~~LIST OF PROCEDURES DONE~~

PROJECT REPORT

TITLE OF THE PROJECT: QUANTIFICATION OF LEFT ATRIAL PRESSURE USING INTRA OESOPHAGEAL BALLOON IN DOGS

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PROGRAMME: D.M. CARDIOLOGY

MONTH & YEAR OF SUBMISSION: NOVEMBER 1986

TITLE:

QUANTIFICATION OF LEFT ATRIAL PRESSURE USING INTRA OESOPHAGEAL BALLOON IN DOGS.

DURATION: ONE MONTH

AIMS OF THE STUDY:

1. To record left atrial pressure waves using an oesophageal balloon positioned behind the left atrium in dogs.
2. To ascertain whether basal left atrial pressure can be quantified using an esophageal balloon.
3. To determine whether change in left atrial pressure is predictably reflected by the esophageal balloon.

ABSTRACT:

A fluid filled balloon catheter system was introduced into the esophagus and positioned behind the left atrium in ten anaesthetised dogs. The wave pattern and basal pressures were recorded and compared with the directly measured left atrial wave forms and pressure. A correlation between left atrial pressures and balloon pressures was sought after interventions to increase the left atrial pressure. It was found that though the esophageal balloon adequately reflected the left atrial pressure wave forms, quantification of left atrial pressure was not possible due to lack of linear correlation.

INTRODUCTION

Haemodynamic monitoring of left-atrial pressure is extremely valuable in the management of critically ill patients especially in the post-operative period and after acute myocardial infarction. An invasive technique involving measurement of pulmonary artery occlusion pressure and thereby estimate the left-atrial pressure is already in widespread clinical use and is extremely useful. But a reliable non-invasive means of quantifying left-atrial pressure would have more practical clinical application.

Left-atrial pressure waves have been recorded in man using intraesophageal balloon as early as 1889. Lasser et-al in 1952 made extensive studies using esophageal balloon to record left-atrial pressure wave forms under varying experimental conditions, producing mitral valvular lesions in dogs. He coined the term " esophageal piezo cardiogram" for the pressure wave pattern observed and characterized the changes. But attempts to quantitate the left atrial pressure by esophageal balloon manometry by these workers were not successful.

An earlier experimental model developed from this institute in 1985 has characterized the physical principles involved in the estimation of left atrial pressure using an esophageal balloon catheter. It was found that there was a linear correlation between the pressure change in the left atrial analogue and the pressure change in the esophageal balloon analogue. However, the various biological variables were not not taken into consideration while conducting this experiment. The present study was undertaken to find out the correlation between the directly measured left atrial pressure and intraesophageal balloon pressure in experimental dogs.

METHOD

The esophageal balloon catheter consisted an 80cm long polythene tubing whose iner diameter was 3.5 mm. One end was ealed and four openings into the lumen ere cut in the sides of the tube, as about cms from the sealed end. A polyvinyl hloride (PVC) balloon 4 cms in length nd 2 cm in diameter with a volume apacity of 12.5ml was fixed over the ylthene tube in such a way that the nside of the balloon was in communication ith lumen of polythene tubing, through e four openings made in the tubing. 3-way stop cock attached to the en end of the tube served to connect with both a saline filled syringe nd the lead tubing leading to the essure transducer.

The esophageal balloon catheter d the direct left atrial pressure catheter re connected to a Statham pressure ansducer system. The transducer was nnected to oscilloscope monitor which

splayed the waveforms along with surface
ectro cardiogram. The Transducer System
as calibrated before each experiment.
e pressure were noted directly from the
igital display. The esophageal balloon
essures and direct left atrial pressures were
easured in quick succession by turning
e 3-way stop cock attached to the
eft-atrial catheter.

Ten mongrel dogs weighing more
an 10 kg were selected for the study. The
ophageal balloon catheter was filled with
aline without air bubbles and partially
inflated. The catheter was then placed in
gastric lavage tube – 50 cm in length so
t the inflated balloon will protrude through
end of the rubber tube. This was intended
ease of introduction of the balloon catheter.

