DETERMINATION OF NORMAL VALUES FOR RIGHT AND LEFT-VENTRICULAR CARDIAC OUTPUT, CARDIOPULMONARY TRANSIT TIMES, AND LEFT-VENTRICULAR EJECTION FRACTION BY NUCLEAR ANGIOCARDIOGRAPHY IN THE DOG.

by

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INTRODUCTION

Radionuclides have been providing quantitative information about the cardiovascular system for over one half of a century (1). In the past decade the scintillation camera and dedicated computer have become an important diagnostic tool for qualitative and quantitative evaluation of the human cardiovascular system (2). Since radionuclide cardiovascular imaging and flow studies are noninvasive, low risk and repeatable, most of the preliminary work was done in man (3). There exists a great need for normal values derived expressly for animals so that the veterinary medical community can make use of these radionuclide techniques.

The purpose of this study was to detail a set of three standardized cardiovascular parameters determined in the dog using nuclear angiocardiography. The three parameters assessed were right and left-ventricular cardiac output, cardio-pulmonary transit times, and left-ventricular ejection fraction.

MATERIALS AND METHODS

Ten 2 - 4 yr old mongrel dogs, 12 - 32 kg, were used to determine Right-Ventricular Cardiac Output (RVCO), Left-Ventricular Cardiac Output (LVCO), transit times between the heart and lungs (Cardio-Pulmonary Transit Times, CPTT), and Left-Ventricular Ejection Fraction (LVEF). All dogs tested were examined for cardiovascular fitness by clinical procedures used in our veterinary college hospital and determined normal. The clinical tests included ventral-dorsal and left lateral radiographs of the chest, multi-lead EKG, and ascultation/palpation (Table 1). Test animals that were found to have evidence of pre-existing cardiovascular disease were removed from the

study. The dogs were anesthetized with Pentobarbital Sodium (.5 cc/kg, 4% solution) one hr before the cardiac imaging was begun to eliminate any induction effects (4). The test animals were then positioned over the scintillation camera, the position used depending on the type of study done. At the end of all studies, all non-client dogs were necropsied and post-mortem finding were correlated with the nuclear angiocardiographic findings.

The nuclear angiocardiographs were made using a General Electric Radicamers II with 13 inch diameter by 1/2 inch thick crystal and a 19 photomultiplier tube detection system (5,6). Two separate study protocols were followed, both dynamic and digital in nature: (a), a first pass radionuclide heart study acquired at a rate of .5 sec/frame for a total of 60 frames; and (b), an equilibrium blood pool study with frame rate and length of study under the control of the computer. The digital data were acquired by interfacing the scintillation camera with a General Electric MED IV series dedicated medical computer. All data were acquired in a frame mode (frame by frame) basis on a 64 x 64 square matrix into a 4,096 channel analyzer. The entire nuclear system was under control of a General Data Nova III computer with a 32K core memory. Graphic output was channeled through the computer oscilloscope and controlled by specific computer programs*. Communication with the computer was through a Texas Instruments (Silent 700) data terminal.

Tc-99m was the radioisotope tracer used in all experiments. The isotope was eluted from a commercially available (14 day) generator# each day for use that day. Tc-99m has a photon energy of 140 keV and a T 1/2 of 6.02 hr. This made it possible to do serial studies at 12 hr intervals with negligible background radiation problems. Tc-99m has a small beta radiation component

and an overall low body radiation dose with the quantities used. The isotope was tagged in vivo to canine erythrocytes by Stannous Pyrophosphate (PYP)≠. PYP was used as the isotope tag of choice because of its blood pool tagging characteristics (7). Dosages of Tc-99m were based on kg weight and volume limitations of the study to be done. In all dogs .75 mCi/kg was the dosage of Tc-99m used (4). In cardiac first-pass acquisitions, an activity of .75 mCi/kg was delivered in a volume no greater than .5 cc; in gated cardiac blood pool studies, .75 mCi/kg of isotope was used with no volume restrictions.

The First-Pass Radiocardiogram. The first-pass radionuclide studies were done in a modified left lateral (MLL) position. This position was developed in our laboratory for use in the canine species.≠ The dogs were initially positioned with their left lateral thoraxes against the collimator surface. Excess mobility (lateral motion) of the canine heart necessitated repositioning of the animals for the best view of their heart chambers and contiguous vessels. The dogs were repositioned to make the apex to base line of the heart parallel to the collimator surface. This was accomplished by elevating the lower spine 25 degrees in most subjects (Fig. 1). The angle was increased (up to 35 degrees) in large, barrel chested dogs such as Boxers and Bull Dogs, or decreased (down to 15 degrees) in small, flat or deep chested dogs such as German Shepherds and Greyhounds. The dorsal-ventral angle of the thorax was adjusted to present the most area of the left thorax to the crystal. In so doing, the individuals' hearts were turned on their axes (apex to base) to bring the ventricular septum perpendicular to the collimator face (Fig. 2). The hearts were lastly positioned in the center of the crystal by referring to radiographs taken previously and ascultation of the apex heart beat from the left side of the thorax. The computer was then set to acquire

a dynamic first-pass of radioactivity through the heart vessels and chambers. A byte frame mode of .5 frames/sec was used with a study time of 30 sec. The isotope was administered as a bolus through a 1 inch by 21 gauge needle into the cephalic vein approximately mid-radius and ulna. The system was immediately flushed with 2 cc of heparinized saline. Computer acquisition was begun at the time of bolus injection. At 10 min post-injection, a static cardiac image was acquired from the precordium for determination of equilibrium counts per sec (8,9) necessary for calculation of cardiac output.

