Bailout Maneuvers to Avoid Brain Infarct During Aneurysm Exclusion Using the Nexus™ Endograft: A Case Report

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The aim of this study is to report our experience with a complication that occurred during a single-branch aortic arch endograft deployment for a symptomatic aortic aneurysm exclusion. An 85-year-old patient was diagnosed with an aortic arch and descending aortic aneurysm associated with chest pain and dyspnea. After a multidisciplinary discussion, we selected an endovascular approach using an off-the-shelf device for the arch (Nexus™ endograft; Endospan) with a single branch for the brachiocephalic trunk (BCT). Supra-aortic trunks debranching (right common carotid-left subclavian bypass and left common carotid artery reimplantation) was planned in the same procedure. After an uneventful main module deployment, the release of the ascending graft was followed by the sudden occlusion of the endograft branch. Suspecting the branch coverage by the ascending module, a relining of the branch using the through-and-through guide wire was performed restoring brain perfusion. The post-operative course was uneventful as well during the follow-up (6 months). In our experience, the Nexus™ endograft (Endospan) presents peculiar technical features that provide great main module deployment stability and allow for rapid bailout maneuvers if complications occur.

Keywords: branched aortic arch endograft; aortic aneurysm; cerebrovascular complications; bailout maneuvers; case report

Introduction

The endovascular repair (ER) of aortic arch pathologies is indicated for patients not suitable for open surgery and with a favorable anatomy [1]. In the last years, many authors have reported their experiences with hybrid or total endovascular solutions, with good results in terms of technical success and acceptable rates of mortality and stroke with a proximal sealing in zone 0 [1–4]. Several technical options are available, from total ER with fenestrations or branches, to hybrid solution involving supra-aortic trunks (SAT) debranching. The Nexus™ single-branch stent graft (Endospan, Herzlia, Israel) is a bi-modular off-the-shelf branched device, designed with a proximal component for the ascending aorta, and a distal main module for the aortic arch and descending aorta with an outer branch for the brachiocephalic trunk (BCT). The midterm results are promising [5], yet the use of this endograft is recommended in experienced centers, with a multidisciplinary team that masters the deployment technique and can perform bailout maneuvers in case of adverse events.

We present the case of a patient with a symptomatic aortic arch and descending aortic aneurysm, treated with a Nexus™ single-branch stent graft (Endospan) and SATs debranching, with the need of an adjunctive maneuver to resolve the intraoperative occlusion of the endograft branch. To our best knowledge, this is the first report describing acute branch occlusion during deployment, successfully resolved with a bailout maneuver.

Case Report

An 85-year-old patient with a history of atrial fibrillation, chronic kidney disease (stage IIIb) and dyslipidemia, was admitted to the emergency room with chest pain and dyspnea. The computed tomography angiography (CTA) revealed the presence of an aneurysm of the aortic arch and the descending thoracic aorta, with a maximum diameter of 67 mm, without signs of aortic rupture. Preoperative imaging included also cerebral computed tomography (CT) and CTA, which excluded significant cerebral vascular pathology. The case was discussed in a multidisciplinary team, and an exclusive open repair was excluded because of an unacceptable operative risk due to a severe chronic obstructive pulmonary disease. We selected an endovascular treatment using the Nexus™ endograft (Endospan, Herzlia, Israel) with a single branch for the BCT.

