Article published online: 2024-08-30

Review Article

Pseudoephedrine-Induced Risks of Posterior Reversible Encephalopathy Syndrome and Reversible Cerebral Vasoconstriction Syndrome

Naina Mohamed Pakkir Maideen[1] Rajkapoor Balasubramanian[2] Arun Shanmugam[2] Mirunalini Gobinath[3] Mohamed Harshath Jahir Hussain[4]

[1] Department of Pharmacy, Dubai Health, Dubai, United Arab Emirates
[2] Department of Pharmacology, J.K.K. Nattraja College of Pharmacy, Komarapalayam, Tamil Nadu, India
[3] Research Scholar, JSS College of Pharmacy, Ooty, Tamil Nadu, India
[4] Student Researcher, Ratnam Institute of Pharmacy, Nellore, Andhra Pradesh, India

Address for correspondence Rajkapoor Balasubramanian, PhD, Department of Pharmacology, J.K.K. Nattraja College of Pharmacy, Komarapalayam 638183, Tamil Nadu, India (e-mail: rajkapoorb@gmail.com).

Ibnosina J Med Biomed Sci

Abstract

Background Pseudoephedrine is a sympathomimetic drug used as a nasal/sinus decongestant in common cold remedies.

Objective The purpose of this review article is to discuss the pseudoephedrine-associated posterior reversible encephalopathy syndrome (PRES) and reversible cerebral vasoconstriction syndrome (RCVS), which have been reported to the Medicines and Healthcare products Regulatory Agency (MHRA) of United Kingdom and Pharmacovigilance Risk Assessment Committee (PRAC) and Committee for Medicinal Products for Human Use (CHMP) of European Medicines Agency (EMA).

Methods The aim is to review the literature pertinent to PRES and RCVS linked to the use of pseudoephedrine; the literature was searched in databases such as Medline/PubMed/PMC, Google Scholar, Science Direct, Ebsco, Scopus, Web of Science, Embase, and reference lists.

Results The review by MHRA of the United Kingdom and PRAC and CHMP of EMA, all available evidence, including postmarketing safety data, and a few case reports, have confirmed the rare risk of PRES and RCVS associated with the use of pseudoephedrine.

Conclusion Health care professionals should be aware of pseudoephedrine-associated PRES and RCVS. Patients with severe or uncontrolled hypertension or those with severe acute or chronic renal disease should avoid using products containing pseudoephedrine.

Keywords
- pseudoephedrine
- pharmacovigilance
- adverse effects
- posterior reversible encephalopathy syndrome
- reversible cerebral vasoconstriction syndrome
- pseudoephedrine-containing medicines

DOI https://doi.org/10.1055/s-0044-1789215.
ISSN 1947-489X.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Introduction

On February 20, 2024, the United Kingdom's Medicines and Healthcare Products Regulatory Agency (MHRA) advised health care professionals to counsel patients and caregivers about posterior reversible encephalopathy syndrome (PRES) and reversible cerebral vasoconstriction syndrome (RCVS) linked to the use of products containing pseudoephedrine. Neurologic conditions such as PRES and RCVS are tied to reduced blood flow to the brain and can result in severe and potentially fatal complications. Similarly, on January 26, 2024, the Committee for Medicinal Products for Human Use (CHMP) of the European Medicines Agency (EMA) recommended medical practitioners to take certain actions to lower pseudoephedrine-associated PRES and RCVS.[1]

In fact, due to concerns about the risks of PRES and RCVS, the Pharmacovigilance Risk Assessment Committee (PRAC) of EMA started reviewing the evidence related to PRES and RCVS associated with the use of pseudoephedrine-containing medicinal products on February 10, 2023.[2] Furthermore, on February 23, 2023, the MHRA began reviewing medications that contain pseudoephedrine to determine whether or not they increase the risk of PRES and RCVS.[3] As a result, on December 1, 2023, the PRAC recommended a few measures to decrease the risks of PRES and RCVS related to the use of medicines containing pseudoephedrine.[4] Later, on January 26, 2024, the CHMP approved the suggestions made by the PRAC.[1]

