# PAD Venous Arterialization: Systematic Review with ☸SAIMSARA.

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**Abstract:** This paper aims to systematically review the current evidence on venous arterialization for PAD, particularly in the context of limb salvage and wound healing, and to identify key clinical and research implications. The review utilises 37 studies with 44718 total participants (naïve ΣN). Technical success rates for percutaneous deep venous arterialization (pDVA) and transcatheter arterialization of deep veins were consistently high, with a median technical success of 100% and a range from 96.6% to 100% across multiple studies. These results suggest that venous arterialization is a feasible and effective intervention for patients with advanced peripheral arterial disease and chronic limb-threatening ischemia, particularly those with no conventional revascularization options. However, the small sample sizes and heterogeneous study designs represent the single limitation that most affects certainty regarding broad generalizability. A concrete next study should involve larger, multicenter randomized controlled trials to definitively establish the efficacy and long-term benefits of venous arterialization.

**Keywords:** Peripheral Artery Disease; Venous Arterialization; Chronic Limb-Threatening Ischemia

**Review Stats**

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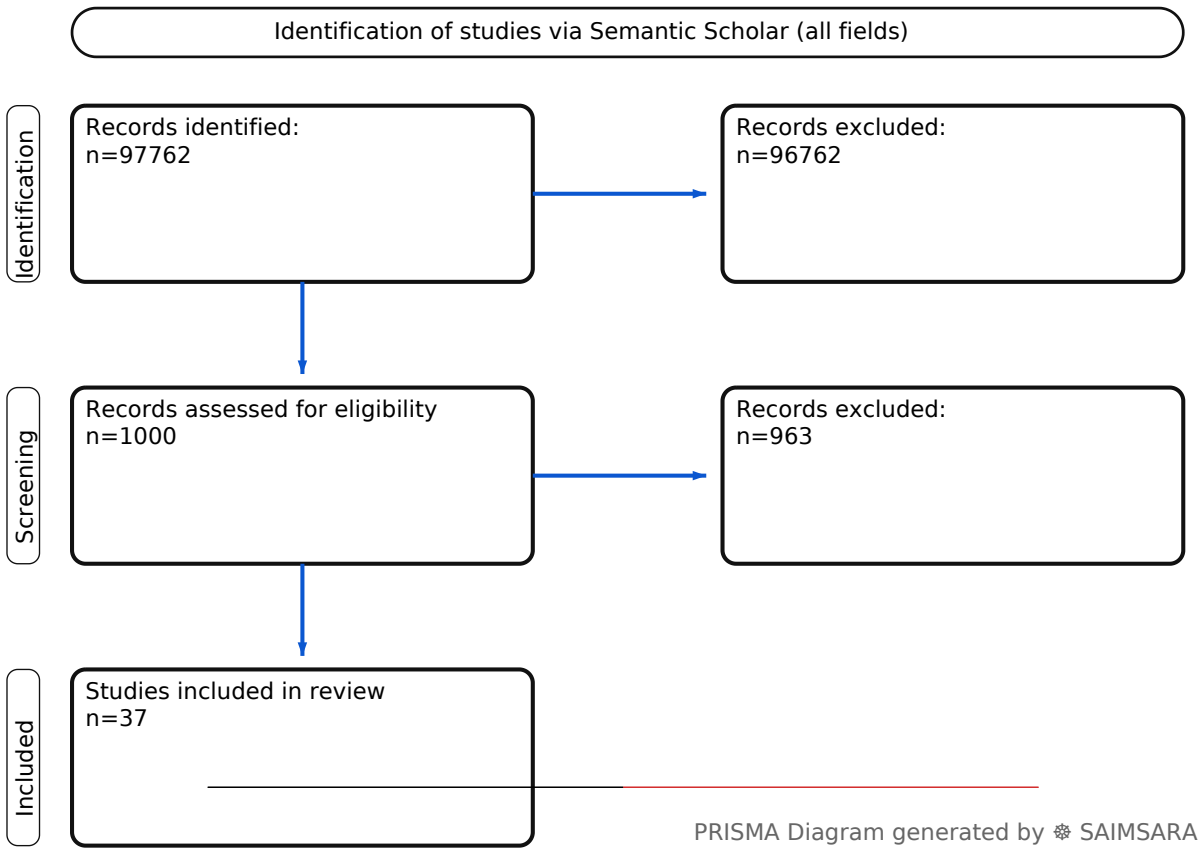
- Total study participants (naïve ΣN): 44718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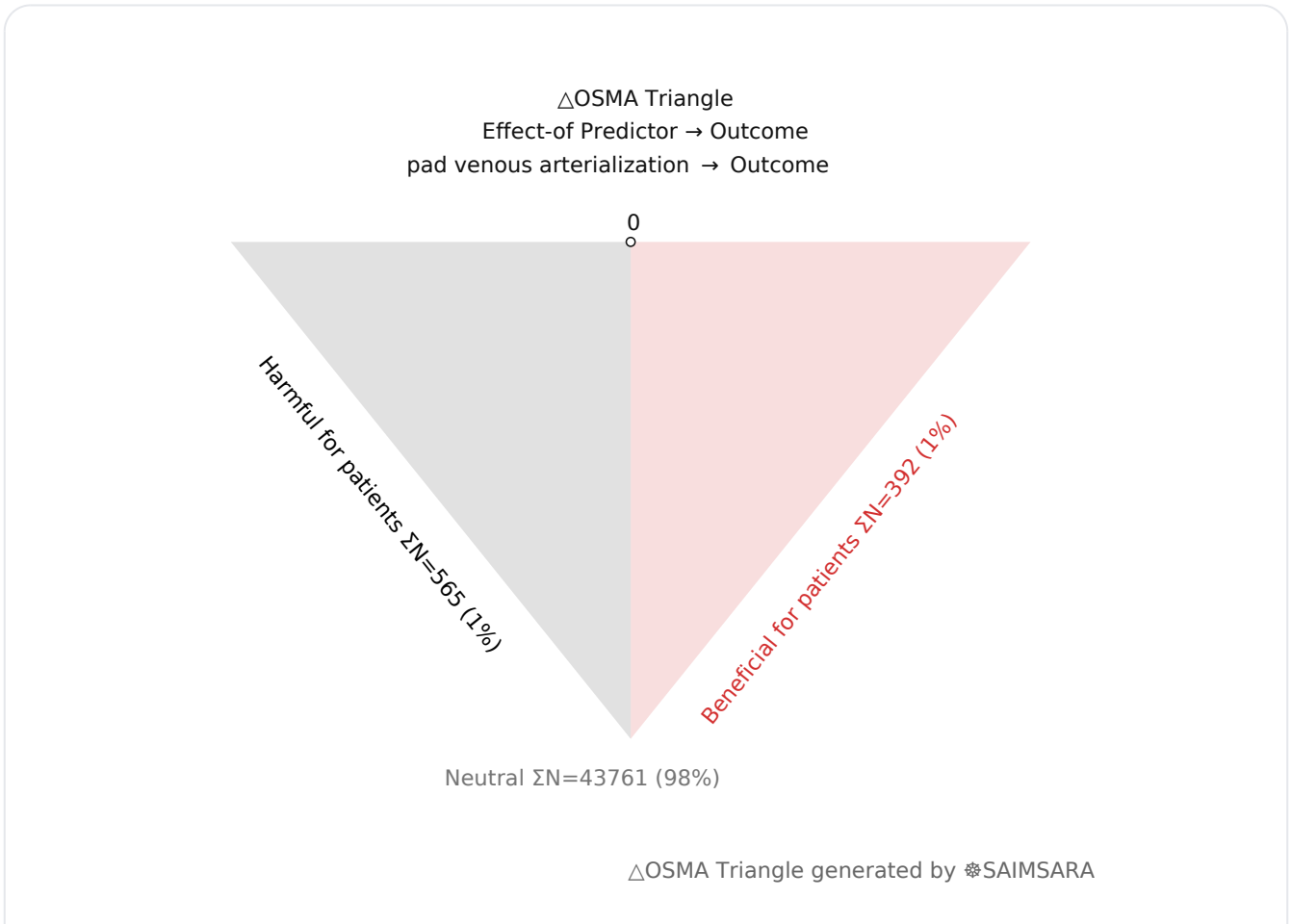
PRISMA Diagram generated by ☸ SAIMSARA


