Case report

Prolonged Hemodynamic Instability with Hypotension and Bradycardia Following Carotid Artery Stenting: A Case Report

Abstract

Introduction: Carotid artery stenting (CAS) is a commonly performed procedure for the treatment of carotid artery stenosis. However, the occurrence of prolonged hemodynamic instability, characterized by hypotension and bradycardia, can present challenges during and after CAS. Interestingly, this phenomenon does not seem to be related to the patients' underlying cardiac conditions but may be more prevalent in elderly women.

Case presentation: In this case report, we describe the clinical case of a 60-year-old male patient with a history of multiple cardiac conditions who encountered prolonged bradycardia and hypotension following CAS. The management approach focused on continuous monitoring and prompt intervention to stabilize the vital signs.

Conclusion: By enhancing our understanding of these complications and associated risk factors, healthcare providers can develop safer and more effective treatment strategies for patients undergoing CAS for carotid artery stenosis. This knowledge will contribute to improved patient care and better outcomes in this particular clinical setting.

Key words: Carotid artery stenting, hemodynamic instability, hypotension, bradycardia.

Introduction

Several comparative studies examining carotid artery stenting (CAS) and carotid endarterectomy (CEA) have led to the conclusion that these two treatment modalities exhibit similar prognosis and complication rates. Consequently, CAS has emerged as a viable alternative to CEA for managing carotid artery stenosis [1–5]. However, despite its growing popularity, hemodynamic instability, characterized by occurrences of hypotension and bradycardia, remains a relatively common occurrence following CAS procedures [6,7].

The hemodynamic instability observed during and after CAS is mediated through the activation of baroreceptors located in the adventitia at the carotid bifurcation. These baroreceptors are stimulated by the stretch caused by balloon angioplasty, initiating a reflex arc involving the sinus nerve of Hering, a branch of the glossopharyngeal nerve, and the *nucleus tractus solitarius*. Consequently, this reflexive response leads to changes in peripheral sympathetic and vagal neural activity, resulting in a decrease in blood pressure and bradycardia. The placement of a stent may further contribute to persistent stimulation of these baroreceptors. (8,9,10)

Previous studies have revealed two distinct patterns of hypotension after CAS. The first pattern involves acute-onset hypotension, necessitating vasopressor administration, but resolving relatively quickly within 24 to 6 hours. Patients displaying this pattern often have a history of myocardial infarction, possibly due to increased carotid artery baroreceptor sensitivity observed in individuals with coronary artery disease. Studies have shown that patients with cardiac risk factors, including coronary artery disease, unstable angina, and previous myocardial infarction, are more prone to post-procedural hypotension after CAS [6,11,12].

The second pattern of hypotension manifests with more prolonged course, requiring sustained vasopressor support. Interestingly, this pattern does not appear to be associated with the underlying cardiac conditions of the patient, but may be more prevalent in elderly women. Advanced age-related physiological changes, such as baroreceptor dysfunction, low blood pressure, and age-related ventricular dysfunction, may contribute to the increased susceptibility to hypotension observed in older individuals during CAS procedures. (6,11,12)

Presented herein is the case of a 60-year-old male patient who experienced prolonged bradycardia and hypotension following carotid artery stenting. This case highlights the need to explore the risk factors contributing to such complications in order to enhance our understanding and management of hemodynamic instability during CAS procedures.

Case presentation

Clinical history and imaging before treatment

A 60-year-old right-handed male admitted for treatment of symptomatic calcified high-grade stenosis in the right carotid artery (CA). CT angiography revealed a severe heavily calcified stenosis in the right internal carotid artery (ICA) at the bulbus area (Fig.1A, B). The anticipated procedure was regular carotid artery stenting (CAS).

In his prior medical history atherosclerotic coronary artery disease was detected, he underwent percutaneous coronary angioplasty with stent placement 10 years ago. He also presented with primary arterial hypertension, chronic heart failure (class II) and paroxysmal atrial fibrillation.

The patient exhibited longstanding ECG changes indicating systolic and diastolic dysfunction, left ventricular myocardial hypertrophy, left atrium dilatation. Additionally, the patient

underwent biphasic cardioversion with 200 J, 300 J, 360 J, and received bradycardization therapy with a solution of Digoxin 0.25 mg under general anesthesia to restore the rhythm 2 month ago.

