ELECTROMANOMETRIC CONFIRMATION OF NEEDLE POSITION IN
HAEMOPERICARDIUM WITH SEVERE TAMPONADE

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SUMMARY

Simultaneous recording of the electrocardiogram and of the pressure transmitted through the drainage needle in patients with haemopericardium provided confirmation that the needle tip was in the pericardial cavity. Proper position was indicated by a positive pressure wave beginning before the QRS complex, reaching its maximum value in the first part of the ST segment and ending with the T wave. In contrast, ventricular penetration was signalled by a positive pressure wave beginning in the first part of the QRS complex, reaching its maximum during the T wave and ending between the T and P waves.

METHODS

Five dogs (20–23 kg) were anaesthetized with ketamine i.m. and thiopentone sodium i.v. After endotracheal intubation, facilitated with suxamethonium, anaesthesia was maintained with a mixture of 70% nitrous oxide, 30% oxygen and 1% enflurane with intermittent positive pressure ventilation of the lungs.

The thorax was opened to expose the pericardium. Catheters of 1.5 mm i.d. were inserted to the tracheal tube and to the pericardial cavity for the recording of the airway and pericardial (PP) pressures. A similar catheter was introduced to the right ventricle via the atrium in four dogs for the recording of the ventricular pressure (VP). During this procedure, one dog exhibited severe cardiac arrhythmia and was withdrawn from the study.

In the other four animals, the catheters were connected to pressure transducers (Statham P23AC) and the pressure changes were simultaneously recorded, by means of an ink-writing polygraph (Grass D 5), together with the e.c.g. An extracorporeal reservoir containing isotonic saline was connected to the pericardial cavity through a catheter of 4 mm i.d. affording controlled volume changes of the pericardial fluid.

RESULTS

No pressure could be recorded from the empty pericardial cavity. Following the introduction of saline 50 ml, the basal pressure was 5–8 cm H₂O with two types of oscillation: a wide oscillation reflecting airway pressure; two low pressure waves (a and b, fig. 1) occurring with every cardiac cycle. Gradual introduction of an additional saline 50–60 ml to the pericardial cavity increased basal...
FIG. 1. Three anaesthetized animals receiving intermittent positive pressure ventilation. Pericardial pressure increased from 0 to 20–24 cm H$_2$O by introducing about 150 ml of saline to the pericardial cavity: a and b, ab PP indicate the cardiogenic pericardial pressure waves associated with the cardiac cycle, represented here by the e.c.g. Note the a and b wave transformation to the ab wave as the basal pericardial pressure was increased to greater than 15 cm H$_2$O and the sharp reduction of the b or ab pressure waves during the ST segment and the T wave.

PP to greater than 15 cm H$_2$O. That pressure increase was associated with the transformation of the a and b waves into a single ab wave of the same global duration (fig. 1). The ab wave persisted with the further addition of saline 50–60 ml, resulting in a baseline increase to 20–24 cm H$_2$O.

In one dog the cyclic respiratory increase of PP was sufficient to cause the periodic transformation of the a and b waves into the ab wave and vice versa in spite of there being only 70 ml of saline in the pericardial cavity. In this dog the thorax was temporarily closed and the tidal volume increased to facilitate the wave transformation (fig. 2).

The following relationships were found between cardiogenic pressure waves (a, b and ab) of PP and the e.c.g. waves (fig. 1): (i) The rising phase of a and of ab began immediately after the T wave when VP was at its lowest value. (ii) The rising phase of b started with the P wave and before the systolic increase of the VP. (iii) The falling phase of a ended before the appearance of the P wave. (iv) The falling phase of ab and b started during the ST segment at the moment of the highest value of the VP and ended during the T wave.