The dogs were anaesthetised with
ntathol sodium, intubated and ventilated
th a mixture of nitrous oxide and oxygen.
e esophageal balloon catheter was then
troduced into the dog's esophagus. The
alloon was then filled to its capacity

and connected to the transducer. The position of the balloon is adjusted so as to obtain the best waveforms. The chest of the dog was then opened by a left lateral thoracotomy and the esophagus exposed. The position of the balloon in the esophagus and it's relation to left-atrium was confirmed and minor adjustements of the balloon position made. The pericardium was then opened and through a purse string a catheter was introduced into the left-atrium. The catheter was then connected to the transducer for measurement of direct left-atrial pressure. Basal pressures in the balloon and the left-atrium were then recorded in quick succession. Only the mean pressures were taken into consideration. All pressures were recorded with the dogs in supine position, the mid chest level being used as zero reference point.

600 ml of normal saline was then rapidly infused through the left-atrial catheter, in increments of 200 ml. After each 200 ml infusion, the maximum pressure attained in both systems were recorded

in quick succession.

After fluid infusion, mitral regurgitation was created by cutting few chordae with an artery forceps introduced through a purse string at left ventricular apex and directed posteriorly. Creation of mitral regurgitation was confirmed by noting the abrupt pressure rise with prominent 'V' wave in left atrial pressure recording. The mean pressures in both systems were then noted. Next the ascending aorta was cross clamped to increase the severity of mitral regurgitation and again the pressures were recorded in both systems. Pressures were then rechecked after release of aortic cross clamp.