Common cold remedies contain pseudoephedrine, a sympathomimetic drug, which acts as a decongestant for both the nose and the sinuses. Pseudoephedrine is typically found in common cold remedies along with antihistamines such as triprolidine, cetirizine, loratadine, and fexofenadine.[5] Pseudoephedrine acts as an agonist on α1-adrenergic receptors present in blood vessels, causing vasoconstriction, which reduces nasal secretions and relieves nasal congestion. Additionally, synaptic nerve terminals stimulated by pseudoephedrine release norepinephrine, which in turn enhances sympathomimetic activity.[6] Pseudoephedrine is chemically related to amphetamine and phenethylamine and is used/misused as a stimulant, weight loss aid, and appetite suppressant in modern times.[7]

Adverse effects of pseudoephedrine may include those to the cardiovascular system (increased blood pressure, enhanced heart rate, arrhythmia, myocardial infarction, and ischemic stroke in rare cases), central nervous system (restlessness, nervousness, anxiety, insomnia, headaches, tremors, and seizures in rare cases), gastrointestinal tract (nausea, vomiting, diarrhea, and abdominal pain), urinary retention, and allergic reactions.[8]

PRES is an acute neurotoxic syndrome characterized by vasogenic edema mainly in the parieto-occipital regions and headache, altered mental status, encephalopathy (somnolence, stupor, coma), seizures (generalized tonic-clonic seizures, partial seizures, and status epilepticus), visual disturbances (diplopia, decreased visual acuity, visual field deficits, visual hallucinations), nausea/vomiting, focal neurological deficits (aphasia, hemiparesis), and impairment of the level of consciousness.[9]

Possible pathophysiological mechanisms underlying PRES may include severe hypertension, cerebral vasoconstriction, and cerebral endothelial cell damage. Severe hypertension (increased arterial pressure) may lead to brain hyperperfusion, endothelial injury, and cerebral vessel damage with subsequent failure of cerebral autoregulation and extravasation of plasma that results in vasogenic edema. Brain hypoperfusion brought on by cerebral vasoconstriction can result in cerebral ischemia followed by vasogenic edema. Cerebral endothelial cell damage induces damage to the blood–brain barrier, followed by increased vascular leakage and vasogenic edema. Neuronal cell death can ultimately occur in cases of vasogenic edema due to hypoxia and impaired microcirculation.[10]

RCVS is a complex neurovascular syndrome that manifests as reversible segmental and multifocal cerebral vasoconstriction, thunderclap headache (severe, sudden-onset headache reaching peak intensity within 1 minute), nausea, vomiting, photophobia, phonophobia, focal neurological deficits, encephalopathy, visual changes, aphasia, dysarthria, ataxia, epileptic seizures, and focal numbness or weakness.[11]

Dysfunction of cerebral vascular tone, sympathetic hyperactivity, excessive oxidative stress, endothelial dysfunction, disruption of the blood–brain barrier, altered trigeminovascular nociception, genetic predisposition, sex hormones, and inflammation are some of the likely underlying mechanisms of RCVS. Cerebral vasoconstriction may result from dysfunction of cerebral vascular tone linked to excessive sympathetic discharge.[11]

Predisposing and precipitating factors of RCVS may induce excessive sympathetic activity, endothelial dysfunction, and excessive oxidative stress, resulting in dysfunction of cerebral vascular tone and disruption of the blood–brain barrier. All these factors can lead to cerebral vasoconstriction, thunderclap headache, subarachnoid hemorrhage (SAH), intraparenchymal hemorrhage (IPH), cerebral venous thrombosis, PRES, ischemic stroke, and other complications.[12]

As soon as a patient is diagnosed with RCVS based on both clinical and radiological findings, the triggering factor should be discontinued. In addition, patients with RCVS are managed with intra-arterial vasodilators, including nimodipine, nicardipine, milrinone, and papaverine, to reverse cerebral vasoconstriction.[13]

The MHRA, PRAC, and CHMP have recently released guidelines for health care professionals to inform patients and caregivers about PRES and RCVS related to the use of pseudoephedrine-containing medicines. As a result, the evidence pertaining to PRES and RCVS associated with the use of pseudoephedrine is the main focus of our current review.