DISCUSSION
The intermittent increases of PP attributable to respiratory fluctuations and parallel to events recorded in BAP can be discounted. Endothoracic pressure change during IPPV is well known (Spalding and Smith, 1963) and can be found in all low-resistance structures such as venous and
capillary beds, oesophagus, cardiac atria, mediastinum and pleural space. Our data indicate they reach the cardiac surface, contributing to its tamponade.

PP changes coupled to the cardiac cycle are relevant to our inquiry. These are drawn in figure 3 using the e.c.g. as a common reference to other events (Hamilton, 1962; Ruch and Fulton, 1962; Werko, 1962; Keele and Neil, 1966).

The PP began to increase during the initial phase of ventricular diastole, because of rapid ventricular relaxation. Immediately following this, the increase may lessen or there may be a decrease, the pressure waveform assuming all intermediate shapes between a and b and ab. These different responses to the same cardiac events are because pericardial tension increases from one pattern to the other. Rapid ventricular relaxation and its slower filling produce two separate events when the pericardium is relaxed, the a wave being mainly dynamic. There is a continuous PP increase (ab wave) when pericardial tension is high. The end-diastolic atrial filling could contribute in part to the final increase of PP.

The rapid decrease of PP at the beginning of the isotonic ventricular contraction, because of a sudden decrease of the cardiac volume, can indicate correct needle position; there should be no confusion with other cardiac pressure events. Frequently the c wave is absent (Werko, 1962) and the atrial hypertension during cardiac tamponade (De Quirot et al., 1974) must be partly responsible. The final decrease of PP begins during the ST segment and ends during the T wave; its previous rising phase precedes the QRS complex. The c wave starts with this complex and its decreasing phase, attributed to ventricular emptying and lowering of the atrioventricular ring (Gordon, 1966), ends during the ST segment. Careful needle placement should make atrial penetration highly unlikely.

Confirmation of our experimental data has been obtained in a patient with mild signs of cardiac tamponade. The gradual evacuation of 750 ml of blood reduced the basal PP from 13 to about 0 cm H₂O. An ab wave was recorded above 8 cm H₂O, at which point it assumed the a and b wave configuration. However, the less the basal PP the more evident was the background pressure noise from patient movement, cough, and irregular breathing. In this condition it can be useful to average the PP signal, taking the Q wave as a triggering stimulus.

REFERENCES

**CONFIRMATION ELECTROMANOMETRIQUE DE LA POSITION D’UNE AIGUILLE DANS UN HEMOPERICARDE LORS D’UN EPANCHEMENT GRAVE DE LA CAVITE PERICARDIQUE**

**RESUME**

L’enregistrement simultané d’un électrocardiogramme et de la pression transmise par l’intermédiaire de l’aiguille de drainage sur des patients souffrant d’un hémopericarde a permis de confirmer que la pointe de l’aiguille se trouvait dans la cavité péricardique. Son emplacement exact a été indiqué par une onde de pression positive commençant avant le complexe QRS, atteignant sa valeur maximale dans la première partie du segment ST et finissant avec l’onde T. Par contraste, la penetration ventriculaire a été signalée par une onde de pression positive commençant dans la première partie du complexe QRS, atteignant son maximum pendant l’onde T et finissant entre les ondes T et P.

**CONFIRMACION ELECTROMANOMETRICA DE LA POSICION DE LA AGUJA EN EL HEMOPERICARDIO CON TAPONAMIENTO**

**SUMARIO**

El registro simultáneo del electrocardiograma y de la presión transmitida a través de la aguja de drenaje colocada en pacientes con hemopericardio, permitió la confirmación de que la punta de la aguja se encontraba en la cavidad pericardial. La posición apropiada se indicó mediante una onda de presión efectiva que comenzó antes del complejo QRS, alcanzó su valor de cresta durante la primera parte del segmento ST y terminó con la onda T. Por el contrario, la penetración ventricular se indicó mediante una onda de presión efectiva que comenzó en la primera parte del complejo QRS, alcanzó su valor de cresta durante la onda T y terminó entre las ondas T y P.