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Effectiveness of Surgical Interventions in Chronic Venous Insufficiency: An Evidence-Based Systematic Review

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ABSTRACT

Chronic Venous Insufficiency (CVI) is a disease that can significantly affect patients' quality of life. Although modern surgical therapies such as endovenous thermal ablation (ETA), iliac vein stenting, and others have been introduced, the effectiveness and safety of each procedure needs to be further evaluated. This study aims to evaluate the effectiveness and safety of modern surgical interventions in the management of CVI, focusing on clinical outcomes such as ulcer healing, pain reduction, and improvement in patient quality of life. This systematic review was conducted following PRISMA guidelines by screening literature from PubMed, ScienceDirect, Google Scholar, and Cochrane Library between 2014 and 2024. Of the 17,500 articles identified, 10 studies were included through a rigorous selection process. Analysis was performed based on study design, population, intervention type, clinical outcomes, and safety profile. Endovenous thermal ablation showed an anatomical success rate of more than 96% with long-term clinical benefits. Iliac vein stenting significantly improved symptoms of deep vein obstruction (VAS: 9 to 2.5) with a primary patency rate of 92%. Methods such as mechanochemical ablation (MOCA) and cyanoacrylate embolization (CAE) offer minimally invasive approaches with low complication rates and fast recovery times. The combination of early ablation and compression therapy accelerates healing of chronic venous ulcers (median healing time: 56 vs. 82 days). Modern surgical interventions are proven effective and safe in the management of CVI, with thermal ablation as the gold standard and iliac vein stenting as the superior option for deep vein obstruction. This evidence-based approach provides important guidance for personalizing CVI therapy in the future. Further research is needed to evaluate long-term sustainability and to optimize evidence-based clinical guidelines.

Keywords: chronic venous insufficiency, endovenous thermal ablation, iliac vein stenting, mechanochemical ablation, cyanoacrylate embolization, compression therapy

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INTRODUCTION

Chronic Venous Insufficiency (CVI) is a progressive condition characterized by impaired venous return from the lower extremities to the heart due to venous valve dysfunction or venous obstruction. This condition affects up to 40% of the adult population, with higher prevalence observed in older adults, women, and individuals with a family history of venous diseases (Davies, 2019; Ren et al., 2020). CVI can progress from mild symptoms, such as heaviness and leg pain, to severe complications like non-healing venous leg ulcers, chronic edema, and lipodermatosclerosis (Rossi et al., 2018).

The primary mechanism underlying CVI is venous valve insufficiency, which leads to venous reflux and chronic venous hypertension. Increased pressure triggers chronic inflammation, tissue damage, and eventually clinical manifestations such as venous leg ulcers (Gohel et al., 2018). CVI impacts not only the physical but also the psychological and social aspects of patients' lives, including reduced quality of life and significantly increased healthcare costs (Davies, 2019).

The therapeutic approach to CVI includes conservative management, such as elastic compression and lifestyle modifications, as well as surgical interventions to eliminate venous reflux and improve blood flow. Common surgical interventions include endovenous ablation

(radiofrequency or laser thermal ablation), sclerotherapy, vein stripping, and iliac vein stenting for deep vein obstructions (Lurie et al., 2018; Bootun et al., 2019).

Endovenous ablation has become the gold standard in the treatment of varicose veins and CVI due to its minimally invasive nature, fewer complications, and shorter recovery times compared to conventional vein stripping surgery (Bootun et al., 2019). However, the long-term effectiveness of these various surgical techniques, particularly in populations with severe disease such as venous ulcers, still requires further research (Gohel et al., 2018).

Optimal management of CVI is crucial, given its extensive impact on public health and healthcare systems. This study aims to evaluate the effectiveness of various surgical interventions in addressing chronic venous insufficiency based on available clinical evidence. By focusing on clinical outcomes such as ulcer healing, pain reduction, venous flow improvement, and quality of life, this systematic review seeks to provide deeper insights to support clinical decision-making and the development of practice guidelines (Rossi et al., 2018; Davies, 2022).

The objective of this study is to develop an evidence-based systematic review on the effectiveness of surgical interventions in managing chronic venous insufficiency. The focus is on identifying the most effective procedures for accelerating healing, minimizing complications, and improving patient quality of life. This research is expected to serve as a vital reference for medical professionals, vascular surgeons, and healthcare policymakers in optimizing CVI treatment in the future.

