LOCUS JOURNAL: Research & Devotion
Volume 4 No. 8 August 2025
E-ISSN 2829-7334| P-ISSN 2829-5439
Hompage:
https://locus.rivierapublishing.id/index.php/jl

Recanalization Rates and Complications of Post-Endovenous Microwave Ablation in Chronic Vein Insufficiency with Large GSV Diameter

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Abstract

Endovenous Microwave Ablation (EMA) is one of the thermal ablation modalities to treat chronic venous insufficiency (CVI). The effectiveness and safety of EMAs in large-diameter saphena magna veins (GSVs) still require further research. This study aimed to compare the rates of recanalization and post-EMA complications in CVI patients with GSV diameters of <8 mm and ≥8 mm. This retrospective cohort study used data from 54 patients from a multicenter (January 2023 – May 2025). Statistical analysis was performed with an unpaired t-test and a Chi-square test. The rate of venous occlusion reached 100% in both groups. The recanalization rate at 3 months post-procedure was higher in the GSV group ≥8 mm (11.1%) compared to the GSV <8 mm (3.7%), although the difference was not statistically significant (p=0.299). There were no significant differences in complications of ecchymosis, thermal skin injury, and paresthesia. However, pain was reported to be significantly higher in the ≥8 mm GSV group (33.3% vs 7.4%; p=0.018). The EMA is effective in achieving occlusion in a wide range of GSV diameters, but patients with a GSV of ≥8 mm (especially ≥10 mm) have a higher tendency to recanalize and post-procedure pain. Additional strategies are needed to be considered to increase effectiveness and comfort in the group.

Keywords: Endovenous Microwave Ablation (EMA), chronic venous insufficiency, saphena magna vein, large diameter, complications, effectiveness.

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INTRODUCTION

Chronic Venous Insufficiency (CVI) is a pathological condition characterized by a progressive and persistent disruption of venous reverse flow from the lower extremities to the heart. CVI is often associated with chronic increased venous pressure that causes edema, trophic changes in the skin, as well as clinical symptoms such as pain and heaviness in the legs. The morbidity caused by CVI can have a significant impact on the quality of life of patients, causing functional limitations, and reducing the productivity of affected individuals. [1]

With rapid technological advancements, CVI disease management modalities are also increasingly developed and up-to-date. One of the non-invasive management modalities recommended in CVI patients is thermal ablation. According to the 2022 ESC guidelines, endovenous thermal ablation can be performed without *high ligation* in patients with a large GSV size (>12 mm). One of the ablation techniques that is currently developing rapidly is endovenous [2] *microwave ablation* (EMA). EMA is a thermal ablation technique developed in recent years for the treatment of CVI in the lower extremities. This method utilizes microwave energy to generate heat that causes coagulation and obliteration of the veins that are experiencing insufficiency, thereby reducing venous reflux and increasing venous blood flow more efficiently. EMA offers a minimally invasive alternative to conventional surgical procedures, with a lower potential risk of complications and a faster recovery time for patients. In addition, when compared to other laser ablations, the EMA has the potential to reduce operating time which can lower procedural risks. In addition, this technique has been shown to be equivalent to [3,4] *Endovenous Laser Ablation* (EVLA) in treating varicose veins caused by chronic venous insufficiency with a lower temperature than EVLA. With its advantages in procedural efficiency and comparable therapeutic effectiveness, EMA can be a promising alternative option in minimally invasive varicose veins therapy. [5]

The factors that affect the success of the EMA still need to be investigated further to minimize the failure factors of the EMA procedure. To date, there have been studies that explain the influence of vein diameter on the success of EVLA. One of the factors that affects the success of therapy with ablation is the diameter of the GSV vein. Study by [6] Kemaloglu et al revealed that venous diameter is a predictor of recanalization after thermal ablation. Until now, there are few studies that have examined the relationship between GSV vein diameter and recanalization in patients undergoing EMA, in contrast to EVLA which has more and varied studies. Several studies related to EVLA compared recanalization and complications in patients with large veins using varying cut-offs. One [7] [8] *Cut-off* The diameter of the vein is greater than 8 mm as done by Kemaloglu et al. and Desmyttere et al. [7] [9] This is in line with ESVS 2022 guidelines regarding the management of CVI patients, it is stated that one of the limits for GSV that is categorized as large is more than 8 mm. [2]

