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DEFYING AN OMINOUS SIGN: COMPLETE NEUROLOGICAL RECOVERY AFTER BILATERAL FIXED DILATED PUPILS IN HYPERCAPNIC RESPIRATORY FAILURE

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ABSTRACT

Introduction: Bilateral fixed dilated pupils (BFDP) have traditionally been regarded as an ominous sign indicating severe brainstem dysfunction and poor neurological prognosis, often prompting discussions regarding withdrawal of life-sustaining treatment. However, pupillary abnormalities can also result from reversible metabolic derangements, including severe hypercapnia, profound acidosis, and hypoxia. Current guidelines emphasize that pupillary assessment should occur after correction of confounding factors such as hypoxemia, hypotension, and metabolic disturbances.

Case report: A 66-year-old man with a history of ischemic stroke six months prior presented with prolonged generalized seizures, vomiting, and progressive loss of consciousness. On arrival to the Emergency Department, he was unconscious with bilaterally dilated, unreactive pupils. Venous blood gas analysis revealed severe respiratory acidosis with pH 6.96 and pCO_2 102 mmHg. Despite intubation and mechanical ventilation, he developed profound desaturation followed by cardiac arrest with ventricular tachycardia requiring cardioversion. A brain computed tomography scan showed no new intracranial pathology. Chest radiography demonstrated massive bilateral aspiration pneumonia. Following aggressive resuscitation, mechanical ventilation, broad-spectrum antibiotics, and supportive care, his respiratory parameters and acidosis gradually improved. As his respiratory status normalized, his pupils became constricted and reactive to light. The patient was successfully weaned from mechanical ventilation and regained full consciousness with complete restoration of cognitive function.

Conclusion: Bilateral fixed dilated pupils in severe hypercapnic respiratory failure may be a transient and fully reversible phenomenon when driven by metabolic derangements rather than structural brain injury. Timely resuscitation and deferral of definitive prognosis until confounding metabolic factors have been corrected is essential to avoid premature withdrawal of life-sustaining treatment.

KEYWORDS

Bilateral fixed dilated pupils, hypercapnic respiratory failure, pupillary abnormalities, prognostication, respiratory acidosis

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LEARNING POINTS

- Bilateral fixed dilated pupils in severe hypercapnic respiratory failure may reflect reversible metabolic dysfunction rather than irreversible brainstem injury.
- Correction of hypercapnia, hypoxia, and acidosis before formulating a prognosis may prevent premature limitation of care in critically ill patients.
- For internists, this case highlights the diagnostic risk of relying on a single ominous sign without integrating the full metabolic and respiratory context.

INTRODUCTION

Bilateral fixed dilated pupils (BFDP) have historically been regarded as a harbinger of catastrophic neurological injury, often prompting discussions regarding withdrawal of life-sustaining treatment[1]. The presence of BFDP typically suggests severe brainstem dysfunction from increased intracranial pressure, transtentorial herniation, or diffuse hypoxic-ischemic injury[2,3]. However, pupillary abnormalities can also result from reversible metabolic derangements, including severe hypercapnia, profound acidosis, and hypoxia[4]. The brainstem is relatively resistant to anoxic injury compared to cortical structures, and pupillary reflexes mediated by the midbrain (cranial nerves II and III) are among the most valuable prognostic indicators in comatose patients[2]. Current guidelines emphasize that pupillary assessment should occur after correction of confounding factors such as hypoxemia, hypotension, hypothermia, and sedative medications[3].

We present a case of complete neurological recovery following BFDP in the context of severe hypercapnic respiratory failure from massive aspiration pneumonia, prolonged seizures, and cardiac arrest. This case illustrates the reversibility of pupillary abnormalities when caused by metabolic rather than structural aetiologies and highlights the importance of avoiding premature prognostication.

