Case Report

Intraoperative Pulsus Alternans Caused by Iatrogenic Hypovolemia

Ching-Jung Su, Shao-Wei Hsieh

Pulsus alternans is usually caused by severe cardiac contractility failure, dilated cardiomyopathy or aortic stenosis/regurgitation. It is rarely caused by pure diastolic dysfunction. We herein presented a patient with uncommon manifestations whose pulsus alternans was induced by iatrogenic hypovolemia during neurosurgery. This patient received mitral valve replacement with a bileaflet mechanical prosthetic valve several years ago and has had normal left ventricular contractility. The occurrence of pulsus alternans for him was precipitated by impeded ventricular filling due to mannitol-related iatrogenic hypovolemia and smaller effective orifice area of mechanical valve than indigenous mitral valve. His pulsus alternans dissipated progressively with fluid resuscitation afterwards. This case agreed with the theory that alternating loading condition operates more than contractility failure in the pathogenesis of pulsus alternans.

Key words: pulsus alternans, hypovolemia, mechanical prosthetic valve, diastolic dysfunction

Case Report

A 38-year-old male, 186 cm and 81 kg, underwent a craniotomy for clipping of his cerebral aneurysm and ventriculoperitoneal shunt, due to subarachnoid hemorrhage (SAH) and brain edema. Before craniotomy he underwent extra-ventricular drainage for hydrocephalus 2 weeks ago, and was kept intubated in the intensive care unit. In the operation room, general anesthesia was maintained with isoflurane inhalation and intravenous fentanyl plus rocuronium administration, under standard anesthetic monitoring and direct arterial pressure monitoring. The central venous pressure was not measured from the femoral central venous catheter because of its inaccuracy in assessing preload status. During craniotomy, the arterial pressure tracing developed a particular waveform of beat-to-beat alternating variations with normal sinus thyrhm after mannitol infusion. It was recognized as pulsus alternans (Fig. 1). Similar alternating pattern occurred on finger pulse oximetry at the same time. Because of his grossly stable hemodynamics and meticulous fluid management for brain relaxation, no specific intervention was

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applied.

For this patient, the uncommon arterial pressure waveform was not caused by any significant arrhythmias, cardiomyopathies or conceivable myocardial contractility failure. None of cardiac aberrances but a mitral mechanical valve may account for this condition. Fours years before neurosurgery, he had received mitral valve replacement with a St. Jude bileaflet mechanical valve of No. 31 (St. Jude Medical Inc., St. Paul, Minnesota, USA) because of infectious endocarditis and severe mitral regurgitation. Left ventricular (LV) ejection fraction was 65% with a normal E/A ratio of transmitral inflow pattern at the last echocardiographic follow-up, signifying a good systolic function.

Acknowledged to be a sign of poor outcome, pulsus alternans is usually caused by significant LV systolic dysfunction, aortic regurgitation or stenosis, congestive or dilated cardiomyopathy, and severe diastolic dysfunction secondary to systolic impairment.[1,2] However, intraoperative pulsus alternans occurred rarely in the absence of systolic dysfunction. The precipitating factor for this patient was contemplated to be hypovolemia jointly caused by fluid restriction due to brain edema, intraoperative mannitol infusion for brain relaxation and concomitant blood loss. Hypovolemia was evidenced with the drop of cardiothoracic ratio (CTR, from 51% preoperatively to 41% postoperatively) and the body weight (BW) loss by 2.4 kg perioperatively (Fig. 2). As a coarse tool to track the change in volume status, CTR was measured on a chest X-ray as the ratio of maximal horizontal cardiac diameter over maximal horizontal thoracic diameter between the inner edges of bilateral ribs. Consequently his pulsus alternans dissipated after fluid resuscitation on the next day, but the patient died of neurological mishap two weeks later.

Discussion

The potential cause of pulsus alternans was speculated to be hemodynamic theory, indicating that alternative changes in preload status could result in beat-to-beat changes in systolic contractility and stroke volume (SV), based on the Frank-Starling mechanism.[1,2] Relatively small effective orifice area (EOA) of bileaflet mechanical valve (2.2 cm^2 by pressure half-time method) would decelerate LV diastolic filling.[3] Compared with indigenous

Fig. 1 (A) Snapshot of intraoperative hemodynamic monitoring panel revealed normal sinus rhythm accompanied with alternating beat-to-beat variations on both arterial pressure waveform tracing and finger pulse oximetry simultaneously. (B) Another snapshot of hemodynamic monitoring taken several days later showed that pulsus alternans had no longer been seen in spite of hypotension. Arterial pressure waveform fluctuated synchronically with the efforts of mechanical ventilation. We didn't know the exact time that pulsus alternans faded away.

