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A Case Report on Cardiovascular Rehabilitation After Repair of Residual Aortic Dissection: An Under-Explored Benefit?

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Abstract

Aortic aneurysms present a high risk of dissection and mortality. They are associated with decreased functional capacity and activities of daily living after surgical correction. Although supervised cardiovascular rehabilitation (SCR) is an important therapeutic resource in the treatment of patients with cardiovascular diseases, its use in patients with aortic aneurysms after dissection is still incipient and little discussed. The aim of this study is to foster discussion on the safety and benefit of SCR in patients with aortic aneurysms after corrected dissection through the description of a case report. The patient was male, 45 years old, with grade II obesity, heart failure with normal ejection fraction, systemic arterial hypertension, and familial dyslipidemia. He was referred to the SCR service of the Actus-Cordios Clinic in July 2022 after correction of residual chronic dissection in the descending aorta. He underwent SCR for seven months. This case report was approved by the Ethics and Research Committee under CAAE No. 94518825.0.0000.5544. After seven months of treatment, there was an increase of 240 meters, representing a 200% improvement in the 6-minute walk test (120 vs. 360 meters), a reduction in blood pressure (140 vs. 125 mmHg and 90 vs. 80 mmHg, respectively, for systolic and diastolic blood pressure), in addition to regaining the autonomy to work and study. In this case report, we document the feasibility of an SCR program following the repair of a Type A aortic dissection with residual aortic disease. No clinically detected cardiovascular or aortic adverse events were reported during the program, while we observed an increase in functional capacity and a reduction in resting blood pressure, accompanied by a return to activities of daily living. These observations that the multidisciplinary team to consider SCR for this population whenever there is no absolute contraindication.

Categories: Physical Medicine & Rehabilitation, Cardiology, Cardiac/Thoracic/Vascular Surgery
Keywords: aortic aneurysm, aortic dissection, cardiac rehabilitation, exercise, return to work

Introduction

According to the aortic disease guideline produced by the American Heart Association/American College of Cardiology [1], an arterial aneurysm is defined as any artery that is dilated to at least 1.5 times its expected normal diameter. For the aortic root and ascending aorta, the defined value is ⩾4.5 cm. Aortic dissection is characterized by a rupture in the intima layer that allows blood to pass into the media layer of the aorta, dividing the aortic wall into two longitudinal layers. This event creates a flap that separates the true lumen from a newly formed false lumen. Finally, dissection can culminate in complications ranging from acute aortic insufficiency, myocardial ischemia, stroke, peripheral organ ischemia, and even sudden death [1].

According to the Stanford classification, aortic dissections are classified as Type A and Type B. Type A encompasses all dissections involving the ascending aorta, regardless of the location of the intimal rupture. Type B includes all dissections that do not involve the ascending aorta (including dissections involving the aortic arch but sparing the ascending aorta) [1]. Furthermore, according to the Society of Thoracic Surgeons and the Society for Vascular Surgery, aortic dissection can be classified as acute (1 to 14 days), subacute (15 to 90 days), and chronic (over 90 days) based on the onset of symptoms [1].

Although the literature indicates significant advances in the management of these patients, including those undergoing surgical repair [2], the negative impact on quality of life and functional capacity, as well as the mortality risk in this population, remains high [3]. Supervised cardiovascular rehabilitation (SCR) with physical exercise as its primary intervention modality stands out among the measures that can be adopted to improve functional capacity and quality of life, reduce preoperative risk for chronic dissection repair, and optimize risk factor control in these patients [4,5]. The 2022 ACC/AHA Guideline for the Diagnosis and

Management of Aortic Disease recommends postoperative SCR for patients undergoing corrective surgery for aortic aneurysm or dissection (Class 1, Level of Evidence C-EO). However, evidence remains limited regarding the optimal exercise dosage, the use of resistance and isometric training, and strategies for monitoring and individualizing exercise progression for this population.

Therefore, given the uncertainties that still surround the indication of SCR for patients with dissecting aortic aneurysm, the present study aims to foster discussion about the safety and benefit of this therapy for this population. To this end, we describe in this case report how an SCR program consistently improved functional capacity and return to work after surgical correction of a patient affected by a Stanford A aortic dissection.

