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Cerebral hyperperfusion syndrome

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ABSTRACT

Carotid endarterectomy and carotid artery stenting are the standard therapies for the prevention of stroke in patients with significant carotid artery disease. Cerebral hyperperfusion syndrome (CHS) is a rare complication that may occur following either technique. This syndrome can develop at any time, from immediately after surgery to up to a month later. The causes appear to be impaired cerebral autoregulation and postoperatively elevated systemic blood pressure. CHP causes headache, nausea, vomiting, confusion, macular edema, visual disturbance and focal motor seizures and intracerebral or subarachnoid hemorrhage. In this review, the definition, causes, diagnosis and treatment options of CHS are discussed.

Keywords: *Cerebral Hyperperfusion, Carotis, Endarterectomy, Stenting*

1. DEFİNİTİON

Cerebral hyperperfusion syndrome (CHS) is defined as ipsilateral frontotemporal or periorbital headache, nausea, vomiting, confusion, macular edema, visual disturbance, and diffuse, and it is also characterized by focal motor seizures and intracerebral or subarachnoid hemorrhage. Cerebral hyperperfusion syndrome (CHS) is a condition that can often be seen after carotid endarterectomy (CEA) or carotid artery balloon/stent intervention (CAS). The underlying pathophysiological mechanism is thought to be the uneven distribution of cerebral blood flow. Although most patients who develop SHS show mild symptoms and signs, if this syndrome is not diagnosed in time and adequately treated, it may progress to severe and become life-threatening.

Because SHS is based on many nonspecific signs and symptoms, patients may be misdiagnosed. Therefore, information on SHS among physicians is limited.

2. HİSTORY

Spetzler et al. In 1978, he first reported the development of CHS, including intracerebral hemorrhage, following surgical resection of the arteriovenous malformation (1). They attributed this to the loss of autoregulation in the surrounding normal brain tissue due to the occlusion of large A-V fistulas. Later, Sundth et al. First defined the triad of ipsilateral frontal headache, transient focal seizures, and intracerebral hemorrhage after CEA as CHS (2). CHS was also defined for other procedures in which cerebral blood flow increased. Most of the reports on CHS are post-CEA, but there have been many publications reporting the development of CHS after CAS (3–5).

3. EPİDEMİOLOGY

Hyperperfusion syndrome is a known complication of carotid artery revascularization and AVM treatment and occurs with edema and/or hemorrhage due to the sudden normalization of blood flow in the cerebral tissue accustomed to low perfusion (12,13). CHS is seen in 0.4–7.7% of patients who underwent CEA (6–8). The reason why this range is so wide is the difficulties and hesitations in diagnosing CHS. Another reason is that cerebral blood increase is not 100% of the baseline value in all patients, so patients show symptoms and signs of moderate perfusion increase. CHS can occur at any time in the first 28 days after carotid endarterectomy but often occurs in the first few hours to a few days (9). It is known that the risk of cerebral hyperperfusion develops more frequently in the patient group where carotid artery stenosis is more than at least 80-90%. After CEA, most patients experience a 20–40% increase in ipsilateral cerebral blood flow within a few hours. Severe hyperemia occurs with the increase of cerebral blood flow, which can be maximum on days and 100–200% of the basal value, which can last for a long time. This condition usually occurs postoperatively in 6-7 days. It usually returns to normal in 1–2 weeks (10).

4. PHYSİOPATHOLOGY

As a result of the effects of carbon dioxide and cerebral autoregulation, cerebral blood flow is maintained in the range of 60–160 mmHg. While carbon dioxide is mainly effective on arteries with a diameter of less than 0.5–1 mm in the cerebral system, it is not effective on arteries with a diameter greater than 2–5 mm, such as the carotid artery (11). Cerebral autoregulation has myogenic and neurogenic components. In myogenic autoregulation, Increased intravascular pressure, depolarization of vascular smooth muscle cells, and increased systemic blood pressure result in vasoconstriction of small arterioles. When blood pressure exceeds the limit of myogenic autoregulation, existing autoregulation in large arterioles and small arteries becomes dependent on sympathetic autonomic innervation in the adventitia (12).