Furthermore, he was prescribed an angiotensin II receptor antagonist to improve his cardiovascular risk factors, along with Amiodarone 200 mg, Rivaroxaban 20 mg, Spironolactone 25 mg, Torasemide 5 mg and cardioselective β1-blocker. Moreover, three months ago, the patient underwent endocardial electrophysiological examination and cryoablation for pulmonary vein isolation. The patient had mild hyperlipidemia and he was being treated with HMG-CoA reductase inhibitors.

Treatment options/results

Digital subtraction angiography (DSA) confirmed the presence of hemodynamically significant calcified stenosis in the ICA bulbus area >70%. The CAS procedure followed a standard protocol, which included the following steps: placement of a 5.5 mm filter protection device over the 0.014" wire distal to the stenosis, predilatation of the stenotic area with a 3.5 x 30 mm monorail angioplasty balloon, placement of 8 x 40 mm dual-layer micromesh stent, and postdilation using a 5 x 20 mm balloon catheter at 7 atm. Prior to stent placement, the patient received 1 mg of i/v *Sol. Atropine*, which had almost no effect. The final DSA showed complete resolution of the stenosis and proper stent positioning. (Figure 1 c,d) However, slight vasospasm of the ICA was observed in the intracranial DSA, without any significant pathology and no neurological deficits. Right after postdilatation of the stent, patient developed bradycardia with heart ranging from 40-45 beats per minute and systolic blood pressure drop to 65-70 mmHg. i/v Sol. Euphyllin 10mg was administered immediately and within following 15 minutes interval with favorable response and rise of systolic blood pressure to 110mmHg. Although technical

steps of the procedure were concluded successfully and the patient was transferred to a ward with a stable neurological condition, bradycardia and hypotension with repeated systolic blood pressure drop till 65mmHg was detected, it was decided to do overnight monitoring in intensive care unit. For the first three days following the procedure, the patient required continuous i/v perfusion of small doses of vasopressors: Sol. Noradrenaline 4mg was performed with rate 0,03-0,047 mcg/kg/min, to keep systolic blood pressure above 100mmHg and avoid acute thrombosis of CAS. Despite the discontinuation of all antihypertensive medications and the continuation of vasopressor medication, the patient's bradycardia and hypotension persisted for 72 hours. After 72 hours additional physiotherapeutic activation was initiated and the blood pressure stabilization was achieved. Patient was discharged on a fourth day after CAS with instructions for close monitoring in an outpatient setting.

Discussion

In this case report, we presented a detailed account of a patient who experienced prolonged hemodynamic instability including hypotension and bradycardia after CAS, emphasizing the importance of understanding and managing such complications for optimal patient outcomes.

Our case involved a 60-year-old male patient with multiple chronic heart diseases who underwent CAS for heavily calcified right internal carotid artery stenosis. Following the procedure, the patient exhibited prolonged bradycardia and hypotension, necessitating immediate intervention and close monitoring. The management approach included the administration of vasopressors and targeted interventions to address the bradycardia and hypotension response. Despite the extended duration of hemodynamic instability, the patient did not experience any significant cardiac or other complications.

The occurrence of hemodynamic instabilities, such as bradycardia or hypotension, after catheter-based carotid artery intervention (CAS) can be attributed to the activation of baroreceptors located at the carotid bifurcation [10,11] and has been reported at incidences ranging from 5% to 76% [12,13]. Additionally, approximately 12% to 40% of cases have reported persistent hypotension necessitating the use of vasopressor infusion [14,15].

Hemodynamic fluctuations are well-documented physiological responses during CAS, and they are typically temporary and self-limiting. However, in severe cases, these hemodynamic responses can lead to peri-procedural cardiopulmonary and neurological complications [16,17].

Several risk factors have been associated with post-CAS hemodynamic instability. Previous studies have identified a history of myocardial infarction as a potential risk factor for acute-onset hypotension following CAS. Additionally, advanced age and physiological changes related to aging, such as reduced baroreceptor sensitivity, may contribute to prolonged hemodynamic instability [18,19].

