

The effect of endoscopic polidocanol carbon dioxide foam for internal hemorrhoids: a retrospective study

Jiahui Xiang ¹, Shichao Li ¹, Tengjiang Yu ¹, Qingfeng Jiang ¹, Yuexi Chen ², Xia Jiang ², Wusheng Li ^{Corresp., 1}, Yong Lan ^{Corresp. 2}

¹ The Anorectal Department, The Affiliated Traditional Chinese Medicine Hospital, Southwest Medical University, Luzhou, Sichuan, China

² The Civity Mirror Department, The Affiliated Traditional Chinese Medicine Hospital, Southwest Medical University, Luzhou, Sichuan, China

Corresponding Authors: Wusheng Li, Yong Lan
Email address: 58422840@qq.com, 1025213332@qq.com

Aim : The purpose of this article is to investigate the efficacy of polidocanol carbon dioxide foam in the treatment of internal hemorrhoids.

Methods: A retrospective analysis was performed on 158 patients who underwent endoscopic polidocanol foam sclerotherapy for internal hemorrhoids from October 2022 to September 2023. Among them, endoscopic polidocanol sclerotherapy was administered 78 cases were treated with polidocanol air foam (control group), and 80 cases were treated with polidocanol carbon dioxide foam (study group). The primary outcome of this study is the clinical effect and the incidence of complications one month after surgery. Patients self-reported anal bleeding and anal prolapse were taken as the basis for with three classes of evaluation clinic efficacy criteria. We defined the clinical effect by the efficacy index. The final efficacy index was used to judge the efficacy. The incidence of various postoperative complications, including anal pain, anal swelling, urinary retention, perianal infection, ectopic embolization, and anal edema, were recorded. Secondary outcomes include: the cost of surgery , length of stay , and dosage of polidocanol.

Result: The treatment success at the end of the sclerotherapy session in the study and control group was 85.0% and 83.3%, respectively ($P = 0.829$) . The effective rates of the study group and the control group were 98.8 % and 98.0 % respectively one month after endoscopic sclerotherapy ($P = 0.829$). Compared with the clinical effects one month after surgery of the two groups of patients, postoperative complications, surgical cost, hospitalization time and the dosage of polidocano l , w e found 11 patients with anal pain and 12 patients with anal swelling in the control group . In the study group, 3 patients had anal pain, and 4 patients had anal swelling. The number of patients with anal pain and anal swelling in the study group were significantly lower than those in the control group ($P < 0.05$) and there were none of the severe complications. Both groups of the clinical effects, surgical costs, hospitalization time, and the dosage of polidocanol were similar, and there

were no significant difference (all $P > 0.05$).

Conclusion: The clinical efficacy of endoscopic polidocanol carbon dioxide foam and polidocanol air foam is comparable . Sclerotherapy of endoscopic polidocanol carbon dioxide foam for internal hemorrhoids can effectively reduce the occurrence of anal swelling and anal pain .

1 **The effect of endoscopic polidocanol carbon dioxide foam for 2 internal hemorrhoids: a retrospective study**

3 Jiahui Xiang, MM^a, Shichao Li, MD^a, Tengjiang Yu, MM^a, Qingfeng Jiang, MD^b, Xia Jiang,
4 MD^b, Wusheng Li, PhD^{a,*}, Yong Lan, PhD^{b,*}

5 ^aThe Anorectal Department, The Affiliated Traditional Chinese Medicine Hospital, Southwest
6 Medical University, Luzhou, Sichuan, China

7 ^bThe Civity Mirror Department, The Affiliated Traditional Chinese Medicine Hospital,
8 Southwest Medical University, Luzhou, Sichuan, China

9 Jiahui Xiang and Shichao Li contributed equally to this work.

10 *Corresponding author at:

11 **Yong Lan**, ^bThe Civity Mirror Department, The Affiliated Traditional Chinese Medicine
12 Hospital, Southwest Medical University, Luzhou, Sichuan, China

13 E-mail address: 1025213332@qq.com

14 **Wusheng Li**,^aThe Anorectal Department, The Affiliated Traditional Chinese Medicine Hospital,
15 Southwest Medical University, Luzhou, Sichuan, China

16 E-mail address: gck3162226@163.com

17 **Abstract**

18 **Aim:** The purpose of this article is to investigate the efficacy of polidocanol carbon dioxide foam
19 in the treatment of internal hemorrhoids.

20 **Methods:** A retrospective analysis was performed on 158 patients who underwent endoscopic
21 polidocanol foam sclerotherapy for internal hemorrhoids from October 2022 to September 2023.

22 Among them, endoscopic polidocanol sclerotherapy was administered 78 cases were treated with
23 polidocanol air foam (control group), and 80 cases were treated with polidocanol carbon dioxide
24 foam (study group). The primary outcome of this study is the clinical effect and the incidence of
25 complications one month after surgery. Patients self-reported anal bleeding and anal prolapse
26 were taken as the basis for with three classes of evaluation clinic efficacy criteria. We defined
27 the clinical effect by the efficacy index. The final efficacy index was used to judge the efficacy.

28 The incidence of various postoperative complications, including anal pain, anal swelling, urinary
29 retention, perianal infection, ectopic embolization, and anal edema, were recorded. Secondary
30 outcomes include the cost of surgery, length of stay, and dosage of polidocanol.