△OSMA Triangle
Effect-of Predictor → Outcome
pad venous arterialization → Outcome
0
Harmful for patients ΣN=565 (1%)
Beneficial for patients ΣN=392 (1%)
Neutral ΣN=43761 (98%)
△OSMA Triangle generated by ☸SAIMSARA

**Outcome-Sentiment Meta-Analysis (OSMA):** *(LLM-only)*
*Frame*: Effect-of Predictor → Outcome • *Source*: Semantic Scholar
*Outcome*: Outcome Typical timepoints: 24-mo, 6-mo. Reported metrics: %, CI, p.
*Common endpoints*: Common endpoints: healing, patency, survival.
*Predictor*: pad venous arterialization — exposure/predictor. Routes seen: oral. Typical comparator: venous aneurysms, provider management, those without pad, the control group….

- **1) Beneficial for patients** — Outcome with pad venous arterialization — [2], [3], [4], [5], [6], [9], [11], [12], [15], [16], [22], [25], [31], [37] — ΣN=392
- **2) Harmful for patients** — Outcome with pad venous arterialization — [21], [33] — ΣN=565
- **3) No clear effect** — Outcome with pad venous arterialization — [1], [7], [8], [10], [13], [14], [17], [18], [19], [20], [23], [24], [26], [27], [28], [29], [30], [32], [34], [35], [36] — ΣN=43761

**1) Introduction**

Peripheral arterial disease (PAD) represents a significant global health burden, often leading to chronic limb-threatening ischemia (CLTI) and severe tissue loss, particularly in patients with no-option revascularization. Traditional revascularization strategies aim to restore arterial flow directly. However, for patients with diffuse or end-stage PAD, these options may be exhausted. Venous arterialization, a technique that repurposes the venous system to deliver arterialized blood to ischemic tissues, has emerged as a promising alternative. This approach seeks to improve perfusion by reversing flow in the venous network, thereby supplying oxygen and nutrients to compromised distal extremities. The current paper synthesizes recent findings on venous arterialization, focusing on its application, outcomes, and associated considerations in PAD management.

**2) Aim**

This paper aims to systematically review the current evidence on venous arterialization for PAD, particularly in the context of limb salvage and wound healing, and to identify key clinical and research implications.

**3) Methods**

Systematic review with multilayer AI research agent: keyword normalization, retrieval & structuring, and paper synthesis (see SAIMSARA About section for details).

- **Bias:** Qualitatively inferred from study design fields, with case reports and small case series having high potential for publication bias and limited generalizability, while larger prospective cohort studies and randomized controlled trials offer higher evidence levels.

## 4) Results

### 4.1 Study characteristics:

The included studies comprise a mix of designs, predominantly retrospective and prospective cohort studies, case series, and mixed-design studies, along with individual case reports and experimental animal models. Populations primarily include patients with advanced peripheral arterial disease (PAD), chronic limb-threatening ischemia (CLTI), and specific injuries like heel pad degloving. Follow-up periods typically range from 6 months to 3 years, with some studies reporting longer-term or in-hospital observations.

