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Comparison of polyvinyl alcohol particles and tris-acryl gelatin microspheres embolic agents used in uterine artery embolization: A systematic review and meta-analysis

Uterin arter embolizasyonunda kullanılan polivinil alkol partikülleri ve tris-akril jelatin kaplı mikroküreleri karşılaştırılması: Sistematik bir derleme ve meta-analiz

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Abstract

Objective: To identify the preferred agent by comparing the therapeutic efficacy, degree of infarction, and side effects of polyvinyl alcohol particles (PVA) and tris-acryl gelatin embolization (TAGM) agents in uterine artery embolization.

Materials and Methods: We included available articles comparing PVA with TAGM embolization agents in the management of fibroids. The primary outcomes included the decrease in uterine volume (%), decrease in dominant tumor volume (%), fibroid infarction rate, complete infarction fibroid, complications, pain score after 24 h, procedure time (minutes), duration of hospital stay, fluoroscopy time (minutes), and the change in symptom severity score.

Results: Eight articles that met our inclusion criteria were included in this study. Our analysis yielded an overall superiority of PVA compared to TAGM regarding complete fibroid infarction rate at the first 24 h. However, TAGM was better than PVA concerning <90% infarction rate outcome. While both embolization techniques showed similar effects regarding the change in symptom severity score, the percentage of decrease in uterine volume, percentage of decrease of dominant tumor volume, 90-99% infarction rate, complete infarction rate when assessed after the first 24 h, pain score after the first 24 h, procedure time, fluoroscopy time, minor, and major complications.

Conclusion: Both PVA and TAGM embolization agents are effective and safe modalities in treating patients with fibroids, with no significant variation of both agents in most outcomes.

Keywords: Polyvinyl alcohol particles, tris-acryl gelatin microspheres, uterine fibroid, uterine artery embolization

Öz

Amaç: Bu çalışmanın amacı, uterin arter embolizasyonunda polivinil alkol partikülleri (PVA) ve tris-akril jelatin kaplı embolizasyon (TAGM) ajanlarının terapötik etkinliğini, enfarktüs derecesini ve yan etkilerini karşılaştırarak tercih edilecek ajanı belirlemektir.

Gereç ve Yöntemler: Miyomların tedavisinde PVA ile TAGM embolizasyon ajanlarını karşılaştıran mevcut makaleleri derledik. Birincil sonlanımlar arasında uterus hacminde azalma (%), baskın tümör hacminde azalma (%), fibroid enfarktüs oranı, tam enfarktüs fibroid, komplikasyonlar, 24 saat sonra ağrı skoru, işlem süresi (dakika), hastanede kalış süresi, floroskopi süresi (dakika) ve semptom şiddeti skorundaki değişiklik yer almaktadır.

PRECIS: There is no significant difference between polyvinyl alcohol particles and tris-acryl gelatin microsphere embolic agents in treating fibroid patients with uterine artery embolization.

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Bulgular: Dahil edilme kriterlerimize uyan sekiz makale bu çalışmaya dahil edildi. Analizimiz, ilk 24 saatte tam fibroid enfarktüs oranı açısından TAGM'ye kıyasla PVA'nın genel bir üstünlüğünü ortaya çıkardı. Ancak TAGM, <%90 enfarktüs oranı sonucu açısından PVA'dan daha iyiydi. Her iki embolizasyon tekniği semptom şiddeti skorundaki değişim, uterus hacmindeki azalma yüzdesi, dominant tümör hacmindeki azalma yüzdesi, %90-99 enfarktüs oranı, ilk 24 saatten sonra değerlendirildiğinde tam enfarktüs oranı, ilk 24 saatten sonraki ağrı skoru, işlem süresi, floroskopi süresi, minör ve majör komplikasyonlar açısından benzer özelliklere sahipti.

Sonuç: Hem PVA hem de TAGM embolizasyon ajanları, miyomlu hastaların tedavisinde etkili ve güvenli modalitelerdir ve çoğu sonlanım açısından her iki ajan arasında önemli bir fark görülmemektedir.

Anahtar Kelimeler: Polivinil alkol partikülleri, tris-akril jelatin kaplı mikroküreler, uterin fibroid, uterin arter embolizasyonu

Introduction

Uterine artery embolization (UAE) is a minimally invasive radiological procedure used to treat various gynecological conditions, such as fibroids and adenomyosis[1]. Additionally, UAE could also be used to control bleeding in obstetric emergencies, such as postpartum obstetric hemorrhage. Uterine fibroid is a benign tumor that affects up to 70% of fertility-seeking women, causes menorrhagia and dysmenorrhea and results in a lower quality of life[2].

During a UAE procedure, a catheter is advanced from the femoral artery to the uterine artery using fluoroscopy and contrast dyes; then, embolic agents are injected into the uterine arteries that supply fibroids, causing the formation of a clot that obstructs blood flow and eventually results in fibroid shrinkage. This raises the question of whether different embolic agents have varying efficacy in treating fibroids[3,4].

Despite a higher reintervention rate and severe post-procedural pain, UAE remains a popular option for fibroid management compared with conservative surgery because of its minimal blood loss, reduced recovery time, and lower operation risks[1,2,5]. Multiple studies have demonstrated the efficacy and safety of UAE in treating fibroid symptoms and reducing uterine volume[6,7]. Post-embolization pain is commonly noted due to ischemia resulting in significant inflammatory reactions during UAE, which can be severe and necessitate hospitalization with intravenous analgesics[8].

Various embolic agents have distinct properties and absorption rates. The shape of embolic agents also affects their difficulty in administration. Spherical agents are easier to administer, whereas irregularly shaped agents may clump and block microcatheters[9]. Additionally, temporary agents such as Gelfoam is the preferable choice for treating obstetric hemorrhage because they can quickly reabsorbed[2]. Other longer-lasting agents, such as Polyvinyl alcohol (PVA) particles or tris-acryl gelatin microspheres (TAGM), are more effective at reducing uterine volume. Conversely, an embolic agent with lasting effects may weaken the potency of the uterine artery and hence reduce fertility. Thus, Gel-bead is a bioresorbable embolic agent in calibrated spheres of varying sizes that is resorbable within 12 weeks and has a high infarct rate for fibroid reduction[10].