Materials and Methods

We aimed to review the literature using online databases such as Medline/PubMed/PMC, Google Scholar, Scopus, and Web of Science, and reference lists were searched using Medical Subject Headings (MeSH) terms including pseudoephedrine, pharmacovigilance, adverse effects, PRES, and RCVS. The online databases have been searched from

January 2010 to March 2024, for publications pertinent to PRES and RCVS associated with the use of pseudoephedrine. Three case reports each of pseudoephedrine-induced PRES and RCVS and few reviews by regulatory bodies were included in the review. The case reports published in the English language were included in this review, while discarding duplicate publications.

Results

Few case reports have been identified indicating the association of pseudoephedrine use with a rare risk of neurovascular conditions, including PRES and RCVS. In addition, the review by the MHRA of the United Kingdom and the PRAC and CHMP of the EMA and all available evidence, including postmarketing safety data, have confirmed the rare risk of PRES and RCVS associated with the use of pseudoephedrine.

Pseudoephedrine-Associated PRES

Pseudoephedrine-associated PRES has been reported in a small number of case reports (►**Table 1**). After taking an over-the-counter (OTC) cold remedy containing pseudoephedrine 60 mg, a 19-year-old woman with a history of hypocomplementemic urticarial vasculitis arrived at the emergency department with PRES-associated complications, including headache, vomiting, and other symptoms. The magnetic resonance imaging (MRI) of the brain revealed hyperintensities on T2/fluid-attenuated inversion recovery (FLAIR) sequences. Clinical manifestations and radiological abnormalities were resolved with the discontinuation of pseudoephedrine and a treatment with the antihypertensive drug nicardipine.[14] In addition, an 18-year-old female patient with end-stage renal disease (ESRD) who self-medicated with paracetamol + pseudoephedrine (500/60 mg) was admitted to the emergency department complaining of headaches, blurred vision, mental confusion, and vomiting. The diagnosis of PRES was confirmed by an MRI of the brain, which revealed bilateral hyperintense occipitotemporoparietal lesions and thickening of the cortex on T2/FLAIR sequences. The patient received a continuous intravenous infusion of nicardipine, intermittent hemodialysis, and a continuous infusion of piperacillin-tazobactam, followed by piperacillin-alone therapy.[15]

Moreover, a 56-year-old man who had hyperglycemia experienced a seizure following the administration of a second dose of the combination product that contains paracetamol and pseudoephedrine (500/60 mg). Bilateral cortical and subcortical hyperintensities were seen in the cerebellar hemispheres and the posterior regions of the hemispheres, according to the FLAIR sequence of MRI of the brain, which confirmed the diagnosis of PRES. To treat the patient's generalized tonic–clonic seizure, midazolam 5 mg was administered intravenously. In addition, the treatment protocol involved the use of both symptomatic therapy and

Table 1 Pseudoephedrine-associated PRES

Sl. no.	Medication used	Precipitating factors	Clinical manifestations	Radiological abnormalities	Treatment	Reference
1	OTC cold remedy containing pseudoephedrine 60 mg	Hypocomplementemic urticarial vasculitis	Headache, vomiting and other symptoms	MRI of the brain—hyperintensities on T2/FLAIR sequences	• Discontinuation of pseudoephedrine • Treatment with antihypertensive drug nicardipine	Ebbo et al[14]
2	Self-medicated with paracetamol + pseudoephedrine (500/60 mg)	End-stage renal disease (ESRD)	Headaches, blurred vision, mental confusion, and vomiting	MRI of the brain—bilateral hyperintense occipitotemporoparietal lesions and thickening of the cortex on T2/FLAIR sequences	• Continuous intravenous infusion of nicardipine • Intermittent hemodialysis • Continuous infusion of piperacillin-tazobactam followed by piperacillin-alone therapy	Zerbib et al[15]
3	Prescription of a combination product that contains paracetamol and pseudoephedrine (500/60 mg)	Hyperglycemia	Seizures	MRI of the brain—bilateral cortical and subcortical hyperintensities in the cerebellar hemispheres and the posterior regions of the hemispheres	• Patient's generalized tonic–clonic seizure—treated with intravenous midazolam 5 mg • Administration of esmolol infusion to manage elevated arterial pressure • Subcutaneous insulin injection to manage hyperglycemia • Intravenous administration of 20% mannitol to manage edema	Gunduz[16]