The majority of previous studies have primarily concentrated on identifying risk factors associated with the occurrence of hemodynamic instability (HDI) itself, often overlooking the consideration of the duration of HDI. While transient hemodynamic changes can generally be effectively managed with medical interventions without significant complications, it is imperative to emphasize the significance of investigating strategies aimed at preventing prolonged HDI which can lead to severe complications such as acute cerebral infarction, intracranial hemorrhage (ICH), myocardial infarctions, and renal failure [20,21].

Prolonged HDI has been found to have associations with various factors, including female gender, old age, symptomatic lesion, stenotic lesion near the carotid bulb, posterior carotid

plaque, ulcerated atherosclerotic plaque, calcified plaque, contralateral occlusion, a previous history of CEA, and general anesthesia [22, 23,24,25].

The presence of an eccentric type of stenosis and calcification at the carotid bifurcation has been associated with extended hypotension lasting over 3 hours [26]. Previous research demonstrated a relationship between prolonged HDI and the presence of eccentric stenosis and calcified plaque. Extensive plaque, defined as atherosclerotic carotid plaque located within 5 mm on both sides of the bifurcation from CCA to ICA, has also been linked to prolonged HDI [27]. While baroreceptors are commonly observed in the proximal ICA just above the carotid bifurcation, they can also be found in the distal CCA near the carotid bifurcation [27,28,29]. The results indicated that extensive plaque extending from CCA to the carotid bulb was associated with prolonged HDI.

Many patients undergoing CAS have multiple risk factors for HDI, making it challenging to provide counseling regarding the future occurrence of hemodynamic changes. Therefore, patients at a high risk for extended HDI may benefit from treatment strategies such as avoiding sudden activation of baroreceptors [27,30]. Moreover, hypotension associated with CAS may persist, potentially attributed to the ongoing stretching of the carotid sinus caused by the self-expanding stent. Based on Rhim JK et al in such cases, suboptimal expansion without post-stent balloon expansion and preventive therapies aimed at increasing circulating volume can be advantageous [15].

The pattern of more protracted hypotension necessitating vasopresor support appeared to be unrelated to the patients' underlying cardiac conditions; rather, it may represent a prolonged reflexive response to which elderly women are more susceptible. Previous studies have found

age to be a risk factor for hemodynamic instability during CAS, which may be related to dysfunction of baroreceptors. (31-34)

By focusing on preventing and minimizing the duration of HDI episodes, the potential for associated complications, such as adverse cardiac events, neurologic sequelae, and other adverse outcomes, can be significantly reduced. Therefore, it is advisable to prioritize the resolution of extended HDI as it carries a greater likelihood of resulting in neurological complications.

The typical approaches for managing CAS-related hemodynamic depression involve intravenous fluid resuscitation and the administration of intravenous inotropes such as dopamine and norepinephrine. Generally, these treatments prove effective, but in cases of an unfavorable response, alternative measures like oral midodrine have been proposed [35,36]. Midodrine functions as an alpha-1 adrenergic agonist, stimulating vasoconstriction and elevating blood pressure. Primarily used for addressing orthostatic hypotension [37], midodrine offers a potential therapeutic option in CAS-related hypotension. Additionally, tailored interventions should consider the individual patient's risk profile and comorbidities.

Despite our case deviating from the typical risk factors such as age, gender, and heart function, which are associated with prolonged hemodynamic instability following CAS, it emphasizes the significance of identifying and addressing this complication. Furthermore, since the patient tolerated the hypotension and bradycardia well, a decision was made to refrain from additional interventions or treatments aimed at increasing blood pressure.

Conclusion

This case report highlights the occurrence of prolonged hemodynamic instability, specifically hypotension and bradycardia, following carotid artery stenting (CAS). Despite the absence of

traditional risk factors, like age and gender the patient experienced a protracted period of hemodynamic instability without significant cardiac or other complications. The management of hemodynamic instability in CAS requires a comprehensive approach, including continuous monitoring, prompt intervention, and tailored therapies. Understanding the underlying mechanisms, such as the activation of baroreceptors at the carotid bifurcation, helps elucidate the pathophysiology of hemodynamic instability during CAS. Further research is needed to better comprehend the risk factors for prolonged hemodynamic instability and refine risk stratification. By implementing tailored interventions and optimizing perioperative care, healthcare providers can mitigate complications and ensure successful outcomes in CAS patients.

