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Visualization of Intrathoracic Vena Cava, Effect of Respiration on Diameter of the Vessel.

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The work of Franklin, Janker, Naegeli and others[1-6] has shown that the thoracic portion of the posterior vena cava undergoes changes in volume during respiration; that a lengthening, and therefore a decrease, in caliber occurs with each contraction of the diaphragm. These workers concluded that the blood flowing in the thoracic portion of the posterior vena cava is subjected to considerable churning. We are particularly interested in this question because of its important bearing on the accurate measurement of blood flow with the thermostromuhr. More nearly complete knowledge of the degree of changes in diameter of this vessel occurring during the respiratory cycle seemed imperative and, in the present report, our observations are recorded.

Four normal, well-trained dogs were selected for the investigation. With the animals under ether anesthesia and with the use of surgical technic, thorotrast (thorium dioxide) was injected directly into the wall of the vena cava as was done by Steggerda and Gianturco[7] in their studies on the colon. This method of rendering a blood vessel opaque to roentgen rays has the advantage of being more physiologic than the introduction of the material into the circulation, as was done by previous workers. It has the added advantage of being relatively permanent since the wall of the vena cava retains the thorotrast for an indefinite period and repeated roentgenograms can be taken as desired. The veins of dogs injected more than a year before seem just as opaque to roentgen rays as immediately after injection. The walls of the vena cava are so clearly defined that satisfactory measurements of changes in diameter can be made.

1 Franklin, K. J., *J. Physiol.*, 1933, **79**, 470.

2 Franklin, K. J., A monograph on veins, Springfield, Illinois, Charles C. Thomas, 1937, Chap. XIX, p. 236.

3 Franklin, K. J., and Janker, R., *J. Physiol.*, 1934, **81**, 434.

4 Franklin, K. J., and Janker, R., *J. Physiol.*, 1936, **86**, 264.

5 Franklin, K. J., and McLachlin, A. D., *J. Physiol.*, 1936, **87**, 87.

6 Naegeli, T., and Janker, R., *Deutsch. Z. f. Chir.*, 1931, **232**, 560.

7 Steggerda, F. R., and Gianturco, *Anat. Rec.*, 1937, **67**, 405.

The first roentgenograms were taken with the dogs lying on their sides (Fig. 1). In this position changes in diameter of the vena cava resulting from inspiration and expiration could not be detected except by actual measurement, which showed a slight decrease during inspiration. Besides the single roentgenograms, a series of pictures, one each second, was taken on roentgenographic film. By this means the size of the vena cava could be followed throughout the respiratory cycle. Later, the dogs were trained to stand in a Pavlov rack and roentgenograms were made both from the lateral and dorsoventral aspects.

In order to determine whether the method used to visualize the vena cava was capable of demonstrating changes in diameter 2 critical experiments were performed. The walls of the venae cavae of the dogs used in the experiments were injected with thorotrast as in the other experiments. Under amytal anesthesia, roentgenograms were taken during voluntary and artificial respiration. After laparotomy roentgenograms were taken while traction was applied to the stomach and liver, which exerted traction on the vena cava. Study of the roentgenograms disclosed that voluntary respiration

