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Trans Arterial Embolization of Spontaneous Abdominal Muscle Bleeding

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Spontaneous abdominal muscle bleeding is an uncommon condition that usually arises in elderly and fragile patients. Commonly affected areas include body wall muscles, particularly the rectus sheath and the iliopsoas, with clinical manifestations such as abdominal pain, groin pain, anemia, and in severe cases, hemorrhagic shock. A computed tomography multiphase scan is the preferred modality of examination, as it allows the characterization of hematomas and the assessment of active bleeding. Conservative management of coagulopathy is standard care for stable patients while embolization and surgical options are reserved for those with hemodynamic instability or significant bleeding. Current literature provides incongruous results on outcomes, while some authors consider embolization only after conservative treatment failure, other authors advocate for a more aggressive approach in patients who are at high risk of developing a poor outcome. This discrepancy underlines the need for further standardized research to optimize management approaches in this fragile patient population.

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SPONTANEOUS ABDOMINAL BLEEDING

Spontaneous abdominal bleeding is defined as a hemorrhage not caused by a traumatic injury. The reported incidence for this condition varies between 0.6% and 6% but may be under-reported. However, the frequency of these events in Western countries is expected to increase due to the aging population and the increasing number of indications for anticoagulation therapies, which are a significant risk factor for spontaneous bleeding [1].

Cases due to anticoagulation or bleeding diatheses commonly involve multiple sites, especially the abdominal muscles (e.g. the iliopsoas or rectus sheath muscle), while viscera are less frequently involved [2].

Clinical presentation varies and is non-specific, including abdominal pain or mass, groin or hip pain, anemia, and hypotension. Most cases are indolent and do not require any intervention other than correction of the underlying coagulopathy, but if not promptly recognized and strictly monitored, they could result in a sudden and catastrophic evolution.

Ethical Approval and Informed Consent

Ethical approval was not required. Written informed consent was not required.

DIAGNOSIS

The effects of hemorrhage on laboratory testing, in particular hemoglobin and hematocrit, could manifest only after hours, and misdiagnosis is frequent. In worst-case scenarios, spontaneous abdominal muscle bleeding could lead to hemodynamic instability and become life-threatening, with reported mortality rates of 30% for retroperitoneal hematomas [3,4].

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The cornerstone for diagnosis is the multiphase computed tomography (CT) scan: it allows evaluation of size, location of hematoma, and signs of active or recent bleeding, and also the detection of responsible arteries [5].

The reported sensibility of a multiphase CT scan in detecting active (arterial) contrast extravasation is between 47% and 93% [6–8]. Another CT sign of bleeding is the so-called "hematocrit sign," a cellular–fluid level caused by the settling of cellular elements in the dependent portion of a hematoma, which is a very sensitive (87%) and specific sign of coagulopathic hemorrhage [9].

Digital subtraction angiography is the gold standard for the diagnosis and localization of active bleeding, but spasm, tamponade, shock, and technical limitations may limit the visibility of bleeding during angiographic procedures. The CT scan plays a key role in pre-procedural planning to reduce procedural time in difficult cases.

PHYSIOPATHOLOGY

Physiopathology of spontaneous muscle hematomas is complex and based on a multifactorial microangiopathy. Risk factors include age, atherosclerosis, vascular lesions from chronic arterial hypertension, and especially diabetes. Anticoagulant-induced immune microangiopathy has been reported to be a predisposing factor. Bleeding is the result of micro-traumatic damage (e.g. closed glottis straining, isometric muscle contractions) causing tears in muscles and fragile capillary vessels [3,10].

RISK FACTORS

Approximately two-thirds of spontaneous retroperitoneal and rectus sheath hemorrhages are associated with therapeutic anticoagulation and/or with conditions that either increase the effect of anticoagulation drugs (chronic renal insufficiency and dialysis, estimated glomerular filtration rate (eGFR) <30) or directly affect coagulation function (coagulation disorders, hepatic insufficiency, international normalized ratio (INR) ≥ 2.0) [5,11].

However, spontaneous fatal bleeding or major bleeding in patients undergoing anticoagulation therapy is relatively uncommon, ranging from 0.06% to 0.30% and 1.1% to 4%, respectively [12,13]. Direct oral anticoagulants (DOACs) present a lower bleeding risk compared to classical vitamin K antagonists, but routine coagulation tests cannot evaluate the degree of anticoagulation, and treatment relies on specific reversal agents which are expensive and may not be readily available [14,15].