The Gated Blood Pool Study. Gated blood pool studies were performed in two positions, the MLL position and the left anterior oblique/ventral approach (LAO/VENT) position developed for use in human angiocardiography (10). To position the dogs in the LAO/VENT position, the animals were first placed in sternal recumbency on the collimator face with their hearts in the center of the crystal. Secondly, the dorsal-ventral angle of the thorax was adjusted to tilt the subjects hearts to the left side to an approximate angle of 45 degrees. If the proper position was attained, the left ventricle (LV) appeared spherical to conical in shape with the right ventricle (RV) and right atrium (RA) wrapped around the LV approximately 1/2 - 2/3 the LV circumference (Fig. 3). EKG leads in standard fashion for lead II determination were connected to the subjects in preparation for the gated equilibrium study. As in all gated equilibrium studies (10,11,12,13), the patient's R-wave spike triggered the computer to acquire raw data (Fig. 4). At the R-wave spike (one half depolarization of the ventricular mass or end diastole), the computer began to acquire data for either several milliseconds, or a calculated period of time so that 25 - 28 frames of data encompassing a single heart cycle from end diastole to end systole were collected. In the next cardiac cycle, the same process was

repeated and the 25 - 28 corresponding heart images were added to the previous images from the same phase of the cardiac cycle (Fig. 3). This data acquisition cycle was maintained until 200,000 counts were accumulated.

Data Processing and Computer Analysis. RVCO's were calculated from the first-pass radiocardiogram in the MLL position and the static heart image taken for 10 sec that followed. Cardiac output was calculated by the formula (14,15):

$$\text{CARDIAC OUTPUT (l/min)} = \frac{\text{BLOOD VOLUME X EQUILIBRIUM COUNTS/SEC}}{\text{AREA UNDER THE CARDIAC OUTPUT CURVE}}$$

To determine the area under the cardiac output curve, a software program for byte mode data retrieval was used.// The first-pass radiocardiogram was observed frame by frame (Fig. 5) to determine the frames for region of interest (ROI) determination in the area of the RV. Using the accumulative frames that best showed the RV at diastole ROI's were drawn by computer light pen to outline the RV with exclusion of all other structures (Fig. 6). From the ROI' determined RV time activity curves (TAC) were generated and the areas under those curves elucidated. Blood volume was calculated as 8% of the animal's kg weight. Equilibrium counts/sec were calculated from the 10 sec static image. This was accomplished by using the computer light pen to draw ROI's in the area of the RV and the counts in that area determined for 1 sec of real time. Using these values, RVCO was calculated for each dog. At the end of the data processing, the computer printed out the RVCO TAC on a counts vs time axis along with the data necessary for recalculation of that subject's RVCO (Fig. 7). The cardiac index (l/min/m^2) was also calculated

by the computer. All RVCO calculations were repeated three times to check computer and operator error (Table 2).

LVCO's were determined in the same manner as the RVCO's, with the exception that computer light pen drawn ROI's in the first-pass radiocardiogram and 10 sec static study were made in the LV instead of the RV for area under the cardiac curve and equilibrium counts/sec calculation (Fig. 8).

Cardio-pulmonary transit times (CPTT) were computer calculated from the first-pass radiocardiogram (Table 3). Three compartments or transit routes were calculated for blood flow times. These were the transit time for blood flow from the RV to the diaphragmatic lobe of the left lung (DL), from DL - LV, and the total blood flow time from RV - LV. The above were determined by breaking down the first pass radiocardiogram into its component 60 frames and drawing ROIs with computer light pen in the RV, LV, DL. The computer using a transit time determination program drew corresponding TACs and extrapolated time from one curve to another knowing the sequence in which the curves occurred in time. This process permitted the computer to calculate the time that the radioactive bolus took to reach each individual ROI.

LVEFs were calculated from the gated equilibrium blood pool studies done in the MLL and LAO/VENT positions. The same protocol for study analyses were used in both positions. Using a software computer program** 25 - 27 frames of the gated study were packed into a movie loop showing the cine heart functioning. By observing this movie loop, the operator assessed qualitative LVEF, LV wall motion, left AV valve motion, relative RV and LV volumes, and LA filling and emptying. When qualitative heart function was assessed another computer program## was instated for the calculation of LVEF. This computer program allowed the operator to draw edges around the LV in each of the 25 -

27 frames of raw data. In so doing, the computer found the frame having the greatest enscribed area, or end diastole (ED), and the frame having the smallest enscribed area, or end systole (ES). From these frames, counts were then calculated by the computer. The computer then generated a horse shoe shaped ROI in the 25 - 27 frames of raw data from which it calculated the background counts (BGD) arising from structures behind the LV (3,10,16). The computer generated ROI for background quantitation was altered in each dog study. In the MLL position, the ROI was moved to a position between the RV and LV (Fig. 9). In the LAO/VENT position accurate results could be expected if the ROI was anterior to the LV (Fig. 10). In either position, if the background ROI fell into any portion of the LV, incorrect results could be expected. If the ROI for BGD was acceptable to the operator, the computer subtracted that amount of BGD from each frame of data. If not, the operator using the computer light pen moved the BGD ROI to an acceptable position and instructed the computer to calculate LVEF by the formula (9,10,12,17):

$$\text{LVEF} = \frac{\text{END DIASTOLIC COUNTS (ED) - END SYSTOLIC COUNTS (ES)}}{\text{ED - BACKGROUND COUNTS FROM EACH FRAME (BGD)}}$$

RESULTS

The results of this study are summarized in Table 4. Numerical data descriptive of each dog studied are presented in Table 5. The RVCO determined for all of the test subjects ranged from .644 1/min - 3.14 1/min with an average RVCO of 1.30 1/min. LVCO for all of 10 test subjects ranged from .702 1/min - 3.81 1/min with an average LVCO of 1.78 1/min. CPTTs (RV - LV) ranged from 4.74 sec to 7.53 sec with an average CPTT of 5.88. The LVEF

calculated from the gated equilibrium studies in the MLL position ranged from 65% - 85% with an average LVEF of 76%. Ejection fractions calculated from the standard LAO/VENT position revealed a slightly wider, 60% - 84% range and an average value of 74% LVEF.

DISCUSSION

The radionuclide techniques described were not tested against standard angiocardiographic methods because RVCO, LVCO, CPTT and LVEF determinations have been previously validated in human and in some animal studies (18,19). In human medicine, radionuclide determinations of cardiac performance are now considered the standard by which future cardiac performance tests will be judged; however, systematic checks were done to monitor operator and computer error.