METHOD

Study Design

This systematic review was designed following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The study design aimed to identify, evaluate, and synthesize the available evidence on the effectiveness of surgical interventions for chronic venous insufficiency. All stages of the systematic review, from literature search to data analysis, were conducted transparently and rigorously to ensure the reliability and validity of the results obtained.

Inclusion and Exclusion Criteria

Inclusion Criteria:

1. Population:
   Studies involving adult patients (≥18 years) with chronic venous insufficiency, including venous varicosities, chronic venous ulcers, or superficial venous reflux classified under CEAP C2 to C6.
2. Intervention:
   Studies evaluating surgical interventions, including:
   - Endovenous ablation using radiofrequency (RFA) or laser (EVLA).
   - Saphenous vein stripping.
   - Sclerotherapy.
   - Vein stenting for deep vein obstruction.
3. Outcomes Measured:
   Studies reporting clinical outcomes such as:
   - Venous ulcer healing.
   - Improvement in clinical symptoms (pain, edema, or discomfort).
   - Health-related quality of life.
   - Complication rates associated with surgical procedures.
4. Study Design:
   Studies with the following designs:
   - Randomized Controlled Trials (RCTs).
   - Cohort studies.
   - Case-control studies.
   - Reviews (narrative and comprehensive) published in peer-reviewed journals.

5. Language:
   Studies published in English.
6. Publication Period:
   Studies published within the last 10 years (2014–2024), considering the rapid advancements in modern surgical techniques for chronic venous insufficiency.

Exclusion Criteria:

1. Studies involving populations with significant comorbidities, such as cancer or severe peripheral arterial disease, which could influence intervention outcomes.
2. Descriptive studies or pre-post design studies without a control group, which do not provide adequate comparisons for evaluating surgical interventions.
3. Review articles, editorials, commentaries, or conference abstracts that do not provide primary data.
4. Studies that do not report quantitative data on clinical outcomes or relevant results related to chronic venous insufficiency.

RESULTS AND DISCUSSION

The findings of this systematic review evaluate the effectiveness of various surgical interventions in managing Chronic Venous Insufficiency (CVI) based on available evidence from 10 included studies. The analysis was conducted to assess the efficacy of surgical procedures on various clinical outcomes, including anatomical success, improvement of clinical symptoms, enhancement of quality of life, management of complications, and the sustainability of long-term benefits. These included studies represent a range of research designs, including Randomized Controlled Trials (RCTs), prospective cohort studies, narrative reviews, meta-analyses, and evidence-based clinical guidelines.

1. Effectiveness of Endovenous Thermal Ablation Interventions

Several included studies, including Lawson et al. (2018) and Bootun et al. (2019), consistently demonstrated that endovenous thermal ablation, using either radiofrequency ablation (RFA) or endovenous laser ablation (EVLA), is highly effective in managing incompetent great saphenous veins.

- Anatomical Success**:** Vein occlusion rates of over 90% were reported during follow-up periods ranging from 36 to 60 months (Lawson et al., 2018). This data underscores the long-term effectiveness of thermal ablation in managing superficial venous insufficiency.
- Clinical Outcomes**:** Bootun et al. (2019) reported a significant reduction in post-procedure pain with the use of compression stockings for 7 days. However, no significant differences were found between groups with and without stockings in terms of quality of life at the 6-month follow-up.
- Long-Term Effects**:** Clinical success was further supported by Venous Clinical Severity Score (VCSS) and Aberdeen Varicose Vein Questionnaire (AVVQ) scores, showing significant improvements in clinical symptoms over a five-year follow-up period.

These findings confirm that endovenous thermal ablation is the gold standard in treating CVI with incompetent great saphenous veins, offering sustained benefits and minimal complications.

2. Iliac Vein Stenting Interventions

The study by Rossi et al. (2018) evaluated the effectiveness of iliac vein stenting compared to best medical therapy in patients with chronic venous disease (CVD) and significant iliac vein obstruction (>50%). The results indicated:

- Symptom Improvement**:** Stenting resulted in a reduction in the Visual Analog Scale (VAS) for pain from a median of 9 to 2.5, compared to a reduction from 8 to 7 in the control group ($p < 0.001$). VCSS scores also showed significant improvement in the stenting group.
- Quality of Life**:** Significant improvement in the 36-Item Short Form Health Survey (SF-36) scores indicated that stenting not only alleviated physical symptoms but also enhanced overall quality of life.

