AN EVALUATION OF SELECTED METHODS FOR OBTAINING ANGIOCARDIOGRAMS, ELECTROCARDIOGRAMS AND BLOOD PRESSURE READINGS IN THE CANINE SPECIES

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B. S., Kansas State University, 1958
D. V. M., Kansas State University, 1960

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Surgery and Medicine

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

Approved by:

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INTRODUCTION

Cardiovascular disease has long been recognized in dogs, however, little information was recorded concerning such diseases until 1952. Epidemiological surveys conducted in Philadelphia and in New York City to determine the incidence and types of cardiovascular disease in the canine population indicate that one dog in ten is affected by some type of cardiovascular disease. This incidence reflects the significance of canine cardiovascular disease in veterinary medicine today.

The heart accounts for approximately 0.8% of the normal animal body weight in the canine species (Miller, 1964). While its location within the thorax makes it a difficult organ to examine, the heart does generate physical forces which can be recorded. These forces are sound, electrical activity and work. Disease may interfere with any one or a combination of two or more of these forces. The management of heart disease depends upon the ability to recognize and differentiate the cause of the specific disorder.

Signs of heart disease are generally demonstrated by auscultation, radiography, angiocardiography, electrocardiography, pulse and blood pressure determinations. Detweiler (1952) listed the clinical signs of heart disease as:

1. A Grade 4 or 5 systolic murmur;
2. A Grade 3 systolic murmur in the absence of anemia;
3. A diastolic murmur;
4. A palpable precordial thrill;
5. Generalized venous engorgement;
6. Atrial fibrillation or flutter;
7. Paroxysmal ventricular tachycardia;

8. Atrial or ventricular extra systoles consistently present and of frequent occurrence;
9. Complete atrioventricular blocks;
10. Left bundle branch block;
11. Electrocardiographic right ventricular enlargement pattern;
12. Radiographic evidence of heart disease.

The purpose of this study is to compare some of the reported methods of angiocardiography, electrocardiography, and blood pressure determinations, and to evaluate the methods for possible inclusion in standard patient diagnostic procedures to be utilized in the undergraduate training program.

REVIEW OF LITERATURE

Literature concerning heart disease in dogs prior to 1950 is concerned primarily with post mortem lesion (Detweiler, 1952). Detweiler (1952) reported on clinical findings of heart disease in the canine patients presented to the University of Pennsylvania Small Animal Clinic. Prior to this study, little was known about the nature, history, or incidence of heart disease which was generally thought to be rare and relatively unimportant in the canine species.

In 1952 Detweiler reported a study in which the subjects of the investigation were categorized in one of four classes, i.e. 1. no heart disease, 2. heart disease, 3. possible heart disease, and 4. potential heart disease. The same classification had been utilized for cardiovascular studies in man (Burch and Reaser, 1947). Procedures used for screening the patients for heart disease were auscultation, palpation of the precordium, palpation of the femoral arteries, and single lead electrocardiograms.

Detweiler and Patterson (1965) reported 11.3% of all dogs screened were afflicted with some form of heart disease. The major diseases noted were chronic valvular fibrosis, chronic myocardial disease, and congenital heart disease with chronic valvular fibrosis being the most frequently diagnosed disease and accounted for 8.3% of the dogs screened. Myocardial disease comprised most of the rest (1.4%) and included degenerative, inflammatory, necrotic and fibrotic lesions. Congenital lesions have been noted in 0.5% of the dogs screened for heart disease (Patterson, 1965).

The most common cardiovascular anomalies noted in Pattersons study were patent ductus arteriosis, pulmonic stenosis, aortic stenosis, persistent right aortic arch and ventricular septal defects. Purebred dogs had the highest incidence with chilhuahuas, poodles, German shepherds, and boxers constituting the breeds most frequently found with congenital heart lesions. Patent ductus arteriosis occurred most frequently in the French poodle, pulmonic stenosis in boxer and German shepherd breeds, and persistent right aortic arch in German shepherds and sporting dogs (Patterson, 1965).

A breed predilection was noted with an incidence of congestive heart failure in male cocker spaniels occurring approximately four and one-half times that noted in female cocker spaniels and seven times that in females of all breeds (Detweiler and Patterson, 1965).

The diagnosis of heart disease can be accomplished by auscultation of the heart, radiographs of the thorax, or a combination of both. An occasional diagnoses can be made only with the use of an electrocardiogram (Hamlin, 1967).

Radiographic techniques for the diagnosis of heart disease in the canine species have been reported by Hamlin (1960) and Rhodes (1963). Rhodes suggested that 2 lines be placed on a lateral radiograph of the canine thorax. When the line was drawn from the base of the heart to the apex, the right heart was cranial and ventral to the line whereas the left heart was caudal and dorsal. The atria were demarcated from the ventricles by drawing a second line through the heart perpendicular to the longitudinal line 2/5 of the distance from the base to the apex.

Dorsal-ventral radiographs normally demonstrate an elliptical shaped heart. The cranial and right borders are formed by the right atria and ventricle and the image of the cranial portion of the left border of the heart is formed by the pulmonary artery (Hamlin, 1960). A dense area, running from the base through the apex of the heart, was noted and was attributed to the aorta. These structures can be outlined and demonstrated more successfully by angiocardiography (Hamlin, 1960, Tashjion and Albanese, 1960, and Rhodes, 1963) and gross changes occurring in the heart due to different etiological factors may require angiocardiograms in arriving at the diagnosis (Maksic and Small, 1965).

Angiocardiography is the radiographic study of the cardiac chamber and great vessels after a radiopaque contrast substance has been injected intravenously, intracardially, or intracardially via a venous catheter (Paul and Juhl, 1959).

Castellanos, Pereiras, and Garcia (1937 from Schobinger and Ruzicka, 1964) were the first to describe the angiocardiography in the diagnosis of congenital heart disease in children. Robb and Steinberg (1938, from Schobinger and Ruzicka, 1964) later extended its use to adults. Intracardial injection of a contrast substance via a trocar was first described by Beato and Ponsdomenech (1960 from Castellanos and Augustin, 1959) who applied the term cardioangiography to this method.

Early contrast agents used were strontium bromide, sodium iodide, lithium bromide, potassium iodide and later the iodinated products sodium diatrizoate, methylglucamine diatrizoate and mixtures of both. Effective concentrations of sodium and methyglucamine diatrizoate ranged from 50-90% (Schobinger and Ruzicka, 1964).

Sodium diatrizoate is a highly radiopaque water soluble compound containing 59.87% iodine. The toxicity of the compound is unusually low although in man mild side effects such as nausea, vomiting, salivation, flushing, dizziness, and urticaria were noted in 10-14% of the recipients. Mortality in man varies from 0.3%-1% (Meschan, 1956) and usually occurred in poor risk patients exhibiting severe signs of heart disease (Schobinger and Ruzicka, 1964). Sodium diatrizoate is excreted immediately and unchanged in urine and is contraindicated only in patients with severe renal disease.

Hamlin (1959) reports the best angiocardiographic results with 90% diatrizoic acid given at the rate of 3 milliliters for dogs under 10 pounds and 1 milliliter per 3 pounds body weight for dogs 10-40 pounds and injected either intravenously via the jugular vein or intracardially. Detweiler (1961) recommends the use of 90% sodium and meglumine diatrizoate at the rate of 0.5 milliliter per 16 pounds body weight. The material was injected under high pressure. Radiographs were taken 1 second, 3 seconds, and 5 seconds after the injection of contrast agent.

Meschan (1956) lists indications for angiocardiography as nearly all congenital and acquired cardiac and vascular lesions and in the study of chronic pulmonary disease with its greatest value in the diagnosis and differentiation of congenital heart defects.

A third diagnostic aid in cardiovascular medicine is the electrocardiogram. Its importance has been well demonstrated in human medicine where one of its uses is to identify and locate areas of myocardial infarction. Myocardial lesions, so important in man, seldom occur in the dog (Luginbuhl and Detweiler, 1965). Hamlin (1967) stated that the use of an electrocardiogram is essential in only 1% of cardiovascular diagnosis. Electrocardiograms have been studied extensively in dogs, however, and much data exists relative to their findings (Lannek, 1949, Detweiler, 1959, Hamlin, 1960, Clark, C. H., 1963, Clark, D. R. et. al., 1966, and Crawley and Swenson, 1966).

