

## HAEMODYNAMIC EFFECTS OF TRANSIENT ATRIOVENTRICULAR DISSOCIATION IN GENERAL ANAESTHESIA

G. HALDEMANN AND H. SCHAEER

### SUMMARY

Isorhythmic atrioventricular dissociation occurs frequently under general anaesthesia but is rarely recognized without continuous electrocardiographic monitoring. Since this arrhythmia was observed in about 50 per cent of the cases during the onset of the neuromuscular blocking action of alcuronium or pancuronium during halothane anaesthesia, the opportunity was taken to investigate the haemodynamic parameters during atrioventricular dissociation. In nine patients the haemodynamic parameters during atrioventricular dissociation as compared to sinus rhythm were characterized by an absence of significant differences in cardiac rate, by a mean lowering in arterial mean pressure of 14 per cent and by a mean decrease in cardiac output of 15 per cent. The calculated peripheral resistance remained unaltered.

Alterations in cardiac rhythm frequently occur during anaesthesia and surgery. The reported incidence of arrhythmias, however, varies considerably, depending on the method of evaluation of the electrocardiogram. It is higher when the electrocardiogram is recorded continuously than when it is observed on the oscilloscope tracing only (Katz and Bigger, 1970). If cardiac rhythm is assessed by palpation of a peripheral pulse, all isorhythmic arrhythmias will completely escape attention.

It follows that the incidence of arrhythmias is actually higher than observed in routine practice. Kuner and associates (1967) analyzed rhythm irregularities during various types of anaesthesia from a continuous recording and noted arrhythmias in 61.7 per cent of the cases. About one-third of these were classified as isorhythmic atrioventricular dissociation or atrioventricular nodal rhythm; thus arrhythmias of these types occurred in about 20 per cent of all patients under anaesthesia.

It is said that the consequences of such a pacemaker shift are of no haemodynamic relevance (Holzmann, 1965; Lennox, Graves and Levine 1922; Ruskin et al., 1970). Clinical practice, however, has shown that episodes of atrioventricular dissociation are usually associated with a fall of arterial pressure, which is to be expected in view of the importance of a properly timed atrial systole for ventricular function.

During an investigation of the haemodynamic effects of several curarizing agents (Schubert and Schaer, 1971) an incidence of transient atrio-

ventricular dissociation of more than 50 per cent was observed during the onset of neuromuscular blocking action under halothane anaesthesia. This appeared to provide an ideal opportunity to obtain more information about the haemodynamic consequences of these frequently seen dysrhythmias during anaesthesia in man.

### METHOD

The present study was performed in patients with no cardiorespiratory disease. All were undergoing surgery for which endotracheal intubation, muscle relaxation and intermittent positive pressure ventilation would normally have been employed.

All patients were premedicated with atropine 0.5 mg and pethidine 50 mg, given 30–40 min before induction of anaesthesia. After the administration of a sleep dose of thiopentone (300–400 mg, given in increments of 100 mg every 20 sec) intubation was performed with the aid of suxamethonium 1 mg/kg. Mechanical ventilation was started with an Engström ventilator as soon as spontaneous respiration had reappeared. Ventilation was adjusted to maintain a  $P_{CO_2}$  of 30–40 mm Hg with a gas mixture of oxygen/nitrous oxide 1:1. Halothane was administered from a calibrated vaporizer (Fluotec, Mark II) in a concentration of 0.25–0.75 per cent.  $P_{O_2}$ ,  $P_{CO_2}$  and pH were measured using Gas Check AVL equipment (Haldemann and Schaer, 1971).

G. HALDEMANN, M.D.; H. SCHAEER, M.D.; Department of Anaesthesiology, University Clinics, Kantonsspital, Zürich, Switzerland.

After insertion of suitable catheters, arterial and central venous pressures were measured with Statham transducers and, together with the electrocardiogram, the peripheral pulse from an ear lobe, and heart rate, were continuously recorded on an Offner Dynograph.

Cardiac output was measured by the Stewart-Hamilton dye-dilution method using indocyanine green (Cardiogreen) as indicator. Calibration of the dye-dilution curves was not considered necessary, as the object of the investigation was to measure the relative changes produced by atrioventricular dissociation as compared to sinus rhythm.