Abbreviations: FLAIR, fluid-attenuated inversion recovery; MRI, magnetic resonance imaging; OTC, over-the-counter; PRES, posterior reversible encephalopathy syndrome.

supportive care, such as the administration of esmolol infusion to manage elevated arterial pressure, subcutaneous insulin injection to manage hyperglycemia, and intravenous administration of 20% mannitol to manage edema.[16]

Furthermore, the Pharmacovigilance Expert Advisory Group (PEAG) of the Commission on Human Medicines (CHM) reviewed the case reports received by the MHRA and other available evidence. In fact, the MHRA received four case reports (yellow card reports) of suspected PRES or RCVS associated with the use of pseudoephedrine.[17]

Pseudoephedrine-Associated RCVS

There are few case reports published regarding pseudoephedrine-associated RCVS (►**Table 2**). A 53-year-old woman took a cold remedy containing pseudoephedrine for 3 days before experiencing severe fluctuating headaches, fatigue, nausea, and vomiting. Her systolic blood pressure was exceeded 200 mm Hg. Significant changes in the brain were found by both MRI and magnetic resonance angiography (MRA) of the brain, which resulted in a provisional diagnosis of PRES. Her headache and blood pressure did not improve, and she also experienced cortical blindness, right hemiparesis, and paresthesias. The degree of vasoconstriction improved after 20 minutes of verapamil injection into the vertebral artery, prompting the consideration of RCVS. The patient's level of consciousness improved after receiving additional intra-arterial injections of verapamil into the internal carotid arteries, anterior cerebral artery, and left vertebral artery.[18] In addition, a 46-year-old woman took pseudoephedrine to manage allergic rhinitis. Three days later, she was admitted with a thunderclap headache and left hemiparesis, and a computed tomography (CT) angiography revealed multifocal narrowing of the basilar artery. After receiving nimodipine treatment for suspected RCVS, her headache gradually improved, and a follow-up CT angiography showed normalized cerebral vessels.[19]

Moreover, a 52-year-old man began screaming and experiencing sudden, sharp, significantly worsening posterior headache along with photophobia and phonophobia after taking two 60-mg pills of pseudoephedrine just before boarding the aircraft. Because of triggering factors, which included pseudoephedrine, high altitude, cocaine, and marijuana (consumed 5 days prior to admission), PRES was suspected. Based on his symptoms, triggering factors, and radiological changes, the patient was diagnosed with PRES in conjunction with RCVS. Once the patient was treated with calcium channel blockers (CCBs) like nicardipine followed by oral verapamil SR 180 mg daily, his headache and blood pressure improved significantly. After 1 month, complete resolution of radiological changes related to PRES and RCVS was observed in the head MRA and brain MRI.[20]

Furthermore, the PEAG of the CHM reviewed the case reports received by the MHRA and other available evidence. In fact, the MHRA received four case reports (yellow card reports) of suspected PRES or RCVS associated with the use of pseudoephedrine.[17]

Probable Mechanisms of Pseudoephedrine-Associated PRES and RCVS

The pathological mechanisms underlying PRES and RCVS linked to pseudoephedrine are controversial and are not

