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# Clinical results and cost-effectiveness of radiofrequency and cyanoacrylate ablation compared with traditional surgical stripping for treating varicose veins

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## ABSTRACT

**Background:** Disease of the venous system is an underappreciated public health problem. Minimally invasive treatments such as radiofrequency ablation (RFA) or cyanoacrylate adhesive ablation (CAA) have almost entirely replaced surgical stripping (SS) of the great and small saphenous veins. The purpose of the present study was to compare the outcomes at 3 years after SS, RFA, and CAA by assessing the incidence of complications and reinterventions and performing a cost-effectiveness analysis.

**Methods:** From February 2016 to February 2019, all consecutive patients with symptomatic varicose veins treated at vascular department of two hospitals using SS, RFA, or CAA were included in the present study. The clinical outcomes were measured by quality-adjusted life years (QALYs), complications, and reintervention. A comparison with conservative treatment was also performed. A detailed resource use was recorded for each procedure. All costs were normalized to May 2020 U.S. dollars and euros. Analysis of the data was by the treatment received. All statistical tests were two-sided, and the significance level was set at 5%. Two perspectives of the analysis were considered: the social perspective and that of the Spanish Public Health System. The study period was 3 years. No discount rate was applied.

**Results:** A total of 233 patients were enrolled in the present study: SS, n = 90 (38.6%); RFA, 93 (39.9%); and CAA, n = 50 (21.5%). The number of complications was 11 (12.2%), 3 (3.3%), and 3 (6%) in the SS, RFA, and CAA groups, respectively ($P =$ .06). No patient had required reintervention. The median loss of workdays for the SS, RFA, and CAA group was 15 days (interquartile range [IQR], 10-30 days), 0 days (IQR, 0-6 days), and 0 days (IQR, 0-1 days), respectively ($P <$ .001). The median level of satisfaction for the SS, RFA, and CAA group was 9 (IQR, 8-10), 10 (IQR, 9-10), and 10 (IQR, 9-10), respectively ($P <$ .001). The QALYs was 2.6 years for all three procedures. The median overall cost was €852 (US$926) for SS, €1002 (US$1089) for RFA, and €1228.3 (US$1335) for CAA. The total cost per QALY was €323/QALY (US$351/QALY) for SS, €380/QALY (US$413/QALY) for RFA, and €467/QALY (US$508/QALY) for CAA. The indirect costs were measured by the cost of the workdays lost for each patient and were €1527 (US$1660; IQR, €1018-3054); €0 (IQR, €0-611) for RFA, and €0 (IQR, €0-102) for CAA ($P <$ .001).

**Conclusions:** All three techniques were cost-effective (procedures with an incremental cost-effectiveness ratio <€30,000/QALY can be recommended). From the Spanish Public Health System perspective, when considering only the health care costs, the most cost-effective technique was SS. From the social perspective, including the opportunity costs of medical leave, CAA was the most cost-effective technique, saving €1600 per patient, a cost that more than compensated for the savings realized from using SS in direct health care costs. (J Vasc Surg Venous Lymphat Disord 2022;10:846-54.)

**Keywords:** Chronic venous insufficiency; Cost-effectiveness; Cyanoacrylate; Radiofrequency ablation; Stripping; Varicose veins

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Chronic venous disease is an underappreciated public health problem affecting all industrialized countries.[1] Varicose veins are one of the main causes of chronic venous disease. Although conservative treatment will be effective in the initial stages of the disease, surgery should be preferred for the more advanced phases. For more than a century, the standard surgical treatment has been high ligation and surgical stripping (SS) of the truncal veins.[2] However, endovenous ablation of the great saphenous vein (GSV) and small saphenous vein (SSV) using radiofrequency ablation (RFA) has become the most commonly used procedure.[3,4] Endovenous treatment with cyanoacrylate adhesive ablation (CAA) has recently been introduced and, because it is nonthermal, can be used without tumescent anesthesia.

Despite the many perceived advantages of minimally invasive techniques, they have been thought, by some, to be more expensive than traditional surgery owing to the high costs of consumable items, and their use has been restricted in many centers.[5] However, minimally invasive procedures are less invasive and could, therefore, result in shorter convalescence and the ability to resume work sooner, reducing the costs of lost productivity. To be best of our knowledge, the real costs of these three procedures—SS, RFA, and CAA—including the intervention costs and social costs, to treat varicose veins (VVs) have not been investigated. Thus, the aim of the present study was to compare conventional SS with RFA and CAA for endovenous saphenous vein obliteration and to evaluate the outcomes in terms of postoperative complications, cost and cost-effectiveness, sick leave, health-related quality of life (QoL), and satisfaction after 36 months of follow-up.

## ARTICLE HIGHLIGHTS

- **Type of Research:** An original research, two-center, retrospective analysis
- **Key Findings:** A total of 233 patients (90 in the surgical stripping [SS] group, 93 in the radiofrequency ablation, and 50 in the cyanoacrylate adhesive ablation [CAA] group) with 3 years of follow-up were evaluated for cost-effectiveness. No patient had required reintervention. The number of complications was 11, 3, and 3 in the SS, radiofrequency ablation, and CAA group, respectively ($P = .06$). The total costs/quality-adjusted life years were €144 lower for SS than for CAA. The indirect costs, including sick leave, were €1527 lower for CAA than for SS.
- **Take Home Message:** CAA was the most cost-effective technique, with a savings of ~€1600 per patient because of the shorter time to return to work and normal activities, which compensated for the lower health care costs of SS.