### 4.2 Main numerical result aligned to the query:

Technical success rates for percutaneous deep venous arterialization (pDVA) and transcatheter arterialization of deep veins were consistently high, with a median technical success of 100% and a range from 96.6% to 100% across multiple studies [3, 4, 5, 6, 16]. Amputation-free survival (AFS) at 6 months ranged from 66.1% to 83.9% [3, 6]. Limb salvage rates ranged from 71% to 86.8% [3, 4, 5, 6]. Complete wound healing rates showed more variability, ranging from 25% to 100% [2, 3, 4, 5, 6].

### 4.3 Topic synthesis:

- **Percutaneous Deep Venous Arterialization (pDVA) Efficacy:** pDVA using devices like LimFlow demonstrated high technical success (96.9% to 100%) and promising midterm amputation-free survival (66.1% to 83.9% at 6 months) and limb salvage (71% to 86.8%) in patients with no-option CLTI [3, 4, 5, 6].
- **Wound Healing Outcomes:** Complete wound healing after venous arterialization varied significantly, with rates from 25% at 6 months to 72.7% at 24 months in CLTI patients, and 75% in a case series of end-stage PAD [3, 5, 6]. A single case of advanced PAD with foot necrosis achieved complete wound healing by 25 weeks [2].
- **Novel Surgical Techniques:** A novel technique for heel pad degloving injury reconstruction was described, utilizing arterialization of the plantar venous system via a vein graft [1]. Initial experience with dorsal venous arch arterialization for limb salvage was also reported [10].
- **Physiological Responses and Biomarkers:** Studies in mice investigated early adaptive responses of the vascular wall during venous arterialization [7]. In PAD patients, exercise training improved calf muscle oxygen metabolism and decreased the venous/arterial ratio of

blood [22]. Lower venous BNP concentrations suggested consumption in ischemic legs [34].

- **Peripheral Artery Disease (PAD) Risk Factors and Comorbidities:** PAD was associated with longer hospital stays in heart failure patients with COVID-19 [21], increased risk for vascular thromboembolic events (VaTEs) in cancer patients [33], and was negatively related to bilirubin levels in males [18]. Patients undergoing lower extremity revascularization (LER) for PAD were at risk for venous thromboembolism (VTE) [8].
- **Adjunctive and Alternative Therapies:** Arterial assist intermittent pneumatic compression (IPC) with venous outflow obstruction increased toe capillary flow and improved walking distance in ischemic legs [11, 12]. In situ bypass using the great saphenous vein (GSV) demonstrated high patency and limb salvage rates (80-95%) for PAD [15, 16].
- **Diagnostic Modalities:** Non-contrast enhanced Quiescent Interval Single Shot (QISS) magnetic resonance angiography (MRA) at 3T was found to be a reliable alternative to CT angiography (CTA) for evaluating lower extremity PAD [27]. Triggered angiography non-contrast-enhanced magnetic resonance imaging (TRANCE-MRI) showed high accuracy for venous pathology and could detect occult PAD [13].

## 5) Discussion

### 5.1 Principal finding:

The principal finding is that technical success for venous arterialization procedures in patients with advanced peripheral arterial disease (PAD) and chronic limb-threatening ischemia (CLTI) is remarkably high, with a median of 100% (range 96.6% to 100%) [3, 4, 5, 6, 16]. This indicates the feasibility and immediate procedural effectiveness of this innovative approach in a challenging patient population.

### 5.2 Clinical implications:

- **Salvage for No-Option Patients:** Venous arterialization offers a viable limb salvage option for patients with CLTI who have exhausted conventional revascularization strategies, demonstrating promising limb salvage rates (71% to 86.8%) [3, 4, 5, 6].
- **Wound Healing Potential:** Despite variability, venous arterialization can lead to complete wound healing in a significant proportion of patients with advanced foot necrosis, particularly over longer follow-up periods [2, 3, 5].
- **Consideration of Comorbidities:** Patients with PAD undergoing revascularization are at risk for venous thromboembolism (VTE), suggesting the need for careful anticoagulant management [8, 24].
- **Diagnostic Utility:** Advanced imaging techniques like QISS MRA and TRANCE-MRI can reliably assess PAD and venous pathology, aiding in patient selection and procedural

planning [13, 27].