Electrocardiograms are graphic recordings of the electrical activity of the heart in which the potential difference between two or more electrodes is measured. Electrodes for standard leads are attached to the extremities of the patient and are classified according to the electrodes utilized in the recording. Leads normally used in the dog are the same as those employed in electrocardiography of man.

Methods of recording utilize two classifications for lead arrangement, unipolar and bipolar. In unipolar leads the electrical potential at one point in the animal's body is compared to a zero or near zero potential. Augmented unipolar limb leads are unipolar leads in which a large resistor in the circuit tends to cause the electrical potential in leads from two extremities to be near zero and the potential difference from this is measured against a third lead.

Bipolar leads utilize a positive electrode and a negative electrode and the potential difference between them represents the recorded electrocardiogram. There are three standard bipolar leads - Lead I, Lead II, and Lead III. Lead I utilizes the right foreleg as the negative pole and left foreleg as the positive pole. Lead II utilizes the right foreleg as the negative pole and the left rear leg as the positive pole and Lead III utilizes the left foreleg as the negative pole and the left rear leg as the positive pole. Electrocardiograms in a specific bipolar lead are recorded by measuring the potential difference between the negative and positive poles, therefore, a Standard Lead II electrocardiogram is an electrical recording of the potential difference between the right foreleg and the left rear leg in the dog.

The augmented unipolar limb leads are aVR, aVL, and aVF. Lead aVR utilizes the right foreleg as the origin of the positive electrode, aVL the left foreleg, and aVF the left rear leg.

A limb lead is generally connected to the right rear leg and acts only as a ground.

Three general types of information are available from a study of an electrocardiogram. They include the:

1. Rate and rhythm of the heart;
2. Duration, form, amplitude and spacing of the bioelectrical forces or wave fronts (P.Q.R.S.T.) of the cardiac cycles;
3. Duration and magnitude of the bioelectrical forces (Clark, Syabuniewiez, and McCrady, 1966).

The rate and rhythm of the heart and the duration, form, amplitude, and spacing of the bioelectrical forces can be studied with a single lead electrocardiogram.

Electrocardiograms can be recorded from unrestrained animals through a wireless transmission linkage referred to as telemetry (Ko, 1967). Early attempts at radio-telemetering physiological information in 1947 utilized an 80 pound transmitting unit and battery pack (Slater, 1963). Extensive development did not occur until 1948 and the discovery of transistors. Fuller (1948) used telemetry to record pneumographs and pulse rates from unrestrained animals. Development of transmitting devices have progressed to the point where transmitters weigh less than one gram.

Still another important diagnostic aid in human medicine is the determination of blood pressure. Hypertension is an important problem in man although rare in the dog (McCubbin and Corcoran, 1953). Hypertension does occur spontaneously in the dog, however (Detweiler, 1959).

Hypotension, on the otherhand, can be a problem in the dog particularly the surgical patient or the patient in shock. In such cases blood pressure determinations may be quite useful (Detweiler, 1959).

Blood pressure determinations can be accomplished by two basic methods, direct or indirect. The pressure in the direct method is recorded from the lumen of the artery itself. This requires placing a needle or catheter into the artery.

The indirect method parallels that used most extensively in human medicine. A peripheral artery is occluded by a pressure cuff wrapped around an extremity and the return of flow through the artery is checked by auscultation or palpation as pressure is released from the cuff. This method is only an approximation of the blood pressure but in most instances is accurate enough to be quite adequate (Wilhelmj, 1963).

Wakerlin (1943) described a method of direct blood pressure determination by inserting a 20-22 gauge needle directly into the femoral artery and recording the pressure with the use of a mercury or aneroid manometer.

Allen (1941) described indirect blood pressure determination. A pressure cuff is applied to the region of the thigh and a small stethoscope is placed over the femoral artery just above the hock. The pressure within the cuff is then increased to exceed that of the systemic arterial pressure. As the pressure is gradually released, a faint tapping sound can be heard. This represents the systolic pressure. When the pressure within the cuff is further reduced, the tone becomes louder and then diminishes rapidly or completely disappears. This represents the diastolic pressure.

Wilson and Clark (1964) described an indirect method for blood pressure determination using a special sphygmomanometer with a Xylol pulse indicator which eliminates the necessity of auscultation or palpation.

The indirect method described by Shingatgeri, Nambia, and Govindan (1963) is similar to that described by Allen (1941) except the forelimb is used instead of the rear limb.

Physic factors greatly influence the blood pressure in dogs. It requires only very slight changes in the environment or routine procedure to alter the pressure markedly (Wilhelmj, 1963).

Zapp (1949) studied blood pressures in dogs over a 12 month period and found no seasonal variations. He trained the dogs used in his study to set procedures and during the period of training did note a drop in the basal blood pressure.

MATERIALS AND METHODS

Thirty dogs used in the study included 14 males and 13 females. The sex was not recorded in 3 dogs. The ages ranged from 3 months to 15 years and the weight from 12 to 83 pounds. Twenty-seven were of mongrel breed, one a cocker spaniel, one a beagle, and one a dalmation with congenital deafness.

The cocker spaniel was 15 years old with a systolic heart murmur and the beagle, twelve years old, with a cardiac arrhythmia. The remaining dogs appeared healthy on clinical examination.

The radiographic unit consisted of a General Electric mobile 200 diagnostic X-Ray machine[1] with a maximum 200 milliampere and 100 K.V.P. output.

Eight by 10 inch cassettes utilizing Royal Blue Medical X-Ray Film[2], were used throughout the investigation. The cassettes[3] were equipped with high speed screens[4] and an 8:1 stationary grid[5] was used to eliminate scatter radiation.

Lead lined aprons and gloves were worn by all those participating in the taking of the radiographs.

Sodium diatrizoate, U.S.P.[6] and sodium and meglumine diatrizoate 90%[7]

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[1]Model No. 11CK4-1, General Electric Company, Milwaukee, Wisconsin.

[2]Eastman Kodak Company, Milwaukee, Wisconsin.

[3]Moulded Cassettes, General Electric Company, Milwaukee, Wisconsin.

[4]Dupont Stainless Intensifying Screens, General Electric Company, Milwaukee, Wisconsin.

[5]Liebel-Flarsheim Company, Cincinatti, Ohio.

[6]"Hypaque Sodium 50%", Winthrop Laboratories, New York, New York.

[7]"Hypaque M", Winthrop Laboratories, New York, New York.

were utilized as contrast agent. One-half milliliter sodium diatrizoate, U.S.P. per pound of body weight was used in seven series of angiocardiograms, one series in Dog 3 and two series each in Dogs 6, 12, and 24. Sodium diatrizoate, U.S.P. at the rate of 3/4 milliliter per pound of body weight was used in three series of angiocardiograms each in Dogs 5 and 11 and two series each in Dogs 7 and 8. One milliliter of sodium diatrizoate, U.S.P. per pound of body weight was administered for two series of angiocardiograms each in Dogs 2 and 4 and for one series in Dog 5.

Sodium and meglumine diatrizoate 90% was used in eight series of angiocardiograms and involved three series in Dog 9, three series in Dog 10, and two series in Dog 24.

A wooden trough for rapid cassette changing was constructed from 1/2" plywood. The outside dimensions were 12 1/4 inches wide, 28 inches long, and 2 inches thick. The center opening was just large enough to accept the 8" x 10" cassettes. The top of the trough, except for the center 1/3, was lined with 1/8" sheet lead thus allowing only the center cassette to be exposed to the electron beam. Film exposure was based on the small animal technique chart in the radiology section of the Department of Surgery and Medicine at Kansas State University. The focal film spot distance in each case was 36 inches with an exposure time of 1/20 of a second. One-hundred milliampers were used. The K.V.P. varied according to the thickness of the chest in centimeters which ranged from 10-20 centimeters. The K.V.P. for 12 centimeters was 68 and for each centimeter above 12 an increase of 2 K.V.P. was used and a decrease of 2 K.V.P. was used for each centimeter below 12.