References

1.T.G. Brott, R.W. Hobson 2nd, G. Howard, et al., Stenting versus endarterectomy for treatment of carotid-artery stenosis, N. Engl. J. Med. 363 (2010) 11–23.

2.Dietz A, Berkefeld J, Theron JG, Schmitz-Rixen T, Zanella FE, Turowski B, et al. Endovascular treatment of symptomatic carotid stenosis using stent placement: long-term follow-up of patients with a balanced surgical risk/benefit ratio. Stroke. 2001;32:1855–1859.

3.Brown MM, Venables G, Clifton A, Gaines P, Taylor RS. Carotid endarterectomy vs carotid angioplasty. Lancet. 1997;349:880–881. [PubMed] [Google Scholar]

4.Brooks WH, McClure RR, Jones MR, Coleman TL, Breathitt L. Carotid angioplasty and stenting versus carotid endarterectomy for treatment of asymptomatic carotid stenosis: a randomized trial in a community hospital. Neurosurgery. 2004;54:318–324.

5.NASCET Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. North American Symptomatic Carotid Endartectomy Trial Collaborators. N Engl J Med 1991;325:445-53.

6.Trocciola SM, Chaer RA, Lin SC, Ryer EJ, De Rubertis B, Morrissey NJ, McKinsey J, Kent KC, Faries PL. Analysis of parameters associated with hypotension requiring vasopressor support after carotid angioplasty and stenting. J Vasc Surg. 2006 Apr;43(4):714-20. doi: 10.1016/j.jvs.2005.12.008. PMID: 16616226.

7.Choi J, Lee JY, Whang K, Cho S, Kim J. Factors associated with hemodynamic instability following carotid artery stenting. Clin Neurol Neurosurg. 2021 Apr;203:106589.

8.Berne RM, Levy MN. The peripheral circulation and its control. In: Berne RM, editor. Physiology. St. Louis: Mosby-Year Book; 1993. pp. 478 –93.

9.Alpman A, Oral D, Guldal M, Erol C, Omurlu K, Berkalp B, et al. Cardioinhibitory response to carotid sinus massage in patients with coronary artery disease. Int J Cardiol 1993;42:277-83.

10. Chalmers J, Pilowsky P. Brainstem and bulbospinal neurotransmitter systems in the control of blood pressure. J Hypertens. 1991;9:675–694.

11. Mangin L, Medigue C, Merle JC, Macquin-Mavier I, Duvaldestin P, Monti A, et al. Cardiac autonomic control during balloon carotid angioplasty and stenting. Can J Physiol Pharmacol. 2003;81:944–951.

12. S.N. Mylonas, K.G. Moulakakis, C.N. Antonopoulos, J.D. Kakisis, C.D. Liapis, Carotid artery stenting-induced hemodynamic instability, J. Endovasc. Ther. 20 (2013) 48–60, https://doi.org/10.1583/12-4015.1.

13. B.W. Ullery, D.P. Nathan, E.K. Shang, et al., Incidence, predictors, and outcomes of hemodynamic instability following carotid angioplasty and stenting, J. Vasc. Surg. 58 (2013) 917–925, https://doi.org/10.1016/j.jvs.2012.10.141.

14.T. Nonaka, S. Oka, K. Miyata, et al., Prediction of prolonged postprocedural hypotension after carotid artery stenting, Neurosurgery 57 (2005) 472–477.

15.Rhim JK, Jeon JP, Park JJ, Choi HJ, Cho YD, Sheen SH, Jang KS. Prediction of Prolonged Hemodynamic Instability During Carotid Angioplasty and Stenting. Neurointervention. 2016 Sep;11(2):120-6.

16.Qureshi AI, Luft AR, Sharma M, Janardhan V, Lopes DK, Khan J, et al. Frequency and determinants of postprocedural hemodynamic instability after carotid angioplasty and stenting. Stroke 1999;30:2086-93.

17.T.Y. Wu, S.W. Ham, S.G. Katz, Predictors and consequences of hemodynamic instability after carotid artery stenting, Ann. Vasc. Surg. 29 (2015) 1281–1285,

18. Mlekusch W, Schillinger M, Sabeti S, Nachtmann T, Lang W, Ahmadi R, et al. Hypotension and bradycardia after elective carotid stenting: frequency and risk factors. J Endovasc Ther. 2003;10:851–859.

