Original Article

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Efficacy of Transcatheter Arterial Embolization in Managing Rectus Sheath Hematoma: A Tertiary Single Center Results

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Abstract

Aim: Rectus sheath hematoma (RSH) is a rare but potentially life-threatening condition. This study aimed to evaluate the effectiveness of transcatheter arterial embolization (TAE) in the management of RSH by analyzing imaging features, embolization techniques, and clinical outcomes.

Methods: In this retrospective observational study, 22 patients with RSH who underwent TAE between June 2020 and June 2023 were included. Etiological factors, hematoma classification, angiographic findings, embolization materials, and clinical outcomes were analyzed. Laboratory values and transfusion requirements were compared before and after the procedure.

Results: The most common etiology was anticoagulation therapy (50%), followed by trauma (13.6%) and post-abdominal surgery (13.6%). A bleeding source was identified in 36.3% of patients on computed tomography angiography and 45.4% on digital subtraction angiography. Technical success was 100%, and clinical success was 90.9%. Post-embolization, transfusion requirements decreased significantly ($p<0.05$). Hemoglobin and hematocrit levels increased by 17.2% ($p=0.004$) and 20.7% ($p=0.001$), respectively. No significant difference was observed between Type 2 and Type 3 hematomas in terms of clinical and procedural outcomes.

Conclusion: TAE is a safe and highly effective treatment for RSH, leading to significant hemodynamic stabilization and reduced transfusion requirements. It should be considered a primary treatment option in patients with moderate to severe RSH, particularly those who are hemodynamically unstable.

Keywords: Rectus sheath hematoma, interventional radiology, embolization, epigastric artery

Introduction

Rectus sheath hematoma (RSH) is a rare but serious condition where there is bleeding in the covering of the rectus abdominis muscle, usually caused by a tear in the superior or inferior epigastric arteries or an injury to the muscle itself. Common predisposing factors include anticoagulant therapy, trauma, and conditions that increase intra-abdominal pressure, such as coughing, straining, or pregnancy. While the majority of RSH cases are self-limiting and managed conservatively, severe hemorrhage can lead to hemodynamic instability, necessitating urgent intervention (1,2). With the widespread use of anticoagulants and the aging population, the incidence of spontaneous RSH has been increasing. Cross-sectional imaging, particularly contrast-enhanced computed tomography (CT), plays a pivotal role in diagnosing RSH,

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assessing hematoma extent, and detecting active bleeding (3). In hemodynamically unstable patients or those with ongoing hemorrhage, endovascular approaches such as transcatheter arterial embolization (TAE) have emerged as safe and effective alternatives to surgery, offering high technical success with minimal invasiveness (4,5).

Although TAE has been widely adopted for managing spontaneous soft tissue hematomas, data specifically focusing on its efficacy in RSH remain limited, with most studies comprising small patient cohorts and heterogeneous bleeding etiologies (2,6). Moreover, the impact of embolization techniques, choice of embolic agents, and the predictive value of imaging findings on clinical outcomes are yet to be clearly defined in this subset of patients (7-9). We hypothesized that TAE achieves a highly effective and safe treatment modality for managing RSH with high technical and clinical success rates, regardless of hematoma type or the presence of angiographic active bleeding.

The primary aim of this study was to evaluate the imaging characteristics, embolization techniques, and clinical outcomes of patients with RSH who underwent TAE at our institution over a four-year period. By providing detailed procedural and clinical data, this study aims to contribute to the optimization of endovascular management strategies for RSH. This, in turn, is expected to facilitate timely intervention, reduce transfusion requirements, and improve patient outcomes in clinical practice.

Materials and Methods

Compliance with Ethical Standards

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the University of Health Sciences Turkey, Basaksehir Cam and Sakura City Hospital Ethics Committee (approval no.: 130, date: 24.07.2024). As this was a retrospective study based on anonymized data, the requirement for informed consent was waived by the ethics committee.

Study Population

In this retrospective observational study, medical records of patients diagnosed with RSH and treated with TAE in our department between June 2020 and June 2023 were reviewed. The patient selection process is summarized in Figure 1.

Inclusion Criteria

- Development of RSH during anticoagulation therapy.
- Iatrogenic RSH
- Decreased hemoglobin/hematocrit levels due to RSH, requiring blood transfusion.
- Age ≥18 years.
- Availability of medical records and cross-sectional imaging.