A scout film was taken prior to the injection of contrast agent. In three series of radiographs utilizing Dog 1, the contrast agent was injected into the right atrium through a .047" I.D. polyethylene catheter[1]. In 7 radiographic series utilizing Dogs 2, 3, 4, and 6, the contrast agent was injected into the jugular vein through a 15 gauge hypodermic needle. In 11 series of radiographs involving Dogs 5, 7, 8, and 9, the contrast agent was injected into the jugular vein through a .106" I.D. polyethylene catheter[2]. In the 12 series of radiographs utilizing Dogs 10, 11, 12, and 24, the contrast media was injected into the jugular vein through an 18 gauge hypodermic needle.

Fifteen series of angiocardiograms were taken with the subject in ventral-dorsal position in Dogs 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, and 24. Two series each were taken using Dogs 10 and 24 and three series were taken using Dog 1.

Angiocardiograms were obtained with the patient in right lateral recumbency in Dogs 3-12 and 24. Two series each were taken in Dogs 11 and 24.

Four series of angiocardiograms were taken with the patient in dorsal-ventral recumbency in Dogs 5, 7, 8, and 9.

Surgical anesthesia was induced by intraveous injection of pentabarbital sodium, U.S.P.[3] at the rate of 12 milligrams per pound body weight to Dogs 1-12 and 24.

The right atrium of Dog 1 was catheterized by a .047" I.D. catheter. The hair on the ventral surface of the neck was clipped, shaven, and scrubbed with soap containing hexachloraphene[4]. A 4 centimeter incision through the skin was made over the right jugular vein. Venous blood flow was interrupted by

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[1]"Cat. No. PE190 Intramedic" Polyethylene Tubing, Clay-Adams, Inc., New York, New York.

[2]"Cat. No. PE320 Intramedic" Polyethylene Tubing, Clay-Adams, Inc., New York, New York.

[3]Haver-Lockhart Laboratories, Shawnee Mission, Kansas.

[4]"Gamophen", Ambrook Division of Ethicon, Inc., Somerville, New Jersey.

applying traction to an 00 silk ligature placed around the vein and a 3 millimeter incision was made through the vein wall. The distance from the incision to the right atrium was measured and the catheter was inserted through the incision into the jugular vein and threaded down the jugular vein and anterior vena cava the measured distance.

Polyethylene tubing was used for catheterization in Dogs 5, 7, 8, and 9. The hair on the ventral surface of the neck was clipped, shaven, and scrubbed with soap containing hexachloraphene. A 4 centimeter incision was made through the skin over the jugular vein. The jugular vein was isolated and ligated with 00 silk suture material. A 4 millimeter incision was made through the vein wall distal to the ligature. Eight centimeters of .106" I.D. catheter was then placed into the jugular vein. A ligature was then passed around the jugular vein and the catheter was secured by ligation.

In Dogs 2, 3, 4, and 6, a 15 gauge hypodermic needle was utilized for simple jugular venipuncture. The venipuncture into the jugular vein of Dogs 10, 11, 12, and 24 was accomplished with an 18 gauge hypodermic needle. A 000 silk suture was placed through the skin and the needle hub ligated in place. A 12 inch section of .106" I.D. polyethylene tubing was then attached to the hypodermic needle. A 3-way valve[1] attached to the section of polyethylene tubing was also attached to IV tubing connected to a bottle of 5% dextrose.

The initial radiograph was taken immediately after the injection of contrast agent, a second radiograph was taken 3 seconds post injection, a third at 5 seconds post injection, and in 13 instances a fourth radiograph was taken 7 seconds after the injection of contrast agent.

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[1]Number MS02, Bectin-Dickinson Company, Rutherford, New Jersey.

The exposed plates were developed for 5 minutes in Supermix X-Ray Developer[1] at 70 degrees F. The films were rinsed in water and then fixed in a solution of Supermix X-Ray Fixer[1] for 10 minutes. After fixing, the films were rinsed in water for a minimum of one-half hour. A second rinsing in very dilute solution of detergent[2] was then used after which the films were allowed to dry.

An E & M Physiograph "Four" Recorder[3] with a high gain preamplifier was used in the phase of investigation relating to electrocardiography and telemetry. The recorder had a fixed speed paper control and a gravity fed inking system with rectilinear write out. The preamplifier possessed a maximum voltage gain of 2,500 with a sensitivity in excess of 30 microvolts per centimeter of pen deflection. Needle electrodes (1 1/2" x 22 gauge) were used in Dogs 3, 4, 5, 7, 9, 12-21, and 27 and #60 alligator clips served as the electrodes in Dog 27. The anesthetic agents used were intravenous pentabarbital sodium, U.S.P.[4] at the rate of 12 milligrams per pound body weight and thiamyl sodium[5] at the rate of 10 milligrams per pound body weight.

The effect of patient position on the results of an electrocardiogram was studied in 3 dogs. Standard Lead II was selected and 1 1/2", 22 gauge needles were used as electrodes. Alcoholic roccal was used to cleanse the site of the electrode placement. The negative electrode was placed subcutaneously in the right lateral humoral area just distal to the scapulo-humoral

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[1]General Electric Company, Milwaukee, Wisconsin.

[2]Lux Soap, Proctor and Gamble, Cincinatti, Ohio.

[3]E & M Instrument Company, Inc., Houston, Texas.

[4]Haver-Lockhart Laboratories, Shawnee Mission, Kansas.

[5]Parke-Davis Company, Detroit, Michigan.

articulation. The positive electrode was placed subcutaneously in the left lateral stifle area. The electrodes were connected to corresponding poles of the high gain preamplifier which in turn was connected to the recorder preamplifier. The system was calibrated so that 1 millivolt action potential gave a pen deflection of 1 centimeter. Electrocardiograms were taken at 25 millimeters per second paper speed. The recording paper used was 1 millimeter continuous grid[1].

The initial electrocardiogram in Dog 27 was taken with the patient in the standing position. The dog was then anesthetized with pentabarbital sodium, U.S.P. and placed in left lateral recumbency with the legs placed perpendicular to the body in an attempt to approximate a normal standing position. The second electrocardiogram was recorded.

A third recording was made with the patient in right lateral recumbency with the legs placed perpendicular to the body. A fourth recording was made with the animal in right lateral recumbency with the forelegs extended forward and the rear legs extended backward. A fifth recording was made with the forelegs extended backward and the rear legs extended forward. The right foreleg and the left rear leg were extended forward with the left foreleg and right rear legs in the natural position. The sixth recording was made in this position. The final and seventh recording was taken with the animal in sternal recumbency. Experimental animals #9 and 12 were anesthetized with pentabarbital sodium. Electrocardiograms were recorded with the subjects in right lateral recumbency with the legs placed perpendicular to body to approximate a normal standing position. A second electrocardiogram was taken with the subjects front legs extended forward and rear legs extended backward. A

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[1]E & M Instrument Company, Inc., Houston, Texas.

third electrocardiogram was taken in sternal recumbency with all four extremities flexed in a natural position.

The effect of electrodes on electrocardiograms was studied in experimental animal 27. The negative needle electrode was placed subcutaneously in the right lateral foreleg just distal to the humoral-radial-ulnar articulation and the positive electrode was placed subcutaneously in the left lateral stifle area just proximal to the patella. The preamplifier was calibrated to give a 1 centimeter pen deflection from a 1 millivolt input action potential. An electrocardiogram was taken at 25 millimeters per second paper speed. An alligator clip was clipped to the fold of skin at the right elbow and connected by an electrical wire to the negative pole of the preamplifier. The second alligator clip was clipped to the fold of skin at the cranial mid-femoral area of the left rear legs and connected by an electrical wire to the positive pole of the preamplifier. The preamplifier was calibrated to give a 1 centimeter pen deflection from a 1 millivolt input action potential. An electrocardiogram was taken at 25 millimeters per second paper speed.

Electrocardiograms from Standard Lead II taken by telemetry were compared with electrocardiograms taken by direct electrode connection in Dogs 3, 4, 5, 7, 9, and 12-21.

Equipment for telemetry consisted of a transmitter Model FM-1100-E2[1] and a receiver Model FM-1100-4[1]. The system had a reported range of 100 feet. Needle electrodes (1" x 22 gauge) were used in the telemetric studies.

The patient was anesthetized with thiamyl sodium and placed in right lateral recumbency with the legs perpendicular to the body simulating a normal standing position.