In this study, we conducted a meta-analysis of available studies to identify the preferred agent by comparing the therapeutic efficacy, degree of infarction, and side effects of PVA and TAGM embolization agents.

Materials and Methods

The PRISMA protocol was used as a guideline in performing our meta-analysis[11].

Searchs and Information Databases

We used the following search strategy in our search until Oct 2022: ("uterine artery embolization" OR "uterine artery occlusion" OR UAE) AND (fibromyoma OR leiomyomata OR myoma OR leiomyoma OR fibroid) AND (polyvinyl alcohol OR PVA OR tris acryl OR "tris-acryl gelatin microspheres" OR TAGM OR "gelatin sponge particles" OR gelfoam OR Embosphere OR Embosphere OR "embolic agents"). PubMed, Web of Science, Cochrane library, and Scopus were the main used databases.

Selection Criteria and Eligibility Criteria

We selected our included articles in two steps. First, we depended on titles and abstracts to identify relevant articles, which were then were further evaluated to reach the final included studies according to our eligibility criteria. We included all articles comparing the efficacy and safety of PVA versus TAGM embolization agents in UAE for uterine fibroids. We excluded any studies which did not report our assessed outcomes, single-arm studies, and secondary studies such as systematic reviews and meta-analyses.

Data Extraction

Data from the included studies were retrieved and plotted on an excel sheet. We extracted the general information data about studies such as study design, used imaging techniques, and follow-up period. We also extracted baseline characteristics of included patients, including age, preprocedural uterine volume, preprocedural dominant tumor volume, embolization agent volume, and health-related quality of life. Then we extracted data of our main outcomes, including decrease in uterine volume (%), decrease in dominant tumor volume (%), fibroid infarction rate, complete infarction of fibroid, complications, pain score after 24 h, procedure time (minutes), duration of hospital stay, fluoroscopy time (minutes), and change in symptom severity score. Finally, we collected the data required for the quality assessment.

Quality Assessment

We included both randomized controlled trials (RCTs) and observational studies. Therefore, we used two different tools for the quality assessment of the included studies. Concerning the clinical trials' quality assessment, we used the Cochrane assessment tool[12]. RCTs were categorized as high, moderate, or low quality according to the state of randomization, allocation concealment, sequence generation, adequate blinding, if the trial was free of selective reporting, and if the missing outcome data were adequately addressed. Regarding the quality assessment of the included observational studies, we used the National Heart, Lung, and Blood Institute (NHLB) tool[13].

Statistical Analysis

We analyzed data of our main outcomes using RevMan 5.4.1. We used the inverse variance and Mantel-Haenszel analysis methods for continuous and dichotomous data, respectively. Continuous outcomes were analyzed using mean difference (MD) or standardized mean difference (standard MD) and 95% confidence intervals (CIs). Dichotomous outcomes were analyzed using the risk ratio (RR) and 95% CIs. The p-value of the chi-square test and the I^2 assessed the heterogeneity among the studies. The outcome is considered heterogeneous if $p<0.1$ or $I^2>50\%$. We tried solving the inconsistency among data using subgroup analysis and the Cochrane leave-one-out method[14].

Results

Search Results and Characteristics of the Included Studies

The results of our search are shown in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram (Figure 1). Eight articles[9,10,15-20] met our eligibility criteria and were included in our meta-analysis. We evaluated 403 women who underwent UAE for uterine fibroid. One hundred ninety-seven women underwent PVA embolization, while TAGM embolization agent was used in 206 women. The mean age of all the included women was 44.11 years. Table 1 shows the general characteristics of the included studies. Table 2 shows the baseline data of the included patients.

Results of the Quality Assessment

According to Cochrane's tool[21], all trials[9,15,16,18-20] reported proper randomization, blinding of outcomes assessment, blinding of participants and personnel, and selective reporting bias was not detected; therefore, they were categorized as low-risk in the previous domains. Regarding selection bias, all studies reported proper allocation concealment except Han et al.[19], which did not report sufficient details, so it was categorized as an unclear risk of bias. Four studies concerning attrition bias[9,16,18,20] were categorized as high risk due to inadequate handling of incomplete outcome data. In contrast, the other two trials[15,19] were categorized as low risk of bias. A detailed illustration of the quality assessment is shown in Figure 2. The quality assessment of the included observational studies yielded an average score of 9.5 out of 14, according to NHLB[13]. A detailed summary of the quality assessment of our included studies is illustrated in Figure 2 and Table 3.

Analysis of Outcome

Decrease in Uterine Volume (%)

Five of our included studies reported a decrease in uterine volume percentage[9,10,15,16,18]. Our final results demonstrated a similar decrease in both groups MD=-1.29 (-5.44, 2.86), p=0.54. Data were homogenous (p=0.12); I^2=46% (Figure 3).

Decrease in Dominant Tumor Volume (%)

We conducted a subgroup analysis of this outcome according to the imaging method used to assess dominant tumor volume. The first subgroup included five studies[9,10,15,16,18] that used magnetic resonance imaging (MRI). The combined analysis demonstrated that patients allocated to PVA showed a comparable decrease in the dominant tumor volume with patients allocated to TAGM MD= 9.04 (-4.20, 22.27), p=0.18. We faced heterogeneity among studies in this subgroup (p=0.03); I^2=66% (Figure 4a). The second subgroup includes one study[20] that assessed the

