical methods, which may limit direct comparisons between cohorts and preclude pooled analysis.

Across the selected studies, definitions of reamputation and follow-up intervals were not uniform. Variability in outcome definitions and follow-up duration affects reported incidence rates, which ranged from 10.1% to 41%, and influences the interpretation of predictive factors.10,14 Some authors considered reamputation any ipsilateral soft-tissue or bony revision at the same or a more proximal anatomical level after the initial procedure,[6,8-10] whereas others focused specifically on reamputations at a more proximal level 5 or excluded soft-tissue revisions.[2] One study reported in-hospital reamputations,[14] whereas others used defined follow-up windows ranging from 285 days 5 to 12 months[6,8-10], and one study extended follow-up to over a decade.[2] Early reamputations likely reflect healing failure or infection, whereas later reinterventions might suggest disease progression. Norvell et al. performed a time-to-event analysis and found that half of reamputations occurred within the first month, with the remaining half occurring gradually over subsequent months.[10] This temporal distribution suggested two distinct phases of risk: a sharp early peak likely related to stump-healing failure or infection, and a later, more gradual risk curve possibly reflecting disease progression.

Differences in how studies classified initial amputation level also contributed to heterogeneity. Some studies included only patients with initial major amputations [2,6,9], whereas others included a broader spectrum of minor amputations, such as toe and TM levels.[5,8,10,14] Because distal amputations are associated with higher reamputation risk[5,8,10,14], studies that included more distal initial interventions consistently reported higher rates of subsequent reamputation, whereas series confined to major amputations observed lower absolute risks but still identified clinically meaningful reamputation events during follow-up.[6,9]

As expected, studies using broader definitions of reamputation and including more distal initial amputations tended to report higher reamputation rates, especially when paired with longer follow-up periods.

Analytical approaches and statistical methodologies also differed across studies. Some used logistic regression to report odds ratios[5,9,14]; others applied time-to-event analysis with hazard ratios[2,10]; and one developed a predictive model using multivariable logistic regression and evaluated its performance.[8] Variations in covariates, such as hemodynamic markers[5,10], comorbidities[5,9,10,14], and laboratory parameters[8,10], could shift effect estimates and limit comparability of predictors across studies, illustrating why consistent risk factors (diabetes, renal impairment, distal initial level of amputation) are more reliable than any single study's point estimate. Heterogeneity in endpoints, follow-up, amputation-level definitions, and modeling strategies accounts for much of the variation in reported reamputation rates and effect sizes. Future work would benefit from standardized outcome definitions, harmonized follow-up windows, and common analytical frameworks to enable benchmarking and meta-analytic synthesis.

Although most studies in this review focused primarily on mortality and reamputation rates, several acknowledged that reamputation has important functional consequences, including delayed wound healing, reduced mobility, prolonged hospitalization, and increased burden on patients and families.[5,8-10] These functional impairments may delay or preclude prosthetic fitting and hinder return to ambulation. Some authors noted that multiple reinterventions may lead to greater physical decline than a single, more proximal amputation: in the Norvell et al. cohort, 40% of patients did not undergo their final reamputation until five months after the initial amputation. The authors suggested that the intervening period between the initial amputation and the final reamputation was often associated with repeated wound care visits, limitations in ambulatory mobility, and dependence in care, leading to deconditioning, muscle atrophy, and joint contracture, and ultimately limiting the potential for ambulation once healed.[10]

None of the studies included in this review conducted a systematic or quantitative analysis of functional status, prosthetic use, or rehabilitation trajectories within their cohorts. These outcomes were discussed based on clinical interpretation rather than directly assessed. This remains an important gap in the literature and underscores the need for future studies to evaluate reamputation not only as a surgical endpoint but also for its broader impact on recovery and quality of life.

This scoping review has several limitations. First, we did not conduct a formal critical appraisal of study quality or risk of bias, which is inherent to the scoping methodology but may limit interpretation of individual study findings. Second, although we described heterogeneity in outcome definitions, follow-up duration, and analytical methods, we did not quantitatively assess it. Third, all included studies were retrospective observational cohorts and were subject to inherent biases such as selection bias and unmeasured confounding. Lastly, although the original studies discussed functional outcomes, they did not systematically evaluate them. In addition, studies did not consistently analyze important factors related to primary stump healing, such as tissue perfusion parameters (e.g., $TcPO_2$, presence of palpable pulses) and nutritional status, limiting assessment of their role in reamputation risk.

Future remarks

Predictive tools to guide clinical decisions are scarce. The AMPREDICT score, which incorporates clinical and laboratory variables to estimate the individual risk of reamputation within 1 year of the initial amputation procedure, demonstrated strong usability characteristics and clinical relevance.[8,17] Nevertheless, external validation in diverse healthcare settings and worldwide availability and applicability remain limited.[17]

Moreover, while international data have offered valuable insights, national variations in healthcare infrastructure, comorbidities, and surgical practices warrant localized assessments.[18] This is evident in the substantial heterogeneity among the populations studied in this review. Therefore, future efforts should focus on analyzing rates and risk factors for reamputation, adjusted to local settings, to support the development of personalized and reliable predictive models.

CONCLUSION

Despite efforts to predict wound healing after amputation, reamputation rates remain high. Identifying and understanding risk factors is crucial for targeting patients who may benefit from a more proximal initial amputation, which could reduce reamputation rates, expedite rehabilitation, and enhance quality of life. Diabetes, renal insufficiency, initial amputation level, and prior revascularization consistently emerged as key predictors. These factors reflect systemic disease burden and impaired limb perfusion, underscoring the need for accurate risk stratification.

While tools like AMPREDICT offer promising insights, broader validation and integration of local data are essential. Future research should prioritize developing context-specific predictive models to improve surgical planning, reduce reinterventions, and optimize long-term outcomes.

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