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Case Report

Extensive ischemic brainstem lesions and pneumocephalus after application of hydrogen peroxide (H_2O_2) during lumbar spinal surgery

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Abstract

BACKGROUND CONTEXT: The hemostatic properties of hydrogen peroxide (H_2O_2) are often used in neurosurgical practice.

CASE REPORT: We present the case of an 81-year-old woman who underwent lumbar spinal surgery (microsurgical decompression) in an external hospital. H_2O_2 was used during the procedure. The patient was transferred to our hospital. She remained unconscious postoperatively, with progressive loss of brainstem reflexes. Computed tomography showed intra- and extradurally trapped air ascending from the operated lumbar segment up to frontal lobe. Magnetic resonance imaging demonstrated severe brainstem lesions on T2- and diffusion-weighted series. The patient died 10 days after surgery. Autopsy was not performed.

CONCLUSIONS: Our case demonstrates a fatal complication with ischemic brainstem lesions and pneumocephalus after the use of hydrogen peroxide. Therefore, H_2O_2 should only be used in cases without any signs of dural injury.

Keywords: Hydrogen peroxide; Pneumocephalus; Ischemic brainstem lesion; Stroke; Lumbar surgery; Spinal stenosis

Background and importance

The frequency of spinal operations in the Western world has increased over the last few decades. Hydrogen peroxide (H_2O_2) is a clear liquid and its hemostatic effect is often used in neurosurgical practice [1]. There are a few reports about adverse effects and complications after the application of H_2O_2 [2–4]. We present a case of a fatal complication with severe brainstem destruction and pneumocephalus after spinal lumbar surgery and application of hydrogen peroxide.

Clinical presentation

An 81-year-old woman was surgically treated for lumbar spinal stenosis (microsurgical decompression) in an external hospital. After surgery she could be extubated but remained comatose. Therefore, the patient was transferred to our neurointensive care unit on the same day. On admission, the patient was somnolent and showed a severe tetraparesis with only minimal residual movement of her right arm in response to pain stimuli. As a sign of brainstem injury, the patient showed horizontal and vertical gaze palsy. The pupils were dilated with only little response to light. The clinical condition deteriorated rapidly. Intubation and mechanical ventilation was necessary because of acute respiratory failure. The patient developed wide and fixed pupils. Corneal and cough reflexes were lost. EEG (electro-encephalogram) showed an alpha rhythm without any focal pathology or epileptogenic activity. Computed tomography of the spine and head demonstrated intra- and epidural air trapping at the level of the operated lumbar stenosis (lumbar vertebral 4/5) ascending up to the upper thoracic spine. Moreover, intracranial air trapping could be observed in the area of the frontal lobe on the left side and in the subarachnoidal space on the right side (Fig. 1). During placement of an external ventricular drain, spontaneous

FDA device/drug status: Not applicable.

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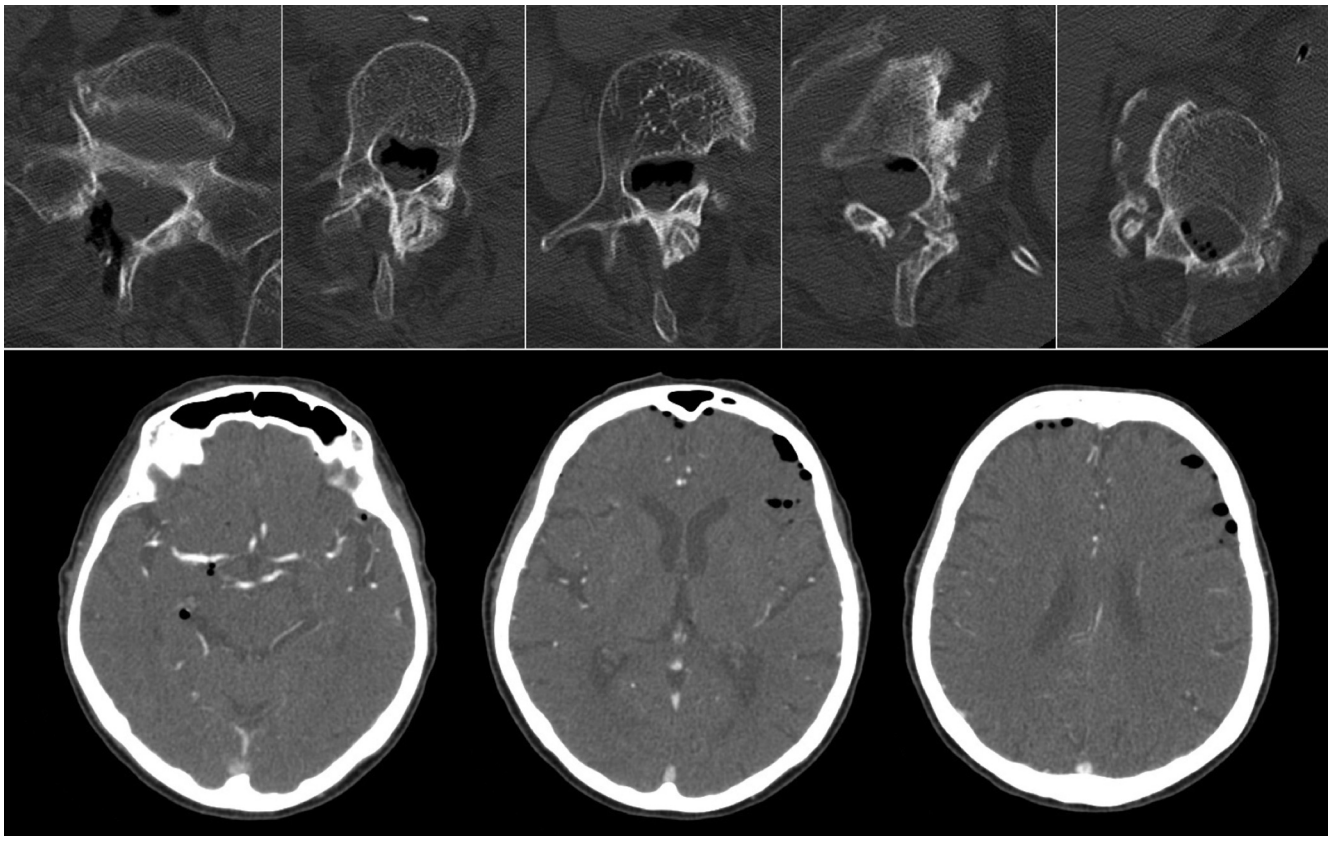