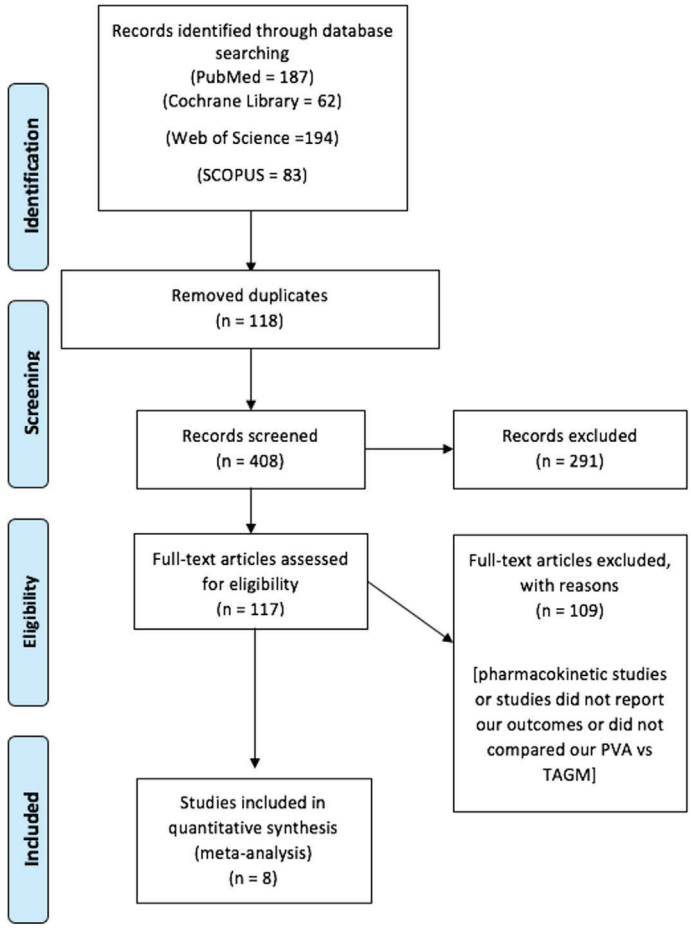

Figure 1. Shows a PRISMA flow diagram of our literature search

Table 1. Shows general characteristics of the included studies

Study name	Study Design	Used imaging techniques	Follow-up after procedure
Galvez et al.[17]	Observational cohort	MRI with gadolinium	1, 3, and 6 months
Han et al.[19]	RCT	Contrast-enhanced MRI (gadolinium chelate)	Three months
Maclean et al.[10]	Retrospective cohort	MRI/MRA	Three months
Shlansky-Goldberg et al.[28]	RCT	Contrast-enhanced MRI	The first day, three months, and one year
Siskin et al.[16]	RCT	MRI	Four weeks
Spies et al.[15]	RCT	Contrast-enhanced MRI	Three months
Spies et al.[15]	RCT	Contrast-enhanced MRI	Three months
Yu et al.[20]	RCT	Ultrasonographic with Doppler	Two years

RCT: Randomized controlled trial, MRI: Magnetic resonance imaging

Table 2. Shows the baseline data of the included patients

Study name	Age (year)				Preprocedural uterine volume (cm^3)				Preprocedural dominant tumor volume (cm^3)			
	PVA		TAGM		PVA		TAGM		PVA		TAGM	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Galvez et al.[17]	NR	NR	NR	NR	656 mL	440	757 mL	680	NR	NR	NR	NR
Han et al.[19]	45	5	44	4	406	227	423	216	6.2 cm	1.6	6.8	1.8
Maclean et al.[10]	47.1	6.3	46.2	4.7	674	498	401.9	288	352.2	421	136.1	158
Shlansky-Goldberg et al.[28]	43.9	5	41.7	5.4	1536.7	937.3	1491.6	1456.5	203.3	275.1	141.1	179.6
	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Siskin et al.[16]	44.9	NR	45.1	NR	518.2	477.4	611.6	281.575	190.6	167.57	196.9	130.625
Spies et al.[15]	42.5	5	43.4	5.4	603.9	343.3	648.7	326.7	162.4	169.3	138.4	139.5
	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Spies et al.[15]	44.9	6.2	45.9	4.4	510.5	314.8	618.8	305.1	142.4	126.6	150.1	178.9
	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Yu et al.[20]	42.7	5.15	40.3	5.1	14.18	3.29	14.2	3.2	197.7	179	181.26	139.5

Study name	Embolization agent volume (cm^3)				Scale	Health-related quality of life			
	PVA		TAGM			PVA		TAGM	
	Mean	SD	Mean	SD		Mean	SD	Mean	SD
Galvez et al.[17]	NR	NR	NR	NR	NR	NR	NR	NR	NR
Han et al.[19]	NR	NR	NR	NR	HRQOL	62	14	65	8.25
Maclean et al.[10]	NR	NR	NR	NR	NR	NR	NR	NR	NR
Shlansky-Goldberg et al.[28]	12.8 mL	9.4	12.6	7.2	UFSQOL symptom score	64.2	20.6	65.1	20.3
	NR	NR	NR	NR	UFSQOL subscores	42.1	20.2	42	23.7
Siskin et al.[16]	8.4	12.50	11.6	4	NR	NR	NR	NR	NR
Spies et al.[15]	3 cm^3	1.6	9.4	5.7	Fibroid-specific QOL symptom score	50.2	23.2	57.4	19.8
	NR	NR	NR	NR	Fibroid-specific QOL total score	57.8	22.5	47.6	21.1
Spies et al.[15]	5.3 mL	3.6	7.8	6.3	UFSQOL symptom score	57.4	22.4	61.5	19.3
	NR	NR	NR	NR	UFSQOL total score	51.6	20.3	43.5	26.3
Yu et al.[20]	NR	NR	NR	NR	NR	NR	NR	NR	NR

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin microspheres, SD: Standard deviation, NR: Unreported, UFSQOL: Uterine fibroid symptom and quality of life