Systematic checks were different for each study type. RVCO was compared to LVCO in each case. In all normal dogs, the RVCO should be equal to the LVCO. None of the dogs tested had a difference greater than 10% between the calculated values for LVCO and RVCO ($\bar{x}$ = 1.72 l/min sd = .06). CPTT calculations were checked by comparing the sum of the transit times from RV - DL ($\bar{x}$ = 3.07 sec ad = .4) and DL - LV ($\bar{x}$ = 2.84 sec ad = .4) with the total CPTT ($\bar{x}$ = 5.88 sec ad = .95). In two cases there was no difference between the sums of the two compartments and the total CPTT. LVEF was calculated from the LAO /VENT position to check the calculated value for LVEF in the MLL position preceding on the assumption that the values would be equal. This assumption was found to be inaccurate (Table 6). Structures containing radioactive blood behind the LV in the LAO/VENT position made it impossible to detect most of the ventricular

wall motion. Therefore, LVEF in the LAO/VENT position was falsely reduced.

At the end of the study, 8 of the research dogs were necropsied. Two dogs belonging to clients were not. Post-mortem examination indicated that the dogs were in normal limits of cardiovascular fitness except for one dog with 8 heartworms in the RV. At this stage of expertice, we were unable to diagnose this case. Necropsy results are listed in Table 7.

As part of this study, a position was developed which showed the LV, RV, LA, RA, left A-V valve, diaphragmatic lung tissue and aorta with maximum delineation not possible in the LAO/VENT position. Using this position, cardiovascular data were standardized in each test subject by eliminating the need for different positions.

Tc-99m-PYP was the isotope-tag combination used in this study because of its narrow peak, sufficient energy characteristics, and its 6.02 hr T1/2 which allowed 12 hr interval serial studies. Another isotope acceptable for use was In-113; however, due to licensing restrictions, we did not use it. PYP was the isotope tag used because it directly binds in vivo canine (H. S. A.), another vascular scanning agent, used in cardiac studies, was not used because it does not tag erythrocytes. Instead, it stays in the vasculature due to its large molecular size. Antigenic responses are possible with HSA.

Preprogrammed software were used to acquire and analyze all studies. The programs allowed consistent data processing by virtue of a step by step procedure, but also permitted operator modification for more accurate analyses. They also allowed faster analyses of data than could be attained on a non-programmable (hard-wired) computer.

RVCO, LVCO, right-ventricular cardiac index (RVCI), and left-ventricular cardiac index (LVCI) were calculated for each subject. Cardiac indices were

considered more representative of cardiac performance than cardiac outputs because wieght and body size vary among dogs. Cardiac indices equate the animal's weight and body size to its blood volume, and therefore, are a more reliable index of cardiac function.

CPTTs were separated into two compartments for calculation; arterial flow into the lungs (RV - DL), and the venous flow into the LV (DL - LV). In pathology involving the lungs, these transit times would become important. An increase in total CPTT would indicate pathology, and an increase in the RV - DL or the DL - LV would localize the lesion to the arterial or venous side of the lung.

In human medicine, LVEF is considered the best measurement of an individual's cardiac performance. LVEF was calculated from ventricular wall motion. The MLL and LAO/VENT positions show different aspects of ventricular wall motion. A view of the heart in the LAO/VENT position would conceal dyskinesis in the heart apex. A MLL heart view could conceal dyskinesis in the lateral ventricular wall. Therefore, both views are necessary for a proper determination of LVEF.

At present, radionuclide angiocardiography is not a routine clinical study used in veterinary medicine. Without the described study completed, correct positioning and normal values for RVCO, LVCO, CPTT and LVEF were not known. Using these procedures and values, routine cardiovascular testing can begin. Applications of this study include: (1) rapid assessment of cardiac performance in the critically ill, (2) management of systemic vascular disease, and (3) identification of the cardiovascular diseased patient.

SUMMARY

Sequential quantitative first-pass radiocardiograms and gated equilibrium blood pool studies were done to determine right-ventricular cardiac output (RVCO), left-ventricular cardiac output (LVCO), cardiopulmonary transit times (CPTT), and left-ventricular ejection fraction (LVEF) in 10 normal dogs. The purpose of this study was to determine normal values for the above parameters in the canine for use as part of a veterinary clinical examination of cardiovascular fitness in the dog. Direct comparison of these techniques had already been worked out and validated in man. Clinical applications in man have already demonstrated the ability of the radionuclide angiocardiograph to provide large amounts of quantitative and qualitative information unattainable from other studies. It is likely that the normal values determined in this study will form a base for further experimentation involving cardiovascular pathological systems in the canine species.

TABLE 1. STANDARD CLINICAL DETERMINATIONS OF CARDIOVASCULAR FITNESS IN TEN RESEARCH DOGS

Dog #	Asculation/Palpation	Radiographs *	EKG ≠
1	no murmurs	slight left atrial enlargement slight left ventricle enlargement	normal
2	no murmurs	slight right heart hypertrophy	normal
3	no murmurs	right heart enlargement slight pulmonary artery enlargement possible heart worms	normal
4	no murmurs	slight left atrial enlargement secondary pulmonary changes	normal
5	no murmurs	right atrial enlargement secondary lung changes	normal
6	no murmurs	slight right heart enlargement slight pulmonary artery enlargement slight left atrial enlargement	normal
7	no murmurs	slight left atrial enlargement	normal
8	no murmurs	right heart dialatation secondary lung changes possible heart worms	normal
9	no murmurs	some mitral insufficiency left atrial enlargement and left ventricle hypertrophy	normal
10	no murmurs	completely normal	normal