31 **Result:** The treatment success at the end of the sclerotherapy session in the study and control
32 group was 85.0% and 83.3%, respectively ($P = 0.829$). The effective rates of the study and
33 control groups were 98.8% and 98.0%, respectively, one month after endoscopic sclerotherapy
34 ($P = 0.829$). Compared with the clinical effects one month after surgery of the two groups of
35 patients, postoperative complications, surgical cost, hospitalization time and the dosage of
36 polidocanol, we found 11 patients with anal pain and 12 patients with anal swelling in the control
37 group. In the study group, three patients had anal pain, and four patients had anal swelling. The
38 number of patients with anal pain and anal swelling in the study group was significantly lower
39 than those in the control group ($P < 0.05$), and there were none of the severe complications. Both
40 groups of the clinical effects, surgical costs, hospitalization time, and dosage of polidocanol
41 were similar, and there were no significant differences (all $P > 0.05$).

42 **Conclusion:** The clinical efficacy of endoscopic polidocanol carbon dioxide foam and
43 polidocanol air foam is comparable. Sclerotherapy of endoscopic polidocanol carbon dioxide
44 foam for internal hemorrhoids can effectively reduce the occurrence of anal swelling and anal
45 pain.

46 **key words:** hemorrhoids, endoscopic sclerotherapy, polidocanol, carbon dioxide, air.

47 **Introduction**

48 Hemorrhoids are a common disease worldwide, with a peak prevalence between 45 and 65 years
49 of age in both men and women[1]. Epidemiological survey results in China show that the
50 prevalence of anorectal diseases is as high as 50.1%, among which 98.08% of patients have
51 hemorrhoid symptoms[2]. Patients often show repeated hematochezia, anal swelling and pain
52 etc., which have severe effects on their health and life[3].

53 Nowadays, endoscopic sclerotherapy is widely practised as a minimally invasive procedure to
54 treat internal hemorrhoids and provides an alternative to conventional hemorrhoidectomy[4], it

55 has simple operation, less trauma, good efficacy, low cost and fewer postoperative
56 complications[5]. Common sclerosants have Aluminum potassium sulfate tannic acid (ALTA),
57 phenol in almond oil (PAO) and polidocanol. Polidocanol has the advantages of being safer and
58 more effective, and it can effectively reduce complications and improve patient satisfaction[6].

59 But at present, most hospitals use air foam hardening agent to treat internal hemorrhoids,
60 which has the characteristics of slow postoperative absorption, long duration of anal swelling and
61 so on. A search of relevant articles found that with the development of sclerotherapy, the
62 treatment of varicose veins was significantly reduced if CO2 rather than air was employed to
63 make the sclerosing foam for chemical ablation of superficial veins of the lower extremity [7].
64 Also, in a literature report, patients with CO2 / O2 foam were well tolerated with fewer similar
65 therapeutic side effects than air foam[8]. In a study that specifically investigated the neurological
66 side effects associated with migraine for the use of sclerotherapy and physiological foam, the use
67 of CO2 or CO2 / O2 foam should be considered for those patients at increased risk of
68 neurological side effects, such as patients with migraine with aura and those with known Patent
69 foramen ovale [9]. The half-life of air and carbon dioxide binding with polidocanol was different.
70 This leads to the different stability of the foam[10]. The combination of air and polidocanol has
71 the longest half-life, which results in a prolonged contact time between the sclerosant and the
72 tissue. Additionally, air is not easily absorbed by the human body, leading to prolonged
73 stimulation, which may trigger a series of complications. Carbon dioxide, a common
74 physiological gas, is frequently used as the foundational gas for establishing pneumoperitoneum
75 in laparoscopic surgery and is easily absorbed by the human body, potentially addressing these
76 issues. Although similar findings have been reported in studies on the application of carbon
77 dioxide foam in varicose veins and other sclerotherapy treatments, there has been no specific
78 report on the effects of polidocanol foam sclerosing agents made with air or carbon dioxide
79 respectively in the treatment of internal hemorrhoids. Therefore, this paper makes a retrospective
80 and comparative analysis of the efficacy of endoscopic polidocanol carbon dioxide foam
81 sclerotherapy and polidocanol air foam sclerotherapy of internal hemorrhoids.

82 MATERIALS & METHODS

83 Study design and setting

84 The protocol was approved by the Medical Ethics Committee of the Affiliated Traditional
85 Chinese Medicine Hospital to Southwest Medical University (approval number:BY2023033).

86 The flowchart of this trial is shown in Figure 1.

87 A retrospective analysis was performed on 158 patients who underwent endoscopic
88 polidocanol foam sclerotherapy for internal hemorrhoids in the Anorectal Department of the
89 Affiliated Traditional Chinese Medicine Hospital to Southwest Medical University from October
90 2022 to September 2023. Among them, polidocanol sclerotherapy was administered 78 cases
91 were treated with polidocanol air foam (control group), and 80 cases were treated with
92 polidocanol carbon dioxide foam (study group).

93 Participants

94 All the patients were from the Affiliated Traditional Chinese Medicine Hospital to Southwest
95 Medical University.

96 Inclusion criteria

97 Participants will need to meet the following criteria:(1) Patients who met the diagnostic criteria
98 for degree I-III internal hemorrhoids by using the most commonly used Goligher classification
99 of internal hemorrhoids[11];(2) Patients willing to receive endoscopic sclerotherapy;(3)
100 Complete clinical data.

