Hyperbaric Oxygen Therapy for the Adjunctive Treatment of Stroke Associated with Post-Cardiac Surgery Due To Native-Valve Endocarditis Infected by *Cutibacterium Acnes*: A Case Report

Pei-Ku Chen
Taipei Municipal Gan-Dau Hospital https://orcid.org/0000-0001-6421-7135

Tzu-Ting Kuo
Taipei Veterans General Hospital

Szu-Ying Lin
Taipei Municipal Gan-Dau Hospital

Jiang-Hwa Kao
Taipei Municipal Gan-Dau Hospital

Yen-Wen Chen (ywchen5@gmail.com)
Taipei Veterans General Hospital

Case report

Keywords: Cutibacterium (Propionibacterium) acnes, Hyperbaric oxygen therapy, Infective endocarditis, Stroke

Posted Date: September 17th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-861270/v1

Abstract

Background

Stroke is an uncommon but significant complication of cardiac surgery. Cutibacterium (previously known as Propionibacterium) rarely causes infective endocarditis (IE), accounting for approximately 0.3% of all IE cases. Hyperbaric oxygen therapy (HBOT), involving the administration of 100% oxygen at a pressure of > 1.4 atmospheres absolute, increases the partial pressure of oxygen; therefore, it is recommended as an adjunctive treatment for stroke and some infections. However, there are no data supporting HBOT as an adjunctive therapeutic option for ischemic stroke related to post-cardiac surgery due to IE caused by *Cutibacterium acnes*.

Case presentation:

This study reports the case of an 68-year-old male patient who underwent cardiac surgery for native-valve IE caused by *C. acnes*. He underwent HBOT on postoperative day 11 for the treatment of ischemic stroke. The patient received 20 sessions of HBOT along with 6-week antimicrobial treatment with ceftriaxone and rehabilitation programs.

Conclusions

We have summarized the patient's successful recovery and our clinical experience regarding the use of HBOT in our clinical setting. HBOT is an effective adjunctive therapeutic option for ischemic stroke related to post-cardiac surgery due to IE caused by *C. acne*s.

Background

Hyperbaric oxygen therapy (HBOT), administration of 100% oxygen at pressures greater than 1.4 atmospheres absolute (ATA), increases the partial pressure of oxygen in the patient's blood. HBOT, as a non-drug and non-invasive treatment, has been applied in the treatment of stroke since 1960s. It is proposed for the treatment of strokes based on pathophysiological principles that suggest it may decrease intracranial pressure and reduce cerebral edema, decrease lipid peroxidation, and stabilize the blood-brain barrier [1–3]. However, the use of HBOT for acute stroke remains controversial [3, 4]. One prospective trial demonstrates that HBOT can prompt the neuroplasticity of brain tissues in post-stroke patients, even in the chronic phase [5].

Stroke is one of the major complications of cardiac surgery. Regarding perioperative stroke in cardiac surgery, the incidence of which varies according to the procedure, 2–13% of patients experience neurological sequelae during the postoperative period [6–8]. The effects of HBOT on post-cardiac surgery ischemic stroke are unclear and lack adequate evidence.

HBOT is also useful in wound healing as well as deep and chronic infections such as osteomyelitis, necrotizing fasciitis, and chronic soft-tissue infection [9, 10]. However, studies regarding its role in treating infective endocarditis (IE) are limited. A rat model of *Staphylococcus aureus*-caused IE showed that as an adjunctive therapy, HBOT reduced bacterial load and proinflammatory cytokine levels by augmenting the efficacy of tobramycin [11]. The mechanism underlying the synergistic effects of HBOT with antimicrobial agents against *Cutibacterium acnes*-caused IE, accounting for approximately 0.3% of all IE cases [12], remains unclear.

Therefore, the present report describes a patient who underwent cardiac surgery due to native-valve IE caused by *Cutibacterium acnes* and was subsequently treated with HBOT for ischemic stroke during his surgical recovery.

Case Presentation

A 68-year-old man underwent mitral and tricuspid valve annuloplasty and aortic valve replacement, resulting from IE. The patient presented with congestive heart failure, pulmonary hypertension (right ventricular systolic pressure upon admission was 99.7 mmHg) and severe aortic regurgitation causing from right coronary cusp perforation. The patient's only comorbidity was gout. Preoperatively, there was insufficient evidence of IE, however, the postoperative tissue culture yielded *C. acnes*. The patient was experiencing left-sided hemiparesis and left homonymous hemianopia (National Institute of Health Stroke Scale: 14) after awaking from anesthesia postoperatively (day 0).

The muscle power assessment with the Medical Research Council's (MRC) scale was grade zero in the patient's left limbs, with sensory loss at the left foot and calf. Computed tomography revealed no intracranial hemorrhage or proximal large vessel occlusion. Thrombolysis was not performed because the patient was still recuperating from major surgery. Magnetic resonance imaging of the brain revealed hyperintensity on diffusion-weighted imaging and hypointensity on apparent diffusion coefficient values involving the right high frontal and parietal areas of the brain, compatible with acute ischemic stroke.

He underwent HBOT on postoperative day 11 for the treatment of ischemic stroke. The treatment protocol for HBOT was 90 minutes at 2.5 ATA with two air breaks, followed by a 15-minute compression and a 15-minute decompression. The patient received 20 sessions of HBOT along with 6-week antimicrobial treatment with ceftriaxone and rehabilitation programs.