When alcuronium 0.15–0.3 mg/kg or pancuronium 0.05–0.1 mg/kg were rapidly injected intravenously, in about 50 per cent of the cases isorhythmic atrioventricular dissociation or nodal rhythm occurred approximately 1 minute after injection and persisted for 4–10 min. In nine patients in whom this arrhythmia appeared, cardiac parameters were determined during the periods of atrioventricular dissociation and again as soon as sinus rhythm was restored. All measurements were finished before the onset of surgery.

All results are expressed as mean values  $\pm$  standard error of the mean. Significance of differences were assessed by the Student *t*-test (Snedecor, 1967).

### RESULTS

Reappearance of sinus rhythm was accompanied by small changes in mean cardiac rate (91 beats/min during nodal rhythm, 85 beats/min during sinus rhythm). The changes in cardiac output and mean arterial pressure (m.a.p.) are shown in figures 1 and 2. The absence of a properly timed atrial contraction decreased cardiac output by  $15 \pm 3$  per cent ( $P=0.001$ ) as compared to the control value during sinus rhythm, and m.a.p. by  $14 \pm 4$  per cent ( $P=0.01$ ). There was no significant difference between the calculated total peripheral resistance (98.5 per cent of the control value). During periods of atrioventricular dissociation or nodal rhythm pulsations of the right external jugular vein were clearly visible.

The effects of atrioventricular dissociation on some haemodynamic parameters can be demonstrated by the example shown in figure 3. During halothane anaesthesia episodes of atrioventricular dissociation occurred spontaneously at regular intervals. During periods of slightly decreasing cardiac rate, the P-QRS interval shortened and finally the P wave disappeared in the QRS complex.

The electrocardiogram tracing, however, does not allow us to distinguish between an isorhythmic atrio-

ventricular dissociation with either sinus node or atrioventricular node as active pacemakers or a true middle nodal rhythm with retrograde activation of the atrium. The changes in rhythm were accompanied by a fall in atrial pressure from 110/85 mm Hg to 85/65 mm Hg and an accentuation of the A waves in the venous pressure recording.

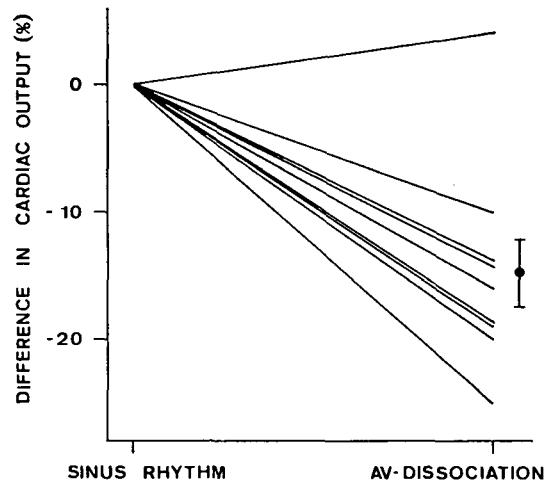


FIG. 1. Percentage difference of cardiac output during episodes of AV dissociation as compared to control measurements during sinus rhythm (nine patients).

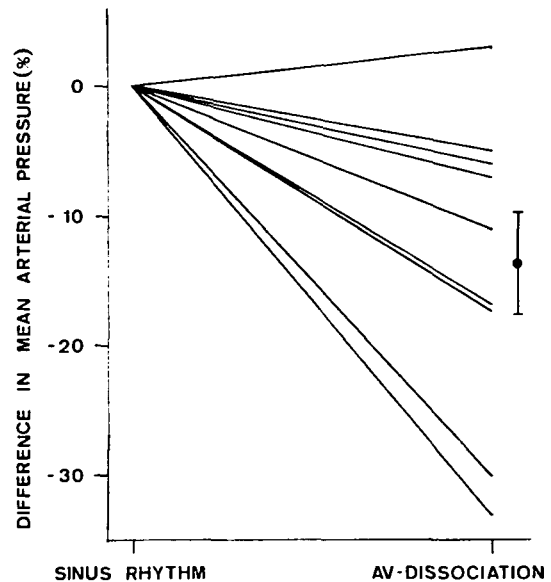


FIG. 2. Percentage difference of mean arterial pressure during episodes of AV dissociation as compared to control measurements during sinus rhythm (nine patients).