101 Exclusion criteria

102 Participants will be excluded if they meet any of the following criteria:(1) Patients with other
103 diseases such as incarcerated hemorrhoids, ring mixed hemorrhoids, perianal abscess, anal
104 fissure, anal fistula, rectal prolapse, intestinal tumours and other diseases;(2) Treatment with
105 hemorrhoid ligation. (3) Important organs include the heart, brain, liver and kidney, lungs, and
106 others with primary severe diseases.(4) Abnormal coagulation function or the use of antiplatelet
107 anticoagulants.

108 Withdrawal/termination criteria

109 If participants meet the following criteria, they will be withdrawn or terminated from the trial: (1)
110 Data are incomplete or missing during the follow-up process, so the curative effect cannot be
111 determined. (2) Those who also receive traditional surgery and other treatments during
112 observation; (3) Do not cooperate with the follow-up observers.

113 **Interventions**

114 Patients in the control group provided informed consent prior to surgery, underwent fasting, and
115 performed an enema on the day of the procedure. The left lateral decubitus position was adopted
116 during the surgery, and a transparent cap was affixed to the tip of the colonoscope. After
117 completing the ileocolon examination, internal hemorrhoids were observed, and their specific
118 location and degree were evaluated. The foam hardening agent was prepared by the Tessari
119 technique[12](Figure 2). A U-shaped inverted mirror or a transparent cap was utilized to ensure
120 clear visibility during the procedure. The injection needle is inserted at an angle of 30° to 40° ,
121 targeting the injection sites located within the submucosal vessels of the hemorrhoids, which are
122 positioned over 0.5 cm above the dentate line. A volume of 1 to 2 ml of polidocanol sclerosing
123 agent is injected at each site, with a total of 4 to 5 injection points selected for treatment. The
124 total injection volume typically does not exceed 20 ml. Specifically, the injection should be
125 administered such that the mucosa at the injection site appears grey and white, with clearly
126 defined blood vessel textures. The needle should be withdrawn slowly while the injection is
127 being administered. After the injection, pressure is recommended to be applied to the injection
128 site for 5 to 8 seconds to prevent bleeding (Figure 3). Post-surgery, patients should adhere to a
129 liquid diet, ensure smooth bowel movements, and utilize laxatives if necessary to prevent
130 constipation. Patients are followed up for one month. Those in the treatment group received a 3%
131 polidocanol carbon dioxide foam injection (Figure 4). The preoperative preparation, injection
132 site, injection method, injection depth, and volume are consistent with those of the control group.
133 The preparation of the foam hardening agent also employs the Tessari technique. The control
134 group extracted 8 ml of indoor air, while the treatment group extracted 8 ml of carbon dioxide.
135 The subsequent treatment procedures were identical for both groups. Both groups received the

136 same postoperative care. All surgeries were performed by attending physicians or higher-level
137 medical professionals.

138 **Outcomes**

139 The primary outcome of this study is the clinical effect and incidence of complications one
140 month post-surgery. Patients self-reported instances of anal bleeding and anal prolapse were used
141 as the basis for evaluating clinical efficacy, categorized into three classes: (1) Cure—very
142 satisfied with no or mild symptoms; (2) Improvement—occasional symptoms; and (3) Invalid—
143 no improvement or worsening of symptoms[13]. In order to evaluate the clinical effect more
144 accurately, we defined the clinical effect by the efficacy index (efficacy index (%)) = [(pre-
145 treatment score - post-treatment score)/pre-treatment score] × 100%). We defined anal bleeding
146 and anal prolapse scores by the following method (anal bleeding score: 0 was < 1 episodes per
147 month, 1 was <1 episode per week, 2 was 1–3 episodes per week and 3 was 4 more episodes per
148 week; anal prolapse score: no anal prolapse = 0, mild anal prolapse = 1, moderate anal prolapse =
149 2, severe anal prolapse = 3)[14-15]. We defined the efficacy index as follows: a value of $\geq 90\%$
150 indicates a cure, 30% to 89% signifies improvement, and <30% is classified as invalid. By
151 calculating the efficacy index for anal bleeding and anal prolapse, we determined that both cure
152 and improvement qualify as effective outcomes. The incidence of various postoperative
153 complications, including anal pain, anal swelling, urinary retention, perianal infection, ectopic
154 embolization, and anal edema, was meticulously recorded. Secondary outcomes included the
155 dosage of polidocanol, the cost of surgery, and the length of hospital stay.

156 **Statistical analysis**

157 Data are analyzed by using the SPSS 25.0 statistical software. Count data are represented by the
158 number of cases and percentage [n (%)]. Comparisons between groups are performed using the χ^2
159 test. Rank data are compared by using the rank-sum test. Measurement data are expressed as
160 mean \pm standard deviation ($\bar{x} \pm s$). Comparisons between the groups are performed by
161 using the t-test. $P < 0.05$ is considered as a statistically significant difference.

162 **Result:**

163 A total of 168 patients consented to participate in the study. General data for both groups are
164 presented in Table 1. The mean ages of the patients in the study and control groups were 48.76
165 \pm 12.05 years and 50.71 \pm 10.46 years, respectively. The study group consisted of 56 males
166 and 24 females, whereas the control group included 60 males and 18 females. No significant
167 differences were observed in general demographics, including age and sex, between the two
168 groups (all $P > 0.05$).