CASE DESCRIPTION

A 66-year-old man with a history of cerebrovascular accident six months prior was brought to the Emergency Department by Advanced Life Support personnel. His previous stroke had involved a large thrombus in the middle cerebral artery treated with pharmacologic thrombolysis, and he was maintained on anticoagulation therapy and amiodarone for atrial fibrillation. He had been undergoing neurological rehabilitation with good functional recovery. On the day of presentation, the patient awoke normally and remained fully conscious for several hours. He subsequently developed dysarthria, began vomiting, and suffered generalized seizures with progressive loss of consciousness. Despite administration of midazolam, the seizures persisted. During the 30-minute hospital transport, he required continuous manual bag-mask ventilation with repeated suctioning due to ongoing vomiting and copious secretions. His blood pressure was approximately 150 mmHg systolic, but oxygen saturation fluctuated between 80-85%. An electrocardiogram revealed atrial fibrillation without acute ischemic changes.

Upon arrival to the resuscitation room, the patient remained unconscious with bilaterally dilated, unreactive pupils. Rapid sequence intubation was successfully performed. Venous blood gas analysis revealed severe respiratory acidosis with pH 6.96 and pCO_2 102 mmHg. Despite mechanical ventilation, oxygen saturation remained below 85% and continued to decline. Pupillary examination again confirmed bilaterally dilated pupils with absent light reflexes. Given the patient's history of stroke, anticoagulation, and the ominous finding of BFDP, a catastrophic intracranial event such as massive haemorrhage or severe cerebral ischemia was suspected.

Before brain imaging could be obtained, the patient experienced sudden profound desaturation despite adequate ventilation. No pulse was palpable, and the monitor displayed asystole. Cardiopulmonary resuscitation was immediately initiated with external chest compressions and intravenous epinephrine. Shortly thereafter, cardiac monitoring revealed a rapid wide-complex rhythm consistent with monomorphic ventricular tachycardia. Electrical cardioversion was performed, successfully restoring sinus rhythm with return of palpable pulses and blood pressure exceeding 100 mmHg.

A chest radiograph demonstrated severe bilateral pulmonary infiltrates consistent with massive aspiration pneumonia, explaining the impaired gas exchange, marked hypercapnia, and severe acidosis. A brain computed tomography scan revealed no new intracranial pathology beyond the previous ischemic lesion from his stroke six months earlier. The patient was given broad-spectrum antibiotics and maintained on mechanical ventilation with gradual improvement in respiratory parameters and correction of acidosis. Remarkably, as his respiratory status stabilized and acidosis corrected, his pupils became constricted and reactive to light. Over the following days, the patient was successfully weaned from mechanical ventilation and regained full consciousness with complete restoration of cognitive function.

DISCUSSION

The bilateral pupillary dilation observed in this patient likely resulted from multiple pathophysiological mechanisms related to severe hypercapnia, profound acidosis, and

hypoxia. Severe respiratory acidosis has profound effects on the central nervous and cardiovascular systems[5]. During asphyxia and respiratory failure, sympathetic activation causes pupillary dilation even in the absence of intact midbrain function[6]. Hypercapnia affects autonomic nervous system function, with pupillary responses correlating with respiratory rate and pCO_2 values[4]. The combination of hypercapnia, acidosis, and hypoxia creates a synergistic effect on brainstem function, potentially causing reversible pupillary abnormalities without permanent structural damage[7].

The rapid normalization of pupillary function following correction of respiratory acidosis in this case is consistent with emerging evidence that pupillary abnormalities caused by metabolic derangements can be completely reversible[8]. The American Heart Association guidelines emphasize that pupillary light reflex is vulnerable to metabolic derangements[3]. The brainstem is the least susceptible to injury from anoxia[2]. Recent evidence demonstrates that even in patients with transtentorial herniation and BFDP, improved pupillary response following osmotic therapy or decompressive surgery is associated with favourable outcomes, with younger age and less midline shift serving as additional favourable prognosticators. This underscores that pupillary recovery—whether from metabolic correction or surgical intervention—can herald meaningful neurological recovery[9].