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[1]E & M Instrument Company, Houston, Texas.

The negative electrode (1 1/2" x 22 gauge needle) for the direct electrode connection electrocardiograms was placed subcutaneously on the medial aspects of the right forelimb. The electrode was inserted at the humoral-ulnar-radial joint and directed proximally. The positive electrode for the direct electrode connection electrocardiogram was placed subcutaneously in the left lateral midstifle area. The electrodes were connected to the high gain preamplifier which in turn was connected to the recording channel.

Electrodes (1" x 22 gauge needles) for telemetry electrocardiograms were inserted 1 centimeter posterior and parallel to the corresponding electrode for direct recording. The telemetry electrodes were then connected to corresponding poles on the telemetry transmitter.

The transmitter was preset at a frequency of 90 megacycles and the receiver tuned to receive the 90 megacycle wave length. The telemetry receiver was then connected to the high gain preamplifier and subsequently into the Physiograph recording channel.

The direct wire electrocardiogram was calibrated so that a 1 millivolt action potential gave 1 centimeter of pen deflection on the recording paper. Because of a lack of a calibration system for the telemetry, this system was adjusted so that the amplitude of pen deflection for telemetry was set at the point that the QRS complex gave an identical millimeter deflection of that of the calibrated direct system. Electrocardiograms were recorded simultaneously from the two systems at a paper speed of 25 millimeters a second on channels 2 and 3 of the Physiograph recorder and on 1 millimeter continuous grid write out paper. The recorder channel input cables were then switched and repeat electrocardiograms taken.

The telemetry range for recording electrocardiograms was investigated. Dogs 7 and 9 were used in this phase of investigation. Needle electrodes were placed subcutaneously for recording a Standard Lead II electrocardiogram. The telemetry system was adjusted so that a 1 millivolt impulse produced approximately 1 centimeter of pen deflection. In Dog 7, the height of the P wave and QRS complexes were compared at 25 feet and 50 feet. In Dog 9, the height of the QRS complexes were compared at 15, 50, 75, and 100 feet.

Dog 26 exhibited cardiac arrhythmia when auscultation of the heart was performed in the patients cage. This arrhythmia did not exist when the patient was removed from the cage and placed on the examination table. An electrocardiogram was made by telemetry with the patient remaining quiet and undisturbed in the cage. Standard Lead II was used by placing needle electrodes subcutaneously in the right humoral aréa and the left stifle area. Electrocardiograms were taken at 1 centimeter a second and 25 millimeters a second. A second electrocardiogram was made by direct wire connection with the dog on the examination table.

Nineteen dogs were used in the phase of investigation relating to blood pressure determinations. The Physiograph "Four" recorder[1] and a Physiograph Carrier Preamplifier[1] were used. The Physiograph Carrier Preamplifier had a maximum sensitivity of 20 microvolts per centimeter of pen deflection and a voltage gain of 2,000. Polyethylene tubing size .047" I.D.[2] was utilized in the arterial catheterization. A Stathum pressure transducer[3] was used.

Direct blood pressures from the femoral artery were recorded on the Physiograph recorder by a technique with three minor variations.

The first method utilized .047" I.D. polyethylene tubing. The animal

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[1]E & M Instrument Company, Inc., Houston, Texas.

[2]"Cat. No. PE190 Intramedic" Polyethylene Tubing, Clay-Adams, Inc., New York, New York.

[3]Stathum P23H, Stathum Transducers, Inc., Hato Ray, Puerto, Rico.

studied was anesthetized by the intravenous injection of pentabarbital sodium. The hair over the femoral artery was shaven and the skin scrubbed with soap containing hexachloraphene. The femoral artery was palpated and an incision through the skin was made over the artery. The artery was isolated and occluded distally by a 000 silk ligature. A 3 millimeter incision was made through the arterial wall and the polyethylene tubing inserted into the lumen directed toward the stream of blood flow. A 000 silk ligature was placed around the artery over the catheter. The external end of the polyethylene tubing was attached to a 3-way valve[1] on the pressure transducer. A syringe containing a 1:10,000 solution of heparin[2] was attached to the 3-way valve and was injected into the catheter and pressure dome to prevent blood from clotting in the tubing. The pressure transducer was connected to the carrier preamplifier which in turn was connected to the recording channel. The system was then calibrated with the aneroid manometer by connecting the manometer to a Y tube. A pressure bulb was then connected to the Y and a 30 centimeters section of tubing used to connect the Y to the 3-way valve on the pressure transducer. Pressure was applied in the system with the pressure bulb. The pressure was noted on the aneroid manometer and this pressure was recorded on the recording paper.

The second method was essentially the same as the first technique except that a percutaneous arterial puncture with a 20 gauge hypodermic needle was utilized instead of arterial catheterization. The needle was connected by tubing to the 3-way valve on the pressure transducer.

The third method paralleled that of the second except that a 23 gauge

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[1]Number MS02, Bectin-Dickinson Company, Rutherford, New Jersey.

[2]Abbott Laboratories, North Chicago, Illinois.

hypodermic needle was substituted for the 20 gauge hypodermic needle.

Dogs 4, 22, and 25 were used in the study with polyethylene catheters. Dogs 24 and 25 were studied in which 20 gauge hypodermic needles were used and Dogs 2, 3, 4, and 25 were studied in which 23 gauge hypodermic needles were used.

A fourth method for direct blood pressure readings was undertaken in Dogs 28, 29, and 30. An aneroid manometer[1] was connected by polyethylene tubing to a 3-way valve. The 3-way valve was then connected by polyethylene tubing to a 20 gauge hypodermic needle and to a syringe containing sterile saline. Saline was instilled via the 3-way valve into the polyethylene tubing to the extent of 1/2 the distance to the aneroid manometer. The 3-way valve was then turned and saline was injected through the hypodermic needle.

The dog was placed in lateral recumbency and held in this position by an assistant. The area over the femoral artery was cleansed with alcohol. The femoral artery was palpated and a percutaneous arterial puncture performed with the 20 gauge hypodermic needle. As arterial blood commenced filling the tubing, the 3-way valve was turned so that the pressure could be read on the aneroid manometer.

Dogs 2, 3, 4, and 13-23 were used to determine the blood pressure by an indirect method. A pressure cuff was constructed from a bicycle innertube. The section of innertube utilized measured 30 centimeters and contained the valve stem in the middle. A clamp for the innertube was made from 2 pieces of 3/16" x 3/4" steel 2 3/4 inches long. The steel pieces were covered with polyethylene tubing and two 1/4" steel bolts with winged nuts were used to hold the clamps together.

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[1]E & M Instrument Company, Inc., Houston, Texas.

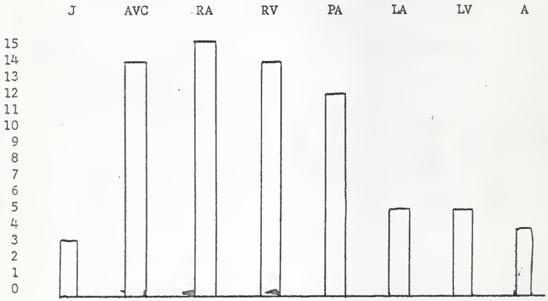
The dogs in this study were anesthetized with thiamyl sodium. The tube pressure cuff was placed around the foreleg of the dog proximal to the elbow. Polyethylene tubing connected the valve stem of the tube pressure cuff to a Y tube which in turn was connected to an aneroid manometer and a pressure bulb. The pressure cuff was inflated. A bell stethoscope was placed over the median artery just distal to the pressure cuff. The pressure was slowly released. The systolic pressure was recorded at that point that the pulsations in the artery could first be heard. The diastolic pressure was recorded when the intensity of the pulsation diminished rapidly or completely disappeared. The same technique was utilized in Dogs 15 and 16 using the rear leg and femoral artery and in Dog 15 using the tail and middle coccygeal artery.

RESULTS AND DISCUSSION

Thirteen dogs were used in the phase of investigation relating to radiography and angiocardiography. The dogs were numbered consecutively 1-12 and number 24.

Fifteen radiographs taken within 1 second after the injection of the contrast agent were viewed to determine the structures outlined by the contrast agent (Fig. 1). The number of radiographs that outlined the different heart chamber and great vessels are illustrated in Fig. 1.