Table 2 Pseudoephedrine-associated RCVS

Sl. no.	Medication used	Clinical manifestations	Radiological abnormalities	Treatment	Reference
1	Cold remedy containing pseudoephedrine for 3 d	Severe fluctuating headache, fatigue, nausea, vomiting, cortical blindness, right hemiparesis, and paresthesias	MRI and MRA of the brain—FLAIR shows bilateral parieto-occipital white matter edema	• Verapamil injection into the vertebral artery—degree of vasoconstriction improved • Intra-arterial injections of verapamil into internal carotid arteries, anterior cerebral artery, and left vertebral artery—level of consciousness improved	Farid et al[18]
2	Pseudoephedrine	Thunderclap headache and left hemiparesis	CT angiography—multifocal narrowing of the basilar artery	Nimodipine administration—gradual improvement of headache	Lee et al[19]
3	Two tablets of pseudoephedrine 60	Sudden, sharp, significantly worsening posterior headache, photophobia, and phonophobia	Brain MRI—confluent white matter T2/FLAIR hyperintensities in occipital lobes Head MRA—multisegment narrowing of intracranial vessels	CCBs like nicardipine followed by oral verapamil SR 180 mg daily—headache and blood pressure were improved significantly	Jacoby et al[20]

Abbreviations: CCB, calcium channel blockers; CT, computed tomography; FLAIR, fluid-attenuated inversion recovery; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; RCVS, reversible cerebral vasoconstriction syndrome.

elusive as of this writing. Pseudoephedrine may cause cerebral vasoconstriction, cerebral endothelial cell damage, and increased arterial pressure/severe hypertension that results in vasogenic edema (►**Fig. 1**). By causing cerebral vasoconstriction, pseudoephedrine can cause brain hypoperfusion, which can lead to cerebral ischemia followed by vasogenic edema. Moreover, pseudoephedrine may increase arterial pressure (severe hypertension), which can result in brain hyperperfusion, capillary injury, cerebral vessel damage, and endothelial injury. These effects can cause failure of cerebral autoregulation and extravasation of plasma followed by vasogenic edema. Furthermore, pseudoephedrine-associated elevated arterial pressure may result in impaired cerebral autoregulation that increases cerebral blood flow and endothelial dysfunction, which is believed to play a pivotal role in the pathogenesis of PRES and RCVS.[21,22]

Measures to Overcome Pseudoephedrine-Associated PRES and RCVS in Real-World Setting

Health care practitioners need to understand PRES and RCVS linked to pseudoephedrine. Patients with severe acute or chronic renal disease or patients with uncontrolled hypertension should not use pseudoephedrine-containing products. In the event that patients experience any PRES or RCVS symptoms, such as sudden severe headaches or thunderclap headaches, seizures, confusion, or visual disturbances, the health care professionals should advise the patients to cease using products containing pseudoephedrine. Patients with pseudoephedrine-associated PRES and RCVS may be managed with the cessation of pseudoephedrine-containing products; they may also be treated with antihypertensive medications such as nicardipine, nimodipine, verapamil, and esmolol; intravenous midazolam may be used to treat generalized tonic–clonic seizures; subcutaneous insulin injection may be used to treat hyperglycemia; and 20% mannitol may be administered intravenously to treat edema.

Recommendations from the MHRA and EMA

Owing to the increased risk of PRES and RCVS linked to pseudoephedrine use, regulatory bodies such as the United Kingdom's MHRA and EMA's PRAC and CHMP have released a few guidelines for health care professionals to reduce the incidence of negative outcomes (►**Table 3**). Because of the increased risks of PRES and RCVS, the MHRA advised health care professionals to use pseudoephedrine only for brief periods. Patients with severe hypertension, uncontrolled hypertension, or severe renal disease should not use products containing pseudoephedrine. When patients experience symptoms of PRES and RCVS, such as sudden severe headache/thunderclap headache, seizures, confusion, or visual disturbances, the patients and caregivers should be advised to cease using pseudoephedrine-containing products and seek medical attention right away.[17]