169 Table 2 presents a comparison of the clinical effects between the study and control groups.
170 The treatment success rates at the conclusion of the sclerotherapy session were 85.0% for the
171 study group and 83.3% for the control group ($P = 0.829$), indicating that the difference is not
172 statistically significant.

173 The comparison of the clinical effects between the study group and the control group is
174 presented in Table 2. One month after endoscopic sclerotherapy, the effective rates were 98.8%
175 for the study group and 98.0% for the control group, with no significant difference observed ($P =$
176 0.829). Table 3 illustrates the comparison of postoperative complications. In the control group,
177 11 patients reported postoperative anal pain, while only 3 patients in the study group experienced
178 this complication, indicating a significant difference ($P = 0.022$). Additionally, anal swelling was
179 reported in 4 patients from the study group and 12 patients from the control group, which was
180 also statistically significant ($P = 0.031$). Neither group experienced urinary retention, perianal
181 infection, ectopic embolism, or anal edema, and no significant differences were found for these
182 complications ($P > 0.05$).

183 The comparison of the two treatments is shown in Table 4. The cost of surgery and length of
184 stay in study group were significantly less than those in control group (all $P < 0.05$). The dosage
185 of polidocanol were similar, and there was no significant difference ($P > 0.05$).

186 **Discussion:**

187 Hemorrhoids are one of the most common anorectal diseases that can occur at any age and of
188 any sex and have been reported to occur in half of the population over 50 years[16]. Despite the
189 relatively good results reported in the literature, the significant haemorrhoidectomy

190 complications include postoperative pain, urinary incontinence, stricture, and bleeding. Thus,
191 dramatic changes have occurred in treating hemorrhoids in the past few decades, including non-
192 surgical modalities such as sclerotherapy. Sclerotherapy is widely used in Western countries to
193 cause fibrous reactions in the submucosal and haemorrhoid tissues. Sclerotherapy has gradually
194 been recognized as a minimally invasive treatment for internal hemorrhoids in adults.

195 In 1928, Blanjold first used sclerotherapy for hemorrhoids, but it was gradually replaced due
196 to severe complications. Subsequently, sclerotherapy has gradually become a well-established
197 clinical treatment. Usually, sclerosing agents are critical to efficacy. Different sclerosants have
198 their own advantages and disadvantages and are not identical in treatment. Aluminum potassium
199 sulfate and tannic acid is obviously more useful than phenol in almond oil for injection
200 sclerotherapy; ALTA was more effective than PAO in hemostatic [17]. In a study comparing 3%
201 polidocanol and 5% phenol, polidocanol needs less treatment frequency and higher patient
202 satisfaction [5]. Three percent polidocanol foam vs 3% polidocanol liquid, foam polidocanol is
203 more effective and equally safe compared to liquid polidocanol [18]. PAO is effective for internal
204 hemorrhoids up to grade III, while ALTA has shown efficacy in treating prolapsing internal
205 hemorrhoids at grades II, III, and IV [19]. Polidocanol has the advantages of being safer and
206 more effective, and it can effectively reduce complications and improve patient satisfaction[20].

207 Polidocanol foam hardener belongs to the surface activator, which has the advantages over
208 other hardening agents[21]: First, the foam inside it naturally replaces the blood in the blood
209 vessels, and the degree of dilution to the minimum so that the drug concentration in the vein to
210 get a better grasp. As the volume of the bubble becomes smaller, the surface area of the
211 hardening agent increases the area in contact with the inner membrane, which improves the
212 therapeutic effect and can significantly reduce the total dose injected. Second, the foam
213 sclerosing agent can be evenly distributed on the surface of the vascular endothelium, which
214 extends the contact time between the sclerosing agent and the endothelium. Finally, the strong
215 cohesion of foam means that it can be aspirated and reinjected after the first injection. 3%
216 polidocanol foam sclerotherapy has already become an effective conservative treatment for

217 symptomatic second- and third-degree hemorrhoids.[22] In a comparative study on the treatment
218 of grade I/II/III hemorrhoidal disease, the efficacy of polidocanol foam sclerotherapy was found
219 to be superior to rubber band ligation.[23]

220 However, the endoscopic polidocanol sclerotherapy of internal hemorrhoids also has
221 postoperative complications. Related articles show that postoperative complications of
222 sclerotherapy of internal hemorrhoids are anal swelling and anal pain, et al., and they are almost
223 curable[24]. Although the complications are curable, they reduce the patient's quality of life.
224 Medical technology has made significant progress, but patients' demand for minimally invasive
225 technology and an excellent medical experience remains unchanged. Currently, most hospitals
226 use air foam hardening agent to treat internal hemorrhoids. However, our study found that
227 polidocanol carbon dioxide foam sclerosant can be effective in reducing the occurrence of
228 postoperative complications. This may be due to the different half-lives of air and carbon dioxide
229 when combined with polidocanol, which results in varying degrees of foam stability. The
230 combination of air and polidocanol has the longest half-life, leading to a prolonged contact time
231 of the sclerosing agent with the tissue, thereby causing longer-lasting irritation post-surgery.
232 Additionally, air is not easily absorbed by the human body, further contributing to increased
233 inflammation. Carbon dioxide, as a common physiological gas, is frequently used as the
234 foundational gas for establishing pneumoperitoneum in laparoscopic surgery and is readily
235 absorbed by the body, thereby reducing the occurrence of complications. This innovative method
236 of medication deserves further promotion.