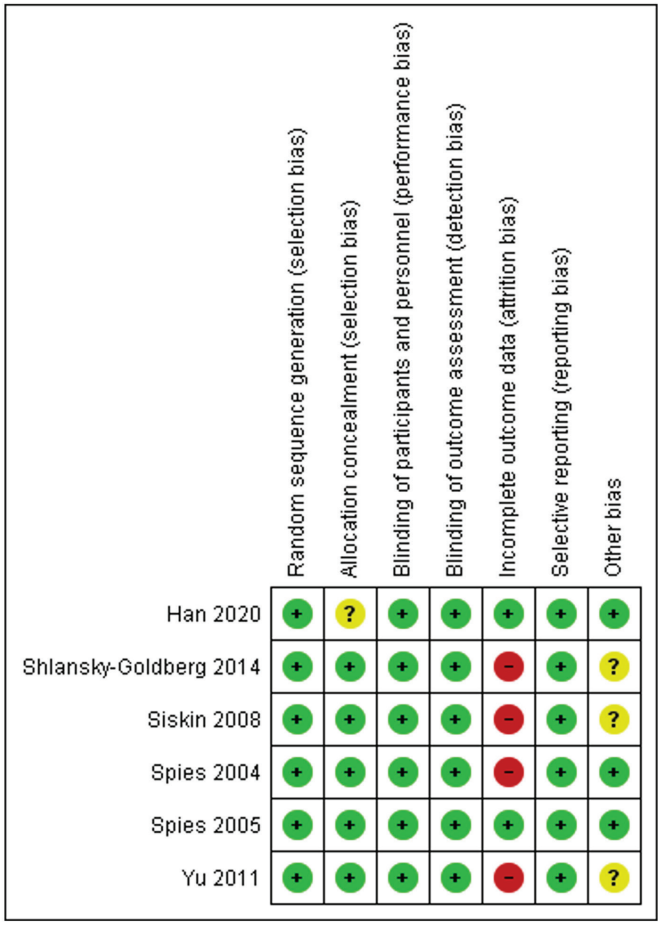

Figure 2. Shows a detailed illustration of the risk of bias of included studies

decrease in dominant tumor volume using ultrasound. We found similar results in both groups MD= 1.30 [-18.49, 21.09], p=0.90 (Figure 4b).

Fibroid Infarction Rate

Regarding the 90-99% infarction rate, four studies[9,10,15,16] reported this outcome. The overall RR was similar in both groups RR=0.70 [0.36, 1.37], p=0.30. Data were homogenous (p=0.35); I^2=9% (Figure 5a).

Three studies[10,15,16] reported <90% infarction outcome. The combined analysis showed a significant favoring of the TAGM group RR=2.92 [1.26, 6.73], p=0.01. Analysis was homogenous (p=0.25); I^2=28% (Figure 5b).

Complete Infarction of a Fibroid

Two studies[9,19] reported the rate of complete infarction outcome in the first 24 h after UAE. We found that the percentage of complete infarction was significantly lower in the TAGM group RR=1.16 [1.00, 1.33], p=0.04. We found no heterogeneity among data in this subgroup (p=0.78); I^2=0% (Figure 6a).

Five studies[9,10,15-17] assessed this outcome in the period after the first 24 h. There was no significant variation between the groups RR=0.86 [0.67, 1.10], p=0.22. We faced heterogeneity among studies in this subgroup (p=0.04); I^2=61% (Figure 6b).

Complications

Data of minor complications were retrieved from four studies[16,18-20]. The percentage of minor complications was similar in both groups RR= 0.81 [0.62, 1.07], p=0.14. The overall analysis was homogenous (p=0.87); I^2=0% (Figure 7a).

Three studies[16,18,20] compared major complications between both groups. The overall RR showed no significant difference between both embolization agents RR=2.42 [0.73, 8.03], p=0.15. Analysis was homogenous (p=0.99); I^2=0% (Figure 7b).

Pain Score After 24 h

The pain score was assessed in four studies[9,15,18,19]. The pain score in both groups was comparable SMD=-0.06 [-0.31, 0.19], p=0.66. Data were homogenous (p=0.50); I^2=0% (Figure 8).

Procedure Time (Minutes)

This outcome was reported in three studies[9,15,19]. The combined mean difference did not favor any group over the other MD=-0.16 [-3.54, 3.23], p=0.93. There was no heterogeneity among studies (p=0.59); I^2=0% (Figure 9).

Duration of Hospital Stay

Two studies[9,20] reported the duration of hospital stay. Patients in both groups showed approximately similar duration of hospitalization MD= 0.00 [-0.10, 0.10], p=0.98. Data were homogenous (p=0.79); I^2=0% (Figure 10).

Fluoroscopy Time (Minutes)

Four studies[9,15,18,19] evaluated the fluoroscopy time. The overall mean difference did not show any difference between both groups MD=-0.21 [-1.34, 0.93], p=0.72. Analysis was homogenous (p=0.15); I^2=43% (Figure 11).

Change of Symptom Severity Score

Data of symptom severity score were retrieved from four studies[9,15,18,19]. The combined analysis did not favor any embolization agent MD=-2.81 [-13.88, 8.26], p=0.62. We faced heterogeneity among data (p=0.02); I^2=69% (Figure 12a). We could decrease the heterogeneity by excluding Spies et al.[18] I^2=52%; (p=0.12). The overall mean difference after solving the heterogeneity showed a comparable change in both groups MD=1.31 [-9.96, 12.59], p=0.82 (Figure 12b).

Discussion

Uterine fibroids are present in about 60% of females during their reproductive period[22]. Leiomyomas are associated with various adverse events that affect the physical, psychological, and social functions of women[23]. Thus, the presence of a complicated uterine fibroid is a reliable indication for performing hysterectomy[24]. To avoid the complications of such invasive procedures and preserve women fertility, alternative minimally invasive techniques have been developed. UAE effectively

Table 3. Shows the quality assessment of observational studies

Study name	Galvez et al.[17]	Maclean et al.[10]
1. Was the research question or objective in this paper clearly stated?	Yes	Yes
2. Was the study population clearly specified and defined?	Yes	Yes
3. Was the participation rate of eligible persons at least 50%?	Yes	Yes
4. Were all the subjects selected or recruited from the same or similar populations (including the same period)? Were inclusion and exclusion criteria for being in the study specified and applied uniformly to all participants?	Yes	Yes
5. Was a sample size justification, power description, or variance and effect estimate	No	Yes
6. For the analyses in this paper, were the exposure (s) of interest measured before the outcome(s) being measured?	No	Yes
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Yes	Yes
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	No	No
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	No	Yes
10. Was the exposure(s) assessed more than once over time?	NA	NA
11. Were the outcome measures (dependent variables) learly defined, valid, reliable, and implemented consistently across all study participants?	Yes	Yes
12. Were the outcome assessors blinded to the exposure status of the participants?	No	No
13. Was the loss to follow-up after baseline 20% or less?	Yes	Yes
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	Yes	Yes
Total score (out of 14)	8	11

