Superior Rectal Artery Embolization with Tris-Acryl Gelatin Microspheres: A Randomized Comparison of Particle Size

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ABSTRACT

Purpose: To evaluate the safety and efficacy of superior rectal artery embolization (SRAE) with different-sized tris-acryl gelatin microspheres in symptomatic hemorrhoidal disease (HD).

Materials and Methods: Forty-two patients (male, 30; female, 12; median age, 45 years) with symptomatic HD (2 grade I, 8 grade II, 17 grade III, and 15 grade IV) were divided into 3 experimental arms (500–700 μm, 700–900 μm, and 900–1,200 μm groups; each had 14 patients) in a prospective randomized style to perform SRAE. Follow-up was performed by rectoscopy, clinical examination, and questionnaires. The primary outcome measure was the clinical success rate at 12 months. Secondary outcome measures were technical success rate, recurrence rate, procedure-related mortality, procedure-related complications, and any outcome changes between particle sizes.

Results: No procedure-related deaths or major morbidities were observed. There was a 54% minor complication rate (n = 23/42) in the treated zone: 45% sustained small superficial ulcerations (n = 19/42), 7% small rectosigmoid junction ulcerations (n = 3/42), and 2% small fibrotic scar tissue (n = 1/42). The clinical success rate was 93%. Of the groups, the best French bleeding score decrease was obtained in the 900–1,200 μm group. There were improvements in the quality of life score and visual analogue scale score after the SRAE procedure, although not in the Goligher score. No recurrent disease was observed.

Conclusions: SRAE with tris-acryl gelatin microspheres for symptomatic HD is a safe and efficient treatment, with results favoring the use of larger microspheres.

ABBREVIATIONS

CCR = corpus cavernosum recti, FBS = French bleeding score, GPS = Goligher prolapse score, HD = hemorrhoidal disease, MDCTA = multidetector computed tomography angiography, MRECA = middle rectal artery, PVA = polyvinyl alcohol, QOLS = quality of life score, SRA = superior rectal artery, SRAE = superior rectal artery embolization, VAS = visual analogue scale

INTRODUCTION

Hemorrhoidal disease (HD) is a major cause of discomforting symptoms in patients worldwide. However, the causes and pathophysiology of HD are not well established. There are several treatment strategies for symptomatic HD; however, the unity and consensus on the treatment and classifications of different stages of HD are under discussion (1–9).

One of the main studies about the underlying pathology was reported by Aigner et al, who demonstrated the vascular nature of hemorrhoids (10). The increased caliber and arterial blood flow in the terminal branches of the superior rectal artery (SRA) were correlated with the appearance of hemorrhoids. Doppler-guided transanal hemorrhoidal dearterialization is the premise of the superior rectal artery embolization (SRAE) method (8).

SRAE with coils was described in earlier studies, especially by Vidal et al (11–19). This technique was termed the "emborrhoid" technique. The emborrhoid technique was a safe and effective treatment method for symptomatic HD in previous experimental animal studies and human clinical trials. A total of 60%–80% of patients demonstrated symptoms

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RESEARCH HIGHLIGHTS

- A randomized prospective trial comparing different sizes of embolic microspheres without the use of coils was performed on superior rectal artery embolization (SRAE) for symptomatic hemorrhoids.
- SRAE achieved 93% clinical success in decreasing bleeding, relieving pain, and improving quality of life in 1 year follow up, with no early recurrences.
- Smallest microspheres (500-700 μm) resulted in earliest decrease in bleeding and pain, but largest microspheres (900-1200 μm) showed the greatest improvements at 1 year.
- Post-embolization pain, self-limited superficial rectal and rectosigmoid ulcerations, and late small fibrotic scars were more frequently encountered after treatment by smallest microspheres, suggesting greater ischemia.

STUDY DETAILS

Study type: prospective, clinical, randomized controlled trial

Study phase: 3

resolution during follow-up. The 30% recurrence rate and the need for reinterventions are still salient issues (11–19).

