



Atypical cervical spondylotic radiculopathy resulting in a hypertensive emergency during cervical extension: A case report and review of literature

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Specialty type: Orthopedics

Provenance and peer review:

Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification

Scientific Quality: Grade A

Novelty: Grade A

Creativity or Innovation: Grade A

Scientific Significance: Grade A

P-Reviewer: de Araújo Júnior FA

Received: May 16, 2024

Revised: September 6, 2024

Accepted: September 14, 2024

Published online: October 18, 2024

Processing time: 147 Days and 17.5 Hours



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Abstract

BACKGROUND

Extensive research revealed the absence of reports documenting hypertensive emergencies precipitated by changes in the cervical spine posture.

CASE SUMMARY

We here present a 57-year-old woman diagnosed as having cervical spondylotic radiculopathy (CSR) who was scheduled for anterior cervical decompression and fusion. During post-anesthetic positioning, a sudden hypertensive surge was observed when the patient was in a supine position with the neck being slightly extended. This surge was promptly reversed through cervical flexion and head elevation. This event however required an alternate surgical approach for recovery – posterior laminoplasty and endoscopy-assisted nucleus pulposus removal. Following the 6-month outpatient follow-up period, cervical flexion and extension activities substantially improved in the patient without any episodes of increase in acute blood pressure.

CONCLUSION

Maintaining a safe hypotensive posture and performing rapid, thorough decompression surgery may serve as effective interventions for patients presenting symptoms similar to those of CSR accompanied by hypertensive emergencies (HE). This would mitigate the underlying causes of these HEs.

Key Words: Atypical cervical spondylotic radiculopathy; Hypertensive emergency; Supine position; Endoscopic-assisted; Case report

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Core Tip: Cervical spondylotic radiculopathy (CSR) is the most common form of cervical spondylotic disease. To date, no study has documented any link between CSR and hypertensive emergencies. We here present a case of a typical patient with CSR who experienced a hypertensive crisis during the preparatory phase for anterior cervical discectomy and fusion surgery. This event was attributable to slight cervical spine hyperextension. Ultimately, the patient's CSR was resolved through posterior cervical canal expansion and foraminoscope-assisted transforaminal nucleus pulposus extraction. After the 6-month follow-up period, the patient exhibited normal neck flexion and blood pressure was stable during neck movements.

Citation: Cui HC, Chang ZQ, Zhao SK. Atypical cervical spondylotic radiculopathy resulting in a hypertensive emergency during cervical extension: A case report and review of literature. *World J Orthop* 2024; 15(10): 981-990

URL: <https://www.wjgnet.com/2218-5836/full/v15/i10/981.htm>

DOI: <https://dx.doi.org/10.5312/wjo.v15.i10.981>

INTRODUCTION

Hypertensive emergency (HE) is a critical medical condition presenting as a rapid and substantial elevation in blood pressure, which leads to a progressive impairment and potential failure of target organs[1]. This sudden spike in blood pressure can cause considerable harm to the body's physiological systems. It may also trigger numerous severe conditions, including hypertensive encephalopathy, acute stroke, acute coronary syndrome, acute left heart failure, aortic dissection, and eclampsia[2]. Mortality statistics are sobering, with death rates possibly ascending to 6.9% in the acute phase of HE. Moreover, mortality and readmission rates can reach 11% within 90 days of the condition's onset. For a subset of patients with severe hypertension, the mortality rate may increase to 50% within 1 year[3]. Various precipitating factors can contribute to HE. These factors include discontinuation of antihypertensive medication, onset of acute infections, acute urinary retention, episodes of acute or chronic pain, ingestion of sympathomimetic drugs (*e.g.*, cocaine, lysergic acid diethylamide, and amphetamines), panic attacks, and use of medicines inhibiting the effectiveness of antihypertensive treatment (*e.g.*, non-steroidal anti-inflammatory drugs and gastric mucosa protectors)[4]. The HE pathophysiology is related to the activation of sympathetic hypertonia and the release of vasoconstrictive substances, such as renin and angiotensin II. The surge in the activation and release of these substances abruptly elevates blood pressure over a short period[4].

To our knowledge, no case reports or clinical studies have documented cervical spondylotic radiculopathy (CSR)-induced HE. Here, we present a rare case of a 57-year-old female patient who presented with atypical symptoms of CSR, which was diagnosed during an outpatient consultation. After appropriate assessments were performed, the patient was scheduled to undergo anterior cervical discectomy and fusion (ACDF). During surgical preparation, when the patient was placed in the supine position for the procedure, blood pressure significantly increased (reaching as high as 270/100 mmHg) following minor cervical spine extension. Rapidly elevating the patient's head caused a gradual decline in blood pressure. The patient provided written informed consent for the publication of this case report.

CASE PRESENTATION

Chief complaints

A 57-year-old woman presented to our department in August 2022. She complained of pain in her neck and right upper limb, which had been persistent for the past 2 months.

History of present illness

The patient started experiencing neck and back pain 2 months ago, without an identifiable etiology, along with discomfort in the right upper limb and difficulty in posterior neck extension. These symptoms are aggravated during sitting or ambulation but alleviated following recumbency and rest. Orally administered non-steroidal anti-inflammatory drugs were ineffective.

History of past illness

Despite having a decade-long history of diabetes, the patient had no hypertension or coronary heart disease, and effective glycemic control was achieved with oral metformin and acarbose. Blood pressure was measured twice daily before surgery, and the maximum reading of 148/74 mmHg was obtained.

