Transeptal Left Heart Catheterization: *

A New Method of Left Atrial Puncture

JOHN ROSS, JR., M.D.

From the Clinic of Surgery, National Heart Institute, Bethesda, Maryland

THE DEVELOPMENT of methods for catheterization of the left heart has made possible the accurate assessment of mitral and aortic valve lesions, and has permitted many new physiologic investigations in patients. Transbronchial [1, 4, 6] and percutaneous [3, 7] puncture of the left atrium are in widespread use. Both of these methods, however, have been found to have limitations in certain clinical situations.

The ease with which a cardiac catheter introduced from the leg can be passed through an atrial septal defect suggested the possibility that the intact interatrial septum could be crossed in the course of right heart catheterization. This valuable clinical observation was made by Dr. E. del Campo as he was observing a right heart catheterization at the National Heart Institute. The present communication describes a method of left heart catheterization in which the interatrial septum is punctured with a retractable needle passed through a cardiac catheter. The details of this technic and its experimental application are described.

Methods and Equipment

Mongrel dogs averaging 10 Kg. in weight were used. All were anesthetized with sodium pentothal administered intravenously. Intracardiac pressures were measured with Statham pressure transducers and recorded simultaneously with the electrocardiogram on a direct-writing oscillograph. Following catheterization, the dogs were sacrificed at varying intervals up to six months.

Left atrial puncture is accomplished with a long, flexible needle passed through a Cournand catheter. Stainless steel needles of two sizes are used: ** one has outside and inside diameters of 0.035 and 0.023 inches respectively (#20 gauge); the other, outside and inside diameters of .049 and .041 inches (#18 gauge, thin wall). Both needles are 61 cm. long, slightly curved at their distal ends, and are fitted with metal indicator handles attached to the needle hubs for ease in manipulation (Fig. 1). The proper curvature for the needle and the design of its point were determined by autopsy studies in dogs. The smaller needle can be passed readily through the lumen of a #8 Cournand catheter; a #9 catheter is used with the larger needle. The Cournand catheters have removable adaptors and are shortened to allow the needle tips to protrude 1.5 cm. when fully inserted. The lumen of the #18 gauge needle permits the passage of a small plastic catheter 80 cm. long and .039 inches in diameter † which is used for catheterization of the left ventricle and aorta.

Catheterization is performed with the dog lying on its left side on a fluoroscopic table. The right hind leg is externally ro-

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** Made by the Superior Tubing Co., Norristown, Pa.

† Vinyl compound tubing, #442-T, manufactured by the Becton-Dickinson Co., Rutherford, New Jersey.

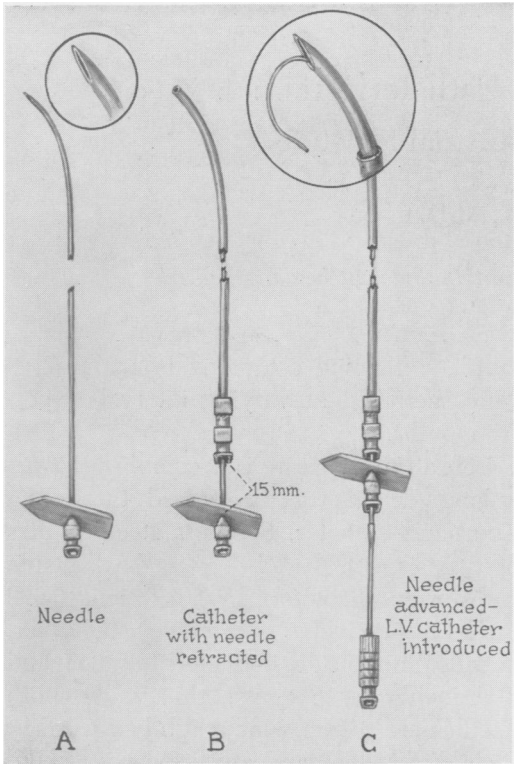


FIG. 1. Design and details of the #18 gauge needle, Cournand catheter, and small plastic catheter.

tated to allow exposure of the right femoral vein. The Cournand catheter is introduced and pressures in the right ventricle and pulmonary artery are measured. The catheter is then withdrawn into the right atrium where a pressure tracing and a blood sample are obtained. Under fluoroscopic control, the catheter is positioned with its tip at the junction of the inferior vena cava and right atrium. The adaptor on the catheter is disassembled and fitted over the curved end of the left atrial needle. The needle is then inserted a short distance into the catheter, and the adaptor is replaced and tightened. An assistant rotates the hub end of the needle in the manner shown (Fig. 2), while the operator, holding the catheter stationary, advances the needle until its point lies just inside the distal end of the catheter. The needle and catheter are then directed posteriorly and somewhat medially until resistance is encountered, approximately 1 cm. above the mouth of the inferior cava. The catheter tip should now lie against the interatrial septum in

