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Transcatheter Arterial Embolization of Spontaneous Soft Tissue Hematomas: A Systematic Review

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Abstract

Background Severe spontaneous soft tissue hematomas (SSTH) are usually treated with transcatheter arterial embolization (TAE) although only limited retrospective studies exist evaluating this treatment option. The aim of this study was to systematically assess the efficacy and safety of TAE for the management of SSTH.

Methods Medline, EMBASE, PubMed and Cochrane Library were searched from inception to July 2017 using MeSH headings and a combination of keywords. Eligibility was restricted to original studies with patients suffering from SSTH treated with TAE. Patients with traumatic hematomas or who were treated with solely conservative or surgical management were excluded. For each publication, clinical success based on the control of the bleed, rebleeding rates and complications (including mortality) was collected, as well as technical details.

Results Sixty-three studies met the inclusion criteria, with an aggregate total of 267 patients. Follow-up extended from 1 day to 10 years. Bleeding was mainly localized to the iliopsoas (n = 113/267, 42.3%) and anterior abdominal wall (n = 145/266, 54.7%). When information was available, 81.0% (n = 158/195) of patients were on anticoagulant therapy prior to the bleeding episode. Initial stabilization with control of the bleed was obtained in 93.1% (n = 242 patients, n = 60 studies). The most common embolic materials were coils (n = 129, 54.4%). Rebleeding was reported in 25 patients (9.4%). Only two embolization complications were reported (0.7%). The 30-day mortality was 22.7% (n = 42/1857).

Conclusion TAE represents a safe and effective procedure in the management of SSTH. We present a management algorithm based on these data, but further studies are needed to address the knowledge gap.

Keywords Interventional radiology · Embolization · Abdominal wall hemorrhage · Anticoagulant therapy · Psoas hemorrhage

Introduction

Spontaneous soft tissue hematomas (SSTH) are potentially serious complications of anticoagulation therapy, with increasing reports noted in recent years [1]. With the increased number of patients undergoing anticoagulant

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therapy, the incidence is expected to increase [2]. The rectus sheath and the psoas muscles represent the most common sites of SSTH, and computed tomography (CT) is the best technique to make the diagnosis and to assess the extent of hemorrhage [3]. CT angiography may also be performed at the same time.

Most etiological hypotheses incriminate microvascular atherosclerosis that increases the fragility of vessels coupled with micro-traumatic episodes such as cough, causing muscular tears [4]. Microvascular atherosclerosis affects the walls and inner lining of tiny vessels that may not be calcified but present increased risks of occlusion and tears.

When the bleeding occurs in the abdominal wall musculature, it can be contained to some extent by the surrounding fascia and muscle groups. The resulting hematomas are usually self-limited due to tamponade by surrounding structures [3]. Conservative management is often sufficient and remains the standard of care in hemodynamically stable patients. However, progressive, uncontrolled bleeding can lead to significant hemodynamic instability in some patients and may also lead to compression of neuronal structures and skin necrosis. A recent study reported a mortality rate of 30% in cases of iliopsoas hematomas [4]. Interventional management is favored for unstable patients, while surgery may be indicated to evacuate a compressive hematoma. However, ligation of the bleeding vessels at surgery may be challenging in a hemodynamically unstable patient and is no longer considered the standard of care in most situations except in case of failed embolization or for surgical drainage of the hematoma [5]. Percutaneous trans-arterial embolization (TAE) has gained acceptance in the past years, with an increasing number of published case report and recent case series [6–10]. Some studies have suggested management algorithms for SSTH based on clinical experience [9, 11]. However, there are currently no accepted guidelines stratifying therapy based on different clinical scenarios, and no predictive factors have been identified to optimize tailored management.

Therefore, the aim of this study is to systematically search the literature for determinants of efficacy and safety of TAE in SSTH. The secondary aim was to characterize embolization materials used, compare CTA and DSA findings and document rates of recurrence and mortality of this potentially lethal condition.