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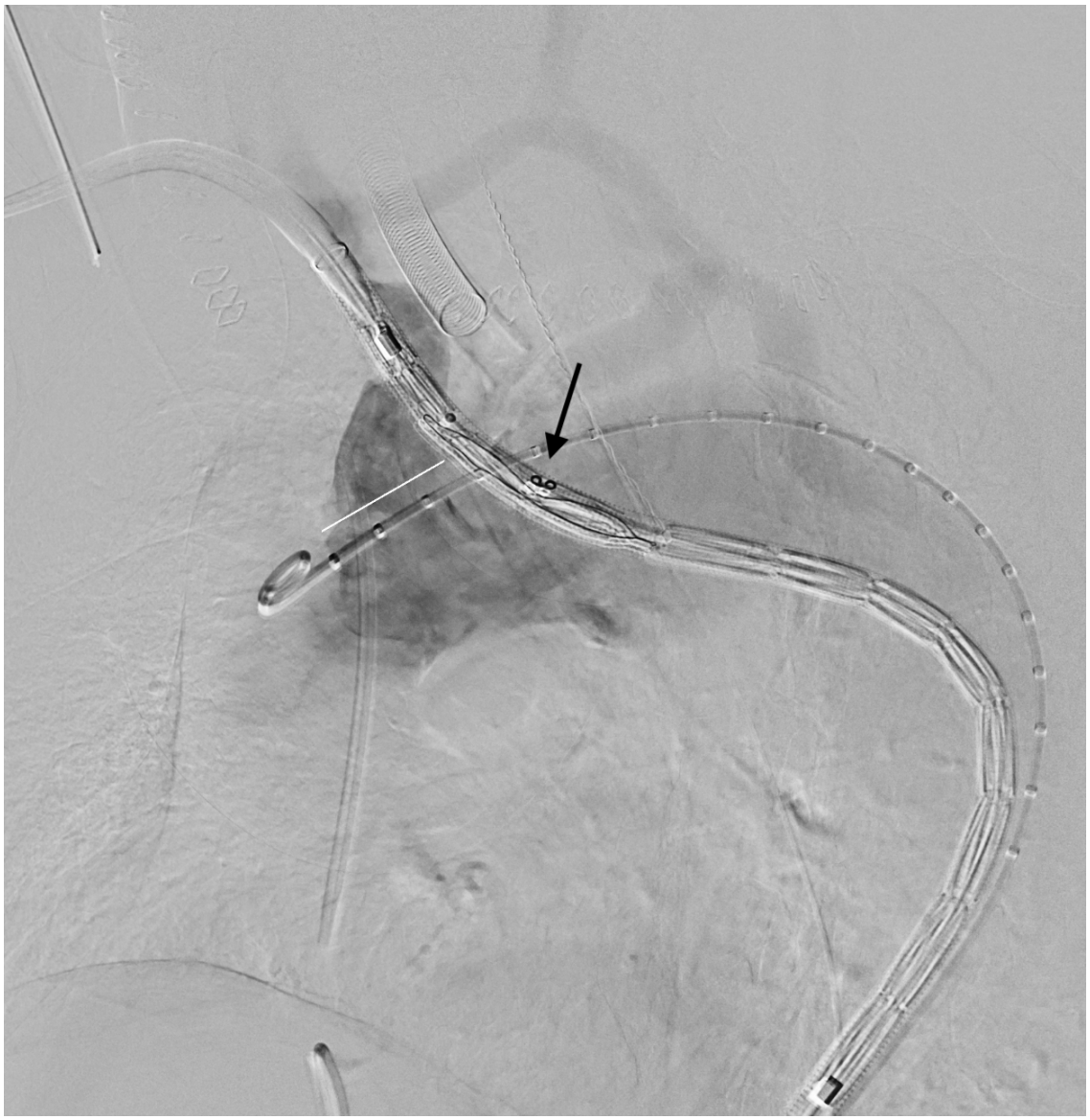

Fig. 1. The main module is advanced over the through-and-through guidewire system and the correct graft position and orientation are verified (the black arrow highlights the graft marker).