19. Wong JH, Findlay JM, Suarez-Almazor ME. Hemodynamic instability after carotid endarterectomy: risk factors and associations with operative complications. Neurosurgery. 1997;41:35–41.

20. Leisch F, Kerschner K, Hofman R, Bibl D, Engleder C, Bergmann H. Carotid stenting: acute results and complications. Z Kardiol. 1999;88:661–668. [PubMed] [Google Scholar]

21. Morrish W, Grahovac S, Douen A, Cheung G, Hu W, Farb R, et al. Intracranial hemorrhage after stenting and angioplasty of extracranial carotid stenosis. AJNR Am J Neuroradiol. 2000;21:1911–1916.

22. Qureshi AI, Luft AR, Sharma M, Janardhan V, Lopes DK, Khan J, et al. Frequency and determinants of postprocedural hemodynamic instability after carotid angioplasty and stenting. Stroke. 1999;30:2086–2093.

23. Mlekusch W, Schillinger M, Sabeti S, Nachtmann T, et al. Hypotension and bradycardia after elective carotid stenting: frequency and risk factors. J Endovasc Ther. 2003;10:851–859.

24. Wong JH, Findlay JM, Suarez-Almazor ME. Hemodynamic instability after carotid endarterectomy: risk factors and associations with operative complications. Neurosurgery. 1997;41:35–41.

25. Taha MM, Toma N, Sakaida H, Hori K, Maeda M, Asakura F, et al. Periprocedural hemodynamic instability with carotid angioplasty and stenting. Surg Neurol. 2008;70:279–285.

26. 4. Nonaka T, Oka S, Miyata K, Mikami T, Koyanagi I,et al. Prediction of prolonged postprocedural hypotension after carotid artery stenting. Neurosurgery. 2005;57:472–477.

27. Jeon JS, Sheen SH, Hwang G. Hemodynamic instability during carotid angioplasty and stenting-relationship of calcified plaque and its characteristics. Yonsei Med J. 2013;54:295–300.

28. Fadel PJ. Arterial baroreflex control of the peripheral vasculature in humans: rest and exercise. Med Sci Sports Exerc. 2008;40:2055–2062.

29. Fadel PJ, Ogoh S, Keller DM, Raven PB. Recent insights into carotid baroreflex function in humans using the variable pressure neck chamber. Exp Physiol. 2003;88:671–680.

30. Jin SC, Kwon OK, Oh CW, Jung C, Han MG, Bae HJ, et al. A technical strategy for carotid artery stenting: suboptimal prestent balloon angioplasty without poststenting balloon dilatation. Neurosurgery. 2010;67:1438–1442.

31. Mlekusch W, Schillinger M, Sabeti S, Nachtmann T, Lang W, Ahmadi R, Minar E. Hypotension and bradycardia after elective carotid stenting: frequency and risk factors. J Endovasc Ther 2003;10:851-9.

32. Roubin GS, New G, Iyer SS, Vitek JJ, Al-Mubarak N, Liu MW, et al. Immediate and late clinical outcomes of carotid artery stenting in patients with symptomatic and asymptomatic carotid artery stenosis: a 5-year prospective analysis. Circulation 2001;103:532-7.

33. Mathur A, Roubin GS, Iyer SS, Piamsonboon C, Liu MW, Gomez CR, et al. Predictors of stroke complicating carotid artery stenting. Circulation 1998;97:1239-45.

34. Chastain HD 2nd, Gomez CR, Iyer S, Roubin GS, Vitek JJ, Terry JB, et al. Influence of age upon complications of carotid artery stenting. UAB Neurovascular Angioplasty Team. J Endovasc Surg 1999;6:217-22.

35. Anstey MH, Wibrow B, Thevathasan T, Roberts B, Chhangani K, Ng PY, et al.Midodrine as adjunctive support for treatment of refractory hypotension in the intensive care unit: a multicenter, randomized, placebo controlled trial (the MIDAS trial). BMC Anesthesiol. 2017;17(1):1–7.

36. Sharma S, Lardizabal JA, Bhambi B. Oral midodrine is efective for the treatment of hypotension associated with carotid artery stenting. JCardiovasc Pharmacol Ther. 2008;13(2):94–7.

37.Molinof PB. α- and β-adrenergic receptor subtypes: properties, distribution and regulation. Drugs. 1984;28(2):1–15.