Exclusion Criteria

- Patients with RSH who did not undergo endovascular treatment and were managed conservatively.
- Unavailable medical records and cross-sectional imaging.
- Patients referred from an external center for the procedure who were lost to follow-up at our institution, with unavailable follow-up laboratory values and clinical data.
- Patients with multiple trauma where the primary bleeding site was outside the rectus sheath, such as in the spleen or liver.

Data Collection and Analysis

Clinical and radiological variables were recorded in a dedicated dataset, including age, RSH etiology (spontaneous, traumatic, post-endovascular transfemoral procedures, abdominal surgery, or anticoagulation-related causes), and laboratory values before and after embolization [hemoglobin, hematocrit, platelets, and international normalized ratio (INR)]. Additional variables

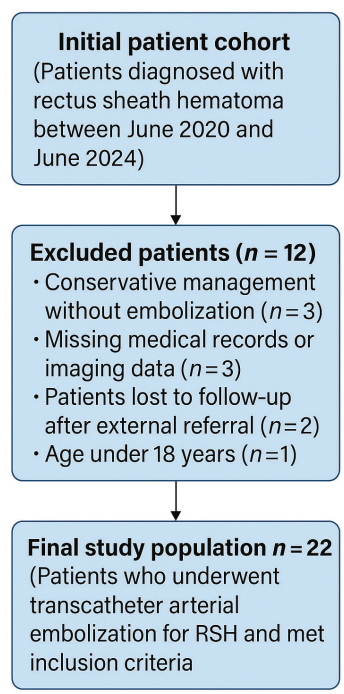

Figure 1. Flowchart of patient selection. Among 34 patients diagnosed with rectus sheath hematoma between June 2020 and June 2024, 12 patients were excluded due to conservative management, missing data, loss to follow-up, or age under 18 years. The final study population included 22 patients who underwent transcatheter arterial embolization

included the history of blood transfusion and the duration of hospital stay. Pre-embolization transfusion data were collected by counting the number of blood products administered within the 24 hours preceding embolization. Pre-embolization, hemodynamic parameters were assessed by recording the lowest hemoglobin level within this period. Similarly, post-embolization transfusion data were obtained by quantifying the number of blood products given within 24 hours after embolization, while post-embolization hemodynamic values were determined based on the lowest hemoglobin level recorded during the same timeframe.

RSH Diagnosis and Classification

The initial diagnosis of RSH was made using ultrasonography, while CT and CT angiography (CTA) provided a more detailed evaluation, enabling the assessment of retroperitoneal and extraperitoneal involvement (2,10).

Patients with RSH were classified according to the system proposed by Berná et al. (11), which categorizes hematomas based on their extent and severity.

- Type 1 RSH: Hematoma confined within the rectus muscle with minimal bleeding.
- Type 2 RSH: Hematoma extending within the rectus muscle with moderate hemorrhage.
- Type 3 RSH: Acute bleeding that extends beyond the muscle into surrounding tissues.

This classification was applied in the present study to evaluate and compare treatment outcomes among patient groups.

Angiography and TAE Procedure

Digital subtraction angiography (DSA) was performed under local anesthesia via femoral artery access on the affected side. A 5F introducer sheath was placed under ultrasound guidance, followed by catheterization of the inferior and/or superior epigastric artery using a 4F or 5F Berenstein Type 1 or 2 catheter (Cordis, Miami Lakes, FL, USA). Upon identification of a bleeding focus, selective catheterization and embolization were performed using a 2.4F coaxial microcatheter (Progreat™ Micro Catheter System; Terumo, Tokyo, Japan). Embolization was carried out using either coils (Concerto Helix Detachable Coil System, Medtronic Inc., Minneapolis, USA) or N-butyl cyanoacrylate (NBCA) (Histoacryl®, B. Braun, Tuttlingen, Germany). N-butyl cyanoacrylate embolization was performed using a mixture of NBCA and Lipiodol in a 1:6 ratio. For coil embolization, detachable coils were selected based on the diameter of the target vessel to ensure complete occlusion.

In the absence of active extravasation, empirical embolization was performed targeting the arteries supplying the hematoma site. The embolization was considered technically successful if there was complete occlusion of the target vessel(s) without residual filling on post-embolization angiography. Clinical success was determined by hemodynamic stabilization and an increase in hemoglobin levels (≥1 g/dL) within the first 24 hours following the embolization.