Similarly, the PRAC of EMA examined all relevant data, including postmarketing safety reports, and concluded that patients with severe or uncontrolled hypertension and with severe acute or chronic kidney disease should not take medicines containing pseudoephedrine. The PRAC further recommended that health care professionals should counsel patients who experience symptoms of PRES or RCVS, such as severe headache with a sudden onset, feeling sick, vomiting, confusion, seizures, and visual disturbances, to cease taking pseudoephedrine-containing medications right away and seek immediate medical attention.[4] Moreover, on January 26, 2024, the EMA's CHMP approved the PRAC's suggested actions to minimize the risks of PRES and RCVS related to the use of medicines containing pseudoephedrine.[1] Furthermore, on February 8, 2024, the EMA Web site published a direct health care professional communication (DHPC) regarding pseudoephedrine-associated PRES and RCVS on a dedicated page.[23]

Conclusion

The use of medications containing pseudoephedrine has been shown to increase the risks of PRES and RCVS,

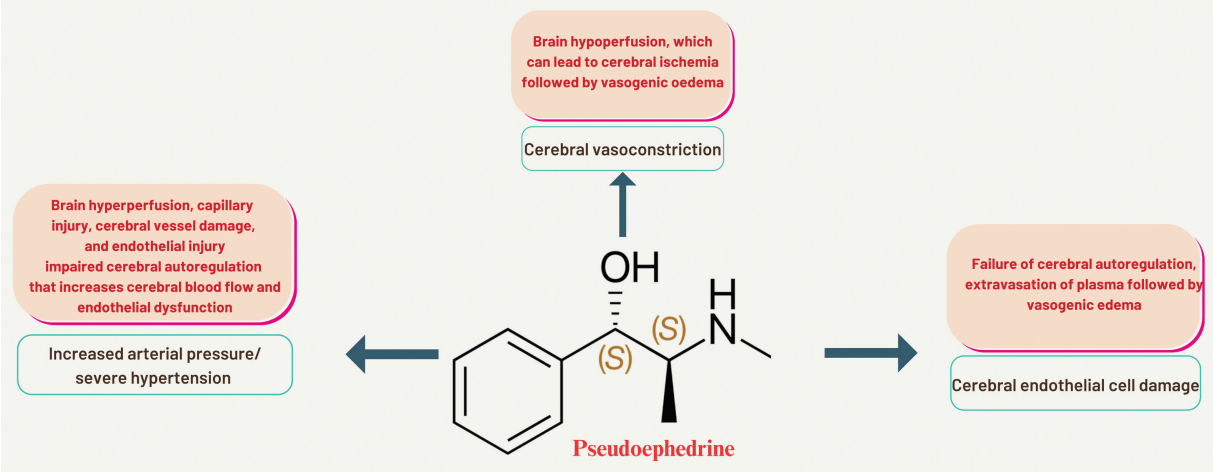

Fig. 1 Probable mechanisms of pseudoephedrine-associated posterior reversible encephalopathy syndrome (PRES) and reversible cerebral vasoconstriction syndrome (RCVS).

Table 3 Recommendations from regulatory bodies

Sl. no.	Regulatory agency	Recommendations	Reference
1	UK's MHRA	• Health care professionals should prescribe pseudoephedrine-containing products only for brief periods of time • Patients with severe hypertension, uncontrolled hypertension, or severe renal disease should not use products containing pseudoephedrine • When patients experience symptoms of PRES and RCVS, such as sudden severe headache/thunderclap headache, seizures, confusion, or visual disturbances, the patients and caregivers should be advised to cease using pseudoephedrine-containing products and seek medical attention right away	MHRA[17]
2	PRAC of EMA	• Patients with severe or uncontrolled hypertension and with severe acute or chronic CKD should not take medicines containing pseudoephedrine • Health care professionals should counsel patients who experience symptoms of PRES or RCVS, such as severe headache with a sudden onset, feeling sick, vomiting, confusion, seizures, and visual disturbances, to cease taking pseudoephedrine-containing medications right away and seek immediate medical attention	EMA[4]
3	CHMP of EMA	• Approved the PRAC's suggested actions to minimize the risks of PRES and RCVS related to the use of medicines containing pseudoephedrine • Published a direct health care professional communication (DHPC) regarding pseudoephedrine-associated PRES and RCVS, on a dedicated page	EMA[1]

