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REVIEW ARTICLE

Rotational vertebral artery occlusion ("bow hunter syndrome")

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Abstract

Purpose To review the literature, analyze and discuss diagnostic and treatment options for the Bowhunter Syndrome. A clinical case of idiopathic rotatory C1-C2 subluxation causing dynamic vertebral artery occlusion is presented.

Methods Literature review between 1960 and 2019, discussion of diagnostic methods and treatment options. Description of diagnostic and treatment methods in the aforementioned case.

Results We present a patient with dynamic left vertebral artery occlusion associated with idiopathic rotatory C1-C2 subluxation. A dynamic Angio-CT showed rotatory C1-C2 subluxation with significant flow reduction at the left vertebral artery at the exit of the C2 transverse foramen until the V3 segment when the head rotated towards the right. Due to clinical and radiological worsening in the following months, posterior C1-C2 arthrodesis was performed, with the disappearance of the symptoms. There are 193 cases reported with dynamic vertebral artery occlusion, but in only two, the etiology was primary rotational atlantoaxial instability. The most prevalent etiology was degenerative.

Conclusion Rotatory vertebral artery occlusion is a rare condition presented mostly in adults, aged 50–70 years. Vertebrobasilar insufficiency is triggered by the rotation of the head to the contralateral side of the dominant vertebral artery. Dynamic subtraction angiography is considered the diagnostic gold-standard method, but dynamic Angio-CT scan, Angio-MRI, or Doppler ultrasonography are less invasive options. The treatment options are conservative or surgical. Endovascular surgery is another option in specific cases.

Keywords Vertebral artery occlusion · Vertebrobasilar insufficiency · Cervical instability · Cervical fusion · Cervical arthrodesis

Introduction

Bow hunter's syndrome (BHS) was described for the first time in the scientific literature in 1978 by Sorensen [1], and further studies were published afterward, presenting similar cases. Bow hunter's syndrome is a vertebral artery (VA) occlusion due to contralateral rotation of the head over 45 degrees. VA occlusion is a potentially harmful and life-threatening condition. It may evolve to the cerebellum or brainstem infarctions, producing temporary or permanent neurological disabilities, including coma and death [2]. Symptoms may include visual impairment, diplopia, dysarthria, vertigo, syncope, walking disabilities, sensorial, and motor deficits [3].

Frequent causes of VA occlusion are atherosclerosis and thromboembolic phenomena [4]. Traumatic and mechanical etiologies are infrequent. Chiropractic manipulation, surgery, sports accidents, osteophytes, fibrous bands, atlantoaxial instability, and rheumatoid arthritis are some of the mechanical etiologies reported in the literature [5]. However, in some cases, none of these related factors are identified using complementary imaging studies.

The right vertebral artery is a branch of the brachiocephalic trunk. The left vertebral artery starts from the subclavian artery. The entrance to the transverse foramen is mostly described at C6 level (extraosseous segment), exiting at C1 level (foraminal segment), continuing its path to the magnum foramen (extraforaminal segment) where it attaches to the dura mater. Finally, both vertebral arteries converge (intradural segment) and form the basilar artery. The left

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vertebral artery is usually dominant, although there is scarce evidence confirming this fact [6].

Due to the low prevalence of this condition, patients' diagnostic may delay for months or even years [5]. Patients usually consult different specialists, using syndromic workup diagnosis, being the chance of BHS often underestimated or even unknown as a causing clinical entity by the physicians.

Materials and methods

We report a case of a patient diagnosed and treated by dynamic VA occlusion at our institution. The access to the clinical record and images database of the patient is consented for publication and approval of the local clinical ethics board.

A literature review from 1960 to 2019 on Medline (PubMed), Cochrane, and Embase databases was performed. Only literature in the English language was included.

Results

A case of a 58-year-old woman with a medical record of arterial hypertension was presented. She worked as a primary teacher in a school**.** She experienced a year of progressive symptoms, consisting of dizziness and blurry vision each time she wrote on the blackboard when rotating her head, precisely the right rotations. The woman suffered a couple of syncope episodes during the year. After multiple consults with orthopedic surgeons, neurologists, vascular surgeons, a rheumatologist, and a psychiatrist, the patient was referred to our spine surgery team in February 2018.

The physical and neurological examination showed normal findings, except for a defensive posture of her neck, avoiding the triggering positions of the symptoms.