Methods

This systematic review was conducted using a pre-specified protocol and was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist [12]. A systematic search of the Medline (via Ovid), EMBASE (via Ovid), PubMed and Cochrane Library databases from inception to July 2017 was performed. Keywords and Medical Subject Headings (MeSH) terms were established with the help of an academic librarian. The combination of the following keywords was used to execute the search: “embolization”, “spontaneous”, “hematoma”, “retroperitoneum” and “muscle”. Medical Subject Headings (MeSH) terms and EMBASE Subject Headings (EMTREE) terms were used where applicable (supplemental Tables 1, 2, 3 and 4). Moreover, published reviews, case reports and case series were manually searched for additional studies.

Study Selection

After exclusion of duplicates, the titles and abstracts of publications identified by the database search were screened for studies that potentially met the inclusion criteria. This screening was independently performed by two of the authors (LT and OB). A third reviewer resolved all disagreements. Full-text publications were reviewed to determine final eligibility. Eligibility was restricted to original studies with patients suffering from SSTH treated with TAE. Patients with traumatic hematomas or who were treated with solely conservative or surgical management were excluded from this study. Only articles published in English were included in our study. Commentaries, abstract, review articles and conference presentations were excluded. Quality assessment for the included studies was performed using the Quality Rating Scheme developed by the Oxford Centre for Evidence-based Medicine (supplemental Table 5). For each study, two reviewers independently assigned scores of 1–5. Disagreements were resolved by consensus or a third reviewer (AD). All eligible studies were included in this systematic review regardless of their assessed quality.

Data Extraction

For each included study, data on patient characteristics were extracted on a case by case basis when possible. Extracted information includes age, sex, location of bleeding, anticoagulation medications, lowest blood pressure, coagulation profile, blood and plasma transfusions and hemodynamic state. Data on diagnostic studies were also collected for each patient when available including computed tomography and angiographic findings. The following technical data and outcomes were extracted: embolized artery, embolization material, result of embolization based on technical success (embolization of the target artery), clinical success (control of bleed: hemodynamic stabilization or stop of hemoglobin drop), rebleeding, complications, survival and cause of death, if

applicable. To perform the analysis on patients with multiple bleeding locations, the bleeding locations were compiled individually and the same patient was counted more than once if bleeding occurred in several locations. Duration of follow-up was also noted, if available.

Results

The systematic search identified 1358 potentially eligible studies, in addition to 4 publications found through manual searching of references. There were 359 duplicates while 999 articles were screened by abstract and title. This screening left 83 publications for full-text review, of which 59 met our inclusion criteria. At this stage, the 4 publications from the manual searching were added. A total of 63 studies that studied patients who had undergone TAE for SSTH were identified for inclusion (Fig. 1) [3, 7–10, 13–69].

Study and Patients Characteristics (Table 1)

The 63 included publications reported a total of 267 patients who were treated by TAE for SSTH. Study sample size ranged from one (N = 44 studies) to 42 patients, with only 6 studies including more than 10 consecutive patients [3, 6–10]. No prospective study was found. Only one study specifically compared embolization to conservative management [25]. Overall, studies had a high risk of bias, as assessed by the Quality Rating Scheme from the Oxford Centre for Evidence-based Medicine (supplemental Table 5).The main outcome of all studies was survival with a follow-up period ranging from 1 day to 10 years. Indication for TAE was mainly hemodynamic instability and failure of medical management (n = 212/267, patients, 79.4%).

Mean age of patients was 68 years (range 19–93 years), with a female predominance (n = 163/267, 61.0%). The localization of the SSTH was mainly in the iliopsoas muscle (n = 113 patients, 42.3%) and the rectus sheath (n = 146 patients, 54.7%). Other less common locations included the oblique muscle (n = 11 patients, 4.1%), the thigh (n = 9 patients, 3.4%) and the gluteal region (n = 1 patient, 0.4%).

