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Intravenous Oxygenation with Lactated Ringer's Solution

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This experimental work was performed on 4 rabbits to demonstrate that administrations of oxygenated Ringer's lactate through the central venous infusion could be used as a means of oxygenation. The oxygen tensions of Ringer's lactate were determined upon changing the amount of oxygen being bubbled and the solutions with the mean PO2 and pH of 575.5 mmHg and 6.34 were used in this study. We did not use the solutions having the values below 416.6 mmHg PO2 and pH 6.08.

After the infusion of the oxygenated solution through central vein, PaO2 values throughout the 1 hour experimental procedure were significantly increased above the control value. Other parameters such as pH, PaCOs, $HCO3^-$, BE, O2 saturation did not show any statistically significant changes.

Some degree of oxygenation could be obtained by infusing the oxygenated Ringer's solution. This suggested that oxygenation by infusion through the central venous line could used clinically in the treatment of some forms of hypoxia with hypovolemia.

Key Words: *Central venous oxygenation, Ringer's lactate*

INTRODUCTION

Various means have been tested to provide an alternative way of oxygenation with or without the use of the lungs. Intravenous and intraperitoneal injections of oxygen (Cole, 1951; Awad et al., 1970), intraperitoneal oxygenation with hydrogen peroxide (Awad et al., 1970; Smith and Hanning, 1986) and fluorocarbons (Erdmann 1985; Faithfull et al 1984; Klein et al 1986) have been studied in experimental basis. The method of intravenous oxygen injection to restore the arterial blood pressure in circulatory failure with hypovolemia has been used clinically and provided beneficial results be attained within minutes. But the extra-pulmonic oxygenation could not be (Cole, 1951). Intraperitoneal injections of oxygen to hypoxic dogs, although it increased the arterial oxygen tension, failed to provide the quick beneficial results clinically (Awad et al., 1970). Alternatively, while it resulted in the formation of emboli in the lungs and coronary arteries. Transperitoneal administration of hydrogen peroxide a moderate increase in the blood oxygen tension, on the other hand, the intraperitoneal installation of fluorocarbons was evidenced to be an effective way of supplying oxygen without embolization (Faithfull et al., 1984).

Catheterization of the central venous line provides convient means to measure the pressure, to sample blood, to permit drug infusion, and to rapidly increase the circulatory volume by infusion.

Lactated Ringer's solution is an easily obtainable isotonic saline and its electrolyte concentration is similar to that of the blood and can be used in metabolic acidosis syndrome (Goldberger, 1986).

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The aim of this study is to acertain whether the infusion of oxygenated Ringer's lactate solution a means of oxygenation via a central venous catheter could be employed as the technique of intravenous oxygenation before proceeding the sophisticated studies. To this end, our preliminary work was done and reported here.

MATERIALS AND METHODS

Adult rabbits, ranging in weights from 1.8 to 2.6 Kg, were used. Anesthesia was included with an intramuscular injection of ketamine (10 mg/Kg) and maintained by a continuous infusion of ketamine as needed (500 mg in 500 ml of 5% dextrose water). Animals were allowed to breath spontaneouly (Clifford 1984).

The femoral artery was exposed and a 22-gauge catheter was inserted for measuring arterial blood gas tension. Heparin was administered to prevent clotting in the catheter. Another epidural catheter (outer diameter 0.9 mm, Potex Limited, Kythe, Kent, England) was inserted into the left femoral vein for infusion of the oxygenated fluid.

Following oxygenation of the Ringer's lactate solution by bubbling oxygen, the fluid were kept warm by passing through a FloTem-II blood/fluid warmer (Dala Chem, Inc, Carmel, Indiana, USA). between 37 and 38°C. The warmed solution (37~38°C) was infused through the central venous catheter by employing the diginfusa infusion pump (Schoch electronics AG, Zürich, Switzerland) at the rate of 30 drops per minute. Oxygen passing through the solution in the reservoir was run out via the oxygen