237 As this study is retrospective and involves a relatively small sample size, it may impact the
238 accuracy, reliability, and generalizability of the research findings. To minimize potential errors,
239 we accurately recorded cases through the hospital's electronic medical record system. Therefore,
240 although retrospective cohort studies have inherent limitations, such as recall bias, the use of
241 objective medical records helps mitigate the distortion of results caused by such biases.
242 Moreover, we enhanced the validity of the study by strictly assessing and recording complication
243 scores through patient follow-up visits at the hospital.

244 The limitations of this study are that it is a single-centre study and the sample size needed to
245 be larger. The study still needs a multicenter, large sample, prospective randomized controlled
246 clinical trial for further confirmation. We lack in-depth research on the mechanisms by which
247 carbon dioxide foam can reduce complications, and in the future, we will further explore its
248 underlying mechanisms.

249 In conclusion, the clinical efficacy of endoscopic polidocanol carbon dioxide foam and
250 polidocanol air foam is comparable. Sclerotherapy of endoscopic polidocanol carbon dioxide
251 foam for internal hemorrhoids can effectively reduce the occurrence of anal swelling and anal
252 pain.

253 **Data Availability** The following information was supplied regarding data availability: The raw
254 measurements are available in the Supplemental File.

255 References

256 [1] Xie, Y. T., Yuan, Y., Zhou, H. M., Liu, T., Wu, L. H., & He, X. X. (2022). Long-term efficacy and
257 safety of cap-assisted endoscopic sclerotherapy with long injection needle for internal
258 hemorrhoids. *World journal of gastrointestinal surgery*, 14(10), 1120–1130.
259 <https://doi.org/10.4240/wjgs.v14.i10.1120>

260 [2] Johanson, J. F., & Sonnenberg, A. (1990). The prevalence of hemorrhoids and chronic constipation. An
261 epidemiologic study. *Gastroenterology*, 98(2), 380–386. [https://doi.org/10.1016/0016-5085\(90\)90828-0](https://doi.org/10.1016/0016-5085(90)90828-0)

263 [3] Margetis N. (2019). Pathophysiology of internal hemorrhoids. *Annals of gastroenterology*, 32(3), 264–
264 272. <https://doi.org/10.20524/aog.2019.0355>

265 [4] Hachiro, Y., Kunimoto, M., Abe, T., Kitada, M., & Ebisawa, Y. (2011). Aluminum potassium sulfate
266 and tannic acid (ALTA) injection as the mainstay of treatment for internal hemorrhoids. *Surgery*
267 *today*, 41(6), 806–809. <https://doi.org/10.1007/s00595-010-4386-x>

268 [5] Nastasa, V., Samaras, K., Ampatzidis, C. h., Karapantsios, T. D., Trelles, M. A., Moreno-Moraga, J.,
269 Smarandache, A., & Pascu, M. L. (2015). Properties of polidocanol foam in view of its use in
270 sclerotherapy. *International journal of pharmaceutics*, 478(2), 588–596.
271 <https://doi.org/10.1016/j.ijpharm.2014.11.056>

272 [6] Mishra, S., Sahoo, A. K., Elamurugan, T. P., & Jagdish, S. (2020). Polidocanol versus phenol in oil
273 injection sclerotherapy in treatment of internal hemorrhoids: A randomized controlled trial. *The*
274 *Turkish journal of gastroenterology : the official journal of Turkish Society of Gastroenterology*, 31(5),
275 378–383. <https://doi.org/10.5152/tjg.2020.19276>

276 [7] Morrison, N., Neuhardt, D. L., Rogers, C. R., McEown, J., Morrison, T., Johnson, E., & Salles-Cunha,
277 S. X. (2008). Comparisons of side effects using air and carbon dioxide foam for endovenous chemical
278 ablation. *Journal of vascular surgery*, 47(4), 830–836. <https://doi.org/10.1016/j.jvs.2007.11.020>

279 [8] Morrison, N., Neuhardt, D. L., Rogers, C. R., McEown, J., Morrison, T., Johnson, E., & Salles-Cunha,
280 S. X. (2010). Incidence of side effects using carbon dioxide-oxygen foam for chemical ablation of
281 superficial veins of the lower extremity. *European journal of vascular and endovascular surgery : the
282 official journal of the European Society for Vascular Surgery*, 40(3), 407–413.
283 <https://doi.org/10.1016/j.ejvs.2010.04.018>

284 [9] Wong M. (2015). Should foam made with physiologic gases be the standard in
285 sclerotherapy?. *Phlebology*, 30(9), 580–586. <https://doi.org/10.1177/0268355514560275>.