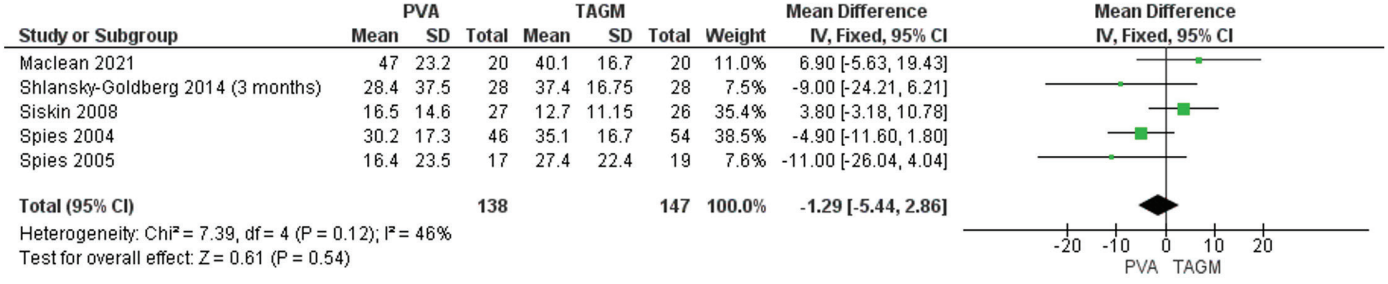

Figure 3. Shows the decrease in uterine volume (%)

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Standard deviation

reduces fibroid symptoms, volume, and complications since it was first conducted in 1995[3]. PVA, a non-biodegradable agent, is the first and most prevalent used embolization agent in UAE[25]. While Microporous cross-linked acrylic beads are used to create the calibrated microspheres known as TAGM[20]. In this systematic review and meta-analysis, we compared the post-procedural outcomes of PVA versus TAGM in treating uterine fibroids. Our combined analysis demonstrated that PVA was superior to TAGM in terms of complete fibroid infarction rate when assessed at the first 24 h. However, TAGM was better than PVA, concerning a less than 90% infarction rate outcome. While both embolization techniques showed similar effects regarding the change in symptom severity score, the percentage of decrease in uterine volume, percentage of decrease of dominant tumor volume, 90-99% infarction rate, complete infarction rate when assessed after the first 24 h, pain score after the first 24 h, procedure time, fluoroscopy time, minor, and major complications.

In 2013, Das et al.[26] conducted a meta-analysis, which compared embospheres (TAGM) with spherical PVA (sPVA),

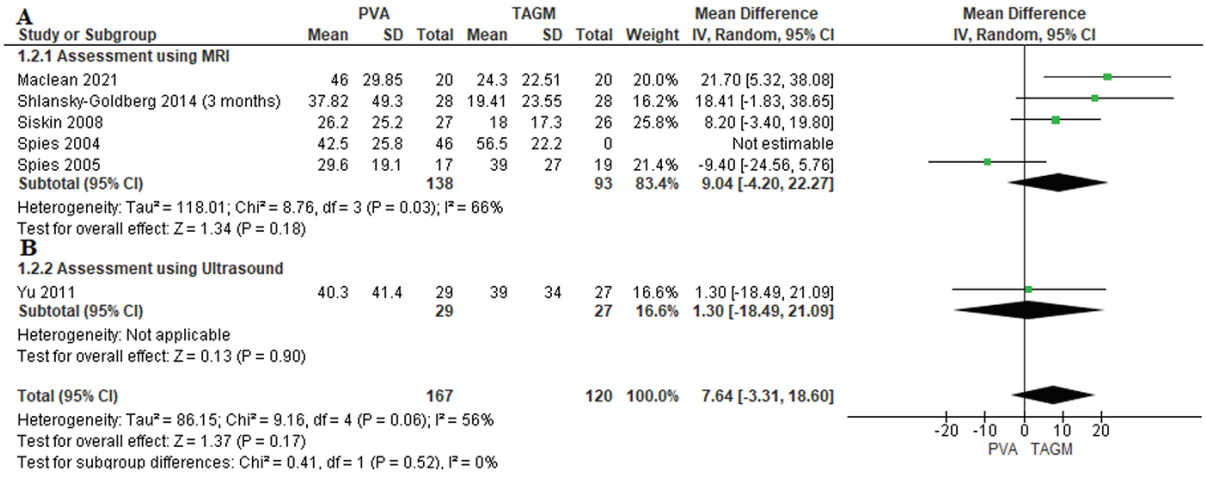

Figure 4. Shows the decrease in dominant tumor volume (%)-Part A includes five studies[9,10,15,16,18] using MRI & Part B includes one study[20] using ultrasound

MRI: Magnetic resonance imaging, PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Standard deviation