Statistical Analysis

All data were analyzed using SPSS Statistics Version 25.0 (SPSS, Chicago, IL, USA). The normality of numerical variables was assessed using the Kolmogorov-Smirnov test and Q-Q plots. Descriptive statistics were reported as mean ± standard deviation. Comparative statistical analyses were performed using the Mann-Whitney U test for non-normally distributed numerical variables and the Wilcoxon signed-rank test for paired data comparisons. A p-value of less than 0.05 was considered statistically significant.

Results

Etiology and Imaging Findings

A total of 22 patients (7 male and 15 female) with a mean age of 63±15.23 years met the inclusion criteria and underwent endovascular embolization in our department. The clinical and laboratory characteristics of these patients are summarized in Table 1. A sample patient is depicted in Figure 2.

Table 1. Demographics, etiology, imaging findings, embolization details of patients with rectus sheath hematoma

Patients (n)	22
Age (years)	63±15.23
Male/female ratio	7/15
Etiology of RSH n (%)	
Anticoagulation therapy Penetrating trauma Spontaneous Post-abdominal surgery Femoral endovascular procedures	11 (50%) 3 (13.6%) 3 (13.6%) 3 (13.6%) 2 (9.1%)
Laterality (Side) n (%)	
Right Left Bilateral	9 (41.9%) 11(50%) 2 (9.1%)
CT angiography findings	
Contrast extravasation Pseudoaneurysms of the inferior epigastric artery	2 (9.1%) 6 (27.2%)
Angiography findings	
Contrast extravasation Pseudoaneurysms of the inferior epigastric artery	4 (18.2%) 6 (27.2%)
Embolization material	
Coil N-butyl cyanoacrylate	18 (81.8%) 4 (18.2)
Procedure duration time (minutes) (mean+SD)	38.45±12.22
Duration of hospital stay (days) (mean+SD)	13.64±12.21

RSH: Rectus sheath hematoma, CT: Computed tomography, SD: Standard deviation

TAE Procedure and Technical Findings

The TAE procedure was performed by radiologists with at least four years of experience in vascular interventional radiology. During the procedure, pseudoaneurysms of the inferior epigastric artery were detected in 4 patients (18.2%), while active extravasation was observed in 6 patients (27.2%). In the remaining 12 patients (54.6%), no definitive bleeding focus was identified. In cases where a bleeding focus was detected, the bleeding inferior or superior epigastric artery was embolized. Technical success was achieved in 100% of cases, with complete occlusion of the target vessels confirmed on post-procedural angiography.

Transfusion Requirements and Hematologic Parameters

Prior to TAE, the mean packed red blood cell (PRBC) transfusion requirement was 2.27±2.27 units, and the fresh frozen plasma (FFP) transfusion requirement was 1.14±1.32 units. Post-embolization, these values significantly decreased to 1.09±1.15 units for PRBC (p=0.007) and 0.32±0.72 units for FFP (p=0.002), reflecting a 52% and 72% reduction in transfusion requirements, respectively.

The mean hemoglobin level increased from 8.66±2.32 g/dL pre-embolization to 10.15±2.17 g/dL post-embolization, corresponding to a 17.2% increase (p=0.004). Similarly, the mean hematocrit level rose from 26.02±6.44% to 31.4±6.34%, reflecting a 20.7% increase (p=0.001). The mean platelet count increased from 319.95±258.65×10^9/L to 370.82±287.27×10^9/L, corresponding to a 15.9% increase (p=0.023). Conversely, the INR decreased slightly from 1.51±1.02 to 1.43±0.7, but this change was not statistically significant (p=0.51) (Table 2). In two patients (9.1%), hemoglobin levels dropped within 24 hours post-embolization, requiring additional transfusion. Despite this, clinical success was achieved in 90.9% of cases with hemodynamic stabilization and hemoglobin improvement. The mean hospital stay was 13.64±12.21 days.

Procedure-Related Complications and Mortality

The procedure was well tolerated by nearly all patients, with no major complications observed. The overall complication rate was 9.1% (n=2). One patient developed a groin access site hematoma, which was managed conservatively. Another patient required additional drainage due to an infected hematoma. Both patients showed improvement during follow-up.