Cervical X-rays, head, and neck MRI showed physiological changes according to her age. The upper limb electrophysiological study did not show any abnormal findings.

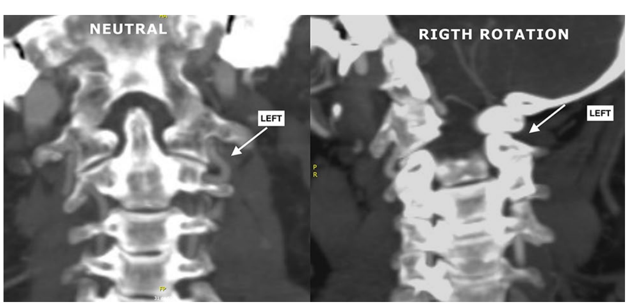

Fig. 1 Angio-CT scan, coronal view. Left: neutral, both vertebral arteries are visible. Right: right rotation of the head produces occlusion of the left artery

Otorhinolaryngologic evaluation of the patient, including the VIII pair test and an ear CT scan showed normal findings.

Suspecting a dynamic vascular occlusion, a dynamic Angio-CT scan of the neck vessels (Fig. 1) was performed. Arterial images with flexion, extension, neutral position, and left to right rotations were obtained, detecting a severe diameter reduction of the left vertebral artery at the foraminal segment at C2. During the CT scan, the symptoms of the patient appeared with the right rotation and extension. The case was discussed with the vascular surgery team, choosing conservative treatment at first, using a rigid collar and cilostazol. A periodical clinical and imaging follow-up program was also indicated. One year later, the patient referred significative aggravation of her symptoms. The Angio-CT scan was repeated, concluding the absence of flow of the left VA at the exit of its C2 transverse foramen until the V3 segment when rotating the head to the right, representing a dynamic occlusion of the segment, more evident than the previous imaging study (Fig. 2). It also described a C1-C2 subluxation when rotating the head either to the left or to the right (Fig. 3). Due to the worsening of the symptoms, it was decided to perform a posterior C1-C2 arthrodesis with the Harms technique (Fig. 4). There were no complications

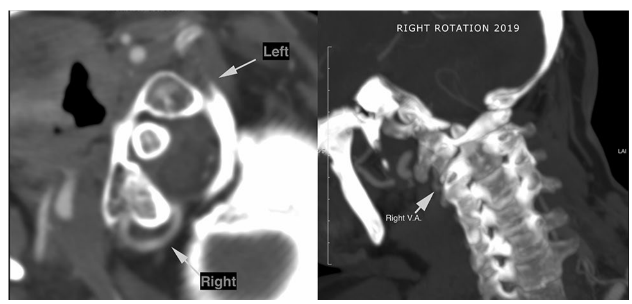

Fig. 2 Angio-CT scan, axial and coronal views. At the right rotation of the head, only the right vertebral artery is visible

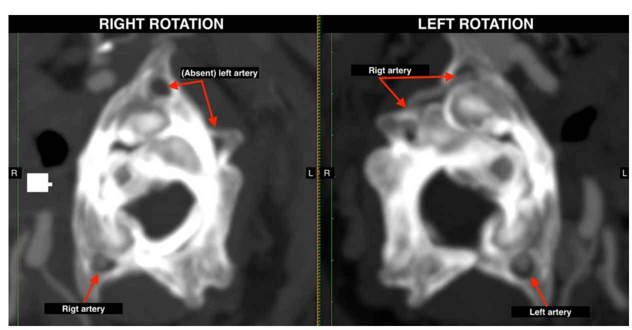

Fig. 3 Angio-CT scan, axial views. Left: during the right rotation, only the right artery is visible. Right: in left rotation, both arteries are visible

Fig. 4 Postoperative result

during the surgery, and there was a disappearance of the occlusion symptoms.

Literature review

Table 1 summarizes the result of our literature review.

Frequency and age of presentation

A total of 194 cases reported with dynamic VA occlusion (85 papers) were found (Table 2). The majority was located below C2 (105 cases, 54%). The upper cervical spine was involved in 83 cases (43%): 1 patient at C0-C1, 9 cases at C1, 10 cases at C2, 62 cases at the C1-C2 level, and 1 patient at C2-C3. There were five cases with simultaneous involvement at the upper and lower cervical spine. One report (1 patient) did not specify the anatomical location. It was described slightly more prevalent in men, at about fifth to the seventh decade of life [18].

