Treatment of an iatrogenic subclavian artery pseudoaneurysm near vertebral artery branch: endovascular approach or open surgery?

Pseudoaneurisma da artéria subclávia próximo à origem da artéria vertebral após punção inadvertida: tratamento endovascular ou cirurgia aberta?

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INTRODUCTION

The classical treatment of pseudoaneurysms is open surgery for resection and end-to-end anastomosis, venous graft, suture, or bypass[1]. Surgeries to treat subclavian artery aneurysms have been attempted since 1818, first by Valentine Mott[2], and then, in 1864, by Smyth, who was the first to achieve success. In 1924, Halsted described the difficulties of treating this type of lesion[3]. Open surgery involves considerable morbidity and mortality, particularly in the case of high-risk patients[1] and urgent surgeries[4].

Percutaneous endovascular treatments using covered stents or embolization, a minimally invasive method that does not require general anesthesia, has been one of the therapeutic alternatives in the last decade. Arterial lesions were first treated using an endovascular approach in 1915, by Carrel et al.[4]. The first animal studies with placement of endoluminal stents were published in 1969 by Dotter et al. In 1987, Nicholas Volodos[5] performed the first endovascular correction of an aortic artery aneurysm in Kharkov, in the then Soviet Union, but this technique only became popular in 1991, when Parodi et al. published the first human study about the use of covered stents in the treatment of abdominal aortic aneurysms introduced percutaneously through the femoral artery[6]. After that, in 1992, they used covered stents for the treatment of an arteriovenous fistula[7]. In 1994, Marin et al.[8] conducted the first study about the use of covered stents to treat pseudoaneurysms.

Embolization was first used in 1930 in a study conducted by Brooks, who described a surgery for the embolization of a carotid-cavernous sinus fistula using muscle fragments. In 1968, Doppman used a percutaneous catheter and embolization to treat a case of intramedullary arteriovenous malformation[9]. Some years later, the transcatheter embolization technique was applied to the treatment of digestive hemorrhages[10], urinary tract bleeding[11], pelvic trauma[12], arteriovenous fistulas and hemoptysis[13]. After the development of numerous embolization agents and a range of new angiographic resources, such as microcatheters, the percutaneous transcatheter embolization technique became an alternative therapeutic option and changed the course of these lesions.

Endovascular approaches are less invasive treatment options, and their use in the treatment of vascular trauma has become more frequent. In some situations, superselective transcatheter arterial embolization may be very useful because it controls bleeding and does not compromise essential functions. In this study, we discuss the advantages and disadvantages of the different therapeutic options to treat subclavian artery lesions.

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PART I - CLINICAL CASE

A conscious, 78-year-old man weighing 60 kg presented with strong abdominal pain, deteriorating general physical conditions, fever, hypotension, and tachycardia. An emergency exploratory laparotomy was indicated. He denied any comorbidity. During the surgery, the patient became hemodynamically unstable, and the anesthesiology team decided to obtain a central venous access, for which they chose an anterior approach to the right internal jugular vein. An iatrogenic puncture, possibly of the carotid artery, was followed by the expansion of the volume of the cervical region to the right, more markedly in the supraclavicular region, and by slight tracheal deviation that did not respond to local compression. The vascular surgery team was called in and ruled out active bleeding after duplex ultrasound scanning of the cervical and right supraclavicular regions using a portable scanner (*Sonosite*®). However, there was significant expansion of the volume of the cervical region in the first hours after surgery, particularly in the supraclavicular area, with tracheal deviation after a hypertensive peak (Figure 1). Orotracheal intubation ensured airway patency, and another duplex ultrasound examination detected a large cervical hematoma, a pseudoaneurysm of about 3.0 cm in its largest diameter, and flow coming from the subclavian artery (Figure 2). Another angiogram was requested for a better diagnostic assessment and to define the need to treat this condition using an invasive approach.