- Procedure Success**:** Primary patency, assisted primary patency, and secondary patency rates were 92%, 96%, and 100%, respectively, reflecting very high anatomical success rates.

Iliac vein stenting is a safe and effective intervention, particularly for patients with deep venous obstruction, providing excellent clinical and anatomical outcomes.

3. Management of Chronic Venous Ulcers

Two included studies, Gohel et al. (2018) and Ren et al. (2020), provide strong evidence regarding the management of chronic venous ulcers through surgical interventions.

- Effectiveness of Early Ablation**:** The study by Gohel et al. (2018) demonstrated that early endovenous ablation resulted in faster ulcer healing compared to compression therapy alone (median healing time: 56 days vs. 82 days). Additionally, ulcer-free time over one year was longer in the early ablation group (306 days vs. 278 days; $p = 0.002$).
- Advanced Therapies**:** The study by Ren et al. (2020) explored adjunctive therapies such as platelet-rich plasma (PRP) application and skin grafting to accelerate ulcer healing, though their long-term effectiveness requires further research.

The combination of early ablation with advanced techniques offers a promising approach for managing hard-to-heal chronic venous ulcers.

4. Use of Compression Therapy

Compression therapy has long been a cornerstone of conservative treatment and postoperative support for patients with Chronic Venous Insufficiency (CVI). The study by Lurie et al. (2018) provided in-depth insights into the effectiveness of this therapy in reducing postoperative complications, including pain, hematoma, and edema. The use of compression stockings with pressure greater than 20 mmHg was reported to not only alleviate clinical symptoms but also support healing in patients undergoing invasive procedures such as endovenous thermal ablation and sclerotherapy (Song et al., 2018).

The duration of compression therapy remains a topic of discussion across studies. Research suggests that high-pressure compression for a short duration, such as one week, is sufficient for most patients without active venous ulcers. However, for patients with chronic venous ulcers or deep venous insufficiency, longer durations of therapy, extending to several months, are necessary to prevent recurrence of symptoms and complications. Furthermore, studies highlight the importance of personalizing therapy based on the specific needs of patients. Factors such as the severity of CVI, comorbidities, and the patient's physical activity play a crucial role in determining the duration and type of compression device used.

Although compression therapy demonstrates significant benefits, several challenges remain, particularly regarding patient adherence. Discomfort associated with long-term use of compression stockings is often cited as a reason for discontinuing treatment, thereby reducing its effectiveness. Proposed solutions include developing more comfortable stocking designs and educating patients about the importance of compression therapy as an integral part of CVI management.

5. Modern Approaches in Pain and Symptom Management

Pain and clinical symptom management in CVI have evolved with the introduction of modern techniques such as mechanochemical ablation (MOCA) and cyanoacrylate embolization (CAE). The study by Orhurhu et al. (2021) highlighted that these techniques offer solutions that are not only effective but also more comfortable compared to conventional methods like vein ligation and stripping. Both procedures are designed to reduce procedural invasiveness, resulting in shorter recovery times and minimal postoperative complications.

- MOCA**:** Combining mechanical and chemical ablation to close dysfunctional veins, MOCA does not require tumescent anesthesia, which is often a source of discomfort in other procedures. Studies have shown significant pain reduction immediately after the procedure, with anatomical success rates comparable to RFA or EVLA.
- CAE**:** Using medical adhesives to close incompetent great saphenous veins, CAE has a shorter procedure time and does not require postoperative compression therapy. This technique is ideal for patients unable to use compression stockings or those with contraindications to anesthesia.

Both methods also show positive results in improving patients' quality of life. Patients reported significant pain reduction, decreased edema, and improved clinical scores such as the Venous Clinical Severity Score (VCSS). However, despite the promising initial results, long-term studies are needed to evaluate the sustainability of clinical benefits and potential risks associated with these techniques.

