ventricles, or an aberrant course, and whether the rate of propagation from the auricle to the ventricle was normal or delayed. An instrument which pictures all these facts with mathematical precision must be and is more accurate than the registration of cardiac movements by means of the polygraph, which depicts alone the changes in intra-auricular, intraventricular, and intravascular pressure. However, though the electrocardiograph will be the court of last resort, the ink polygraph, because of its portability, its comparatively small cost, and the large amount of information it is capable of providing, is in no danger of being relegated to the shelf. Again, the knowledge obtained from electrocardiograms makes easier the interpretation of polygraph curves with greater accuracy, and a knowledge of the information afforded by both instruments increases the diagnostic ability of the physician by means of the palpating finger and the stethoscope alone. The different forms of cardiac irregularity have been shown to vary widely in their prognostic significance and their reaction to treatment. In the future the patient will expect, the insurance companies will often require, and the conscientious physician will not rest satisfied without a determination of the exact character of the cardiac irregularity in question.

The increased working reliability of a good electrocardiograph, the decreased price, and the known refinements in diagnosis it affords render the possession of one necessary by every hospital trying to do the best grade of work in cardiac diseases. Since the best deflections of the string are obtained in a strong magnetic field, the electrocardiograph with a *permanent* magnet must prove its worth before its greatly reduced price should be a factor in selecting an instrument.

The writer has attempted to treat the subject in a general way. Those not already familiar with it will find the whole subject technically yet simply set forth in *Clinical Electrocardiography*, by Dr. Thomas Lewis, to whom the writer wishes to express appreciation of his work and of the opportunities to participate therein in his laboratory which Dr. Lewis has afforded those interested in the subject.

A SIMPLE METHOD FOR THE INDIRECT TRANSFUSION OF BLOOD.

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The method consists of two parts: (1) obtaining blood from the donor, by means of an aspirating apparatus, and its defibrina-

tion by shaking in flasks with glass beads; (2) the introduction, intravenously, of the defibrinated blood into the patient.

Apparatus Required. Five Erlenmeyer flasks, each of 300 c.c. capacity, two ounces of glass beads, one infusion bottle, two infusion needles, twelve and one-half feet of rubber tubing, eighteen inches of glass tubing, one thumb-screw, one rubber stopper, with two holes, and four plain rubber stoppers.

Preparation of the Apparatus. For the aspirating outfit two pieces of glass tubing, each four inches long, are bent at the middle to form right angles; one end of each of these tubes is passed through the rubber stopper containing two holes, and to the free end of one of these tubes an infusion needle is attached by means of a short rubber connection not over one and one-half inches long. The needle should be about two and one-half inches long, and of fairly large caliber. To the free end of the other glass tube is attached six inches of thick-walled rubber tubing fitted with two inches of glass tubing to serve as a mouth-piece.

Into each of four of the Erlenmeyer flasks is placed one-half ounce of glass beads, and the flasks are stoppered with cotton wool.

The apparatus for the introduction of the defibrinated blood is made ready by attaching a small infusion needle to the infusion bottle by twelve feet of rubber tubing. This tubing is interrupted by two glass cannulæ, three or four inches long, one placed at its middle and the other about three inches from the needle. A thumb-screw is placed on the rubber tubing between the second glass cannula and the needle. All the connections between rubber tubes, glass tubes, and needles are made secure against leakage with heavy silk thread.

Sterilization of Apparatus.—The four flasks containing glass beads are sterilized by dry heat, and may be prepared in advance and kept on hand ready for an emergency.

The remainder of the apparatus, consisting of the infusion bottle with its attached tubing, needle, and thumb-screw; one Erlenmeyer flask, four plain rubber stoppers and the rubber stopper with its attached tubes and needle, is sterilized, just previous to using, by boiling.

After sterilization the rubber stopper carrying the needle is fitted into the empty Erlenmeyer flask and a little melted paraffin, which has been heated to 200° C., is aspirated through the needle into the flask, in order to coat the inside of the needle and tube to prevent the blood from coagulating there while it is being taken from the donor.