SRAE with particles only is an emerging concept for the embolization of the SRAs. Combining synthetic polyvinyl alcohol (PVA) particles of 300 μm in size with metallic coils was more effective than the coils-only treatment described in a previous study (14). PVA embolization of the distal rectal arteries first and embolization of the SRA trunk with metallic coils after yielded better general patient satisfaction rates, varying between 83% and 94%, than those reported in previous studies (11–19). In another study, tris-acryl gelatin embolization with 300–500-μm particles in addition to 2–3-mm metallic coils resulted in no significant difference compared with the coil-only group, with an overall clinical success rate of 68% (19). In a recent retrospective study, the particle only embolization (300–500 μm tris-acryl gelatin microspheres) showed a 96.9% clinical success rate without any major or minor complications (20). The current randomized prospective study aimed to evaluate the safety and efficacy of different-sized microspherical tris-acryl gelatin microspheres for symptomatic HD.

MATERIALS AND METHODS

This randomized prospective study was registered with ClinicalTrials.gov in November 2018. The study was completed after the last patient's 12-month follow-up. It was approved by the local ethics committee, and informed consent was obtained from all patients. A flowchart of the study is summarized in **Figure 1**. Forty-two patients with a

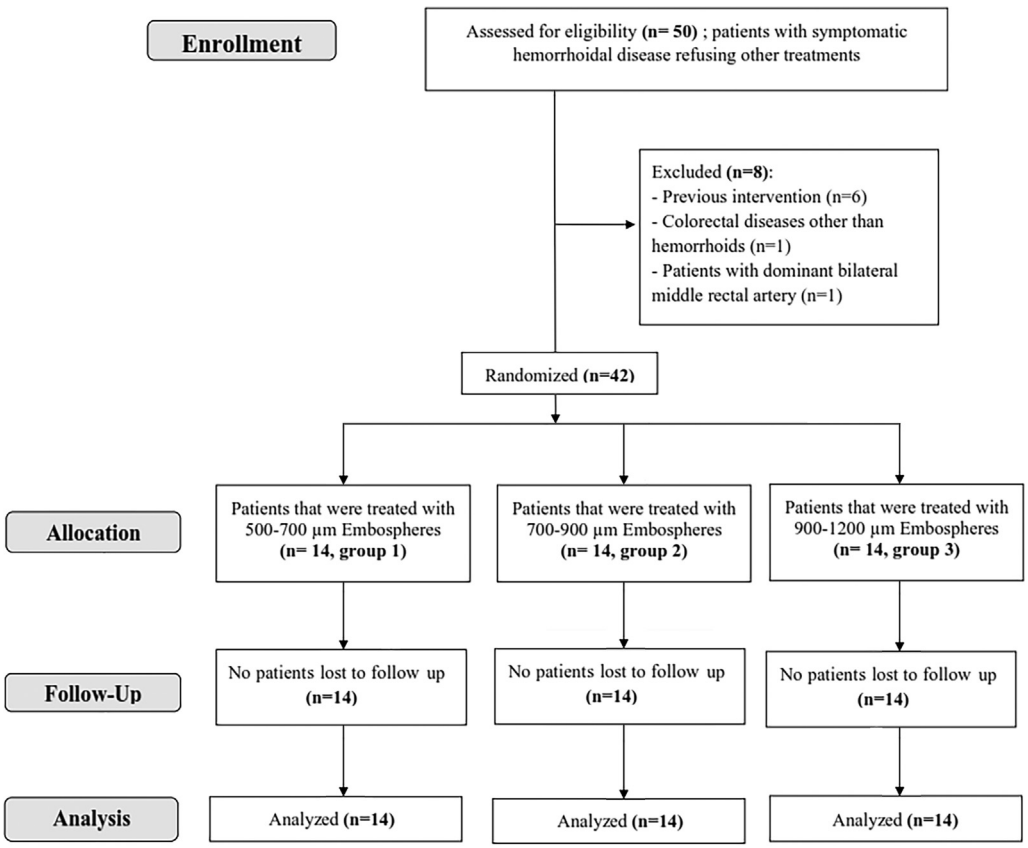

Figure 1. Flowchart of the study.

median age of 45 (range, 18–72) years were prospectively recruited into the study.