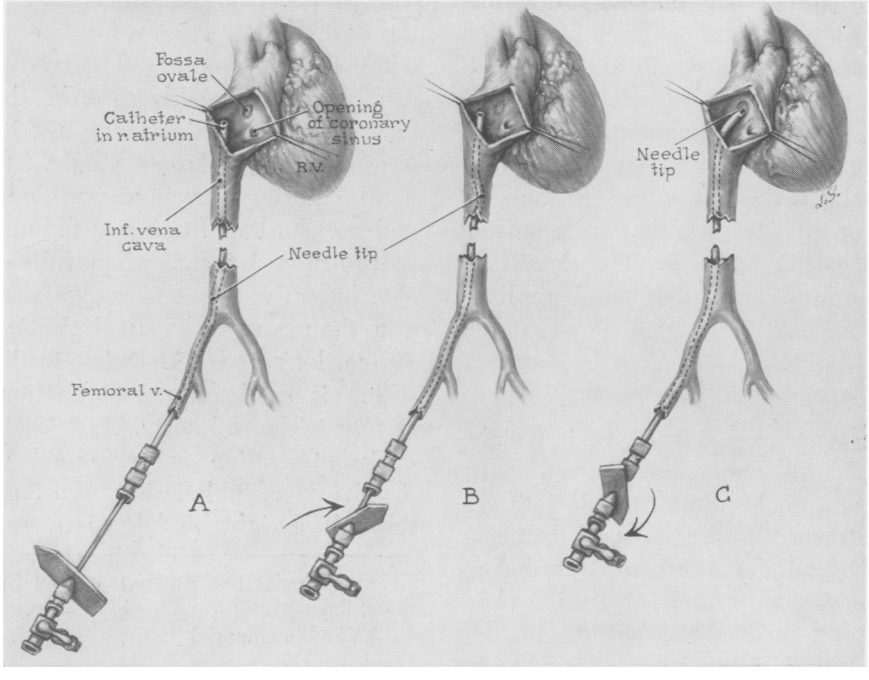


FIG. 2. Technic for inserting needle into the Cournand catheter. The needle hub is rotated clockwise after passing the bifurcation of the inferior vena cava.

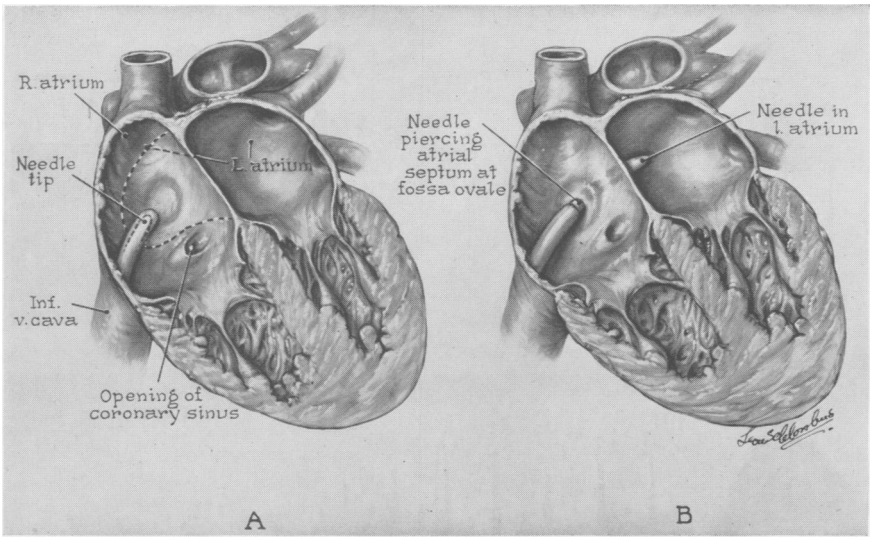


FIG. 3. Position of needle tip before (A) and after (B) puncture of the interatrial septum.

the region of the fossa ovalis as shown in Figure 3A. Then, with the catheter held stationary, the needle is pushed forward, punctures the septum, and enters the left atrium (Fig. 3B). A change in resistance is usually felt as the puncture is made. Figure 4 illustrates the radiographic appearance of the catheter and needle following septal puncture. A sample of blood is withdrawn at once through the needle and a pressure tracing obtained. Correct placement of the needle is readily verified by visual comparison of the blood sample and pressure tracing with those previously obtained from the right atrium. The first puncture is usually successful; if not, however, the puncture is repeated at a slightly higher level in the atrium, where the catheter tip may be lodged beneath the annulus ovalis.