CHS is thought to result from a defect in the autoregulation mechanism related to cerebral blood flow. As a result of severe stenosis in the carotid arteries, vasodilation develops in the more distal vessels due to an autoregulatory mechanism in order to ensure adequate blood flow. If the blood flow above normal pressure is restored, the autoregulatory mechanism cannot restore equilibrium for a moment, leading to hyperperfusion in tissues that had previously developed hypoperfusion. This dysfunction at the microvascular level affects the blood-brain barrier. Extravasation occurs due to the osmotic effect of serum proteins. In many cases, microvascular dysfunction results in cerebral hemorrhage (13–15). One of the possible mediators of impaired autoregulation in CHS is nitric oxide, which leads to vasodilation and increased permeability of cerebral vessels. Free oxygen radicals are produced during CEA, even if the cross-clamp time is minimal. These free radicals cause damage to the cerebral vascular endothelium and lead to postoperative CHS. The use of free radical scavengers can prevent CHS (16-20). Another important factor is blood pH. Some acid-base protocols used during CPB result in increased cerebral perfusion, which indicates impaired autoregulation (21). Increases in carbon dioxide concentration in the postoperative period may worsen hyperperfusion due to impaired autoregulation. Impairment of baroreceptor reflexes may be related to the development of CHS. Baroreceptor reflexes act as buffers for acute changes in systemic blood pressure. Impairment of baroreceptor reflexes may occur in situations where receptor denervation occurs, as in the CEA process. Impairment of baroreceptor reflexes accompanied by hypertension may increase cerebral perfusion (22).

5. POTENTİAL RİSK FACTORS FOR SHS

Many conditions can be predisposing factors for SHS. Decreased cerebrovascular reserve, postoperative hypertension, and hyperperfusion from a few hours to a few days after CEA, previous stroke, In addition to severe internal carotid artery stenosis, concomitant contralateral tight carotid artery stenosis, preoperative and postoperative hypertension, a significant increase in ipsilateral peak middle cerebral artery flow velocity in the postoperative period are the most critical risk factors for the development of CHS. Patients with low preoperative cerebral blood flow and decreased cerebrovascular reserve are at the highest risk for the development of prolonged postoperative hyperperfusion. Control of blood pressure in the postoperative period is essential for the control and management of SHS.

6. IMAGİNG TECHNİQUES FOR SHS

Computed tomography, magnetic resonance, and transcranial doppler are frequently used tests in the diagnosis of preoperative cerebral hypoperfusion and/or preoperative or postoperative hyperperfusion.

1-Computed Tomography (CT): If it is performed in the early period when CHS symptoms develop after CEA, the findings may be as expected. CT anomalies of CHS are diffuse or limited white matter edema, mass effect, petechial or massive hemorrhage on the same side as CEA. Due to the sparse sympathetic innervation of the vertebrobasilar system, edema in the white matter mainly involves the posterior parietal-occipital region (23).

2-Magnetic resonance (MR): It is more sensitive than CT in detecting ischemic changes, and preoperative MR can visualize angiography and carotid and cerebral arteries. Even if the MRI findings taken in the postoperative period are normal, it does not exclude CHS that will occur after CEA. White matter edema, focal infarction, and local or more extensive hemorrhage, mainly involving the posterior parietal, and occipital region, can be detected on MRI (24).

3-Transcranial Doppler: Transcranial Doppler measures the cerebral blood flow velocity in the middle cerebral artery (ASM). With the direct and real-time measurement of the flow in this artery, information is obtained about preoperative cerebral hypoperfusion, cerebrovascular reactivity, postoperative hyperperfusion, and embolism after CEA. In patients who develop CHS, while the velocity increases by 150-300% in the ipsilateral arteria cerebri media (ACM) on transcranial Doppler, the hyperperfusion picture returns to normal when the systolic blood pressure returns to normal with clinical improvement. Transcranial Doppler shows that time is needed for the adaptation of autoregulation, which is usually six weeks. Decreased flow velocity, pulsatile index, and cerebrovascular reactivity preoperatively are associated with hyperperfusion that may develop postoperatively (25,26).

4-Single-photon-emission CT: It can detect preoperative cerebral blood flow reserve and postoperative hyperperfusion. Persistence of hyperperfusion on single photon emission CT between the 1st and 3rd postoperative days may indicate that the patient is at risk of CHS (27).

5-Transcranial regional cerebral-oxygen-saturation monitoring: An increase in regional cerebral oxygen saturation is a sign of increased cerebral blood flow when cerebral oxygen consumption and blood oxygen saturation are stable. After CEA, a strong correlation was found between increased transcranial regional cerebral oxygen saturation and cerebral blood flow when compared with single-photon-emission CT findings, the sensitivity, and specificity of transcranial regional cerebral oxygen saturation for detecting hyperperfusion after CEA was found to be 100% (28).