Abbreviations: CHMP, Committee for Medicinal Products for Human Use; CKD, chronic kidney disease; EMA, European Medicines Agency; MHRA, Medicines and Healthcare products Regulatory Agency; PRAC, Pharmacovigilance Risk Assessment Committee; PRES, posterior reversible encephalopathy syndrome; RCVS, reversible cerebral vasoconstriction syndrome.

particularly in patients with other concomitant precipitating/triggering factors. Health care professionals should advise patients to cease taking pseudoephedrine-containing medications right away and seek immediate medical attention if they experience symptoms of PRES or RCVS, such as sudden-onset severe headaches, nausea, vomiting, confusion, seizures, and visual disturbances. This recommendation comes from the MHRA of the United Kingdom and the PRAC and CHMP of the EMA. Furthermore, patients with severe or uncontrolled hypertension and with severe acute or chronic renal disease should not use products containing pseudoephedrine.

Statement of Ethics

The manuscripts entitled "Enhanced risks of PRES and RCVS associated with the use of pseudoephedrine: a review" reporting data from the studies does not involving human or animal participants, since the manuscript is a review article. The study does not require approval from an appropriate institutional review board (IRB) or ethics committee.

Author's Contributions

N.M.P.M contributed to conceptualization and designing of the review and acquisition of data, and drafted the manuscript. R.B contributed to data analysis and interpretation of data, and reviewed the manuscript. A.S. assisted with data analysis and interpretation of data, and reviewed the manuscript. M.G. assisted with data analysis and interpretation of data, and reviewed the manuscript. M.H.J.H. assisted with data analysis and interpretation of data, and reviewed the manuscript.

Compliance with Ethical Principles

No ethical approval is required for review articles.

Funding and Sponsorship

None.

Conflict of Interest

None declared.

References

1 European Medicines Agency. EMA confirms measures to minimize the risk of serious side effects with medicines containing pseudoephedrine. 2023. Accessed February 21, 2024 at: https://www.ema.europa.eu/en/news/ema-confirms-measures-minimise-risk-serious-side-effects-medicines-containing-pseudoephedrine

2 European Medicines Agency. PRAC starts safety review of pseudoephedrine-containing medicines. 2023. Accessed February 21, 2024 at: https://www.ema.europa.eu/en/documents/referral/pseudoephedrine-containing-medicines-article-31-referral-review-started_en.pdf

3 United Kingdom Medicines and Healthcare Products Regulatory Agency (MHRA). Vigilance, safety alerts and guidance. MHRA safety review of medicines containing pseudoephedrine. 2023. Accessed February 21, 2024 at: https://www.gov.uk/government/news/mhra-safety-review-of-medicines-containing-pseudoephedrine

4 European Medicines Agency. PRAC recommends measures to minimize the risk of serious side effects with medicines containing pseudoephedrine. 2023. Accessed February 21, 2024 at: https://www.ema.europa.eu/en/documents/referral/prac-recommends-measures-minimise-risk-serious-side-effects-medicines-containing-pseudoephedrine_en.pdf

5 De Sutter AI, Eriksson L, van Driel ML. Oral antihistamine-decongestant-analgesic combinations for the common cold. Cochrane Database Syst Rev 2022;1(01):CD004976

6 Petkovic S, Maletic I, Djuric S, Dragutinovic N, Milovanovic O. Evaluation of nasal decongestants by literature review. Serb J Exp