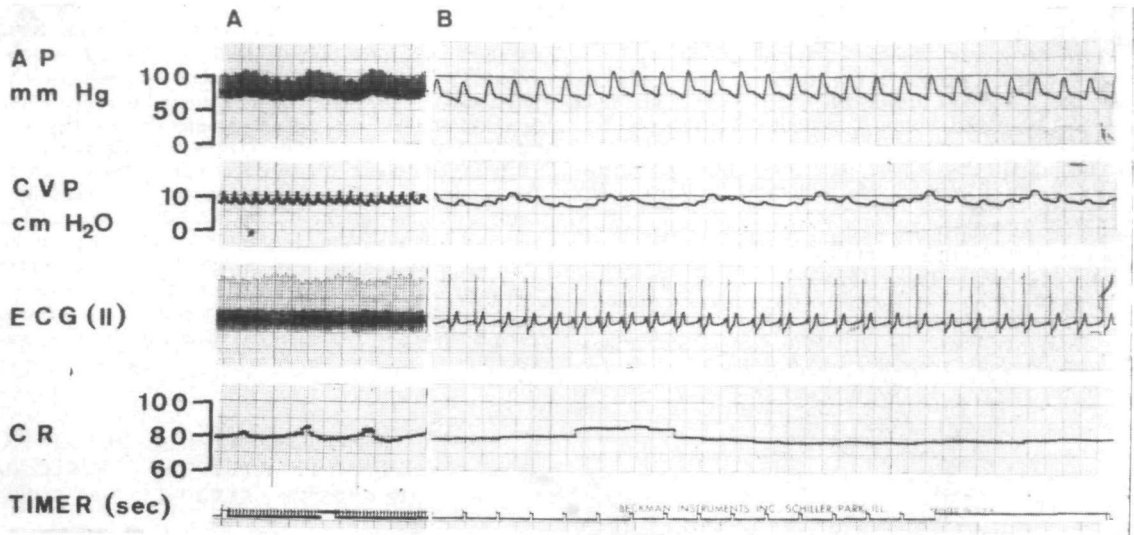


FIG. 3. Patient aged 19. Halothane/nitrous oxide/oxygen anaesthesia. Controlled ventilation at 20 b.p.m. Recurrent spontaneous episodes of atrioventricular dissociation. AP, arterial pressure; CVP, central venous pressure; ECG, electrocardiogram lead II; CR, cardiac rate; A, paper speed 25 mm/min; B, paper speed 10 mm/sec.

#### DISCUSSION

Atrioventricular dissociation or nodal rhythm occurs in about 20 per cent of all anaesthetics (Kuner et al., 1967). Usually, no clinical relevance is attributed to this kind of arrhythmia, though physiological investigations have pointed out the importance of atrial contraction (Wiggers and Katz, 1921; Jochim, 1938; Gesell, 1941). These early reports have been recently confirmed by experimental and clinical studies in man (Mitchell, Gupta and Payne, 1965; Snyder et al., 1966; Gillespie et al., 1967).

A properly timed atrial contraction is supposed to exert its favourable circulatory effects by two mechanisms; first by an increased filling of the left ventricle and secondly by a reduction in the amount of mitral regurgitation due to a better closing of the mitral valves (Mitchell, Gupta and Payne, 1965; Rutishauser et al., 1966). In dogs, shortening of the interval between atrial and ventricular contraction leads to a decrease in mean arterial pressure of 18 per cent and in aortic flow of 12 per cent (Skinner et al., 1963). In patients under halothane anaesthesia a change from sinoatrial to atrioventricular nodal rhythm was associated with a fall in systolic pressure of 17.1 per cent and a rise in central venous pressure (Laver and Turndorf, 1963).