Personal and family history

No personal and family history.

Physical examination

Physical examination revealed a normal gait, pain-induced passively flexed cervical position, and remarkable limitation in cervical extension. The roof pressure test and the right brachial plexus pull test yielded positive results, whereas the

bilateral paper clamp test yielded negative results. In the patient, muscle strength and tone in all limbs were normal. Neurologically, both Hoffman's and Babinski's signs were negative.

Laboratory examinations

Routine blood tests, liver function tests, biochemical assays, C-reactive protein levels, and erythrocyte sedimentation rate parameters were all within normal limits.

Imaging examinations

The cervical spine radiographs revealed various degrees of osteophyte formation and sclerosis on the edges of the C2–C7 vertebrae, along with a pronounced reduction in the intervertebral space at C6–C7 and calcification of the nuchal ligament. A computed tomography scan displayed the disappearance of the physiological curvature and inverting arch formation. The scan also showed a right posterior herniated disc in the C6–C7 space, which led to right nerve root canal stenosis. Magnetic resonance imaging (MRI) of the cervical spine demonstrated a right-sided C6–C7 nucleus pulposus protrusion, which caused compression of the right C7 nerve root (Figure 1). Based on these findings, a diagnosis of CSR at the C6–C7 intervertebral level was made.

A preoperative electrocardiogram indicated sinus rhythm and normal findings. Color ultrasonography unveiled a normal size of the heart cavity, normal inner diameter of large blood vessels, and normal thickness of the ventricular septum and posterior wall of the left ventricle. The left ventricular systolic function was good, with an ejection fraction of 64%. However, cervical vascular ultrasonography unveiled bilateral carotid atherosclerosis with plaques. Yet, the bilateral vertebral arteries and internal carotid venous flow were unobstructed.

FINAL DIAGNOSIS

Once all surgical contraindications were excluded, the patient was prepared for ACDF under general anesthesia. After anesthesia was successfully induced, the patient was positioned supine with the neck being slightly extended. During this process, invasive monitoring detected a sudden elevation in arterial blood pressure from 150/85 to 270/100 mmHg. Immediately, the patient's neck position was readjusted from hyperextension to flexion, and the head was elevated. Following a 10-minute observation period, the blood pressure gradually decreased. Given these circumstances, the surgeons decided to abort the procedure and awaken the patient. After anesthesia reversal was achieved, the patient's blood pressure normalized to 130/90 mmHg, with a satisfactory return of limb motor function and skin sensation. The patient exhibited no previous medical history indicative of hypertension. Following consultation with the deputy chief of cardiology, the acute elevation in the patient's intraoperative blood pressure was concluded to be a possible result of cervical extension or anesthesia administration. Suggestions: Changes in patients' blood pressure must be continuously monitored. Antihypertensive medication should be initiated if hypertension is observed. If acute elevation of blood pressure is recurrent, sodium nitroprusside or nitroglycerin may be administered for symptomatic relief. A final diagnosis of atypical CSR was made.

TREATMENT

Three days later, following an intragroup discussion, a decision to perform laminoplasty through a posterior approach and endoscopy-assisted C6/7 right nerve root canal nucleus pulposus discectomy procedures was made. Anesthesia was successfully administered, and the patient was positioned supine. Arterial blood pressure was invasively monitored to assess hemodynamic stability for 5 minutes. The blood pressure was consistently fluctuating between 120–140/80–100 mmHg. Once blood pressure stabilized, the patient was positioned prone without any significant changes noted in hemodynamics. Once the patient was successfully placed in the prone position, the surgical site was meticulously disinfected and sterile drapes were applied.

A 10-cm-long longitudinal incision was made, with each layer being successively cut through. After the paraspinal muscle was dissected, the C2 spinous process served as the localization marker for exposing the bilateral C4–C6 lateral mass. The lateral cortex of the left lamina was excised using an ultrasonic bone knife, thereby the "portal axis side" was formed. The bilateral cortex on the right side was incised to form the "door side", followed by the cautious elevation of the C4–C6 lamina and decompression of the spinal cord. An appropriately sized single-door plate was used to fix the "door side" of the C4 and C6 lamina. Portions of the C3 and C7 lamina were excised. Following thorough decompression, spinal cord distension was observed, and pulsation resumed. The C7 right nerve root was exposed using a foraminal lens. Three fragments of the broken nucleus pulposus tissue were extracted from the ventral axillary side of the C7 right nerve root by using the foraminal lens and crochet. When the crochet probe was reapplied, the nerve root was found to be relaxed, which indicated the completion of the operation (Figure 2).

OUTCOME AND FOLLOW-UP

On the third postoperative day, pain in the neck and right upper extremity ceased. The sutures were removed on the 12th postoperative day, with the subsequent discharge of the patient from the hospital. A 6-month postoperative outpatient