Clin Res 2019 (e-pub ahead of print). Doi: 10.2478/sjecr-2019-0002
7 Munafò A, Frara S, Perico N, et al. In search of an ideal drug for safer treatment of obesity: The false promise of pseudoephedrine. Rev Endocr Metab Disord 2021;22(04):1013–1025
8 Pandal P, Singh A, Sharma K, et al. Ephedrine and pseudoephedrine: a comprehensive review of their pharmacology and clinical applications. J Chem Health Risks 2024;14(01):1447–1455
9 Li K, Yang Y, Guo D, Sun D, Li C. Clinical and MRI features of posterior reversible encephalopathy syndrome with atypical regions: a descriptive study with a large sample size. Front Neurol 2020;11:194
10 Anderson RC, Patel V, Sheikh-Bahaei N, et al. Posterior reversible encephalopathy syndrome (PRES): pathophysiology and neuroimaging. Front Neurol 2020;11:463
11 Ribas MZ, Paticcié GF, de Medeiros SDP, de Oliveira Veras A, Noleto FM, Dos Santos JCC. Reversible cerebral vasoconstriction syndrome: literature review. Egypt J Neurol Psychiat Neurosurg 2023;59(01):5
12 Chen SP, Wang SJ. Pathophysiology of reversible cerebral vasoconstriction syndrome. J Biomed Sci 2022;29(01):72
13 Singhal AB. Reversible cerebral vasoconstriction syndrome: a review of pathogenesis, clinical presentation, and treatment. Int J Stroke 2023;18(10):1151–1160
14 Ebbo M, Benarous L, Thomas G, et al. Posterior reversible encephalopathy syndrome induced by a cough and cold drug containing pseudoephedrine. Rev Med Interne 2010;31(06):440–444
15 Zerbib Y, Gibert L, Bennis Y, Masmoudi K, Maizel J, Brault C. Posterior reversible encephalopathy syndrome after self-medication with an oral decongestant: a case report. Front Med (Lausanne) 2022;9:837324
16 Gunduz ZB. Posterior reversible encephalopathy syndrome occurred during the use of pseudoephedrine: a case report. Clin Neuropharmacol 2022;45(05):145–147
17 United Kingdom Medicines and Healthcare Products Regulatory Agency (MHRA). Drug Safety Update. Pseudoephedrine: very rare risk of posterior reversible encephalopathy syndrome (PRES) and reversible cerebral vasoconstriction syndrome (RCVS). 2024. Accessed February 21, 2024 at: https://www.gov.uk/drug-safety-update/pseudoephedrine-very-rare-risk-of-posterior-reversible-encephalopathy-syndrome-pres-and-reversible-cerebral-vasoconstriction-syndrome-rcvs
18 Farid H, Tatum JK, Wong C, Halbach VV, Hetts SW. Reversible cerebral vasoconstriction syndrome: treatment with combined intra-arterial verapamil infusion and intracranial angioplasty. AJNR Am J Neuroradiol 2011;32(10):E184–E187
19 Lee DH, Lee SC, Choi N, Lee SW, Lee TK. Reversible cerebral vasoconstriction syndrome induced by pseudoephedrine. J Neurocritical Care. 2016;9(01):28–32
20 Jacoby N, Kaunzner U, Dinkin M, Safdieh J. Diagnosing RCVS without the CV: the evolution of reversible cerebral vasoconstriction syndrome. Neurohospitalist 2016;6(03):NP1–NP4
21 Pilato F, Distefano M, Calandrelli R. Posterior reversible encephalopathy syndrome and reversible cerebral vasoconstriction syndrome: clinical and radiological considerations. Front Neurol 2020;11:34
22 Jeanneret V, Jillella DV, Rangaraju S, et al. PRES and RCVS: two distinct entities or a spectrum of the same disease? J Stroke Cerebrovasc Dis 2022;31(06):106472
23 European Medicines Agency. Direct healthcare professional communication (DHPC): Pseudoephedrine—Risks of posterior reversible encephalopathy syndrome (PRES) and reversible cerebral vasoconstriction syndrome (RCVS). 2024. Accessed February 21, 2024 at: https://www.ema.europa.eu/en/documents/dhpc/direct-healthcare-professional-communication-dhpc-pseudoephedrine-risks-posterior-reversible-encephalopathy-syndrome-pres-reversible-cerebral-vasoconstriction-syndrome-rcvs_en.pdf