Antiplatelet therapy is also considered a risk factor accounting for 30–40% of patients with spontaneous retroperitoneal hematoma, but usually alongside anticoagulation [16].

Spontaneous muscle hematomas occur in a fragile population: the mean population age is advanced (mean range of different studies reported between 68 and 72 years), with most patients (96%) having documented known comorbidities prior to presentation [8,17].

Frequently, a slight female predominance is noted and this is thought to be caused by a lower muscular mass fraction [8].

SITES OF BLEEDING AND ANATOMY

The localization of spontaneous abdominal muscle hematomas occurs mainly in the rectus in the anterior compartment (Figure 1) and in the iliopsoas muscle in the posterior compartment, while it happens more rarely in other muscles such as the oblique, the thigh, and the gluteal region [8,18].

The arteries most involved in rectus muscle bleeding are the inferior epigastric artery, the circumflex iliac artery, and the superior epigastric artery, while the ileo-lumbar artery and the lumbar arteries are involved in iliopsoas muscle bleeding [5].

Anatomically, the anterior compartment is divided into two parts by the arcuate ligament, located at the junction of the middle and inferior third of the rectus muscles, at the level of which the posterior sheath of the rectus muscles becomes anterior. Above the arcuate ligament, where the posterior aspect is covered by both the posterior rectus sheath and the transversalis fascia, hematomas usually result from distal lesions of the inferior epigastric artery and are usually contained and self-limiting. Below the arcuate ligament, only the transversalis fascia is found posteriorly, and hematomas result from proximal lesion of the artery which has weakened walls. Moreover, the lowest part of the rectus muscle is the longest and subject to the greatest shortening with contraction, generating higher tensional forces [19–21].

All these factors result in larger inferior anterior wall hematomas that dissect the muscle, possibly crossing the median line and creating new foci of bleeding while expanding.

MANAGEMENT

There are no clear guidelines regarding which subgroup(s) of patients require an intervention. Generally, in hemodynamically stable patients the standard of care is conservative treatment, including management of hemostasis disorders, stop and/or antagonization of anticoagulants, vascular filling, and transfusion.

In the last decades, the role of surgery in the management of this condition has been progressively reduced.