The intervention was performed in a hybrid operating room, under general anesthesia and CTA fusion-guidance. After a bilateral supraclavicular incision, both common carotid arteries and the left subclavian artery were exposed. Systemic heparinization was repeated as needed during the intervention, depending on the activated clotting time value. A right carotid-left subclavian bypass via an antero-tracheal way, using an 8 mm polytetrafluoroethylene graft (Gore Medical, Flagstaff, AZ, USA). Then, the left common carotid artery was reimplanted on the graft, and its proximal stump was secured with a suture. Through ultrasound guidance, bilateral percutaneous femoral and right axillary accesses were achieved, using a pre-closure technique with two Perclose ProGlide™ (Abbott, Chicago, IL, USA) for each access. A 6 Fr introducer was also positioned in the right common femoral vein, in order to advance the rapid pacing catheter into the right atrium. The endograft deployment required a through-and-through system from the right axillary artery to the right femoral artery, using a hydrophilic 0.035–400 cm guidewire (Radifocus™, Terumo, NJ, USA). After an accurate flushing of the endograft (CO_2 + 140 mL saline solution), the 32 × 180 main module of the Nexus™ stent graft (with a 14 × 20 branch) was advanced through the right femoral access up to the aortic arch with the shaft-tip in the innominate trunk. After the verification of the correct graft orientation (Fig. 1), the main module was released. Through a guidewire with the proximal loop in the left ventricle (SAFARI^2, Boston Scientific, Marlborough, MA, USA), the Nexus™ ascending module (36 × 55; Endospan) was placed in the ascending aorta and released in rapid pacing.

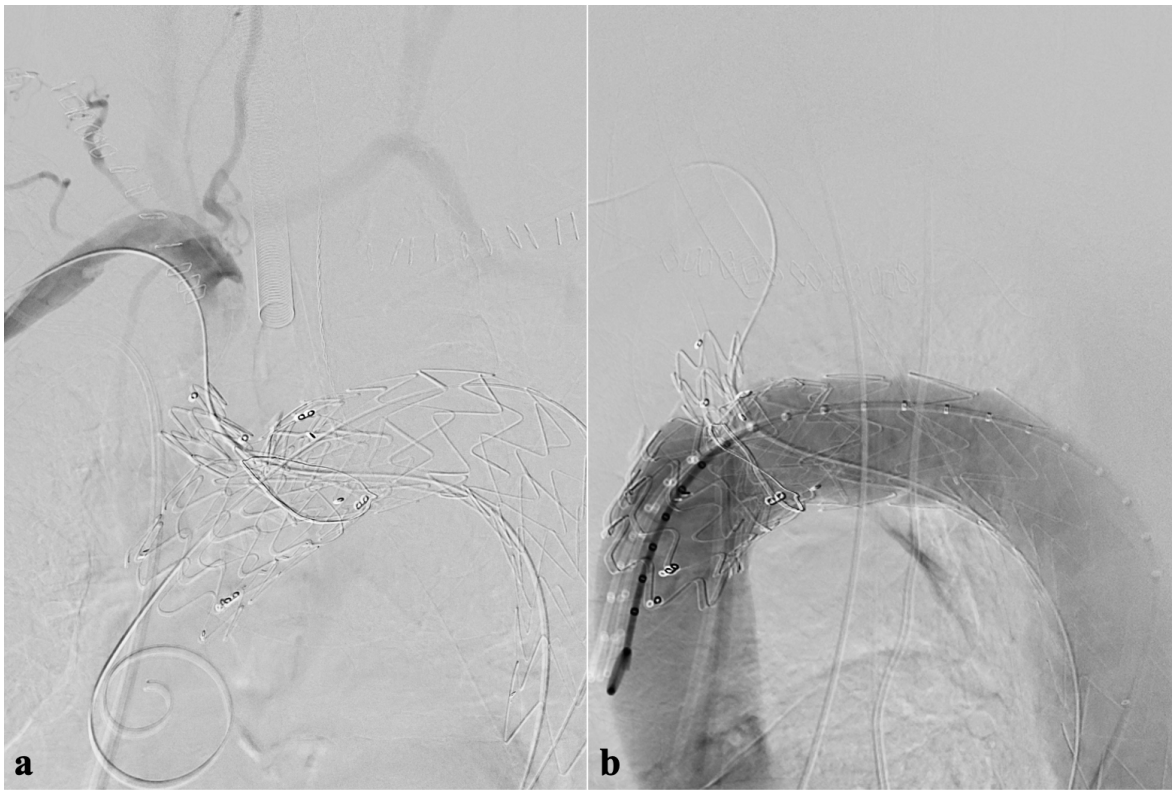

Fig. 2. Both digital subtraction angiographies performed from the right axillary access (a) and the ascending aorta (b) show the branch occlusion.