Fig. 1. Number of radiographs illustrating the heart chamber of great vessels during the first second after the injection of sodium diatrizoate, U.S.P. or sodium and meglumine diatrizoate 90%.

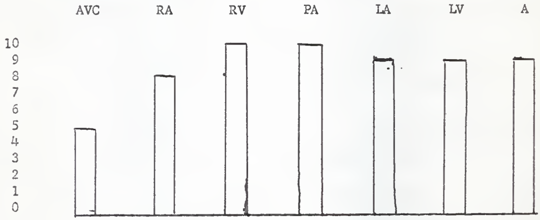


J = Jugular Vein, AVC = Anterior Vena Cava, RA = Right Atrium, RV = Right Ventricle, PA = Pulmonary Artery, LA = Left Atrium, LV = Left Ventricle, A = Aorta.

Fifteen radiographs clearly demonstrated contrast during the first second following the injection of the contrast agent. The anterior vena cava, right atrium, right ventricle, and pulmonary artery were shown in 13 or more of the radiographs. Five radiographs demonstrated that the contrast agent had progressed beyond the pulmonary arteries.

Ten radiographs taken 3 seconds following injection of the contrast agent demonstrated contrast. The heart chamber and great vessels delineated in these radiographs are shown in Fig. 2.

Fig. 2. The number of radiographs illustrating the heart chamber of the great vessels 3 seconds after the injection of sodium diatrizoate, U.S.P. or sodium and meglumine diatrizoate 90%.



AVC = Anterior Vena Cava, RA = Right Atrium, RV = Right Ventricle, PA = Pulmonary Artery, LA = Left Atrium, LV = Left Ventricle, A = Aorta.

The contrast agent was found to be equally distributed in the right ventricle, pulmonary artery, left atrium, left ventricle, and aorta.

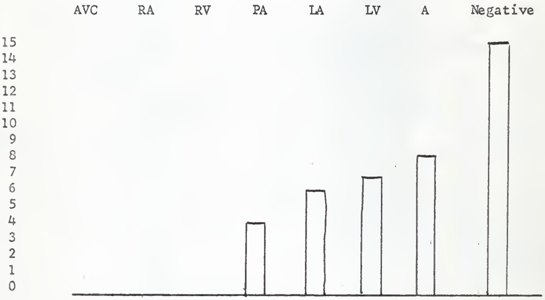
Twenty-three radiographs were taken 6-8 seconds following the injection of contrast agent. The heart chambers or great vessels at this duration following the injection of the contrast agent are shown in Fig. 3.

Six to eight seconds after the injection of the contrast agent much of the contrast is lost. In 4 radiographs the pulmonary artery was visualized. The left atrium could be seen in 6 radiographs, the left ventricle in 7, and the aorta in 8. The remaining 15 radiographs failed to demonstrate contrast.

Satisfactory results were obtained with injection of the contrast agent by venipuncture through a 15 or 18 gauge hypodermic needle or through a .106"

I.D. catheter. The .047" I.D. polyethylene tubing failed to outline any of the heart structures. The .047" I.D. catheter lumen was too small to allow rapid injection of the contrast agent resulting in the substance being diluted to a point that it would not record on the radiographs.

Fig. 3. The number of radiographs that illustrate the heart chambers or great vessels 6-8 seconds or longer after the injection of sodium diatrizoate, U.S.P. and sodium and meglumine diatrizoate 90%.



AVC = Anterior Vena Cava, RV = Right Atrium, RV = Right Ventricle, PA = Pulmonary Artery, LA = Left Atrium, LV = Left Ventricle, A = Aorta, Negative = no contrast seen.

The .106" I.D. intravenous catheter required surgery for the insertion of the catheter and this factor would be considered a disadvantage in routine use. The 15 gauge and 18 gauge hypodermic needles worked equally well. The 18 gauge hypodermic needles were preferred in this study because less trauma was caused to the patient. Hematomas measuring 3-5 centimeters around the site of venipuncture occurred with each use of the 15 gauge hypodermic needles. Hematomas measuring 1-2 centimeters developed with each 18 gauge venipuncture.

Fifteen angiocardiogram series were taken in the ventral-dorsal position, 13 in the right lateral position, and 4 in the dorsal-ventral position. The heart image from the dorsal-ventral position was identical to that of the ventral-dorsal position, however, the positioning of the dog was easier to achieve for those radiographs taken in the ventral-dorsal position. Contrast shown by lateral radiographs were uniformally better than those shown in the ventral-dorsal or dorsal-ventral position. The heart chambers were delineated better in the lateral position. The aorta and pulmonary artery was overlying the heart in the ventral-dorsal and dorsal-ventral positions thus obscuring part of the heart chambers.

One-half milliliter and 3/4 milliliter per pound body weight sodium diatrizoate, U.S.P. produced comparable results. One milliliter per pound body weight appeared to be excessive. The slight increase of time required to inject the larger volume and the fact that more contrast agent was circulating through the heart led to the demonstration of contrast agent in all of the heart chambers. Sodium and meglumine diatrizoate 90% failed to mix well in the blood so that the heart chambers were not delineated. As the agent circulated through the heart and lungs to the left ventricle, it became dilute enough so that little contrast could be seen. Based on the results obtained, sodium diatrizoate, U.S.P. is the preferred contrast agent for angiocardiographic studies.

The rapid injection of sodium diatrizoate, U.S.P. at the rate of 1/2-3/4 milliliter per pound body weight via an 18 gauge hypodermic needle into the jugular vein was the preferred method of administration.

The lack of acute toxicity of sodium diatrizoate, U.S.P. or sodium and meglumine diatrizoate 90% was effectively demonstrated by the fact that as many as four angiocardiographic series were performed within 1 1/2 hours without evident harm to the subject. All dogs recovered from the anesthesia in the anticipated time for the anesthetic used and all appeared normal on clinical examination twenty-four hours later.

Seventeen dogs were used in the phase of investigation relating to electrocardiography and telemetry. The dogs were numbered 3, 4, 5, 7, 9, 12-21, 26, and 27. The effect of positioning of the animal on the electrocardiogram was investigated in 3 dogs. The factors for comparison included the amplitude of the P wave, QRS complex, and T wave on a Standard Lead II electrocardiogram (Fig. 4).

Fig. 4. Amplitudes in millivolts of the P wave, QRS complex, and T wave from subjects in various body positions.

		P	QRS	T
Dog 9	Right Lateral Recumbency	.2	.3	.1
	Legs Extended	.25	.5	.05
	Sternal Recumbency	.3	1.2	.25
Dog 12	Right Lateral Recumbency	.2	.3	.15
	Legs Extended	.25	.25	.15
	Sternal Recumbency	.4	.8	.3
Dog 27	Standing	.3	1.1	.15
	Left Lateral Recumbency	.25	1.2	.05
	Right Lateral Recumbency	.2	1.2	.1
	Legs Extended	.25	1.2	.2
	Sternal Recumbency	.2	1.2	1.3

Based on the results obtained, it can be stated that the position of the dog during the recording of an electrocardiogram does have an effect on the amplitude of the P wave, QRS complex, and T wave. The greatest amplitudes were recorded in the position of sternal recumbency in Dogs 9 and 12. In Dog 27 the P wave had the greatest amplitude in the standing position whereas the QRS complex and T wave amplitudes were greatest in sternal recumbency.

Each body position change of the dog produced a change in position of the heart within the thorax. The change in heart position produced a change in the electrical axis of the heart which resulted in a change in the amplitude of the various electrical waves on the electrocardiogram. Electrocardiograms in four body positions are shown in Fig. 5.

Based on the results it can be concluded all the recordings must be taken with the subject in standardized position if the electrocardiographic results are to be compared.

The feasibility of using alligator clips in preference to needle electrodes for recording electrocardiograms was investigated in Dog 27. Alcohol soaked cotton placed between the animals skin and the alligator clip was necessary in order for electrical contact to be made.