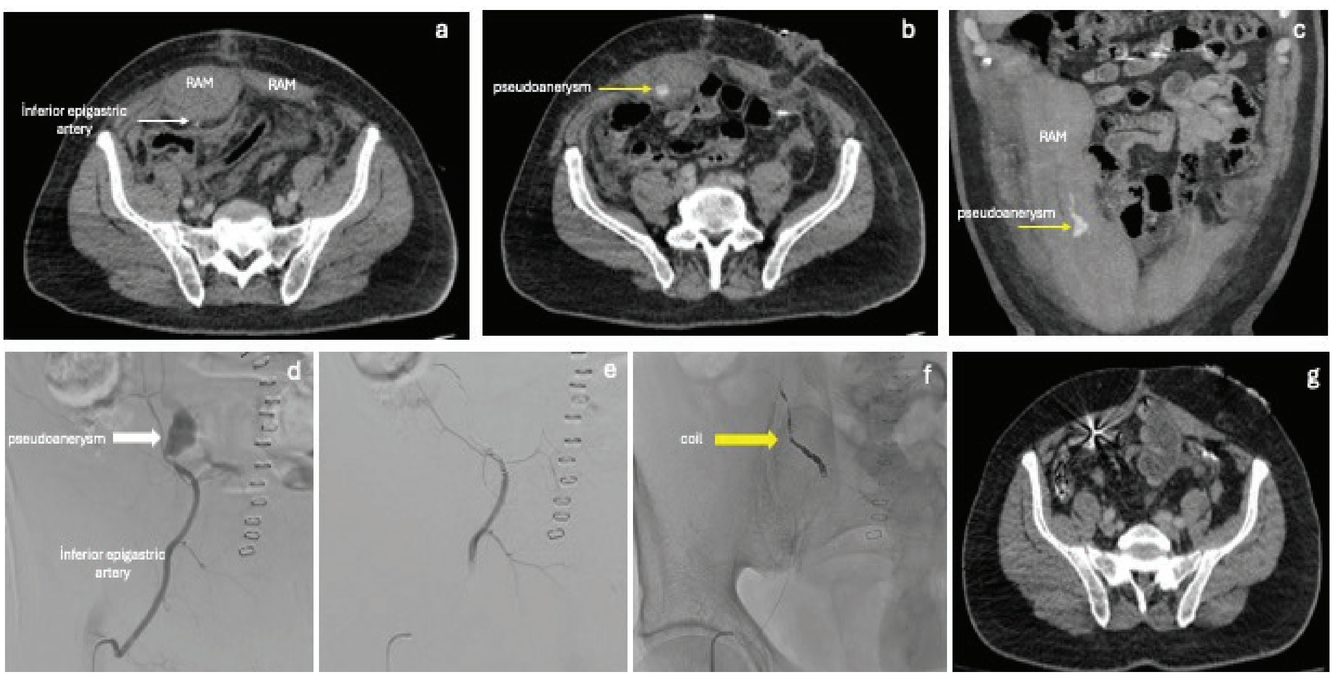

Figure 2. A 65-year-old male patient who developed right-sided RSH after surgery for colorectal cancer. **(a, b)** Axial and **(c)** coronal CT angiography images demonstrating the inferior epigastric artery (thin white arrow), a pseudoaneurysm (thin yellow arrows), and the presence of RSH, **(d)** selective angiography of the inferior epigastric artery, showing pseudoaneurysm filling (thick white arrow), **(e)** post-embolization DSA, confirming successful coil embolization with no residual pseudoaneurysm filling, **(f)** non-subtracted fluoroscopic image, displaying embolization coils (thick yellow arrow), **(g)** follow-up contrast-enhanced CT one week after the procedure, showing metallic artifact from the coils and resolution of the hematoma

RSH: Rectus sheath hematoma, RAM: Rectus abdominis muscle, DSA: Digital subtraction angiography

However, one patient (4.5%) died 17 days after the procedure due to underlying comorbidities and disease progression. This mortality was not directly related to the embolization procedure.

Hematoma Classification and Outcomes

According to the Berná et al. (11) classification, 10 patients had type 2 hematomas, while 12 patients had type 3 hematomas. The comparison of hematoma size, pre- and post-procedural transfusion requirements, hemoglobin, hematocrit, platelet count, INR levels, procedure duration, and hospital stay did not reveal any statistically significant differences among the classified groups (Table 3).