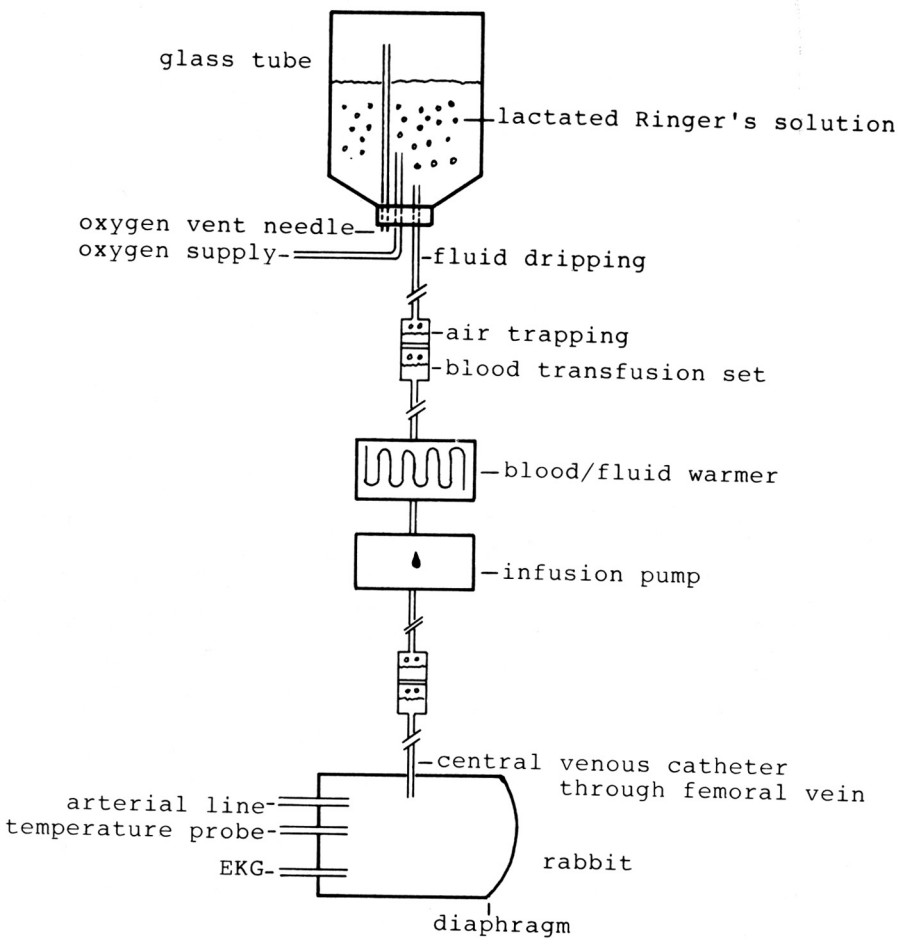

Fig. 1. Schematic presentation of experimental design.

vent needle stuck into the glass bottle (fig. 1).

Running oxygen bubbles in the infused solution was trapped within the transfusion set prior to passing through the blood/fluid warmer.

Temperatures of anesthetized rabbits were maintained around 37°C and monitored rectally using a tele-thermometer (Yellow Springs Instrument Co., Inc., Ohio, USA). The electrocardiogram was recorded from standard leads.

During perfusion, arterial blood gas tensions were measured at every 15 minutes for 1 hour. Prior to the administration of oxygenated Ringer's lactate, the control values were also measured. PH and PO2 of the solution were also measured just before applying and during its preperation.

The data were analyzed by the one-way analysis of variance (ANOVA) with repeated measures and where appropriate, the unpaired Student's t-test has been applied to test the equality of mean values between each measures. Differences between specific measures were tested with the Schéffe's test for multiple comparisions (Auh 1984; Norušis 1986). Probability values of less than 0.05 were considered statistically significiant. All data are presented as the mean +s.d..

RESULTS

Animals in this experiment remained normothermic ranges throughout the whole procedure and arrythymia were not observed.

The mean PO2 of the oxygenated perfusate used

Table 1. Comparision between perfusate used in animals and experimental in vitro solution.

(mean+s.d.)

	pH	PCO2	PO2	$HCO3^-$	BE	O2 sat.
Perfusate used (n=5)	6.34 +0.43	8.0 +1.41	575.5 +32.67	0.5 +1.0	–46.75 +11.96	98.5 +1.29
Experimenal solution (n=6)	6.08 +0.48	7.8 +1.3	416.6* +10.71	0.4 +0.55	–48.0 +11.7	96.8 +3.11

Table 2. Blood gas tension in rabbits ventilated at 0.2 of Fi02 before (control) and during central venous infusion.

(n=4) (mean+s.d.)