Results of electrocardiograms recorded with needle electrodes and electrodes of alligator clips are illustrated as Fig. 6. The large exposed surfaces of the alligator clip resulted in the pickup of 60-cycle electrical interference. Electrical wires transmit small amounts of 60-cycle current into the surrounding area in the way that a radio transmitter transmits a radio wave through the air. This wave of current was picked up by the recording apparatus along with the electrical impulses from the heart. The 60-cycle interference was illustrated by 60 regular waves per second or 25 vertical lines per second on the electrocardiogram. These waves were demonstrated most easily on the isoelectric line of the electrocardiogram which on the recording with needle electrodes was straight.

When the needle electrodes were placed subcutaneously in Dog 27, he remained quiet and undisturbed by the electrodes. The application of the alligator clips resulted in the animal struggling throughout the recording of the electrocardiogram and the dog made numerous attempts to remove the

EXPLANATION OF PLATE I

Fig. 5. Electrocardiogram recorded from a dog in A, standing position, B, left lateral recumbency, C, right lateral recumbency, and D, sternal recumbency.

Fig. 6. Electrocardiogram from a dog utilizing A, alligator clip electrodes and B, subcutaneous needle electrodes.

Fig. 5

A B

C D

Fig. 6

A B

electrodes. Needle electrodes are recommended because of the lack of discomfort and less electrical interference recorded following their use.

Electrocardiograms of Dogs 3, 4, 5, 7, 9, and 12-21 were recorded by telemetry and direct electrical connection simultaneously on channels 2 and 3 of the Physiograph recorder. The cardiac cycles recorded by direct electrical connection were examined and the duration of the P-R interval, QRS segment, and T wave compared with the cardiac cycle recorded simultaneously be telemetry. The duration of each segment in 25 of the 30 cardiac cycles studied were identical. A time difference of 0.04 seconds occurred in five of the segments in the remaining cardiac cycles. The difference was so slight that they might be explained by differences in pen writing.

Figure 7 illustrates electrocardiograms recorded simultaneously by direct connection and telemetry. Identical electrocardiograms were shown after the input cables to the recording channels were switched.

A 12 year old female beagle (Dog 26) was noted to have a marked arrhythmia when auscultation of the heart was done in the animal cage. With the animal at rest the heart rate was 130 beats per minute and arrhythmic. Removal of the patient from the cage resulted in a disappearance of the arrhythmia. An electrocardiogram was taken with the patient on the examination table. The rhythm was regular and at a heart rate of 246 beats per minute. A second electrocardiogram was taken with the subject remaining quiet and undisturbed in the animals cage (Fig. 8). The initial electrocardiogram illustrated a regular cardiac rhythm at a rate of 246 beats per minute. The electrocardiogram recorded with the subject in the animals cage illustrated a cardiac rate of 60 beats per minute for 3-4 seconds followed by a rate of 200 beats per minute for 3-4 seconds. The conclusion was the telemetry system can be used to record electrocardiograms with results that cannot be shown by the conventional direct method.

EXPLANATION OF PLATE II

Fig. 7. Electrocardiograms recorded simultaneously from a dog by direct wire connection and telemetry on two separate recording channels; A, direct recording, B, telemetry, C, telemetry, and D, direct recording.

Fig. 8. Electrocardiograms of Dog 26 recorded, A, by telemetry from the subjects cage and B, by direct wire connection from the examination table.

Fig. 7

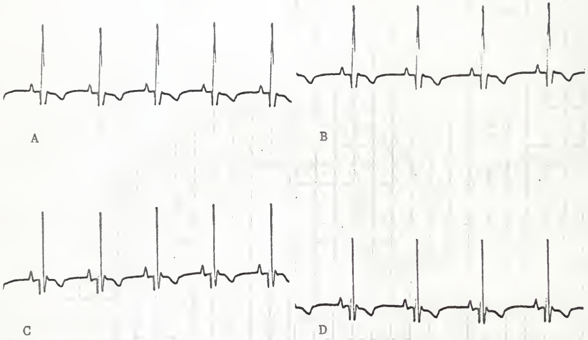
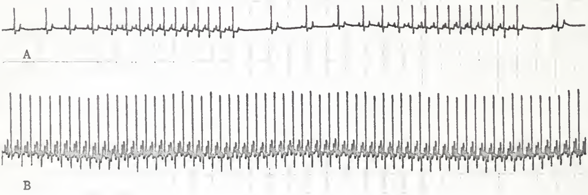


Fig. 8



Electrocardiograms recorded by telemetry were essentially identical to those recorded by direct electrical connection. The wave configurations were the same and the duration of the different segments studied was the same. The telemetry system had an advantage over the direct system in that no equipment was required near the patient other than an 18 gram transmitter.

The conclusion was that electrocardiograms transmitted by telemetry were identical to those recorded by the more standard direct electrical connection and that a telemetry system could be used in instances where it was not acceptable to use the direct system.

The distance the radio signal could be transmitted by the specific telemetry system was explored in Dogs 7 and 9. The telemetry system was calibrated to give approximately 1 centimeter of pen deflection for each 1 millivolt impulse from the animal when the transmitter was adjacent to the receiver. The height of the QRS complex on the electrocardiogram recorded from Dog 7 at 25 feet was 1.5 centimeters. The QRS complex height dropped to 0.9 centimeters at 50 feet. The P wave of Dog 7 dropped from 0.3 centimeters at 25 feet to 0.2 centimeters at 50 feet.

The electrocardiogram of Dog 9 had a recorded QRS complex height of 1.2 centimeters when the patient was adjacent to the telemetry receiver. The recorded QRS complex height dropped to 1.05 centimeters when the patient was 50 feet from the receiver and to 0.65 when the patient was 75 feet from the receiver. The transmitter could not transmit a signal 100 feet for the recording of an electrocardiogram.

The transmission of a signal for electrocardiographic recordings were demonstrated up to 75 feet although the amplitudes of the various waves of the electrocardiograms was nearly 50% less at this distance.

Nineteen dogs (Dogs 2, 3, 4, 13-25, 28, 29, and 30) were used in the phase of investigation relating to blood pressure determinations. The femoral artery pressure of Dog 25 was 145/90 millimeters of mercury (mm Hg) utilizing the .047" I.D. arterial catheter as compared to a pressure of 130/100 mm Hg using a 20 gauge hypodermic needle. Changing to a 23 gauge hypodermic needle resulted in a pressure of 110/90 mm Hg. The differences between the recorded systolic pressures and diastolic pressures were 55 mm Hg utilizing the .047" I.D. arterial catheter, 30 mm Hg by using a 20 gauge hypodermic needle and 20 mm Hg with the 23 gauge hypodermic needle. The mean arterial pressures were 117, 115, and 100 respectively. It was concluded, therefore, that the mean femoral artery pressures were nearly identical by using 20 gauge hypodermic needles as those using .047" I.D. polyethylene catheters. The mean femoral artery pressures with 23 gauge hypodermic needles was 5 mm Hg less. The greatest difference in these three methods was the range between the recorded systolic and diastolic pressures.

The femoral artery pressure of Dog 4 was 180/100 mm Hg with the arterial catheter and that of Dog 22 was 170/90 mm Hg. Recordings in Dogs 2, 3, 4, and 10 by arteriopunctures with 23 gauge hypodermic needles resulted in pressures of 60 mm Hg, 70/60 mm Hg, 136/128 mm Hg, and 65/55 mm Hg.

The range between systolic and diastolic pressures in Dogs 4 and 22 utilizing arterial catheters was 80 mm Hg. The maximum range shown with the use of 23 gauge hypodermic needles was 10 mm Hg. The mean arterial pressure in Dog 4 utilizing these two methods was 140 and 132 mm Hg, respectively. The resistance of the smaller lumen in the 23 gauge hypodermic needles was great enough that the true pressure changes of blood flow within the artery were not recorded and only the mean pressure was observed. This pressure did correspond closely to the mean pressure recorded by arterial catheterization, however, a disadvantage of the arterial catheterization method was that the procedure required surgery. After the pressure recordings were made, it was then necessary to suture the arterial incision and the skin. On the otherhand, the 23 gauge and 20 gauge arteriopunctures were simple to perform although clotting occurred quite rapidly within the lumen of the needles thus necessitating periodic flushing with a dilute solution of heparin. Pressures recorded following flushing were 3-5 millimeters of mercury lower and clotting occurred even more rapidly. Small hematomas were noted with both 20 and 23 gauge arteriopunctures.