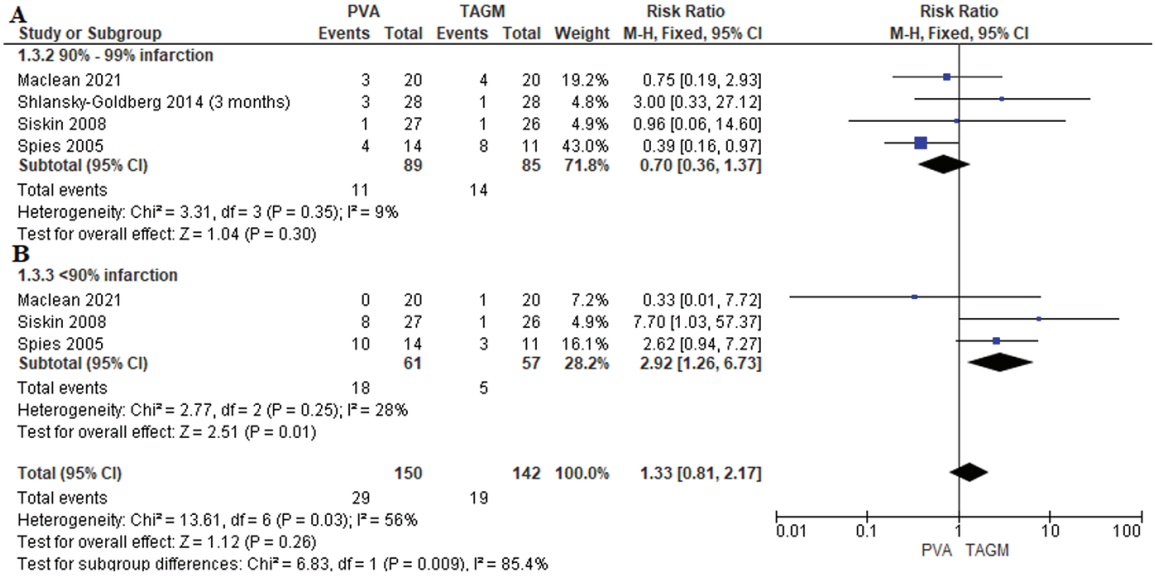

Figure 5. Shows the outcome of fibroid infarction rate-Part A includes four studies[9,10,15,16] with 90-99% infarction rate & Part B includes three studies[10,15,16] with <90% infarction outcome

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval

non-spherical PVA, or acrylamido PVA in terms of post-procedural MRI assessment of both uterine and tumor volume and the quality of life of treated women. The overall analysis between TAGM and sPVA showed that TAGM was associated with a significantly more fibroid devascularization percentage. However, similar to our findings, both embolization agents showed a similar reduction of the uterine and dominant fibroid volume. The lack of randomized trials in both groups was the main limitation of this study.

Galvez et al.[17] evaluated the MRI infarction rate of 101 patients who underwent UAE using sPVA, non-spherical PVA, or TAGM. They found that sPVA was associated with a less complete fibroid infarction rate and more incidence post-procedural residual enhancement. These results are similar the to previously published studies[27,28] that demonstrated the superiority of non-spherical PVA over sPVA. The inability of the spherical-shaped PVA to occlude the blood vessels because it is created from compressible materials, which may allow its distal migration through the blood circulation to reach small vessels may explain the superiority of non-spherical PVA over sPVA. Moreover, to get the spherical shape of sPVA, it is created in a specific technique that increases its *in vivo* dissolution

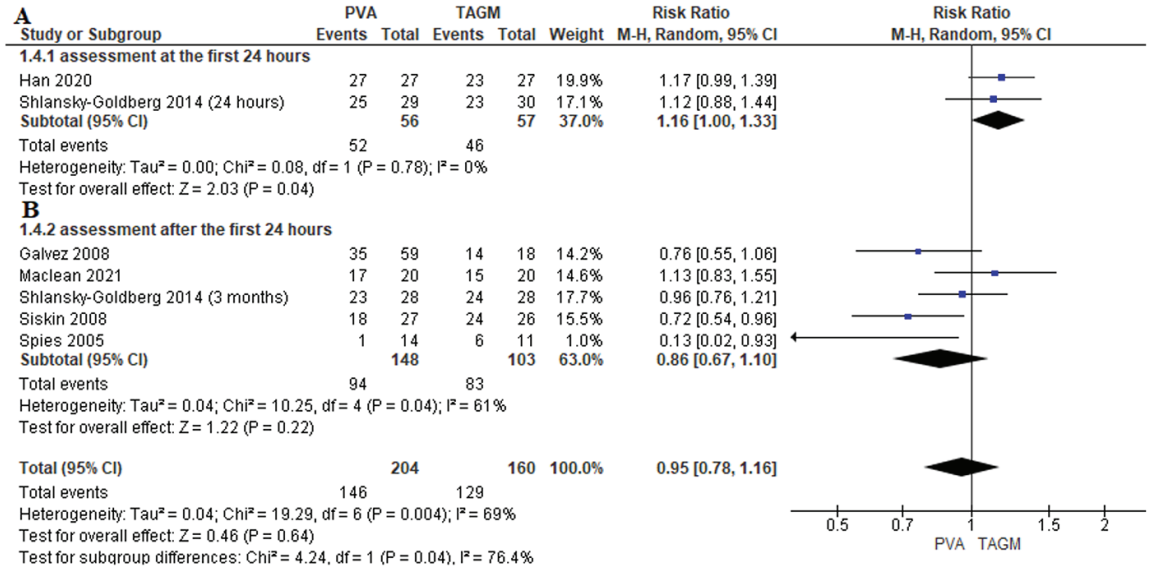

Figure 6. Shows the outcome of complete infarction of fibroid-Part A includes two studies[9,19] that assessed the outcome within the first 24 hours after UAE & Part B includes five studies[9,10,14-16] that assessed the outcome after the first 24 hours

UAE: Uterine artery embolization, PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval

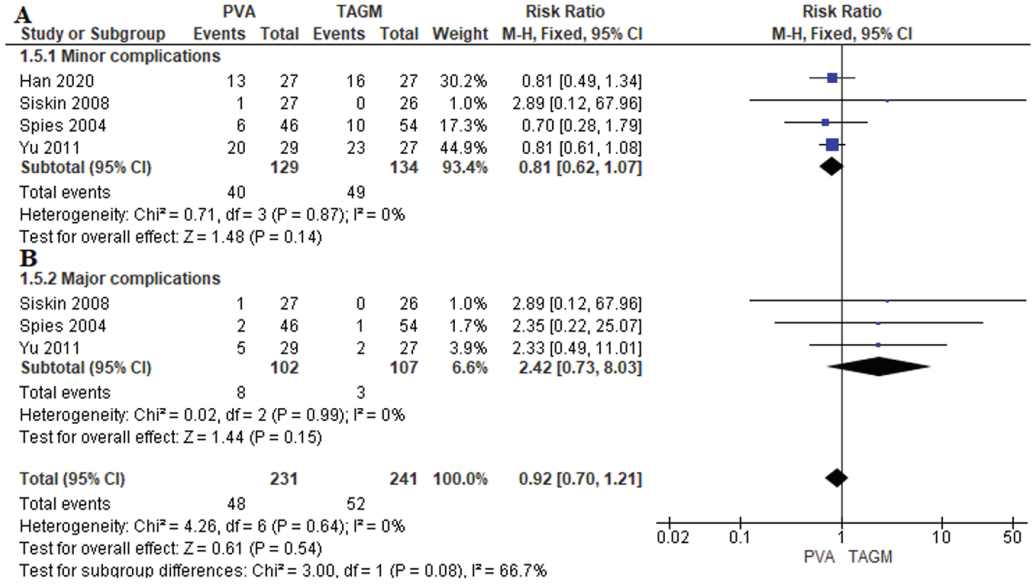

Figure 7. Shows the outcome of complications-Part A includes four studies[16,18-20] with minor complications & Part B includes three studies[16,18,20] with major complications