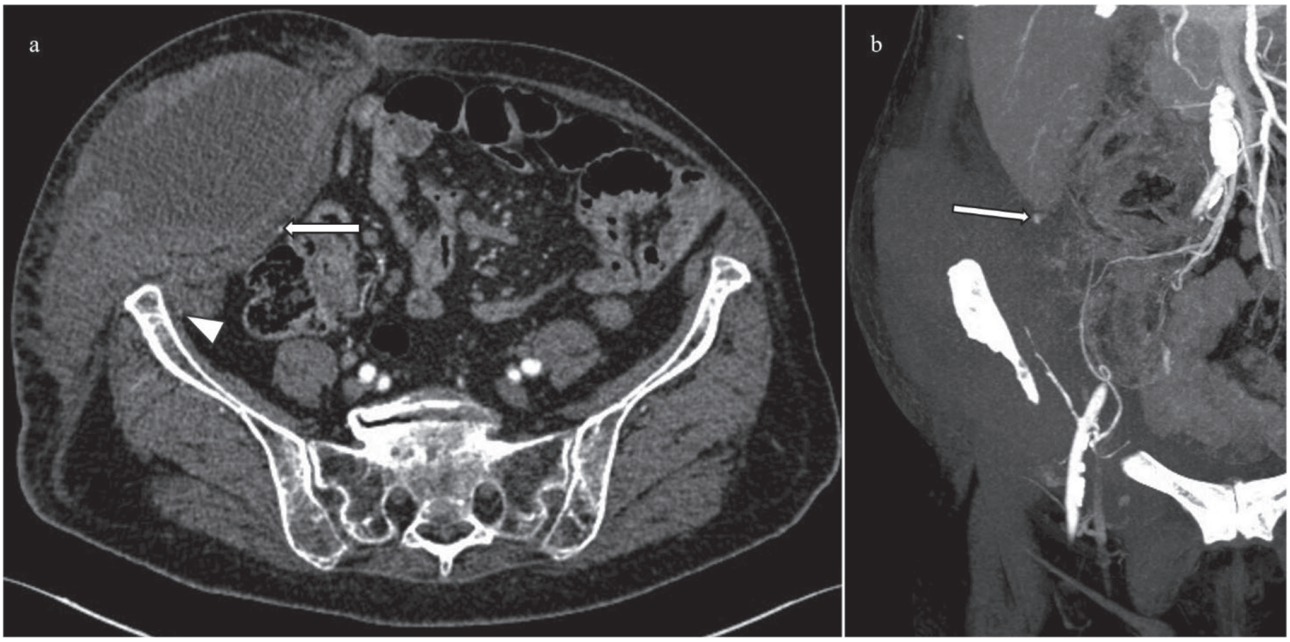

Figure 1 Right rectus sheath hematoma. (**a**) Pre-procedural axial arterial-phase CT image showing a large right rectus sheath hematoma refurnished by the inferior right epigastric artery (thin arrow) and the circumflex artery (arrowhead). (**b**) Pre-procedural coronal CT maximum intensity projection (MIP) reconstruction image showing the active bleeding (thin arrow) refurnished by the inferior right epigastric artery.

In patients with hemodynamic instability surgical arterial ligation may be challenging, and considering the comorbidities that usually occur in this patient population, surgery is often not a feasible option. Surgery is usually reserved for hematoma evacuation or in cases of compression ischemia.

Nowadays the most performed treatment is trans arterial embolization (TAE), which is fast, safe, and effective; moreover, it does not require general anesthesia and is less invasive, reducing morbidity, and mortality [6,22].

INDICATION FOR EMBOLIZATION AND TREATMENT ALGORITHM

Hemodynamic instability, uncontrolled bleeding despite adequate conservative treatment, low hemoglobin (Hb) values, and the need for continued transfusions account for 80% of the indications for embolization reported in the literature [8].

Other indications reported are active arterial-phase bleeding, rupture of fascia or muscles with hemoperitoneum, and clinical conditions, including the impossibility of stopping anticoagulation due to comorbidities.

Active arterial iliopsoas bleeding is a strong predictor of treatment, which is correlated with severity of hematoma and associated with unsuccessful conservative treatment [5,17].

Factors that are also considered are hematoma localization, as retroperitoneal hematomas are reported to be more severe, and the hematoma volume, even if no clear cutoff exists [8,17,23].

Most of these factors are included in the interesting treatment algorithm for patients with spontaneous intramuscular hematoma proposed by Popov et al. [24].

Stable patients with no active bleeding found on a CT scan are treated conservatively; the same treatment is performed in unstable patients and/or those with CT identified active bleeding that have no fascia rupture and that can stop anticoagulation.

Conversely, patients who are unstable and/or have CT identified active bleeding with fascia rupture, who cannot stop anticoagulation, or who are not on anticoagulation therapy then undergo TAE. Lastly, embolization is performed when conservative treatment fails [24].

TIMING AND FINDINGS AT ANGIOGRAPHY

Indications for treatment should be a joint decision after discussion in a multidisciplinary team composed of interventional radiologists, surgeons, and internal and emergency medicine physicians. Embolization should be performed as soon as possible, but the reported time between CT scan and angiography varies widely in the literature; average mean procedural time has been reported to be between 43 min and 7 h 50 min in different studies [6,23,24].

At angiography, the signs of active bleeding (Figure 2) may be direct (contrast blush extravasation, focal spot of enhancement, hemorrhagic petechiae, pseudoaneurysm) or indirect (vessel cutoff sign or massive vasospasm).