However, previous studies have not been able to provide conclusive evidence regarding the effect of GSV diameter on the success of venous occlusion performed by EMA actions. Brittenden et al. showed that a larger vein diameter provides better occlusion results. Gibson and Ferris also reported that in veins with larger diameters, occlusion results were more often successful due to a more even and more effective heat distribution in larger veins. In contrast to the study of Woo et al., the group with an average venous diameter of 6.00 ± 1.74 mm and with a mean diameter of 13.17 ± 1.28 mm showed a high rate of venous occlusion, 98.9% and 100% respectively at 12 months, with no significant difference ($p = 0.428$). There was no significant difference in the incidence of complications between the two groups. In addition, both groups experienced significant improvements in VCSS and AVSS clinical scores with no significant differences between them, suggesting that there was no effect of initial GSV diameter on therapy success. Meanwhile, a study by Li Zilun et al. in China showed that GSV

diameter is an independent factor that influences recanalization after minimally invasive measures. Although ablation remains effective at GSVs >10 mm, the rate of recanalization tends to be higher. In patients undergoing EMA alone, success decreases, especially if the GSV diameter is ≥13 mm. Therefore, high ligation before the EMA is recommended for a GSV of ≥13 mm to increase the success of the procedure. [8] [10] [11] [12]

The parameter of success of venous ablation therapy in CVI patients is the rate of symptom recurrence in the patient. Two systematic reviews and meta-analyses reported that neovascularization was the most common cause of recurrence after *the high ligation and stripping* (HLS) procedure, while recanalization was more common after endovenous ablation. Meanwhile, post-venous detachment monitoring can be carried out within a period of one month. This is in line with previous research by Yun et al., which stated that postoperative observations are usually performed within a week to one month after the procedure. The main purpose of this monitoring is to evaluate the success of the ablation. During this period, ultrasound is used to confirm the presence of incompetent saphena veins at the site of the ablation as well as to detect possible complications, such as [13,14] *deep vein thrombosis* (DVT) or *endothermal heat-induced thrombosis* (EHIT). [15]

Meanwhile, the safety parameters of EMA therapy can be seen in complications that occur in postoperative patients. According to the guidelines of the Society of Interventional Radiology (SIR), post-venous ablation complications are differentiated into mild and severe complications. Mild complications include pain, ecchymosis, pareesthesia, induration, phlebitis, and pigmentation, while severe complications include deep vein thrombosis, pulmonary embolism, severe infections, the need for emergency surgery, and death.

The *follow-up time* of the recanalization rate and post-procedure complications of the EMA is based on several clinical considerations and supporting scientific evidence. In previous studies, the 3-month period was consistently used as the primary evaluation point to assess venous occlusion success, recanalization events, and the emergence of post-operative complications. The study by Yang et al evaluated patients undergoing EMA and EVLA at the 1st, 6th, and 12th months, and showed that most complications such as paresthesia, ecchymosis, and induration appeared and peaked within the first month, with gradual improvement up to 3 months after the action. Similarly, a study by Chen et al evaluated the quality of life and clinical outcomes of post-EVLA patients at the 3rd and 12th months, showing that the improvement in clinical symptoms (assessed by the VCSS and Villalta scales) was already significant at the 3rd month and relatively stable until the 12th month. A large study by Nemoto et al also recommended post-EVLA monitoring via deep vein ultrasound on day 3 and between 1 to 3 months post-action, as serious complications such as EHIT or DVT often occur during this time period. These findings suggest that a 3-month period is a critical phase for detecting complications and assessing the initial success of ablation. Taking all these findings into account, the evaluation at the 3rd month is considered to represent the initial stabilization stage after the intervention, in which acute complications have been detected, and the initial effectiveness of venous occlusion can be objectively measured through clinical examination as well as ultrasound. [16] [17] [18]

Therefore, given that there are still research gaps in understanding the influence of GSV diameter on the effectiveness and safety of EMA, this study aims to evaluate and compare the rates of recanalization and complication incidence in CVI patients undergoing EMA procedures with different sizes of GSV diameter. The benefits of this study are expected to provide up-to-date scientific evidence regarding the safety and effectiveness of EMA techniques, especially in blood vessels with large diameters (≥8 mm). Practically, the results of this study can be used as clinical considerations for interventionists in choosing the most optimal therapy strategy, determining ablation parameters, and providing comprehensive counseling to CVI patients,

especially regarding outcome expectations and potential complications such as post-transplant pain.