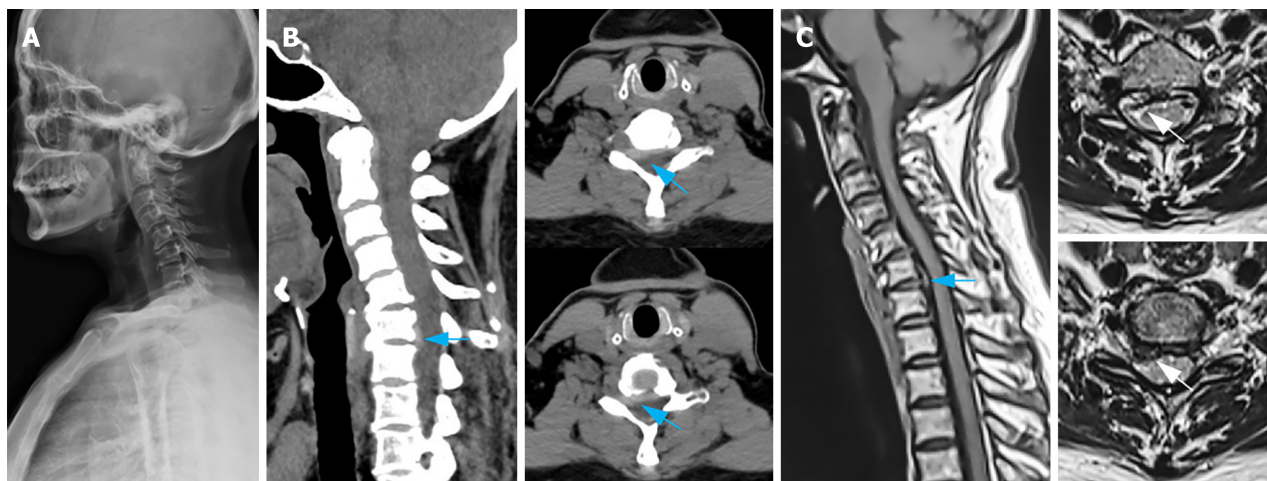


Figure 1 Preoperative imaging examinations. A: A lateral plain film of the cervical vertebra depicts cervical vertebra's reversed arch, narrowed C6/7 space, and patchy calcification of the nuchal ligament; B: Cervical vertebra computerized tomography sagittal reconstruction and plain scan demonstrate an intervertebral disc prolapse and upward displacement in the C6/7 space, along with right nerve root canal stenosis (indicated by the blue arrow); C: Sagittal magnetic resonance imaging and plain scan of cervical vertebra present herniation and upward displacement of the intervertebral disc in the C6/7 space (indicated by the blue arrow), discontinuous intervertebral disc signal, and compression of the right C7 nerve root (indicated by the white arrow).

follow-up demonstrated markedly improved neck flexion and extension activities. MRI confirmed that the nucleus pulposus tissue was absent in the C7 nerve root canal (Figure 3). Ambulatory blood pressure monitoring exhibited no acute increase in blood pressure following excessive flexion or extension of the patient's neck (Figure 4). The patient was satisfied with the treatment effect.

DISCUSSION

Diagnosis of atypical CSR

CSR, the most common form of cervical spondylotic disease, occurs due to various pathologies including cervical disc degeneration, osseous hyperplasia, instability or dislocation of cervical articular ligaments, and cervical nerve root irritation or compression. Classic clinical manifestations of CSR are neck, shoulder, and back pain; radiating discomfort; numbness; and upper limb and finger weakness[5]. A subset of patients developed additional symptoms such as vertigo, headache, nausea, tinnitus, blurred vision, palpitations, memory loss, and gastrointestinal discomfort, collectively known as Barre-Lieou syndrome as it was initially described by Barre and Lieou in 1926[6]. Despite these symptoms being linked to degenerative cervical changes, current diagnostic modalities have been unable to identify radiological or pathological abnormalities responsible for these manifestations, thus rendering them atypical symptoms of cervical spondylosis[7]. Within the broader classification of cervical spondylotic diseases, this cervical spondylosis-associated atypical symptomatic presentation was termed sympathetic cervical spondylosis[8].

The diagnosis of atypical cervical spondylosis is controversial as definitive pathological mechanisms are unknown and specific diagnostic assays are lacking. Nevertheless, the diagnosis and treatment of atypical cervical spondylosis has garnered widespread acceptance in China's medical community[9] as well as by global scholars. A consensus has been reached that physical therapy and conservative manipulative treatment can mitigate cervical spondylosis-associated sympathetic nervous symptoms[10,11]. Machaly *et al*[12] identified a possible correlation between cervical spondylosis and occlusion of the vertebralbasilar artery during cervical rotation, which frequently leads to vertebralbasilar insufficiency and dizziness[12]. Sympathetic nervous symptoms were markedly alleviated in many patients with sympathetic cervical spondylosis after they underwent conventional anterior cervical decompression and fusion surgery[13]. While the etiology of cervical spondylosis-associated atypical symptoms remains elusive, clinical observations and intervention outcomes offer valuable diagnostic insights. Our patient's preoperative evaluation revealed no vertebral artery malformations or uncovertebral joint irregularities. Moreover, further diagnostic procedures eliminated the possibility of pheochromocytoma and primary aldosteronism. Although no reported instances of CSR concurrent with similar HEs are available, the patient's case qualifies as CSR presenting atypical symptoms, considering the predisposing factors for blood pressure elevation and complete resolution of symptoms after surgery.

