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Cardiorespiratory Responses on Administration of Lactic Acid in Anaesthetized Cats

Sharda Singh[1], K. Ravi[2]

[1]Assistant Professor, Department of Physiology, World College of Medical Science and Research, Jhajjar, Haryana.
[2]Professor & Head (retd.), Department of Physiology, Vallabhbhai Patel Chest Institute, New Delhi.

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ABSTRACT

Background : It has been well established in cats that intravenous/right atrial injections of phenyldiguanide and capsaicin produce apnea, bradycardia and hypotension by stimulating pulmonary C-fiber receptors. The present study was planned to investigate the reflex responses to bolus injections of lactic acid in anaesthetized cats. **Methods:** The present study was conducted in the department of Physiology, Vallabhbhai Patel Chest Institute, New Delhi during 1999 – 2000. The cats were anaesthetized and the cannulas were introduced into the femoral vein and artery on both the sides. The tip of venous cannula on one side was advanced as far as right atrium (confirmed at post-mortem). Intrapleural pressure and arterial blood pressure were recorded using strain gauges. 0.2 & 0.3 mmol/Kg of lactic acid were injected into the right atrium and the cardiorespiratory responses elicited were recorded. **Results:** In present study right atrial injection of a small dose(0.2mmol/kg) elicited either tachypnea or apnea. However on increasing dose to 0.3mmol/Kg, tacypnea was more pronounced or replaced by apnea. Along with the respiratory responses, bradycardia and hypotension were also elicited. Discussion – The cardiorespiratory responses of right atrial injection of lactic acid occurred within pulmonary circulation time 0.9 – 3.3 sec. Bilateral vagotomy abolished the cardiorespiratory responses elicited by right atrial injections of lactic acid. **Conclusion:** The study suggests that the lactic acid is producing the similar reflex response as with phenyldiguanide and capsaicin by stimulating pulmonary C- fiber receptors.

Keywords: Pulmonary C-fiber receptors, Right atrial injection, Vagotomy.

INTRODUCTION

Lungs and airways are extensively innervated by non-myelinated (C-fiber) vagal afferents that play an important role in regulating various airway functions (Coleridge & Coleridge, 1977). Two populations of C-fiber endings have been described in the respiratory tract: bronchial and pulmonary (Coleridge & Coleridge, 1977). The primary criterion for their identification as bronchial or pulmonary is based on their preferential circulatory accessibility through the systemic or the pulmonary circulation, respectively.

There are variety of chemicals that, when administered intravenously, are capable of inducing bradycardia, hypotension, and apnea by activating pulmonary C-fiber (type J) receptors (Paintal, 1973).Low pH solutions induce pulmonary chemoreflexes also (Lee et al., 1997; Trenchard, 1986) by activating bronchopulmonary C-fiber receptors. A previous study has shown that lactic acid activates pulmonary C-fiber receptors in rats (Lee, 1997). The present study was planned to investigate the reflex responses to bolus injections of lactic acid in anaesthetized cats.

Name & Address of Corresponding Author
Dr Sharda Singh
144,GH-3,Milap Appartment,
Paschim Vihar,
New Delhi.
110063

MATERIALS AND METHODS

The present study was conducted in the department of Physiology, Vallabhbhai Patel Chest Institute, New Delhi during 1999 – 2000.

Experiments were performed on healthy cats (n = 18) of either sex between 2.5 – 4.5 Kg. The cats were anaesthetized giving trichloroethylene vapours initially and later by injecting α-chloralose.

The polyethylene cannulas were introduced into the femoral vein and artery on both the sides. The tip of venous cannula on one side was advanced as far as right atrium (confirmed at post-mortem). The trachea was cannulated and artificial ventilation when needed was provided by a Starling ideal pump (rate 24 breaths/min, tidal volume 10 – 12 ml/Kg). The arterial pCO2 and pH were maintained within the normal range by adjusting the tidal volume and by infusing sodium bicarbonate.

A wide bore cannula connected to a pressure transducer was inserted into the pleural space on the right side after making a small slit. The intrapleural pressure tracing was used as an index of respiration (Anand & Paintal, 1980). Pneumothorax was minimised by periodic suctions.

Intrapleural pressure and arterial blood pressure were recorded using strain gauges (P23DC, Statham Instruments Ltd., Puerto Rico). Mean pressure was obtained by electronic damping of the pulsatile signals. An ECG (lead II) was recorded. Instantaneous heart rate was obtained by a cardiotachometer triggered by the R wave of the

ECG. All variables were recorded in an ink writing recorder (Grass 7D Polygraph).

0.2 & 0.3 mmol/Kg of lactic acid were injected into the right atrium and the cardiorespiratory responses elicited were recorded. An interval of 15 – 20 min was given between lactic acid injections.

Analysis of Data – the group data were expressed as mean ± SEM. A p value < 0.05 was considered as significant.

RESULTS

In these cats the control respiratory, heart rate & mean arterial blood pressure were 13± 1 breaths/min, 220±10 beats/min and 149±11 mmHg respectively. The arterial pH, pO2 and PCO2 were 7.33±0.01, 156±23 mmHg and 39±3.26 mmHg respectively.