Once completed the release, the invasive arterial monitoring placed in the right radial artery registered a sudden decrease in blood pressure, while the arterial monitoring in the left radial artery did not show any variation. The digital subtraction angiography (DSA) performed from the right axillary artery showed the occlusion of the endograft branch (Fig. 2a), confirmed by the DSA from the Pigtail catheter (Cordis, Santa Clara, CA, USA) placed in the ascending aorta, (Fig. 2b). The near infrared spectroscopy (NIRS) did not register any significant variations in cerebral oximetry. The aneurysm sac was still perfused from the distal edge of the graft, all SATs were patent and perfused through the left subclavian artery (LSA) and the bypass since the LSA plug had not yet been deployed.

We suspected that the ascending module was positioned at the level of the branch, covering its origin. Since the through-and-through guidewire system was still in place, we advanced a Dryseal™ (Gore Medical, Flagstaff, AZ, USA) 16 Fr and thereafter a Gore® Excluder® PLC161000 graft (Gore Medical) in the branch, and we performed a new molding of the whole implant. The completion DSA showed the patency of the new branch, the bypass and the SATs (Fig. 3). The patient awakened without any neurological complication. After a week, the procedure was completed by releasing a distal thoracic graft extension up to the celiac trunk origin and by LSA embolization with a 14 mm Amplatzer™ Vascular Plug (Abbott, Chicago, IL, USA). The post-operative course was uneventful. The 30-days CTA showed the patency of the endograft and the SATs, without graft kinking or compressions and without endoleaks. At one-year follow-up, the patient maintained a satisfactory quality of life, compatible with age, and remained free of neurological complications.

This case has been reported in line with the case report guidelines: Case Report (CARE) Guidelines to ensure the accuracy and completeness of the report (**Supplementary Material**).

Discussion

The ER of aortic arch pathologies provides undeniable advantages, such as the avoidance of hypothermic circulatory arrest and of cardiopulmonary bypass, and a minimally invasive approach. Symptomatic cases requiring a proximal sealing in zone 0 are often challenging since endovascular solutions such as tubular thoracic endografts with SATs debranching or parallel graft techniques are associated up to 40% of complications and reintervention rate, with a 6-year aortic event-free rate of 57% [3,6]. A recent meta-analysis analyzed 18 studies on fenestrated and branched devices for the aortic arch, showing an overall technical success of 96.8% and 96%, respectively, with a lower rate of type I and III endoleaks for branched devices [7].

In our institution, aortic arch pathology is treated either with open replacement, which is still the gold standard in fit pa-