Patients

The following were inclusion criteria: *(i)* symptomatic HD; *(ii)* refusal of or contraindication for surgery; *(iii)* patients who refused other interventional methods; *(iv)* ability to give written informed consent and to comply with the follow-up protocol; *(v)* bleeding due to hemorrhoids with any grade (I, II, III, or IV); *(vi)* patients who had previous physical and colonoscopy examinations for proof of rectal bleeding; and *(vii)* patients who had a dominant SRA as seen or identified in a pre-procedural multidetector computed tomography angiography (MDCTA).

The following were exclusion criteria: *(i)* asymptomatic patients; *(ii)* patients who had previous interventions; *(iii)* patients who had colorectal diseases other than hemorrhoids; *(iv)* anal stenosis; *(v)* patients with rectal prolapse; *(vi)* pregnancy; *(vii)* patients with contraindications for technical steps or contrast medium use; *(viii)* inability to give written informed consent; *(ix)* a dominant bilateral middle rectal artery (MRECA) branch feeding the corpus cavernosum recti (CCR) identified on MDCTA.

Design

The allocation was randomized. The intervention model was a parallel assignment (a blocked, randomized, single-blind [the physician who performed the embolization procedures did not know the particle size], prospective study). The masking was triple (participant, care provider [the physician who performed the embolization procedures], and outcomes assessor). There was insufficient prior information to calculate an adequately powered sample size. Therefore, the study was conducted as a pilot study (21). The patients were divided into 3 experimental arms, with each arm consisting of 14 patients (group 1 [500–700 μm] consisting of 11 males and 3 females; group 2 [700–900 μm] with 8 males and 6 females; and group 3 (900–1,200 μm) with 11 males and 3 females [$P > .05$]; median age, 45 [range, 18–72] years; the age of the patients did not significantly differ, $P > .05$). The severity of symptoms due to HD before and after the intervention (1-, 3-, 6-, and 12-month follow-ups) were obtained from several questionnaire forms that were defined in detail in previous articles (12–14). These include the French bleeding score (FBS), visual analogue scale (VAS), quality of life score (QOLS), and Goligher prolapse score (GPS).

Technical success was defined as the successful embolization of all SRA branches that feed the CCR. Clinical success was defined as at least a 2-point decrease in the FBS at the 12-month follow-up, as described in previous articles (12,14).

Recurrence was defined as any recanalization of previous embolized SRA branches or any collateral feeding to the CCR after embolization. Recurrence was suspected in patients without an improvement of symptoms, such as worsening of bleeding after the embolization procedure. These patients were examined with MDCTA.