## METHODS

**Patient population.** The present study was designed as a retrospective, clinical, and economic observational study and was conducted at two participating centers. From February 2016 to February 2019, 233 patients with symptomatic VVs who had undergone RFA, CAA, or SS were included in the present study. The patients had been treated at the vascular and endovascular surgery department of the La Zarzuela University Hospital (private hospital) using RFA (Closure System; VNUS Medical Technologies, Inc, Sunnyvale, Calif) or CAA (VenaSeal Sapheon Closure System; Sapheon, Inc, Morrisville, NC) if judged clinically and anatomically suitable or at the vascular and endovascular surgery department of the Hospital Universitario Fundación de Alcorcón (public hospital) using SS. The decision to perform CAA or RFA was determined by the overall evaluation findings from the vascular surgeon. All 233 patients had provided written informed consent for their procedure, and the institutional review board of both hospitals approved the present study.

The effectiveness measurements used were the quality-adjusted life years (QALYs), complications (local or general complications from the intervention or anesthesia), and reintervention, satisfaction, and sick leave during the clinical follow-up period. The criteria for technical success were a sealed GSV with an absence of flow in the RFA and CAA groups and an absent GSV in the SS group. A recanalized GSV or treatment failure in the CAA and RFA groups was defined as a patent segment of the treated vein of ≥5 cm. The indirect costs were calculated as the opportunity costs from lost productivity owing to sick leave. The value of the lost workdays was assessed using the average wage level in Madrid, Spain, in the second trimester of 2019 (including wages, social security, and taxes).

A cost-effectiveness analysis (CEA) was performed to compare the three techniques, including the procedure and follow-up costs and the outcomes. The perspectives of the CEA were that of the Spanish Public Health System (SPHS) and that of society, and the study period was 3 years.

The inclusion criteria were age ≥18 years, the presence of unilateral or bilateral primary symptomatic VVs (CEAP [clinical, etiologic, anatomic, pathophysiologic] classification, 2-5), and GSV or SSV incompetence >0.5 second after manual compression of the calf or Valsalva maneuver with the patient standing, measured using duplex ultrasound. For endovenous treatment, the saphenous vein treated was in the intrafascial space.

The exclusion criteria were current deep or superficial vein thrombosis, a main truncal saphenous vein diameter of <4 mm or >15 mm, and pregnancy. The specific exclusion criteria for RFA or CAA were tortuous veins considered unsuitable for endovenous treatment and contraindications to the use of CAA. No conflicts of interest were identified by any surgeon.

**Technique.** The patients who had undergone CAA were treated in the ambulatory room (no preoperative tests and no fasting required). The treated area was disinfected, and sterile drapes were applied, with the patient placed in a supine or prone position for GSV or SSV treatment, respectively. The procedure was performed under local anesthesia. After the procedure, a Steri-Strip (3M, St Paul, Minn) was used on the puncture point, and the patient was allowed to ambulate immediately and return home. At 3 months of follow-up, microfoam sclerotherapy of the tributary varicosities was proposed and performed if indicated and agreed to by the patient.

The patients who had undergone RFA had required preprocedure blood tests and an anesthesiology consultation. Those patients receiving oral anticoagulation therapy were switched to subcutaneous heparin before RFA. RFA was performed with the patient under general anesthesia, and phlebectomies were performed during the same procedure. Finally, the leg was bandaged, and a long stocking was placed over the bandage. The patients were not instructed to limit their mobilization or ambulation, and the patients who had undergone CAA or RFA were encouraged to walk beginning the day of the procedure. The follow-up protocol for both techniques was reexamination after 10 days, 1 month, 6 months, and 1 year with color duplex ultrasound to assess recanalization.

The patients who had undergone SS had required a blood test before the intervention and an anesthesiology consultation. Additionally, before SS, the patients receiving oral anticoagulation therapy were switched to subcutaneous heparin. The correct area was marked before the procedure with duplex ultrasound guidance. Next, the patients were moved to the day hospitalization unit, where they rested on a gurney before being moved to the surgery room. The patients received a single dose of preoperative antibiotics. High ligation and invagination SS were performed through a groin incision of 4 to 6 cm, with flush division of the GSV and division of all tributaries behind the second level of the division. An inversion SS technique was used to the knee. The groin incision was closed in two layers.

After the procedure, the leg was wrapped in sterile absorbent bandages and covered with a compressive cohesive bandage (Co-plus; Smith & Nephew, London, UK). Next, the patient was moved to a recovery room and then to the day hospitalization unit, where a dose of heparin was administrated, and oral fluids were resumed. The patients then returned home, where they continued heparin prophylaxis for 0 to 10 days, guided by the Caprini score of heparin prophylaxis for ambulatory major procedures. After 48 hours, the patient was instructed to remove the bandage and to wear a class 2 compression stocking during the day for ≥4 weeks. At 10 days after the intervention, the patient visited the general doctor, and a nurse removed the sutures of the phlebectomies. At 3 months after the procedure, the patient attended the vascular consultation, color duplex ultrasound was performed, and the patient was discharged.

At 3 years of follow-up, all the patients were asked to rate how satisfied they were with the cosmetic outcome and the intervention overall using a 10-cm unmarked visual analog scale (0, completely unsatisfied; to 10, completely satisfied). They were also asked what duration of sick leave had been necessary.

**Cost and effectiveness evaluations.** CEA is a type of economic analysis that compares the relative costs and outcomes (health effects) of two or more interventions with one intervention used as the reference. The analysis was performed from the perspectives of the SPHS and society. The study period was 3 years. No discount rate was applied. The reference for the CEA was SS.