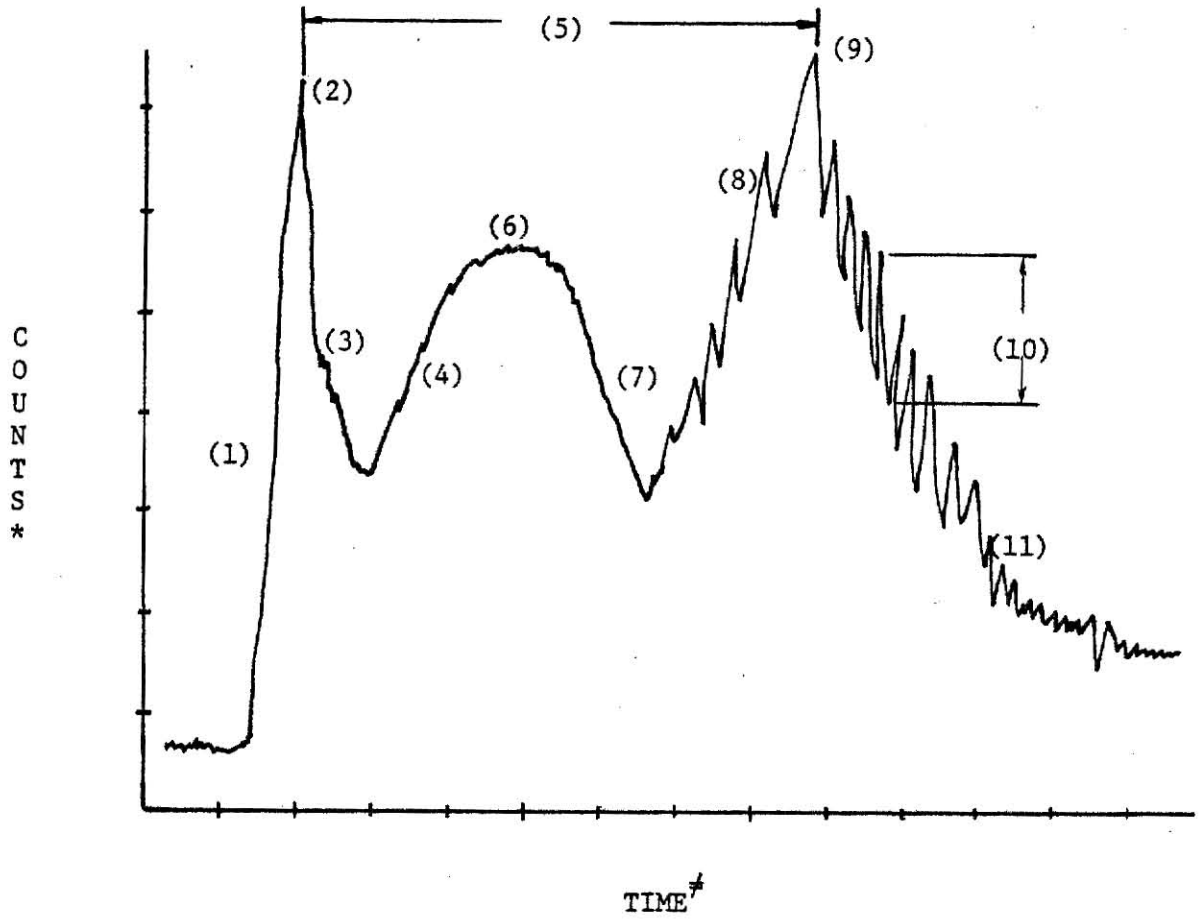
* Ventral-dorsal and lateral radiographs
≠ Lead II EKG determinations

TABLE 2. MULTIPLE DATA PROCESSING OF RVCO AND LVCO FOR DETERMINATION OF SYSTEMATIC ERROR

	RVCO (1/min)*				LVCO (1/min)≠		
Dog #	Trial #1	Trial #2	Trial #3	Dog #	Trial #1	Trial #2	Trial #3
1	1.98	1.27	1.29	1	1.42	1.35	1.01
2	1.51	1.21	1.22	2	1.25	1.20	1.18
3	1.20	1.20	1.21	3	1.20	1.31	1.25
4	2.34	1.99	2.18	4	2.38	2.39	2.45
5	3.20+	3.18+	3.14+	5	2.98+	3.81+	4.30+
6	.664Ɪ	.620Ɪ	.895Ɪ	6	.715	.700	.715
7	.669	.580	.980	7	.702Ɪ	.689Ɪ	.750Ɪ
8	2.59	2.58	2.59	8	2.39	2.30	2.43
9	1.51	1.23	1.21	9	1.49	1.51	1.42
10	2.50	2.81	2.38	10	2.52	2.52	2.54

* Normal averages: Trial #1, 1.81 1/min, Trial #2, 1.67 1/min, Trial #3, 1.71 1/min.
≠ Normal averages: Trial #1, 1.70 1/min, Trial #2, 1.78 1/min, Trial #3, 1.80 1/min.
\+ High values.
Ɪ Low values

TABLE 3. THE FIRST-PASS OF BLOOD FLOW THROUGH THE RV, LUNG, AND LV.



1) appearance of isotope in RV
2) maximum activity in RV
3) downslope of RV washout
4) appearance of isotope in lung
5) cardio-pulmonary transit time
6) maximum activity in DL
7) downslope of lung washout
8) appearance of isotope in LV
9) maximum activity in LV
10) LVEF
11) downslope of LV washout

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* Gamma count events/sec.
≠ Time in secs.

TABLE 4. RADIONUCLIDE VALUES FOR RVCO, LVCO, RVCI, LVCI, CPTT AND LVEF IN TEN NORMAL DOGS.