Fig. 1. (Top) Computed tomography (CT) images of the thoracic and lumbar spine show epi- and intradural air trapped in the operated lumbar segment ascending cranially up to the upper thoracic spine. (Bottom) The subdural air entrapment in the posterior cranial fossa and supratentorial, reaching up to the frontal region, can be seen on these CT-angiography images as well. No vascular abnormalities were observed.

leakage of gas bubbles could be observed. The opening pressure of the cerebrospinal fluid was normal with 12 cm of water column. Elevated intracerebral pressure could not be observed in the following episode. Cranial magnetic resonance imaging (MRI) scan the next day showed hyperintense ischemic lesions on T2- and diffusion-weighted sequences in the brainstem (Fig. 2). Median nerve evoked potentials demonstrated loss of cortical potentials bilaterally. The patient remained unconscious without brainstem reflexes and died 10 days after surgery.

Operative notes from the initial hospital documented a sudden intraoperative systolic drop of blood pressure from 150 to 80 mmHg. Furthermore, there was a perioperative laceration of the dura, which was supplied with TachoSil (Takeda Austria, Linz, Austria).

Conclusion

This case presents a rare but fatal complication after lumbar surgery of spinal stenosis and application of hydrogen peroxide. There are only a few case reports in the literature of lethal complications after neurosurgical operations of the spine or head [2–5]. Typical causes of brainstem destruction, namely hemorrhage and atherosclerosis, were excluded via computed tomography and MRI. Elevated intracranial pressure was not observed. However, intraspinal and intracranial air trapping and spontaneous leakage of air bubbles during the placement of the external ventricular drain highly suggests the free diffusion of H_2O_2. The conversion of H_2O_2 to water and O_2 led to O_2-bubbles. Since 1 mL of H_2O_2 produces about 10 mL oxygen, serious complications can arise, especially when used in closed cavities [6].

A toxic effect of H_2O_2 does not seem realistic since the pattern of the lesion is restricted to the vertebrobasilar vessel territory and there was no toxic damage demonstrably in the MRI. Most likely the ascended H_2O_2 led to vasoactive responses with platelet aggregation and thrombus formation, which has been described before in an experimental mice study [7]. Previous studies have proven the ability of H_2O_2 to permeate easily across an intact cell wall using aquaporins [7,8]. Even more, H_2O_2 may change to peroxynitrite when used under pressure, which cannot be metabolized by the endothelium rapidly. This may potentially result in the disruption of endothelial lining and subsequent air-embolism [7].