Etiologies

There are diverse causes (Table 3), being the most prevalent degenerative disease (osteophytes, spondylosis, and disc protrusion or herniation), representing 104 cases (54% of the reports). There is a group of miscellaneous etiologies, like muscle hypertrophy, thyroid cartilage impingement, osseous and ligamentous malformations as fibrous bands, condyle, or transverse process hypertrophy, and tumors. This heterogeneous group ranks the second most frequent, totaling 25 cases (13%). Instability is a rather rare etiology, with 12 cases representing 6% of the reported cases, followed by vascular etiologies (aneurysm, vertebral artery hypoplasia, other vascular malformations, vertebral artery dissection, atherosclerosis or embolism) with 11 patients (5%). In 42 cases (22%), the etiology was not specified.

Diagnosis

The diagnostic methods include Dynamic Angio Computed Tomography scanner (dynamic Angio-CT), dynamic Angio Magnetic Resonance (dynamic MRI), Angiography, and Doppler ultrasonography. The dynamic Angio-CT, dynamic MRI, and Angiography have a similar sensibility and specificity applying protocols with a maximum rotation of the head, but they need at least 2 min of a sustained position to show the occlusion [7]. The Digital Dynamic Subtraction Angiography is the most accurate of all the imaging exams [8]. It also shows the occlusion without delay, being the main reason why it is still the gold-standard method [7]. Doppler ultrasonography is an emerging diagnostic method for this condition, when performed by a well-trained operator. It has an excellent diagnostic performance, like the other methods, with the advantage of almost no adverse events [9].

Treatment options and treatment results

There are three options of treatment described: conservative, open surgery, and endovascular procedures (Table 4).

Conservative treatment

Conservative treatment in BHS is reported in 16 papers, which means 37 patients, mostly vascular etiology. This therapeutic option is based on the education regarding the pathology, including avoidance of extreme rotation of the head, the use of cervical orthosis (rigid and soft collars), preventive antiplatelet, or anticoagulant therapy (e.g., aspirin, clopidogrel, cilostazol, warfarin) [10]. The conservative treatment is not a definitive one, but the complications reported are minimum, being the main reason for its choice in some patients [10]. Choi et al. published a series of 21 patients, 19 of them conservatively treated. He describes favorable outcomes in the conservative group [10]. However, the outcomes of this treatment alternative are controversial due to inconsistent reports [10, 11]. Residual symptoms were reported in 12 of the 37 cases.

Surgical treatment

The surgical treatment is the most documented management of this pathology, as seen in our review: 154 patients (79%) in 72 publications. It can be divided into two main surgical acts: decompression and instrumented arthrodesis. Hence, options are three: each one separated or merging both in the same surgery. The most common strategy is pure decompression with 105 patients (68%), followed by decompression with fusion in 29 cases (19%), and stand-alone fusion in 20 patients (13%). Decompression options are diverse,

Table 1 Summary of the available literature between 1960 and 2019

Study	Year	n	Journal	Anatomical location	Etiology	Treatment	Outcomes
Sheehan et al. (1960)	1960	5	Neurology 1960;10(11):968–986	V2	Spondylosis	Surgery	Not reported
Bauer et al. (1961)	1961	1	Arch Neurol 4:119–131, 1961	C3-C7	Spondylosis	Surgery	Resolution
Gortvai (1964)	1964	1	Br Med J 2(5403):233–234, 1964	C5-C6	Osteophyte	Surgery	Resolution
Hardin (1965)	1965	9	Arch Surg 90:629–633, 1965	C2 (1), C5-C6 (3), C6 (4), C2-C6 (1)	Osteophyte	Surgery	Resolution (5), residual symptoms (4): dizziness, arm paresis, right central hemianopsia, deafness and tinnitus
Bakay and Leslie (1965)	1965	2	J Neurosurg 23(6):596–602, 1965	C5-C6	Osteophyte	Surgery	Resolution
Nagashima (1970)	1970	20	J Neurosurg 32(5):512–521, 1970	C4-C7	Osteophyte	Surgery	Resolution (14), Residual symptoms (4), Not reported (2)
Smith et al. (1971)	1971	2	J Neurol Neurosurg Psychiatry 34(4):388–392, 1971	C5-C6, C4-C6	Osteophyte	Surgery	Resolution
Sorensen (1978)	1978	1	Neurosurgery 1978;2:259–261	V1	Aneurysm	Conservative	Residual symptoms (ataxia)
Kojima et al. (1985)	1985	1	Neurosurgery. 1985;16(5):672–4	C6	Longus colli and scalenus hypertrophy	Surgery	Resolution
Dadsetan et al. (1990)	1990	1	Neuroradiology. 1990;32(6):514–5	C6	Fibrous band	Surgery	Resolution
Takahashi et al. (1994)	1994	1	Neuroradiology. 1994;36(4):273–5	C1-C2	Not specified	Surgery	Resolution
Morimoto et al. (1996)	1996	1	J Neurosurg. 1996;85(3):507–9	C1-C2	Instability	Surgery	Resolution
Matsuyama et al. (1997)	1997	17	J Neurosurg 1997;86:619–623	C1-C2	Not specified	Surgery	Residual symptoms in 11/17 stand-alone decompression (8 treated later with fusion). 6/17 patients treated with decompression alone with resolution 100%. Resolution 100% in the revision surgery group (fusion group). 3 patients remained with symptoms

