Journal of Artificial Organs (2019) 22:246–248
https://doi.org/10.1007/s10047-019-01099-2

CASE REPORT

Artificial Heart (Clinical)

Therapeutic hypothermia after global cerebral ischemia due to left ventricular assist device malfunction

Shunsuke Saito[1] · Koichi Toda[2] · Shigeru Miyagawa[2] · Yasushi Yoshikawa[2] · Hiroki Hata[2] · Daisuke Yoshioka[2] · Satoshi Kainuma[2] · Shohei Yoshida[2] · Yoshiki Sawa[2]

Received: 11 November 2018 / Accepted: 20 February 2019 / Published online: 2 March 2019

Abstract
Herein we report the case of a patient who suffered from global cerebral ischemia due to pump stoppage of Jarvik2000 Left ventricular assist device (LVAD) for unknown reason and fatal ventricular arrhythmia at home. Cardiopulmonary resuscitation was started by paramedics 6–7 min after the patient fell down. The patient was transferred to our hospital after the restoration of the LVAD function by exchanging external cables. Mild therapeutic hypothermia was induced and body temperature was kept at 33 °C for 24 h. After rewarming, the patient recovered his consciousness without any neurological deficit.

Keywords Left ventricular assist device · Device malfunction · Therapeutic hypothermia · Jarvik 2000

Introduction

From successful use of left ventricular assist device (LVAD) as a bridge to transplantation, its permanent use has also become realistic. However, it is known that the frequency of life-threatening complications increases with the prolonged duration of support [1], and once a critical complication occurs outside the hospital, it is very hard to save the patient's life.

We report the case of a patient with LVAD support who experienced global cerebral ischemia due to fatal device malfunction, whose brain function was fully recovered by therapeutic hypothermia.

Case

A 39-year-old male patient with dilated cardiomyopathy underwent implantation of Jarvik 2000 LVAD (Jarvik Heart, Inc., New York, N.Y., USA) at our institution and was discharged home after he safely passed the 3-min-LVAD off test. His life with LVAD was uneventful except for one admission due to ventricular fibrillation. He had almost no symptom with ventricular fibrillation under LVAD support. The arrhythmia was controlled medically and he was discharged home again. Four hundred and one days after implantation, he suddenly lost consciousness and fell down at home. Paramedics arrived 6–7 min later and found that the patient was asystole on the electrocardiogram. Cardiopulmonary resuscitation was begun immediately, and the cardiac rhythm shifted to ventricular fibrillation. Defibrillation was carried out but the cardiac rhythm did not recover. His wife, taking contact with a medical staff by phone, found that the light of the flow indicator lamp of the Jarvik2000 was invisible. After she exchanged connector cables between the controller and the battery following the directions of the staff, the light became visible. Defibrillation was carried out again and the patient returned to sinus rhythm. The LVAD was running properly when he arrived at the emergency room of our hospital, but he was deeply comatose with a decerebrate posture. Computed tomography (CT) of the brain revealed no cerebral bleeding or infarction (Fig. 1). Therapeutic

✉ Shunsuke Saito
shunsaito0404@gmail.com

[1] Department of Cardiovascular Surgery, Fukui Cardiovascular Center, 2-228, Shimpo, Fukui 910-0833, Japan

[2] Department of Cardiovascular Surgery, Osaka University Graduate School of Medicine, Suita, Osaka, Japan

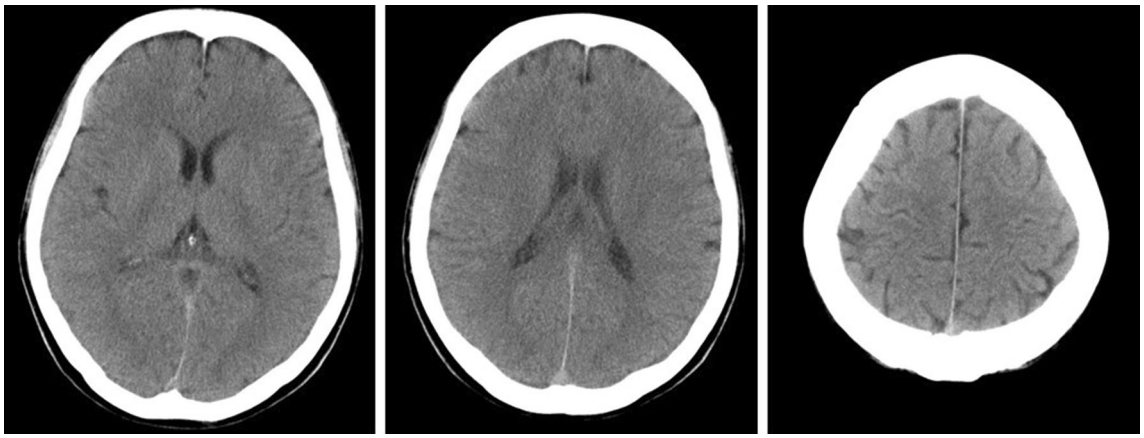

Fig. 1 Although the patient was deeply comatose with a decerebrate posture on arrival at the emergency room, computed tomography of the brain revealed no sign of brain damage

hypothermia was induced using ice water nasogastric lavage and body surface cooling. The body temperature was controlled at 33 ± 1 °C for 24 h. After rewarming, sedatives were stopped and he recovered his consciousness without any neurological deficit. Follow up brain CT revealed no organic brain damage. The LVAD controller, batteries, and all the external cables were sent to the manufacturer (Jarvik Heart, Inc) and underwent investigation. Only a partial damage of the Y-cable, which connects the controller and the batteries, was found, and it did not fully explain the cause of the event. The patient underwent successful heart transplantation 453 days after the event.

