TITLE : RESPIRATORY EFFECTS OF THE JARVIK-7 ARTIFICIAL HEART

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INTRODUCTION

It is clinically evident for any attentive observer, that the chest wall of a patient with a Jarvik-7 artificial heart moves in a similar way to that observed in a patient under high-frequency ventilation. We undertook a propective study to quantify this phenomenum and to evaluate its effects on gas exchange.

METHODS

Patients : Among 33 patients who underwent a Jarvik-7 artificial heart implantation between May 1986 and March 1988, 5 were selected for the study according to the following criteria : 1) presence of acute respiratory failure requiring mechanical ventilation 2) presence of agitation requiring heavy sedation. In each case informed consent was obtained and authorization was given by the Ethical Committee of our Institution. Each patient had a Utah total artificial heart model Jarvik-7[1], and the drive functions were adjusted to obtain physiologic ranges of cardiac output, cardiac filling pressures and arterial pressure. A mean heart rate of 107±09 bpm was used.

Hemodynamic and respiratory measurements : Arterial and mixed venous blood samples were analysed within 2 minutes for PaO2, PaCO2, $P\bar{v}O2$ and pH (IL 1302 blood gas analyser). SaO2 (arterial oxygen saturation) and $S\bar{v}O2$ (mixed venous oxygen saturation) were measured using a Co-oximeter OSM3. Oxgen consumption ($\dot{V}O2$), oxygen delivery ($\dot{D}O2$) and pulmonary shunt ($\dot{Q}s/\dot{Q}t$) were calculated using standart formula. For measuring pulmonary volume displacement related to cardiogenic oscillations generated by the Jarvik-7 artificial heart, 2 differential linear transformers mounted on 2 belts, previously used for measuring tidal volume during high-frequency jet ventilation[2], were used. An example of the tracing obtained in a patient spontaneously breathing is represented in figure 1.

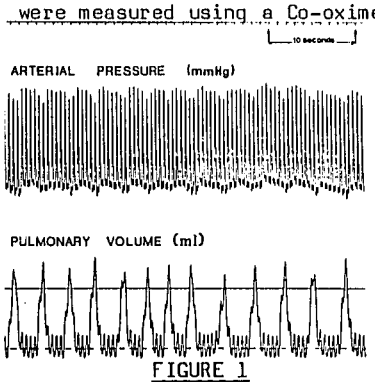

FIGURE 1

Procedure : Each patient was sedated with morphine and vecuronium and was intubated with a HI-LO jet TM Mallinckrodt endotracheal tube. A 20 minute period of Intermittent Positive Pressure Ventilation (IPPV) was then administered using FIO2 = 1. Hemodynamic and respiratory parameters were recorded on a GOULD ES 1000 recorder and served as control values. The patient then was disconnected from the ventilator and was given, as shown in figure 2, tracheal insufflation of pure oxygen at a constant flow rate of 20 l/min for 15 minutes. Then, IPPV was resumed. Hemodynamic and respiratory parameters

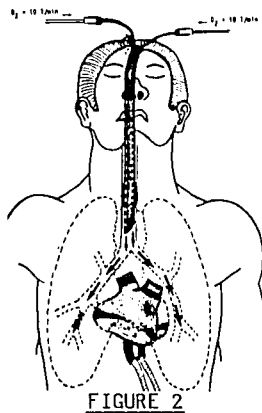
FIGURE 2

were measured 5, 10 and 15 minutes after the begining of apnea. All data were expressed as mean ± SD and analysed using a one way analysis of variance followed by a student's t-test.

RESULTS

In all patients, each cardiac beat was associated with a change in pulmonary volume ranging from 67 ml to 152 ml. As shown in the table, the combination of Jarvik-7 induced cardiogenic oscillations with tracheal insufflation of oxgen was associated with a progressive and significant increase in PaCO2 and with a significant decrease in pH. However, after 15 minutes of apnea, 2 patients showed normal PaCO2 values (37 mmHg and 43 mmHg respectively). Simultaneously PaO2, $\dot{Q}s/\dot{Q}t$, $\dot{D}O2$ and $\dot{V}O2$ remained unchanged.

| | IPPV | APNEIC TRACHEAL INSUFFLATION OF OXYGEN | | |
|---|---|---|---|---|
| | C | 5 min | 10 min | 15 min |
| PaCO2 (mmHg) | 29 ± 5 | 39 ± 5 * | 44 ± 6 * | 47 ± 6 * |
| VT (ml) | 694 ± 383 | 105 ± 29 | 107 ± 35 | 93 ± 16 |
| pH | 7.52 ± 0.13 | 7.41 ± 0.08 * | 7.37 ± 0.07 * | 7.32 ± 0.04 * |
| PaO2 (mmHg) | 361 ± 99 | 325 ± 115 | 295 ± 106 | 289 ± 144 |
| $\dot{Q}s/\dot{Q}t$ (%) | 20 ± 9 | 21 ± 7 | 22 ± 6 | 24 ± 10 |
| $\dot{D}O2$ (ml/min) | 761 ± 59 | 714 ± 39 | 704 ± 44 | 707 ± 62 |
| $\dot{V}O2$ (ml/min) | 161 ± 28 | 168 ± 22 | 178 ± 16 | 177 ± 13 |

DISCUSSION

If we compare our results with the only human study on constant flow ventilation using tracheal insufflation of pure oxygen close to the carina[3], we could obtain a twofold lower rate of increase in PaCO2 (0.8 mmHg/min vs 1.8 mmHg/min) using a threefold lower flow of pure oxygen (0.3 l/min/kg vs 1 l/min/kg). This suggests that cardiogenic oscillations generated by the artificial heart contribute to maintain a certain degree of alveolar ventilation. As a consequence, the Jarvik-7 artificial heart may provide a potent respiratory support to patients with compromised respiratory function.

REFERENCES

1 De Wries et al : N.E.J.M. ; 310 : 273, 1984
2 - Rouby et al : J.A.P. ; 63 : 2216, 1987
3 - Breen et al : Anesth. Analg. 1986 ; 65 : 1161