Thirty-six-patients were not under anticoagulation therapy. The anticoagulant agent was reported in 121 out of the 140 patients where anticoagulation status was presented (86.4%, with data missing in 127 patients). Specific methods of anticoagulation therapy reversal were reported in 59 patients (48.8%). The indications for anticoagulant therapy were mainly atrial fibrillation (22.9%), presence of a prosthetic heart valve (14.3%), deep venous thrombosis (10.7%) and pulmonary embolism (7.9%). For the 91 remaining patients, the anticoagulation status was not

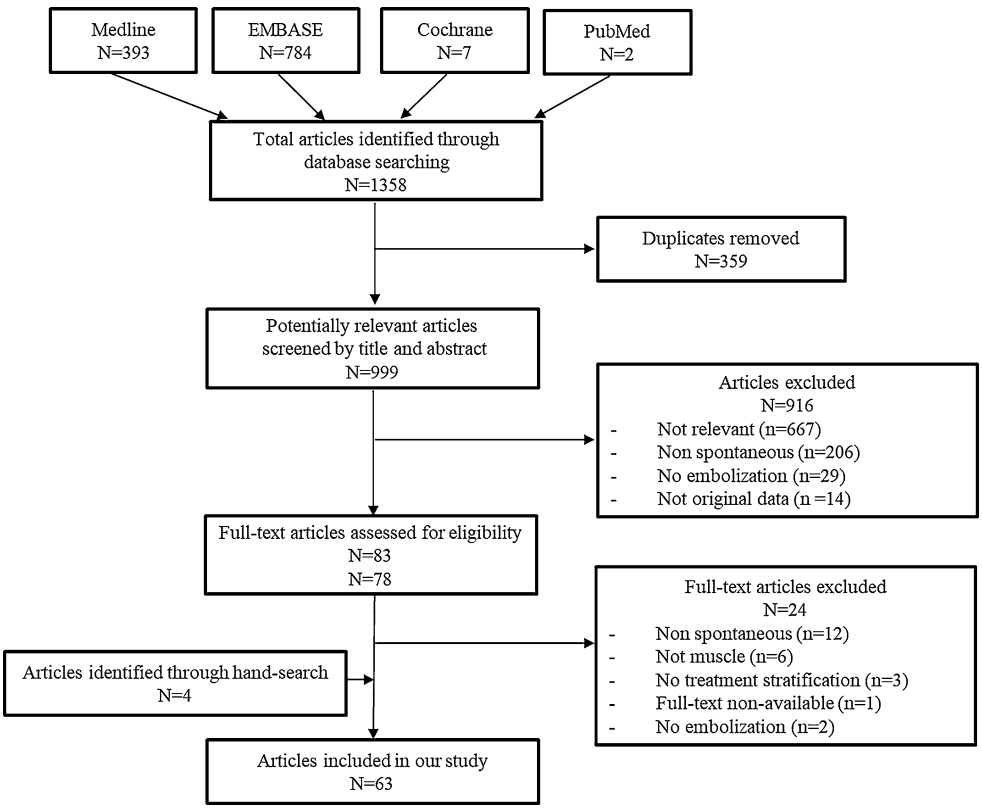

Fig. 1 PRISMA flow diagram

Table 1 Study and patient characteristics

Number of studies/patients	63/267
Retrospective studies of more than 4 consecutive patients	10/199
Cases reports (≤ 4 patents)	53/68
Number of patients per study (range)	1–42
Follow-up (range)	1 day–10 years
Mean age (mean, [range])	68 years [19–93]
Female	163/267 (61.0%)
Patients on anticoagulants	157/194 (80.9%)
Indication for anticoagulation	
Atrial fibrillation	32 (22.9%)
Deep venous thrombosis	15 (10.7%)
Valve replacement/pathology	20 (14.3%)
Pulmonary embolism	11 (7.9%)
Anticoagulation treatment (at presentation)	
Heparin	74 (64.9%)
Fondaparinux	4 (3.5%)
Warfarin	24 (21.1%)
Acenocoumarol	11 (9.6%)
Reported anticoagulation reversal	58/121 (47.9%)

reported. Hemodynamic status was not reported in 103 patients. Hemodynamic instability was clearly reported in 109 patients. The remaining 55 patients were considered as hemodynamically stable.

Primary Efficacy

Overall, clinical success (hemodynamic stabilization or stop of hemoglobin drop) was achieved in 93.1% (n = 242 patients, N = 60 studies). After excluding case reports (≤ 4 patients), the rate remained similar with a success rate of 94.3% (n = 183 patients, N = 9 studies). The overall mortality rate was 22.8% (n = 61/267). Excluding the case reports (≤ 4 patients), the morality rate reported remained the same at 23.1% (46/199 patients, N = 10 studies) during the follow-up period. In cohort studies, the mortality rate was estimated at 30 days after TAE [3, 6, 7, 9]. Globally, among 185 patients for whom time to death was available, 42 patients (22.7%) died within the 30 days after TAE. However, some studies reported non-standardized follow-up ranging from 1 to 70 days, and sometimes in years [8]. The main causes of mortality across studies were multi-organ failure, cardiogenic shock and secondary infection.