If the #18 gauge needle is used, angiocardiography with left atrial injection may be performed. The needle is first filled with 70 per cent Urokon, and 1 to 2 cc. of dye are injected slowly under fluoroscopic control. Immediate disappearance of this test dose indicates that the needle is free within the cavity of the left atrium. 6 to 8 cc. of 70 per cent Urokon are then injected manually as serial x-rays are exposed.

Use of the #18 gauge needle also per-

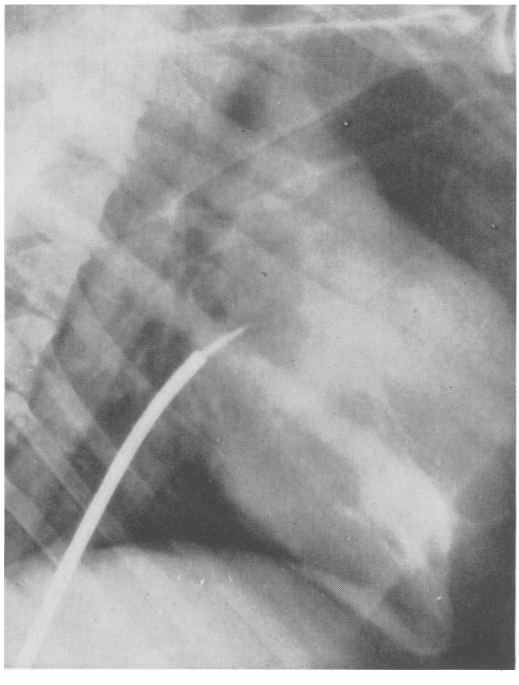
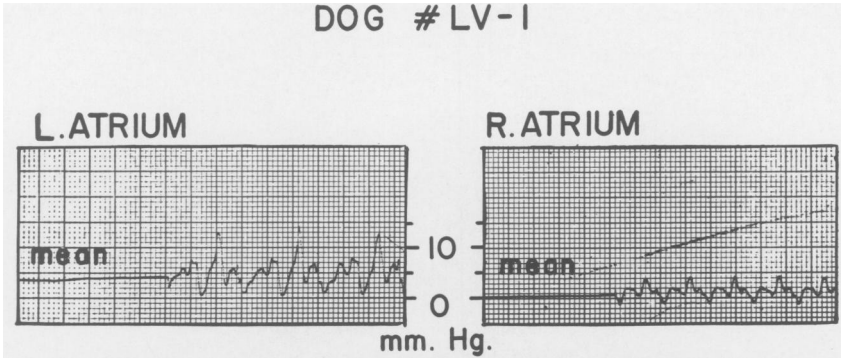


FIG. 4. Roentgenogram showing the proper position of the needle and catheter following septal puncture (Dog LA #13).



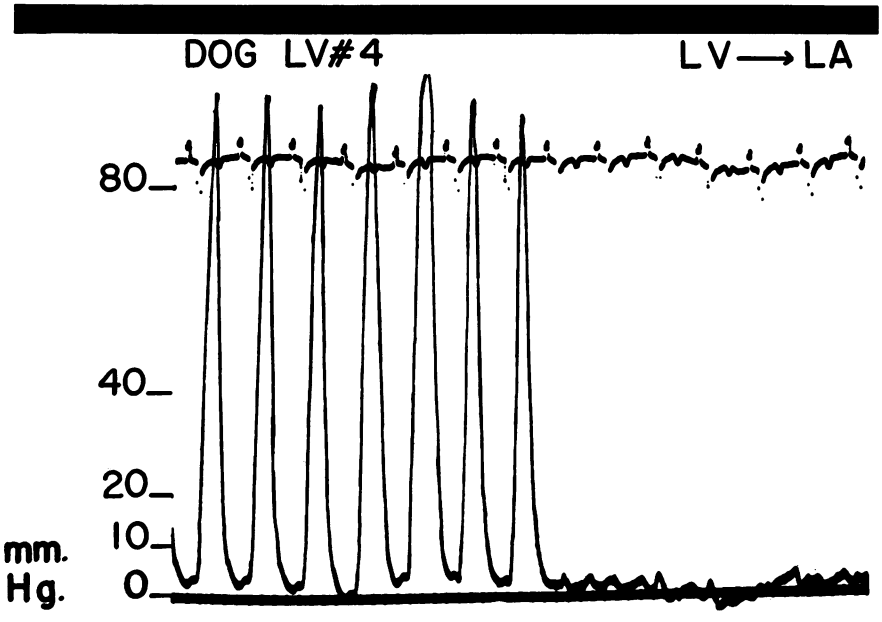


FIG. 5 (upper). Atrial pulse contours in a normal dog. Left atrial tracing obtained through the transeptal needle; right atrial tracing through a Cournand catheter.