Case Presentation

The patient was male, 45 years old, with a body mass index of 36 kg/m² (grade II obesity) and a sedentary lifestyle (for the past 10 years). He has a prior clinical diagnosis of heart failure with preserved ejection fraction, systemic arterial hypertension, and primary dyslipidemia (for 25 years), as well as venous insufficiency (Clinical-Etiological-Anatomical-Pathophysiological classification III) and a history of transient ischemic attack with motor sequelae in the right lower limb (resulting in a claudicating gait). He also reports a history of obstructive sleep apnea (for 10 years), glomerulonephritis (2018), and deep vein thrombosis in the right lower limb (2020).

The patient was referred to the Cardiovascular and Metabolic Rehabilitation service at Actus-Cordios Clinic, Salvador, Brazil, in July 2022, after being complemented with the correction of residual chronic dissection in the descending aorta in May 2022. He was taking the following medications: acetylsalicylic acid 100 mg, metoprolol succinate 100 mg tablet twice a day, amlodipine besylate 10 mg once a day, valsartan 360 mg once a day, rivaroxaban 20 mg once a day, atorvastatin calcium 40 mg once a day, and esomeprazole magnesium 40 mg.

Despite the aforementioned drug treatment, the patient exhibited symptoms of functional class III-IV (New York Heart Association), reporting fatigue during usual activities such as talking, eating, and walking, a feeling of suffocation while sleeping, and restrictions on work activities (being away from work and college for three years). The patient also reported no family history of a similar condition among first-degree relatives.

During the physical examination, a heart rate of 97 bpm, blood pressure of 140/90 mmHg, oxygen saturation of 97%, handgrip strength of 31 kg in the dominant limb (expected for age: 56 kg), and a distance of 120 meters were recorded in the 6-minute walk test (expected for age: 599 meters).

The complementary examinations performed included an echocardiogram (June 2022), which showed an aortic root of 45 mm, a left atrial diameter of 39 mm, an interventricular septal thickness of 12 mm and a posterior wall thickness of 11 mm, a left ventricular mass of 227 g, and an ejection fraction of 76%. The electrocardiogram (April 2022) revealed sinus rhythm, a positive Morris index, diffuse nonspecific ventricular repolarization abnormalities, and signs suggestive of concentric ventricular hypertrophy. The main results of the laboratory tests performed in April 2022 are presented in Table *1*.

Laboratory variable	Value obtained	Reference value*
Creatinine (mg/dL)	1.42	Up to 1.2
Triglycerides (mg/dL)	111	Up to 150
Low-density lipoprotein (mg/dL)	22	Up to 130
High-density lipoprotein (mg/dL)	32	Ideal above 50
Fasting blood glucose (mg/dL)	92	Up to 99
Glycated hemoglobin (%)	5.7	Up to 5.6
Fibrinogen (mg/dL)	402	Up to 400
Pyruvic glutamic transaminase (U/L)	23	Up to 50
Glutamic-oxaloacetic transaminase (U/L)	19	Up to 50

TABLE 1: Laboratory results (April 2022)

*According to the laboratory method and kit used by the pathology laboratory.

Regarding the surgical correction, we highlight that initially, a Type A aortic dissection was repaired in 2019 (Hemashield tube), and subsequently, in May 2022, the treatment was complemented by the correction of residual chronic dissection in the descending aorta using an endoprosthesis implant that extended from the ascending aorta to the descending thoracic aorta. Figure *1* shows the aortic angiotomography before and after the surgical correction.



FIGURE 1: Aortic computed tomography angiography before and after endoprosthesis implantation

Figure *2* describes the temporal sequence of the main clinical events that the patient presented with, as well as the start and end of the SCR. We highlight the diagnosis of HTN and glomerulonephritis that preceded the surgeries. As the guidelines indicate [1,2], two important factors in the development of aneurysm include HTN and kidney disease.