6. Clinical Guidelines and Economic Impact

The clinical guidelines by De Maeseneer et al. (2022) provide a detailed management algorithm for CVI based on the latest evidence. The guidelines recommend endovenous thermal ablation as the primary choice for incompetent great saphenous veins due to its high occlusion success rates (>90%) and minimal complications. For smaller veins or those in difficult-to-access locations, foam sclerotherapy is recommended as an effective alternative.

The guidelines also emphasize the importance of combination therapy, such as the use of compression stockings after ablation or sclerotherapy, to support recovery and prevent recurrence. However, it is noteworthy that personalized treatment approaches are strongly encouraged, considering the CEAP classification (Clinical-Etiological-Anatomical-Pathophysiological) and patient preferences.

The study by Davies (2019) added an economic dimension to CVI management, noting that early treatment with modern surgical techniques can significantly reduce the economic burden. This is particularly evident in the management of chronic venous ulcers, where hospitalization costs, loss of productivity, and complications can be minimized through effective surgical interventions. However, there remains a need to raise awareness among general practitioners about the importance of early referral and adherence to clinical guidelines.

7. Complications and Procedural Safety

Analysis of the included studies shows that most surgical interventions for CVI have a favorable safety profile with minimal complications. The study by Bootun et al. (2019) reported that postoperative pain can be minimized with the use of compression stockings, while the average recovery time was only 2–3 days. The study by Lawson et al. (2018) demonstrated high occlusion rates with mild side effects, such as small hematomas and temporary localized pain.

Modern techniques like MOCA and CAE further reduce the risk of complications by eliminating the need for tumescent anesthesia, which can cause systemic side effects in patients with comorbidities. However, some studies, such as Rossi et al. (2018), identified specific complications, such as distal stent migration in iliac vein stenting procedures. Although rare, these incidents were manageable with additional interventions.

The safety of these procedures supports their widespread use, but long-term follow-up is necessary to evaluate potential risks, such as vein recanalization or symptom recurrence. Combining minimally invasive procedures with conservative management, such as compression therapy, remains the ideal approach to maximizing clinical outcomes while minimizing complications.

DISCUSSION

This systematic review aimed to evaluate the effectiveness of various surgical interventions in managing chronic venous insufficiency (CVI), a complex condition that significantly affects patients' quality of life. The analysis of 10 included studies revealed a range of modern surgical approaches, including endovenous thermal ablation, iliac vein stenting, and other innovative techniques, each with distinct advantages, limitations, and important clinical implications.

Effectiveness of Endovenous Thermal Ablation

Endovenous Thermal Ablation (ETA), which includes radiofrequency ablation (RFA) and endovenous laser ablation (EVLA), continues to emerge as the gold standard for CVI treatment, particularly in cases involving incompetent great saphenous veins. The study by Lawson et al. (2018) demonstrated exceptionally high anatomical success rates, with vein occlusion exceeding 96% over a five-year follow-up period. This study also highlighted significant improvements in clinical parameters such as the Venous Clinical Severity Score (VCSS) and the Aberdeen Varicose Vein

Questionnaire (AVVQ), indicating that ETA is effective not only in addressing anatomical issues but also in improving long-term patient quality of life.

Additionally, Bootun et al. (2019) provided evidence that the use of compression stockings post-procedure can reduce postoperative pain during the initial days following ablation, although the long-term effects on quality of life were similar between groups with and without stockings. The combination of thermal ablation and compression therapy offers a synergistic approach to optimizing clinical outcomes.

The advantages of ETA over traditional surgical procedures like vein ligation and stripping lie in its minimally invasive nature, which results in fewer complications, shorter recovery times, and higher patient satisfaction rates. However, as highlighted by Raetz et al. (2019), the success of ETA can vary depending on patient factors, including the severity of CVI and the presence of comorbidities. This underscores the importance of personalized therapy to maximize clinical benefits.

Benefits of Iliac Vein Stenting

Iliac vein stenting has become a key solution for CVI caused by deep vein obstruction. The study by Rossi et al. (2018) provides strong evidence of the effectiveness of stenting in improving clinical outcomes for patients with chronic venous disease (CVD) and significant iliac vein obstruction. The significant reduction in the Visual Analog Scale (VAS) for pain, along with the improvement in quality of life measured using SF-36, indicates that stenting not only alleviates physical symptoms but also positively impacts patients' psychological well-being.