RESEARCH METHODS

Based on the documents provided, this study used a retrospective cohort study design with data taken from the medical records of patients undergoing Endovenous Microwave Ablation (EMA) for Chronic Venous Insufficiency (CVI) at RSCM and network hospitals in the period from January 2023 to May 2025. The target population of the study was all CVI patients who had undergone EMA, while the affordable population consisted of post-EMA CVI patients who met the inclusion and exclusion criteria. The research sample was selected from the affordable population by considering the completeness of the data and the suitability with the criteria that have been set.

The sample size was calculated using a two-group comparison formula for multiple outcome variables. Based on the calculation for the EMA success variable (recanalization), a minimum sample number of 27 people per group (total 54 people) was obtained. Similar calculations were also carried out for complication variables such as eczemosis (42 people), thermal skin injury (36 people), paresthesia (36 people), and pain (40 people). Of all these calculations, the largest number of samples was 54 people, so this study used a total of 54 samples divided into two groups based on the diameter of the GSV, namely <8 mm and ≥8 mm, each consisting of 27 patients

Sample Selection Criteria

Inclusion Criteria:

a. Subjects diagnosed as CVI with CEAP stage C2–C6, which was confirmed by Doppler ultrasound examination to have reflux in the saphena magna vein
b. The subject underwent EMA action at the Dr. Cipto Mangunkusumo Hospital and the network hospital in the period of January 2024 until
   May 2025
c. The EMA action that the patient gets is the first action in the course of CVI disease that the subject is naturally
d. Subjects with post-EMA obliterated GSV were proceeded for recanalization assessment.

2. Exclusion criteria

a. Subjects with incomplete medical record data
b. Subjects with comorbidities of chronic kidney disease or congestive heart failure, who have bilateral limb edema.
c. Patients who had DVT prior to EMA

Sampling Techniques

The sampling technique in this study was adjusted based on the distribution of subjects in each GSV diameter group. For the ≥8 mm GSV group, *a consecutive sampling* technique was used because the number of patients in this group was relatively limited. All patients who met the inclusion and exclusion criteria were included sequentially until the minimum number of samples was met. Meanwhile, in the <8 mm GSV group which has a larger number of patients, *a random sampling* technique was carried out with a *matching method* so that the number and basic characteristics of patients were comparable to the ≥8 mm GSV group. The *matching* process is carried out based on variables that are clinically relevant and proven to have an effect on the success of ablation, namely gender, age, body mass index (BMI), and

main comorbidities such as diabetes mellitus or hypertension with the order of BMI, gender, and comorbidities possessed. The matching method used is *frequency matching*, to ensure that the distribution of basic characteristics between groups remains balanced so that the comparison results are more valid.

Research Procedure

This research begins with the process of making a research proposal. The research proposal is made by first compiling the background and formulation of the research problem. Furthermore, the research proposal is submitted by presenting it to the supervisor. After obtaining approval from the research supervisor, the process of submitting an ethics review to the Ethics Committee of the Faculty of Medicine, University of Indonesia continues.

Furthermore, research is carried out by first determining the research subject. The research subjects were determined based on predetermined inclusion and exclusion criteria. For subjects who meet the criteria, an explanation of the research will be carried out and their willingness to participate in the research will be requested. If the subject is willing, then the subject is asked to sign an *informed consent* sheet.

The study began with the division of the subject groups based on GSV diameter data of <8 mm and ≥8 mm. Then, an evaluation was carried out within 3 months postoperatively to see the recanalization and complications experienced by the patient. Data is collected and processed into numerical or categorical data for statistical analysis.

After the data processing process is completed, a research report is prepared that includes the results and discussion of the results of this research. Furthermore, the research process continued with the presentation of research reports and publication of research results.

Data Collection and Management Procedures and Statistical Analysis

The research data obtained will be recorded in the research subject datasheet with *the Microsoft Excel 2016 for Windows program.* Furthermore, data analysis will be carried out using *SPSS 20.0 for Macintosh* with the following steps.

Univariate analysis, descriptive analysis was carried out to see the distribution of the data characteristics of each variable. The results of the descriptive analysis will then be presented in the form of tabulers or graphs. Numerical data will be tested for normality with *the Kolmogorov-Smirnov* test, if it is distributed normally, the data used is in the form of *a mean*, while if the data distribution is abnormal, the median is used. Meanwhile, categorical data will be presented in the form of percentages and statistical tests will be carried out.