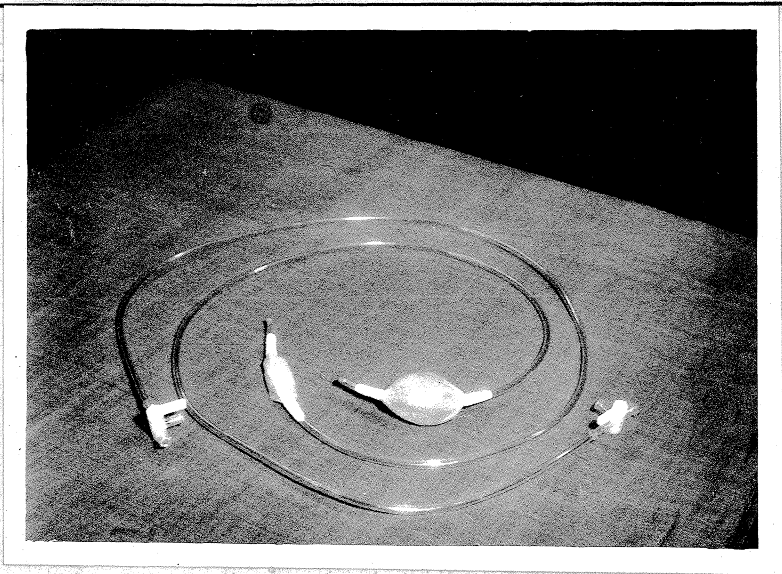

FIG 1 ESOPHAGEAL BALLOON CATHETER

FIG 2 LEFT ATRIAL CATHETER BEING INTRODUCED

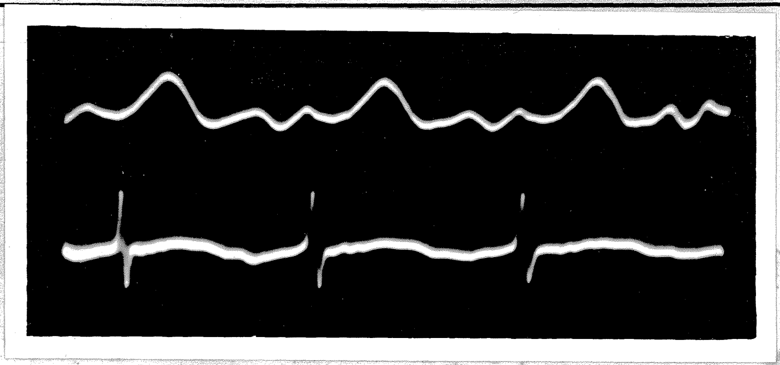

FIG. 3 LEFT ATRIAL WAVE FORMS AS RECORDED BY THE ESOPHAGEAL BALLOON CATHETER

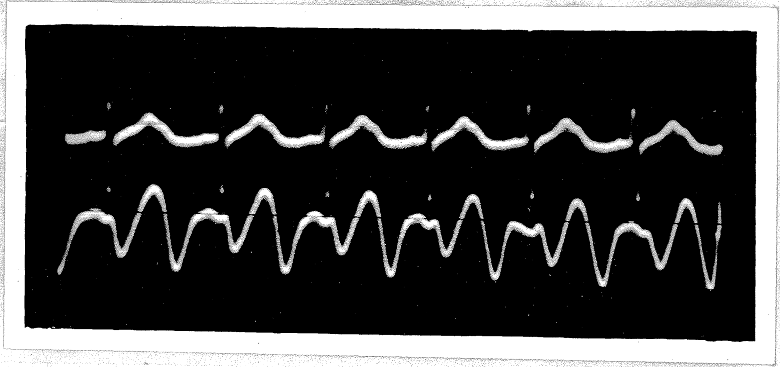

FIG 4 LEFT ATRIAL WAVE FORMS AS RECORDED BY THE DIRECT LEFT ATRIAL CATHETER

FIG 5 WAVE FORMS RECORDED BY LEFT ATRIAL CATHETER AND BALLOON CATHERER IN QUICK SUCCESSION.

OBSERVATIONS AND RESULTS

In all dogs studied a satisfactory pressure wave form was recorded from the esophageal balloon catheter.

Despite using the same sized balloon and same volume of fluid for inflation, the basal pressure recorded from the balloon catheter in different dogs was highly variable as shown in Table I. The basal pressures recorded from the balloon ranged from 4 mm to 19 mm of Hg. However the variation in the direct left atrial pressure was in the order of 3-12 mm of Hg. It was also observed that the wave pattern from the oesophageal balloon primarily depended upon the position of the balloon inside the esophagus. The best wave forms were obtained when the balloon was placed immediately behind the left atrium. But the mean balloon pressures did not show any significant change, irrespective of the position of the balloon in relation to left atrium.

DOG	BASAL (IN MM OF HG)		AFTER SALINE INFUSION					
			200 ML		400 ML		600 ML	
S.NO	LA	BAL	LA	BAL	LA	BAL	LA	BAL
1	7	11	13	14	17	16	21	17
2	6	16	10	17	14	20	17	22
3	3	8	6	5	11	9	15	10
4	9	4	15	12	21	14	25	15
5	9	17	17	18	19	19	20	20
6	5	9	12	18	14	19	21	20
7	9	19	13	22	16	24	19	24
8	12	4	16	5	18	5	21	8
9	8	14	12	15	16	15	20	16
10	9	5	13	7	16	8	19	10

TABLE I: SHOWING MEAN PRESSURE IN MM OF HG. IN THE TWO SYSTEMS BEFORE AND AFTER FLUID INFUSION

Basal pressures in the balloon were checked with the dogs in supine and right and left lateral decubitus position. Though the wave forms were better in the supine position there was no significant change of mean pressure in different positions.

When cotton padding was placed in front of the heart, the pressure waves recorded from the balloon were much superior.

Changes in both the pressure systems after fluid challenge is shown in Table I. In all the dogs studied pressure in both systems rose after fluid challenge, but the degree of rise in the balloon was very small when compared to the rise in direct left atrial pressure.

Table II shows changes in direct left atrial pressure and esophageal balloon pressure after creation of mitral regurgitation, and after application of aortic cross clamp and its release. Here again both pressures rose after creation of

DOGS	BASAL PRESSURE		AFTER MITRAL REGURGITATION		AFTER AORTIC CROSS CLAMP		AFTER RELEASE OF AORTIC CROSS CLAMP	
S-NO	LA	BALLOON	LA	BALLOON	LA	BALLOON	LA	BALLOON
1	10	12	19	13	26	18	13	12
2	12	19	DOG DEVELOPED VENTRICULAR FIBRILLATION.					
3	5	9	17	10	23	12	8	10
4	12	13	27	16	30	18	18	14
5	16	19	22	22	33	25	15	19
6	15	18	19	21	34	26	16	20
7	17	23	20	21	27	23	20	18
8	14	10	28	11	38	12	18	10
9	12	9	31	14	35	16	22	14
10	9	5	18	7	25	9	15	8

TABLE II: MEAN PRESSURES IN THE TWO SYSTEMS AFTER INTERVENTIONS TO INCREASE LEFT ATRIAL PRESSURE
(PRESSURES IN MM OF HG)

mitral regurgitation and application of aortic cross clamp, but the degree of pressure rise was much less in the esophageal balloon.