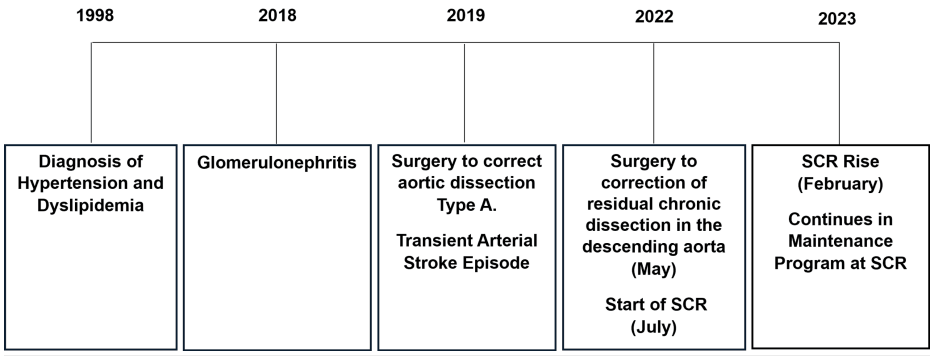


FIGURE 2: Timeline of key clinical events, from the start to discharge of supervised cardiovascular rehabilitation (SCR)

SCR program

At the end of the evaluation, the following objectives for the SCR program were determined: Improve functional capacity (achieve grade II on the NYHA functional capacity scale); increase activities of daily living, especially enabling the patient to return to work and study (complete higher education); achieve blood pressure ⩽120/80 mmHg. The proposed prognosis for achieving these objectives was seven months.

We started the SCR program on July 4, 2022, and it ended in February 2023. With two weekly sessions in the first month and three weekly sessions in the following months, totaling 8 to 12 sessions per month. In the event of an absence, the session was made up within the same week. The sessions consisted of inspiratory muscle training (IMT), hand grip training, resistance exercises, and cyclic exercise, all performed under electrocardiographic monitoring (ECAFIX multiparameter cardiac monitor, model Active®, São Paulo, SP, Brazil).

To determine the intensity of effort, two Rating of Perceived Exertion (RPE) scales were presented and anchored: the Omni scale and the Borg scale. The Borg scale was applied to cyclic exercises, and the Omni scale was used to determine the effort of the active musculature in resistance exercises. It is worth noting that the Borg scale was also applied to resistance exercises to limit cardiorespiratory intensity, that is, to ensure that cardiorespiratory effort did not exceed >10 in the first month and >13 in subsequent months. The resistance training program was adjusted monthly after scheduled reassessments.

The IMT load was prescribed based on the Borg scale, as proposed by our research group [6]. This approach was based on the correlation identified between the inspiratory muscle glycemic threshold and perceived exertion assessed using the Borg scale [6]. Accordingly, the initial training load was adjusted to a Borg rating between 9 and 10 and progressively increased to a Borg rating of 13. The patient was instructed to perform breathing exercises using the Powerbreathe Classic Medic device (POWERbreathe International Ltd, Southam, Warwickshire, United Kingdom), with the aid of a nose clip, following a rhythm of faster inhalation and slower exhalation (approximately 1.5 seconds for inhalation and 2.5 seconds for exhalation). To determine the initial handgrip load, we used the WCT Fitness® Hand Grip hand dynamometer (WCT Fitness, Joinville, Santa Catarina, Brazil), following the dynamometry protocol of the American Society of Hand Therapists [7]. The entire evolution of the program is summarized in Table *2*.

Month/year	Exercise employed	Volume	Duration	Interval	Intensity
July/2022	Bilateral hand grip	3 sets, 2 times a week	30 seconds of isometric hold	1 minute between sets	No load
	IMT	3 sets of 3 repetitions, 2 times a week	-	1 minute between sets	Light, Borg 9 to 10, load: 1
	Resistance exercise¥	3 single-joint exercises, 4 sets of 6 repetitions, 2 times a week	-	2 minutes between sets	Light, Borg up to 10*, Omni 1 to 2#
August and September/2022	Bilateral hand grip	3 sets, 3 times a week	1 minute of isometric contraction	1 minute between sets	10% of MHS
	IMT	3 sets of 10 repetitions, 3 times a week	-	1 minute between sets	Moderate, Borg 10 to 12, load: 2-4
	Resistance exercise¥	4 single-joint exercises, 4 sets of 6 repetitions, eccentric contractions only, 3 times a week	-	2 minutes between sets	Moderate, Borg up to 11*, Omni 3 to 4#
October and November/2022	Bilateral hand grip	4 sets, 3 times a week	1 minute of isometric contraction	1 minute between sets	20% of MHS
	IMT	3 sets of 10 repetitions, 3 times a week	-	1 minute between sets	Moderate, Borg 12 to 13, load: 5-7
	Resistance exercise¥	4 single-joint exercises, 4 sets of 6 repetitions, eccentric contractions only, 3 times a week	-	2 minutes between sets	Moderate, Borg up to 11*, Omni 5 to 6#
	Squat	2 sets of 8 repetitions	-	2 minutes between sets	Moderate, Borg up to 12
	Treadmill	3 sets	2 minutes	2 minutes of passive rest between sets	Light, Borg 9 to 10
December/2022 January/2023	Resistance exercise¥ + IMT (20% of the final training load)	4 multi-joint exercises, 4 sets of 6 repetitions, 3 times a week	IMT during the execution of movements with 20% of the training load	2 minutes between sets	Moderate, Borg up to 12*, Omni 7 to 8#, IMT load: 2
	Climbing stairs	1 set of two floors	-	-	Moderate, Borg up to 12
	Treadmill	Heating	3 minutes	-	Light, Borg 9 to 10
		Conditioning: 4 sets	2 minutes	2 minutes of passive rest between sets	Moderate, Borg 13