In case an intervention was indicated, the treatment options would be:

- Open surgery;
- Endovascular approach using a covered stent graft;
- Endovascular approach using superselective embolization, a nonstandard indication, because it consists of the occlusion of the extravascular space maintained by flow coming directly from the subclavian artery.

PART II - TREATMENT

The endovascular approach using superselective embolization was chosen. Access was established by means of a retrograde puncture and catheterization of the right common femoral artery using an 11-cm 5F introducer sheath (*St. Jude Medical*®). To plan the intervention, arteriography of the aortic arc and of the supra-aortic trunks was performed using a pig-tail 5F catheter (*Merit*®), and the results showed extravasation of the contrast medium in the proximal segment of the right subclavian artery, feeding a pseudoaneurysm through a small fistula close to the vertebral artery branch (Figure 3). We decided to occlude the lesion using coils and fibrin sealant. For that purpose, a 260-cm long 0.035" hydrophilic guide wire (*Aqualiner – Nipro*®) was advanced, followed by a 5F headhunter catheter (*Merit*®) for selective catheterization of the brachiocephalic trunk and the right subclavian artery, to which the hydrophilic guide wire was anchored. An introducer with a larger caliber (8F, 90 cm; *Flexor*, *Cook*®) was introduced, and a JR 6F catheter was advanced over it. Inside it, an Excelsion microcatheter (*Boston Scientific*®) was advanced over a 205-cm long 0.014" micro guide wire (Transend, Boston, Scientific®) for ultra-superselective embolization of the rupture on the wall of the subclavian artery. The microcatheter placed in this area was used for the placement of detachable micro coils according to the following sequence: 12 mm × 20 cm *Micrusphere Microcoil* (*Micrus*®);

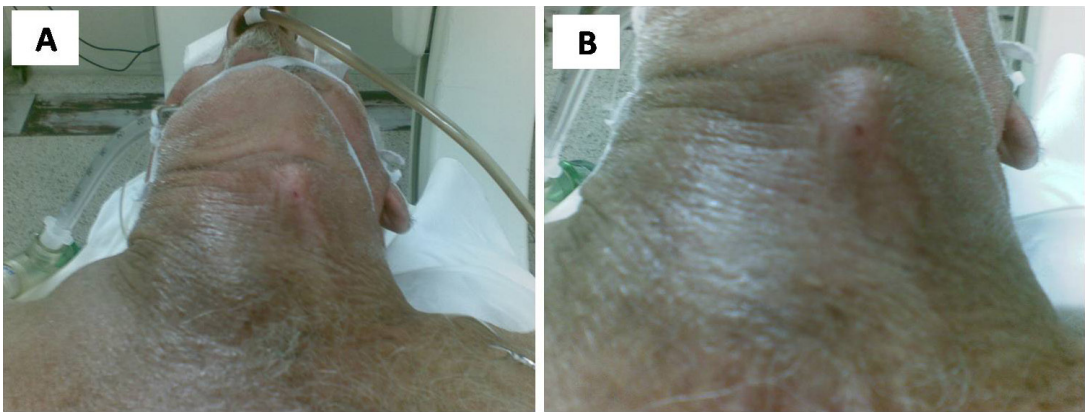

Figure 1. A- Full view of large pulsatile mass in right cervical and supraclavicular regions; B- Detail of hematoma and tracheal deviation.

10 mm × 20 cm *Micrusphere Microcoil* (*Micrus*®); 10 mm × 30 cm *Axium 3D Detachable Coil System* (*EV3*®); 4 mm × 12 cm *Axium 3D Detachable Coil System* (*EV3*®); and 7 mm × 18 cm *Microplex Coil system* (*Microvention - Terumo*®). After their detachment, angiography showed that the lesion was closed and the vertebral artery opacification improved, which suggested that the pseudoaneurysm had been "stealing" flow from this artery (Figure 4).