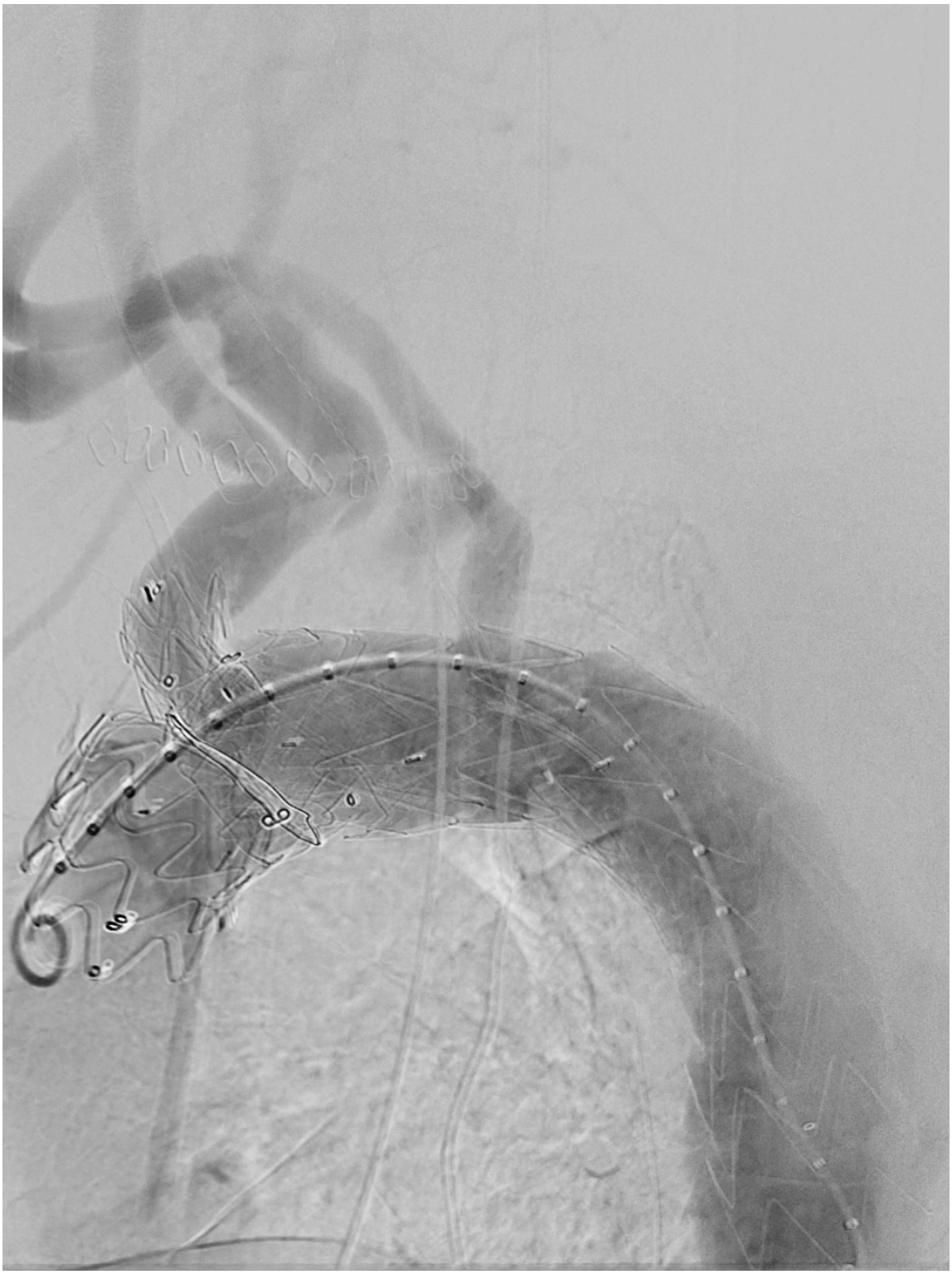

Fig. 3. The final angiography showing the patency of the endograft and the supra-aortic trunks.

tients [8], or with branched endografts. We have wide experience with a variety of custom-made solutions for aortic zone 0, however their manufacturing time prevents the physician from using them in urgent cases. To date, the only off-the-shelf branched device conceived to land in aortic arch zone 0 is the Nexus™ endograft (Endospan) [3], always associated to SATs' debranching. Reports on worldwide experience concentrated in the last five years. Planer *et al*. [9] presented in 2023 a multicenter international experience with preliminary results on 28 patients with aortic aneurysms and chronic dissections. Technical success was 100%, while the successful disease treatment at 30 days was

achieved in 96% of patients. The procedure-related mortality was reported in 2 patients (7.1%), one of them for multiple brain infarcts. Reinterventions were performed in 3 patients in the first post-operative year: in the first case an intraoperative perforation of the left ventricle was resolved by releasing a plug and coils; the second patient had an asymptomatic ascending aorta intramural haematoma, that evolved in a type A asymptomatic dissection in the first three months, and was treated with an open conversion and removal of the ascending module; in the third case the patient underwent a percutaneous embolization of gutters endoleak. A report of the three years results of this endograft were presented by D'Onofrio *et al*. [5], with good results. During the examined period, no open conversion was required, two patients required a distal thoracic extension for disease evolution, and one patient required e left subclavian stent relining. No patient had paraplegia nor myocardial infarction or major stroke, while one patient had a transient ischemic attack that resolved within 24 hours.