Discussion

Recognizing and appropriately managing RSH is crucial, as it is a rare but potentially life-threatening condition. While many cases can be treated conservatively, patients with hemodynamic instability or progressive hemorrhage often necessitate interventional procedures such as TAE. In recent years, TAE has emerged as a minimally invasive and effective technique for controlling RSH-related bleeding, reducing transfusion requirements, and stabilizing patients. Our study adds to the growing body of evidence by evaluating the imaging characteristics, procedural details, and clinical outcomes of patients treated with embolization over a four-year period.

Table 2. Pre- and post-embolization changes in transfusion requirements and laboratory values

Transfusion requirements and laboratory parameters	Pre-embolization	Post-embolization	Percent change (%)	p-value
Transfusions (mean+SD)				
Packed red blood cells (n)	2.27±2.27	1.09±1.15	-52	0.007
Fresh frozen plasma (n)	1.14±1.32	0.32±0.72	-72	0.002
Laboratory values				
Hemoglobin level (g/dL)	8.66±2.32	10.15±2.17	+17.2	0.004
Hematocrit level (%)	26.02±6.44	31.4±6.34	+20.7	0.001
Platelet (10^9/L)	319.95±258.65	370.82±287.27	+15.9	0.023
INR	1.51±1.02	1.43±0.7	-5.3	0.51

SD: Standard deviation, INR: International normalized ratio

Table 3. Comparison of clinical and procedural outcomes between Type 2 and Type 3 hematomas

Laboratory and clinical parameters	Type 2 hematoma n=10	Type 3 hematoma n=12	p-value
Pre-embolization (mean+SD)			
Packed red blood cells (n)	2.5±3.17	1.92±2.45	0.522
Fresh frozen plasma (n)	1.2±1.62	0.92±1.62	0.862
Hemoglobin level (g/dL)	9.02±2.27	8.66±2.32	0.391
Hematocrit level (%)	27.21±6.32	26.02±6.45	0.248
Platelet (10^9/L)	247.2±68.53	319.95±258.65	0.488
INR	1.85±1.44	1.38±0.67	0.245
Post-embolization (mean+SD)			
Packed red blood cells (n)	0.9±1.1	1.17±1.60	0.509
Fresh frozen plasma (n)	0.4±0.97	0.5±0.79	0.928
Hemoglobin level (g/dL)	10.26±2.57	10.15±2.17	0.391
Hematocrit level (%)	31.29±7.28	31.4±6.34	0.998
Platelet (10^9/L)	312.1±138.73	370.82±287.27	0.668
INR	1.85±1.44	1.51±1.02	0.143
Procedure duration time (minutes) (mean+SD)	41.5±15.01	38.45±12.22	0.129
Duration of hospital stay (days) (mean+SD)	14.6±11.98	13.64±12.21	0.321

SD: Standard deviation, INR: International normalized ratio

Notably, we observed a substantial reduction in blood product requirements following embolization, with PRBC transfusions decreasing by approximately 52% and FFP transfusions decreasing by nearly 72%. These improvements were accompanied by significant increases in hemoglobin and hematocrit levels within 24 hours, indicating rapid hemodynamic stabilization achieved through TAE in our patient cohort. Interestingly, a definitive bleeding artery could not be identified in more than half of the cases. Active contrast extravasation was detected in only 36.3% of patients on CTA and 45.5% on DSA, which is lower than the detection rates commonly reported in the literature. In the literature, the detection rate of active bleeding on CTA varies widely, ranging from 47% to 93%, while DSA has been reported to identify active bleeding in 70% to 85% of cases (7,12-14). In clinical practice, our findings emphasize that a negative CTA does not exclude ongoing bleeding, underscoring the importance of clinical evaluation in determining the need for embolization. In cases without visible extravasation, we frequently performed empirical embolization of the epigastric arteries, which proved to be a highly effective strategy. Recent evidence supports this approach, with a 2024 meta-analysis showing no significant difference in rebleeding rates between empirical and targeted TAE techniques (3).