TABLE 2: Supervised exercise program from July 2022 to February 2023

¥Bilateral elbow flexion (first month: 2 kg/last month: 13 kg), unilateral elbow extension (first month: 1 kg/last month: 7 kg), unilateral knee flexion (first month: no load/last month: 5 kg), and bilateral knee extension (first month: 6 kg/last month: 30 kg). *Borg scale was used so that the patient could achieve the proposed muscle effort without exceeding a cardiorespiratory effort >10 in the adaptation training and >12 in the conditioning training. #Subjective scale of effort referred to muscles in activity.

IMT, inspiratory muscle training; MHS, maximum handgrip strength.

It is important to highlight that, as a safety parameter, we used real-time electrocardiographic monitoring (to track the appearance of arrhythmias). Based on the literature, we opted for a conservative safety strategy predefined by the multidisciplinary team. We stipulated that during exercise, systolic blood pressure (SBP) should not exceed 20 mmHg above resting SBP, and diastolic blood pressure (DBP) should not rise more than 10 mmHg above resting DBP. Furthermore, SBP should not exceed 180 mmHg, and DBP should not exceed

110 mmHg, as described by Ehrman et al. [8]. Also, in the first three months, SCR sessions were applied between 10:00 and 11:30 a.m. as an additional conservative strategy, so that the exercises were performed at the time of the circadian cycle of lowest magnitude of pressure response [9].

During the sessions, blood pressure was monitored via regular measurements taken at the end of each exercise modality and after each set of the neuromuscular resistance exercise. There were no episodes of arrhythmia or blood pressure spikes requiring the interruption of any session throughout the duration of the SCR program.

The patient signed a free and informed consent form, authorizing the description and publication of this study. This case report was approved by the Ethics and Research Committee of the Bahiana School of Medicine and Human Health, Salvador, BA, Brazil, under CAAE No. 94518825.0.0000.5544, in accordance with the Declaration of Helsinki.

After seven months, there were no changes to the medication used from the beginning to the end of the SCR. There were also no changes in laboratory tests or echocardiogram.

Figure *3* shows the blood pressure and resting heart rate values (monthly average) from the exercise sessions performed. We highlight the 16% decrease in resting heart rate and the 11% decrease in SBP and DBP.

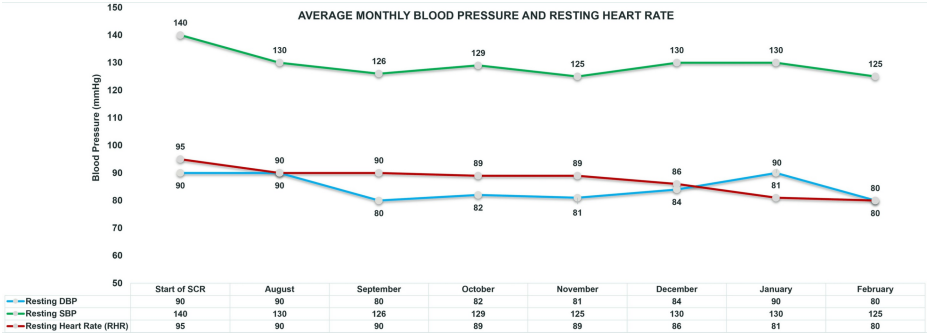


FIGURE 3: Monthly average of blood pressure and heart rate during the months of supervised cardiovascular rehabilitation

DBP, diastolic blood pressure; SBP, systolic blood pressure; SCR, supervised cardiovascular rehabilitation.