Dog #	* RVCO (l/min)	≠ LVCO (l/min)	+ RVCI (l/min/m^2)	ǂ LVCI (l/min/m^2)	CPTT (secs) ** RV - LV	CPTT (secs) RV - DL	CPTT (secs) DL - LV	LVEF (%) ≠≠ MLL	LVEF (%) ++ LAO/VENT
1	1.27	1.35	1.48	1.53	4.74	2.42	2.18	78	83
2	1.22	1.20	1.56	1.53	5.91	2.83	3.10	80	63
3	1.20	1.25	1.79	1.86	5.52	2.79	2.77	89	69
4	2.18	2.38	1.98	2.14	7.53	3.34	4.12	65	70
5	3.14	3.81	3.54	4.29	6.39	3.18	3.21	85	72
6	.664	.715	1.13	1.22	4.92	2.92	1.99	76	77
7	.669	.702	1.48	1.51	4.74	2.63	2.11	78	80
8	2.59	2.39	2.75	2.55	7.19	3.50	3.79	70	60
9	1.23	1.49	1.51	1.82	5.32	3.32	2.13	76	84
10	2.50	2.52	2.38	2.52	6.62	3.82	3.02	65	82

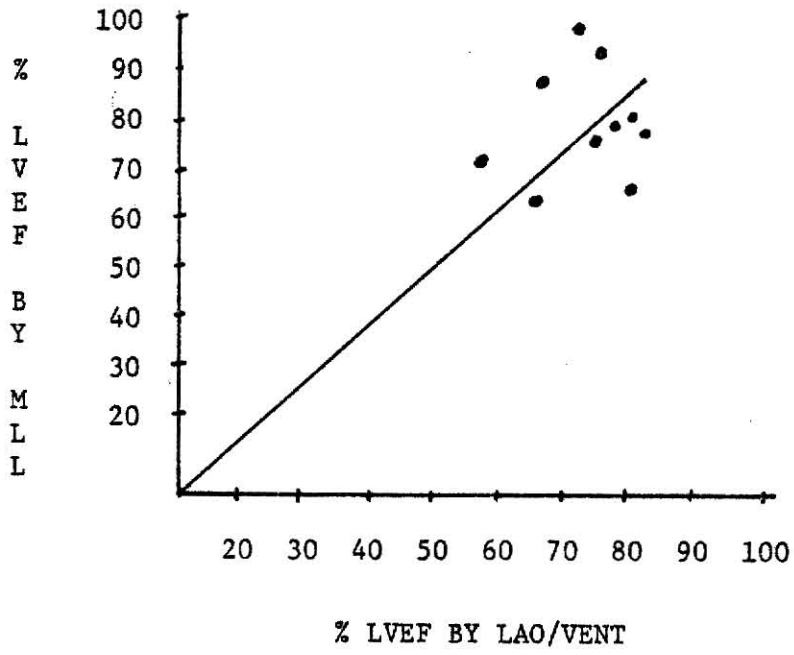
* Total Population: n=10 $\bar{x} \pm$ sd = 1.66 $\pm$ 1.82.
≠ Total Population: n=10 $\bar{x} \pm$ sd = 1.78 $\pm$ 1.92.
\+ Total Population: n=10 $\bar{x} \pm$ sd = 1.96 $\pm$ 1.69.
ǂ Total Population: n=10 $\bar{x} \pm$ sd = 2.09 $\pm$ 1.84.
**Total Population: n=10 $\bar{x} \pm$ sd = 5.88 $\pm$ .95.
≠≠Total Population: n=10 $\bar{x} \pm$ sd = 76 $\pm$ .7
++Total Population: n=10 $\bar{x} \pm$ sd = 74 $\pm$ .8

TABLE 5. DESCRIPTIVE DATA ABOUT EACH RESEARCH DOG

Dog #	Age (yrs)	Weight (kg)	Sex	Body Surface	Breed
1	4+	30	M-1*	.884	Sheperd-husky mix
2	2	14	M-1	.700	hound mix
3	3+	19.5	Fe-1≠	.671	Black Labrador
4	2+	24	Fe-1	.813	Collie-Greyhound mix
5	2+	29	Fe-1	.888	Sheperd-hound mix
6	2+	14	Fe-1	.584	Beagle
7	3+	12	Fe-1	.463	English ointer
8	3+	32	M-1	.939	Doberman
9	3+	27	M-1	.819	Walker Hound
10	3	28	M-c‡	.882	Sheperd mix

* M-1 = intact male.
≠ Fe-1 = intact female.
‡ M-c = cryptorchid male.

TABLE 6. LEFT VENTRICULAR EJECTION FRACTION (LVEF)*



* Shows poor correlation of LVEF determined from MLL position when compared to LVEF determined from the LAO/VENT position.

TABLE 7. NECROPSY FINDINGS

Dog # ≠	Nuclear Diagnosis	Pathology	Post-Mortem Diagnosis
1			
2	nuclear signs of H.W. suspect * some RA enlargement and RV enlargement	slight RV dialation no heartworms	none
3	some RA enlargement RV enlargement*	no lesions visible	none
4	normal heart study	no lesions visible	none
5	normal heart study	no lesions slightly dialated RV	none
6	nuclear signs of slight RA enlargement pulmonary artery slightly enlarged*	no lesions visible	none
7	normal heart study	slightly dialated RV endocardiosis	none
8≠			
9	some nuclear signs of heartworm disease*	moderate dialation of RV 8 heartworms in RV	heartworm disease
10	normal heart study	no visible lesions	none

* Animal within normal limits.
≠ Not necropsied.