Embolization Technique

All procedures were performed by a single interventional radiologist with 15 years of experience in performing embolizations. This single operator had performed >40 hemorrhoidal embolization procedures with coils and particles prior to the initiation of this study. Before the embolization, a detailed analysis of MDCTA images was performed. The origins of the inferior mesenteric artery, SRA branches, and CCR were noted. Using standard digital subtraction angiography techniques, a 2.7-F microcatheter (Embocath Plus; Merit Medical, Salt Lake City, Utah) was advanced through a 5-F hydrophilic catheter (Glidecath; Terumo, Tokyo, Japan) with the help of a 0.018-inch guidewire (Tenor steerable guidewire; Merit Medical, Salt Lake City, Utah) proximal to the branching of the SRA. Embolization procedures were performed using microspherical tris-acryl gelatin microspheres (Embosphere; Merit Medical), 500–700, 700–900, and 900–1,200 μm in size. Each 2-mL syringe of the embospheres was diluted with 2 mL of undiluted contrast agent (Iodixanol; Visipaque, Amersham Health, Amersham, United Kingdom) and further suspended in a 20-mL syringe to yield a 50% Embosphere microsphere and a 50% contrast agent solution as described by the manufacturer. A 5-mL syringe was attached with a 3-way stopcock to a 20-mL syringe and the suspension was mixed gently. The particles were injected from a 5-mL syringe through the microcatheter (**Fig 2**). Technical success was defined as the occlusion of all SRA target branches at an imaginary line parallel to the symphysis pubis level, similar to the transanal Doppler-guided hemorrhoidal artery ligation treatment (22). Stagnation or stasis of contrast agents in this area of up to 3–4 cardiac cycles was defined as the endpoint of a successful embolization. The patients were discharged from the hospital after a 4-hour observation period. Immediate complications were noted.

Follow-Up

The patients were assessed by an internal medicine physician who was unaware of the size of the particles used after the embolization procedure. Follow-up was performed at 3 and 6 months with rectoscopic examinations and 1, 3, 6, and 12 months with questionnaires. During the follow-up, procedure-related complications were noted and classified according to the Society of Interventional Radiology guidelines (23).

Outcome Measures

The primary outcome measure was the clinical success rate at 12 months.

The secondary outcome measures included the technical success, recurrence (re-bleeding due to recanalization or collateralization of the previously embolized rectal arteries), procedure-related mortality, procedure-related complications, and any outcome differences between particle sizes.

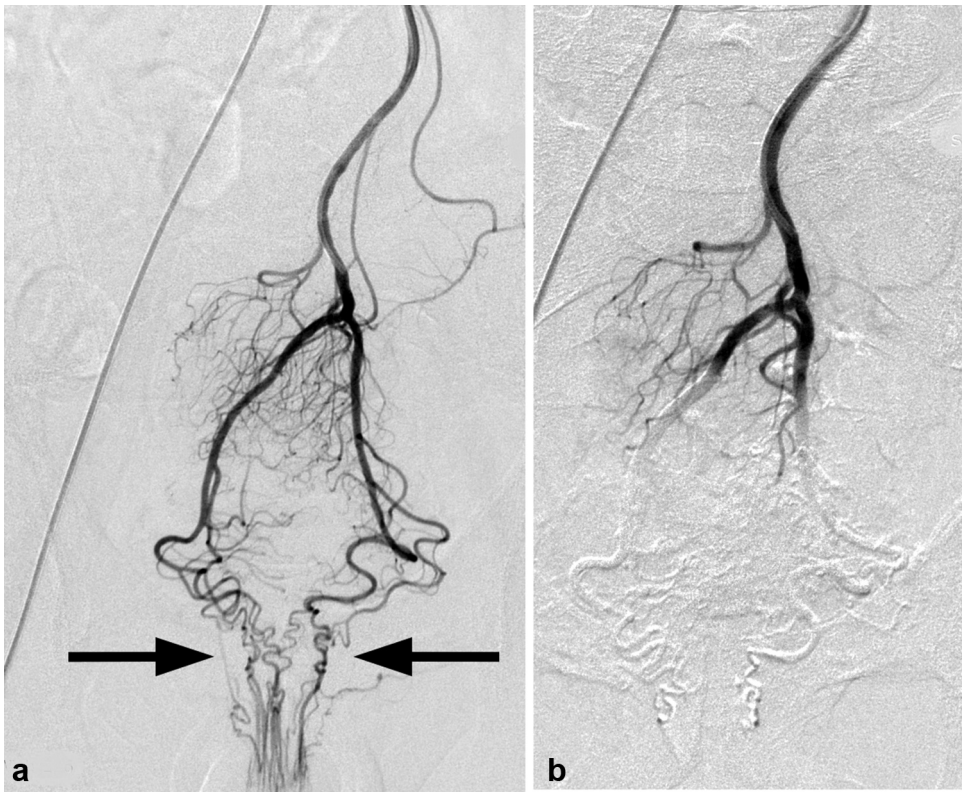

Figure 2. (**a**) A digital subtraction angiography image of the rectal arteries and corpus cavernosum recti arteries (arrows) in a 35-year-old female patient with symptomatic hemorrhoidal disease before embolization. (**b**) A digital subtraction angiography image of the same patient after embolization