Figure *4* shows the evolution of functional capacity measured by the 6-minute walk test. We can observe that the patient increased by 240 meters, representing a 200% improvement when comparing the distance covered at the beginning and end of the SCR program.

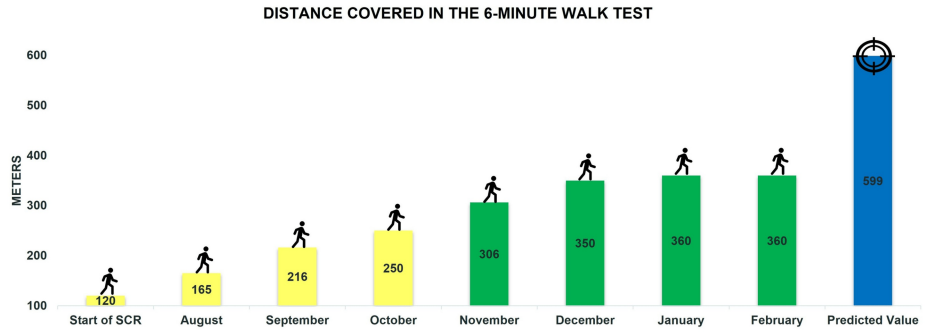


FIGURE 4: Distance covered in meters in the six-minute walk test

Predicted value: equation proposed by Iwama et al. for the Brazilian population [10].

SCR, supervised cardiovascular rehabilitation.

After the SCR, we observed improvements in physical and emotional aspects such as returning to studies and work, as well as walking, speaking, dressing, and eating without experiencing fatigue.

Finally, even after being discharged from the SCR program, the patient chose to continue at the clinic with a supervised maintenance exercise program. In June 2023, a new aortic angiotomography was performed by the same evaluator. A comparison between the exams (January 2022 and June 2023) highlighted a reduction in the maximum aortic diameters in the largest axes (7.2 x 6.9 cm vs. 6.9 x 6.1 cm), with no changes in the other measurements.

Table 3 presents the results of the pre-surgical aortic computed tomography angiography and after the end of the SCR (specifically, four months post-SCR). The patient remained under care at the clinic as part of a supervised maintenance program.

Variable	Pre-surgical (Jan 2022)	Post-SCR (June 2023)
Measurement of the largest aortic axes#	7.2 x 6.9 cm	6.9 x 6.1 cm
True light compression*	Yes	Yes
Measurement of the smallest diameter of true light*	8 mm	8 mm

TABLE 3: Aortic computed tomography angiographies, pre- and post-surgical and post-SCR program

Angiography scans performed by the same professional. #Transition from the arch to the descending segment. *Terminal segment of the aorta.

SCR, supervised cardiovascular rehabilitation.

Discussion

The results of this case report suggest that a supervised cardiac rehabilitation program is a safe intervention for patients with repaired aortic dissection, capable of promoting better blood pressure control, increased functional capacity, and improvements in aspects of daily life.

Resting blood pressure and heart rate decreased over the course of the cardiac rehabilitation program, despite no change in prescribed cardiovascular medication. HTN is one of the comorbidities frequently found in patients with aortic aneurysms or dissections [11]. Furthermore, according to the Brazilian Society of Angiology and Vascular Surgery Guidelines for Abdominal Aortic Aneurysm [2], HTN is identified as a predictor of abdominal aneurysm rupture. In this line of thought, better blood pressure control becomes a preponderant factor in clinical management. Extensive scientific literature attests to the blood pressure-reducing effect promoted by physical exercise [12]. The main reasons for this reduction are the increased production of nitric oxide [13] and the decrease in hyperactivity of cardiac sympathetic tone [14], mechanisms that together improve the neurovascular dysfunction present in patients with aortic aneurysm [1]. The reduction in resting heart rate (15 bpm throughout the SCR period), as shown in Figure 3, may be consistent with improved autonomic cardiovascular regulation.