Table 1 (continued)

Study	Year	n	Journal	Anatomical location	Etiology	Treatment	Outcomes
Kuether et al. (1997)	1997	3	Neurosurgery. 1997;41(2):427–32; discussion 32–3	C2	VA hypoplasia, spondylosis	Surgery (1) conservative (2)	Residual symptoms in all
Kawaguchi et al. (1997)	1997	1	J Neurosurg. 1997;86(6):1031–5	C4-C5	Osteophyte	Surgery	Resolution
Citow and MacDonald (1999)	1999	1	Surg Neurol 51(5):495–8; discussion 498–9, 1999	C5-C6	Osteophyte	Surgery	Resolution
Puca et al. (2000)	2000	1	Br J Neurosurg. 2000;14(4):361–4	C1-C2	Malformation	Conservative	Residual symptoms
Strupp et al. (2000)	2000	1	Neurology. 2000;54(6):1376–9	C2	Hypoplastic VA	Surgery	Resolution
Ogino et al. (2001)	2001	1	Clin Neurol Neurosurg. 2001;103(4):250–3	C5-C6	Osteophyte	Surgery	Resolution
Vates et al. (2002)	2002	1	J Neurosurg. 2002;96(1 Suppl):90–3	C4-C5	Disc	Surgery	Resolution
Tominaga et al. (2002)	2002	1	J Neurosurg. 2002;97(6):1456–9	C1	Osseous prominence of condyle	Surgery	Resolution
Nemececk et al. (2003)	2003	1	J Neurosurg 98(1 Suppl):80–83, 2003	C6-C7	Disc	Surgery	Resolution
Vilela et al. (2005)	2005	10	Neurosurgery 56(1):36–43; discussion 43–5, 2005	C1-C2 (4), C3-C7 (6)	Osteophyte (6), Disc (2), Rotational instability (2)	Surgery	Residual symptoms: 4 (4 of the 8 patients treated with decompression alone): dizziness Resolution in 6 patients: 2 with fusion + decompression, & 4 in the decompression group)
Netuka et al. (2005)	2005	1	Zentralbl Neurochir. 2005;66(4):217–22	C1-C2	Not specified	Surgery	Resolution
Wakayama et al. (2005)	2005	1	J Neurol Sci. 2005;236(1–2):87–90	C1-C2	VA dissection and occlusion	Conservative	Resolution (6 months FU)
Bulsara et al. (2006)	2006	1	Surg Neurol 65(6):625–627, 2006	C5-C6	Osteophyte	Surgery	Resolution
Velat et al. (2006)	2006	1	Surg Neurol 66(4):420–3; discussion 423, 2006	C3-C6	Osteophyte	Surgery	Resolution
Owolabi et al. (2007)	2007	2	Neuropsychiatr Dis Treat. 2007;3(5):675–8	C4-C6, C2-C6	Osteophyte	Conservative	Resolution (6 months F.U.)
Dabus et al. (2007)	2007	1	J Neuroimaging. 2008;18(2):184–7	C6	Thyroid cartilage and C6 transverse process	Conservative	Resolution (9 month F.U.)
Miele et al. (2008)	2008	1	Spine (Phila Pa 1976). 2008;33(11):E366-70	C4-C5	Osteophyte	Surgery	Resolution

Table 1 (continued)