Table 1. Results of the Study (Safety)

	500–700 μm(n = 14)		700–900 μm (n = 14)		900–1,200 μm (n = 14)		*P* value
Procedure-related mortality	0% (n = 0)		0% (n = 0)		0% (n = 0)		> .05
Procedure-related major morbidity	0% (n = 0)		0% (n = 0)		0% (n = 0)		> .05
After interventional pain	100% (n = 14)		64.3 % (n = 9)		14.3 % (n = 2)		< .001
After interventional tenesmus	85.7% (n = 12)		50.0% (n = 7)		85.7% (n = 12)		> .05
Rectoscopic findings							
Small superficial ulcerations, at third month	Yes 71.4% (n = 10)	No 28.6% (n = 4)	Yes 64.3% (n = 9)	No 35.7% (n = 5)	Yes 0% (n = 0)	No 100.0% (n = 14)	< .001
Small recto-sigmoid junction ulcerations, at third month	Yes 21.4% (n = 3)	No 79.6% (n = 11)	Yes 0 (n = 0)	No 100% (n = 14)	Yes 0 (n = 0)	No 100% (n = 14)	< .05
Small fibrotic scars, at sixth month	Yes 7.1% (n = 1)	No 92.9% (n = 13)	Yes 0 (n = 0)	No 100% (n = 14)	Yes 0 (n = 0)	No 100% (n = 14)	> .05

Statistical Analysis

SPSS version 21 was used for statistical analysis (IBM Corp., Armonk, New York). Data are summarized as mean ± standard deviation or median and interquartile range (Q1; Q3) (number is expressed in %). The Shapiro-Wilk test was used to determine whether the data followed a normal distribution. The Friedman nonparametric test was used for comparisons between measurements. Post-hoc multiple comparison tests were used to identify different groups. Independent samples *t* test (Student's *t* test) was used to compare the average age of women and men. Pearson's exact chi-square test was used in the analysis of the created cross tables. $P < .05$ was considered statistically significant.

Table 2. Results of the Study (Efficacy)

		500–700 µm group					700–900 µm group					900–1,200 µm group					*P* value
French Bleeding Score (FBS)FBS	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m	Baseline	
	3.7±0.3	2.4± 0.3	2.3± 0.3	1.9±0.3	1.5±0.3	3.9±0.4	2.7±0.4	2.6±0.4	2.4±0.5	2.1±0.4	4.9± 0.3	3.2± 0.3	2.5±0.3	1.1±0.2	1.1±0.1	< .001	
		P < .001	*P* < .001	*P* < .001	*P* < .001		*P* > .05	*P* > .05	*P* < .05	*P* < .001		*P* > .05	*P* > .05	*P* < .001	*P* < .001		
Pain (VAS)	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m		
	4.0±0.3	2.8±0.4	1.9±0.4	1.7±0.4	1.7±0.4	3.1±0.4	1.9±0.3	1.5±0.4	1.7±0.5	1.7±0.5	3.3±0.4	2.0±0.3	1.3±0.2	1.4±0.2	1.4±0.2	> .05	
		P < .05	*P* < .001	*P* < .001	*P* < .001		*P* > .05	*P* < .05	*P* > .05	*P* > .05		*P* > .05	*P* < .001	*P* < .001	*P* < .001		
QOLS	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m		
	2.5±0.1	1.8±0.2	1.5±0.2	1.5±0.3	1.1±0.2	2.6±0.1	1.8±0.2	1.6±0.3	1.7±0.3	1.5±0.2	2.9±0.7	1.9±0.7	1.8±0.1	1.8±0.1	1.4±0.1	> .05	
		P < .001	*P* < .001	*P* < .001	*P* < .001		*P* > .05	*P* < .05	*P* > .05	*P* < .05		*P* < .05	*P* < .001	*P* < .001	*P* < .001		
Goligher Score GPS	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m	Baseline	1.m	3.m	6. m	12.m		
	2.2±0.1	1.8±0.1	1.8±0.1	1.9±0.1	1.9±0.1	2.1±0.1	1.7±0.2	1.8±0.2	1.8±0.2	1.8±0.2	2.2±0.1	2.0±0.0	2.0±0.0	2.0±0.0	2.0±0.0	> .05	
		P > .05	*P* > .05	*P* > .05	*P* > .05		*P* > .05	*P* > .05	*P* > .05	*P* > .05		*P* > .05	*P* > .05	*P* > .05	*P* > .05		