Discussion

The use of mild therapeutic hypothermia after cardiac arrest was first described in the 1950s, but was soon abandoned without being formally tested [2, 3]. However, over the last decade, many animal and clinical trials have revealed the pathophysiology of cerebral ischemia and mechanisms and effects of therapeutic hypothermia [3]. In November 2005, the Advanced Life Support Task Force of the International Liaison Committee on Resuscitation recommended therapeutic hypothermia in unconscious adult patients with spontaneous circulation after out-of-hospital cardiac arrest [4]. As cerebral injury occurs after any condition in which there is inadequate blood flow to the brain for more than 5 min, it is believed that hypothermia should be induced as early as possible. A randomized multicenter study in Europe revealed 55% of patients with out-of-hospital cardiac arrest patients were benefited from therapeutic hypothermia [3]. This therapeutic option is often successfully used in combination with extracorporeal life support [5, 6], and the decrease in blood temperature is not likely to affect the driving condition of the rotary blood pump. However, the use of therapeutic hypothermia in patients with implantable LVAD have not been well documented in previous literatures.

The Jarvik 2000 is an axial continuous-flow LVAD featuring a miniaturized intrarventricular pump. Long-term device durability is expected because the rotor is the only moving part and the bearings are the only parts subject to failure due to wear. In the report of 102 patients of Jarvik 2000 between April 2000 and December 2004 [7], there were 3 device failures due to external components resulted in patients' death. One was corrosion of power connector with subsequent damage of power plug with clamp and the other 2 were external abdominal power cable break. There were also 6 other breaks of external power cable that resulted in no negative consequences. In another report of Japanese multicenter registry data that includes 83 patients [8], 2 external component failure leading to patients' death were reported.

One of the major causes for consciousness loss in LVAD patients is cerebrovascular events. In case of cerebrovascular events, interventions such as thrombolytic therapy or decompressive craniectomy are required as soon as possible. However, the brain CT scan revealed no cerebral infarction or bleeding in the present case.

Although details of the event that occurred to our patient are not certain, it is clear that his heart was arrest and the LVAD was not correctly working when the paramedics arrived at his home. Two possible scenarios could be speculated: one is that critical arrhythmia caused temporary faintness and the impact of the fall caused LVAD malfunction, and the other is that LVAD malfunction occurred primarily for some reason and the arrhythmia occurred secondary. Either way, concurrence of the two adverse events, LVAD malfunction and arrhythmia, resulted in global cerebral ischemia. If the two events had not occurred at once, global

ischemia was unlikely to occur because he had tolerated both 3-min-LVAD off test and ventricular fibrillation under LVAD support.

In addition to the therapeutic hypothermia, there were several factors contributed to saving the patient's life and neurological function: constant presence of a family member, 24-h available hotline with technical support, presence of well-trained caregiver, the wife in this case, who could exchange the LVAD cables properly, and appropriate cardiopulmonary resuscitation by the paramedics.

In conclusion, we reported a patient who experienced global cerebral ischemia due to arrhythmia and LVAD malfunction. Therapeutic hypothermia successfully protected his brain from organic damage.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Birks EJ, Tansley PD, Yacoub MH, Bowles CT, Hipkin M, Hardy J, Banner NR, Khaghani A. Incidence and clinical management of life-threatening left ventricular assist device failure. J Heart Lung Transpl. 2004;23:964–9.
2. Benson DW, Williams GR, Spencer FC, Yates AJ. The use of hypothermia after cardiac arrest. Anesthn Analg. 1959;38:423–8.
3. Holzer M, Cerchiari E, Martens P, Roine R, Sterz F, Eisenburger P, et al. The hypothermia after cardiac arrest study group: mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N Engl J Med. 2002;346:549–56.
4. Hazinski MF, Nolan JP, Becker LB, Steen PA. Controversial topics from the 2005 International Consensus Conference on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation 2005;112:III-113-6.
5. Pang PYK, Wee GHL, Huang MJ, Hoo AEE, Tahir Sheriff IM, Lim SL, Tan TE, Loh YJ, Chao VTT, Soon JL, Kerk KL, Abdul Salam ZH, Sin YK, Lim CH. Therapeutic hypothermia may improve neurological outcomes in extracorporeal life support for adult cardiac arrest. Heart Lung Circ. 2017;26:817–24.
6. Heidlebaugh M, Kurz MC, Turkelson CL, Sawyer KN. Full neurologic recovery and return of spontaneous circulation following prolonged cardiac arrest facilitated by percutaneous left ventricular assist device. Ther Hypothermia Temp Manag. 2014;4:168–72.
7. Siegenthaler MP, Frazier OH, Beyersdorf F, Martin J, Laks H, Elefteriades J, Khaghani A, Kjellman U, Koul B, Pepper J, Jarvik R, Westaby S. Mechanical reliability of the Jarvik 2000 Heart. Ann Thorac Surg. 2006;81:1752–9.
8. Kohno H, Matsumiya G, Sawa Y, Ono M, Saiki Y, Shiose A, Yamazaki K, Matsui Y, Niinami H, Matsuda H, Kitamura S, Nakatani T, Kyo S. The Jarvik 2000 let ventricular assist device as a bridge to transplantation: Japanese Registry for Mechanical Assisted Circulatory Support. J Heart Lung Transpl. 2018;37:71–8.