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Stardard deviation

more than conventional PVA[29]. To overcome some of these disadvantages, Pelage et al.[30] used larger size sPVA (700-900 µm), which caused complete fibroid infarction in 83% of patients. Additionally, they suggested that five minutes waiting period after each arterial embolization would confirm the appropriate vascular occlusion before catheter removal. The manufacturer of these microspheres has validated this protocol and included it in the guidelines for using the product[16].

Another previously published meta-analysis of five included studies[31] comparing PVA with TAGM showed similar results regarding the mean change in pain score and the average reduction in uterine volume, which is consistent with our findings. However, Contrary to our results, their analysis yielded an overall superiority of TAGM in terms of average fibroid-volume change, symptom, and quality of life change. Besides the clinical and radiological differences in both groups,

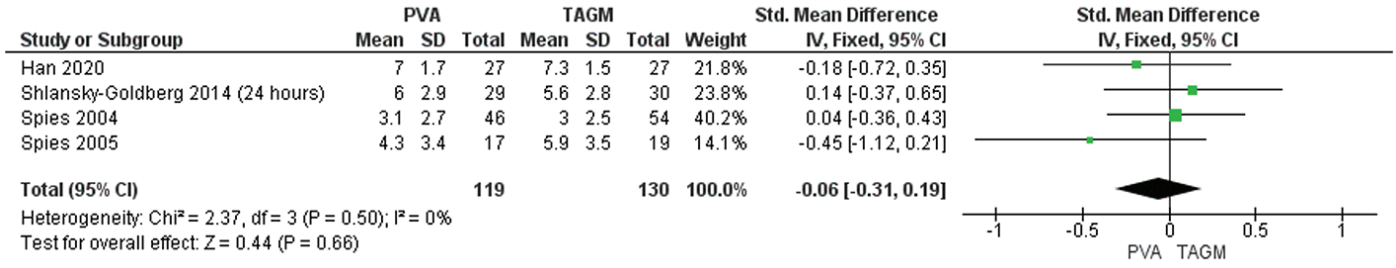

Figure 8. Shows the pain score after 24 hours

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Stardard deviation

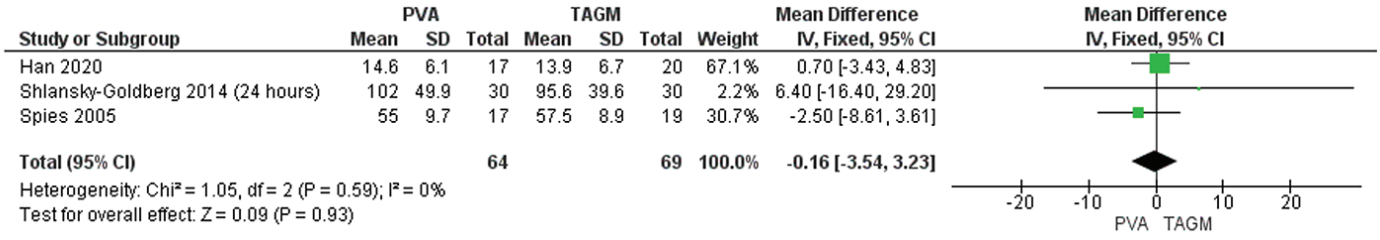

Figure 9. Shows the outcome of procedure time (minutes)

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Stardard deviation

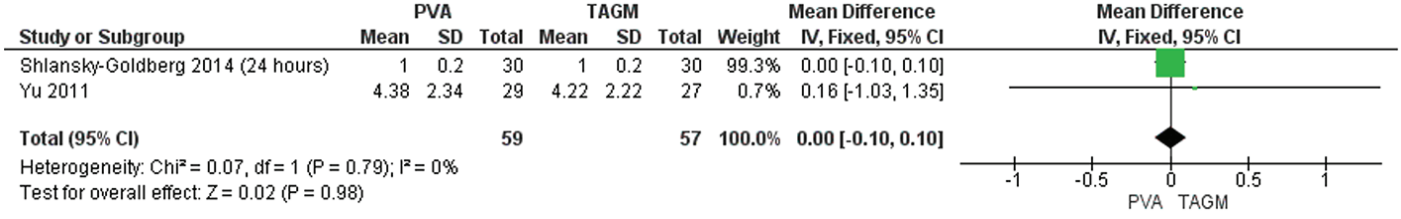

Figure 10. Shows the duration of hospital stay

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Stardard deviation

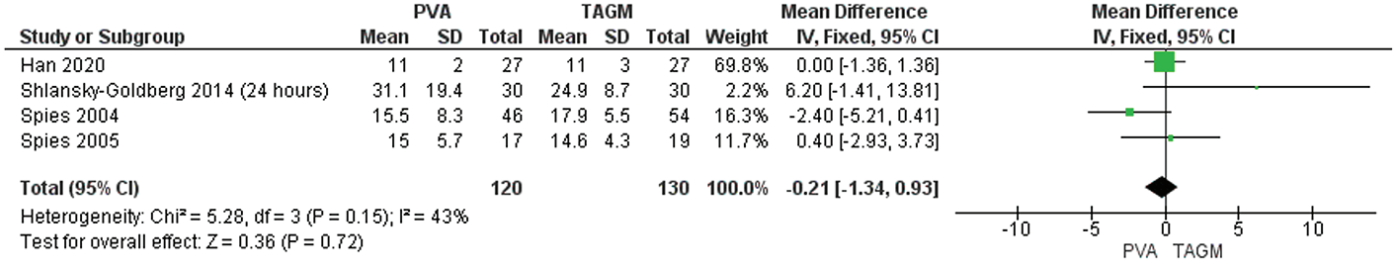

Figure 11. Shows the fluoroscopy time (minutes)

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Stardard deviation

the choice of an embolic agent depends on other factors, including the availability, ease of preparation, and the cost of these agents. Fortunately, both agents are available in most places. UAE requires more TAGM vials than PVA, and the overall cost of TAGM is higher. TAGM is easier to inject with less possibility of catheter occlusion[18].