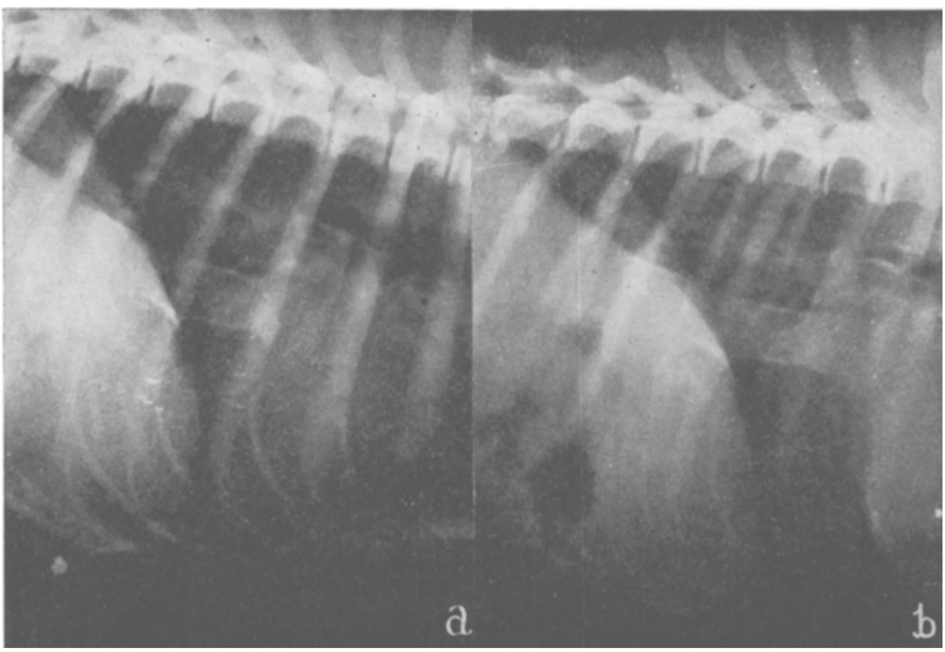

FIG. 1.
Lateral thoracic roentgenograms showing the intrathoracic portion of the inferior vena cava, *a*, during inspiration and *b*, during expiration. Dog lying on side.

caused slight or no changes in diameter while artificial respiration caused definite but small changes. This was probably owing to a greater volume of air being supplied than was inspired with normal respiration, artificial respiration resulting in a greater displacement of the diaphragm. Very marked reduction in the diameter of the vena cava was produced by traction on the stomach and liver.

These relatively negative results in regard to changes in the diameter of the vena cava during voluntary respiration raised the question whether the position of the dog influenced the diameter of the vessel. Roentgenograms were taken of the vena cava while the dog was standing in a Pavlov rack. The horizontal diameter of the vessel could be recorded by a roentgenogram made in the dorsoventral direction. The vertical diameter could be recorded by a roentgenogram taken in the lateral direction. The dorsoventral exposure showed no significant difference between the diameter during inspiration and that during expiration. However, the vertical diameter was distinctly shortened during inspiration (Fig. 2). It is evident, therefore, that the position of the dog definitely affects the diameter of the vena cava during respiration. This may be attributable to the traction exerted on the vena cava by the more pendulous condi-

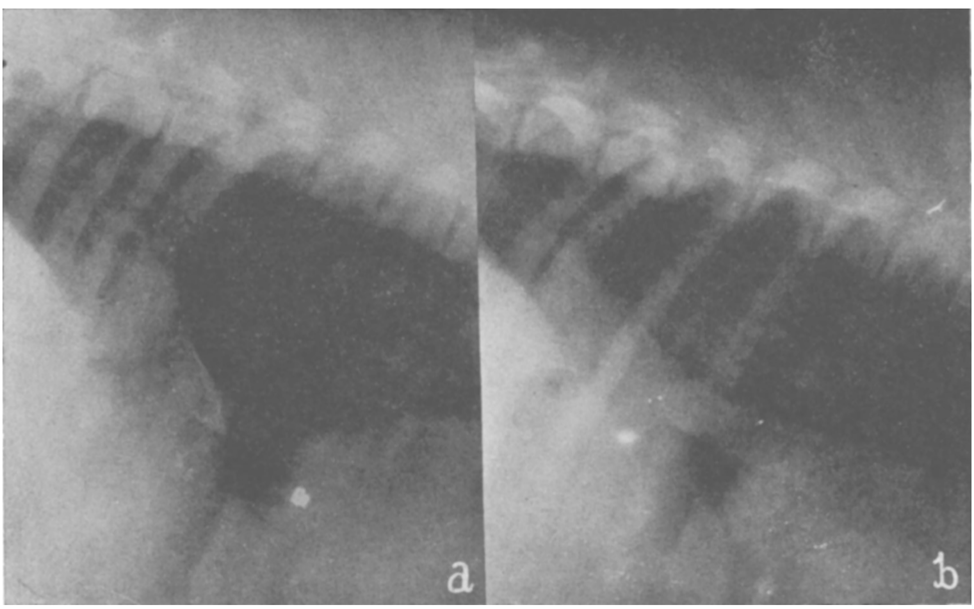

FIG. 2.
Lateral thoracic roentgenograms showing the intrathoracic portion of the inferior vena cava, *a*, during inspiration and *b*, during expiration. Dog standing.