Considering the cumulative stroke rate of endovascular arch devices [10], the Nexus™ endoprosthesis (Endospan) was not associated with a high rate of cerebrovascular events in the aforementioned reports. This may be due to the self-oriented deployment system and to the through-and-through wire [11], both reducing aortic arch manipulation and thus the risk for embolic stroke. This system also increases the stability of the implant during the deployment of the main endograft module, allowing to resist pulsatile pressure and migration forces, and allowing bailout maneuvers when needed. In our particular case, the through-and-through wire system was of primary importance, since it allowed to deploy a novel stent-graft in the branch when it was covered by the ascending module, without the need for re-cannulating it and thus avoiding a repeated arch and BCT manipulation. In fact, even if the ascending module is pre-curved and released under rapid pacing, its deployment is more prone to displacement events related to aortic arch movements and blood pressure.

Our case shares several similarities with the aforementioned literature on the Nexus™ endograft, particularly regarding patient profile (elderly, high-risk) and treatment strategy (single-stage endovascular arch repair with supra-aortic debranching). On the other hand, the main differences between our case and the currently published literature are related to the type, timing, and management of branch-related complications. In prospective multicenter study [5], no cases of acute intra-procedural branch occlusion have been reported. The only supra-aortic vessel intervention described was a left subclavian artery relining performed during follow-up for disease progression, unrelated to the performance of the branch component. In contrast, our case documents the first instance of acute intra-procedural branch occlusion, promptly recognized and successfully managed with immediate relining, thanks to the preservation of through-and-through wire access and the use of comprehensive intraoperative monitoring. This highlights the importance of proactive intra-procedural strategies. In fact, we believe that the crucial take-home messages regarding this case are the importance of maintaining the through-and-through guidewire system until the branch patency confirmation, the usefulness of multimodal monitoring (DSA, NIRS and bilateral arterial pressure monitoring) that has allowed for an early detection of branch occlusion, and the necessity of been prepared for bailout maneuvers with adjunctive grafts or balloons, since the deployment of the ascending module can be more related to displacement.

The main limitations of the Nexus™ single-branch (Endospan) are related to the need for an adjunctive surgical procedure. In fact, it always requires SATs debranching, slowing down the overall procedure in really emergent cases. Furthermore, when the branch is intended for the BCT, the whole brain perfusion relies on a single vessel. Finally, the device adaptability to all anatomies is still a matter of discussion: while according to Hauck *et al*. [12] and Smorenburg *et al*. [13], and respecting the strict instruction for use (IFU), the endograft adapted to 39/101 and 31/377 patients, respectively, Bisdas *et al*. [14] reported a limited experience on the Nexus™ (Endospan) deployed outside IFU, with a 100% technical success and no aortic-related adverse events at 1 year.

Conclusions

The Nexus™ single-branch (Endospan) is related to high intraprocedural technical success, low stroke rate and promising results in the midterm. In our experience, we believe that features such as the through-and-through wire and the self-oriented system for the deployment of the main module provide great stability and allow for bailout maneuvers even when complications occur. The so-far reported literature provides good results, however a longer follow-up and a larger number of patients are advisable.

Availability of Data and Materials

The data used in the current study are available from the corresponding author upon reasonable request.

Author Contributions

Conception and design of the study: ECC, ADO, FG, MA; data collection: GA; data analysis and interpretation: ECC, GA, MP; article drafting and revision: ECC, GA; study supervision: MA, ADO, FG. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The study was performed in accordance with ethical standards of the Declaration of Helsinki. The study obtained the patients' informed consent. Ethics approval has been waived by the Territorial Ethics Committee of Central-East Veneto Area.

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Conflict of Interest

The authors declare no conflicts of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.62713/aic.4103.

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