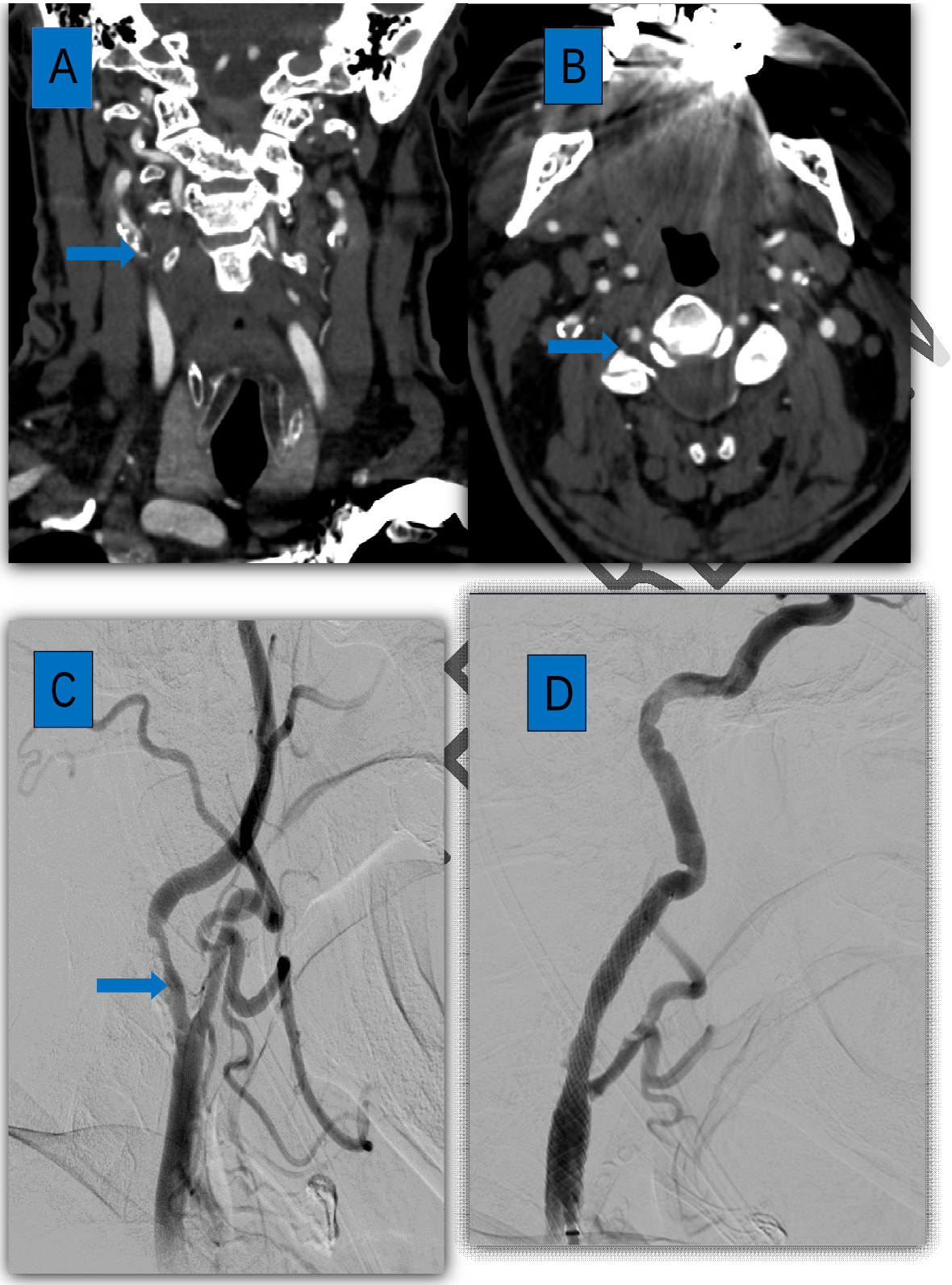
A
B
C
D

Figure 1: CT angiogram, coronal (A) and axial (B) reveal right internal carotid artery (ICA) stenosis with severe calcification.(arrow) Right CCA angiogram pre (C) and post (D) stenting demonstrates excellent dilation.(arrow)