

## Pulsus Alternans as a Complication of Anesthesia

ROBERT C. BROWN, M.D., F.F.A.R.C.S.(E).\*

Pulsus alternans is characterized by regularly alternating high and lower pressure curves, usually without change in the electrocardiogram, and without significant change in the diastolic filling time. It generally indicates severe left ventricular dysfunction. The unexpected occurrence of pulsus alternans in an anesthetized patient is therefore alarming.

### REPORT OF A CASE

A 59-year-old Caucasian woman who had arteriosclerotic cardiovascular disease and transient dizzy spells was scheduled for carotid endarterectomy after narrowing of the right carotid artery was demonstrated by angiography. In the past she had had many operations, including excision of thyroid nodules, hysterectomy, cholecystectomy, appendectomy, and lysis of adhesions. Despite a history of labile hypertension, she had never been treated for this. The electrocardiogram was considered to be within normal limits except for sinus tachycardia of 110/min. There was considered to be no evidence of significant heart disease. Thyroid function tests, ordered because of the prior thyroid operation, were within normal limits, and the patient was not on maintenance therapy. Preoperative evaluation of the patient led to selection of cyclopropane for anesthesia to maintain adequate perfusion of the carotid arteries and to maintain ventilation at or near normal levels.

After premedication with pentobarbital, 100 mg, and atropine, 0.6 mg, the patient came to the operating room with a blood pressure of 160/70 mm Hg and a pulse rate of 72/min. Anesthesia was induced with thiopental, 225 mg, and continued with cyclopropane and oxygen. Intubation was preceded by spraying the larynx with lidocaine, 4 per cent, and facilitated with succinylcholine, 50 mg, iv. Shortly after intubation, a brief period of ventricular bigeminy was noted. At this point, an intra-arterial catheter was introduced into the left radial artery, and the pulse wave was displayed on an oscilloscope. A regular pressure curve, corresponding with the return of normal sinus rhythm, was noted. Moderate hypertension developed 20 minutes after induction of anesthesia. Without change in the electrocardiogram, apart from an increase in rate to 96 beats/min, the blood pressure was now seen on the oscilloscope to alternate regularly between 180/90 and 140/70 mm Hg. After consultation with the surgeon and

telephone consultation with a cardiologist, it was decided to cancel the operation and refer the patient for cardiologic evaluation. When cyclopropane was discontinued, blood pressure decreased to the level recorded at the time of induction of anesthesia, and pulsus alternans disappeared. The patient recovered uneventfully from anesthesia lasting 55 minutes.

A series of electrocardiograms was obtained; this showed no significant abnormality. Heart rates ranged from 77 to 110 beats/min. On physical examination, blood pressure was 140/70 mm Hg with the patient sitting and 125/60 mm Hg with the patient standing. The rate at this time was 90 beats/min. The cardiologist was unable to document significant cardiac disease and was unable to offer any explanation for the observations made in the operating room.

The patient came back to the operating room for a second attempt at the operation five days later. Anesthesia was essentially the same as that given previously, but because of technical difficulties, a radial artery could not be catheterized. Blood pressure was 180/90 mm Hg and pulse rate, 96/min. Seventy minutes after induction of anesthesia, and shortly after the surgeon infiltrated local anesthetic into the area of the carotid sinus and vagus nerve on the operative side, there was a slight increase in blood pressure, and for 25 minutes pulsus alternans, with pressures alternating between 200/90 mm Hg and 160/90 mm Hg, occurred; the heart rate was 100 beats/min. Pulsus alternans was detected by a doubling in rate of the Korotkov sounds, with regular rhythm, when the pressure in the cuff on the arm decreased from 200 to 160 mm Hg. Pulsus alternans was also visible in the exposed carotid artery. When blood pressure fell to 165/90 mm Hg, pulsus alternans was no longer evident. Anesthesia lasted 2½ hours. The patient was taken to the recovery room, where a dilute neosynephrine infusion was started to maintain blood pressure at 140 mm Hg systolic. Ninety minutes later, a member of the surgical team discovered a large swelling on the right side of the neck, and the patient was rapidly returned to the operating room for exploration of the wound.

On this occasion, the surgeon requested that he be allowed to use diathermy to control bleeding. The patient was therefore anesthetized with thiopental, 150 mg, halothane, nitrous oxide, and oxygen. The total procedure lasted 50 minutes, and one stitch in the carotid suture line was necessary. Blood pressure did not increase above 140 mm Hg systolic in this period, and pulsus alternans was not noted. The patient made an uneventful recovery and was discharged eight days later.

\* Associate Professor of Anesthesia, Albany Medical Center, Albany, New York 12208.

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## COMMENT

Pulsus alternans is commonly associated with severe left ventricular dysfunction secondary to coronary-artery disease, aortic valvular disease, hypertension, myocarditis, or pericarditis.<sup>1</sup> It is distinguished from pulsus bigeminus by the relatively regular spacing of the pulse waves and, in the absence of electrical alternans, by the normal configuration of the electrocardiogram.<sup>1</sup> Electrical alternans, with changes in the P, QRS, or T waves, may occur separately or occasionally may be associated with mechanical alternans. Pulsus alternans has been found in patients with apparently normal hearts during attacks of paroxysmal tachycardia. Pulsus alternans may be induced in animals by administration of sympathomimetic amines.<sup>1</sup> Paradoxically, catecholamines have been used to abolish pulsus alternans induced by rapid electrical pacing in animals.<sup>2</sup>

Pulsus alternans has been shown to be related to the state of venous filling. It may be induced in some patients by change to the erect posture or by phlebotomy, or decreased by factors which increase venous return.<sup>3</sup> It is also related to the workload imposed on the heart; the alternation in the strength of ventricular contraction has been shown to be related to the length of end-diastolic fibers, with no constant change in end-diastolic pressure.<sup>4</sup> Some observers suggest that pulsus alternans is not so much an alternation of weak and normal beats (as in pulsus bigeminus) as an alternation of weak and supernormal beats.<sup>1</sup>

Cyclopropane has not, to my knowledge, been implicated as a cause of pulsus alternans. It would not be expected to reduce venous return, and the effects of released catecholamines *per se* are, in this situation, speculative. It seems likely that in this patient the increase in work of the left heart required by the product of heart rate and ventricular

ejection force was enough to cause pulsus alternans. It would be of interest to know whether episodes of pulsus alternans could be produced in the patient by stress in the absence of anesthesia, as latent pulsus alternans may be disclosed by exercise. Patients with extensive arteriosclerotic cardiovascular disease and marked hypertension frequently are treated by coronary bypass operations. They are usually anesthetized with a combination of thiopental, nitrous oxide, and an opiate. True pulsus alternans has not been seen in these patients, although many transient aberrations may be noted when the myocardium is recovering from an episode of hypoxia. Ryan suggests that pulsus alternans occurring only during exercise in patients who are asymptomatic at rest indicates underlying myocardial insufficiency and is therefore of prognostic significance.<sup>5</sup> The evidence available would suggest that while the appearance of pulsus alternans in the anesthetized patient may not prohibit operation, it should be regarded as a warning of potential danger.

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