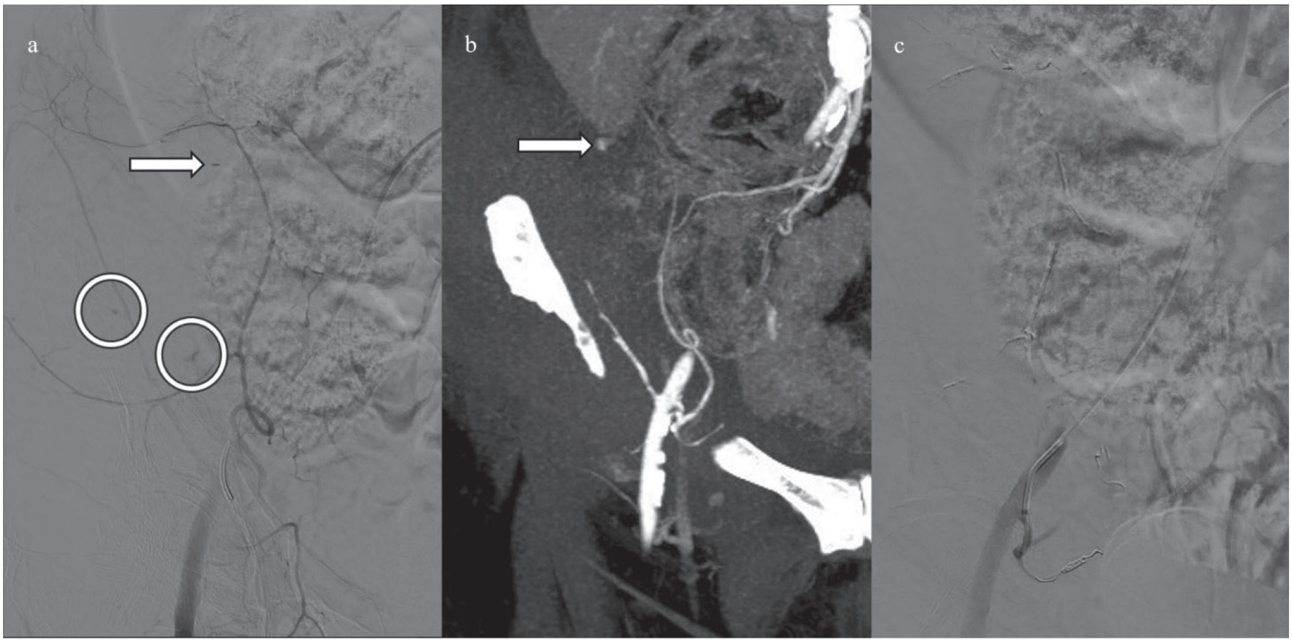

Figure 2 Transarterial embolization of the right rectus sheath hematoma. (**a**) Selective DSA from the right inferior epigastric artery which confirmed the presence of multiple active arterial blushes (circles), one of the bleeding spots, matched the CT findings (arrow). (**b**) Magnification of the pre-procedural coronal CT MIP reconstruction image showing active bleeding (arrow) matching the DSA findings. (**c**) DSA after glue and coils embolization of the right inferior epigastrig artery showing complete devascularization.

The detection rate of active bleeding on digital subtraction angiography (DSA) is reported to be between 70% and 86% [6,25].

In a recent systematic review, the rate of active bleeding at DSA was higher than at CT, confirming that a decision to perform angiographic studies in a patient with spontaneous bleeding relies on multiple factors [8].

EMBOLIC MATERIALS

There is a great heterogeneity of data regarding the embolic materials which are used, with still no evidence to recommend one embolic material over the other [23].

In a systematic review, coils were used in 30.7% of cases, glue in 18.1%, gelfoam in 16.4%, microparticles in 6%, a combination of coils and gelfoam in 13%, and a combination of coils and microparticles in 12.2% of the cases [8]. Coils are frequently reported as the most commonly used embolic agents in the literature even if they have the significant limitation in this patient population of being dependent on the coagulation status.

Gelfoam, which is frequently reported, has the significant disadvantage of being temporary.

Polyvinyl alcohol (PVA) particles are appreciated by some authors due to the filling of the distal diseased microvasculature and have demonstrated their efficacy in the setting of spontaneous bleeding even if they theoretically carry the disadvantage of a higher ischemia degree in the anterior compartment hematomas. Glue has also demonstrated its efficacy, can be prepared in different ways to control polymerization time, and can fill the diseased branches quickly without causing a distal-end embolization.

Non-adhesive liquids could theoretically be good options but are significantly limited by their high cost and relatively long preparation time.

In a study on embolization of anterior abdominal wall hematomas (not all but the majority were spontaneous), no difference in clinical success, survival, and complications was found comparing mechanical, liquid/particulate agents (including gelfoam, PVA, and glue), and their combination [22]. Other authors registered that most cases of recurrent bleeding after embolization of life-threatening retroperitoneal hematomas were associated with coils, concluding that glue may be preferable, with or without mechanical embolic agents [7].

Similar recurrence rates were found with resorbable and non-resorbable materials in a recent systematic review [8].

EMBOLIZATION TECHNIQUES

In this setting, two main strategies are adopted: blind embolization or targeted embolization.