Recurrence of Bleeding

Reported recurrence rate was 9.4% (n = 25 patients, N = 9 studies) (Table 2). After excluding case reports, the reported recurrence rate was 10.1% (20/199 patients). The localization of recurrence was reported in only 9 patients and was the same as the initial localization in 3. The anticoagulation status was known in 14 of these patients, with 92.9% (n = 13/14) of them being anticoagulated. In 20/25 (80%) of the patients who had recurrence, reembolization was attempted and the patient was stabilized in 75.0% (n = 15/20). Three patients required a third intervention due to unsuccessful second intervention and were stabilized after that third intervention. Among patients who had recurrence, the reported mortality rate was 50% (n = 8/16 patients; mortality rate not reported in the 9 remaining patients). Mortality follow-up ranged from 1 day to 6 years between studies.

Complications

Only two complications were reported in two patients from different studies (0.7%). The first one was a non-targeted embolization into a branch of the deep femoral artery, and the second was a retrograde dissection of the external iliac artery. Symptoms related to the non-targeted embolization were not detailed.

Active Bleeding on CTA and DSA

Among patients who were known to have undergone CT scan prior to embolization (n = 245/267), the results of the CTA were reported in 132/245 patients (53.9%). However, a bleeding artery was precisely identified and suspected in only 47.7% of patients (n = 63). The location of the suspected artery was primarily in the inferior epigastric (n = 27), lumbar (n = 18), deep circumflex iliac (n = 6) and iliolumbar arteries (n = 3) (Table 3). In 113/267

Table 2 Recurrence after TAE in SSTH

Patient no	Artery responsible for rebleeding	Same as original bleeding artery	Reembolization attempt	Stabilization after 2nd embolization	3rd embolization attempt	Outcome
1	Left DCIA	No	Yes	Yes	No	Survival
2	NR	–	No	–	No	Death
3	Right CF	No	No	–	No	Death
4	Left SG	No	Yes	Yes	No	Survival
5	Right 2nd, 3rd, 4th and 5th LA	Yes	Yes	Yes	No	Survival
6	NR	–	Yes	Yes	No	Death
7	Left 4th LA	Yes	Yes	Yes	No	Death
8	NR	–	Yes	Yes	No	Death
9	Left IMA, left IEA and left DCIA	No	Yes	Yes	No	Survival
10	NR	–	No	–	No	Survival
11	Collateral supply to IEA	No	Yes	Yes	No	Survival
12	NR	–	No	–	No	Death
13	Left 12th IA	Yes	Yes	No	No	Death
14	Left LA[a]	No	Yes	Yes	No	Survival
15	NR	–	Yes	No	No	Death
16	NR	–	Yes	Yes	No	NR
17	NR	–	Yes	Yes	No	NR
18	NR	–	Yes	Yes	No	NR
19	NR	–	Yes	Yes	No	NR
20	NR	–	Yes	Yes	No	NR
21	NR	–	Yes	No	Yes	NR
22	NR	–	Yes	No	Yes	NR
23	NR	–	No	–	No	Survival
24	NR	–	Yes	Yes	No	NR
25	NR	–	Yes	No	Yes	NR

CF common femoral, *DCIA* deep circumflex iliac artery, *IA* intercostal artery, *IEA* inferior epigastric artery, *IMA* internal mammary artery, *LA* lumbar artery, *SG* superior gluteal, *SSTH* spontaneous soft tissue hematoma, *TAE* transcatheter arterial embolization, *NR* not reported

[a]Spinal level non-specified

Table 3 Bleeding arteries on CTA and DSA

Artery affected	Number of arteries suspected on CTA	Number of arteries identified on DSA
Inferior epigastric	27	110
Lumbar	18	93
Deep iliac circumflex	6	31
Iliolumbar	3	19

One patient may have several bleeding arteries

CTA computed tomography angiography, *DSA* digital substraction angiography

patients, CTA was performed but results were not reported. Among the 267 patients, 232 were reported recently (after 2006) when multi-slice CT was widespread. Among these patients, active bleeding on CT was not reported in 101 patients, and the target vessel was clearly identified in 56/131 patients (42.7%).

