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BROILER PULMONARY HYPERTENSION SYNDROME. II. THE DIRECT MEASUREMENT OF RIGHT VENTRICULAR AND PULMONARY ARTERY PRESSURES IN THE CLOSED CHEST DOMESTIC FOWL

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ABSTRACT

GUTHRIE, A. J., CILLIERS, J. A., HUCHZERMEYER, F. W. & KILLEEN, VALERIE M., 1987. Broiler pulmonary hypertention syndrome. II. The direct measurement of right ventricular and pulmonary artery pressures in the closed chest domestic fowl. *Onderstepoort Journal of Veterinary Research*, 54, 599–602 (1987).

A technique for the catheterisation of the right ventricle and pulmonary artery of the domestic fowl is described. Mean peak systolic, minimum diastolic and mean pressures measured in the right ventricle and pulmonary artery of a group of clinically normal broilers housed at a medium altitude of 1 300 m were 24,3; 8,1; 17,8; 25,0; 22,1 and 22,3 mm Hg respectively. The pulmonary artery pressures are different from those reported elsewhere using the open chest technique. These differences are possibly due to both the effect of opening the thoracic cavity and the hypoxic pressor effect at this altitude.

INTRODUCTION

Burton, Besch & Smith (1967) described the open chest method of direct cannulation of the pulmonary artery of the domestic fowl with subsequent sacrifice of the subject.

Measurement of intracardiac pressures via catheterisation of a superficial blood vessel have made an important contribution to the understanding of the physiology and pathophysiology of the cardiovascular system. This is especially true of the right heart pressures which give a direct indication of the degree of pulmonary vascular hypertension (Ross, 1962).

The technique has been widely used in man (Grossman, 1974) and in animals. Littlejohn & Bowles (1980) review the various studies that have been performed on the conscious horse. The technique has also been used in rats by Herget & Palecek (1972) and Morganroth, Stenmark, Morris, Murphy, Mathias, Reeves & Voelkel (1985), in pigs by McMurtry, Frith & Will (1973) and in turkeys by Einzig, Jankus & Moller (1972).

The right ventricular hypertrophy that resulted secondary to pulmonary disease was termed 'cor pulmonale' by White (1951). Ettinger & Suter (1970) state that the right heart enlargement secondary to pulmonary disease can be termed cor pulmonale in veterinary medicine. The pulmonary hypertension which accompanies lung disease results from the mechanical restriction of blood flow through the affected lung tissue (Berglund, 1968) and the pulmonary vasoconstriction caused by hypoxaemia and hypercapnia (Fishman, Fritts & Cournand, 1960).

Cor pulmonale has been associated with increased pulmonary artery pressure in horses with chronic obstructive pulmonary disease (Bergsten, 1974; Dixon, 1978). Right ventricular hypertrophy, secondary to pulmonary hypertension has been reported in several mammalian species exposed to high altitude by Hultgren, Particorena & Miller (1963). Using the technique described by Burton *et al.* (1967) a direct correlation between the right ventricular and pulmonary arterial pressures and the degree of right ventricular hypertrophy was found in chickens by these authors and Cueva, Sillau, Valenzuela & Ploog (1974), Hernandez (1980) and Sillau, Cueva & Morales (1980). Ascites in broilers at high altitude was found to be associated with right ventricular hypertrophy and shown to be caused by pulmonary hypertension (Cueva, Sillau, Valenzuela, Ploog & Cardenas, 1970). The same was found in broilers with ascites at moderate and low altitude (Huchzermeyer & De Ruyck, 1986).

As there are no published data available on the direct measurement of the pulmonary arterial pressure in broiler chickens via superficial blood vessel catheterisation these techniques have been developed and are described below.

MATERIALS AND METHODS

Subjects

Eight-week-old clinically normal broilers, of both sexes, were used throughout this trial.

Catheters

Polyvinyl tubing[1] was used to catheterise the heart. Lengts of 200 mm had a blunted 25G needle inserted into the one end, and a V-shaped notch cut in the other end to prevent occlusion of the distal end of the catheter.

These catheters were sterilised by placing them in a 0,4 % chlorhexidine[2] solution for a minimum of 12 h.

Pressure transducer

A Statham P50[3] pressure transducer was used. This transducer is designed to measure intravascular pressures in the range −50 to +300 mm Hg, and is sensitive to pressure variations of <1 mm Hg.

Electromanometer and writing device

An electromanometer, Siemens-Elema 863[4], was used to amplify and calibrate the output signal from the pressure transducer. The 863 is a modular unit which plugs into the Mingograf-62[4] recording system, and is designed for use in conjunction with the P50 transducer. The input impedance of this unit was greater than 10 MΩ with an output signal of approximately 1,4 V for maximum pressure.

A Mingograf-62 physiological recording system fitted with 6 ink jet galvanometers was used to obtain permanent records of the pressure readings. The pressure curves were recorded at a paper speed of 10 mm per second.