- **Adjunctive Therapies:** Intermittent pneumatic compression (IPC) shows promise in improving capillary flow and walking distance in ischemic legs, potentially complementing arterialization efforts [11, 12].

**5.3 Research implications / key gaps:**

- **Standardized Outcome Metrics:** Future studies should standardize reporting of amputation-free survival, limb salvage, and wound healing rates at consistent time points to facilitate comparison across trials [3, 6].
- **Larger Prospective Trials:** The current evidence largely stems from case series and small cohorts; larger prospective, multicenter studies are needed to confirm efficacy and safety across diverse patient populations [3, 6].
- **Comparative Effectiveness Research:** Direct comparisons between venous arterialization and other advanced revascularization techniques (e.g., specific bypass types) or best medical therapy are needed to establish its precise role in the treatment algorithm [14, 15].
- **Long-term Patency and Durability:** While midterm outcomes are promising, longer-term follow-up beyond 2-3 years is crucial to assess the durability of venous arterialization and its impact on limb function and quality of life [3, 15].
- **Biomarker Identification:** Research into specific biomarkers (e.g., vascular wall changes, oxygen metabolism, BNP consumption) could help predict patient response to venous arterialization and guide personalized treatment strategies [7, 22, 34].

**5.4 Limitations:**

- **Small Sample Sizes** — Many studies are case series or small cohorts, limiting the generalizability of findings to broader PAD populations.
- **Heterogeneous Study Designs** — The variability in study designs (case reports, retrospective, prospective, mixed) makes direct comparison and synthesis of outcomes challenging.
- **Variable Follow-up** — Inconsistent follow-up durations across studies hinder a comprehensive understanding of long-term efficacy and durability.
- **Lack of Control Groups** — The absence of randomized controlled trials with appropriate comparator groups limits the ability to definitively attribute observed benefits solely to venous arterialization.

- **Specific Injury Focus** — Some studies focus on highly specific injuries (e.g., heel pad degloving), which may not be broadly applicable to all CLTI presentations.

**5.5 Future directions:**

- **Randomized Controlled Trials** — Conduct randomized controlled trials comparing venous arterialization to standard care or alternative revascularization options.
- **Long-term Outcome Data** — Collect long-term data on limb salvage, wound healing, and patient quality of life beyond 2-3 years.
- **Patient Selection Criteria** — Develop robust criteria to identify optimal candidates for venous arterialization based on anatomical and physiological factors.
- **Device Innovation Benchmarking** — Evaluate new devices and techniques for venous arterialization against established benchmarks for safety and efficacy.
- **Cost-Effectiveness Analysis** — Perform economic evaluations to assess the cost-effectiveness of venous arterialization compared to other interventions for CLTI.

**6) Conclusion**

Technical success rates for percutaneous deep venous arterialization (pDVA) and transcatheter arterialization of deep veins were consistently high, with a median technical success of 100% and a range from 96.6% to 100% across multiple studies [3, 4, 5, 6, 16]. These results suggest that venous arterialization is a feasible and effective intervention for patients with advanced peripheral arterial disease and chronic limb-threatening ischemia, particularly those with no conventional revascularization options. However, the small sample sizes and heterogeneous study designs represent the single limitation that most affects certainty regarding broad generalizability. A concrete next study should involve larger, multicenter randomized controlled trials to definitively establish the efficacy and long-term benefits of venous arterialization.