286 [10] Bai, T., Liu, Y., Jiang, W., Li, Y., Liu, J., Yu, C., & Fan, Y. (2020). A Review of Sclerosing Foam
287 Stability in the Treatment of Varicose Veins. *Dermatologic surgery : official publication for American
288 Society for Dermatologic Surgery [et al.]*, 46(2), 249–257.
289 <https://doi.org/10.1097/DSS.0000000000002039>

290 [11] Dekker, L., Han-Geurts, I. J. M., Grossi, U., Gallo, G., & Veldkamp, R. (2022). Is the Goligher
291 classification a valid tool in clinical practice and research for hemorrhoidal disease?. *Techniques in
292 coloproctology*, 26(5), 387–392. <https://doi.org/10.1007/s10151-022-02591-3>

293 [12] Xu, J., Wang, Y. F., Chen, A. W., Wang, T., & Liu, S. H. (2016). A modified Tessari method for
294 producing more foam. *SpringerPlus*, 5, 129. <https://doi.org/10.1186/s40064-016-1769-5>

295 [13] Xie, Y. T., Yuan, Y., Zhou, H. M., Liu, T., Wu, L. H., & He, X. X. (2022). Long-term efficacy and
296 safety of cap-assisted endoscopic sclerotherapy with long injection needle for internal
297 hemorrhoids. *World journal of gastrointestinal surgery*, 14(10), 1120–1130.
298 <https://doi.org/10.4240/wjgs.v14.i10.1120>

299 [14] Giamundo, P., Braini, A., Calabro', G., Crea, N., De Nardi, P., Fabiano, F., Lippa, M., Mastromarino,
300 A., & Tamburini, A. M. (2018). Doppler-guided hemorrhoidal dearterialization with laser (HeLP): a
301 prospective analysis of data from a multicenter trial. *Techniques in coloproctology*, 22(8), 635–643.
302 <https://doi.org/10.1007/s10151-018-1839-5>

303 [15] Rørvik, H. D., Styr, K., Ilum, L., McKinstry, G. L., Dragesund, T., Campos, A. H., Brandstrup, B., &
304 Olaison, G. (2019). Hemorrhoidal Disease Symptom Score and Short Health ScaleHD: New Tools to
305 Evaluate Symptoms and Health-Related Quality of Life in Hemorrhoidal Disease. *Diseases of the colon
306 and rectum*, 62(3), 333–342. <https://doi.org/10.1097/DCR.0000000000001234>

307 [16] Altomare, D. F., & Giuratrabocchetta, S. (2013). Conservative and surgical treatment of
308 haemorrhoids. *Nature reviews. Gastroenterology & hepatology*, 10(9), 513–521.
309 <https://doi.org/10.1038/nrgastro.2013.91>

310 [17] Yano T, Yano K (2015) Comparison of injection sclerotherapy between 5% phenol in almond oil and
311 aluminum potassium sulfate and tannic acid for grade 3 hemorrhoids. Ann Coloproctol 31(3):103–105.
312 <https://doi.org/10.3393/ac.2015.31.3.103>

313 [18] Moser, K. H., Mosch, C., Walgenbach, M., Bussen, D. G., Kirsch, J., Joos, A. K., Gliem, P., &
314 Sauerland, S. (2013). Efficacy and safety of sclerotherapy with polidocanol foam in comparison with
315 fluid sclerosant in the treatment of first-grade haemorrhoidal disease: a randomised, controlled, single-
316 blind, multicentre trial. *International journal of colorectal disease*, 28(10), 1439–1447.
317 <https://doi.org/10.1007/s00384-013-1729-2>

318 [19] Yamana T (2017) Japanese practice guidelines for anal disorders I.Hemorrhoids. J Anus Rectum Colon
319 1(3):89–99. <https://doi.org/10.23922/jarc.2017-018>

320 [20] Figueiredo, L. M., Bordalo Ferreira, F., Rafael, M. A., & Oliveira, A. M. (2022). Sclerotherapy using 2 %
321 polidocanol foam in the treatment of hemorrhoidal disease - a single-center experience. *Revista*
322 *española de enfermedades digestivas*, 114(3), 185–186. <https://doi.org/10.17235/reed.2021.8334/2021>

323 [21] Lobascio P, Laforgia R, Novelli E, Perrone F, Di Salvo M, Pezzolla A, Trompetto M, Gallo G. Short-Term
324 Results of Sclerotherapy with 3% Polidocanol Foam for Symptomatic Second- and Third-Degree
325 Hemorrhoidal Disease. *J Invest Surg.* 2021;34 (10):1059-1065. doi:10.1080/08941939.2020.1745964

326 [22] He, A., & Chen, M. (2023). Sclerotherapy in Hemorrhoids. *The Indian journal of surgery*, 85(2), 228–
327 232. <https://doi.org/10.1007/s12262-022-03414-3>

328 [23] Yamana T (2017) Japanese practice guidelines for anal disorders I. Hemorrhoids. *J Anus Rectum*
329 *Colon* 1(3):89–99. <https://doi.org/10.23922/jarc.2017-018>

330 [24] Jacobs D. (2014). Clinical practice. Hemorrhoids. *The New England journal of medicine*, 371(10),
331 944–951. <https://doi.org/10.1056/NEJMcp1204188>

332

Table 1(on next page)

General data of patients in both groups

1

Table 1 General data of patients in both groups

Baseline date	Study group (n=80)	Control group (n=78)	χ^2/t	<i>P value</i>
Sex			0.970	0.325
Male	56(70.0%)	60(76.9%)		
Female	24(30.0%)	18(23.1%)		
Age (year)	48.76±12.05	50.71±10.46	-1.081	0.294
Height (cm)	167.69±8.69	168.11±6.59	-0.348	0.728

2

Table 2(on next page)

Comparison of the clinical effects one month after surgery between the two patient groups