Study	Year	n	Journal	Anatomical location	Etiology	Treatment	Outcomes
Kim et al. (2008)	2008	1	Acta Neurochir (Wien) 150(3):301–3; discussion 303, 2008	C2-C3	Tethering	Surgery	Not reported
Tsutsumi et al. (2008)	2008	1	Neurol Med Chir (Tokyo). 2008;48(2):90–4	C5-C7	Fibroligamentous	Surgery	Resolution
Petridis et al. (2008)	2008	1	Acta Neurochir (Wien). 2008;150(4):391–4; discussion 4	C4-C5	Spondylosis	Surgery	Resolution
Ujifuku et al. (2009)	2009	1	J Neurosurg Spine 11(3):326–329, 2009	C4-C5	Disc	Surgery	Resolution
Natello et al. (2009)	2009	1	Vasc Med 14(3):265–269, 2009	C4-C6 and origin of VA	Cervical spondylosis, ath-erosclerosis	Endovascular Surgery	Resolution
Lu et al. (2010)	2010	9	Neurosurgery. 2010;67(4):1066–72; discussion 72	C0-C1 (1), C1 (1), C1-C2 (2), C2-C3 (1), C4/C5 (3), C5/C6 (1)	Osteophyte, disc	Surgery	Resolution
Chough et al. (2010)	2010	1	J Korean Neurosurg Soc. 2010;47(2):134–6	C1-C2	Facet hypertrophy	Surgery	Resolution
Yoshimura et al. (2011)	2011	1	Eur Spine J 20 Suppl 2:S266-70, 2011	C3-C4	Uncovertebral Instability	Surgery	Resolution
Noh et al. (2011)	2011	1	J Neurol. 2011;258(10):1775–80	C1-C2	Hypoplastic VA	Conservative	Residual symptoms (nystag-mus, vertigo)
Taylor et al. (2012)	2012	1	Proc (Bayl Univ Med Cent). 2012;25(1):26–7	C1	Posterior ossification	Surgery	Resolution
Choi et al. (2013)	2013	21	Stroke 2013;44:1817–1824	C1-C2 (16), C1-C2 + C6 bilateral (2), C4 (1), C6 (1), VA origin (1)	Not reported	Conservative (19), Surgery (2)	Resolution (both surgically treated), Favorable outcome in the conservative group
Go et al. (2013)	2013	2	J Korean Neurosurg Soc. 2013;54(3):243–5	C1-C2	Fibrous band	Surgery	Resolution
Piñol et al. (2013)	2013	1	Spine (Phila Pa 1976). 2013;38(23):E1503-5	C6-C7	Spondylolisthesis	Surgery	Resolution
Fleming et al. (2013)	2013	1	World Neurosurg. 2013;79(5–6):799.E1-5	C4-C5	Osteophyte	Surgery	Resolution
Dargon et al. (2013)	2013	1	J Vasc Surg. 2013;58(4):1076–9	C4-C5	Band	Surgery	Resolution
Ding et al. (2013)	2013	1	Interv Neuroradiol. 2013;19(2):240–4	C4-C5	Osteophyte	Surgery	Resolution
Inamasu et al. (2013)	2013	1	Clin Neurol Neurosurg. 2013;115(8):1520–3	C1-C2	Instability	Surgery	Resolution

Table 1 (continued)