FIG. 6 (lower). Pressure tracings obtained during transeptal catheterization in a normal dog as the vinyl catheter was pulled back from left ventricle into left atrium.

mits left ventricular and aortic catheterization. The small plastic catheter described above is connected through an adaptor, which does not compromise its lumen, to a Statham P 23 D pressure transducer. The natural frequency of this fluid filled system is approximately 18 CPS. After the location of the needle tip has been verified, the catheter is inserted through the needle into the left atrium. Ordinarily it may then be manipulated across the mitral valve into the left ventricle, and often into the aorta as well. If resistance to passage of the catheter is encountered, the needle is rotated counterclockwise, and withdrawn slightly as the catheter is simultaneously advanced. Once free forward passage is obtained, the needle is withdrawn approximately 2 cm. so that its point lies within the Cournand catheter, which retains its original position. Further manipulation of the left heart catheter may then be carried out and pullback tracings across the aortic and mitral valves obtained.

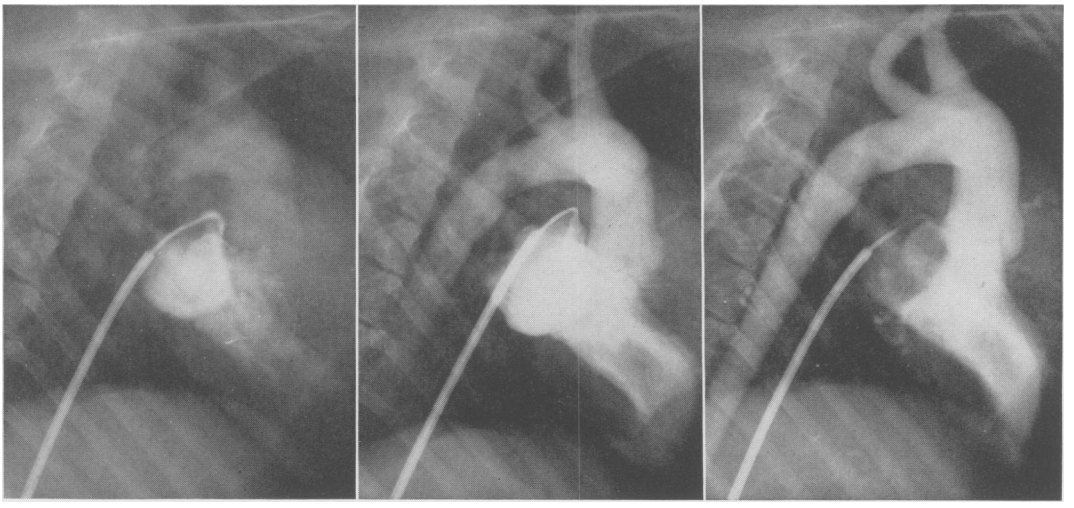


FIG. 7. Selective angiocardiogram with left atrial injection in a normal dog.

Results

Left atrial puncture with the technic described has been performed in 37 dogs. Twenty-six of these were normal animals, ten had surgically produced mitral insufficiency of several months duration, and one had a congenital ventricular septal defect.

In 18 of the normal animals, and in the dogs with mitral insufficiency, the #20 gauge needle was employed. In the normal dogs, left and right atrial pressure tracings revealed characteristically different pulse contours in all instances [8] (Fig. 5). Mean right atrial pressures averaged 1.9 mm. Hg and ranged from 1 to 4 mm. Hg, while the average mean left atrial pressure was 4.3 mm. Hg, with a range of 2 to 9 mm. Hg. The electrocardiograms remained normal in these 18 dogs with the exception of one animal which exhibited atrial coupling following puncture; spontaneous reversion to sinus rhythm occurred with the needle still in place. In the group of ten dogs with mitral insufficiency, complete right heart pressure studies were obtained in addition to left atrial pressure tracings. Myocardial irritability was prominent in three of these dogs during right heart catheterization, and transient bigeminal rhythm occurred at the time of septal puncture. A sinus mechanism returned, however, following removal of the needle. Mean left atrial pressures averaged 10.5 mm. Hg in this group, with several of the animals exhibiting left atrial pressure pulse contours typical of mitral insufficiency.[5]

Fourteen dogs were catheterized with the #18 gauge needle. Successful left ventricular catheterization was accomplished in five of the eight dogs in which the small polyvinyl catheter was passed. Figure 6 shows a recording of left ventricular and left atrial pressures obtained in one of these animals as the catheter was pulled back across the mitral valve. Left atrial angiocardiograms were performed in nine dogs. Films from a typical angiocardiogram obtained in a normal dog are reproduced in Figure 7.