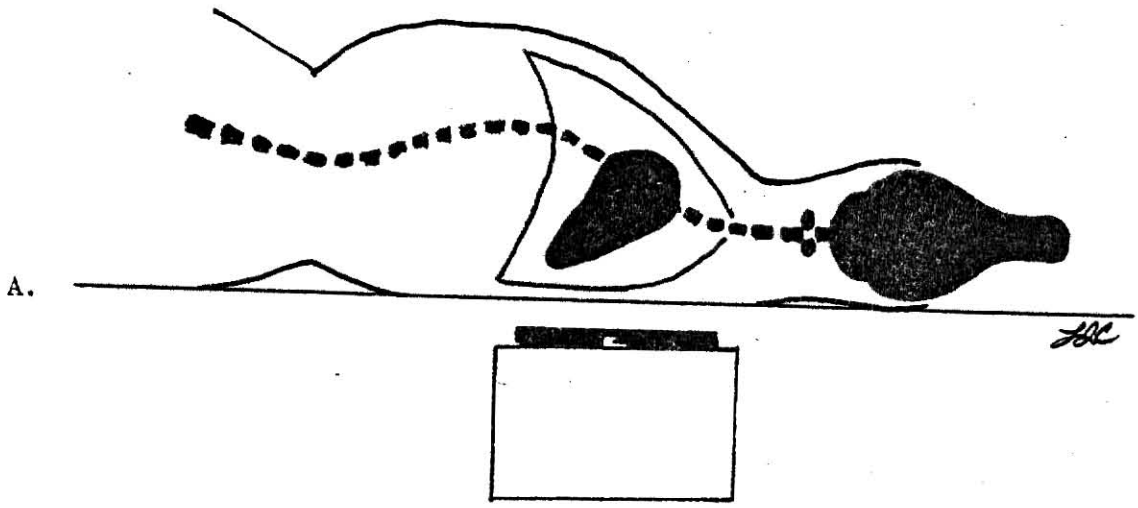
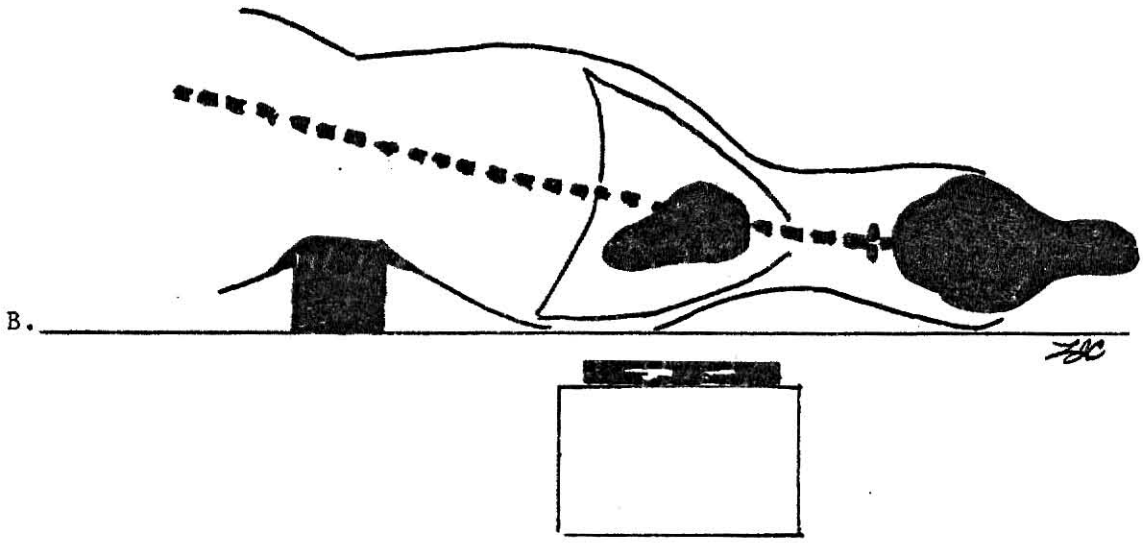


Fig. 1. Elevation of lumbar spine to correct apex to base drop of heart for cardiovascular scanning in MLL position. A)Before elevation, B)After elevation.



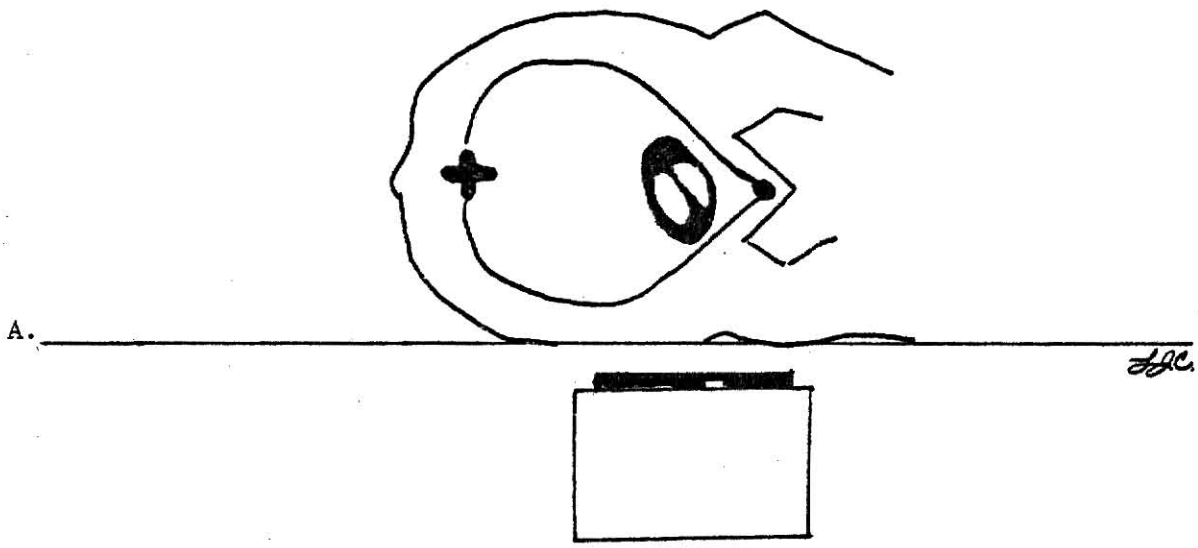
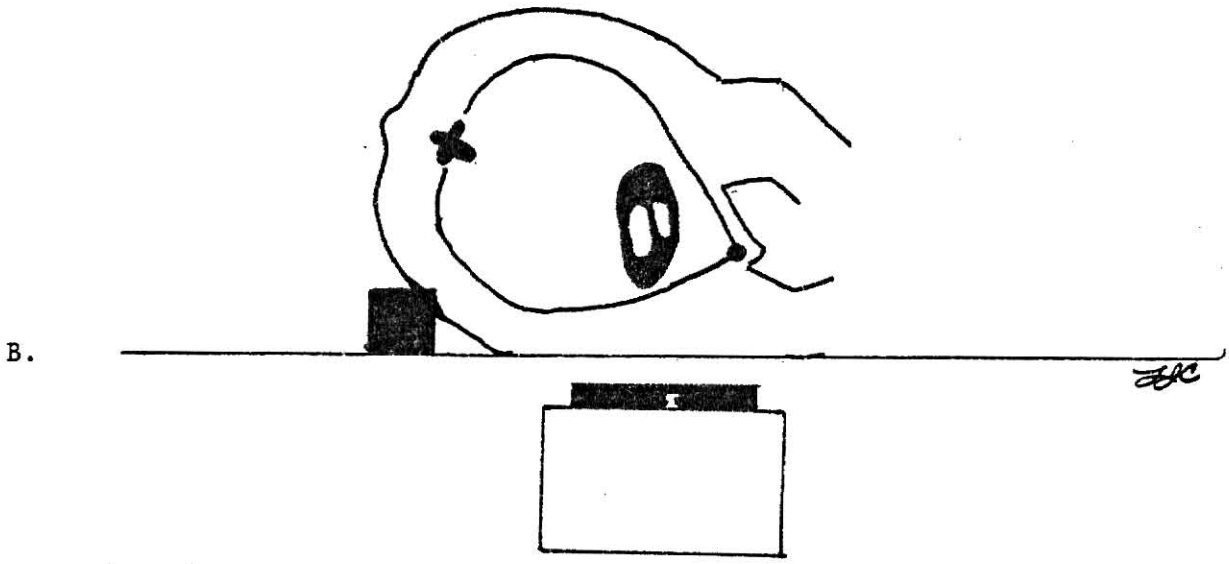