The cost data for each procedure and complications during follow-up were obtained from the financial services department (Supplementary Tables I–IV, online only) of the hospitals. For both hospitals, the costs were calculated using data from their cost accounting system. The data quantify the unit costs paid by the hospital for the purchase of inputs and the costs of the use of resources, such as professional time or operating room time. The operative (skin-to-skin), operating room, and recovery room times were measured (in minutes). The procedure costs included direct and imputed direct health care costs. The overall costs included the procedure costs and the costs of subsequent hospitalizations and Doppler ultrasound examinations for follow-up after the procedure. When used with SS, the cost of heparin was also included. For SS and RFA, the cost of the stocking was also included. If a reintervention was indicated, the additional costs of the reintervention were also recorded.

Indirect costs quantify the value of lost productivity because of sick leave (opportunity costs). They were assessed using the average wage level in Madrid, Spain, in the second trimester of 2019 (€3054 per month according to the Statistics National Institute, including wages, social security, and taxes).[6]

Detailed resource use was recorded for each procedure and patient. The costs were calculated as the product of resource use and the unit cost for each patient (the bottom-up approach, which begins with specific costs and moves to general costs). The costs were calculated as the product of resource use and the unit cost of purchasing by each hospital. The unit costs for the RFA kits were €385 (US$418.5). The unit costs for the CAA kits were €880 (US$956.5) and were obtained from the manufacturers using 2020 prices. All the costs were

**Table I.** Utilities[a]

| Variable | Utility |
|---|---|
| Symptomatic | 0.77 |
| Asymptomatic | 0.88 |
| Pain during workdays lost | |
| SS | −0.0353 |
| RFA | −0.0343 |
| CAA | −0.0346 |

*CAA*, Cyanoacrylate adhesive ablation; *RFA*, radiofrequency; *SS*, surgical stripping.
Data from Instituto Nacional de Estadistica[6] and Gohel et al.[7]
[a]During the postintervention time, patients were considered asymptomatic; for workdays lost, patients were considered symptomatic with pain; and, until complication resolution or reintervention, patients were considered symptomatic.[6,7]

normalized to May 2020 US dollars. The resultant cost data reflected the individual resource usage per patient per department per hospital admission.

The effectiveness of each treatment was measured in QALYs. A QALY is a measure of health-related QoL that provides the number of years a patient who had undergone the intervention under study will live after adjustment for QoL.[6,7] That number of years is weighted by the QoL for each survivor.

The QoL weights or utilities were measured using a scale from 0 to 1, in which 0 and 1 corresponded to the worst and best possible health outcomes, respectively. We used previously reported weights (Table I).[7,8] This value was compared with the QALYs of the base or reference alternative (ie, the standard procedure), which, in our study, was SS. Thus, it represented both the QoL and the quantity of life for each patient. Thus, a patient who had not undergone treatment was considered symptomatic; thus, their real life years was reflected by a utility of 0.77 (Table I). A patient who had undergone treatment was considered asymptomatic with pain (owing to the intervention) during the workdays lost. Patients with complications and those who had required reintervention were considered symptomatic until complication resolution or reintervention.[6,7] A CEA such as that used in the present study, which used QALYs instead of life years gained, is termed a cost−utility analysis because the QoL weights are intended to measure the utilities.

The results of CEA can be summarized as the incremental cost-effectiveness ratio (ICER) and incremental cost−utility ratio (ICUR). ICER and ICUR are defined as the ratio of the change in the costs of a therapeutic intervention (vs the alternative [eg, perform no treatment or use the best available treatment], which in our study was SS) to the change in the magnitude of benefit with the intervention measure in life years and QoL, respectively. The method, therefore, can be used to help choose the best possible intervention with consideration of both effectiveness and costs.

ICERs are often used in CEAs. ICERs are calculated by dividing the difference in costs between two alternatives by the difference in the QALYs. If the resulting ICER is less than a given cost per QALY threshold, the evaluated treatment can be recognized as cost-effective compared with the reference treatment. In Spain, no official threshold is available. A threshold of ∼€30,000 has generally been reported.[9]

**Statistical analysis.** The analysis of data was by the treatment received. The qualitative variables are reported as absolute and relative frequencies. The quantitative variables are presented as the mean ± standard or the median deviation and interquartile range (IQR), depending on the data distribution.

To compare the clinical characteristics of the three treatment groups, we conducted a bivariate analysis using the $\chi^2$ test or Fisher exact test for qualitative variables. For quantitative variables, we used the analysis of variance (ANOVA) F test of one factor for homogeneity of variances and the Welch test in the absence of homogeneity. For the specific case of two groups, the ANOVA F test is equivalent to the *t* test for the comparison of mean values.

ANOVA was also used to study the differences in the average costs. In the case of homogeneity of variances, the F test and Bonferroni correction for multiple comparisons were used. In the absence of homogeneity, the Welch test and Games-Howell correction were used. To compare the average cost of a procedure or alternative against a theoretical cost, we used the Student hypothesis *t* test for a sample. The nonparametric Kruskal-Wallis test and Mann-Whitney *U* test were performed to compare the differences between groups in intervention time, satisfaction, and workdays lost.

To record the data, we designed a data-collection sheet and a relational, normalized database using Microsoft Access (Microsoft Access; Microsoft Inc, Redmond, Wash). All statistical analyses were performed using the SPSS, version 22.0, software program (IBM Corp, Armonk, NY). Statistical significance was considered present at a $P$ value $< .05$.