Two dogs, each of which had received two left atrial Urokon injections totaling 20 cc., died the night following the procedure. One of these animals had a congenital ventricular septal defect with a systolic pulmonary artery pressure of 70 mm. Hg and exhibited gross pulmonary edema at post mortem examination. During the

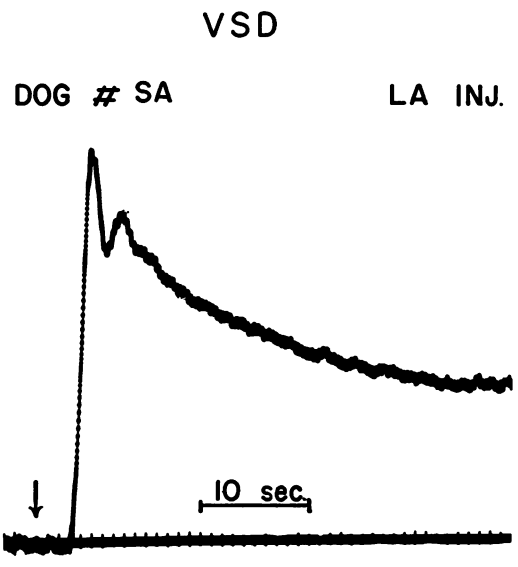


FIG. 8. Indicator dilution curve recorded from the femoral artery following injection of 3 cc. of Evans blue dye into the left atrium. The curve demonstrates a left-to-right shunt through a ventricular septal defect.

catheterization in this animal, an Evans blue dye injection through the needle into the left atrium demonstrated a large left-to-right shunt (Fig. 8). Autopsy of the second animal failed to reveal a cause of death.

Twelve of the 26 normal dogs were operated upon at intervals of from two weeks to four months following septal puncture with the #20 gauge needle. The aorta was clamped in order to distend the left atrium with oxygenated blood. The cavae were then occluded, the right atrium opened, and a careful inspection of the interatrial septum carried out. In two animals the puncture site was still patent and small amounts of oxygenated blood could be forced through the needle hole by manual compression of the left atrium. One of these dogs had been catheterized seven and one-half weeks and the other three and one-half months previously.

Comment

The technic of left heart catheterization described is performed entirely through the venous system and thereby allows the use of a single approach for both left and right heart catheterization. In the laboratory, the method has been proved to be practical and safe. The two deaths in the experimental series both followed the injection of large doses of Urokon into the left atrium; the increased risk associated with left heart catheterization combined with left atrial selective angiocardiography is well documented.[2] Accidental entry into the pericardium, or perforation of the aorta or left ventricle was not encountered. In this connection it should be noted that in man the interatrial septum is larger and the mediastinum less mobile than in dogs. Both these factors should facilitate entry into the left atrium and render even less likely the possibility of a misplaced puncture. In addition the larger human atrium should make left ventricular catheterization less difficult. The persistence of the needle hole in two animals is somewhat puzzling in view of the difficulty usually encountered in keeping experimentally created atrial septal defects open. That a significant interatrial shunt could occur through such a tiny opening seems unlikely.

There are several possible clinical applications for the transeptal technic of catheterization. In infants and small children, left heart catheterization may be difficult by either the transbronchial or percutaneous methods. In such patients dye dilution studies from the left heart can greatly simplify the localization of shunts. In addition, left-sided angiocardiography may be extremely helpful in the delineation of congenital deformities. There is also a small group of adult patients in whom attempts at transbronchial or percutaneous left heart catheterization are unsuccessful. It would be useful to have an alternative route available in this situation. Preliminary studies in human cadavers indicate that with minor modifications the technic described is applicable.

Summary

A new method of left heart catheterization is described. The interatrial septum is punctured by means of a retractable needle passed through a cardiac catheter, the tip of which is positioned in the right atrium against the fossa ovalis. Left ventricular catheterization is accomplished by passage of a second catheter through the needle. Experiences with the method in 37 dogs are presented and its possible clinical usefulness is discussed.

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