Bivariate analysis, if the results of the normality test are declared to be normally distributed data, then a statistical analysis test is carried out using a comparison test for two independent groups, namely the Mann Whitney test. If the results of the normality test are stated that the data is not distributed normally, then the data transformation is carried out as an effort to obtain a normal data distribution. If the transformation results state that the data remains abnormally distributed, then a statistical analysis test is carried out using the Chi-square test.

RESULTS AND DISCUSSION

Characteristics of research subjects

This study involved 54 subjects who underwent endovenous microwave ablation (EMA) for varicose veins saphena magna (GSV). Subjects were grouped based on GSV diameter into two groups, namely the group with a GSV diameter of <8 mm (n = 27) and a group with a GSV diameter of ≥8 mm (n = 27). The demographic and clinical characteristics of the study subjects are presented in Table 4.1.

Before the comparative analysis was carried out, a normality test of numerical data was first carried out using the Kolmogorov-Smirnov test. The test results showed that the variable age was distributed normally. Therefore, age data are presented in the form of mean ± standard deviation and analyzed using a non-paired t-test. For categorical variables such as gender, obesity, hypertension, and diabetes mellitus, a Chi-square test was used to see the difference in proportions between the two groups.

Based on the results of the analysis, the average age of the subjects was 55.13 ± 15.59 years. There was no significant difference between the mean age of the GSV group <8 mm (53.19 ± 17.14 years) and the GSV group ≥8 mm (57.07 ± 13.94 years), with a value of p = 0.365 (p>0.05). The sex composition was relatively balanced between the two groups, with the proportion of males and females at 51.8% and 48.2% respectively, and there was no significant difference (p = 0.586).

Based on BMI values, obesity classifications were found in 53.7% of subjects. The GSV group ≥8 mm had a slightly higher proportion of obesity (66.7%) than the GSV group <8 mm (40.7%), but this difference was not statistically significant (p = 0.056).

A history of hypertension was found in 48.2% of subjects, while diabetes mellitus was found in 29.6% of subjects. No significant differences were found in the distribution of hypertension or diabetes between the <8 mm and ≥8 mm GSV groups (p = 0.586 and p = 0.233, respectively). The occlusion rate in the study subjects reached 100% or was successful entirely based on the results of the post-action ultrasound examination. Thus, there was no difference in the rate of occlusion in GSV less than and more than 8 mm in this study (p = 1.00).

Table 1. Characteristics of research subjects

Characteristic	Total (n = 54)	GSV <8 mm (n = 27)	GSV ≥8 mm (n = 27)	p-value
Age (average ± elementary school)	55.13 ± 15.59	53.19 ± 17.14	57.07 ± 13.94	0.365a
Gender, n (%)				0.586b
Male	28 (51,8%)	15 (55,5%)	13 (48,1%)	
Female	26 (48,2%)	12 (44,5%)	14 (51,2%)	
Obesity				0.056 [b]
Yes	29 (53,7%)	11 (40,7%)	18 (66,7%)	
No	25 (46,3%)	16 (59,3%)	9 (33,3%)	
Hypertension				0.586 [b]
Yes	26 (48,2%)	14 (51,2%)	12 (44,5%)	
No	28 (51,8%)	13 (48,1%)	15 (55,5%)	
Diabetes Mellitus				0.233 [b]
Yes	16 (29,6%)	6 (22,2%)	10 (37,1%)	
No	38 (70,3%)	21 (77,8%)	17 (62,9%)	
Occlusion				
Yes	54 (100%)	27 (100%)	27 (100%)	1.00b
No	0 (0%)	0 (0%)	0 (0%)	

[a] Intergroup difference test with unpaired T test

[b] Test of difference between groups with Chi-square test

Post EMA Recanalization Rate

Evaluation of the success of the EMA post-action occlusion was carried out at 3 months after the procedure. The results of the analysis showed that the rate of recanalization was

significantly higher in the group with a GSV diameter of ≥8 mm (11.1%) compared to the GSV group <8 mm (3.7%) with a value of p = 0.299. These findings suggest that a larger GSV diameter may be related to lower occlusion success after EMA action.