Active bleeding was reported in 85.6% of patients (n = 220/257, data not reported in 10 patients) during DSA. In the remaining 37 patients, no active bleeding was identified and empiric embolization was performed based on previous imaging, clinical presentation, and localization of hematoma and/or the clinician's experience.

In the patients where CTA and DSA could be compared (n = 45), imaging results were concordant according to the origin of bleeding in 38/45 patients (84.4%). Moreover, when both imaging modalities were concordant, DSA was able to identify additional bleeding vessels in 23.7% (n = 9/38) of cases which were then embolized.

Fifty-six patients were described as stable at the time of TAE, but active bleeding was reported on CECT only in 23 patients (CECT findings not reported in 24 patients). However, active bleeding on DSA was reported in 45 patients. These data suggest that active bleeding on CECT despite hemodynamic stability should be included in future management algorithms.

Embolization Procedure

The materials used in TAE were described in 238/267 patients (89.1%) and included coils alone (n = 73, 30.7%), glue alone (n = 43, 18.1%), gelfoam alone (n = 39, 16.4%) and microparticles alone (n = 14, 6.0%). Several material combinations were also reported, including coils and gelfoam (n = 31, 13.0%) as well as coils and microparticles (n = 29, 12.2%). Overall, coils were the most commonly used material (n = 129, 54.2%) for embolization.

In 260 patients, the vessels embolized were reported. The treated arteries were mainly the inferior epigastric (n = 110, 42.3%) and deep circumflex iliac arteries (n = 31, 11.9%) in case of abdominal wall bleeding, and lumbar arteries (n = 93, 35.8%) in case of retroperitoneal hemorrhage (Table 3). In cases specifying the level of lumbar artery embolization, 21 patients required treatment in two or more lumbar vessels, the majority affecting L3, L4 and/or L5. Most case series did not precisely report which arteries were embolized in each patient, but simply reported the general status of the bleed.

In the 25 patients with recurrence, the initial material used was stated only in 14 patients. The embolization material used was gelfoam alone (n = 5, 35.7%), gelfoam with coils (n = 3, 21.4%), coils alone (n = 4, 28.6%) and glue alone (n = 2, 14.3%).

Discussion

The results of this study clearly demonstrate the safety and efficacy of TAE for the treatment for SSTH with a primary efficacy rate of 93.1% for initial stabilization, and only two complications (0.7%). The all-cause 30-day mortality rate of 22.7% obtained in the present systematic review of selected patients confirms previous findings that SSTH can be a life-threatening condition with a high mortality rate.

So far, there are no reports of SSTH occurring in any patient receiving non-vitamin K antagonist oral anticoagulants; however, these treatments are relatively new. However, they have demonstrated lower rates of bleeding than classical antivitamin K treatments [70]. Previous studies have identified multiple risk factors associated with SSTH, principally chronic renal insufficiency, dialysis, heart failure, hepatic insufficiency, coagulation disorders [11]. The exact pathogenesis is complex and still not perfectly understood, but the disturbance of the physiological coagulation pathways and micro-angiopathy in addition to preexisting arteriosclerosis could in part explain the predisposition to bleeding [71, 72]. A superimposed abdominal strain ranging from simple coughing to severe asthmatic reaction could be the triggering event of the bleed. Platelet aggregation inhibition is probably also risk factors, especially with high-dose treatments and clopidogrel [73].

No prospective study has evaluated TAE versus conservative management. Such a trial at this stage of clinical practice, enrolling patients with severe bleeding or hemodynamic instability requiring repeated transfusion would be difficult and non-ethical to conduct. The reported data, although of low methodological quality, argue for an efficacy of TAE in these patients. However, in patients with a less severe clinical presentation, who are stable or do not require transfusion, the efficacy of TAE versus optimal non-interventional management is not clear, indicating the need for a randomized trial.

There have only been low rates of reported complications. There is inherent bias among case reports and retrospective studies in reporting complications such as pain, cutaneous or muscular ischemia, as they rarely lead to additional interventions and are difficult to identify retrospectively in medical charts.

