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Endovascular management of the rectus muscle hematoma

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Abstract
Purpose Non-traumatic spontaneous hematoma of the rectus abdominal muscle is not considered a critical condition. Nevertheless, it can be a serious complication in some patients due to continuous and/or consistent bleeding. The most frequent cause of spontaneous rectus muscle hematoma is the anticoagulation therapy. The natural history of rectus muscle hematoma usually leads to a positive outcome and can be spontaneously self-limited only by conservative therapy. Nevertheless, in some patients, despite a correct and early medical therapy, the continuous bleeding requests a more radical handling. Up to now, the surgical hematoma evacuation and the bonding of blood vessels were considered the most appropriate treatment, while at present, the percutaneous management by means of selective catheters and embolization of the bleeding vessel is considered to be the most used option. Our purpose is to report our experience in the endovascular spontaneous rectus muscle bleeding treatment in the elderly patients.
Materials and methods From the data base and medical reports of the hospital, we selected 144 medical reports. We focused on those cases that showed the following criteria: patients with rectus muscle hematoma undergoing anticoagulation therapy and/or non-traumatic spontaneous hematoma and with persistent bleeding revealed on CT examination despite a pharmacological treatment aimed to timely reverse coagulopathy. These criteria were found in 18 patients: 15 females and 3 males, with a median age of 73 (range 64–81). In all patients, the diagnosis had been confirmed by an abdominal CT in emergency setting, performed before and after contrast medium intravenous administration. Because of clinical conditions, all patients had been moved on the angiographic room for diagnostic arteriography and embolization. The criteria for this treatment were hemodynamic instability and the continuous bleeding despite the correct medical therapy.
Results CT imaging detected rectus muscle hematoma in 18/18 patients and active bleeding in 7/18 patients. Selective catheterization was applied to all 18 patients; arteriographic study confirmed the information of the CT study in all of the seven patients. The inferior epigastric artery was the main cause of the bleeding in all 18 patients. In 14 patients, one single vessel was responsible for the bleeding, while in the other four patients, more than one vessel were involved: In two patients, we also found the involvement of the superior epigastric artery; while the other two patients showed also the involvement of the deep iliac circumflex artery. The material for embolization was compatible coils with microcatheters in 17/18 patients, and glue for 1/18 patient.
Conclusions Patients with large rectus muscle hematoma, which have not yet recovered with conservative therapy, should then consider undergoing endovascular treatment. This procedure is highly recommended in patients with other coexisting pathologies that could eventually lead to a fatal outcome. It is difficult to determine when surgery is necessary when there is very poor data provided by scientific literature review, so the decision to use surgery can be suggested when embolization is unsuccessful or when it is necessary to evacuate a complex huge fluid mass in peritoneal cavity.

Keywords Rectus muscle hematoma · Endovascular management · Embolization · Computed tomography · Arteriography

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Introduction

The rectus muscle hematoma is a blood collection in the sheath of the anterior rectus muscle, due to epigastric artery damage or the tearing of one or more muscle fibers, usually located beneath the umbilicus where blood vessels are not protected by external aponeurotic fascia [1].

Non-traumatic spontaneous hematoma of the rectus abdominal muscle is not a common cause of pain in ordinary medical treatment, and it is not considered a critical condition [2, 3]. Nevertheless, it can be a serious complication in some patients due to continuous and/or consistent bleeding [4].

The most frequent cause of spontaneous rectus muscle hematoma is the anticoagulation therapy [5, 6]. The natural history of rectus muscle hematoma usually leads to a positive outcome and can be spontaneously self-limited only by conservative therapy [7]. Nevertheless, a large hematoma can develop and/or cause a severe hypovolemia that requests not only an early and accurate medical instrumental diagnosis and treatment, but also an adequate therapy with an inversion of the coagulation cascade, liquid infusion and hemostatic treatment [8].

In some patients, despite a correct and early medical therapy, the continuous bleeding requests a more radical handling [8, 9]. Up to now, the surgical hematoma evacuation and the bonding of blood vessels were considered the most appropriate treatment, while at present, the percutaneous management by means of selective catheters and embolization of the bleeding vessel is considered to be the most used option [10].