6-Ocular Pneumoplethysmography: Ocular blood flow is a good indicator of cerebral blood flow, and ocular pnomoplethysmography is an easy and fast test. In patients at risk for SHS, postoperative ocular blood flow increases by more than 204% (29).

7. PREVENTİON OF CHS

Intracerebral hemorrhage that may develop in relation to SHS is a sign of poor prognosis. Therefore, precaution is vital. Monitoring and regulating blood pressure is very important in the perioperative period. In some cases, it is recommended to be below average. If the operation is performed as early as 3-4 weeks after cerebral infarction, the risk of intracerebral hemorrhage increases (4). Since the agents used in general anesthesia have different effects on cerebral blood flow and autoregulation, their dose and type should be chosen carefully. High-dose volatile halogenated hydrocarbon anesthetics can cause SHS (30). Isoflurane is a volatile anesthetic with the least vasodilator effect compared to other equal-dose halogenated anesthetics used in neurological operations. In high doses, it has a negative impact on autoregulation. Nitrous oxide causes minimal increases in cerebral blood flow, intracranial pressure, and cerebral blood volume. It has no effect on autoregulation at concentrations less than 70%. However, if combined with isoflurane, it increases the concentration of isoflurane. Propofol has been used in patients with CHS due to its effect on cerebral metabolism, and it has been found to normalize cerebral blood flow (31–34).

8. TREATMENT

Because SHS symptoms often occur due to high blood pressure, researchers recommend tight regulation of blood pressure. Some drugs that do not directly affect blood flow and have a vasoconstrictive impact may be theoretically advantageous. For this reason, many medications, such as direct-acting vasodilators and calcium channel blockers used in blood pressure regulation, are contraindicated in this regard. While ACE inhibitors protect cerebral blood flow after a single dose, they increase cerebral blood flow despite lowering blood pressure in chronic use. Angiotensin II receptor blockers are limited due to their long half-life and inability to be used intravenously (35).

Beta-blockers can lower blood pressure with minimal effect on intracranial pressure and can therefore be used in hypertensive patients with brain injury. The combined use of alpha-blockers and beta-blocker labetalol does not directly impact cerebral blood flow and reduces cerebral perfusion pressure and mean blood pressure by 30%, so it is successfully used in SHS (36). Since hypertension after CEA is associated with increased cranial and plasma catecholamine levels, treatment should also include centrally acting sympatholytic agents. Clonidine, an alpha agonist agent, is widely used because it lowers mean blood pressure, heart rate, and cardiac output through its vasorelaxant effect. Since this agent reduces cerebral blood flow and protects the baroreceptor sensitivity of the brain stem, it also finds use (37). In conclusion, labetalol and clonidine are the most common agents used in treating hyperperfusion in SHS, while others may worsen the situation.

The duration of treatment varies from patient to patient. Some doctors treat their patients for up to 6 months after surgery, while others continue until the signals recorded by the transcranial Doppler from both hemispheres are equal. Therefore, it is suitable for monitoring transcranial Doppler hyperperfusion. After the hyperperfusion has disappeared and blood pressure has returned to normal, patients are protected from secondary cardiovascular risks.

9. PROGNOSİS

Prognosis depends on the timing and accuracy of diagnosis and treatment. While most patients diagnosed and treated in the early period recover, up to 30% of patients with severe SHS or diagnosed late do not benefit from treatment, and 50% die. Therefore, although intracerebral hemorrhage is rarely seen in CHS, it often has devastating results (38,39).

10. CONCLUSİON

One of the complications that will develop after CEA is CHS. CHS is a pathology typically ipsilateral after cerebral revascularization and presents with headache, neurologic deficit, seizure, or intracerebral hemorrhage; and can be diagnosed more than 100% with transcranial Doppler and single photon emission CT and MRI. Delay in the application makes it difficult to recognize this pathology in the late period. Many risk factors trigger the development of CHS, such as decreased cerebrovascular reserve, postoperative hypertension, and hyperperfusion that extends from a few hours to a few days after CEA. Preoperative risk factors, clinical findings, and diagnostic methods do not 100% exclude the development of postoperative hyperperfusion and CHS. Therefore, it is necessary to be very careful and alert in the postoperative period. Despite some limitations, transcranial Doppler and single photon emission CT can be used in preoperative and postoperative patients. It can be used to diagnose CHS. After diagnosing hyperperfusion, perioperative and postoperative blood pressure regulation is important. Clonidine and labetalol are best drugs for blood pressure regulation.