Three hundred fifty one women with uterine leiomyomas were treated with either PVA or TAGM embolization agents in a recent systematic review[32]. Their final results favored the TAGM embolization agent concerning the overall quality of life, uterine volume, tumor volume, and less than 90% infarction leiomyoma infarction rate. They found no significant variation

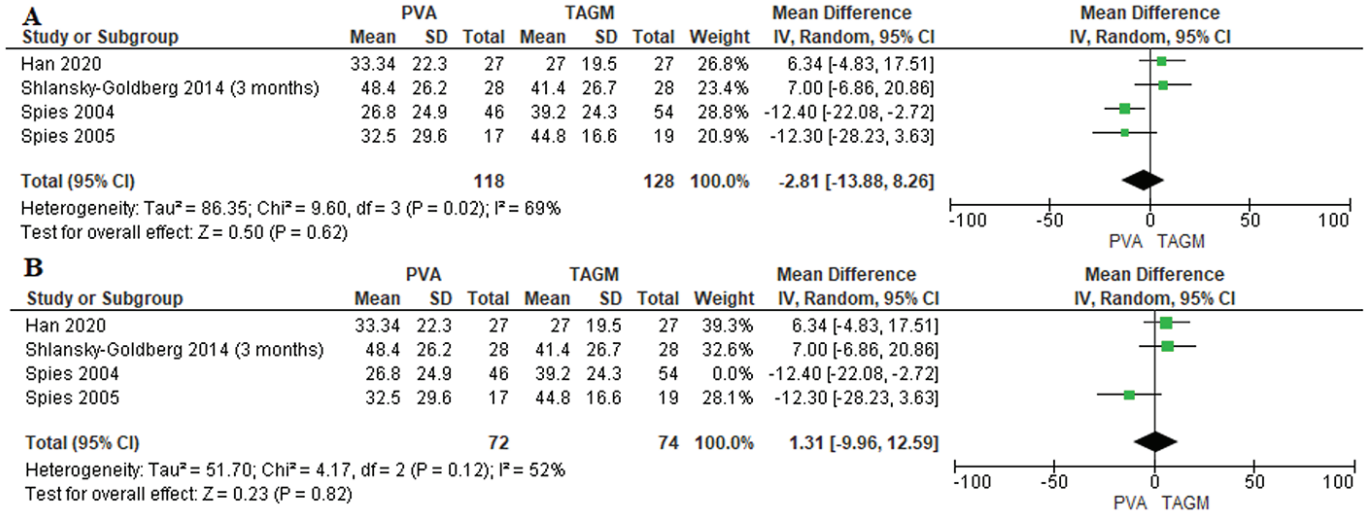

Figure 12. Shows the change of symptom severity score - Part A includes four studies[9,15,18,19] & Part B excludes Spies et al.[18]

PVA: Polyvinyl alcohol particles, TAGM: Tris-acryl gelatin embolization, CI: Confidence interval, SD: Stardard deviation

between the groups in the reduction of symptom severity, 90-99% infarction rate, complete infarction rate, minor, and major complications. This study has some limitations. They included data from Yu et al.[20] in the analysis of imaging-assessed uterine and fibroid changes. Yu et al.[20] used ultrasound while the remaining studies used MRI assessment.

The Fibroid Registry for Outcomes Data (FIBROID) was developed for women undergoing UAE in treating fibroids. They demonstrated that UAE was a reliable method yielding an overall improvement in the quality of life and long-term treatment from uterine fibroids. Additionally, their findings support the broad spectrum practice of this technique in such conditions by interventional radiologists, which is consistent with our results[33]. After approximately three decades of continuous clinical investigations and long-term follow-up of patients who underwent UAE from many previously published studies, UAE has shown promising results in short-term and long-term follow-up, which are similar to the results of conventional surgical intervention. Besides, almost all patients are fit for UAE. When performed by an experienced interventional radiologist, UAE will have the advantage of having a low-cost profile, early recovery, and early return to work. Thus, UAE should be considered as the first-line method in managing uterine leiomyomata[34].

Study Limitations

Our study has some limitations, such as the relatively low number of assessed patients, the inclusion of retrospective studies in our analysis, and the high risk of attrition bias among the included clinical trials. Therefore, in the future, more clinical trials with large sample sizes and long-term follow-up are needed to provide stronger evidence regarding the usage of different embolic agents in treating uterine fibroids. Additionally, we need more future studies that compare all available embolic agents to determine the best option regarding safety and efficacy.

Conclusion

To conclude, most UAE techniques show successful results in almost all patients with minimal side effects and very efficient outcomes. In our study, we suggest that both PVA and TAGM embolization agents are effective and safe modalities in treating patients with fibroids, with no significant variations of both agents in most outcomes. Interventional radiologists can choose the available and cheaper embolic agent to treat women with uterine leiomyoma.

Ethics

Ethics Committee Approval: This is a meta-analysis and systematic review of publicly available data and other materials. For systematic review and meta-analysis studies, the institutional review board (IRB) is exempted.

Informed Consent: Clinical trial registration and informed consent are not applicable.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.A.S., Concept: S.T., Design: S.T., A.A.S., Data Collection or Processing: A.A.S., Analysis or Interpretation: A.A.S., Literature Search: A.A.S., Writing: A.A.S., S.T.

Conflict of Interest: No conflict of interest was declared by the authors.

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