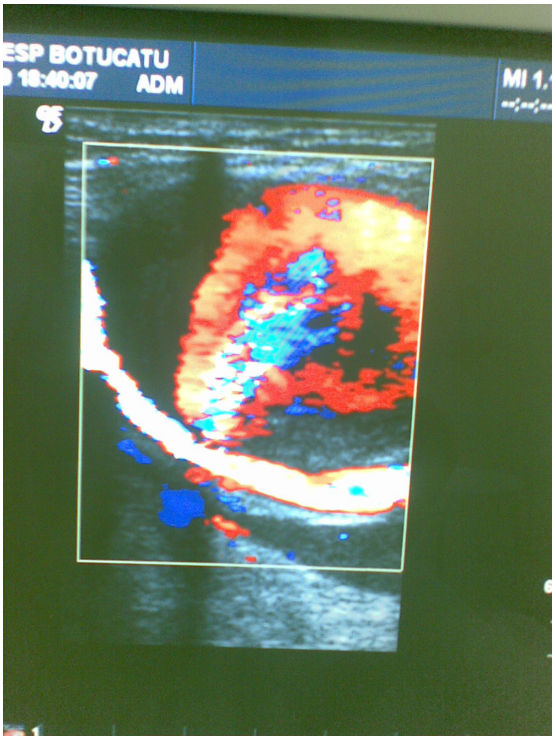

Figure 2. Duplex scan shows large pseudoaneurysm and characteristic bidirectional flow.

Although the result achieved after coil deployment was satisfactory, we chose to complement the procedure using a surgical sealant, because there was no actual wall containing extravascular flow. Cyanoacrylate (*Gluebran*®*-2*, *GEM*®) was selected instead of fibrin sealant because we feared that the latter might adhere to the catheter before it produced the desired effect in the pseudoaneurysm lesion. The treatment was effective, hemodynamic stability was achieved, and hematoma volume was substantially reduced (Figure 5). Control duplex scanning was performed 24 h and 48 h after the procedure, and pseudoaneurysm occlusion was confirmed.

DISCUSSION

A central venous line may be greatly useful in monitoring the cardiovascular functions of patients in critical condition and as a route to administer vasoactive drugs or solutions that would irritate peripheral veins, such as total parenteral nutrition[14-16]. With advances in intensive care practices, the number of such procedures has increased progressively, and numerous, more severe complications are seen today[14,16]. According to the literature, the most frequent complications are incorrect positioning, arterial puncture and pneumothorax, and they may often be diagnosed at the time of the procedure[17]. The main causes of complications are the inexperience of the operating physician or the possible anatomic variations[14,16]. Moreover, there is no direct visualization of structures, which increases the chances of errors[17]. The compression of hematomas and the control of mechanical ventilation parameters, in cases of superficial ventilation or apnea, as well as the use of ultrasound scanning to guide puncture, may minimize problems associated with central

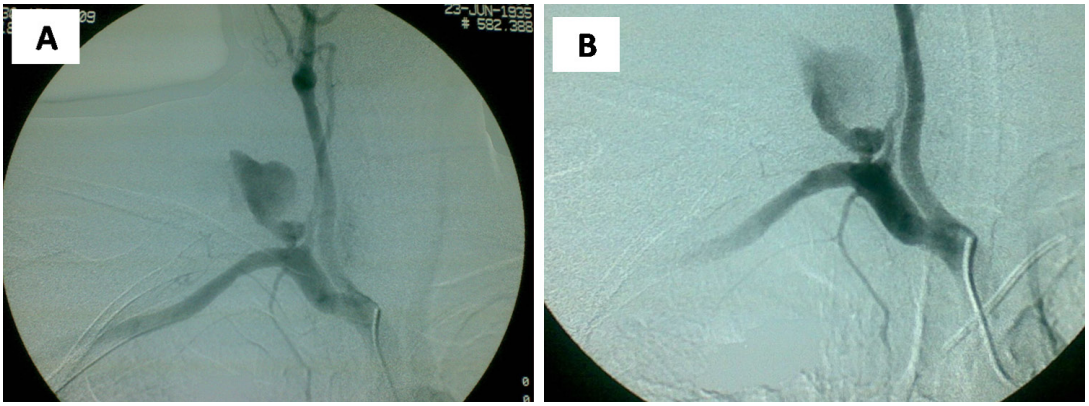

Figure 3. A- Selective arteriogram of brachiocephalic branch shows contrast medium extravasation from lesion in right subclavian artery close to vertebral artery branch. B- Angiogram shows that subclavian artery lesion is close to vertebral artery branch.