Understanding the mechanism underlying CSR-induced HE

The European Society of Cardiology (ESC) guidelines for 2019 defined HEs as sudden and rapid increases in blood pressure that lead to regulatory abnormalities. Specifically, a systolic blood pressure of 220 mmHg or more and/or a diastolic blood pressure of 140 mmHg or more would indicate HE, irrespective of accompanying symptoms[2]. HEs are closely associated with high mortality and disability rates[14,15]. These emergencies are classified as malignant hypertension, rapidly progressive hypertension, and rapidly progressive malignant hypertension[16]. In the present case,

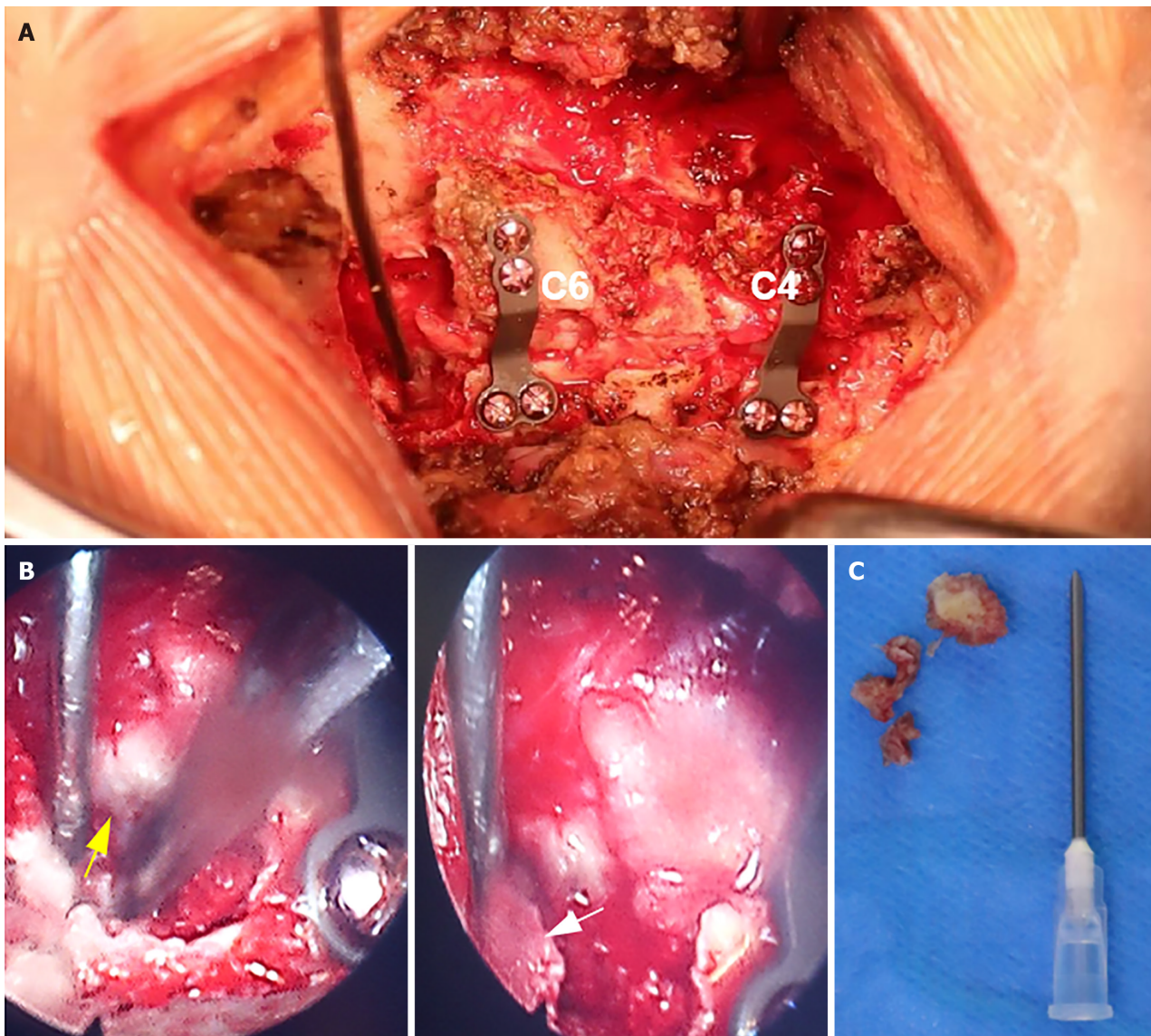


Figure 2 Intraoperative image. A: The vertebral laminae of C4 and C6 were elevated, facilitating decompression of the spinal cord, followed by placement of an internal fixation plate; B: The ventral nucleus pulposus was extracted from the right nerve root of C7 using foraminial mirror-assisted extraction technique. During this procedure, the dural membrane (indicated by the yellow arrow) and excised free nucleus pulposus tissue (indicated by the white arrow) were visually observed; C: Intraoperatively obtained free nucleus pulposus tissue from the ventral aspect of the C7 nerve root.

despite successful administration of initial anesthesia, a minor extension of the patient's neck during postural positioning sharply elevated the blood pressure to 270/100 mmHg, thereby meeting the criteria for HE as per the ESC guidelines.