Table III shows the percentage of change between the basal and peak pressures in the two systems. The percentage change in the balloon was very small and unpredictable.

DOGS	LEFT ATRIAL PRESSURE (MM OF HG)			BALLOON PRESSURE (MM OF HG)		
S.NO	BASAL	PEAK	% CHANGE	BASAL	PEAK	% CHANGE
1	7	26	270	11	18	64
2	6	17	183	16	22	38
3	3	23	666	8	12	50
4	9	30	233	4	18	350
5	9	33	266	17	25	47
6	5	34	580	9	26	190
7	9	27	200	19	23	21
8	12	38	217	4	12	200
9	8	35	337	14	16	14
10	9	25	180	5	9	80

TABLE III: PERCENTAGE CHANGE BETWEEN BASAL AND PEAK PRESSURE IN THE TWO SYSTEMS

DISCUSSION.

Present study has shown that good quality left atrial pressure waves can be reproducibly recorded by means of an intra esophageal balloon using fluid filled catheter transducer system in dogs. It was also found that wave forms were much better in supine position. Similar results were also obtained by previous workers. There was no change in the wave pattern after thoracotomy. Best wave forms were obtained when the heart was padded in front by cotton. Even though the wave forms were observed in all animals, the amplitude of excursion was very variable.

Despite fairly adequate recording of left atrial wave forms in all animals there was no consistent relation between the mean balloon pressure and the simultaneously measured direct left atrial pressure in the basal state. The basal pressure ~~showed~~ in the balloon showed marked fluctuation from dog to dog. This was inspite of using same sized balloon and same inflating fluid volume. When direct left atrial pressure was in the range of 4-12 mm of Hg basal balloon pressure was in the range of 4-19 mm of Hg. It was also found that even when balloon was not in relation to left atrium, mean balloon pressure did not vary significantly. Thus our observation suggested that esophageal balloon pressure cannot be utilized to quantify basal left atrial pressure.

Our experiment carried out after interventions to increase left atrial pressure showed that balloon reflected directional change in the left atrial pressure. But the degree of change was minimal. When the mean change in left atrial pressure was 303% (180 - 666%), the change in esophageal balloon pressure was only 105% (80 - 350%). The change was also not predictable. In one dog for a 666% change in left atrial pressure the balloon pressure changed by only 50%. In another dog with 337% change balloon showed only a 14% change. In yet another dog for a 233% change in left atrial pressure, the balloon pressure changed by 350%. This extreme variability of response make esophageal balloon an inadequate tool for left atrial pressure measurements. Lasser et al also found inadequate correlation between the esophageal balloon pressure and the direct left atrial pressure.

The relationship between the magnitude of pressure fluctuations between the two systems is very difficult to formulate in general terms because many factors which cannot be quantified influence the recording of pressure from the esophageal balloon system. The pressure developed within the esophageal balloon is the resultant of two forces. One force is imposed by the expanding atrium which compresses the balloon against the vertebral column.

The other force is the expression of resistance of the balloon and the esophagus to the change in shape imposed by the first force. It is apparent then, that the pressure in the esophageal balloon at any instant is the result of several variables, even under standard experimental conditions. It could be anticipated that variations in the position of the heart in the chest, level of diaphragm during respiration, proximity of esophagus to atrium, internal dimensions, tone, elasticity and motility of esophagus, amount of fluid in the balloon and elasticity of balloon catheter system, might alter the quantitative relationship of pressure in an unpredictable fashion. Other factors which could influence balloon pressure measurements in a clinical situation are the size of the left atrium, hypertrophy of atrial wall and mediastinal disease. Since most of these factors cannot be standardised and are highly variable balloon esophageal pressure will not reflect actual left atrial pressure.

CONCLUSIONS

This study shows that left atrial pressure waves can be recorded by an esophageal balloon catheter positioned behind left atrium and connected to a fluid filled Transducer System. However there was no correlation between the basal left atrial pressure and the measured balloon pressure. Further the sensitivity of the esophageal balloon to detect a change in the left atrial pressure was very poor and unpredictable. This is because the pressure in the esophageal balloon is influenced by many variables which cannot be standardised. Hence esophageal balloon catheter system cannot be used to quantitate the left atrial pressure in dogs.

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