## RESULTS

**Study population.** A total of 233 patients were included. Of the 233 patients, 90 had undergone SS (38.6%), 93 RFA (39.9%), and 50 CAA (21.5%). No significant differences were found in age (mean, 51.5 ± 13.8 years for SS; mean, 52.7 ± 12.9 years for RFA; and mean, 52.3 ± 15.1 years for CAA). Also, no differences were found in gender (female 62%) between the groups or body mass index (mean, 26 kg/m$^2$). The atherosclerotic risk assessment factors were homogeneously distributed (Table II), and no differences were found in the American Society of Anesthesiologist risk classification. Using the CEAP classification, no differences were found between

**Table II.** Baseline characteristics

| Characteristic | SS (n = 90) | RFA (n = 93) | CAA (n = 50) | $\chi^2$ *P* value |
|---|---|---|---|---|
| Follow-up, years | 3 | 3 | 3 | NA |
| Gender | | | | .91 |
| Female | 55 (61.1) | 59 (63.4) | 30 (60.0) | |
| Male | 35 (38.9) | 34 (36.6) | 20 (40.0) | |
| Hypertension | 16 (17.8) | 18 (19.4) | 10 (20.0) | .93 |
| Diabetes mellitus | 6 (6.7) | 2 (2.2) | 3 (6.0) | .32 |
| Dyslipidemia | 17 (18.9) | 22 (23.6) | 12 (24.0) | .68 |
| Chronic renal insufficiency | 0 (0.0) | 1 (1.08) | 0 (0.0) | 1.00 |
| Smoker | | | | .08 |
| Former | 24 (26.7) | 12 (12.9) | 7 (14.0) | |
| Current | 8 (8.9) | 9 (9.7) | 2 (4.0) | |
| ASA risk class | | | | .38 |
| 1 | 27 (30.0) | 26 (28.3) | 11 (39.0) | |
| 2 | 60 (66.7) | 59 (64.1) | 14 (50.0) | |
| 3 | 3 (3.3) | 7 (7.6) | 3 (10.7) | |
| Anticoagulation | 2 (2.2) | 1 (1.1) | 1 (2.0) | .84 |
| Acetylsalicylic acid | 3 (3.3) | 4 (4.4) | 3 (6.0) | .78 |
| Contraceptive use | 3 (5.5) | 1 (1.7) | 3 (10.0) | .18 |
| Deep vein thrombosis | 1 (1.1) | 2 (2.2) | 0 (0.0) | .12 |
| Superficial venous thrombosis | 4 (4.4) | 0 (0.0) | 0 (0.0) | |
| CEAP class | | | | .93 |
| 2 | 38 (42.2) | 39 (41.9) | 32 (36.4) | |
| 3 | 28 (31.1) | 28 (30.1) | 30 (34.1) | |
| 4-5 | 24 (26.7) | 26 (38.0) | 26 (29.5) | |
| Technique | | | | .06 |
| SSV | 11 (12.2) | 11 (11.8) | 10 (20.0) | |
| GSV | 75 (83.8) | 77 (87.8) | 40 (80.0) | |
| ASV | 4 (4.4) | 4 (4.3) | 0 (0.0) | |
| GSV + SSV | 0 (0.0) | 1 (1.1) | 0 (0.0) | |
| Previous surgery | 12 (13.3) | 11 (11.8) | 7 (14.0) | .94 |
| Leg | | | | .53 |
| Right | 42 (46.7) | 44 (47.3) | 24 (48.0) | |
| Left | 48 (53.3) | 46 (49.5) | 26 (52.0) | |
| Bilateral | 0 (0.0) | 3 (3.2) | 0 (0.0) | |
| Age, years | 51.5 ± 13.8 | 52.7± 13 | 52.3 ± 15.1 | .84[a] |
| BMI, kg/m$^2$ | 26.7 ± 4 | 25.7 ± 4.8 | 25.8 ± 31.7 | .56[a] |

*ASA,* American Society of Anesthesiologists; *ASV,* anterior saphenous vein; *BMI,* body mass index; *CAA,* cyanoacrylate adhesive ablation; *CEAP,* clinical, etiologic, anatomic, pathophysiologic; *GSV,* great saphenous vein; *RFA,* radiofrequency ablation; *SS,* surgical stripping; *SSV,* small saphenous vein. Data presented as number (%) or mean ± standard deviation.
[a]Analysis of variance one-way F test.

the groups. Some patients had undergone surgery on the same leg (SS, n = 12 [13.3%]; RFA, n = 11 [11.8%]; CAA, n = 7 [14%]; *P* = .94; Table II).

Of the patients in the SS, RFA, and CAA groups, 3.3%, 4.4%, and 6% had been treated with acetylsalicylic acid, respectively (*P* = .78). Also, 5.6% of the SS, 1.7% of the RFA, and 10% of the CAA groups had been treated with contraceptives (*P* = .18). Patients had been previously treated with oral anticoagulants in 2.2% of the SS and 1.1% of the RFA groups (both groups were switched to low-molecular-weight heparin before surgery with transition to oral anticoagulant agents 3 days after the procedure). In the CAA group, 2% had been receiving oral anticoagulant agents, and these patients were not transitioned to low-molecular-weight heparin for the intervention. For the SS group, the type of anesthesia was general for 32.2% of the patients, locoregional for 27.8%, and epidural for 40%. In the RFA group, 3.23% of the patients had undergone bilateral treatment.