Our purpose is to report our experience in the endovascular spontaneous rectus muscle bleeding treatment in the elderly patients.

Materials and methods

Going through the data base and medical reports of the hospital, we focused on those medical cases that emphasized "rectus muscle hematoma" in the main diagnosis, which occurred between the year 2001 through 2011. From the selected 144 medical reports, we focused on those cases that showed the following criteria: patients with rectus muscle hematoma undergoing anticoagulation therapy and/or non-traumatic spontaneous hematoma and with persistent bleeding revealed on CT examination despite a pharmacological treatment aimed to timely reverse coagulopathy.

These criteria were found in 18 patients: 15 females and 3 males, with a median age of 73 (range 64–81 years). 10/18 patients had acute and oppressive pain status in the lower abdomen and abdominal swelling which ultrasound had confirmed to be pertaining to the superficial tissue (Fig. 1a, b).

The symptoms had become acute after a cough in nine cases, after Valsalva maneuver in four cases, after a chest torsion in three cases and for unknown causes in two cases. Upon arrival at the hospital, all patients had low hemoglobin levels, at least −4 points percentage which had a further drop despite the medical therapy in 5/8 patients, causing a hypovolemic shock; the other patients showed a stable hemodynamic condition.

In all patients, the diagnosis was confirmed by an abdominal CT (Light Speed 16 General Electric), in emergency setting (Fig. 2a–c), performed before and after contrast medium intravenous administration. CE-MDCT protocol includes arterial and venous phase scans. A nonionic contrast medium volume of 120–150 ml was injected, at 3–4 ml/s through a 18–20 G needle. Arterial active bleeding was diagnosed when CT scans demonstrated within the hematoma a focal or diffuse area of high attenuation that was isodense with adjacent arterial vessels. A delay ranging from 30 to 40 s was used for the arterial phase and from 70 to 80 s for the venous phase.

Because of clinical conditions, all patients were moved on the angiographic room for diagnostic arteriography and embolization (OEC 9800 Plus-General Electric). The criteria for this treatment were hemodynamic instability (arterial pressure below 90/60 mmHg despite therapy) and the continuous bleeding despite the correct medical therapy (so the patient continued to have symptoms or the hematoma continued to grow) [13–18].

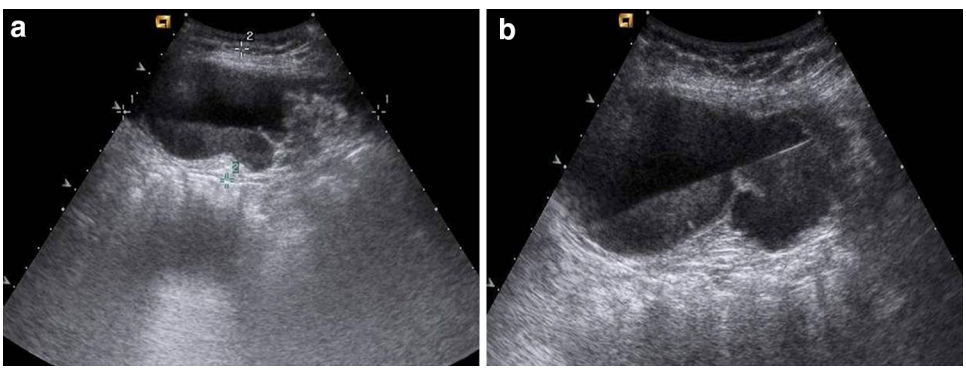

Fig. 1 Ultrasound: diagnostic study, carried out with a 15-MHz linear probe, detects a subcutaneous fluid collection, with a superior hypoechoic portion and a slightly hyperechoic inferior part: The patient's position determines the obliquity of the blood level gathered in the fluid collection