This review confirms a high rate of recurrence (9.4%). Interestingly, the localization of the recurrence was not always the same as the first SSTH [74]. This finding suggests that SSTH may tend to recur especially when reversal of anticoagulation cannot be performed (e.g., in patients with prosthetic heart valves). These recurrences do not seem to be related to the choice of embolization material. The most frequently used materials were definitive such as coils, but recurrences were reported with resorbable and non-resorbable materials with similar rates. As such, definitive conclusions cannot be drawn regarding the optimal embolic agent to use. In practice, the best material is likely the one with which the operator is most familiar and with which non-selective embolization is least likely.

CT angiography (CTA) has gained popularity in the pre-embolization setting to identify active bleeding, localize hematomas and help interventional radiologists target the injured vessels as well as reduce the required quantity of contrast material and radiation exposure during digital subtraction angiography (DSA) [7, 75]. Similarly to gastrointestinal bleeding, the sensitivity of CTA is increased if it is performed while patients are actively bleeding. Currently, no studies exist evaluating the diagnostic efficacy of CTA for the identification of active bleeding in SSTHs. Moreover, as SSTH often occur in elderly patients, and renal insufficiency is frequent in this population, the risk–

benefit ratio must be carefully balanced. Furthermore, CTA may show active bleeding and alter the therapeutic strategy toward favoring embolization even in the absence of hemodynamic instability [7]. CTA technique has to be optimal and has been detailed in previous studies [7].Our study shows that active bleeding from a specific vessel was reported on CTA in 47.3%, while it was found in 85.9% of patients on DSA. This finding confirms that the decision to intervene in clinical practice is not only made on CTA findings but that clinical factors including hemodynamic stability and possibly other findings such as hematoma size are taken into consideration and should definitively be included in any future decision making scoring system. Nevertheless, this finding is surprising as CTA is usually very sensitive, as has been shown for gastrointestinal bleedings for which CTA is more sensitive than DSA [76, 77]. One explanation might be the intermittent nature of the bleeding, and that in some cases, while the bleeding may initially remain contained, delayed worsening of the patient's clinical condition and rebleeding are not uncommon and usually life-threatening [74].

Based on this review, we adapted our practice in our institution. First, we always perform a CTA as it provides important anatomic information and allows depiction of active bleeding. TAE is always performed in unstable patients. In hemodynamically stable patients, TAE is always discussed based on all criteria presented in the literature: (1) active bleeding; (2) rupture of retroperitoneal fascia or abdominal wall with hemoperitoneum; (3) localization of hematoma (as retroperitoneal seems more severe than rectus sheath or other localizations); (4) hematoma volume even though no clear cutoff value is known yet; (5) and clinical condition (comorbidities, valve prosthesis requiring continued anticoagulant therapy, age, renal failure). Given the high mortality of this pathology, we perform TAE as soon as possible after multidisciplinary meeting between interventional radiologists, surgeons and intensivists. Technically, each operator is free to use any material based on the available literature, but we preferably use definitive material such as micro coils or glue.

The main limitation of the present review is the inability to perform a mathematical meta-analysis given the heterogeneity of the reported data in each study. In patients who had recurrence, the initial material used for each case was stated in only two studies with $n > 1$ [7, 24]. In addition, even though all bleeds were reportedly spontaneous, four patients possibly underwent minor trauma in one study [8]. The low rate of complications reported is also a limitation and is probably related to a publication bias. Furthermore, the range for mortality and outcome follow-up is considerable, making meaningful conclusions very difficult to extract.

In conclusion, TAE represents an efficient and safe modality to manage SSTH when conservative management is deemed insufficient. Rebleeding is frequent, and reembolization is feasible with success achieved in 75% of cases. Given the high success rate and heterogeneity of reported data, there is no clear evidence to recommend one particular embolization material over another. There is a definitive need for a prospective clinical trial comparing embolization to conservative management and surgical intervention especially in stable patients and to provide simple guidelines for the management of this potentially severe but heterogeneous condition. Further studies are definitively needed to address this important knowledge gap.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent For this type of study informed consent is not required.

Consent for Publication For this type of study consent for publication is not required.

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