This difference is not statistically significant based on the Chi-square test (statistical value $\chi^2 = 1.080$), but it still indicates an association between the diameter of the saphena vein and the occurrence of recanalization. Value *odds ratio* (OR) shows a figure of 3.25 which means that patients with large GSV have a 3.25 times higher risk of experiencing recanalization even though the results are not statistically significant. Clinically, these results are important because they suggest that patients with large GSV need special attention regarding the possibility of occlusion failure or the need for additional strategies of action.

Table 2. Comparison of recanalization rates in the 3 months post-EMA

	GSV <8 mm (n = 27)	GSV ≥8 mm (n = 27)	Statistics	OR (95% CI)	p-value
Recanalization			1,080a	3,25 (0,316 – 33,409)	0,299*
Yes	1 (3,7%)	3 (11,1%)			
No	26 (96,3%)	24 (89,9%)			

[a] Test of difference between groups with Chi-square test
* Significant value (p< 0.05)

Post-EMA Complications

Complication evaluation is performed to assess the safety of the EMA procedure. The complications analyzed include ecchymosis, *thermal skin injury*, paresthesia, and local pain. Overall, the incidence of complications was relatively low and no significant differences were found between groups based on the diameter of the GSV.

Post-action ecchymosis occurred in 7.4% of subjects in the GSV group <8 mm and 25.9% in the GSV group ≥8 mm (p = 0.068). *Thermal skin injury* found in 1 patient (3.7%) in the GSV group <8 mm, and 3 patients (11.1%) in the GSV group ≥8 mm (p = 0.299). Mild paresthesia was found in 2 patients (7.4%) in the GSV group <8 mm and 3 patients (11.1%) in the GSV group ≥8 mm (p = 0.639). Meanwhile, pain was found in 2 patients (7.4%) in the GSV group <8 mm and 9 patients (33.3%) in the GSV group ≥8 mm with significant differences (p = 0.018).

Table 3. Comparison of complications in the 3 months post-EMA

	GSV <8 mm (n = 27)	GSV ≥8 mm (n = 27)	p-value
Eczemosis			0.068a
Yes	2 (7,4%)	7 (25,9%)	
No	25 (92,6%)	20 (74,1%)	
Thermal skin injury			0.299a
Yes	1 (3,7%)	3 (11,1%)	
No	26 (96,3%)	24 (88,9%)	
Paresthesia			0.639a
Yes	2 (7,4%)	3 (11,1%)	
No	25 (92,6%)	24 (88,9%)	
Pain			0.018a*
Yes	2 (7,4%)	9 (33,3%)	
No	25 (97,6%)	18 (66,7%)	

[a] Test of difference between groups with Chi-square test

Discussion

Characteristics of research subjects

In this study, no significant differences were found in basic characteristics such as age, sex, obesity assessed from BMI, hypertension, or diabetes mellitus between the two groups ($p > 0.05$). These results show that the distribution of demographic and clinical characteristics between the two groups is relatively homogeneous, thus minimizing the potential for selection bias that may affect the analysis of differences in clinical outcomes after EMA. All subjects of this study experienced occlusion (100%) according to the results of post-operative ultrasound examinations

The average age of the subjects in this study was about 55 years, which is in line with previous studies that stated that saphonic varicose veins generally occur in middle to advanced age due to decreased vascular elasticity and venous valve function with age. [71,72]

The male sex was found to be slightly more than female, although there was no significant difference and no difference in the two GSV size groups. The findings are in line with studies that suggest varicose veins can affect both sexes, although some studies report a higher prevalence in women due to hormonal and pregnancy factors. [73]

The prevalence of obesity in this population is also high (53.7%), which is in line with the findings that obesity is one of the important risk factors in the pathogenesis of varicose veins due to increased intra-abdominal pressure and obstruction of reverse venous flow. However, no significant differences were found between the GSV diameter groups and the proportion of obesity, so it is unlikely that this factor will be the main disruptor in the analysis of differences in the rate of recanalization. [74]

Meanwhile, as many as 44.4% of the subjects had a history of hypertension. The GSV group <8 mm showed a slightly higher number (46.3%) than the GSV group ≥8 mm (38.5%), but this difference was not significant ($p = 0.618$). Hypertension is not a major risk factor for varicose veins, but some literature suggests an indirect contribution through systemic hemodynamic changes. In addition, as many as 18.5% of subjects had diabetes mellitus, with a distribution that did not differ significantly between the GSV <8 mm (17.1%) and GSV ≥8 mm (23.1%) groups, $p = 0.627$. Diabetes has not been shown to play a direct role in the pathogenesis of varicose veins, but it can affect post-endovascular healing through chronic inflammatory mechanisms and microcirculatory disorders. [75]