Fig. 2 CT: triphasic CT examination (basal phase, arterial phase and venous phase) allows to determine the topographic, morphological and functional characteristics of the hematoma. The CT basal phase **a** reveals a mass effect developing toward the abdominal cavity in the same level shown in US examination, with a slightly low hyperdensity, as if a recent bleeding had occurred. The CT arterial phase **b** shows an active bleeding in the hematoma: Irregular aspects of the arterial vessel confirm the presence of injury causing the bleeding outcome. Lower level scans **c** allows to follow the bleeding arterial branch, the lower epigastric artery in this specific case, providing important data to request interventional radiology for further management

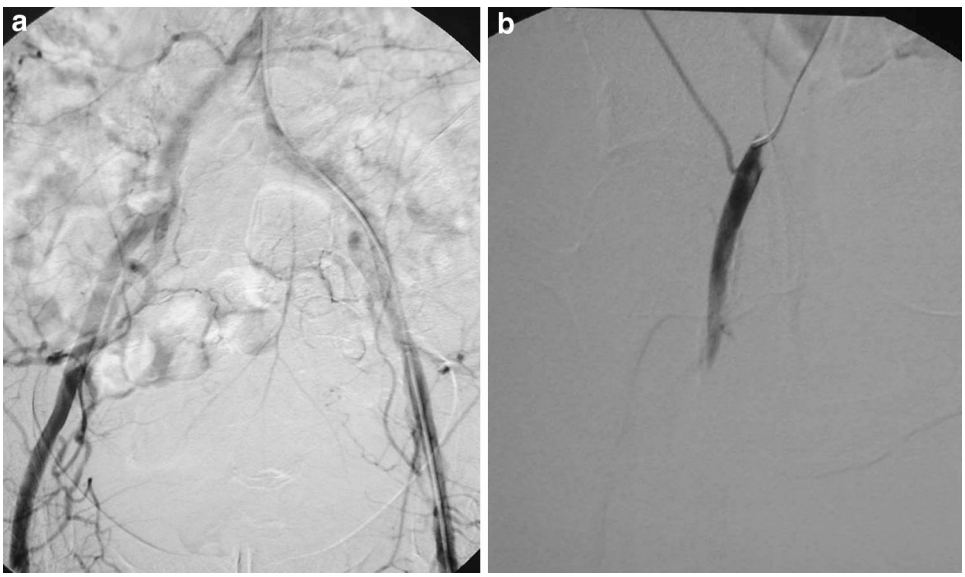

Fig. 3 Angiography: arteriographic examination is performed by opposite side transfemoral access as to the hematoma and consists in an aortoiliac panoramic study, to have an overall anatomic visual reference (**a**); at this point, through selective catheterism, it is possible to point out the origin of the lower epigastric artery (**b**), providing an essential anatomic map for the following super-selective catheterism by micro-catheters

The transfemoral diagnostic arteriography was carried out after local anesthesia, on the opposite side of the hematoma (Fig. 3a); the vascular access was performed by means of a vascular sheath of 5 Fr (Terumo Europe, Leuven, Belgium). After the overall study of the abdominal aorta and of the iliac vessels, a selective catheterization of the external iliac artery was performed, highlighting the anatomic characteristics of the vessels originating (Fig. 3b).

The choice of the angiographic catheter (cobra, headhunter, multipurpose, Cordis Europe) was made considering the morphology of the specific vessel.

The study of the damaged artery and its interventistic treatment were carried out by means of a micro-catheter 3 Fr, coaxial as respect to the angiographic one (Progreat 2,8 Fr-Terumo Europe, Leuven, Belgium); coils (Tornado–Cook Europe, Denmark) and/or other embolization material (Curaspon, Curamedical, BV, Netherlands–Glubran 2, GEM srl, Viareggio, Italy) was used to stop the bleeding: The choice was based on the characteristics of the wound (anatomic location and size of the bleeding vessel).

The absence of contrast material extravasation during a further arteriography, performed at the end of the treatment, was considered to be the crucial criteria determining the technical success of the overall operation.

The increase in the hemodynamic and hemoglobin values was considered a medical success.