These findings correspond well with the results of the present study in which absence of atrial

contraction was associated with a decrease of cardiac output of 15 per cent and of m.a.p. of 14 per cent. The results reported so far have been obtained in experimental animals or in healthy individuals. In patients with heart disease absence of properly timed atrial contraction is likely to cause much greater circulatory disturbance. Indeed, restoration of sinus rhythm in patients with atrial fibrillation leads within one week to an increase in cardiac index of 33 per cent (Rodman and Pastor, 1966). Furthermore Gillespie and associates (1967) demonstrated an increase in right ventricular stroke volume of 40 per cent with normal PR intervals of 0.20–0.25 sec in a group of patients with congenital heart block.

We agree with Holzmann (1965) and Ruskin and associates (1970) who stated that the haemodynamic consequences of atrioventricular dissociation are negligible. A decrease in cardiac output of 15 per cent is indeed of no importance for healthy patients. However, one has to take into account that sometimes patients with a poor circulation, as in hypovolaemia or heart failure, are subjected to anaesthesia and surgery. Under such circumstances the possible haemodynamic effects of atrioventricular dissociation are likely to be more pronounced and must be suspected as possible cause of sudden circulatory impairment.

## REFERENCES

- Gesell, R. (1941). Auricular systole and its relation to ventricular output. *Amer. J. Physiol.*, **29**, 32.
- Gillespie, W. J., Greene, D. G., Karatzas, N. B., and Lee, G. de J. (1967). Effect of atrial systole on right ventricular stroke output in complete heart block. *Brit. med. J.*, **1**, 75.
- Haldemann, G., and Schaer, H. (1971). Der Gas-Check-AVL, ein neuer Mikroblutgasanalysator. *Der Anaesthetist*, **20**, 267.
- Holzmann, M. (1965). *Klinische Elektrokardiographie*, 5th edn., p. 803. Stuttgart: Thieme.
- Jochim, K. (1938). The contribution of the auricles to ventricular filling in complete heart block. *Amer. J. Physiol.*, **122**, 639.
- Katz, R. L., and Bigger, J. Th. (1970). Cardiac arrhythmias during anesthesia and operation. *Anesthesiology*, **33**, 193.
- Kuner, J., Enescu, V., Ursu, F., Boszormenyi, E., and Bernstein, H. (1967). Cardiac arrhythmias during anesthesia. *Dis. Chest*, **52**, 5, 580.
- Laver, M. B., and Turndorf, H. (1963). Atrial activity and systemic blood pressure during anesthesia in man. *Circulation*, **28**, 63.
- Lennox, W. G., Graves, R. G., and Levine, S. A. (1922). An electrocardiographic study of fifty patients during operation. *Arch. intern. Med.*, **30**, 57.
- Mitchell, J. H., Gupta, D. N., and Payne, R. M. (1965). Influence of atrial systole on effective ventricular stroke volume. *Circulat. Res.*, **17**, 11.
- Rodman, Th., and Pastor, B. H. (1966). Hemodynamic response after conversion of atrial fibrillation to sinus rhythm. *Mechanisms and Therapy of Cardiac Arrhythmias*, p. 188. New York: Grune and Stratton.
- Ruskin, J., McHale, Ph. A., Harley, A., and Greenfield, J. C. (1970). Pressure-flow studies in man: effect of atrial systole on left ventricular function. *J. clin. Invest.*, **49**, 472.
- Rutishauser, W., Wirz, P., Gander, M., and Lüthy, E. (1966). Atriogenic diastolic reflux in patients with atrioventricular block. *Circulation*, **29**, 807.
- Schubert, K., and Schaer, H. (1971). Vergleichende klinische und experimentelle Untersuchungen von Pancuronium-Bromid (Pavulon<sup>R</sup>) und N-diallyl-bis-nor-Toxiferin-Dichlorid (Alloferin<sup>R</sup>) beim Menschen. *Proc. III European Congress of Anesthesiology, Prague, 1970* (in press).
- Skinner, N. S., Mitchell, J. H., Wallace, A. G., and Sarnoff, S. J. (1963). Hemodynamic effects of altering the timing of atrial systole. *Amer. J. Physiol.*, **205**, 499.
- Snedecor, G. W. (1967). *Statistical Methods*, 6th edn., p. 59. Iowa: Iowa State University Press.
- Snyder, J. H., Bender, F., Kitchin, A. H., Zitnik, R. S., Donald, D. E., and Wood, E. H. (1966). Atrial contribution to stroke volume in dogs with chronic heart block. *Circulat. Res.*, **19**, 33.
- Wiggers, C. J., and Katz, L. N. (1921). The contour of the ventricular volume curves under different conditions. *Amer. J. Physiol.*, **58**, 439.