FBS = French bleeding score; GPS = Goligher prolapse score; QOLS = quality of life score; VAS = visual analogue scale.

RESULTS

The results of the study are summarized in Tables 1 and 2. The technical success rate was 100%. All patients were treated as outpatients, and overnight hospitalization was not needed. There were 2 Grade I, 8 Grade II, 17 Grade III, and 15 Grade IV hemorrhoid patients with symptomatic HD.

No procedure-related deaths or major complications were observed (23). The pain rate after the procedure was 100% (n = 14/14) in the 500–700 µm group with a median VAS score of 5, 64.3% (n = 9/14) in the 700–900 µm group with a median VAS score of 3, and 14.3% (n = 2/14) in the 900–1,200-µm group with a median VAS score of 2. The 900–1,200 µm group had a significantly lower pain rate after the procedure than the other groups ($P < .001$). The tenesmus rate after the procedure was 85.7% (n = 12/14), 50.0% (n = 7/14), and 85.7% (n = 12/14) in the 500–700 µm, 700–900 µm, and 900–1,200 µm groups, respectively. No significant differences were noted in the tenesmus rates ($P > .05$). Bleeding after the procedure was reported up to 1 month (median, 2 weeks) after embolization procedures due to hemorrhoidal tissue discharge. The patients emphasized that their bleeding was low pressured and brownish in color, different from hemorrhoidal bleeding, which was high pressured and pinkish in color.

There was a 54% (n = 23/42) minor complication rate in the treated zone: 45% (n = 19/42) small (<5 mm), superficial ulcerations at the embolized area; 7% (n = 3/42) small, rectosigmoid junction ulcerations; and 2% (n = 1/42) small, fibrotic scar tissue. Small, superficial ulcerations in the third month were observed during rectoscopy in 45% of the patients (n = 19/42). This was related to microsphere size (n = 10/14 [71.4%] in the 500–700 µm group; n = 9/14 [64.3%] in the 700–900 µm group; and n = 0/14 [0%] in the 900–1,200 µm group; $P < .001$). There was no need for medical treatment for these small ulcerations, and all were healed at the 6-month rectoscopy. Small rectosigmoid junction ulcerations at 3 months were observed on rectoscopy in 7% of the patients (n = 3/42) (n = 3/14 [21.4%] in the 500–700 µm group; n = 0/14 [0%] in the 700–900 µm group; and n = 0/14 [0%] in the 900–1,200 µm group; $P < .05$). These small ulcerations healed after 6 months with medical treatment using mesalazine 4-g enemas (Salofalk; Vifor AG Zweigniederlassung Medichemie, Ettingen, Switzerland). Small fibrotic scar tissue at 6 months was seen in 2% of the patients (n = 1/42) (n = 1/14 [7.1%] in the treated zone in the 500–700 µm group; n = 0/14 [0%] in the 700–900 µm group; and n = 0/14 [0%] in the 900–1,200 µm group; $P < .05$). No puncture site–related complications were observed. Nontarget embolization was assumed in patients (n = 3/42, 7%) with small recto-sigmoid junction ulcerations observed in the third month. Pain and tenesmus after the intervention were considered to be expected post-embolization syndrome instead of minor complications.