The 863 electromanometer has an internal calibration device whereby the desired pressure range is marked on the chart paper by means of an electrical signal. The accuracy of the internal calibration was regularly checked against a mercury manometer.

Calibration was carried out in the 0–40 mm Hg range so that 10 mm on the chart paper represented 20 mm Hg.

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[3] Gould Statham Instruments Inc., Hato Rey, Puerto Rico.

[4] Siemens-Elema AB, Solna, Sweden.

TABLE 1 The pulmonary artery and right ventricular pressures measured in a group of clinically normal eight-week-old broilers

Pressure measurement	Pulmonary minimum diastolic		Pulmonary peak systolic		Pulmonary mean[2]		Ventricular minimum diastolic		Ventricular peak systolic		Ventricular mean	
Subject	mm Hg	kPa[1]	mm Hg	kPa	mm Hg	kPa	mm Hg	kPa	mm Hg	kPa	mm Hg	kPa
1	14,3	1,90	18,5	2,46	—	—	−1,0	−0,13	19,5	2,59	—	—[3]
2	15,0	2,00	18,0	2,39	—	—	−3,0	0,40	19,0	2,53	—	—
3	10,5	1,40	13,0	1,73	—	—	9,0	1,20	23,0	3,06	16,0	2,13
4	22,0	2,93	26,0	3,46	22,5	3,00	9,0	1,20	24,0	3,19	16,0	2,13
5	25,0	3,33	27,0	3,59	—	—	15,0	2,00	23,0	3,06	20,5	2,73
6	21,0	2,79	22,5	3,00	21,0	2,79	13,0	1,73	21,0	2,79	15,0	2,00
7	22,0	2,93	24,1	3,21	23,0	3,06	5,0	0,67	15,0	2,00	10,5	1,40
8	21,0	2,79	25,0	3,23	22,5	3,00	6,0	0,80	26,0	3,46	14,0	1,86
9	34,0	4,52	37,0	4,94	—	—	8,0	1,06	32,0	4,26	20,0	2,66
10	36,0	4,79	40,0	5,32	—	—	14,0	1,86	44,0	5,85	33,0	4,39
11	22,0	2,93	23,5	3,13	—	—	8,3	1,10	20,5	2,73	15,0	2,00
Mean	22,1	2,94	25,0	3,33	22,3	2,97	8,1	1,08	24,3	3,23	17,8	2,37
SD & plm.	7,7	1,02	4,6	0,61	0,9	0,12	4,8	0,64	7,9	0,82	6,4	0,85

(1) kPa = kilopascals = mm Hg × 0,133

(2) Because of excessive undulation of the pressure curve the mean could not be determined in some of the subjects

(3) In the first 2 fowls it was neglected to take the mean ventricular pressure

Atmospheric pressure delineated the base line of the tracing and all readings were made with the transducer at the level of the table on which the bird was lying. Mean values from several consecutive pressure curve tracings were calculated.

Procedure

The fowl was placed on an insulated table in lateral recumbency, and was restrained by holding the legs together, and the wings in an extended position. Standard plastic electrical crocodile clips were used and connected as follows: negative-negative to the right wing, positive-positive to the left leg, negative-positive to the left wing and earth to the sternum. The feathers on the medial aspect of the wing between the elbow and shoulder joints were plucked. An incision approximately 20 mm in length was made in the skin overlying the brachial vein in the humeral region. A 18G teflon cannula[5] was then inserted into the vein. The catheter was aseptically passed through the cannula into the vein and thence into the heart chambers and pulmonary artery. Once 100 mm of the catheter had been inserted, it was flushed with heparinised saline solution, the P50 pressure transducer was attached to the hub of the 25G needle, and a recording of the pressure curve was made on the Mingograf-62 recorder. In most cases the tip of the catheter was found to be in the right ventricle [characterised by a pressure wave in the range 10–30 mm Hg, (Fig. 1a)] or the pulmonary artery [characterised by a pressure wave in the range 15–30 mm Hg which undulated with the respiratory cycle, (Fig. 1b)]. If the tip of the catheter was found to be in the ventricle it was advanced so as to be carried into the pulmonary artery. If the tip of the