The relationship between cervical spondylosis and hypertension has been extensively investigated[17-19], with hypotheses being drawn for its mechanistic connection[20-25]. However, to our knowledge, no study has addressed the potential of cervical spondylosis to induce HEs. These events are often triggered by stress factors, such as activation of sympathetic hypertonia, and an increase in the release of vasoconstrictive substances, which can cause abrupt spikes in blood pressure[26]. Anatomically, the neck's sympathetic trunk lies behind the cervical vascular sheath, anterior to the cervical vertebrae's transverse process. It typically has three sympathetic ganglia (superior, middle, and inferior) on each side, with the middle ganglion usually being the smallest and occasionally absent. The trunk is generally found at the C6 vertebra's transverse process. The inferior ganglion is situated anterior to the root of the C7 vertebra's transverse process, posterior to the start of the vertebral artery. It often fuses with the T1 ganglion to form the cervicothoracic ganglion, alias the stellate ganglion[27]. In our case, MRI unveiled a rupture of the C6/7 fibrous ring, and the herniated nucleus pulposus tissue compressing the C7 nerve root canal. This site coincides with the location of the middle or inferior cervical sympathetic ganglion. Existing evidence demonstrates the presence of segmentally distributed bidirectional neural connections between the cervical spinal and ipsilateral cervical sympathetic ganglia[28]. According to our hypothesis, the patient's neck hyperextension triggered further compression of the C6/7 intervertebral disc. This extra pressure directly affected the spinal ganglion at the posterior root of the right C7 spinal nerve by the prolapsed nucleus pulposus tissue on the right side. The spinal ganglion then stimulated the proximal cervical or subcortical sympathetic ganglion through bidirectional neural fibers, thus inducing the extensive activation of sympathetic hypertonia and release of vasoconstrictive substances. This cascade culminated in a HE (Figure 5).



Figure 3 Outpatient follow-up 6 months post-surgery. A: X-ray examination of the cervical spine in lateral and hyperextension flexion positions displays a

significant improvement in the cervical spine's range of motion; B: Magnetic resonance imaging at 6 months post-surgery: The herniated nucleus pulposus tissue of C6/7 has been eliminated, and the right C7 nerve has been entirely decompressed, with no signal from the nucleus pulposus tissue (indicated by the white arrow).

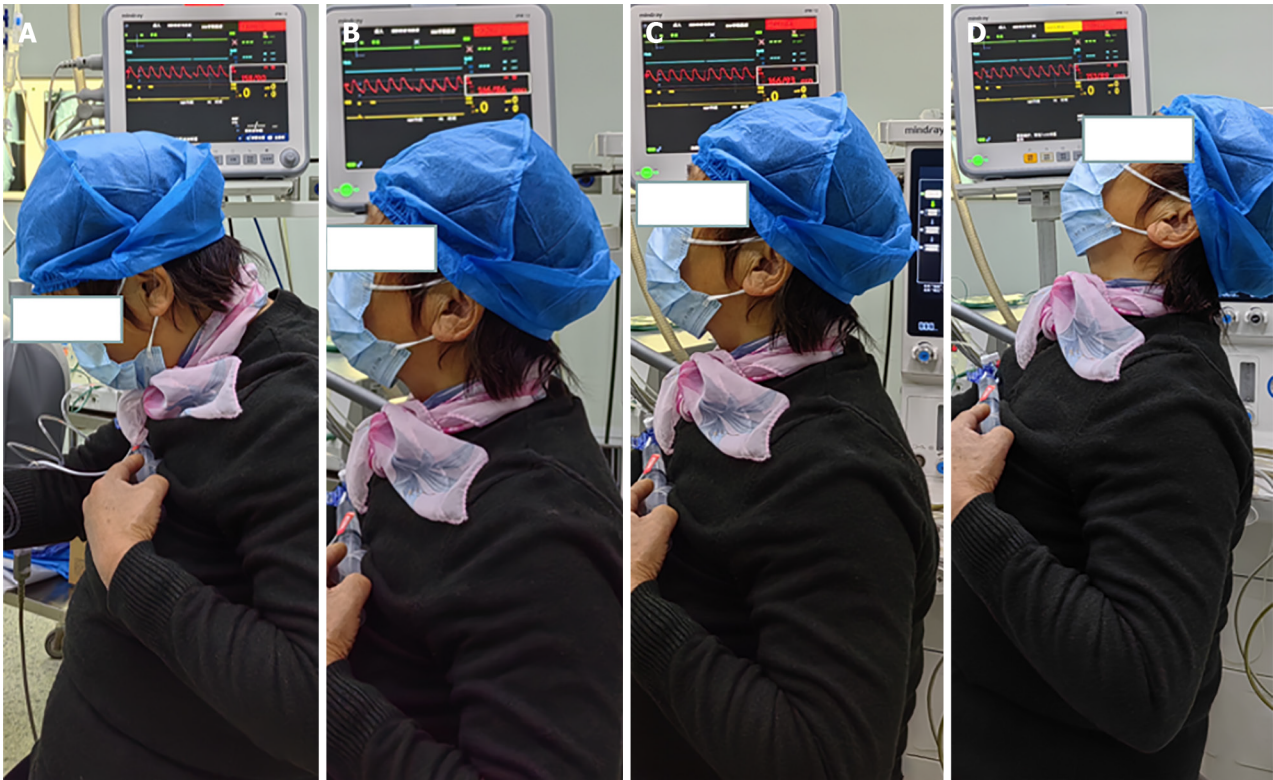


Figure 4 Six months post-surgery, ambulatory pulse blood pressure monitoring indicated systolic blood pressure fluctuations between 146–166 mmHg and diastolic blood pressure variations between 86–93 mmHg. A: Cervical flexion, blood pressure at 158/90 mmHg; B: Neck in neutral position, blood pressure at 146/86 mmHg; C: Neck slightly extended: Blood pressure at 166/93 mmHg; D: Neck in complete extension, blood pressure at 153/89 mmHg.