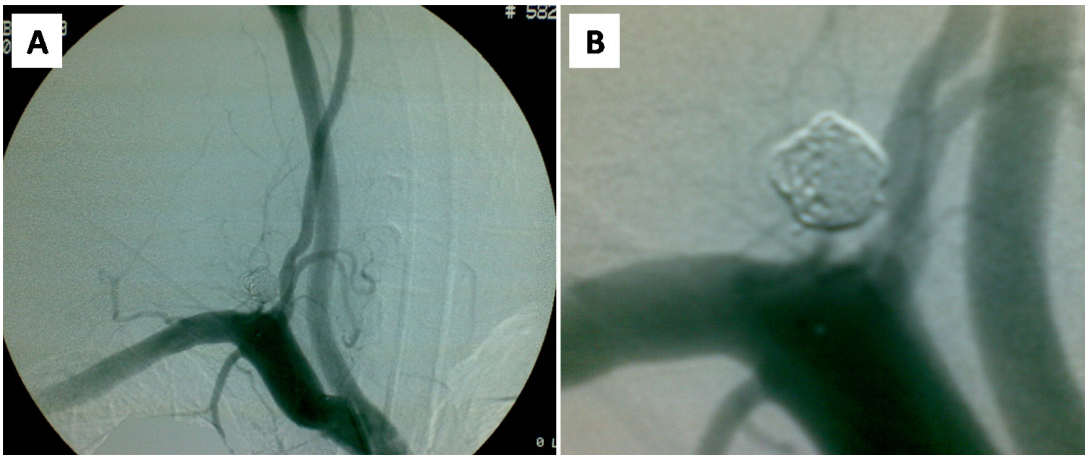

Figure 4. A- Final angiogram after pseudoaneurysm was corrected using superselective embolization and micro coils. B- Lesion details.

Figure 5- Significant reduction of cervical hematoma volume 48 h after procedure.

venous accesses[16]. Pseudoaneurysms of large vessels or the subclavian artery are rare after central venous punctures and are estimated to occur in 0.05 to 2% of the cases. Complications may include the expansion and compression of respiratory and adjacent neurovascular structures, rupture, thrombosis and skin erosion and external bleeding[18,19].

In the surgical treatment of subclavian artery pseudoaneurysms, proximal control may require the exposure of the retroclavicular segment of the subclavian artery, with or without thoracotomy, which poses risks to important structures, such as the left phrenic nerve to the left of the thoracic duct and the brachial plexus, in addition to hemorrhage during disection[20]. In this case in particular, the endovascular approach was, in the authors' opinion, the best option, because it would be difficult to control the lesion during open surgery as the supraclavicular space was occupied by the pseudoaneurysm, which might complicate access. Moreover, the lesion was located in the subclavian artery between the first and second anatomic segments, and open surgery would require that the segment covered by the anterior scalene muscle be approached. The first treatment option was the placement of a covered stent[21], but the proximity to the vertebral artery branch indicated risk of occlusion that might lead to cerebellar ischemia, which would further complicate the patient's already serious clinical condition. The choice was, therefore, to proceed with superselective embolization to treat the lesion.

After the advent of micro catheters and micro guide wires, initially designed for neuroradiology interventions[22,23], pseudoaneurysms can be treated selectively without compromising blood flow to adjacent regions. The precise deployment of micro coils is possible after their correct positioning is confirmed using arteriography. This technique minimizes the risk of coil migration and has better immediate results.[24]

In conclusion, embolization with micro coils may be one more alternative for a less invasive treatment of iatrogenic puncture lesions.

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