1 Table 2 Comparison of the clinical effects one month after surgery between the two patient
2 groups [n (%)]

Clinical effects	Study group (n=80)	Control group (n=78)	χ^2	<i>P value</i>
Cured	68 (85.0%)	65 (83.3%)	0.376	0.829
Improved	11 (13.8%)	11 (14.1%)		
Invalid	1 (1.2%)	2 (2.6%)		

3

Table 3(on next page)

Complication rates one month after surgery in both groups

1 Table 3 Complication rates one month after surgery in both groups [n (%)]

Complication	Study group (n=80)	Control group (n=78)	χ^2	<i>P value</i>
Anal pain	3 (3.8%)	11 (14.1%)	5.208	0.022
Anal swelling	4 (5.0%)	12 (17.9%)	4.680	0.031
Urinary retention	0	0	-	-
Perianal Infection	0	0	-	-
Ectopic Embolization	0	0	-	-
Anal edema	0	0	-	-

2

3

Table 4(on next page)

Table 4

1 **Table 4 Comparison of relevant indicators for treatment between the two patient groups**

Indicators	Study group (n=80)	Control group (n=78)	t	P value	MD (95% CI)
The cost of surgery (RMB)	3846.58±1890.82	3969.08±2331.66	-0.363	0.717	-788.82-543.82
Length of stay (d)	4.73±1.65	4.67±1.66	0.173	0.863	-0.47-0.57
The dosage of polidocanol (ml)	1.90±0.13	1.88±0.15	0.883	0.379	-0.02-0.06

2

3

Figure 1

The flowchart of this trial.

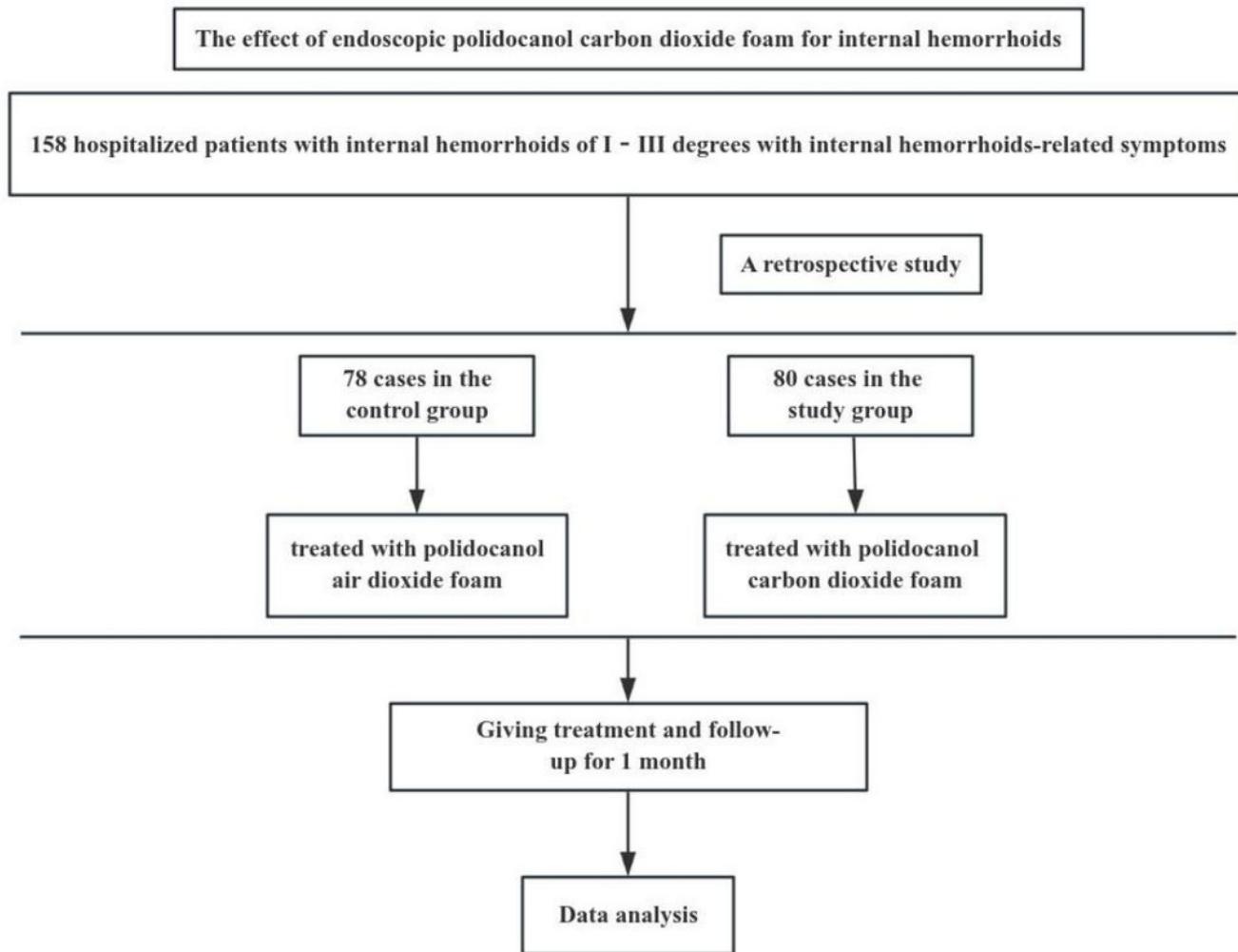


Figure 2

Preparation of polidocanol air foam hardener: A. Instrument preparation, B-D. 2ml of 3% polidocanol injection and 8ml of indoor air are mixed rapidly for 15-20 times.