**Table III.** Procedure and recovery room duration and complications

| Variable | SS (n = 90) | RFA (n = 93) | CAA (n = 50) | Kruskal-Wallis *P* value | *P* value (pairwise comparison) | | |
|---|---|---|---|---|---|---|---|
| | | | | | SS vs RFA | SS vs CAA | RFA vs CAA |
| Duration, minutes | | | | | | | |
| Intervention | 69.5 (60-80) | 40 (35-45) | 52 (47-57) | <.001 | <.001 | .001 | <.001 |
| Recovery room | 90 (65.5-115) | 95 (70-120) | NA | <.001 | 1.00 | NA | NA |
| Total | 160.5 (134.7-190) | 180 (150-205) | 52 (47-57) | <.001 | <.01 | <.001 | <.001 |
| Complications | 11 (12.2) | 3 (3.3) | 3 (6) | .06 | .07 | 0.72 | 1.00 |
| No reintervention | 90 (100) | 93 (100) | 50 (100) | NA | NA | NA | NA |

*CAA*, Cyanoacrylate adhesive ablation; *NA*, not applicable; *RFA*, radiofrequency ablation; *SS*, surgical stripping.
Data presented as median (interquartile range) or number (%).

The complications (nonserious adverse events) are shown in Table III. Of the 90 patients in the SS group, 2 had required hospitalization because of hypotension, 2 had developed neuropathy, and 1 had required treatment of an infection in the groin. The frequency of any procedural complication was lower and were less serious in the RFA group (3.3%) than in the SS group (12.2%). These included superficial thrombosis in one, neuropathy in one, and hyperpigmentation in one patient. The frequency of the procedural complications in the CAA group was also lower and were less serious (6% vs 12.2% in the SS group). These included skin inflammatory reactions in three, superficial thrombosis in three, neuropathy in two, systemic complications in two, hematoma and dehiscence in two, and hyperpigmentation in two patients ($P < .001$).

Microfoam sclerotherapy of tributary varicosities was performed in seven patients in the CAA group. The median time for the SS, RFA, and CAA groups was 69.5 minutes (IQR, 60-80 minutes), 40 minutes (IQR, 35-45 minutes), and 52 minutes (IQR, 47-57 minutes; $P < .001$). The median recovery room time for the SS and RFA group was 90 minutes (IQR, 65.5-115 minutes) and 95 minutes (IQR, 70-120 minutes; $P < .001$). The CAA group had not required a recovery room stay and had returned directly home. The closure rate was 100% during follow-up.

**Index hospitalization resource use and costs.** The procedural costs (recovery room stay and day hospitalization) was for €687 ± 110 (US$747) for SS; €795 ± 30 (US$864) RFA, and €1058 ± 3 (US$1150) for CAA ($P < .001$; Table IV). The mean cost of follow-up (medical consultation and ultrasound follow-up) was €175 ± 84 (US$190) for SS, €165 ± 84 (US$179) for RFA, and €170 ± 66 (US$185) for CAA ($P = .72$; ANOVA). The mean total cost (procedural cost plus follow-up plus stocking plus heparin) was €1004 ± 146 (US$1090) for SS, €1002 ± 87 (US$1088) for RFA, and €1228 ± 66 (US$1334) for CAA ($P < .001$; ANOVA), with no differences between SS and RFA (Table IV). The median number of lost workdays was 15 days (IQR, 10-30 days) in the SS group, 0 days (IQR, 0-6 days) in the RFA group, and 0 days (IQR, 0-1) in the CAA group ($P < .001$; SS vs RFA, $P < .001$; SS vs CAA, $P < .001$; RFA vs CAA, $P < .49$; Table V). The median level of satisfaction for the SS, RFA, and CAA group was 9 (IQR, 8-10), 10 (IQR, 9-10), and 10 (IQR, 9-10), respectively ($P < .001$; Table V).

**Quality-adjusted life expectancy.** The QALYs were 2.6 and were similar in all procedures. Therefore, the cost-effectiveness ratio of the procedural costs for the SS, RFA, and CAA groups was €222.8/QALY (US$242.4/QALY); €262.1/QALY (US$284/QALY), and €369.1/QALY (US$400.2/QALY), respectively. The total cost per QALY was €334.7/QALY (US$350.9/QALY), €334/QALY (US$412.3/QALY), and €409/QALY (US$506.7/QALY) for the SS, RFA, and CAA groups, respectively (Table VI). The ICER was lower than the threshold €30,000 for all comparisons and the three techniques (Table VI). The indirect costs of the workdays lost were a median of €1527 (IQR, €1018-3054), €0 (IQR, €0-611), and €0 (IQR, €0-102) for the SS, RFA, and CAA groups, and the differences were statistically significant ($P < .001$).

## DISCUSSION

The identification and use of cost-effective therapies are desirable in all areas of health care and, specifically, for VV treatment. These issues are pertinent in the current economic climate in which health budgets are likely to be under considerable scrutiny. The National Institute for Health and Care Excellence has estimated that much of the costs would be offset by a decrease in the number of expensive surgical procedures in favor of a cost-effective alternative.[10]

In 2017, 35,798 procedures for VVs were conducted in Spain (21,928 in the SPHS and 13,870 in private hospitals). The national data have suggested that the number of VV procedures performed in Spain are increasing annually.[11]

The present study is, to the best of our knowledge, the first to use real cost data to compare endovenous obliteration using RFA and CAA with traditional SS for the treatment of saphenous insufficiency. Our findings have shown that RFA and CAA obliteration will result in fewer