**References**

SAIMSARA Session Index — session.json

**Figure 1. Publication-year distribution of included originals**

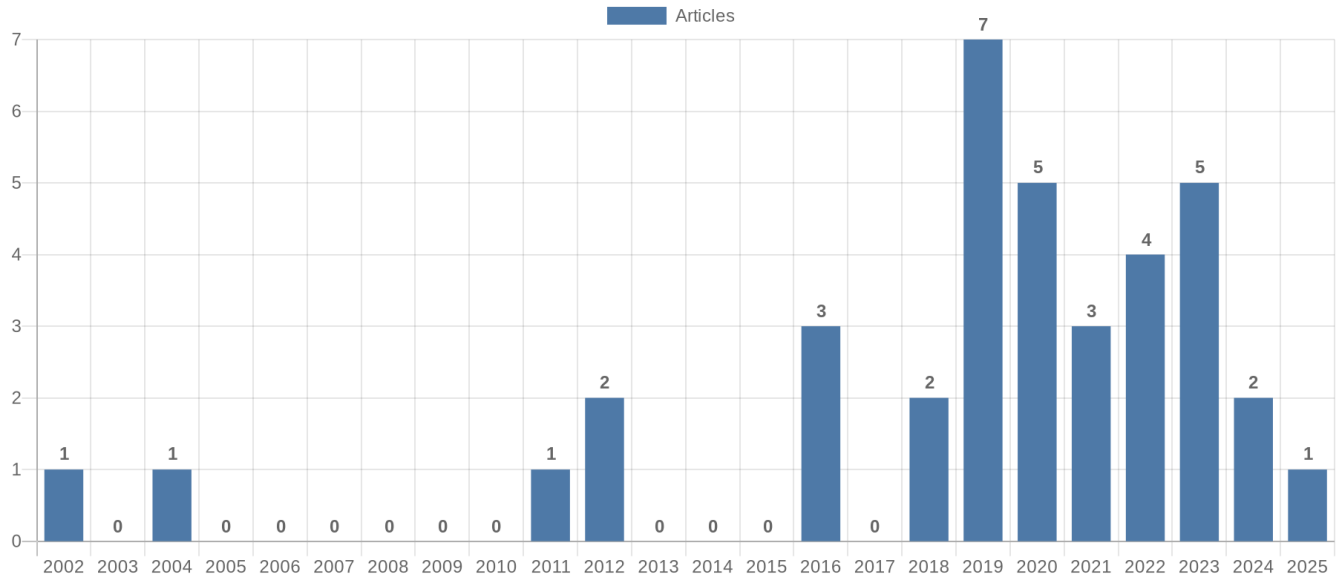



**Figure 2. Study-design distribution of