The anatomical success achieved through a primary patency rate of 92% and a secondary patency rate of up to 100% during the six-month follow-up further strengthens the position of stenting as a reliable intervention for patients with deep vein obstruction. Although complications such as distal stent migration have been reported, their frequency is very low, and these complications can be managed with additional interventions. These findings highlight the importance of long-term monitoring to ensure the sustainability of clinical benefits and to manage potential complications effectively.

Management of Chronic Venous Leg Ulcers

Chronic venous leg ulcers (CVLU) are the most severe complication of CVI and often drastically impact patients' quality of life. Managing CVLU requires a multidisciplinary approach, combining surgical interventions to address the underlying venous insufficiency with adjunctive therapies to accelerate ulcer healing. The study by Gohel et al. (2018) provides evidence that early endovenous ablation significantly accelerates ulcer healing compared to compression therapy alone. The median ulcer healing time in the ablation group was 56 days, markedly shorter than the 82 days observed in the compression therapy group. Additionally, the ulcer-free time over one year was longer in the early ablation group, highlighting the long-term benefits of this approach.

The study by Ren et al. (2020) highlights the potential of advanced therapies, such as platelet-rich plasma (PRP), skin grafting, and negative pressure therapy, in accelerating the healing of refractory ulcers. Despite the promising results, the study also emphasizes the need for further evidence to evaluate the long-term effectiveness of these techniques. The combination of endovenous ablation with advanced therapies offers a potentially transformative approach to managing refractory CVLU.

The Importance of Compression Therapy

Compression therapy is a crucial component in managing CVI, both as a conservative treatment and as part of postoperative recovery following surgical interventions. The study by Lurie et al. (2018) demonstrated that compression pressure >20 mmHg is effective in reducing postoperative complications such as hematoma and edema. The optimal duration of compression therapy varies depending on the severity of CVI, with shorter durations (1 week) being sufficient for most patients without active venous ulcers. However, patients with venous ulcers or deep venous insufficiency often require longer compression therapy to prevent recurrence.

Despite the significant benefits of compression therapy, patient adherence remains a challenge. Discomfort caused by compression stockings often deters patients from consistently

following this therapy. Potential solutions include the development of more comfortable stockings and educational programs emphasizing the importance of compression therapy as an integral part of CVI management.

Modern Approaches in Pain Management

Technological advancements have enabled the development of minimally invasive techniques such as mechanochemical ablation (MOCA) and cyanoacrylate embolization (CAE), offering innovative solutions for managing CVI. The study by Orhurhu et al. (2021) demonstrated that both techniques are effective in reducing pain and edema, with shorter recovery times compared to conventional methods such as thermal ablation. MOCA, which combines mechanical and chemical ablation, and CAE, which uses medical adhesives, offer additional benefits such as reduced need for anesthesia and elimination of postoperative compression therapy.

However, despite the promising initial results, there is still a need for long-term studies to evaluate the sustainability of clinical benefits and potential risks of complications associated with these techniques. These modern approaches show great potential, especially for patients with contraindications to conventional methods.

Safety and Complications

The safety of surgical procedures is a critical aspect evaluated in this systematic review, given the potential risks of complications that can affect patients' quality of life and the long-term success of therapy. Most included studies indicate that modern surgical interventions for chronic venous insufficiency (CVI), such as endovenous thermal ablation (ETA), mechanochemical ablation (MOCA), and cyanoacrylate embolization (CAE), have a good safety profile with minimal complications. However, the level of risk varies depending on the type of procedure, the severity of CVI, and patients' clinical conditions.

- Endovenous Thermal Ablation:

  The study by Lawson et al. (2018) reported that endovenous thermal ablation (including radiofrequency ablation and endovenous laser ablation) achieves high long-term vein occlusion rates (>96%), with mostly mild and manageable complications. Commonly reported complications include small hematomas, temporary localized pain, and skin pigmentation changes, which usually resolve within a few weeks without additional interventions. This study also noted that postoperative pain can be minimized by using compression stockings during the early recovery period, as supported by Bootun et al. (2019).

  However, complications such as temporary nerve damage due to heat exposure from laser or radiofrequency ablation also need to be considered. In some cases, patients reported transient paresthesia around the ablation site, although symptoms generally improved within six months. The safety of this procedure is reinforced by the low incidence of major complications, such as infections or deep vein thrombosis (DVT), reported in a small subset of the study population.