11. REFERENCES

[1] Spetzler RF, Wilson CB, Weinstein P, Mehdorn M, Townsend J, Telles D. Normal perfusion pressure breakthrough theory. Clin Neurosurg. 1978;25:651-72.
[2] Sundt TM, Sandok BA, Whisnant JP. Carotid endarterectomy. Mayo Clinic Proc 1975;50:301-6.
[3] Schroeder T, Sillesen H, Sorensen 0, Engel HC. Cerebral hyperperfusion following carotid endarterectomy. J Neurosurg 1987;66:824-9.
[4] Bernstein M, Fleming JFR, Deck JHN. Cerebral hyperperfusion after carotid endarterectomy: a cause of cerebral hemorrhage. Neurosurg 1984;15:50-6.
[5] Bishop CCR, Butler L, Hunt T, Burnard KG, Browse NL. Effect of carotid endarterectomy on cerebral blood flow and its response to hypercapnia. Br J Surg 1987;74:994-6.
[6] Riegel MM, Hollier LH, Sundt TM Jr, Piepgras DG, Sharbrough FW, Cherry KJ. Cerebral hyperperfusion syndrome: a cause of neurologic dysfunction after carotid endarterectomy. J Vasc Surg 1987;5:628-34.
[7] Henderson RD, Phan TG, Piepgras DG, Wijdicks EF. Mechanisms of intracerebral hemorrhage after carotid endarterectomy. J Neurosurg 2001;95:964-9.

[8] Walther N K A van Mook, Roger J M W Rennenberg, Geert Willem Schurink, Robert Jan van Oostenbrugge, Werner H Mess, Paul A M Hofman, Cerebral hyperperfusion syndrome Peter W de Leeuw Lancet Neurol 2005; 4: 877–88

[9] Ogasawara K, Mikami C, Inoue T, Ogawa A. Delayed cerebral hyperperfusion syndrome caused by prolonged impairment of cerebrovascular autoregulation after carotid endarterectomy: case report. Neurosurgery 20 04; 54: 1258–62.

[10] Karapanayiotides T, Meuli R, Devuyst G, et al. Postcarotid endarterectomy hyperperfusion or reperfusion syndrome. Stroke 2005; 36:21–26.

[11] Huber P, Handa J. Effect of contrast material, hypercapnia, hyperventilation, hypertonic glucose and papaverine on the diameter of the cerebral arteries: angiographic determination in man. Invest Radiol 1967; 2: 17–32.

[12] Ngai AC, Winn HR. Modulation of cerebral arteriolar diameter by intraluminal flow and pressure. Circ Res 1995; 77: 832–40.

[13] G. Pilz, M. Klos, P. Bernhardt, A. Schöne, R. Scheck, B. Höfling Reversible cerebral hyperperfusion syndrome after stenting of the carotid artery –Two case reports Clin Res Cardiol 2006;95:186–191

[14] Mathias K, Jäger H, Henning S, Gissler HM. Endoluminal treatment of internal carotid artery stenosis. World J Surg 2001;25:328–336

[15] Piepgras DC, Morgan MK, Sundt T-\4 fr, Yanagihara T, Mussman Intracerebral hemorrhage after carotid endarterectomy. J Neurosurg 1988; 68:532– 536

[16] Janigro D, West GA, Nguyen TS, Winn HR. Regulation of bloodbrain barrier endothelial cells by nitric oxide. Circ Res 1994;75: 528–38.

[17] Soong CV, Young IS, Hood JM, Rowlands BJ, Trimble ER, Barros D'Sa AA. The generation of byproducts of lipid peroxidation following carotid endarterectomy. Eur J Vasc Endovasc Surg 1996;12: 455–58.

[18] Weigand MA, Laipple A, Plaschke K, Eckstein HH, Martin E, Bardenheuer HJ. Concentration changes of malondialdehyde across the cerebral vascular bed and shedding of L-selectin during carotid endarterectomy. Stroke 1999; 30: 306–11.

[19] Holm J, Nilsson U, Waters N, Waters S, Jonsson O. Production of free radicals measured by spin trapping during operations for stenosis of the carotid artery. Eur J Surg 2001; 167: 4–9.