In Dogs 28, 29, and 30 arterial punctures with 20 gauge hypodermic needles were performed and the pressures read directly on an aneroid manometer. Five to seven seconds were required for pressure to build up in the system so that pulsations could be seen on the manometer. The pressures recorded by this method were 118/116 mm Hg, 136/134 mm Hg, and 142/140 mm Hg, respectively. Air which existed in the tubing was able to compress with the pulsations of blood flow. This along with the resistance of the tubing and small diameter needle allowed for only a 2 mm fluctuation between systolic and diastolic pressures. This reading reflects the mean arterial pressure.

Femoral artery pressures recorded by arterial punctures with 20 gauge hypodermic needles were accomplished with a minimum of effort and time. The only special equipment necessary was a manometer. Based on the results obtained the hypodermic needle was found to be a satisfactory method for determining blood pressure. Pressure recordings were more accurate with the arterial catheter in as much as both systolic and diastolic pressures were recorded, however, the time required for the surgical approach to the vessels constitute a decided disadvantage.

Indirect blood pressures were determined using a compression cuff over the median artery in Dogs 2, 3, 4, and 13-23. Dogs 15 and 20 were large dogs with muscular forearms and the pulsations in the median artery could not be heard. Systolic pressures ranged from 100 mm Hg to 200 mm Hg (Fig. 9). The average systolic pressure for the twelve dogs recorded was 150 mm Hg. Seven dogs (Dogs 2, 4, 13, 14, 17, 18, and 22) were within the range 130/160 mm Hg. Three dogs (Dogs 16, 21, and 23) were above this range and two dogs (Dogs 3 and 19) were below this range. The average diastolic pressure was 120 mm Hg.

Utilization of a pressure cuff in determining blood pressure in the canine species was done with much greater speed than those methods described for direct blood pressure reading. No trauma to the patient resulted with the indirect pressure readings.

Fig. 9. Blood pressure readings obtained with the use of a pressure cuff.

Dog	Breed	Sex	Age	Weight	Blood Pressure (mm Hg)
2	Mix	F	8 mo.	23#	160/130
3	Mix	M	1 yr.	35#	100/80
4	Mix	F	-	20#	130/90
13	Mix	F	8 mo.	29#	130/105
14	Beagle	F	1 yr.	22#	130/110
15	Mix	F	7 yr.	57#	not able to record
16	Mix	F	7 mo.	27#	180/150
17	Mix	F	6 mo.	28#	155/125
18	Mix	M	Aged	48#	155/130
19	Dalmation	M	3 mo.	17#	110/80
20	Mix	M	2 yr.	65#	not able to record
21	Mix	M	1 yr.	55#	190/160
22	Mix	M		31#	150/100
23	Mix	M	6 yr.	83#	200/175

SUMMARY

Thirty dogs were used in the study to determine the applicability of selected methods for obtaining angiocardiograms, electrocardiograms and blood pressure readings.

Thirty-two series of angiocardiograms with a total of 120 radiographs were taken in 13 dogs. Diatrizoate sodium, U.S.P. at 1/2, 3/4, and 1 milliliter per pound of body weight as a contrast agent for angiocardiography was compared with sodium and meglumine diatrizoate, 90% at the rate of 1 milliliter per 2 1/2 pounds of body weight.

Four methods were used to inject the contrast agent. A .047" I.D. catheter placed in the right atrium was used in one dog in which three series of angiocardiograms were taken. Eleven series of angiocardiograms were taken by injecting the contrast agent through a .106" I.D. intravenous catheter. Venipunctures with 15 gauge hypodermic needles were used in 7 series of angiocardiograms and 11 series were taken using 18 gauge hypodermic needles.

Radiographs taken immediately after, 3 seconds after, and 5 seconds after the injection of diatrizoate sodium, U.S.P. produced diagnostic angiocardiograms. The injection of the contrast agent through .106" I.D. intravenous catheters, 15 gauge and 18 gauge hypodermic needles were equally effective, however, less trauma to the patient was caused with the use of 18 gauge hypodermic needles.

Five positions for recording electrocardiograms were studied and compared utilizing three dogs. Different positions did affect the amplitude of the P wave, QRS complex, and T wave on the electrocardiogram. The amplitude of the P wave was greatest in the standing position in Dog 27. The QRS complex and T wave amplitudes were greatest in sternal recumbency. The conclusion was

made therefore, that to compare electrocardiograms from a subject, the recordings must be taken in the same position.

Subcutaneous needle electrodes were compared with electrodes of alligator clips for utilization in recording electrocardiograms. Electrocardiograms taken with alligator clips as electrodes demonstrated 60-cycle interference whereas the electrocardiograms taken with needle electrodes did not. The dog studied exhibited less discomfort from the needle electrodes than from alligator clip electrodes.

A study was undertaken utilizing 15 dogs to determine if electrocardiograms recorded by telemetry were comparable with electrocardiograms recorded by the normal direct electrical connection. The wave configurations and amplitudes were identical by the two methods. An advantage demonstrated by the telemetry system was that no equipment was required near the patient other than the transmitter.

The telemetry system was tested to determine the distance a signal could be sent to record an electrocardiogram and it was found that satisfactory electrocardiograms could be recorded with the patient up to 75 feet from the receiver and recorder. The amplitude of the QRS complex diminished by 50% at this distance, however.

Direct and indirect methods for determining blood pressures in dogs was studied. The Physiograph recorder and a Stathum pressure transducer was used to record direct femoral artery pressure by .047" I.D. polyethylene catheters, 20 gauge hypodermic needles and 23 gauge hypodermic needles. Seven dogs were used in the study. The range between the systolic and diastolic pressures in Dog 25 was 55 mm Hg with the arterial catheter, 30 mm Hg with the 20 gauge hypodermic needle and 20 mm Hg with the 23 gauge hypodermic needle. The mean arterial pressures were 117, 115, and 110 mm Hg, respectively. The range between the systolic and diastolic pressures recorded through .047" I.D. catheters in Dogs 4 and 22 was 80 mm Hg whereas those recorded through 23 gauge hypodermic needles varied by 10 mm Hg. The mean arterial pressures by the two methods differed by only 8 mm Hg.

The mean arterial pressures were comparable by all three methods, however, to record accurate systolic and diastolic pressures the large lumen of the .047" I.D. catheter was necessary. Surgery was required to catheterize a femoral artery, whereas the 20 and 23 gauge hypodermic needles could be placed in the femoral artery with simple percutaneous arterial punctures.

A second method for determining direct femoral artery pressures was investigated utilizing Dogs 28, 29, and 30. Percutaneous arteriopunctures were done with 20 gauge hypodermic needles which were connected by polyethylene tubing directly to an aneroid manometer. Five to 7 seconds were required after the arteriopuncture for the pressure to build up in the system and pulsations observed on the manometer after which time the pressure was read directly on the manometer. The pressure observed was the mean arterial pressure.

Fourteen dogs were studied utilizing a pressure cuff over the median artery in determining blood pressure. The average systolic pressure in 12 dogs was 150 mm Hg, seven were with the range of 130-160 mm Hg. The average diastolic pressure was 120 mm Hg. No reading could be made in Dogs 15 and 20 which were large muscular dogs. It was felt that their size prevented occlusion of the median artery by this method.

The indirect method for reading blood pressures in dogs caused no trauma to the patient whereas blood pressures read directly by percutaneous arteriopunctures resulted in the formation of hematomas around the artery. Both methods were done rapidly.

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. J. E. Mosier for his advice and guidance during this study and in the preparation of the manuscript.

Appreciation goes also to Mrs. Barbara Messmer for typing the manuscript and to my wife, Carol, for her encouragement and assistance.

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APPENDIX

EXPLANATION OF PLATE III

Fig. 8. Lateral radiograph of the thorax of a normal dog.

PLATE III

EXPLANATION OF PLATE IV

Fig. 9. Lateral radiograph of the thorax of a normal dog immediately post injection of diatrizoate sodium, U.S.P. intravenously into the jugular vein.