Scientific literature indicates that physical and functional capacity declines significantly over time following the surgical repair of aortic dissection, noting that the five-year mortality risk for this population is approximately 40% [3]. In contrast to what is described in the literature, the improvement in functional capacity reported in this case was remarkable. As shown in Figure 4, we observed a 200% improvement in the distance covered in the 6-minute walk test, and although the patient did not reach the expected distance for his age (599 meters), it is necessary to consider that he had a motor limitation (sequelae of transient ischemic attack) that made it difficult to walk with his right lower limb. In addition, when the patient entered the SCR, he could not climb a flight of stairs. By the end of the SCR, the patient was able to climb at least two flights of stairs, indicating an improvement in functional capacity, increasing from less than 3 metabolic equivalents of task (METs) prior to the SCR program to at least 5 METs afterward. One MET corresponds to the resting metabolic rate, conventionally defined as approximately 3.5 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$. In general, higher functional capacity is associated with a more favorable prognosis in populations with cardiovascular disease, reducing the relative risk of death from approximately 2.0 to 1.5, as described by Myers et al. [15]. Also, according to Myers et al. [15], each 1 MET increase in functional capacity confers a 12% increase in survival; indeed, for men, functional capacity is a more potent predictor of mortality than other established cardiovascular risk factors. However, it is imperative to acknowledge that, specifically regarding this case, it is not possible to infer any effect on mortality. It is worth noting, as previously mentioned in the results, that the patient remains in a cardiac rehabilitation maintenance program 4.5 years after surgical correction, continuing to engage in work and recreational activities.

According to Eranki A et al. [3], patients undergoing surgery to repair aortic dissection experience impaired quality of life compared with the general population in the same age group. In summary, the effects of the SCR in this case report contributed to improved functionality and the remission of disease-related symptoms, positively impacting the patient's perception of their health. Among the improvements, we highlight the cessation of the sensation of "shortness of breath" and limiting fatigue, the return to work and recreational activities, as well as progress in the feeling of self-control in life, which reduced self-reported feelings of depression.

As described in Table *3*, computed tomography angiography did not identify any unfavorable progression of aortic vascular geometry during the period of regular physical exercise. Experimental scientific evidence (in animal models) suggests that physical exercise provides protection to the aortic wall, leading to reduced elastin fragmentation and a decrease in the expression of matrix metalloproteinases 2 and 9 [16].

The European Society of Cardiology included SCR as the fifth pillar of heart failure treatment, contributing mainly to outcomes such as reduced hospitalization and improved quality of life [17]. Based on what we have already described in the scientific literature [4,5,14] and what was presented in this case report, we project that patients with corrected aortic dissection may also benefit from SCR. In short, an SCR program can be safe, improve functional capacity and aspects of daily life, and provide better control of predisposing factors for aneurysm progression such as blood pressure. However, we emphasize that in this patient profile, the prescribed exercise must strictly follow an ideal and personalized dosage, have adequate monitoring, and be conducted by a multidisciplinary team prepared and qualified for this task.

Although, despite the promising results, we must acknowledge that this is a case report and, therefore, presents inherent limitations, such as the inability to distinguish the magnitude of the independent effect produced by the RCS program. Furthermore, the absence of validated measure to assess patient-reported outcomes such as psychological changes and quality of life should be considered a limitation.

Conclusions

In this case report, we document the feasibility of an SCR program following the repair of a Type A aortic dissection with residual aortic disease. No clinically detected cardiovascular adverse events were reported during the program, while we observed an increase in functional capacity and a reduction in resting blood pressure, accompanied by a return to activities of daily living. These observations generate hypotheses and encourage future research into individualized exercise prescription for this population. This report also suggests that the multidisciplinary team consider SCR for this population whenever there is no absolute contraindication.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Human Research Ethics Committee of the Escola Bahiana de Medicina e Saúde Pública (CEP-Bahiana) issued approval 94518825.0.0000.5544. The patient signed a free and informed consent form authorizing the description and publication of this study. This case report was approved by the Ethics and Research Committee of the Bahiana School of Medicine and Human Health, Salvador, BA, Brazil, under CAAE No. 94518825.0.0000.5544, in accordance with the Declaration of Helsinki. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no

financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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