The Relationship of GSV Diameter with Recanalization Rate

This study showed that there was a non-significant difference in the recanalization rate at three months after endovenous microwave ablation (EMA) between the group of patients with a saphonic magna vein diameter (GSV) of <8 mm and the group with a diameter of ≥8 mm ($p = 0.299$). These findings suggest that larger GSV diameters tend to play a role as one of the determinants in the success of endovenous occlusion techniques, but are not statistically significant ($p > 0.05$). Physiologically, this phenomenon can be explained by the characteristics of veins with large diameters that have a greater cross-sectional area and blood volume, so that the heat distribution of ablation energy throughout the surface of the vein wall becomes less even and less effective. In addition, more elastic and thick venous walls are also more difficult to experience complete collapse, especially if tumescent anesthesia injections are not optimal, which can ultimately increase the risk of venous lumen reformation or recanalization. [59]

In the GSV <8 mm group, the rate of recanalization was observed to be low, but there was one case of occlusion failure. Upon further examination, patients who underwent this recanalization had a high body mass index (obesity category), which is thought to contribute to

the ineffectiveness of ablation. Obesity increases the thickness of subcutaneous tissue, so that the transmission of heat energy to the venous walls becomes less optimal. In addition, high intra-abdominal pressure in obese patients can increase venous backflow, potentially inhibiting collapse and obliteration of the post-ablation venous wall. Another factor that is thought to play a role, but is not systematically documented in medical records, is the level of adherence to the use of post-operative compression stockings. Several studies suggest the use of compression stocking for 4 weeks with varying use at night or during the day, although there have been no conclusive studies on the relationship of compression stocking to recanalization. The classification of CEAP in patients is also important to know in order to provide recommendations for appropriate compression pressure and ablation implementation strategies. In addition, socio-economic variables such as education level or loss of subjects in [76,77] [66] [16,78] *Follow-up* clinical. [79,80]

Meanwhile, in the ≥8 mm GSV group, three cases of recanalization were found. which mostly occur in patients with a vein diameter of ≥10 mm and comorbidities of obesity, hypertension, and diabetes mellitus. The high rate of recanalization in this group confirms the existence of greater technical challenges in large-diameter venous ablation. Procedure evaluation showed that there was a variation in techniques between operators, especially in terms of ablation power, ablation duration per segment, and pullback strategy. Some operators have used low power (40–45 watts), which in previous studies has been associated with an increased risk of recanalization, particularly in large veins with high return pressure. In contrast, 50–60 watts of power with a duration of 7–9 seconds per segment and repeated ablation techniques are reported to provide more optimal occlusion rates. However, because technical documentation is not uniform, interpretations of the relationship between techniques and clinical outcomes have become limited. In addition, compliance with the use of compression stockings and the type of compression class (CCL) used was also not fully recorded, making it difficult to analyze confounding factors thoroughly. [81]

These results are in line with research by Kemaloğlu (2019) which concluded that the diameter of the GSV >10 mm was significantly related to an increase in the recanalization rate, regardless of the ablation method used. The study emphasizes that venous diameter is the sole predictor of premature recanalization. In addition, the results of the study by Pisharody et al also reported similar results, where in the group of patients with GSV >10 mm, a higher rate of recanalization was obtained (15.2%) compared to GSV <10 mm (8.5%). Furthermore, a meta-analysis by Bontinis et al. (2023) showed that large GSV diameters (≥12 mm) were negatively correlated with occlusion rates and technical success on EVTA (Endovenous Thermal Ablation) procedures, both in the >12 mm GSV group and in the overall study population. Regression analysis showed a significant decrease in the occlusion rate along with the increase in GSV diameter ($p < 0.01$). [7] [59] [82]