**Table IV.** Costs analysis

| Analysis stratified by intervention | Cost, € | ANOVA *P* value | *P* Value (pairwise comparison) SS vs RFA | SS vs CAA | RFA vs CAA |
|---|---|---|---|---|---|
| [1] Process cost + reanimation recovery room + stay cost | | <.001 | <.001 | <.001 | <.001 |
| SS | 587 ± 110 | | | | |
| RFA | 692 ± 30 | | | | |
| CAA | 969 ± 3 | | | | |
| [2] = [1] + imputed direct health care cost | | <.001 | <.001 | <.001 | <.001 |
| SS | 687 ± 110 | | | | |
| RFA | 795 ± 30 | | | | |
| CAA | 1058 ± 3 | | | | |
| [3] Total cost = [2] + follow up | | <.001 | .598 | <.001 | <.001 |
| SS | 994 ± 146 | | | | |
| RFA | 992 ± 87 | | | | |
| CAA | 1228 ± 66 | | | | |
| [4] Total cost = [3] + stockings | | <.001 | .598 | <.001 | <.001 |
| SS | 1004 ± 146 | | | | |
| RFA | 1002 ± 87 | | | | |
| CAA | 1228 ± 66 | | | | |
| [5] Total cost = [4] + sclerotherapy on CAA group | | <.001 | .598 | <.001 | <.001 |
| SS | 1004 ± 146 | | | | |
| RFA | 1002 ± 87 | | | | |
| CAA | 1248 ± 73 | | | | |

*ANOVA*, Analysis of variance; *CAA*, cyanoacrylate adhesion ablation; *RFA*, radiofrequency ablation; *SS*, surgical stripping.
Data presented as mean ± standard deviation.

postoperative complications, shorter sick leaves, and faster recovery of physical function compared with traditional surgery. The CAA procedure has higher costs but involves potential economic advantages because the patients can resume their daily activities earlier. In addition, no duplex ultrasound-identified recurrences had developed after CAA or RFA and no neovascularization in the groin had developed in the SS group. Conventional surgery has remained the most common treatment of VVs in Spain and Europe.[12-14]

The RFA and CAA procedure times were shorter than that for the conventional procedure, SS. The mean operative and recovery room times were significantly lower in the endovenous obliteration group, and the CAA group did not require use of the recovery room. The results for cost and cost-effectiveness were better for SS from the hospital and SPHS viewpoint. However, from the social perspective, the most cost-effective technique was CAA. All three techniques had an ICER less than the threshold and, therefore, can be considered cost-effective.

The results from the present study have suggested that either RFA or CAA, performed under general or local anesthesia in an outpatient or office-based setting, or day-case traditional GSV surgery is likely to be a cost-effective strategy for the treatment of saphenous vein

**Table V.** Level of satisfaction and sick leave duration[a]

| Variable | SS (n = 90) | RFA (n = 93) | CAA (n = 50) | Kruskal-Wallis *P* value | *P* value (pairwise comparison; adjusted by Bonferroni method) SS vs RFA | SS vs CAA | RFA vs CAA |
|---|---|---|---|---|---|---|---|
| Satisfaction score | 9 (8-10) | 10 (9-10) | 10 (10-10) | <.001 | .007 | <.001 | .001 |
| Lost workdays, No. | 15 (10-30) | 0 (0-6) | 0 (0-1) | <.001 | .001 | <.001 | .49 |
| Cost of workdays lost, € | 1527 (1018-3054) | 0 (0-611) | 0 (0-102) | <.001 | <.001 | <.001 | .49 |

*CAA*, Cyanoacrylate adhesive ablation; *RFA*, radiofrequency ablation; *SS*, surgical stripping.
Data presented as median (interquartile range).
[a]The cost of workdays lost was assessed using the average wage level in Madrid, Spain, in the second trimester of 2019 and was €3054 per month according to the Statistics National Institute,[6] including costs for social security and taxes.

**Table VI.** Cost-effectiveness analysis

| Analysis stratified by intervention | Mean, € | QALY | QALY vs no intervention | ACER: cost/ LY ratio | ICER | ICER | Cost/QALY ratio | ICUR | ICUR |
|---|---|---|---|---|---|---|---|---|---|
| [1] Process cost + recovery room + stay cost | | | | | | | | | |
| SS | 587 | 2.6 | .33 | 195.7 | Ref | | 222.8 | Ref | |
| RFA | 692 | 2.6 | .33 | 230.7 | 222764.1 | Ref | 262.1 | 22114.5 | Ref |
| CAA | 969 | 2.6 | .33 | 323.0 | −23238.3 | −16381.1 | 369.1 | −38528.8 | −18891.5 |
| [2] = [1] + Imputed direct health care cost | | | | | | | | | |
| SS | 687 | 2.6 | .33 | 229.0 | Ref | | 260.7 | Ref | |
| RFA | 795 | 2.6 | .33 | 265.0 | 229128.7 | Ref | 301.1 | 22746.3 | Ref |
| CAA | 1058 | 2.6 | .33 | 352.7 | −22569.2 | −15553.2 | 403.0 | −37419.3 | −17936.7 |
| [3] Total cost = [2] + follow-up | | | | | | | | | |
| SS | 994 | 2.6 | .33 | 331.3 | Ref | | 377.2 | Ref | |
| RFA | 992 | 2.6 | .33 | 330.7 | −4243.1 | Ref | 375.8 | −421.2 | Ref |
| CAA | 1228 | 2.6 | .33 | 409.3 | −14235.0 | −13956.5 | 467.8 | −23601.4 | −16095.3 |
| [4] Total cost = [3] + stockings | | | | | | | | | |
| SS | 1004 | 2.6 | .33 | 334.7 | Ref | | 381.0 | Ref | |
| RFA | 1002 | 2.6 | .33 | 334.0 | −4243.1 | Ref | 379.6 | −421.2 | Ref |
| CAA | 1228 | 2.6 | .33 | 409.3 | −13626.7 | −13365.1 | 467.8 | −22592.8 | −15413.3 |
| [5] Total cost = [4] + sclerotherapy for CAA group | | | | | | | | | |
| SS | 1004 | 2.6 | .33 | 334.7 | Ref | | 381.0 | Ref | |
| RFA | 1002 | 2.6 | .33 | 334.0 | −4243.1 | Ref | 379.6 | −421.2 | Ref |
| CAA | 1248 | 2.6 | .33 | 416.0 | −14843.3 | −14547.9 | 475.4 | −24610.0 | −16777.3 |