tion of the abdominal viscera when the dog is in the standing position.

Finally we studied the effect of general anesthesia on the diameter of the vena cava. Under anesthesia induced by pentobarbital sodium, the respiration was slow but deep and regular; these were the characteristics desired for this study. Under pentobarbital sodium anesthesia, with the dog lying on its side, no significant change in diameter could be seen during voluntary respiration. Under artificial respiration the diameter during inspiration was about 5% less than that during expiration.

The method of visualizing the vena cava offers distinct possibilities of application to other problems involving the circulatory system. The thoracic portion of the posterior vena cava is anatomically unique since it is the only large vessel lacking a supporting bed of tissues. Consequently, the method employed to visualize it presents two possible sources of error. Adjacent structures, such as the lung, might become adherent to the vein as a result of reaction to operative trauma and the injected substance, causing fixation of the vessel and thus preventing occurrence of changes in diameter. The substance injected might produce sufficient reaction in the wall of the vein to cause it to thicken to such a degree that it would not respond as would a vessel into which nothing had been injected.

In order to evaluate these two possible sources of error, careful necropsy was peformed on some of the animals. The position of the injected region of the vena cava, and adhesions to it, were noted. The vessel was removed and observed both grossly and microscopically. While adhesions from the lung to the vein were noted, the vena cava certainly had not been immobilized in any instance. The wall of the vena cava gave evidence, grossly and microscopically, of a marked reaction having taken place at the site of injection and immediately after it. This reaction subsided so that a few weeks after operation the vein appeared grossly normal. No difference could be detected between a partially filled, injected vena cava and a partially filled vena cava which had not been injected. Slight pressure on the wall of each vessel caused displacement of fluid. Histologically the injected region of the vein could be recognized and some portions of the wall of the vessel remained definitely and probably permanently thickened. The possibility remains that this slight thickening of the wall of the injected vein may have prevented small changes in diameter which might occur in the uninjected vein. This possible source of error does not appear to be of sufficient importance to deter us from making definite conclusions from our observations.

The small changes in diameter of the vena cava of the dog observed by us during respiration do not appear sufficient to produce a significant amount of churning or turbulence regardless of the position of the animal. The churning of the blood described by several workers must be caused by other factors. When the dog is lying on its side changes in diameter are so slight that they may be disregarded. On the basis of this investigation, it appears that thermal and electric contacts with the thermostromuhr unit may be maintained satisfactorily during observations of blood flow, provided care is taken in applying a unit of the proper size. However, turbulence might introduce errors in the values obtained.

Summary and Conclusions. A method of visualizing, roentgenologically, blood vessels such as the vena cava is described. Significant changes in the diameter of the thoracic portion of the posterior vena cava were not observed when the dog was lying on its side. Slight changes in diameter occurred during the respiratory cycle when the dog was standing. The changes in diameter were too insignificant, even in the standing position, to interfere with thermal and electric contacts when the thermostromuhr method of measuring blood flow is used.

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Mitotic Index of Hyperplastic Interstitial Cells of the Guinea Pig.*

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The interstitial cells of Leydig increase both in number and in size when certain gonadotropic hormones are injected. Mitoses are infrequently seen and the source of the new cells is not known. A study was planned which might give some information on this point.

Seventeen immature guinea pigs (190-230 g) were injected daily with 25 R.U. of PU (Follutein, Squibb) for 1-8 days. Animals were autopsied after 2, 4, 6, and 8 days of injections. On

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