Clinical success was achieved in 39 of 42 patients (93%) at 12 months. In 3 patients, in whom clinical success was not achieved, arterial anatomy consisted of unilateral SRA branch and contralateral dominant MRECA. In these patients, the unilateral SRA branch was embolized, and no further intervention was performed for the MRECA-dominant side.

All 3 groups showed a significant decrease in the FBS at 12 months compared with baseline before embolization (3.7 ± 0.3–1.5 ± 0.3 in the 500–700 μm group, 3.9 ± 0.4–2.1 ± 0.4 in the 700–900 μm group, and 4.9 ± 0.3–1.1 ± 0.2 in the 900–1,200 μm group; $P < .001$). The FBS significantly decreased in the 500–700 μm group after 1 month (3.7 ± 0.3–2.4 ± 0.3; $P < .001$). In the other groups, a significant decrease in the FBS was observed 6 months after the treatment ($P < .001$). At 12 months, the best FBS score decrease was observed in the 900–1,200 μm group among all groups ($P < .001$).

There was a significant decrease in the VAS score at 12 months in the 500–700 and 900–1,200 μm groups (4.0 ± 0.3–1.7 ± 0.4 in the 500–700 μm group and 3.3 ± 0.4–1.4 ± 0.2 in the 900–1,200 μm group; $P < .001$). A slight numerical decrease in the VAS score was observed in the 700–900 μm group at 12 months, although the difference was not statistically significant (3.1 ± 0.4–1.7 ± 0.5; $P > .05$). This was not considered recurrence because all other parameters were improved. The onset of significant pain control was achieved at 1, 3, and 6 months in the 500–700 μm, 700–900 μm, and 900–1,200 μm groups, respectively ($P < .05$). With respect to the VAS score, no advantage was observed between the groups.

The QOLS significantly improved in all groups at 12 months (2.5 ± 0.1–1.1 ± 0.2 in the 500–700 μm group [$P < .001$], 2.6 ± 0.1–1.5 ± 0.2 in the 700–900 μm group [$P < .05$], and 2.9 ± 0.7–1.4 ± 0.1 in the 900–1,200 μm group [$P < .001$]). The onset of significant QOLS improvement was achieved at 1 month in the 500–700 μm and 900–1,200 μm groups and at 3 months in the 700–900 μm group ($P < .05$). With respect to the QOLS, no advantage was observed between the groups.

The GPS did not significantly change between the time points and between the groups ($P > .05$). No recurrent disease was observed in the 12-month period. All 42 patients were assessed at this time point.

DISCUSSION

This study demonstrated that SRAE for symptomatic HD using tris-acryl gelatin microspheres ranging from 500-700, 700-900, and 900-1,200 μm diameters is a safe and effective procedure without any mortality or major complications. The clinical success rate was 93%. The earliest significant bleeding control was achieved with 500–700 μm particles, and the best bleeding control was achieved with 900–1,200 μm particles at 12 months. Considering pain relief, quality of life, and prolapse no group showed a greater advantage over the others.

The technical success rate of the SRAE with coils, particles, and other agents was between 90% and 100% in previous studies (11–20). In this study, the technical success rate was 100%.

Concerning the safety of the SRAE procedure, the current study demonstrated similar results as previous studies (11–20). No procedure-related deaths or major complications were observed.