included originals**

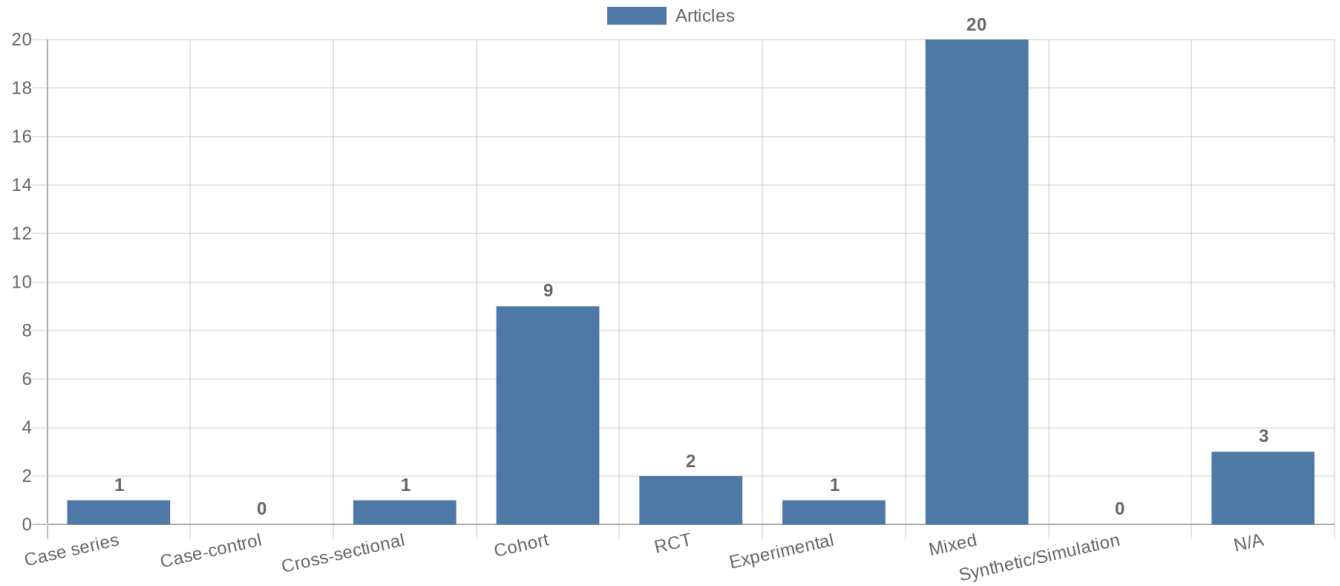



**Figure 3. Study-type (directionality) distribution of included originals**

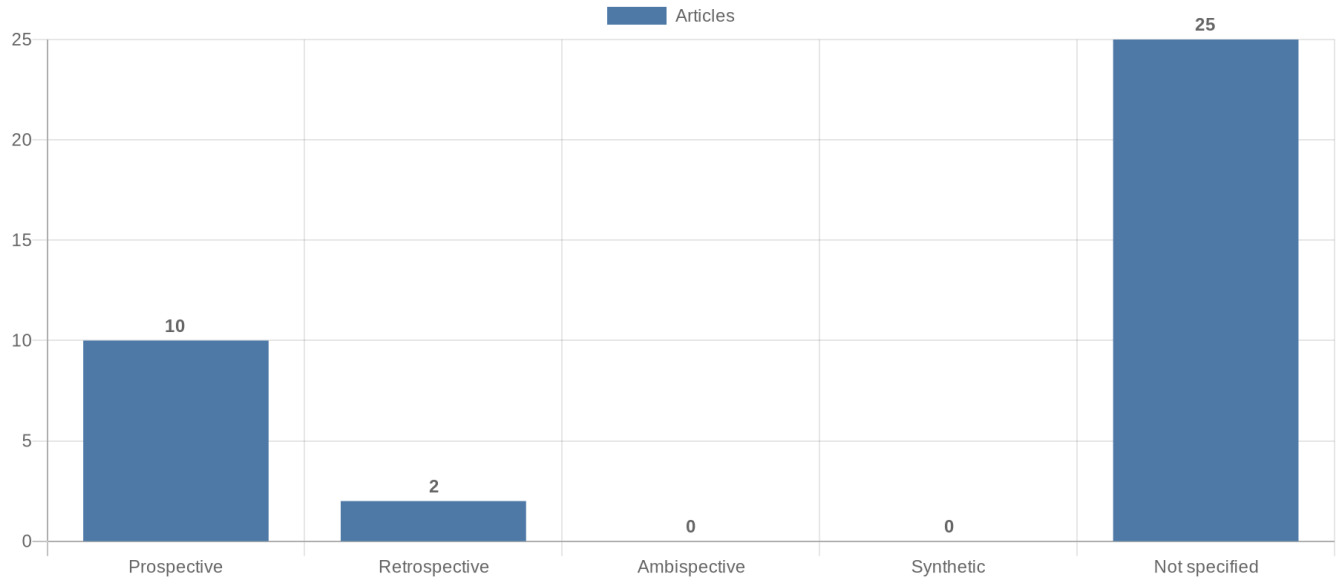