Fig. 2. Dorsal - ventral angle change necessary to present ventricular septum perpendicular to collimator face. A)Before angle change B)After angle change.



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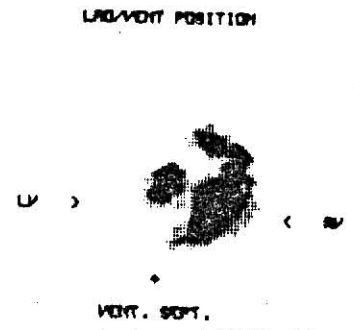

Fig. 3. Gated equilibrium blood pool image - LAO/VENT position.

MULTIGATING THEORY*

ECG Waveform:

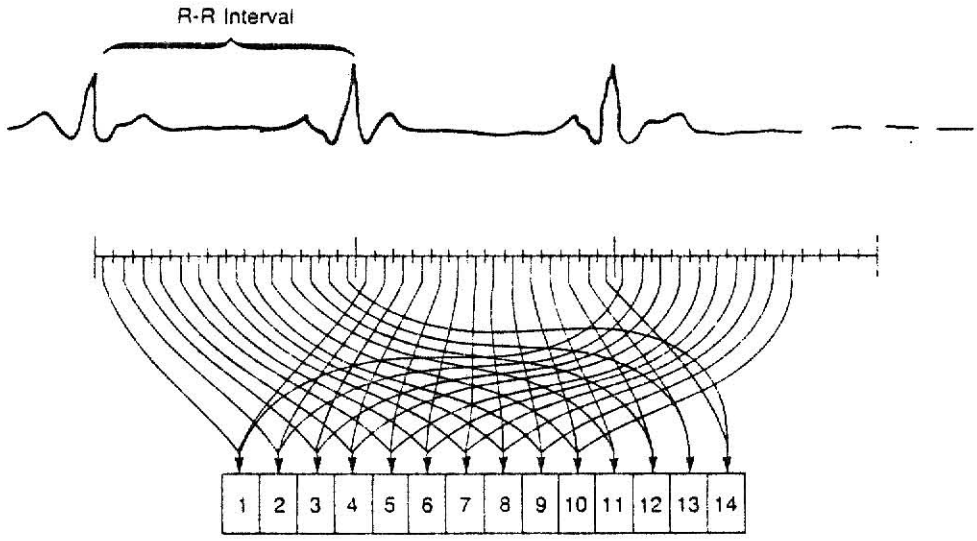

Fig. 4. Multigating computer theory for determination of left-ventricular ejection fraction.

*Courtesy of General Electric Medical Systems

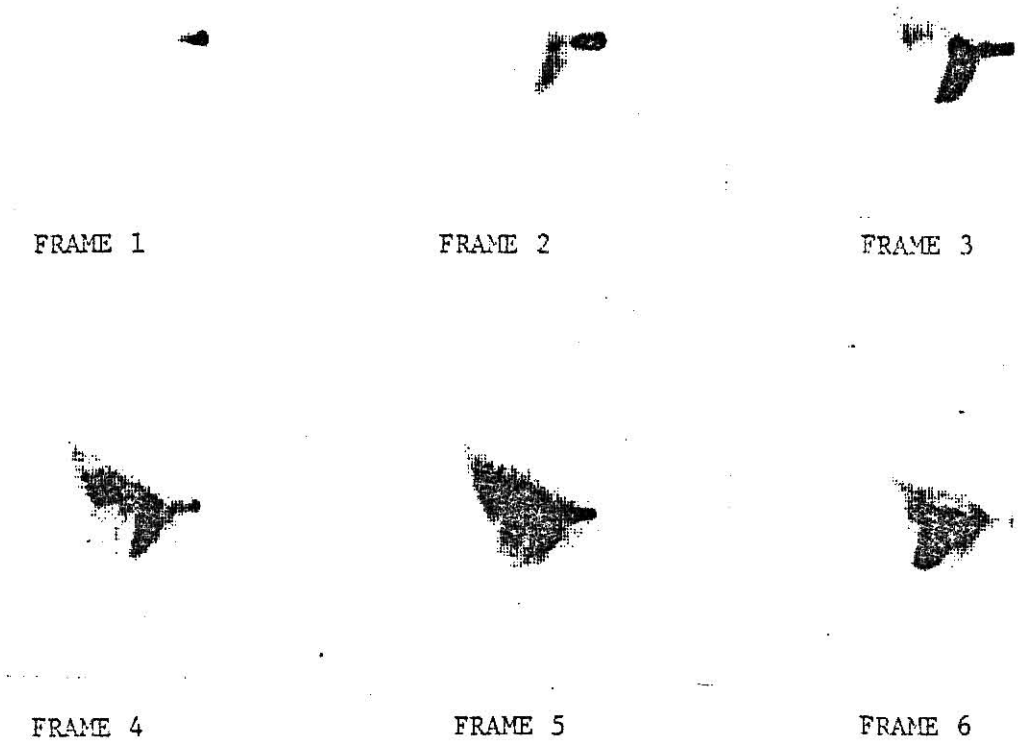

Fig. 5. Sequential images of canine heart after bolus infection of Tc-99m-PYP. Frames 1-3 show passage through superior vena cava, heart (right), and pulmonary artery. Frames 3-6 show lung field, heart (left) and aorta.