Table 1: Changes in respiration following injections of graded doses of lactic acid into the right atria of anaesthetized cats

Primary respiratory responses				
Dose (mmol/Kg)	**Tachypnea**		**Apnea**	
	% Increase	**Latency (sec)**	**Duration (sec)**	**Latency (sec)**
0.2	61±12 (n=6)	2.2±0.3	6.7±1.0 (n=4)	0.9±0.3
0.3	76±15 (n=5)	2.1±0.3	6.8±0.8 (n=7)	1±0.2

- Values are mean ± SEM. The number of animals tested for each dose is the sum of n values in the corresponding row.
- ($P < 0.05$)

Table 2: Changes in heart rate and mean arterial blood pressure following injections of graded doses of lactic acid into the right atria of anaesthetized cats

Primary Cardiovascular Responses				
Dose mmol/Kg	**Heart rate**		**Mean Arterial Blood Pressure**	
	% Fall	**Latency(sec)**	**% Fall**	**Latency (sec)**
0.2	25±6 (n=6)	0.9±0.4	20±3 (n=6)	3.8±0.4
0.3	31±7 (n=9)	1.6±0.42	26±2 (n=9)	3.1±0.5

- Values are mean ± SEM. The number of animals tested for each dose is the sum of n values in the corresponding row.
- ($P < 0.001$)

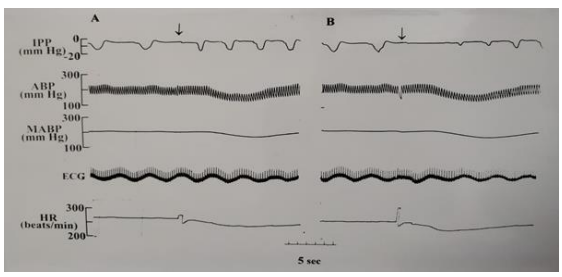

Figure 1: Cardiorespiratory responses following right atrial injections of graded doses of lactic acid in anaesthetized cats. Lactic acid was injected at the arrows and dose administered in A - 0.2mmol/kg & B - 0.3mmol/Kg).

A dose of 0.2 mmol/Kg (n=11) lactic acid was injected into the right atrium of cats. This dose was sufficient enough for eliciting a cardiorespiratory response. At this dose, there was tachypnoea in six whereas apnea in remaining animals [Table 1]. Bradycardia and hypotension occurred in six and no change in heart rate and mean arterial blood pressure were noticed in the remaining animals [Table 2].

With a higher dose of lactic acid (0.3mmol/Kg) (n=12), tachypnea occurred in five and apnea in the remaining animals [Table 1]. Bradycardia and hypotension occurred in nine and no change in heart rate and mean arterial blood pressure were noticed in the remaining animals [Table 2].

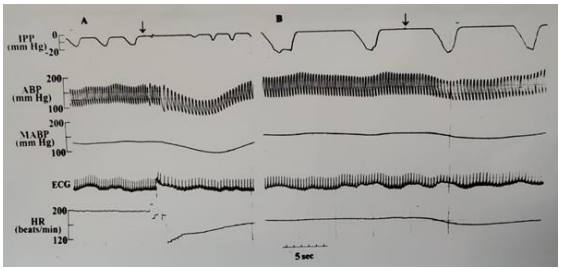

Figure 2: Cardiorespiratory effects of right atrial injection (indicated by the arrows) of lactic acid (0.2mmol/kg) with vagi intact (A) and with vagi cut (B).

DISCUSSION

It has been well established in cats that intravenous/right atrial injections of phenyldiguanide and capsaicin produce apnea, bradycardia and hypotension by stimulating pulmonary C-fiber receptors (Dawes 1951; Fastier 1959; Paintal 1955, 1957; Toh 1955). The latency for cardiorespiratory responses was 0.9 – 3.3 sec (mean 2.1 sec) that is within pulmonary circulation time (Coleridge and Coleridge, 1977). The primary respiratory responses produced by pulmonary C- fiber receptor stimulation has been considered to be tachypnoea(Anand and Paintal, 1980; Ravi, 1988; Ravi and Singh,1996). However on increasing the dose, tachypnea was replaced by apnea.

As observed with phenyl diguanide and capsaicin, right atrial injection of a small dose (0.2mmol/kg) elicited either tachypnea or apnea. However on increasing dose to 0.3mmol/Kg, tacypnea was more pronounced or replaced by apnea. The respiratory responses occurred within pulmonary circulation time. Along with the respiratory responses, bradycardia and hypotension were also elicited [Figure 1].

Bilateral vagotomy abolished the cardiorespiratory responses elicited by right atrial injections of lactic acid [Figure 2]. This suggest that respiratory responses produced by lactic acid injection were due to stimulation of receptors with vagal afferents perfused by pulmonary circulation.

CONCLUSION

Right atrial injection of lactic acid produced cardiorespiratory reflex response by stimulating receptors with vagal afferents perfused by pulmonary circulation. The study suggests that the lactic acid is producing the similar reflex response as with phenyldiguanide and capsaicin by stimulating pulmonary C- fiber receptors (Dawes 1951; Fastier 1959; Paintal 1955, 1957; Toh 1955). The further study required to prove the involvement of the receptors and its further implication during exercise.

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