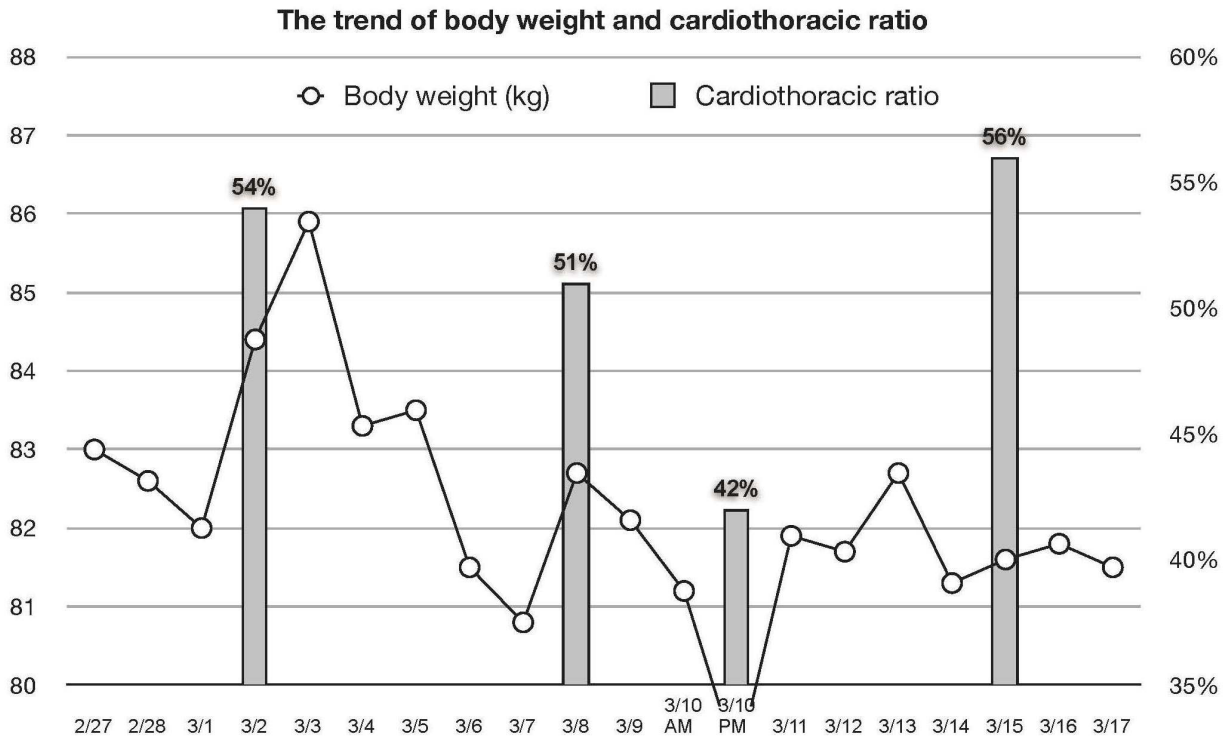

Fig. 2 This figure delineated the trend of body weight (BW) and cardiothoracic ratio (CTR) of this patient, revealing a precipitous drop in CTR. The BWs from March 2nd to March 5th, which included a cooling blanket due to persistent fever, got overestimated. On March 10th, the operation day when pulsus alternans was discovered, the body weight was measured pre-operatively and chest X-ray was taken post-operatively. The operation lasted for over 6 fours with BW drop by about 2.4 kg perioperatively. After that, only crystalloid solutions were given for volume replacement and his original BW got restored on the next day.

mitral valve, higher left atrial pressure (LAP) is needed to overcome the elevated transprosthetic pressure gradient through a reduced EOA to open the mechanical valve.[3] In the former small beat, hypovolemia produced a low LAP, which was unable to effectively open the mechanical valve to fill LV rapidly, resulting in a decreased SV and pulse pressure. In the sequential large beat, residual left atrial volume increased due to previous poor LV filling, creating a high LAP, and achieving a more efficient LV filling. Thereby it generated a greater SV and pulse pressure.[1,2] Other probable predisposing factors of pulsus alternans were upraised sympathetic tone provoked due to SAH-induced increased intracranial pressure or surgical stimulation, albeit their interconnections with pulsus alternans has not been mentioned.

Although pulsus alternans are mostly caused by ventricular systolic failure, diastolic dysfunction-induced pulsus alternans has been reported.[4,5] Our case supports the theory that alternating loading condition predominates over contractility failure in the pathogenesis of pulsus alternans.[4,5] Although rare, pulsus alternans could happen to a patient with a mechanical prosthetic valve in the absence of systolic dysfunction.

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