Lin Yang et al. in China indented the ablation using 50 W energy with a *pullback* of 2 to 4 mm/sec This arrangement is said to guarantee sufficient closure for the vein but also prevent thermal hazards. Another study also conducted in China by Li Zilun et al recommended 50W energy with a [48] *pullback* of 3-4 seconds/cm, including for CVI with a GSV diameter with a diameter above 10 mm. In line with a study conducted by Chernuka et al. in 2021, it also recommends 50 Watts of energy with a pullback of 0.5 cm per 10 seconds to be able to engablast 3 venous layers with minimal effect on the surrounding tissues. Khantiworapong P et al year recommend energy of 50 – 60 Watts, pullback of 10 seconds/0.5cm. The energy is said to give the best results by damaging all the lining of the veins but not causing extraluminal tissue damage. Anjali Bacheta et al. in their study recommended the optimal LEED number for the EMA to be 140-675J/cm, using 35-75W energy and a pullback of 4-9sec/cm. In line with the study by Khantiworapong P et al., Dimitris also recommended 60 Watt energy in his study. [12] [83] [49] [46] [78]

In addition to the above, it is important to know the CEAP class and the assessment of preoperative venous anatomy in patients. In S.K. Van der Velden's study, it was stated that higher CEAP values are associated with more difficult venous anatomy, such as larger diameters, more meandering to make it difficult to achieve optimal ablation results. [84]

The Relationship of GSV Diameter with Post-EMA Complications

Evaluation of the incidence of complications after endovenous microwave ablation (EMA) in this study showed that most complications were mild, transient (self-limiting), and did not show significant differences between the GSV diameter groups of <8 mm and ≥8 mm, except for the incidence of local pain. The complications analyzed include ecchymosis, *thermal skin injury*, paresthesia, and local pain, which are common side effects of endovenous ablation procedures.

Ecchymosis was found with a relatively low frequency, namely in 7.4% of patients with a GSV of <8 mm and 25.9% of patients with a GSV of ≥8 mm ($p = 0.068$). Although it does not reach statistical significance, it remains within the range of events that have been reported in previous studies, which is between 10–25%. The Pisharody et al study reported a hyperpigmentation finding of 2% in patients with a GSV of <10 mm, while no ecchymosis was found in patients with a GSV of >10 mm. Meanwhile, the findings of the hematoma were found in 2 patients (6.1%) in patients with GSV <10 mm and 4 patients (2.6%) in patients with GSV >10 mm. Ecchymosis generally occurs as a result of mechanical trauma from catheter insertion, repeated venous punctures, or tumescent infiltration of anesthesia that causes pressure on the superficial capillaries. This condition does not require specific therapy and usually disappears within a few days to weeks, so it is not considered a major complication. The absence of a meaningful difference suggests that the venous diameter factor does not directly affect the incidence of these mild subcutaneous hemorrhage. [59]

Thermal skin injury, i.e. skin damage due to overheating during the procedure, was found more in the GSV group ≥8 mm (11.1%) than in the GSV group <8 mm (3.7%), although this difference was not statistically significant ($p = 0.299$). In a previous study by Yang et al, it was found that the prevalence of post-EMA burns was 6.54%. Pathopathologically, these complications are usually caused by uneven heat distribution, too shallow vein depth from the skin surface, or inaccuracies in the use of tumescent anesthesia. In large-diameter veins, a wider distribution of energy can increase thermal risk if not balanced with adequate techniques. However, the appropriate and optimal use of tumescent anesthesia has been shown to significantly reduce the risk of skin burns, by creating a space between veins and subcutaneous tissues while acting as a heat absorber. Therefore, although the trend is higher in large GSVs, the incidence of [16] *thermal skin injury* can be minimized with correct procedural techniques.

Post-EMA paresthesia was reported to occur in 7.4% of patients with a GSV of <8 mm and 11.1% of patients with a GSV of ≥8 mm ($p = 0.444$), with no significant differences between groups. In the study of Dermody et al, it was found that paresthesia was postoperative of EVLA in 3.8% of patients and 5.2% in post-operative patients of RFA. Meanwhile, in the study Zhao et al, it was found that the prevalence of paresthesia after EMA was 9.23%. Paresthesia in endovenous ablation is generally related to irritation or mild thermal injury to the saphena nerve or other surrounding cutaneous nerves, especially when the distance between the vein and the nerve structure is too close. These symptoms are usually temporary tingling or numbness and improve within a few weeks without the need for special intervention. Therefore, these complications are influenced more by the individual anatomy and tumescent fluid injection technique than the diameter of the vein itself. [70] [3]