Most of the studies previously published studies demonstrated no ischemia or pain after the intervention resulting from procedures performed with coils alone (11–19). SRAE with small PVA particles (range, 300–500 μm) caused no pain in a previous study (15). A study on SRAE with tris-acryl gelatin microspheres (Embosphere, 300–500 μm) plus coils revealed mild pain in 15% of patients (14). SRAE with only tris-acryl gelatin microspheres (300–500 μm) revealed 81% anal pain after the embolization (20), similar to the results of the current study, except for the 900–1,200 μm group, in which no pain was observed.

In this study, tenesmus after the intervention, which persisted for up to 5 days, was observed in 50%–87.5% of the patients. Previous studies using coils alone as embolization agents showed rates of tenesmus of ranging 0% to 34.8% persisting up to the third day (11–20).

No ischemic complications were previously reported using either coils or small particles for SRAE (11–20). Most of the previous trials did not require routine rectoscopic follow-ups after SRAE (11–20), which may account for the underreporting of this minor complication. Zakharchenko et al performed rectoscopic examinations at 1-day, 1-week, and 1-month intervals after the SRAE procedure and found no mucosal atrophy or dystrophy after embolization with histopathologic analysis (15). The current study revealed that when the particle size decreased, the rectal ulceration rate increased. Small rectosigmoid ulcers were likely due to either nontarget embolization or to anastomoses between the SRA branches and the sigmoidal artery at Sudeck's point (24). However, in previous reports, there was no mention of this minor complication (11–20). Small fibrotic scars around the treated zone were also detected with rectoscopy in the 500–700 μm group, and this was not shown in previous studies (11–20). These scars could represent healing of mucosal ulceration.

The clinical success rate of SRAE was between 63% and 97% in previous trials (11–20). In this study, a 93% clinical success rate was achieved. In the 3 patients with clinical failure, a unilateral dominant MRECA was observed, and only 1 side with the SRA branch was embolized. This may have allowed feeding of the CCR via the MRECA and collateral vessels. The relatively lower clinical success rates with only coil embolization may be explained by the proximal embolization of the SRA and collateral flow. Furthermore, using nonspherical PVA particles may cause heterogeneous obstruction and proximal embolization from clumping (25). After proximal embolization of the SRA, any preexistent or developing anastomoses may become prominent and continue to feed the CCR (15). More distal

embolization proximal to the CCR is likely to result in the most clinical success without complications (15). Sun et al performed inferior rectal artery coil embolizations in addition to SRAE and obtained better results without any major complications (11). Moussa et al demonstrated that adding MRECA embolization in addition to SRAE using microspheres (Embospheres, 300–500 μm) and coils resulted in improved clinical symptoms without any major complications in 2 patients who experienced clinical failure after SRAE with coil only embolization (19). More data and trials are needed to understand the anatomy of the rectal arteries more completely and to optimize treatment of hemorrhoids.

The rate of symptomatic relief in the current study was similar to that reported in previous studies (>85%) (11–19). The GPS did not change significantly between the time points and did not differ between the groups, which was different from the results of the study by Tradi et al (12).

A median recurrence rate of 30% was reported in the previous literature, which was different from the 0% recurrence rate reported in the current study (11,19). Previously reported higher rates could be related to proximal embolization and other technical issues.

This study has several limitations, which include the small sample sizes in all 3 groups. A follow-up period of >1 year could be more able to investigate durability, although most previous studies used this period as a cut-off value. Patients with variant anatomy, except for a single dominant MRECA, were not included in the study, and the rectal arteries other than the SRA were not embolized. There are very few data about the particles used in hemorrhoid embolization, and the 300–500 μm microspheres used in most previous studies were not investigated in the current study. Future studies comparing the benefits of different embolization agents and different techniques are needed.

In conclusion, SRAE with tris-acryl gelatin microspheres for symptomatic HD is a safe and effective treatment. Immediate bleeding control was observed in the 500–700 μm group, and the best bleeding control at 12 months, the lowest postprocedural pain, and the fewest minor ischemic complications were observed with the 900–1,200 μm microspheres.

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