Blind or empiric embolization (Figure 3) is the closure of the suspected vessel based on topographic reference and/or findings of CT in the absence of bleeding at DSA and is performed in patients with spontaneous abdominal muscular bleeding in 13–21% of cases [6–8,23].

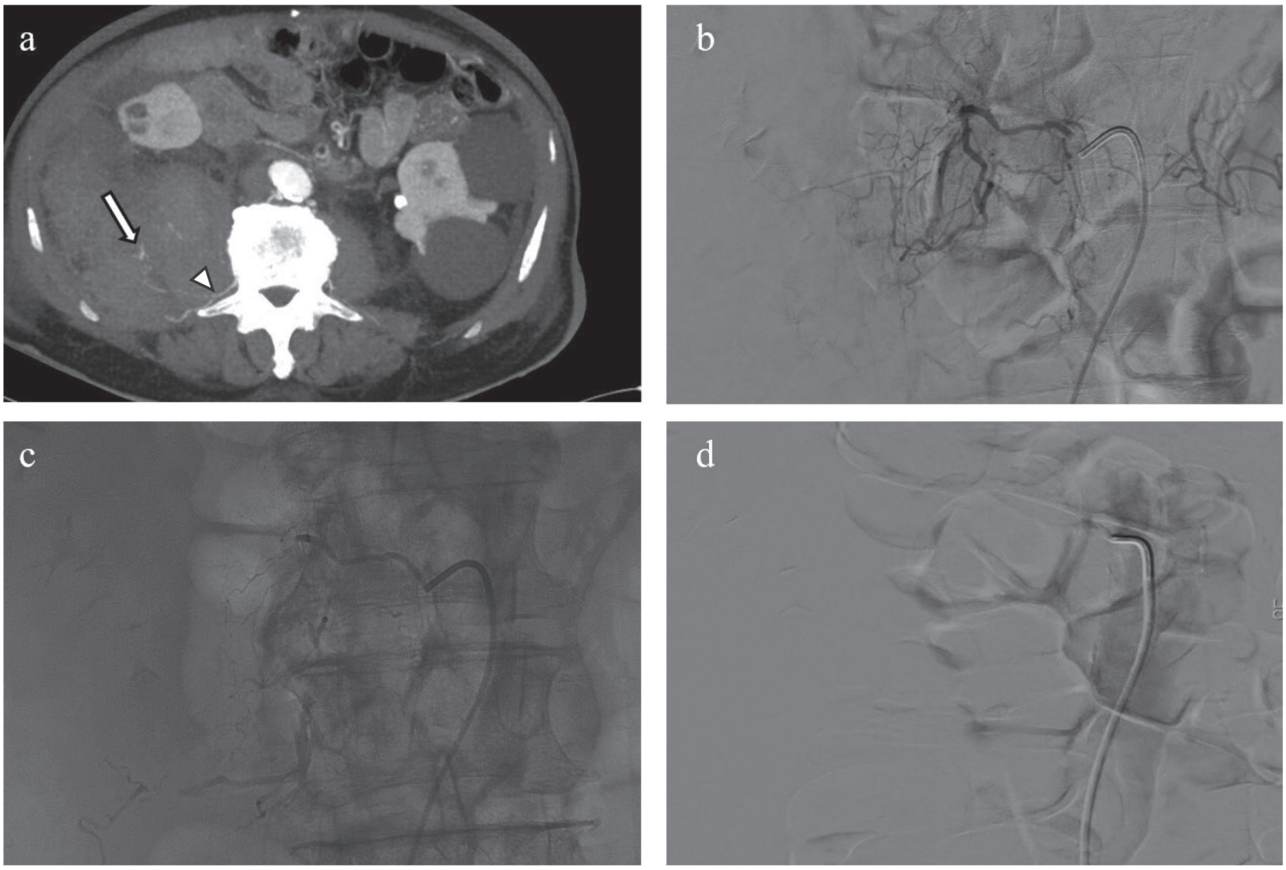

Figure 3 "Blind" embolization technique. (**a**) Pre-procedural axial arterial-phase CT MIP reconstruction image showing a large right iliopsoas hematoma with active arterial spots (arrow) refurnished by a (third lumbar spine vertebra (L3) level) right lumbar artery (arrowhead). (**b**) Selective DSA from a (L3 level) right lumbar artery without evidence of direct or indirect signs of bleeding. (**c**) Fluoroscopic image showing the blind embolization technique. Despite no evidence of active arterial blush, the lumbar artery was occluded with glue that formed multiple casts across the lumbar artery branches. (**d**) DSA after embolization of the (L3 level) right lumbar artery showing complete devascularization.