[20] Traystman RJ, Kirsch JR, Koehler RC. Oxygen radical mechanisms of brain injury following ischemia and reperfusion. J Appl Physiol 1991; 71:1185–95.

[21] Patel RL, Turtle MR, Chambers DJ, Newman S, Venn GE. Hyperperfusion and cerebral dysfunction: effect of differing acid-base management during cardiopulmonary bypass. Eur J Cardiothorac Surg 1993; 7: 457—63.

[22] Timmers HJLM, Wieling W, Karemaker JM, Lenders JWM. Baroreflex failure: a neglected type of secondary hypertension. Neth J Med 2004; 62: 151–55.

[23] Harrison PB, Wong MJ, Belzberg A, Holden J. Hyperperfusion syndrome after carotid endarterectomy: CT changes. Neuroradiology 1991; 33:106–10.

[24] Ances BM, McGarvey ML, Abrahams JM, et al. Continuous arterial spin labeled perfusion magnetic resonance imaging in patients before and after carotid endarterectomy. J Neuroimaging 2004; 14:133–38.

[25] Spencer MP. Transcranial Doppler monitoring and causes of stroke from carotid endarterectomy. Stroke 1997; 28:685–91.

[26] Dalman JE, Beenakkers IC, Moll FL, Leusink JA, Ackerstaff RG. Transcranial Doppler monitoring during carotid endarterectomy helps to identify patients at risk of postoperative hyperperfusion. Eur J Vasc Endovasc Surg 1999; 18: 222–27.

[27] Ogasawara K, Yukawa H, Kobayashi M, et al. Prediction and monitoring of cerebral hyperperfusion after carotid endarterectomy by using single-photon emission computerized tomography scanning. J Neurosurg 2003; 99: 504–10.

[28] Ogasawara K, Konno H, Yukawa H, Endo H, Inoue T, Ogawa A. Transcranial regional cerebral oxygen saturation monitoring during carotid endarterectomy as a predictor of postoperative hyperperfusion. Neurosurgery 2003; 53: 309–14.

[29] Nicholas GG, Hashemi H, Gee W, Reed JF 3rd. The cerebral hyperperfusion syndrome: diagnostic value of ocular pneumonia. J Vasc Surg 1993; 17: 690–95.

[30] Skydell JL, Machleder HI, Baker JD, Busuttil RW, Moore WS. Incidence and mechanism of post-carotid endarterectomy hypertension. Arch Surg 1987; 122: 1153–55.

[31] Strebel S, Lam AM, Matthew B, Mayberg TS, Aaslid R, Newell DW. Dynamic and static cerebral autoregulation during isoflurane, desflurane, and propofol anaesthesia. Anesthesiology 1995; 83: 66–76.

[32] Strebel S, Kaufmann M, Anselmi L, Schaefer HG. Nitrous oxide is a potent cerebrovasodilator in humans when added to isoflurane. A transcranial Doppler study. Acta Anaesthesiol Scand 1995; 39:653–58.

[33] Sato K, Shimizu H, Horinouchi T, Kato M. A case of hyperperfusion syndrome treated successfully by propofol. Masui 2001; 50: 25–28.

[34] Kaisti KK, Langsjo JW, Aalto S, et al. Effects of sevoflurane, propofol, and adjunct nitrous oxide on regional cerebral blood flow, oxygen consumption, and blood volume in humans. Anesthesiology 2003; 99: 603–13.

[35] Tietjen CS, Hurn PD, Ulatowski JA, Kirsch JR. Treatment modalities for hypertensive patients with intracranial pathology: options and risks. Crit Care Med 1996; 24: 311–22.

[36] Muzzi DA, Black S, Losasso TJ, Cucchiara RF. Labetalol and esmolol in the control of hypertension after intracranial surgery. Anesth Analg 1990; 70:68–71.

[37] Faivre JM, Freysz M, Coulon C, Jaboeuf R, David M. Post carotid endarterectomy hypertension: clonidine therapy. Anaesth Intensive Ca re 1981; 9:179–80.

[38] Piepgras DG, Morgan MK, Sundt TM Jr, Yanagihara T, Mussman LM. Intracerebral hemorrhage after carotid endarterectomy. J Neurosurg 1988; 68: 532–36.

[39] Meyers PM, Higashida RT, Phatouros CC, et al. Cerebral hyperperfusion syndrome after percutaneous transluminal stenting of the craniocervical arteries. Neurosurgery 2000; 47: 335–43.