Application of posterior cervical canal expansion and foraminoscope-assisted transforaminal nucleus pulposus extraction

Notable symptom mitigation has been observed in patients exhibiting atypical symptoms of cervical spondylosis who underwent a double-door laminoplasty procedure[29]. In our patient, an anterior approach was deemed unsuitable because of the potential hypertensive crisis instigated by minimal neck extension. Consequently, posterior laminoplasty and foraminoscope-facilitated nucleus pulposus removal from the C6/7 right intervertebral foramen were performed. This combined surgical approach was selected based on the observed success of spinal canal decompression through single or double-door laminoplasty[30] and the efficacy of posterior laminoplasty for managing CSR[31]. Compared with the posterior cervical keyhole technique, the single-door method was less time-consuming, a notable factor for our patients vulnerable to unpredictable hypertensive crises. Additionally, the patient's reversed cervical arch contraindicated the keyhole procedure[32]. Nonetheless, posterior surgical approaches fail to excise the nucleus pulposus or pathological tissue situated ventrally and medially to the nerve root, a major disadvantage relative to anterior methods[33]. Because the patient's hypertensive crisis possibly stems from postural alterations compressing the herniated nucleus pulposus, thus stimulating the sympathetic nervous system, completely excising the ventrally located herniated nucleus pulposus is critical. This was achieved when the intervertebral foramen mirror's magnification and a matching hook needle were used to extract the protruding nucleus pulposus tissue after laminotomy.

CONCLUSION

In conclusion, the clinical findings of our case suggest that the right-sided herniated nucleus pulposus at the C6/7 vertebrae places pressure on the spinal ganglia at the posterior root of the right C7 vertebrae during cervical hyperextension. This induces direct excitation of the cervical sympathetic ganglia through bidirectional nerve fibers, which escalated sympathetic nervous system activity and prompted an acute, short-term elevation in blood pressure. For patients presenting with CSR concurrent with HEs, as in our case, adopting a cautious hypotensive posture and quickly performing comprehensive decompression surgery can proficiently alleviate the causative factors underpinning

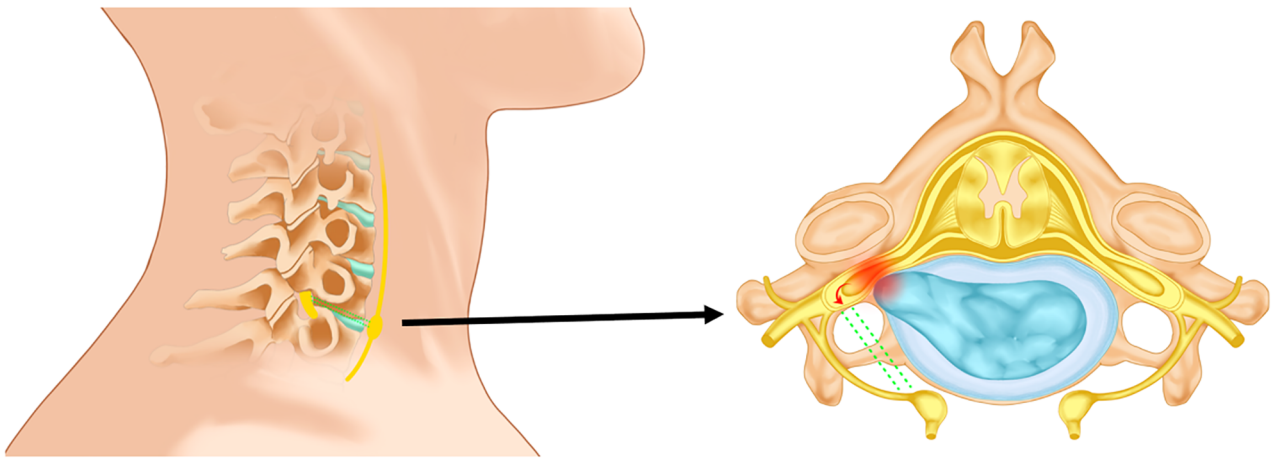


Figure 5 Overextension of the neck leads to further compression of the spinal ganglia by the nucleus pulposus tissue. Following pressure stimulation, the spinal nerves directly excite the neck's sympathetic ganglia *via* bidirectional nerve fibers (represented by green dashed lines), thus activating the sympathetic nervous system and inducing a rapid blood pressure increase.

hypertensive crises safely. Additionally, it may be helpful to record blood pressure during different ranges of neck movement before surgery, which could potentially help identify potential cases of such atypical cervical spine disorders.

ACKNOWLEDGEMENTS

The authors would like to thank the investigators and patient who contributed to this study.

FOOTNOTES

Author contributions: Cui HC and Chang ZQ made substantial contributions to acquisition, analysis and interpretation of data; Chang ZQ was responsible for the conception and design of the study and Cui HC was responsible for the drafting and writing of this manuscript; Zhao SK and Cui HC were a surgical assistant. All authors confirm the authenticity of all the raw data.

Informed consent statement: Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Conflict-of-interest statement: The authors declare that they have no conflict of interest.

CARE Checklist (2016) statement: The authors have read the CARE Checklist (2016), and the manuscript was prepared and revised according to the CARE Checklist (2016).