While traditional bedside pupillary examination remains fundamental, quantitative pupillometry has emerged as a valuable tool for standardized assessment of pupillary reactivity. The Neurological Pupil Index (NPi), a composite numerical score ranging from 0 to 5, provides objective measurement of pupillary light reactivity and global midbrain function [10]. In a large prospective multicentre study of patients with acute brain injury, abnormal NPi values (less than 3) were strongly associated with poor neurological outcomes and increased mortality, whereas improvements in NPi heralded better outcomes[10]. Importantly, the study demonstrated that NPi trajectories particularly recovery from abnormal values provide valuable prognostic information. This supports the principle demonstrated in the present case: that reversible pupillary abnormalities, when caused by metabolic rather than structural aetiologies, can normalize with appropriate treatment and portend favourable recovery.

CONCLUSIONS

This case demonstrates that BFDP, traditionally regarded as a sign of irreversible neurological devastation, can be a transient and fully reversible phenomenon when driven by severe metabolic derangements rather than structural brain injury. Timely and aggressive resuscitation, combined with a deliberate deferral of definitive prognostication until confounding metabolic factors have been corrected, is essential to avoid premature withdrawal of life-sustaining treatment.

REFERENCES

1. Koehler PJ, Wijdicks EF. Fixed and Dilated: The History of a Classic Pupil Abnormality. *J Neurosurg* 2015;**122**:453-463. doi: 10.3171/2014.10.JNS14148
2. Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, et al. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. *Circulation* 2019;**140**:e517-e542. doi: 10.1161/CIR.0000000000000702
3. Hirsch KG, Amorim E, Coppler PJ, Drennan IR, Elliott A, Gordon AJ, et al. Part 11: Post-Cardiac Arrest Care: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation* 2025;**152**:S673-S718. doi: 10.1161/CIR.0000000000001375
4. Yamaguchi J, Kinoshita K, Hosokawa T, Ihara S. The Eyes Are the Windows of the Soul: Portable Automated Pupillometry to Monitor Autonomic Nervous Activity in CO2 Narcosis: A Case Report. *Medicine (Baltimore)* 2023;**102**:e33768. doi: 10.1097/MD.0000000000033768
5. Epstein SK, Singh N. Respiratory Acidosis. *Respir Care* 2001;**46**:366-383.
6. Larson MD, May J. Effect of Asphyxia on the Pupils of Brain Dead Subjects. *Resuscitation* 2002;**55**:31-36. doi: 10.1016/S0300-9572(02)00195-8
7. King TL, Kline DD, Ruyle BC, Heesch CM, Hasser EM. Acute Systemic Hypoxia Activates Hypothalamic Paraventricular Nucleus-Projecting Catecholaminergic Neurons in the Caudal Ventrolateral Medulla. *Am J Physiol Regul Integr Comp Physiol* 2013;**305**:R1112-R1123. doi: 10.1152/ajpregu.00280.2013
8. Dean JB. Hypercapnia Causes Cellular Oxidation and Nitrosation in Addition to Acidosis: Implications for CO2 Chemoreceptor Function and Dysfunction. *J Appl Physiol (1985)* 2010;**108**:1786-1795. doi: 10.1152/japplphysiol.01337.2009
9. Griepp DW, Miller A, Sorek S, Naeem K, Moawad S, Klein D, et al. Emergency Decompressive Surgery in Patients With Transtentorial Brain Herniation and Pupillary Abnormalities: The Importance of Improved Pupillary Response After Osmotherapy and Surgery. *J Neurosurg* 2023;**140**:544-551. doi: 10.3171/2023.5.JNS23163
10. Oddo M, Taccone FS, Petrosino M, Badenes R, Blandino-Ortiz A, Bouzat P, et al. The Neurological Pupil Index for Outcome Prognostication in People With Acute Brain Injury (ORANGE): A Prospective, Observational, Multicentre Cohort Study. *Lancet Neurol* 2023;**22**:925-933. doi: 10.1016/S1474-4422(23)00271-5