Study	Year	n	Journal	Anatomical location	Etiology	Treatment	Outcomes
Zaidi et al. (2014)	2014	11	World Neurosurg. 2014;82(5):733–8	C1-C2 (6); C5-C7 (5)	Osteophyte, disc	Surgery	Resolution in all (1 patient required later fusion at C1-C2 because of post surgical instability)
Buchanan et al. (2014)	2014	1	J Neurosurg Spine. 2014;20(6):714–21	C3-C4	Osteophyte	Surgery	Resolution
Sarkar et al. (2014)	2014	1	Ann Vasc Surg. 2014;28(4):1032.e1-.e10	C7	Muscle (scalene and longus colli)	Conservative	Residual symptoms (nystagmus, vertigo)
Takeshima et al. (2014)	2014	1	Spine (Phila Pa 1976) 2014;39:E860–E863	C1-C2	Osteophyte	Surgery	Resolution
Jost et al. (2015)	2015	2	Neurosurg Focus 2015;38:E7	C5-C6; C6-C7	Disc	Surgery	Resolution
Schelfaut et al. (2015)	2015	1	J Spinal Disord Tech 28(2):66–70, 2015	C5-C6	Osteophyte	Surgery	Resolution
Healy et al. (2015)	2015	1	J Clin Neurosci. 2015;22(1):209–12	C1-C2 and C4-C5	Instability C1-C2, Osteophyte	Surgery	Resolution
Okawa et al. (2015)	2015	1	J Neurosurg Spine. 2015;23(2):166–9	C5-C6	Disc	Surgery	Resolution
Nguyen et al. (2015)	2015	1	Surg Neurol Int. 2015;6:147	C6-C7	Osteofibrous	Surgery	Resolution
Grandhi et al. (2015)	2015	1	BMJ Case Rep 2015:10.1136/bcr-2015–210,654, 2015	C5-C6	Osteophyte	Surgery	Resolution
Rastogi et al. (2015)	2015	1	J Vasc Interv Neurol 2015;8:7–16	C4 -C7	Iatrogenic (post subclavian aneurysm repair) + Osteophyte	Conservative	Residual symptoms (dizziness)
Lee et al. (2015)	2015	1	Clin Neurol Neurosurg. 2015;131:18–20	C5-C6	Disc	Surgery	Resolution
Takekawa et al. (2015)	2015	1	J Med Ultrason (2001). 2015;42(3):437–40	C1-C2	Embolism	Conservative	Not reported
Thomas et al. (2015)	2015	1	J Stroke Cerebrovasc Dis. 2015;24(9):e257-9	Not specified	Osteophyte	Endovascular Surgery	Resolution
Chaudhry et al. (2016)	2016	2	J Clin Neurosci. 2016;30:152–4	C5-C6	Fibrous band	Surgery	Resolution
Felbaum et al. (2017)	2017	1	World Neurosurg. 2017;97:762.e5-.e10	C3-C4	Uncovertebral instability	Surgery	Resolution
Haimoto et al. (2017)	2017	1	NMC Case Rep J. 2017;4(4):101–5	C5-C6	Tumor and Disc	Surgery	Resolution
Yagi et al. (2017)	2017	1	J Stroke Cerebrovasc Dis. 2017;26(4):e60-e1	C4-C5	Osteophyte	Surgery	Resolution

Table 1 (continued)

Study	Year	n	Journal	Anatomical location	Etiology	Treatment	Outcomes
Buch et al. (2017)	2017	1	J Neurosurg Spine. 2017;26(2):199–202	C1-C2	Persistent segmental artery	Surgery	Resolution
Eghbal et al. (2017)	2017	1	World Neurosurg. 2017;101:817.e1-.e3	C1-C2	Post traumatic instability	Surgery	Resolution
Kitahara et al. (2017)	2017	1	Interact Cardiovasc Thorac Surg. 2017;24(5):806–8	Origin of VA	Occlusion	Conservative	Residual symptoms (dizziness)
Gordhan et al. (2017)	2017	1	Case Rep Neurol. 2017;9(2):137–42	C2	Congenital bilateral stenosis	Conservative	Residual symptoms (vertigo, ataxia)
Motiel-Langroudi et al. (2017)	2017	1	World Neurosurg. 2017;98:878.e11-.e15	V1 segment	Tortuous segment	Endovascular Surgery	Resolution
Simpkin et al. (2017)	2017	1	Radiol Case Rep. 2017;12(3):597–601	C1	Bone spur	Conservative	Residual symptoms (dizziness, vertigo, ataxia)
Takeshima et al. (2018)	2018	8	World Neurosurg. 2018;114:e792-e9	C1 (4), C2 (3), C3-C4 (1)	Instability (2), Idiopathic (4), Spondylosis (2)	Conservative (2), Surgery (6)	Resolution
Cai et al. (2018)	2018	1	Asian J Neurosurg. 2018;13(1):133–5	C2-C3, C3-C4	Spondylosis, Osteophyte, hypoplastic contralateral VA	Surgery	Resolution
Cevik et al. (2018)	2018	1	Asian J Neurosurg. 2018;13(2):411–3	C1-C2	Fibrous band	Surgery	Resolution
Cornelius et al. (2018)	2018	1	World Neurosurg. 2018;119:358–61	C6-C7	Not mentioned	Surgery	Resolution
Iida et al. (2018)	2018	1	World Neurosurg. 2018;111:367–72	C3-C4	Osteophyte	Surgery	Resolution
Lukianchikov et al. (2018)	2018	1	World Neurosurg. 2018;117:97–102	C1	Ponticulus posticus and Ponticulus lateralis	Surgery	Resolution
Ng et al. (2018)	2018	1	World Neurosurg. 2018;118:290–5	C3-C4	Osteophyte	Surgery	Resolution
Schunemann et al. (2018)	2018	1	World Neurosurg. 2018, 118:284–289	C2-C3	Disc	Surgery	Resolution
Rendon et al. (2019)	2019	1	J Vasc Surg Cases Innov Tech. 2019;5(1):14–7	C2	Thyroid cartilage (extra osseus VA)	Surgery	Resolution
Hernandez et al. (2019)	2019	1	World Neurosurg. 2019;122:53–7	V3, C1-C2	Pseudoaneurysm	Surgery	Resolution
Karle et al. (2019)	2019	1	Laryngoscope. 2019;129(12):E445-E8	C4	Thyroid cartilage	Surgery	Resolution
Park et al. (2019)	2019	1	World Neurosurg. 2019;121:1–3	C1-C2 and C4-C5	Osteophyte	Surgery	Resolution
Yang et al. (2019)	2019	1	Br J Neurosurg. 2019:1–3	C1-C2, & C6	Instability	Conservative	Residual symptoms