Rectus sheath hematoma can be life-threatening, especially in vulnerable patients, with recent series reporting early mortality rates of 24-30% despite intervention (4). In this context, our findings demonstrate that prompt TAE provides highly effective hemorrhage control in RSH. In this study, we achieved a 100% technical success rate and a 90.9% clinical success rate, with no hemorrhage-related deaths. These results are consistent with existing literature, where reported technical success rates range from 96% to 100%, and clinical success rates vary between 65% and 93% (1,12-14). The high success rate observed in our study underscores the critical role of TAE in the management of severe RSH and aligns with the positive outcomes reported in contemporary series of spontaneous soft-tissue hemorrhages. However, the variability in clinical success criteria across studies complicates direct comparisons, highlighting the need for standardized definitions to improve consistency in future research.

The selection of embolic agents in RSH management is primarily guided by angiographic findings and operator experience. Coils are often preferred due to their controlled deployment and lower risk of non-target embolization, particularly when selective catheterization of the bleeding vessel is feasible. Conversely, in cases with diffuse or poorly accessible bleeding, NBCA provides the advantage of rapid and effective vascular occlusion. In our series, both coils and NBCA were used successfully, with no procedure-related complications observed for either material (15). These findings align with recent studies demonstrating the efficacy and safety of NBCA in emergency embolization scenarios. For instance, a large 2025 series evaluating 113 acute hemorrhage cases reported an 82% clinical success rate with NBCA, without major complications, underscoring its value as a reliable embolic agent when applied judiciously (5). Thus, while coils remain the preferred choice in selective embolization, liquid agents like NBCA are indispensable in complex bleeding patterns, offering complementary strategies for achieving hemostasis.

Berná et al. (11) proposed a diagnostic classification for RSH based on CT findings. Type 1 hematomas are mild and do not require hospitalization, while Type 2 hematomas are moderate and necessitate hospitalization. Type 3 hematomas are more severe, typically occurring in patients on anticoagulant therapy and often requiring blood transfusion (16). In the literature, there is no study comparing the endovascular treatment outcomes of Type 2 and Type 3 hematomas. In this study, we found no significant differences in laboratory value changes or blood product requirements between patients with Type 2 and Type 3 RSH who underwent endovascular treatment.

Study Limitations

Several limitations of this study should be acknowledged. Our findings, based on a retrospective single-center analysis, suggest that our findings may not be generalizable to broader populations. Additionally, we did not compare embolization outcomes with alternative management strategies, such as conservative treatment or surgical intervention, which limits our ability to draw definitive conclusions regarding the superiority of TAE. Another limitation is the relatively small sample size, which may reduce the statistical power of our analysis, particularly in subgroup comparisons. Furthermore, long-term follow-up data on recurrence rates were not available, which could have provided additional insights into the durability of TAE outcomes. Despite these limitations, this study has notable strengths. It represents a consecutive series of patients treated in a high-volume tertiary center, ensuring a standardized treatment protocol and homogeneous patient management. The study provides detailed procedural data, including embolization techniques and materials, and offers valuable insights into the effectiveness of TAE in a real-world clinical setting. Furthermore, the systematic evaluation of pre- and post-procedural hematologic parameters strengthens the reliability of the clinical outcomes reported.

Conclusion

This study demonstrates that TAE is an effective and safe treatment modality for RSH. Particularly in patients with hemodynamic instability or those unresponsive to conservative management, TAE reduces transfusion requirements and contributes to clinical stabilization. Our findings support the consideration of TAE as an important therapeutic option within the management algorithms of RSH.

Ethics

Ethics Committee Approval: Institutional review board approval was obtained from the Basaksehir Cam and Sakura City Hospital Ethics Committee (approval no.: 130, date: 24.07.2024).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: C.E., T.G., M.C., A.D., M.F.A., O.T., Concept: C.E., T.G., M.H.T., M.C., M.F.A., I.N.M., N.O.K., Design: C.E., M.H.T., A.D., O.T., I.N.M., N.O.K., Data Collection or Processing: C.E., Z.O., M.C., MF.A., Analysis or Interpretation: C.E., T.G., Z.O., M.C., A.D., M.F.A., I.N.M., N.O.K., Literature Search: C.E., Z.O., M.H.T., A.D., O.T., I.N.M., N.O.K., Writing: C.E., T.G., M.H.T, O.T.

Conflict of Interest: The authors declare that they have no conflict of interest

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