*ACER,* Average cost-effectiveness ratio; *CAA,* cyanoacrylate adhesive ablation; *ICER,* incremental cost-effectiveness ratio; *ICUR,* incremental cost−utility ratio; *LY,* life year; *QALY,* quality-adjusted life year; *Ref,* reference; *RFA,* radiofrequency ablation; *SS,* surgical stripping.

reflux at a conventional threshold for a cost per QALY in Spain.

Partial, pairwise, economic evaluations of VV treatments from the United Kingdom have also been reported, in which the costs were recorded in randomized trials.[15-17] However, those trials did not include CAA in their comparisons. These studies are of limited value when attempting to assess which of the available treatments are cost-effective, because they have provided only pairwise comparisons, had relatively short follow-up times, and generally did not account for recurrence in the targeted veins or health-related QoL.[18]

Also, none of the cited studies had included bilateral treatment. In our study, 3.23% of the RFA group had undergone bilateral treatment. Because both legs can be treated simultaneously (including phlebectomy for varicosities) and the costs of multiple treatment visits can be avoided, the cost-effectiveness of superficial venous interventions using RFA and CAA might be even better for patients who require bilateral surgery.[7] SS cannot be performed bilaterally in a single session, because of the inherent limitations in the postoperative period.

In the SPHS, sick leave is granted by the primary doctor, not a specialist, as it is in private hospitals. Thus, the granting and duration of sick leave varies by the type of hospital where the procedure is performed. In addition, an opportunity exists for cost-savings favoring CAA and RFA over SS. SS requires an operating room but RFA and CAA can be performed in an intermediate room or even in an office setting.

We compared patients treated in a public and private hospital. A better method would have been to compare patients treated with different techniques at the same hospital. However, in Spain, no hospital usually performs all three techniques. Public hospitals usually perform SS, and private hospitals usually perform RFA and CAA. Thus, we compared the costs for each hospital according to the material and personal costs (Supplementary Tables I−IV, online only), and significance differences were not observed. The private hospital included in our study works with only one insurance company. This company includes both RFA and CAA treatment for their associates. Thus, no economic bias exists in the choice of RFA or CAA for the surgical team. We used a zero discount rate because the effects of the treatments on health-related QoL occur within a short time after the intervention.

The present study had some limitations. First, we used a nonrandomized, retrospective study design. Second, the comparison was between two different hospitals. However, in Spain, no hospitals perform all three techniques. The practice pattern in Spain differs from that of many other countries, which might have been another limitation of our study. Thus, the results might not be generalizable to other countries.

## CONCLUSIONS

To the best of our knowledge, the present study was the first economic study to use real data to compare the three most frequently used techniques in the treatment of chronic venous insufficiency. The data on immediate and late morbidity and the occlusion and absence rate of the saphenous vein were similar to those collected in large international clinical trials. The results in terms of costs and cost-effectiveness indicate that for the process costs and total costs, the lowest costs are for SS and RFA. However, if we consider the savings for the indirect costs resulting from sick leave, CAA and RFA are more cost-effective.

## AUTHOR CONTRIBUTIONS

Conception and design: SV, BL, MM, EP, PC, GR, JN, SD, LD, JF

Analysis and interpretation: SV, BL, MM, EP, PC, GR, JN, SD, LD, JF

Data collection: SV, JN, SD

Writing the article: SV, BL, MM, EP, PC

Critical revision of the article: SV, BL, MM, EP, PC, GR, JN, SD, LD, JF

Final approval of the article: SV, BL, MM, EP, PC, GR, JN, SD, LD, JF

Statistical analysis: SV, EP, GR

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Overall responsibility: SV

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*Additional material for this article may be found online at www.jvsvenous.org.*

**Supplementary Table I (online only).** Costs of preoperative tests at La Zarzuela and Alcorcon Hospitals

| Preoperative test | Alcorcon, € | La Zarzuela, € |
|---|---|---|
| Anesthesiology consultation | 37 | 41 |
| Laboratory test | 7 | 12 |
| Nurse consultation | 23 | |
| Doppler US | 36 | 36 |
| Total | 103 | 89 |

*US,* Ultrasound.