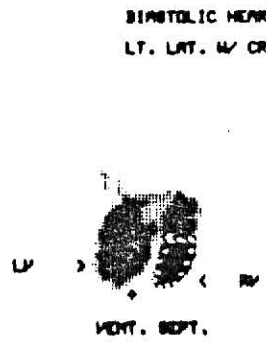

Fig. 6. Region of interest placement in right ventricular for determination of right-ventricular cardiac output.

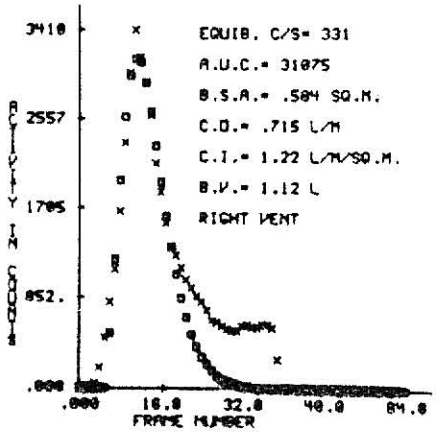

Fig. 7. Right-ventricular cardiac output and Time-Activity Curve.

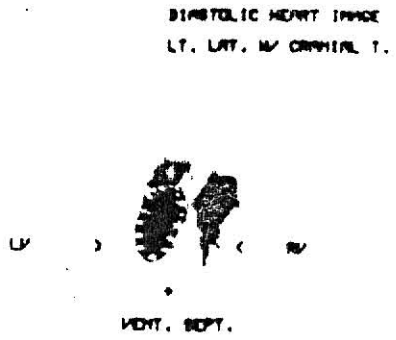

Fig. 8. Region of interest placement in left ventricular for determination of left-ventricular cardiac output.

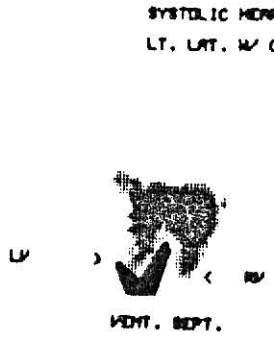

Fig. 9. Background determination for cardiac output calculation in MLL position.

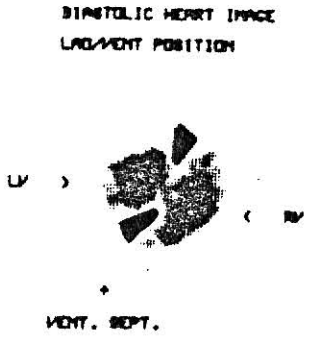

Fig. 10. Background determination for cardiac output calculation in LAO/VENT position.

FOOTNOTES

Squibb and Sons Pharmaceutical Co., Inc., Princeton, NJ

* MDS, MED IV, AD series software package (updated 4/29/80)

≠ Mallinckrodt, Inc., St. Louis, MO

‡ Kansas State University, College of Veterinary Medicine

// DYNB, Direction 14378A (MED Series Computer System)

⌶ MTRN, Direction 14378A (MED Series Computer System)

** SUP8, Direction 14378A (MED Series Computer System)

≠≠ MUGE, Direction 14378A (MED Series Computer System)

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DETERMINATION OF NORMAL VALUES FOR RIGHT AND LEFT-VENTRICULAR CARDIAC OUTPUT, CARDIOPULMONARY TRANSIT TIMES, AND LEFT-VENTRICULAR EJECTION FRACTION BY NUCLEAR ANGIOCARDIOGRAPHY IN THE DOG.

by

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B.S., Texas A&M University, 1977

AN ABSTRACT OF A MASTER'S THESIS

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MASTER OF SCIENCE

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KANSAS STATE UNIVERSITY

Manhattan, Kansas

1980

ABSTRACT

First-pass radionuclide angiocardiograms and gated equilibrium heart blood pool studies were performed on ten anesthetized normal dogs using Tc-99m as the radio-tracer. Tc-99m was tagged in vivo to erythrocytes by Stannous Pyrophosphate (PYP). Each dog was assessed as normal by standard clinical cardiovascular tests used in the Kansas State University Veterinary Medical Center. Data from the nuclear studies were obtained using a General Electric Radicamera II scintillation camera and analyzed with a General Electric MED IV series dedicated computer. Right-ventricular cardiac output (RVCO), left-ventricular cardiac output (LVCO), and cardio-pulmonary transit times (CPTT) were obtained from the first-pass studies with subjects placed in a modified left lateral (MLL) position developed for cardiovascular scanning in the dog. Data from these studies were recorded at a rate of .5 frames/sec for total time of 30 sec. Left-ventricular ejection fractions (LVEF) were calculated from the gated equilibrium studies using both MLL and the lateral anterior oblique/ventral approach (LAO/VENT) positions. From the first-pass and gated equilibrium studies normal values for RVCO, LVCO, CPTT for three compartments, and LVEF were determined. RVCO averaged 1.30 l/min (range .664-3.14 l/min). LVCO averaged 1.78 l/min (range .702-3.81 l/min). The average CPTT from RV to DL was 2.74 sec (range .702-3.82 secs); from DL to LV 2.84 secs (range 1.99-4.12 secs); and from RV - LV 5.88 secs (range 4.74-7.53 secs). LVEF in the MLL and LAO/VENT positions averaged 76% (range 65-85%) and 74% (range 60-84%) respectively.