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S-Editor: Liu H

L-Editor: A

P-Editor: Yu HG

REFERENCES

- 1 Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, Ramirez A, Schlaich M, Stergiou GS, Tomaszewski M, Wainford RD, Williams B, Schutte AE. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. *Hypertension* 2020; **75**: 1334-1357 [PMID: 32370572 DOI: 10.1161/HYPERTENSIONAHA.120.15026]
- 2 van den Born BH, Lip GYH, Brguljan-Hitij J, Cremer A, Segura J, Morales E, Mahfoud F, Amraoui F, Persu A, Kahan T, Agabiti Rosei E, de

- Simone G, Gosse P, Williams B. ESC Council on hypertension position document on the management of hypertensive emergencies. *Eur Heart J Cardiovasc Pharmacother* 2019; **5**: 37-46 [PMID: 30165588 DOI: 10.1093/ehjcvp/pvy032]
- 3 **Katz JN**, Gore JM, Amin A, Anderson FA, Dasta JF, Ferguson JJ, Kleinschmidt K, Mayer SA, Multz AS, Peacock WF, Peterson E, Pollack C, Sung GY, Shorr A, Varon J, Wyman A, Emery LA, Granger CB; STAT Investigators. Practice patterns, outcomes, and end-organ dysfunction for patients with acute severe hypertension: the Studying the Treatment of Acute hyperTension (STAT) registry. *Am Heart J* 2009; **158**: 599-606.e1 [PMID: 19781420 DOI: 10.1016/j.ahj.2009.07.020]
- 4 **Lip GY**, Beevers M, Beevers G. The failure of malignant hypertension to decline: a survey of 24 years' experience in a multiracial population in England. *J Hypertens* 1994; **12**: 1297-1305 [PMID: 7868878]
- 5 **Epstein JA**, Lavine LS, Aronson HA, Epstein BS. Cervical radiculopathy. The treatment of foraminal constriction syndrome with foraminotomy and osteophyctectomy. *Clin Orthop Relat Res* 1965; **40**: 113-122 [PMID: 14304700]
- 6 **Serre H**, Labauge R, Simon L, Lamboley C. [Barré-Liéou syndrome, designated "posterior sympathetic cervical syndrome"]. *Rhumatologie* 1969; **21**: 217-246 [PMID: 5385911]
- 7 **Sun Y**, Muheremu A, Yan K, Yu J, Zheng S, Tian W. Effect of double-door laminoplasty on atypical symptoms associated with cervical spondylotic myelopathy/radiculopathy. *BMC Surg* 2016; **16**: 31 [PMID: 27160834 DOI: 10.1186/s12893-016-0146-1]
- 8 **Garg K**, Aggarwal A. Effect of Cervical Decompression on Atypical Symptoms Cervical Spondylosis-A Narrative Review and Meta-Analysis. *World Neurosurg* 2022; **157**: 207-217.e1 [PMID: 34655819 DOI: 10.1016/j.wneu.2021.09.110]
- 9 **Li J**, Gu T, Yang H, Liang L, Jiang DJ, Wang ZC, Yuan W, Wang XW. Sympathetic nerve innervation in cervical posterior longitudinal ligament as a potential causative factor in cervical spondylosis with sympathetic symptoms and preliminary evidence. *Med Hypotheses* 2014; **82**: 631-635 [PMID: 24629355 DOI: 10.1016/j.mehy.2014.02.029]
- 10 **Kerry R**, Taylor AJ, Mitchell J, McCarthy C. Cervical arterial dysfunction and manual therapy: a critical literature review to inform professional practice. *Man Ther* 2008; **13**: 278-288 [PMID: 18280769 DOI: 10.1016/j.math.2007.10.006]
- 11 **Johnson GM**. The sensory and sympathetic nerve supply within the cervical spine: review of recent observations. *Man Ther* 2004; **9**: 71-76 [PMID: 15040965 DOI: 10.1016/S1356-689X(03)00093-6]
- 12 **Machaly SA**, Senna MK, Sadek AG. Vertigo is associated with advanced degenerative changes in patients with cervical spondylosis. *Clin Rheumatol* 2011; **30**: 1527-1534 [PMID: 21597927 DOI: 10.1007/s10067-011-1770-x]
- 13 **Li J**, Jiang DJ, Wang XW, Yuan W, Liang L, Wang ZC. Mid-term Outcomes of Anterior Cervical Fusion for Cervical Spondylosis With Sympathetic Symptoms. *Clin Spine Surg* 2016; **29**: 255-260 [PMID: 23168395 DOI: 10.1097/BSD.0b013e31827b4ccc]
- 14 **Marik PE**, Varon J. Hypertensive crises: challenges and management. *Chest* 2007; **131**: 1949-1962 [PMID: 17565029 DOI: 10.1378/chest.06-2490]
- 15 **Flack JM**, Calhoun D, Schiffrin EL. The New ACC/AHA Hypertension Guidelines for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults. *Am J Hypertens* 2018; **31**: 133-135 [PMID: 29228096 DOI: 10.1093/ajh/hpx207]
- 16 **Mancia G**, Fagard R, Narkiewicz K, Redón J, Zanchetti A, Böhm M, Christiaens T, Cifkova R, De Backer G, Dominiczak A, Galderisi M, Grobbee DE, Jaarsma T, Kirchhof P, Kjeldsen SE, Laurent S, Manolis AJ, Nilsson PM, Ruilope LM, Schmieder RE, Sirtes PA, Sleight P, Viigimaa M, Waeber B, Zannad F; Task Force Members. 2013 ESH/ESC Guidelines for the management of arterial hypertension: the Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *J Hypertens* 2013; **31**: 1281-1357 [PMID: 23817082 DOI: 10.1097/01.hjh.0000431740.32696.cc]