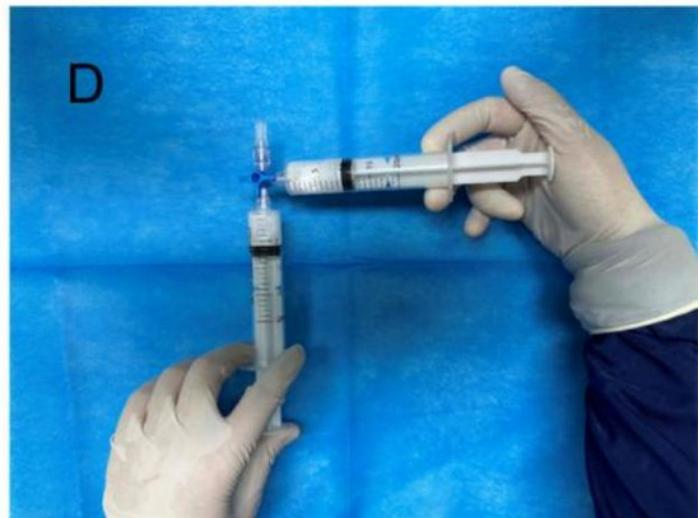


Figure 3

The injection site for 5 to 8 seconds to prevent bleeding

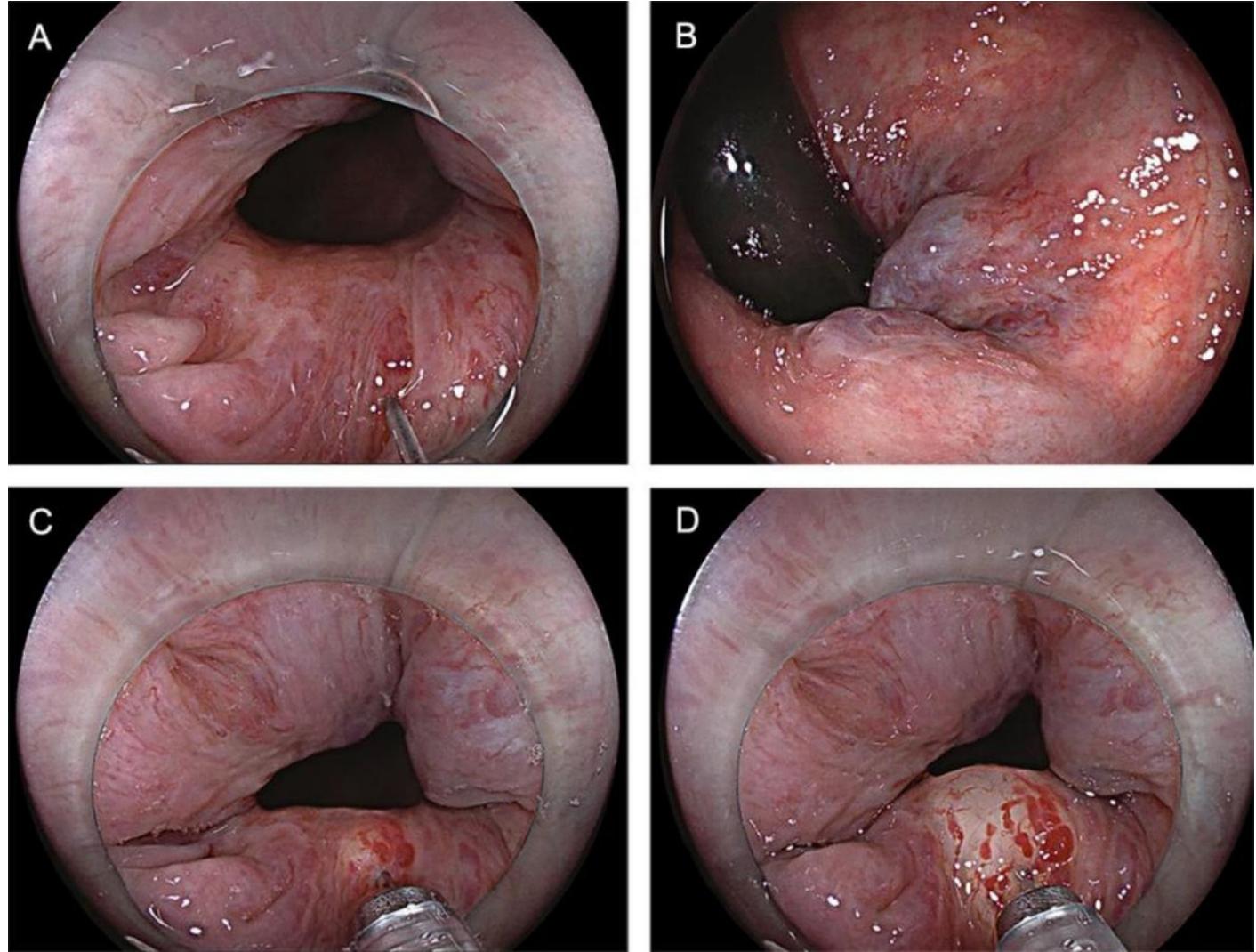


Figure 4

3% polidocanol carbon dioxide foam injection