Results

Preliminary CT studies were performed in all 18 patients and detected hematomas in 18/18 patients. In 11/18

Fig. 4 CT: large *left-sided* rectus muscle hematoma extending its mass effect to the homolateral flank; it is possible to depict a well-shaped mass rim, a mass effect toward the inside, a fluid level with hyperdensity of the declive portion due to recent bleeding and the presence of an active bleeding. The contrast material pooling shows the same density as that in aorta

patients, CT scans demonstrated only the presence of hematoma, with no active bleeding. In 7/18 patients, CT showed an active bleeding within the hematoma (Fig. 4). In this seven cases, active bleeding was considered to be in the territory of the inferior epigastric artery in 5/7 cases and in the territory of the superior epigastric artery in 2/7 cases (Fig. 5).

Selective catheterization was applied to all patients; arteriographic study confirmed the site of the bleeding in all of the seven patients in whose CT demonstrated it.

The inferior epigastric artery was the main cause of the bleeding in all 18 patients. In 14/18 patients, one single vessel was responsible for the bleeding, while in the other 4/18 patients, more than one vessel were involved: In two patients, we also found the involvement of the superior epigastric artery, while the other two patients showed also the involvement of the deep iliac circumflex artery.

The embolization material used was compatible coils with micro-catheters in 17/18 patients, and glue for one patient. Embolization was carried out with success, since no active bleeding was revealed during arteriography at the end of the endovascular treatment.

15/18 patients were submitted to an 18-day CT follow-up. During this period, no further or new bleeding was revealed, and hemodynamic levels were stabilized: Blood pressure had become normal in 14/18 patients; only four patients were treated with blood transfusion to correct anemia, and only one patient needed platelet therapy. None of the cases requested surgery.

Contrast-enhanced ultrasound (CEUS) carried out only in 7/18 patients proved no active bleeding. No further complication was reported neither during nor after embolization procedures; 3/18 patients died during hospitalization (the first after 12 h, the second after 2 days and the last after 8 days), due to multiorgans failure as a result of hemodynamic disorders due to the hematoma: severe kidney failure in two cases and heart failure in one case.

Discussion

Rectus muscle hematoma is a clinical disorder relatively common in the elderly patients.

In order to better understand the pathogenesis of this medical case, it is important to focus on the abdominal anterior wall anatomy. There are two rectus muscles, one for each side. They start from the superior margin of the pubis, and they end in the ventral portion of the 5th, 6th, 7th cartilaginous ribs and on the xiphoid process of the sternum. They are separated by a central alba line while the side edge is represented by the semilunar line. They are formed by several fibers wrapped in sheaths and supplied by vessels from the epigastric artery.

The rectus muscles are divided in two separate portions (upper and lower muscle) by the arcuate line located 5 cm below the umbilicus.

Above the arcuate line, there is the aponeurosis of the external and internal oblique and transverse muscles. Below the arcuate line, there is any muscular insertion and only the transversalis fascia and the peritoneum divide the muscle mass from the posterior abdominal viscerum, thus allowing the hematoma to expand easily beyond the midline and descending toward the bladder in Retzius space: This communication creates a natural dissection level between the rectus muscle back face and the bladder [11, 12].

The artery supply to the rectus muscle is given by the superior and inferior epigastric arteries.

The inferior epigastric artery originates from the external iliac: It starts from the inguinal ligament and curves forward in the subperitoneal tissue, and then, it ascends obliquely along the medial margin of the abdominal inguinal ring; continuing its course upward, it pierces the transversalis fascia and, passing in front of the arcuate line, ascends between the rectus muscle and the posterior lamella of its sheath.

During the contraction of the rectus muscle, the length of the muscle changes and the artery adapts accordingly to prevent stretching.

The combination of the insertion of the inferior epigastric artery with the stabilization provided by the insertion of the muscle fibers makes the artery sensitive to the pressure in the insertion points during intensive physical activity.