**Supplementary Table II (online only).** Personal and material costs for Alcorcon Hospital (source: cost accounting system)

| Variable | Unit, No. | Cost | Total cost, € |
|---|---|---|---|
| Personal | | Hourly | |
| Nurse | 2 | 32.48 | 16 |
| Nurse auxiliary | 1 | 19.27 | 5 |
| Support staff | 2 | 17.17 | 9 |
| Subtotal | | | 30 |
| Material | | Unit | |
| Hypoallergenic adhesive electrode | 3 | 0.04 | 0.13 |
| Green-beet surgical cap | 7 | 0.02 | 0.15 |
| Hypoallergenic mask | 6 | 0.30 | 1.78 |
| Antiseptic towels, chlorhexidine/2% chlorhexidine gluconate | 0.2 | 9.50 | 1.90 |
| Segmented/peripheral catheter, 20-guage, 30 mm | 1 | 0.6172 | 0.62 |
| T nitrile, small N, EST gloves | 1 | 0.03 | 0.03 |
| Infusion IV equipment (solution), macro drip set | 1 | 0.20 | 0.20 |
| Three steps key with extension 25 cm | 1 | 0.26 | 0.26 |
| Saline solution, 500 mL, flexible | 1 | 1.80 | 0.6032 |
| Plaster, hypoallergenic, 2.5 cm × 10 m | 20 cm | 0.69 | 0.01 |
| Transparent adhesive dressing, Opsite 10 × 15 | 1 | 0.42 | 0.42 |
| Sterile contrast gauze pack | 1 | 0.10 | 0.10 |
| Tinted alcoholic chlorhexidine 2%, 250 mL | 1 | 2.035 | 2.04 |
| Cardboard batting | 1 | 0.06 | 0.06 |
| Disposable blade electric scraper, not consumable | 0.4 | 2.59 | 1.04 |
| Double bell adult phonendoscope | 1 | 12.69 | |
| Sphygmomanometer | 1 | 120.56 | |
| Synthetic compressor, flat elastic, 50 cm | 1 | 0.12 | 0.12 |
| Subtotal | NA | NA | 9.45 |
| Overall total | NA | NA | 39 |

*NA,* Not applicable.

**Supplementary Table III (online only).** Imputed direct health care costs, 2019

| Variable | Amount, € | Mean cost |
|---|---|---|
| Surgical block | 484 | 641 |
| Nurses | 237 | 314 |
| Auxiliary nurses | 41 | 55 |
| Support staff | 39 | 51 |
| Food | 0 | 0.0 |
| Waste | 3 | 4 |
| Laundry | 8 | 10 |
| Maintenance | 2 | 3 |
| Medicinal gases | 1 | 2 |
| Electricity | 4 | 6 |
| Electromedicine | 3 | 4 |
| Water | 750 | 1 |
| Gas | 1 | 2 |
| Sanitary consumables | 41 | 54 |
| Prosthesis | 565 | 0.7 |
| Pharmacy | 0 | 0 |
| Structural cost | 30 | 40 |
| Amortization | 3 | 3 |
| Other costs | 69 | 91 |
| Structural and other costs | 28.696 | 38 |
| Structural cost | 24.034 | 32 |
| Admission and clinical documentation cost | 2.640 | 4 |
| Reception | 0 | 0 |
| Usury information | 973 | 1 |
| Social job | 1.048 | 1 |
| Subtotal | 512.426 | 679 |

**Supplementary Table IV (online only).** Cost of material at La Zarzuela Hospital

| Description | Units, No. | Total cost, € |
|---|---|---|
| Gauze, 20 x 40 cm STERILE, RX detectable | 1 | 0.20295 |
| Compress, 45 x 45 cm STERILE | 1 | 0.2904 |
| Compress, 45 x 45 cm with X-Ray detectable | 4 | 3.86496 |
| Sheath 7F | 1 | 16.94 |
| Sutures, 12 × 100 mm | 1 | 0.528 |
| Sticking plaster, 5 | 1 | 0.9907 |
| Dressing, 6 × 7 cm | 1 | 0.03355 |
| Dressing, 10 × 12 cm | 1 | 0.231 |
| Syringe, 5 mL | 2 | 0.06606 |
| Syringe, 10 mL | 1 | 0.05808 |
| Saline solution | 1 | 0.2057 |
| Male cap | 1 | 0.02565 |
| Female cap | 5 | 0.0738 |
| Sterile gloves, size 6.5 | 1 | 0.31968 |
| Sterile gloves, size 7.5 | 1 | 0.31968 |
| Sterile gloves, size 8 | 1 | 0.31968 |
| Mask | 5 | 0.13675 |
| Paper, 60 × 60 cm | 4 | 0.484 |
| Spinal needle, 22 gauge × 3.5 mm | 1 | 0.8349 |
| Spinal needle, 25 gauge × 90 mm | 1 | 5.929 |
| Scalpel blade, no. 11 | 1 | 0.0484 |
| Three steps key | 1 | 0.17787 |
| Nasal glasses | 1 | 0.23 |
| Washed brush with betadine | 3 | 0.7623 |
| Angiographic needle with wing, 18 gauge | 1 | 3.63 |
| Sticking plaster, 7 cm × 8.5 cm | 1 | 0 |
| IV catheter, 18-gauge, 1.3 × 30 mm | 1 | 0.7139 |
| Gauze, nonwoven fabric, 20 × 20 cm Sterile | 1 | 0.05742 |
| Needle, 25 × 0.9 mm, 20-gauge, 1.0 in. | 3 | 0.30747 |
| Needle, 40 × 0.8 mm, 21-gauge, 1.5 in. | 1 | 0.10249 |
| Needle, 16 × 0.5 mm, 25-gauge, 5/8 in. | 1 | 0.10249 |
| Elastic band, 10 × 10 extra strong | 1 | 0.715 |
| Recording electrode | 3 | 0.13794 |
| Desinclor 1% solution concentration | 1 | 3.49072165 |
| Glucosamine 50% blister 20 mL | 1 | 0.52942149 |
| Total cost of material including for RFA | | 43.1795431 |
| Total cost without material for RFA | | 37.27 |

*RFA,* Radiofrequency ablation.