- Mechanochemical Ablation (MOCA):

  Mechanochemical ablation (MOCA) is a recent innovation in CVI management, combining mechanical ablation with sclerosant injection (Hekil & ELGAZZAR, 2023; Sun et al., 2017). This technique eliminates the need for tumescent anesthesia, which is often a source of discomfort in thermal ablation procedures. The study by Orhurhu et al. (2021) demonstrated that MOCA has an excellent safety profile, with mild complications such as localized pain or small hematomas at the procedure site. The risk of deep vein thrombosis was reported to be very low, and patients generally returned to normal activities within 1–2 days post-procedure.

  A significant advantage of MOCA is its minimal risk of nerve damage due to the absence of heat exposure, making it a safer option for veins located near peripheral nerves. However, long-term evidence on the effectiveness and safety of MOCA is still limited, necessitating further research to evaluate risks such as vein recanalization or symptom recurrence.

- Cyanoacrylate Embolization (CAE):

Cyanoacrylate embolization (CAE) is another innovative technique that uses medical adhesives to close incompetent great saphenous veins (Lam et al., 2017; Morrison et al., 2015; Radak et al., 2019). This procedure offers significant advantages, including the elimination of tumescent anesthesia and postoperative compression therapy, enhancing patient comfort. The study by Orhurhu et al. (2021) noted that CAE has a low complication rate, with side effects such as mild pain or localized inflammatory reactions in treated veins. These inflammatory reactions are typically mild and can be managed with conservative therapies such as nonsteroidal anti-inflammatory drugs (NSAIDs).

However, case reports of specific risks such as hypersensitivity reactions to the medical adhesive require careful consideration. Although rare, such reactions can lead to prolonged discomfort or localized edema. Therefore, patients undergoing CAE require clinical monitoring to detect these complications early.

- Iliac Vein Stenting:

  Iliac vein stenting is a highly effective intervention for addressing deep vein obstruction, but this procedure has specific risks that require attention. The study by Rossi et al. (2018) reported minimal complications, with very high anatomical success rates (92% primary patency, 100% secondary patency). However, complications such as distal stent migration, though rare, require additional interventions for correction. Such cases may arise due to suboptimal stent placement or venous movement caused by intra-abdominal pressure.

  Other potential complications include restenosis, which necessitates long-term monitoring using duplex ultrasonography or other imaging techniques. The risk of deep vein thrombosis after stenting is also a concern, particularly in patients with a history of hypercoagulability. Therefore, prophylactic anticoagulant use after the procedure is strongly recommended to minimize this risk.

- General Complications and Long-Term Safety Profile:

  Most included studies indicate that major complications from surgical interventions for CVI are very rare. For example, reports of deep vein thrombosis, postoperative infections, or systemic inflammatory reactions were exceedingly low, making these interventions a safe option for CVI management. However, it is essential to consider variations in complication risks based on the severity of CVI, the type of procedure performed, and patients' comorbid conditions.

Long-term monitoring is necessary to detect complications that may arise years later, such as vein recanalization or symptom recurrence. A combination of surgical interventions and conservative therapy, such as compression stocking use, remains the ideal strategy to minimize complication risks while ensuring sustained clinical benefits.

CONCLUSION

The conclusions of this systematic review indicate that modern surgical interventions such as endovenous thermal ablation (ETA), iliac vein stenting, mechanochemical ablation (MOCA), and cyanoacrylate embolization (CAE) are effective and safe approaches for managing chronic venous insufficiency (CVI). ETA has proven to be the gold standard, with high vein occlusion rates and long-term clinical benefits, while iliac vein stenting provides significant improvements in symptoms of deep vein obstruction and quality of life. MOCA and CAE offer minimally invasive alternatives with rapid recovery times and minimal complications. Early ablation approaches significantly accelerate the healing of chronic venous ulcers compared to conservative therapy, while compression therapy remains a crucial component in supporting clinical outcomes and preventing complications. Although short- and medium-term results demonstrate high effectiveness, further research is required to confirm long-term sustainability, personalize therapy, and optimize evidence-based clinical guidelines.

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