EFFETS HEMODYNAMIQUES D'UNE  
DISSOCIATION ATRIO-VENTRICULAIRE  
TRANSISTOIRE AU COURS D'UNE  
ANESTHESIE GENERALE

## SOMMAIRE

Une dissociation atrio-ventriculaire isorythmique survient fréquemment sous anesthésie générale, mais elle est rarement reconnue en l'absence d'un enregistrement

electrocardiographique continu. Etant donné que ce type d'arythmie a été observé dans environ 50 pour cent des cas lors de l'apparition de l'effet de blocage neuromusculaire de l'alcuronium ou du pancuronium au cours d'une anesthésie à l'halothane, on a saisi cette occasion d'étudier le comportement des divers paramètres hémodynamiques au cours d'une dissociation atrio-ventriculaire. Chez neuf malades, au cours d'une dissociation atrio-ventriculaire, les paramètres hémodynamiques ont été caractérisés, en comparaison du rythme sinusal, par l'absence de différences significatives du point de vue de la fréquence cardiaque, par un abaissement moyen de la pression artérielle moyenne de l'ordre de 14 pour cent et par une diminution moyenne du débit cardiaque de 15 pour cent. La résistance périphérique est demeurée inchangée d'après les calculs effectués.

HÄMODYNAMISCHE WIRKUNGEN EINER  
VORÜBERGEHENDEN ATRIO-VENTRIKULÄREN  
DISSOZIATION IN ALLGEMEINNARKOSE

## ZUSAMMENFASSUNG

In Allgemeinnarkose kommt es häufig zu einer isorhythmischen atrioventrikulären Dissoziation, welche jedoch ohne kontinuierliche elektrokardiographische Ableitung meist unbemerkt bleibt. Nachdem wir bei etwa 50 Prozent der Patienten, die unter Halothannarkose Alcuronium oder Pancuronium erhielten zu Beginn des neuromuskulären Blockes diese Arrhythmie feststellten, benutzten wir die Gelegenheit, die hämodynamischen Parameter unter atrioventrikulärer Dissoziation zu messen. Bei neun Patienten zeichneten sich die hämodynamischen Parameter unter atrioventrikulärer Dissoziation im Vergleich zu Sinusrhythmus durch folgende Befunde aus: Keine signifikanten Unterschiede in der Herzfrequenz, durchschnittliche Blutdruckniedrigung um 14 Prozent des arteriellen Mitteldrucks, durchschnittliche Verminderung des Schlagvolumens um 15 Prozent. Der errechnete periphere Widerstand zeigte keine Veränderungen.

EFFECTOS HEMODINAMICOS DE LA  
DISOCIACION ATRIOVENTRICULAR  
TRANSITORIA

## RESUMEN

La disociación atrioventricular isorrítmica ocurre frecuentemente bajo anestesia general, pero es raras veces reconocida sin monitorización electrocardiográfica continua. Como esta arritmia fue observada en aproximadamente el 50 por ciento de los casos durante la iniciación de la acción de bloqueo neuromuscular de alcuronio o pancuronio durante anestesia por halotano, se aprovechó esta oportunidad para investigar los parámetros hemodinámicos durante la disociación atrioventricular. En nueve pacientes, los parámetros hemodinámicos durante la disociación atrioventricular estaban caracterizados al compara con el ritmo sinusal por una ausencia de diferencias importantes en la frecuencia cardíaca, por una disminución media del 14 por ciento en la presión media arterial y por un descenso medio del 15 por ciento en el gasto cardíaco. La resistencia periférica calculada permaneció constante.