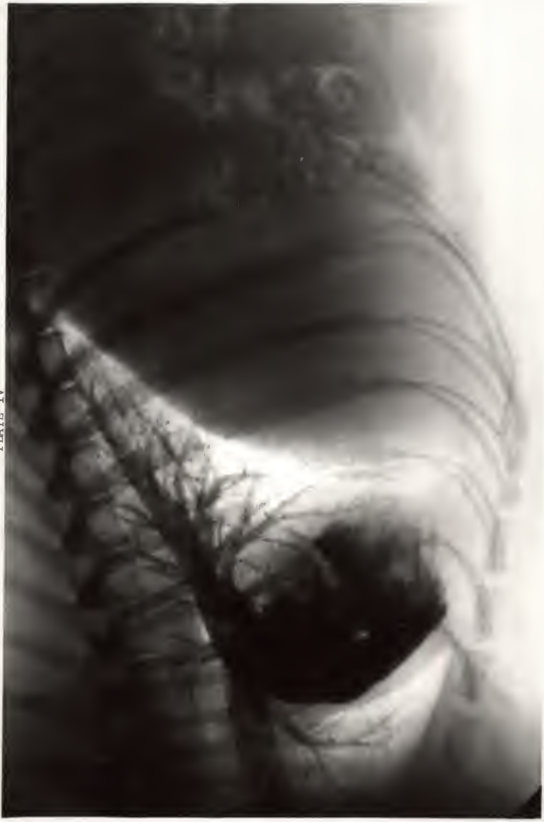
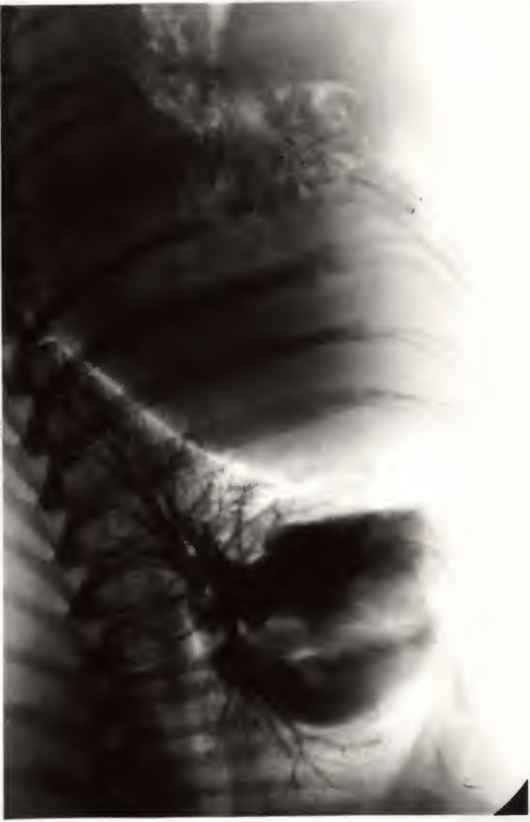


PLATE IV

EXPLANATION OF PLATE V

Fig. 10. Lateral radiograph of the thorax of a normal dog 3 seconds post injection of diatrizoate sodium, U.S.P. intravenously into the jugular vein.

PLATE V



EXPLANATION OF PLATE VI

Fig. 11. Lateral radiograph of the thorax of a normal dog 5 seconds post injection of diatrizoate sodium, U.S.P. intravenously into the jugular vein.

PLATE VI

EXPLANATION OF PLATE VII

Fig. 12. Ventral-dorsal radiograph of the thorax of a normal dog immediately post injection of diatrizoate sodium, U.S.P. intravenously into the jugular vein.

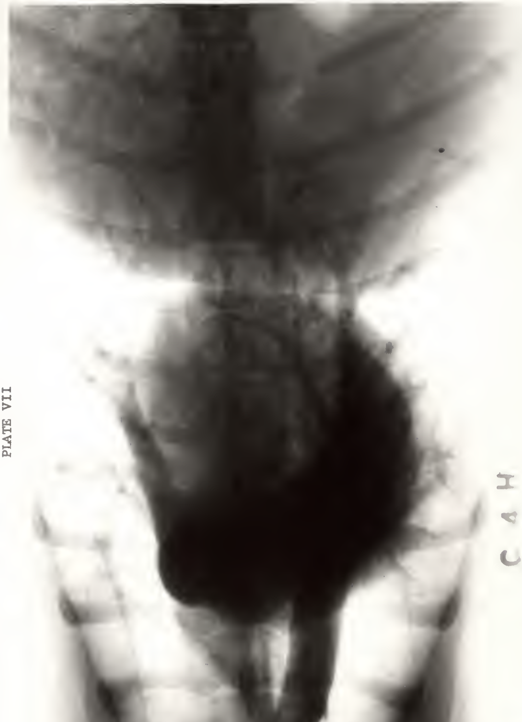


PLATE VII

EXPLANATION OF PLATE VIII

Fig. 13. Ventral-dorsal radiograph of the thorax of a normal dog 5 seconds post injection of diatrizoate sodium, U.S.P. intravenously into the jugular vein.

PLATE VIII

AN EVALUATION OF SELECTED METHODS FOR OBTAINING ANGIOCARDIOGRAMS, ELECTROCARDIOGRAMS AND BLOOD PRESSURE READINGS IN THE CANINE SPECIES

by

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B. S., Kansas State University, 1958
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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Surgery and Medicine

KANSAS STATE UNIVERSITY
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1967

The significance of cardiovascular disease in the canine species has been documented by studies in Philadelphia and New York City. In both investigations, 1 of 10 dogs was afflicted with some form of cardiovascular disease.

The purpose of this investigation was to compare the applicability of several methods used in cardiovascular diagnosis and to evaluate the methods for possible inclusion in the standard patient diagnostic procedures to be utilized in the undergraduate training program.

Twelve clinical signs which indicate heart disease have been described in the canine species. Attempts to elicit the signs by auscultation, radiography, or electrocardiography are successful in the majority of cases.

Studies involving angiocardiograms were conducted on 13 dogs. Two contrast agents, diatrizoate sodium, U.S.P. and sodium and meglumine diatrizoate 90% were compared. Three dosage levels and four methods of injection of the contrast agents were studied.

Angiocardiograms were obtained utilizing standard radiographic equipment. Best results were obtained when diatrizoate sodium, U.S.P. was injected into the jugular vein via an 18 gauge hypodermic needle at the rate of 1/2-3/4 cubic centimeter per pound body weight. Radiographs were taken immediately after injection of the contrast agent, 3 seconds, and 5 seconds later.

The effect of body position, electrodes, and environment were studied in 4 dogs. Electrodes of alligator clips resulted in the pickup of 60 cycle interference and caused discomfort to the subject while subcutaneous needle electrodes resulted in satisfactory electrocardiograms with very little discomfort to the subject, therefore subcutaneous needle electrodes were preferred in this study. Changes in the body position were reflected by alterations in the amplitude of various components of the electrocardiogram with the greatest amplitude being recorded in the position of sternal recumbency. Based on the results it can be concluded recordings must be taken with the subject in a standardized position if the electrocardiographic results are to be compared.

Telemetry was utilized in 16 dogs and compared with electrocardiograms recorded by direct connection in order to evaluate the applicability of telemetry recorded electrocardiograms. Electrocardiograms recorded by these two methods were found to be identical, therefore, it can be concluded that a telemetry system can be used for recording electrocardiograms with satisfactory results. The effective range of the telemetry system was found to be 75 feet although the QRS amplitude decreased by 50% at this distance.

Femoral artery pressures recorded through a .047" I.D. catheter on an electronic recorder were compared with similar recordings through 20 gauge and 23 gauge hypodermic needles. The systolic/diastolic pressure range was smaller with the smaller lumen although the mean arterial pressures were the same.

Percutaneous arteriopuncture with a 20 gauge hypodermic needle as a method of determining direct blood pressure was studied, evaluated, and found to be satisfactory. The mean arterial pressure was read directly on a pressure manometer.

A method of determining indirect blood pressure in dogs utilizing a bicycle innertube as a pressure cuff was studied and found to be effective. The body conformation of the patient resulted in two negative trials although in 12 subjects the systolic and diastolic pressures were recorded satisfactorily.

The indirect method for reading blood pressures in dogs caused no trauma to the patient, however, for ease and accuracy in determining the blood pressure the method utilizing simple percutaneous arteriopuncture with 20 gauge hypodermic needles and reading the blood pressure directly on the manometer was preferred.