**Figure 4. Main extracted research topics**

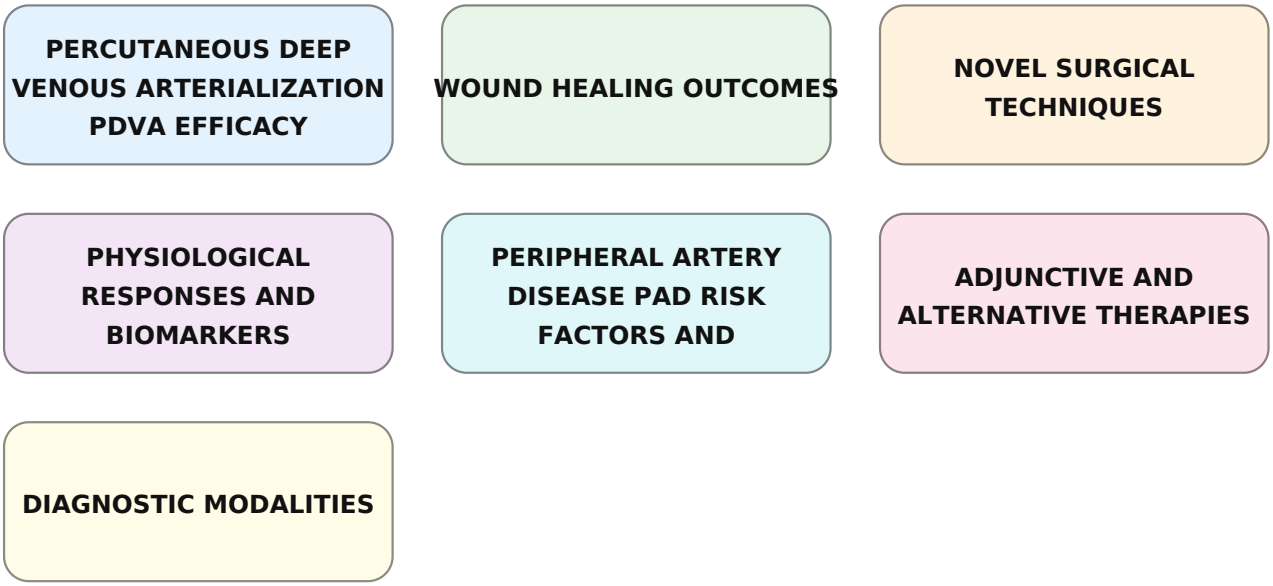



**Figure 5. Limitations of current studies (topics)**

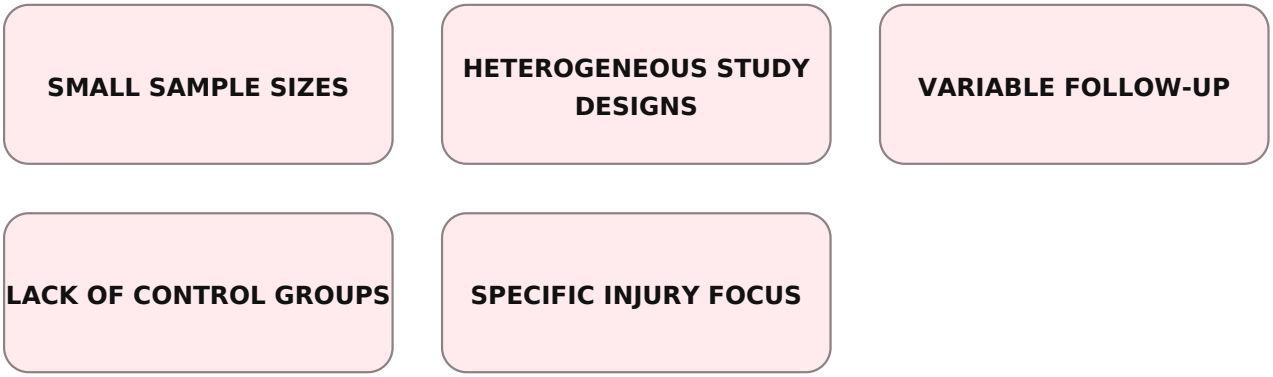



**Figure 6. Future research directions (topics)**