Local pain was the only complication that showed significant differences between groups. The GSV ≥8 mm group experienced 33.3% of post-procedure local pain, while only 7.4% of patients in the <8 mm group reported similar complaints (p = 0.018). This is in line with previous research by Pisharody et al which found that pain was more common in post-EMA patients with GSV >10 mm (12.1%) than GSV <10 mm (2.6%). In addition, Zhao et al also found that the prevalence of pain in post-EMA patients was 41.54%. This difference can be explained by the fact that ablation in larger veins requires greater energy or wider application of heat, thus increasing the potential for tissue trauma. In addition, GSVs with large diameters generally have more elastic walls and are more difficult to collapse perfectly, so the heat energy used can cause wider tissue irritation. This local pain is usually mild to moderate and can be treated with oral analgesics. Nevertheless, these findings are important as a consideration in improving patient comfort, especially in groups with large GSVs. Pain in some studies was also associated with adherence to using postoperative compression stockings. In the study, this can be suspected to be one of the things related to pain complaints, however the use of compression stockings is not discussed further in this study. [59] [3]

Bontinis et al. (2023) in their meta-analysis reported the rate of minor complications such as paresthesia (1.8%), ecchymosis (2.1%), and pigmentation/induration (2.9%), with no significant differences between large and small GSV groups. This corroborates that minor complications after thermal ablation tend not to be directly correlated with venous diameter, but rather are influenced by engineering factors and individual characteristics. [82]

In contrast, a study by Pisharody et al. (2024) on patients undergoing mechanochemical ablation (MOCA) showed that patients with a venous diameter of >1 cm were more likely to experience overall local complications (24.2% vs 7.2%; p < 0.05), including hematoma and pain. However, since MOCA is a non-thermal procedure, direct comparisons to EMAs should be done carefully. [59]

Thus, overall, post-EMA complications in this study were mild and rarely required follow-up intervention. Although most occurrences do not differ significantly between groups, the increase in local pain incidence in groups with large GSV needs to be considered in the context of procedure planning, appropriate selection of ablation energy, and post-operative education and monitoring to improve patient comfort and safety.

Limitations of the study

This study has some important limitations that need to be considered in the interpretation of the results. First, relatively small sample sizes, particularly in groups with a GSV of ≥8 mm, can reduce the strength of statistical analysis and the ability to detect meaningful differences. Second, the documentation of ablation techniques between operators is not uniform, especially in terms of wattage, ablation duration, and frequency of re-ablation, which makes the analysis of the influence of the technique limited, this can be more considered if further studies can be carried out prospectively. Third, there is insufficient data on patient adherence to the use of postoperative compression stocking, even though it plays an important role in reducing complications, its involvement in maintaining long-term success can be further investigated. Fourth, due to the limited follow-up time of only 3 months, the potential for long-term recanalization (>12 months) cannot be assessed comprehensively. Advanced studies involving larger sample counts, longer follow-up durations, and standardization of ablation techniques are needed to produce stronger and more applicable evidence in clinical practice. The findings in this study provide the basis that the selection of an ablation strategy that takes into account the anatomical characteristics of the vein, especially the diameter of the GSV, can increase the effectiveness of therapy and lower the failure rate of the procedure.

CONCLUSION

Based on the results of this study, it can be concluded that Endovenous Microwave Ablation (EMA) is an effective and safe ablation technique to treat Chronic Venous Insufficiency (CVI) in patients with a diameter of both <8 mm and ≥8 mm, with an initial occlusion rate of 100% and no significant difference in recanalization rate at 3 months post-procedure. Nonetheless, the group with a GSV diameter of ≥8 mm tended to show a higher risk of recanalization (OR 3.25), especially in the GSV subgroup ≥10 mm, as well as experience significant post-procedure pain more frequently. No significant differences were found in other complications such as ecchymosis, thermal skin injury, or paresthesia. Thus, EMA may be recommended as a therapeutic modality in both diameter groups, but in patients with GSV ≥10 mm additional strategies need to be considered—such as optimization of ablation parameters, higher energy utilization, or combination with other techniques—to improve long-term effectiveness and reduce pain complaints. Going forward, studies with a prospective design, larger samples, longer follow-up durations, and standardization of ablation techniques are needed to confirm these findings as well as evaluate other factors such as compression usage compliance and the influence of CEAP classes on EMA outcomes.

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