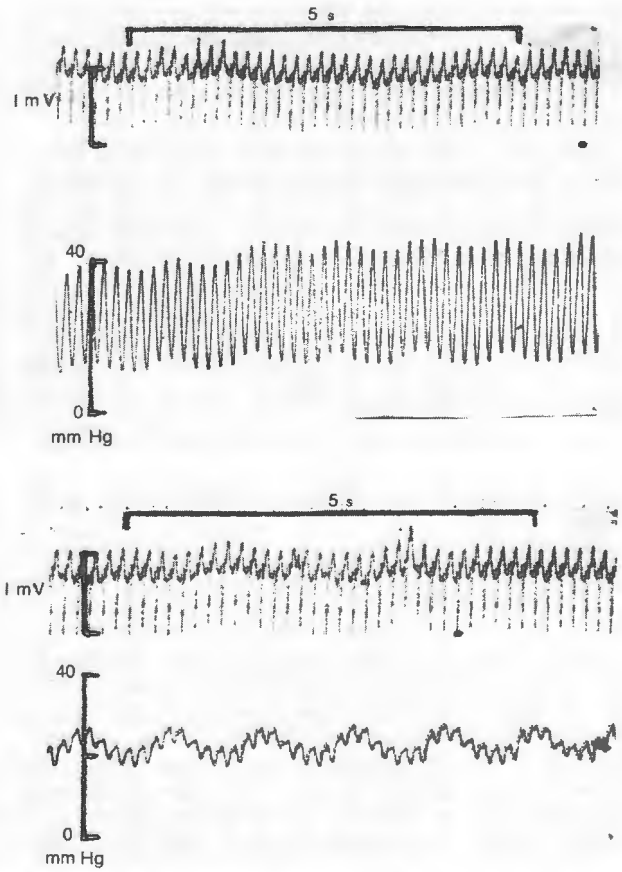

FIG. 1. a. Right ventricular pressure curve, and b. pulmonary artery pressure curve of a normal broiler chicken. EKG tracings were recorded simultaneously.

[5] Surgiflon, Surgiprod (Pty) Ltd, Langlaagte, South Africa.

TABLE 2 Comparison of the mean pulmonary artery pressures measured in mm Hg using the transthoracic method and the catheterisation technique

Pressure measurement	Pulmonary peak systolic	Pulmonary minimum diastolic	Pulmonary mean
Author	mm Hg	mm Hg	mm Hg
Burton *et al.* (1967)[1]	21,5	9,8	15,7
Cueva *et al.* (1970)[1]	—	—	15,95
Cueva *et al.* (1974)[1]	—	—	16,11
Hernandez (1980)[1]	—	—	20,50
Sillau *et al.* (1980)[1]	20,4	12,5	16,6
Present study[2]	25,0	22,1	22,3

[1] Measured at sea level

[2] Measured at 1 300 m above sea level

catheter was not in either the ventricle or the pulmonary artery it was manipulated by repeated retraction, rotation and re-insertion, until the tip was positioned in either the ventricle or the pulmonary artery.

A recording of the electrocardiographic standard limb lead I was made simultaneously with each pressure recording so that the electrophysiological activity of the heart could be correlated with the pressure curves.

RESULTS

Right ventricular and pulmonary artery pressures

Examples of the typical right ventricular and pulmonary artery pressure curves are shown in Fig. 1.

The minimum diastolic, peak systolic and mean right ventricular pressures, the minimum diastolic, peak systolic and mean pulmonary artery pressures and the means and standard deviations of these pressures are shown in Table 1.

DISCUSSION

Technique

The technique has proved to be simple and repeatable in that once the teflon cannula has been placed in the brachial vein it has been possible to measure the intracardiac pressures in all birds examined.

The placing of the teflon cannula requires a great deal of care because, if one punctures the vein without introducing the cannula, a large haematoma forms and it is impossible to reintroduce the cannula. It was due to this, that it was decided to expose the brachial vein rather than to introduce the cannula percutaneously.

The technique described by Burton *et al.* (1967) requires infiltration of relatively large amounts of local anaesthetic, thoractomy and the necessity of subsequent destruction of the fowl. Catheterisation via a superficial vein dispenses with gross interference and allows repeated observations on the same subject.

Pulmonary arterial pressures

The pulmonary artery pressure wave undulated with the respiratory cycle (Fig. 1b.).

The values obtained in this study are compared to those measured using transthoracic cannulation of the pulmonary artery in Table 2.

The peak systolic and mean pressures measured in this study are higher than those measured in open chested fowls, but this is probably due to the mild hypoxic pressor effect that has been reported in other species at an altitude of 1 300 m (Littlejohn & Bowles, 1980). The minimum diastolic pressure measured in open chested fowls was markedly less than that measured in the present study. This could be ascribed to changes in pulmonary vascular resistance which occur when the chest cavity is opened and the subatmospheric pressure within the chest cavity equilibrates with environmental pressure. The undulation of the pulmonary artery pressure with the respiratory cycle has not been described for open chest fowls. This phenomenon has also not been reported in catheterised mammals. The undulation in the pressure curve is probably caused by the effect of the changes in intrapleural pressure on the pulmonary artery during the respiratory cycle.

As the minimum diastolic pulmonary artery pressure and the pressure wave are affected by the opening of the chest cavity, the method described here provides data which are more closely related to the true physiological situation in the fowl.

Right ventricular pressure

The right ventricular pressure wave had a minimum diastolic pressure of less than 10 mm Hg and a peak systolic pressure of approximately 25 mm Hg in most of the subjects. These pressures are slightly less than those measured in turkeys by Einzig *et al.* (1972).

Conclusion

This technique is likely to play an important role as a diagnostic tool in the study of the pathogenesis of the pulmonary hypertension (ascites) syndrome in broilers.

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