Table 1 (continued)

Study	Year	n	Journal	Anatomical location	Etiology	Treatment	Outcomes
Zeeshan et al. (2019)	2019	1	Oper Neurosurg (Hagerstown). 2020 Mar 1;18(3):E79	C1-C2	Not specified	Surgery	Resolution
	Total	194					

varying between laminectomy, a transverse foramen opening, or the resection of any structure that causes the occlusion (e.g., osteophytes, fibrous band, cartilage) [12]. The anterior approach is the usual option for the lower cervical spine and the posterior approach for the upper cervical spine pathology.

Arthrodesis strategies and approaches are diverse. At the C1-C2 level, the preference is the posterior approach, using different techniques like the Gallie or the Brooks arthrodesis with wire and structural bone graft, or the more modern Harms or Magerl techniques [13, 14]. The two latter options have higher rates of fusion, being the main reason for the spine surgeons' preference [13]. At the lower levels, the approach can be anterior or posterior, being the first one the usual preference [15].

Significant differences in the outcomes by comparing the three surgical options were found. All the patients treated with decompression associated with fusion showed successful results. The 20 patients treated with stand-alone fusion also reported successful results.

105 patients were treated with stand-alone decompression. 7 authors reported residual symptoms in 26 patients (17%). 10 of them required later revision surgery: in 9 cases a fusion was performed (with complete recovery), and in one case, an additional foraminal decompression was necessary.

Overall, surgical treatment has documented complete recovery in 130 patients (84%), with 16 (10%) patients remaining with residual symptoms including dizziness, arm paresis, right central hemianopsia, deafness, and tinnitus.

Three authors (8 patients) did not report, or partially report their outcomes (Nagashima 1970 reported outcomes only in 18 of their 20 cases, Sheehan 1960, Kim 2008 did not report the outcomes).

Endovascular procedures

The reports of percutaneous treatment consist of the use of coils or stents, for decompressing or expanding the vertebral artery occlusion. Its indication is vascular pathology causing the occlusion, like aneurysms, atherosclerosis, or malformations. These causes are rare as dynamic occlusion, being more frequent as static occlusion conditions, usually considered in cases of transient ischemic episodes or strokes [8, 16]. In our review, we found three cases of percutaneous treatment: two stents and one coil (atherosclerosis and a tortuous VA malformation), all with complete resolution.

Discussion

The BHS is a clinical entity described as symptomatic ischemia of the brainstem or cerebellum due to vertebral artery occlusion, most frequently presented at the atlas-axis

Table 2 Anatomical location

C0-C1	C1	C2	C1–C2	C2-C3	C3–C7	Not reported	Multiple	Total
1	9	10	62	1	105	1	5	194

Table 3 Etiology

Degenerative	Miscellaneous: fibrous bands, cartilage malformations, muscular hypertrophy, tumor, idiopahtic	Instability	Vascular	Not reported	Total
104	25	12	11	42	194

Table 4 Treatment method

Surgery	Conservative	Endovascular	Total
154	37	3	194

level [1]. However, the analysis of the literature showed that the subaxial cervical spine is a more prevalent location (52%). The occlusion occurs because of the local lengthening and compression of the vertebral artery at rotation or extension of the neck, reducing the blood flow at the segment.