- 17 **Yamada H**, Honda T, Yaginuma H, Kikuchi S, Sugiura Y. Comparison of sensory and sympathetic innervation of the dura mater and posterior longitudinal ligament in the cervical spine after removal of the stellate ganglion. *J Comp Neurol* 2001; **434**: 86-100 [PMID: 11329131 DOI: 10.1002/cne.1166]
- 18 **Liu H**, Ploumis A. Cervicogenic hypertension - A possible etiology and pathogenesis of essential hypertension. *Hypothesis* 2012; **10** [DOI: 10.5779/hypothesis.v10i1.297]
- 19 **Peng B**, Pang X, Li D, Yang H. Cervical spondylosis and hypertension: a clinical study of 2 cases. *Medicine (Baltimore)* 2015; **94**: e618 [PMID: 25761188 DOI: 10.1097/MD.0000000000000618]
- 20 **Wang Z**, Wang X, Yuan W, Jiang D. Degenerative pathological irritations to cervical PLL may play a role in presenting sympathetic symptoms. *Med Hypotheses* 2011; **77**: 921-923 [PMID: 21890278 DOI: 10.1016/j.mehy.2011.08.012]
- 21 **Cassaglia PA**, Griffiths RI, Walker AM. Sympathetic withdrawal augments cerebral blood flow during acute hypercapnia in sleeping lambs. *Sleep* 2008; **31**: 1729-1734 [PMID: 19090329 DOI: 10.1093/sleep/31.12.1729]
- 22 **Heistad DD**, Marcus ML, Gross PM. Effects of sympathetic nerves on cerebral vessels in dog, cat, and monkey. *Am J Physiol* 1978; **235**: H544-H552 [PMID: 103441 DOI: 10.1152/ajpheart.1978.235.5.H544]
- 23 **Wang YJ**, Shi Q, Lu WW, Cheung KC, Darowish M, Li TF, Dong YF, Zhou CJ, Zhou Q, Hu ZJ, Liu M, Bian Q, Li CG, Luk KD, Leong JC. Cervical intervertebral disc degeneration induced by unbalanced dynamic and static forces: a novel in vivo rat model. *Spine (Phila Pa 1976)* 2006; **31**: 1532-1538 [PMID: 16778684 DOI: 10.1097/01.brs.0000222019.84095.23]
- 24 **Wilmink JT**. The normal aging spine and degenerative spinal disease. *Neuroradiology* 2011; **53** Suppl 1: S181-S183 [PMID: 21863427 DOI: 10.1007/s00234-011-0924-5]
- 25 **Esler MD**, Eikelis N, Lambert E, Straznicki N. Neural mechanisms and management of obesity-related hypertension. *Curr Cardiol Rep* 2008; **10**: 456-463 [PMID: 18950554 DOI: 10.1007/s11886-008-0072-7]
- 26 **van den Born BJ**, Koopmans RP, Groeneveld JO, van Montfrans GA. Ethnic disparities in the incidence, presentation and complications of malignant hypertension. *J Hypertens* 2006; **24**: 2299-2304 [PMID: 17053554 DOI: 10.1097/01.hjh.0000249710.21146.38]
- 27 **Michels T**, Lehmann N, Moebus S. Cervical vertigo--cervical pain: an alternative and efficient treatment. *J Altern Complement Med* 2007; **13**: 513-518 [PMID: 17604554 DOI: 10.1089/acm.2007.6102]
- 28 **Zhu X**, Han J, Zang R, Qiu S, Chang G, Zuo J. Functional Pathway Between Cervical Spinal and Sympathetic Ganglia: A Neurochemical Foundation Between Neck Pain and Vertigo. *Pain Physician* 2019; **22**: E627-E633 [PMID: 31775416]
- 29 **Sun Y**, Muheremu A, Yan K, Yu J, Zheng S, Tian W. Effect of different surgical methods on headache associated with cervical spondylotic myelopathy and/or radiculopathy. *BMC Surg* 2015; **15**: 105 [PMID: 26399694 DOI: 10.1186/s12893-015-0092-3]
- 30 **Wada E**, Suzuki S, Kanazawa A, Matsuoka T, Miyamoto S, Yonenobu K. Subtotal corpectomy versus laminoplasty for multilevel cervical spondylotic myelopathy: a long-term follow-up study over 10 years. *Spine (Phila Pa 1976)* 2001; **26**: 1443-7; discussion 1448 [PMID: 11458148 DOI: 10.1097/00007632-200107010-00011]
- 31 **Heary RF**, Ryken TC, Matz PG, Anderson PA, Groff MW, Holly LT, Kaiser MG, Mummaneni PV, Choudhri TF, Vresilovic EJ, Resnick DK;

Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and Congress of Neurological Surgeons. Cervical laminoforaminotomy for the treatment of cervical degenerative radiculopathy. *J Neurosurg Spine* 2009; **11**: 198-202 [PMID: 19769499 DOI: 10.3171/2009.2.SPINE08722]

32 **Galbraith JG**, Butler JS, Dolan AM, O'Byrne JM. Operative outcomes for cervical myelopathy and radiculopathy. *Adv Orthop* 2012; **2012**: 919153 [PMID: 22046575 DOI: 10.1155/2012/919153]

33 **Korinth MC**, Krüger A, Oertel MF, Gilsbach JM. Posterior foraminotomy or anterior discectomy with polymethyl methacrylate interbody stabilization for cervical soft disc disease: results in 292 patients with monoradiculopathy. *Spine (Phila Pa 1976)* 2006; **31**: 1207-14; discussion 1215 [PMID: 16688033 DOI: 10.1097/01.brs.0000217604.02663.59]



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