The patient's muscle power recovered to MRC scale grade 4 + with minimal left-sided weakness. He was able to stand and walk slowly unassisted when he was discharged from the acute care ward. The patient was recovering well at his six months follow-up visit. He could move his limbs freely without assistance and his heart function was good although he had mild claw toes on the left foot and limited left ankle plantar flexion and dorsiflexion.

Discussion And Conclusions

This case report describes our experience using HBOT in a patient who underwent cardiac surgery due to native-valve endocarditis infected with *C. acnes* and experienced a post-surgery ischemic stroke. Based on pathophysiological principles and our clinical experience, we believe that HBOT benefited our patient.

Possible mechanisms for the development of post-cardiac surgical strokes include atheromatous plaque fragments dislodged from the aorta during cross-clamping, decreased cerebral perfusion, and gas embolisms [6, 7, 13]. Cerebral edema and neuronal apoptosis follow the passage of air bubbles, inducing endothelial damage and an inflammatory response. This may lead to endothelial swelling, increased vascular resistance, leucocyte and platelet adherence, and damage to the blood-brain barrier. There is a major risk of significant air embolisms during procedures in which the left ventricle or aorta are opened, such as in valve replacement surgery [13], which could explain why our patient experienced a post-operative stroke. Similar Gibson *et al* [13], HBOT was administered for our patient in treating post-cardiac surgical stroke, basing on the reason that cerebral air embolism is the likely etiology theoretically and the nature of the operation the patient had received.

HBOT also has bactericidal and bacteriostatic effects on both aerobic and anaerobic bacteria [14]. HBOT may have a direct antimicrobial effect, enhance the antimicrobial effects of the immune system, or work synergistically with certain antimicrobial agents [14]. The culture from the patient tissue showed the presence of *C. acnes*, a gram-positive anaerobic bacillus that is ubiquitous in the skin flora. Banzon *et al* [15] reported that the most common antibiotics used for the treatment of *C. acnes* infection were vancomycin (59%) and ceftriaxone (25%). Furthermore, the use of beta-lactams (benzylpenicillin was the most frequently used) and the addition of rifampicin or aminoglycosides for cases of *C. acnes* endocarditis have been elucidated in previous studies [16]. The antimicrobial therapy for *C. acnes* in combination with HBOT has not been previously addressed, and our case was the first to apply HBOT in this setting.

HBOT has proven effective adjunctive treatment in chronic Lyme disease, clostridial myonecrosis, necrotizing fasciitis, and refractory osteomyelitis [9, 17]. The antimicrobial effects of HBOT are believed to result from the formation of reactive oxygen species (ROS) [14], the reactive radicals that are continually produced as alternative metabolites of several cell biological pathways. HBOT promotes aerobic metabolism, leading to enhanced ROS production in bacteria. HBOT aims to induce the aerobic metabolism of bacteria and to reoxygenate the O_2-depleted infectious tissues, thereby increasing the microbial susceptibility to antibiotics. In our patient, there was not enough evidence of IE preoperatively until the tissue culture was obtained. We believe that the debridement was not performed completely, and the bacteria were still present. Consequently, HBOT was considered an effective adjunctive therapeutic option in our case.

Finally, HBOT facilitates wound healing by inducing angiogenesis [18, 19] and suppressing interferon-γ and proinflammatory cytokines such as interleukin (IL)-1, IL-6, and tumor necrosis factor-α [18]. HBOT induces partial high tension of oxygen in the circulating plasma and stimulates oxygen-dependent collagen matrix formation, an essential phase in wound healing [20]. Our patient had undergone major

open-heart surgery, including pericardiotomy and sternotomy, aortic valve replacement, tricuspid annuloplasty, mitral annuloplasty, and aortotomy. We believe that HBOT accelerated his wound healing and recovery, benefiting our patient enough for him to participate in rehabilitation programs within first month, which is considered the gold recovery phase after a stroke.

In conclusion, our patient demonstrated good recovery from ischemic stroke related to post-cardiac surgery due to IE infection by *C. acnes* despite a delay of one week before HBOT initiation. HBOT was effective as an adjunctive therapeutic option in our setting, However, evidence on when to apply HBOT and the number of intervention cycles for effective therapeutic outcomes requires further studies.

Abbreviations

HBOT
Hyperbaric oxygen therapy
ATA
Atmospheres absolute
IE
Infective endocarditis
MRC
Medical Research Council's
ROS
Reactive oxygen species
IL
Interleukin

Declarations

Availability of data and materials: The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate: Not applicable.

Consent for publication: Written informed consent was obtained from the patient for publication of this case report.

Competing interests: The authors have no conflicts of interests to disclose.

Funding: This research did not receive any grant from funding agencies in the public, commercial or not-for-profit sectors.

Authors' contributions:

Writing-original draft: P.K.C, T.T.K. Writing-review & editing: P.K.C, S.Y.L, J.H.K, Y.W.C. Patient care: T.T.K, S.Y.L. Supervision: Y.W.C. Validation: T.T.K, S.Y.L, J.H.K, Y.W.C

All authors read and approved the final manuscript.

Acknowledgment

The authors would like to thank all the healthcare workers in the Taipei Veterans General Hospital and Taipei Municipal Gan-Dau Hospital for their valuable contribution to patient care, as well as, Vikas Narang, Editaghe, a division of Cactus Communications for the help with language editing.

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