The superior epigastric artery enters the sheath at the 7th cartilaginous rib and then descends between the rectus

Fig. 5 **a** US, **b** CT, **c**, **d** angiography. The rapid upcoming of abdominal and *right-side* inguinal mass after violent coughing due to paint inhalation has lead a woman to the Emergency Department. The patient's anamnestic report showed a regular anticoagulant treatment due to past cardiac surgery. Ultrasound (**a**) showed a well-shaped mixed subcutaneous mass with mixed echostructure. The hematoma's progressive increase in size and the worsening of the hemodynamic conditions requested a CT study (**b**), which confirmed the presence of a non-malignant mass with an inside active bleeding. Once undergoing angiography, a panoramic study of the iliac abdominal artery was carried out. The selective study of the *external right* iliac artery (**c**) allowed to confirm not only the presence of active bleeding shown through the collection of contrast material outside the physiological vascular flow, but also an increase in the collection during further phases of the artery study. This procedure also identified the artery responsible for the bleeding, which was then treated with micro-catheters (**d**) and coils for embolization

muscle and the posterior lamella of its sheath. The two arteries form anastomosis in the level of the umbilicus, which are microscopic and help lower the possibility of blood vessel trauma during an important muscle strain; given the artery supply, hematoma concentrates mainly in the posterior muscle area, thus creating diagnostic problems [13].

Hematoma above the arcuate line is usually due to the damaging of the superior epigastric artery or of its perforating arteries: Patients usually show a small spindled unilateral mass; hematoma is isolated by the rectus sheath and by the tendons that allow the self-limiting bleeding.

Hematoma below the arcuate line is a consequence of the inferior epigastric artery damaging or of its perforating branches. It is generally located at posterior muscle area and has spherical shape because in this point the rectus muscle is supported only by the transversalis fascia and parietal peritoneum. Hematoma can cause blood loss and can extend easily because there are no tendons that can stop it expansion. Hematoma can also go beyond the midline and become bilobar [12].

The main cause of hematoma is the anticoagulant therapy; the exact pathogenesis of this association is still unknown. It is thought to be a heparin-induced micro-angiopathy, involving a sublayer of a preexisting vascular arteriosclerosis; further damaging issues concern the clinical condition such as abdominal strains, e.g., coughing, asthmatic reaction, an abrupt torsion of the chest and a Valsalva maneuver. All of these aspects can lead to rectus muscle hematoma [8, 14].

The increase in the number of clinical cases is also due to the extended overall age length and to the major implementation of anticoagulant therapies in elderly people and arteriosclerotic patients. Given the benefits that the therapy

guarantees in various clinical cases (arterial fibrillation, deep vessel thrombosis and pulmonary embolia treatment), recently there has been an increase in patients undergoing double antiaggregation to obtain patency of vascular stents [2, 5, 6, 14, 15].

It has been reported that there has been a threefold increase in female patients, due to less abdominal muscular mass [16].

The rectus muscle bleeding can determine clinical symptoms according to the size of the hematoma: ranging from a weak abdominal pain with hematoma within the muscle to an acute strain pain with abdominal hematoma, the latter case presenting problems in the diagnosis phase, especially in pregnancy [17–19]. It can cause an acute hypovolemia that needs to be treated in emergency. In particular, the physical examination of the patient could suggest a diagnosis, but the imaging gives a detailed pathology and allows to depict a non-pulsating mass, non-mobile despite the breathing, more or less depictable according to the patient's obesity: The Fothergill's sign can be used to determine whether the mass is part of the abdominal wall (the patient is in supine position and bends both head and legs at the same time, and the hematoma does not change with flexion but is more painful, and more stretched and even more depictable while an abdominal mass is less distinct and less stretched) [1–3, 20].

In large rectus muscle hematoma, the purpose of standard diagnostic techniques, ultrasound (US) and CT, are used to reveal its real size and extension, but also to depict the existence of the active bleeding.

In particular, US can show a different aspect of the hematoma according to its dating: solid or mixed mass (non-homogeneous), liquid part or with septa. US aspect is not specific, and it can be confused with abdominal or inflammatory mass [21]. Further detailed information on the abdominal rectus muscle is obtained through contrast-enhanced CT. The intravenous contrast medium administration allows to depict the active bleeding: hyperdense focal areas in the hematoma during artery phase and the persistence of the bleeding in the late study phase [22, 23].