Targeted embolization consists of the closure of arteries where direct or indirect signs of active bleeding were demonstrated in the DSA study.

In a recent study there were no differences in clinical success or rebleeding rates between patients treated with targeted versus blind embolization, with success rates of 77% and 78% and rebleeding in 22% and 23% of patients, respectively [6].

The same clinical success rate (86%) after embolization in patients treated with targeted or blind embolization was also found in another recent study, in which patients from the two groups did not differ regarding gender, age, mean pre-procedural hemoglobin, localization of hematoma, or time to DSA [23].

Regarding embolization technique, one important aspect is to consider systematic embolization of anastomotic arteries if there is a high risk of backflow. This concept is particularly important in the retroperitoneum, which has a high collateral supply, and in which closure of the lumbar/iliolumbar arteries above and/or under the bleeding site, as well as the bleeding artery itself, may be advised to reduce the possibility of procedure failure or rebleeding.

In one study, the bleeding recurrence rate after first embolization was as high as 24.1% [7]. Other authors reported their experience showing that, among 42% of their patients who underwent embolization in >1 arterial territory, the majority had bleeding in the posterior compartment.

TAE OUTCOMES

Technical success rates, defined as the complete occlusion of all target vessels, reported in the literature are between 96% and 100% while reported clinical successes, defined as absence of signs of rebleeding in the following 96 h, range between 65% and 93% [6,8,22,23].

In a recent systematic review, the estimated mortality rate after TAE was 23.1%, with 22.7% of deaths occurring within the first 30 days after embolization; multiorgan failure, cardiogenic shock, and secondary infection were the main reported causes of deaths [8]. Notably, up to 50% of patient deaths are not related to bleeding but to coexisting conditions [17].

In patients who underwent TAE, rebleeding occurred in 10.1% of patients, with 92.9% of these cases occurring in patients still on anticoagulation. A second embolization attempt is often performed in most patients with rebleeding, with this being successful in 75% of cases.

Complication rates after TAE range between 0.7% to 4%, with most being related to vascular access sites (e.g. femoral artery pseudoaneurysm, groin haematoma) [8,22].

Non-target embolization and skin necrosis are very rare, the latter being described only in a case report after embolization of an anterior muscle wall spontaneous bleed with gelfoam [26].

CONSERVATIVE TREATMENT VERSUS EMBOLIZATION – WHAT IS KNOWN AND WHAT IS NEEDED

Actual guidelines lack clear indications on which subgroup of patients should be treated conservatively and which should be treated with embolization. In the absence of clear treatment algorithms, some authors have tried to directly compare conservative treatment and embolization. In a recent single-center case control retrospective study, 54 patients with spontaneous retroperitoneal hemorrhage were divided into two groups based on the treatment received within the first 24 hours from diagnosis. Group 1 was treated conservatively while group 2 was treated with TAE. In this study, conservative management presented a higher clinical success rate compared to TAE and both all-cause and bleeding-related mortality were more likely to occur after TAE [13].

Nevertheless, the TAE group patient population presented a higher percentage of active bleeding on CT scan, a shock index >1, and received a higher volume of blood transfusion; moreover, the latter two characteristics were more likely to be present in fatal cases (15%). The authors stated that most patients with spontaneous retroperitoneal hemorrhage can be safely treated conservatively, with conservative treatment being successful also in 13% of initially unstable patients, but also acknowledge that the lower success rate in the embolization group was likely caused by underlying coagulopathy, which develops in cases of major blood loss [13].

The paper stimulated some discussion among experts. Although a common agreement was reached on the importance of prompt medical management, early diagnosis, and treatment in all cases, the authors concluded that a variety of factors can affect success, including patient-, operator-, and technique-related factors. The difference in these factors is likely to justify the difference in clinical success obtained with embolization in different centers. Therefore, the preference of conservative management over embolization should be carefully debated, and there is a strong need for standardization in reporting and in the use of materials and techniques [27,28].

Moreover, as some predictors of outcome are known, including volume of hematoma and simplified acute physiology score, randomized, prospective, controlled studies with patient stratification would be highly valuable for further advancement of knowledge [29].

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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