Although no extraordinary event, but the use of TachoSil, has been reported by the surgeons, a dural leakage during the operation must be considered through which hydrogen peroxide passed into the intradural space. This case demonstrates the necessity for caution when using

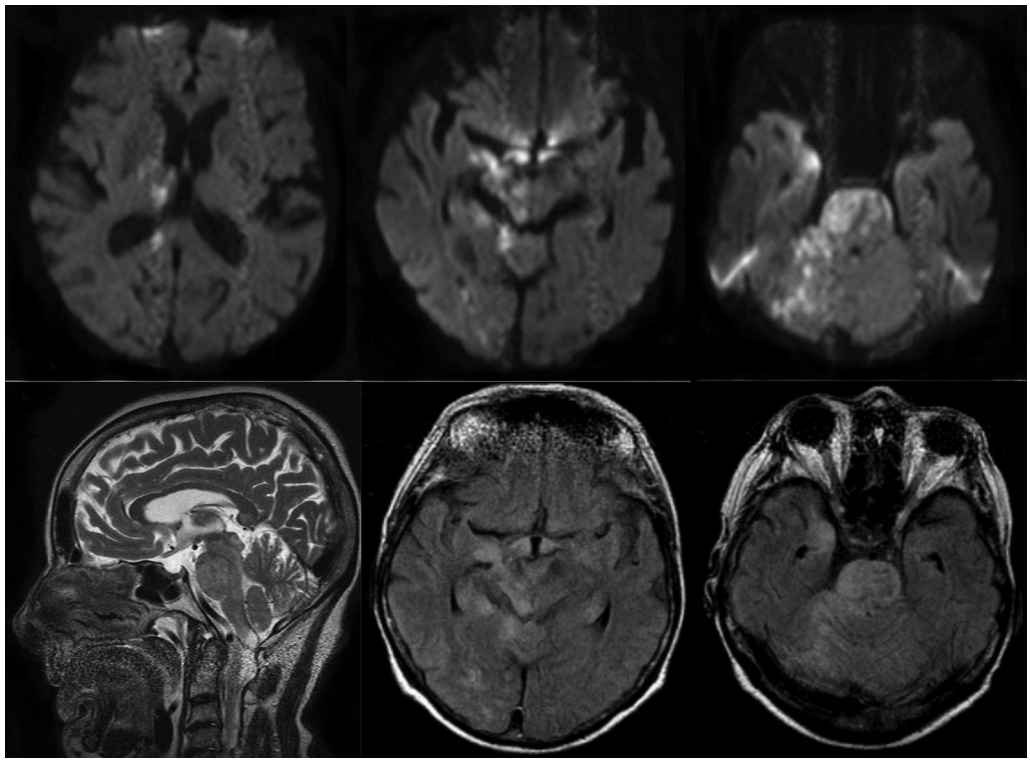

Fig. 2. (Top) Magnetic resonance imaging shows multiple lesions (intracellular edema) on diffusion-weighted sequences, mainly in the right frontal, occipital, temporo-occipital, and thalamic regions as well as in the pontine area and right cerebellum. Time-of-flight angiography (not shown here) was normal without signs of vascular pathology. (Bottom Left) The T2-weighted midsagittal plane showing signal enhancement of the pons compatible with a branistem edema. (Bottom Right) Fluid attenuated inversion recovery showing an intercellular edema of the brainstem, with the involvement of the right cerebellar hemisphere and the mesial temporal lobe including the corpus amygdaloideum. Midbrain on the right side is affected as well.

hydrogen peroxide during spinal surgery. Hydrogen peroxide should strictly be used only for open wounds without any signs of dural injury. The use of H_2O_2 in closed cavities and the combined use with other agents that might increase the pressure of H_2O_2 on the dura mater and blood vessels should be avoided.

References

[1] Epstein JA. Hydrogen peroxide for hemostasis. Neurosurgery 1987;20:63.

[2] Zimmerman GA, Lipow KI. Pneumocephalus with neurological deficit from hydrogen peroxide irrigation. Case illustration. J Neurosurg 2004;100:1122.

[3] Morikawa H, Mima H, Fujita H, Mishima S. Oxygen embolism due to hydrogen peroxide irrigation during cervical spinal surgery. Can J Anaesth 1995;42:231–3.

[4] Baharnoori M, Lazarou J. A case of acute cerebral gas embolism due to ingestion of hydrogen peroxide. J Neurol 2012;259:381–3.

[5] Prasanna SP, Shashank SJ, Kishor AC. Air-embolism and cerebral ischaemia following epidural hydrogen peroxide irrigation in a closed lumbar cavity. Br J Neurosurg 2014;28:556–8.

[6] Haller G, Faltin-Traub E, Faltin D, Kern C. Oxygen embolism after hydrogen peroxide irrigation of a vulvar abscess. Br J Anaesth 2002;88:597–9.

[7] Mut M, Yemisci M, Gursoy-Ozdemir Y, Ture U. Hydrogen peroxide-induced stroke: elucidation of the mechanism in vivo. J Neurosurg 2009;110:94–100.

[8] Bienert GP, Schjoerring JK, Jahn TP. Membrane transport of hydrogen peroxide. Biochem Biophys Acta 2006;1758:994–1003.