Comparing clinical data and CT reports, it was possible to determine the size and severity of hematoma and divide it into three main groups: weak/type I, moderate/type II and severe/type III [24].

Brief, type I consists in an enlarged rectus muscle. The hematoma within the muscle creating a limited unilateral swollen area in the abdominal wall and the prognosis leads to a positive outcome, within a month, without the need of any type of surgery intervention.

Type II is often a bilateral hematoma with blood loss between muscle and transversalis fascia with inside fluid levels linked to a significant fall in hemoglobin. It requires a short-term hospitalization period, to confirm the diagnosis and begin an appropriate medical treatment, e.g., drainage and/or blood transfusion when requested.

Type III is the case of a large hematoma, mainly as a consequence of a traumatic iatrogenic event, easily recognizable (paracentesis, intracutaneous heparin injection, needle biopsy) [25–28]; the patient requests hospitalization due to the worsening of general conditions; there is a significant fall in hemoglobin, and hemodynamic stabilization may request not only medicines but also a surgical treatment and vascular therapy.

All our patients treated belonged to type III.

With the multislice CT, it is possible to exactly visualize the course of the inferior epigastric artery, its perforating branches, and detect the location of the bleeding [29].

There is usually a natural and good outcome in most cases of rectus muscular hematoma only through conservative therapy, with spontaneous self-limited evolution [14, 16, 30]; vitamin K and platelets subministration are useful to stabilize the hemocoagulation status if the patient is undergoing heparin or protamine solphate. The decision of undergoing a blood transfusion depends on the patient's hemodynamic status and the presence of other pathologies such as severe coronaropathy or anemia [31].

Despite correct medical treatment, some patients can develop a large hematoma causing a consistent hypovolemia or persistent bleeding, which requests an even more radical intervention. Even if hematoma surgery evacuation and the bonding of concerned bleeding vessels have, in the past, been the most used procedures in hemostatic treatment of a severe rectus muscle hematoma [32, 33], with very good results, still it was quite difficult to identify the bleeding artery concerned.

At present, the endovascular percutaneous treatment is the gold standard. Selective catheterization, the use of micro-catheters and the versatility of embolization material allow a correct management in any type of situation [10].

Selective arteriography, being the first phase of percutaneous endovascular therapy, is the most useful image technique to identify the presence and location of the bleeding; it provides information on the involved artery branches that support the bleeding and its exact location [34, 35]. The use of a micro-catheter allows to stop the bleeding in a precise and selective way reducing eventual dispersion of permanent embolization material or mechanical material.

The material used is basically and exclusively coils, which allow a more precise handling at the given location, which immediately stops the bleeding, especially when little vessels are concerned. Glue was used only in one of our cases, but we avoided further use of this material, due to difficulties encountered in the catheter removal.

This technique must be used when bleeding is persistent, despite an adequate medical approach. It is known that hematoma can involve several blood vessels due to

the natural gap between inferior and superior epigastric arteries.

For this reason, it is suitable to study in detail the origin of the bleeding and undergo embolization all around the bleeding location in order to stop the blood supply "a tergo."

Our experience was similar to medical literature reports cases concerning isolate cases of spontaneous rectus muscle hematoma, with considerable hemodynamic alteration [2]. After embolization, bleeding stopped in all cases; the successful outcome was found in 75 % of the patients. The 100 % successful outcome in endovascular hemostasis suggests that this procedure should be considered as the first step in approaching cases with large rectus muscle hematoma that cannot be handled only with a conservative treatment therapy.

Conclusions

Patients with large rectus muscle hematoma, which have not yet recovered with conservative therapy, should then consider undergoing endovascular treatment.

This procedure is highly recommended in patients with other coexisting pathologies that could eventually lead to a fatal outcome.

It is difficult to determine when surgery is necessary when there is very poor data provided by scientific literature review, so the decision to use surgery can be suggested when embolization is unsuccessful or when it is necessary to evacuate a complex huge fluid mass in peritoneal cavity.

Conflict of interest The authors declare no conflict of interest.

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

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