The reported cases of BHS in primary, idiopathic, atlantoaxial instability (without associated pathology like rheumatoid arthritis) are less than a dozen. Furthermore, the literature review reported only two BHS due to atlantoaxial rotational instability. The case presented is thus relevant, due to its rareness.

There are various diagnostic tools described in the literature. The Angio-CT scan with dynamic images (flexion, extension, rotations) was the one used, although the Angio-MRI, Angiography, and Doppler ultrasonography were also mentioned in the literature [7]. The Angio-CT scan offers the advantage of availability in most health centers without the requirement of a surgical operating room. It is also a fast exam (about 30 min) and can document previous brainstem or cerebellar infarctions. The disadvantages are the radiation, the use of intravenous contrast, and the need for at least 2 min of a sustained position to see the VA blood flow reduction [12].

The Angio-MRI is another exam that does not need the use of an operating room; it is a non-invasive exam, except for the use of intravenous gadolinium. It can document any ischemic episode, but it is not a fast exam, and it is not of easy availability in our healthcare system [12].

Currently, the Angio-CT scan and the Angio-MRI are closed to the performance of the Angiography; hence, they are used as first-line imaging when suspecting BHS. The logic after this preference is that the Angiography needs the use of an operating room and a vascular surgeon, and the amount of radiation is not predictable.

There are publications about the Doppler ultrasonography as a new method of diagnosis, advocating the advantages of being a fast, non-invasive exam, with no adverse events reported. The main disadvantage is that all the ultrasonographic studies are operator-dependent, and the learning curve of this procedure is not well established yet [9].

As mentioned, the indication of the diagnostic method depends on various factors. It cannot be recommended one of these diagnostic methods over the other ones with the available information. In our healthcare system, the dynamic Angio-CT appears to be the most indicated because of the advantages cited above. In selected cases of diagnostic uncertainty, a dynamic digital subtraction angiography may improve diagnostic accuracy.

Because of its infrequent presentation, there is not a gold-standard treatment. Treatments strategies may consider the etiology, as well as individual circumstances. The conservative treatment has not demonstrated improvement of the condition, only partial control of the symptoms. Besides, it is usually not well tolerated. On the other hand, it is usually safe considering the infrequent adverse events. There are reports of good outcomes [10], but the results are still contradictory because of another report standing only 37% of good results [11]. Some patients manage to follow the indications prescribed and tolerate the use of rigid or soft cervical orthosis for an extended period [10, 11]. There are not high-level evidence publications on this subject, just existing case reports and literature reviews.

The available literature suggests the surgical treatment is successful in reducing the symptoms. However, the surgery decision needs to consider potential risks and complications [12, 17]. Although stand-alone decompression is the most frequently described technique, it showed lower success rates (80%), when compared with the other surgical techniques. Stand-alone fusion, as well as fusion with decompression, were successful in all cases. Complication rates are not well described.

Conclusion

Dynamic VA occlusion, also known as "Bow hunter´s syndrome" (BHS), is a rare condition. The symptoms are a consequence of vertebrobasilar insufficiency, usually derived from the rotation of the head of at least 30º (usually 45º) contralateral to the dominant vertebral artery. The latter may be in combination with a variable degree of extension. Dynamic subtraction angiography is still the gold standard method. Still, other methods like Dynamic Angio-CT scan, Dynamic Angio-MRI, and recently Doppler ultrasonography are emerging as less invasive tests, useful to perform a proper diagnosis thanks to better technology and resolution of the images. The treatment methods depend on the etiology; also, it must be considered other patient factors such as age, severity, comorbidities, lifestyle, and occupation to choose the most appropriate option.

From the three surgical options, fusion and fusion combined with decompression showed better results.

The use of endovascular therapy may legitimate itself as a valid option.

Conservative treatment may be the preference anytime the patient is not eligible for surgery or endovascular therapy.

The pitfall to determine the success of any treatment may rest on the lack of documented follow-up and the absence of a standard measurement tool.

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Compliance with ethical standards

Conflict of interest The authors of the present paper declare no personal, financial or commercial conflicts of interest.

Consent for publication The patient included in this study signed an informed consent authorizing publication of his/her clinical case.

Ethical approval The present study has the approval of the institutional review board.

Consent to participate The patient included in this study received adequate information and signed an informed consent form.

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