Time period	pH	PaCO2	PaO2	$HCO3^-$	BE	O2 sat.
Control	7.38 +0.02	40.6 +4.01	94.5 +14.62	–0.1 +3.67	23.6 +3.97	97.8 +1.29
15 min.	7.39 +0.03	39.0 +3.56	128.2* +14.25	–2.24 +1.46	25.7 +32.86	97.4 +0.96
30 min.	7.39 +0.03	40.12 +4.21	124.6* +14.3	–2.18 +3.25	23.65 +3.32	98.2 +1.03
45 min.	7.36 +0.06	42.3 +2.68	112.8* +9.04	–2.6 +2.63	24.8 +2.97	98.0 +1.0
60 min.	7.37 +0.04	39.1 +6.24	116.5* + 8.97	–0.54 +3.44	23.24 + 3.61	98.2 +1.72

* Different from control ($p < 0.05$)
PCO2, PO2 (mmHg)
$HCO3^-$, BE (mmol/L)
O2 sat.: oxygen saturation (%)

in this study was 575.5+32.67 mmHg and that of experimental preparation in trial was 416.6+10.71 mmHg, while pH was 6.34+0.43 and 6.08+0.48, respectively (table 1).

Table 2 shows the result of PaO2 prior to and during central venous infusion. As can be seen, PaO2 values throughout the 1 hour experimental period were significantly higher than control value. Changes from 94.5+14.62mmHg to 128.2+14.25, 124.6+14.3, 112.8+9.04 and 116.5+8.97 mmHg were resulted.

But no significant changes were found in the PaO2 values of the infusion period.

Results shown in table 2 which are similar to the those observed with the control value seen in the PaCO2, BE and pH of the arterial blood, studied.

DISCUSSION

Because varying amounts of oxygen was bubbled in a given minute, the solutions had different PO2 for the perfusion fluid employed in the in vivo animal study, bubbling speed of oxygen was 5 liters per min and 3 L per minute for the solution used in the in vitro experiment. But both fluids had similar pH; 6.3 for perfusate used in the in vivo animal study, and 6.1 for the invitro experimental solution. The solution employed for the in vivo study was slightly more basic than the in vitro experimental solution. This may have lead to the shifting of the oxygen dissociation curve slightly to the right.

Efficiency of oxygen transport depends on the oxygen content in arterial blood and also the cardiac output. Oxygen content is the sum of dissolved oxygen and that bound to hemoglobin. Nearly full saturation of central infusion of oxygenated Ringer's lactate would deliver: 0.98 x 11.9 x 1.39 = 16.21 ml of oxygen per minute. 0.98 is saturation of hemoglobin. The mean hemoglobin concentration of the rabbit is 11.9 g/ 100 ml and 1.39 ml/g is the oxygen-combing power (Albritton, 1952; Faithfull et al., 1984). Such amount of oxygen content is sufficient to requirement of 9.3 ml/Kg/min. At hypoxic conditions, this content of oxygen might be more favorable and somewhat more oxygen can be taken up into the central circulation. Faithfull et al. (1984) demonstrated the changes in PaO2 following administrating of intraperitoneal Fluosol. At 0.2 of FiO2 changes in PaO2 against the control was 15.6 mmHg. Such result are half of value with ours. On the other hand, the $PaCO_2$ decreased by 3 mmHg or more in cases of using fluorocarbons, changes were not observed in our experiment. It was suggested that intraperitoneal perfusate might decrease PaCO2 if the diffusion gradient was high enough. The reason for no more elevation of arterial oxygen tension than around 130 mmHg was suspected that blood was diluted by oxygenated Ringer's lactate, oxygen dissociation curve was shifted to the right and fixed amount of infused solution was administered.

It is concluded that some degree of oxygenation can be obtained by central vein perfusion with oxgenated Ringer's lactate as a mean of oxygrenation to increase tension of the arterial blood with loading of blood volume. Also, it could be argued that the more alkalinized solution of perfusate employed in future study might be more benefit to provide increasing affinity of hemoglobin to the central venous blood through the catheter. The result of this preliminary trial have shown the possibility of the central venous oxygenation in the treatment of some kinds of hypoxic patient with hypovolemia as a simple and safe method of extra-plumonary oxygenation with vloume replacement instead of the others such as extracorporeal oxygenator (Hall and Kaplan, 1983).

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