After the paraffin has been introduced, air must be continuously aspirated through the needle until the paraffin solidifies on the inner walls of the needle and tubing in order to prevent the lumen from becoming occluded. This stopper is now fitted into one of the

flasks containing beads and a little sterile cotton is inserted into the mouth-piece attached to the rubber tubing.

Obtaining Blood from the Donor. The skin over the large veins at the bend of the elbow is rendered aseptic, a muslin bandage is placed around the upper arm tightly enough to cause the veins to stand out prominently, but not so as to obliterate the arterial pulse, the needle of the aspirating apparatus is introduced into one of the large veins, and blood aspirated rapidly into the flask by means of suction applied to the appropriate tube with the mouth.

FIG. 1.—Obtaining blood from the donor.

When 200 c.c. of blood have been obtained the flask is gently removed from the stopper without disturbing the needle in the vein, another flask is substituted, and the aspiration continued as before; meanwhile the first flask is closed with a sterile rubber stopper and an assistant immediately defibrinates the blood by shaking it vigorously for ten minutes, using a circular motion. An up-and-down motion is apt to break the flask by throwing the beads violently against its bottom.

A second and a third flask of blood are obtained and treated in the same way; 600 c.c. should yield 500 c.c. of defibrinated blood.

Injection of the Defibrinated Blood into the Patient. From 300 to 400 c.c. of sterile normal salt solution are placed in the infusion bottle and allowed to fill the rubber tubing and needle connected therewith. Care must be taken to get all the air out of the rubber tubing and connections. This is somewhat difficult, and is best

accomplished by alternately raising the bottle and lowering the needle several times and then allowing the salt solution to run through the needle until only a few cubic centimeters remain in the bottle. The thumb-screw is now closed; four layers of sterile gauze are placed over the mouth of the bottle and pushed down into it a short distance to form a funnel-shaped depression; the tops of the flasks containing the defibrinated blood are then thoroughly flamed with an alcohol lamp and the blood filtered through the gauze into the infusion bottle.

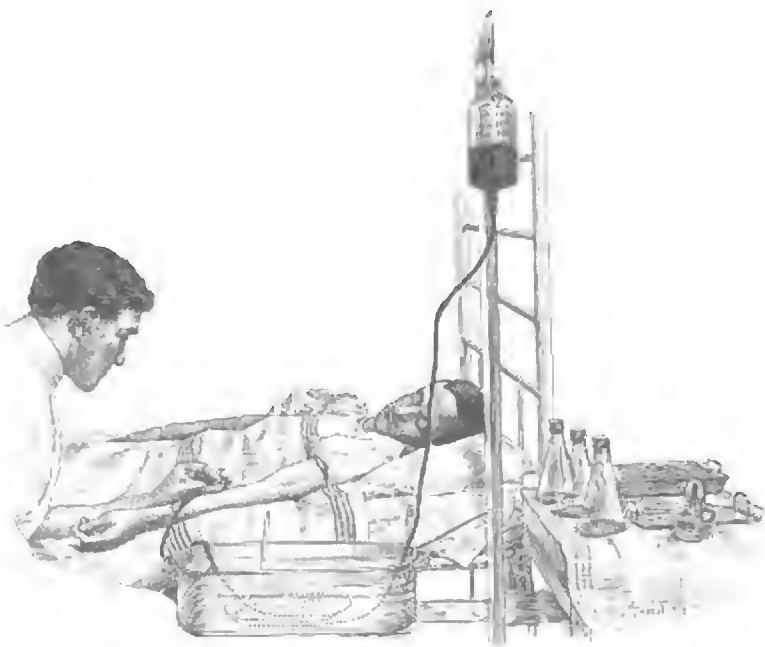

FIG. 2.—Injection of defibrinated blood into the patient.

The skin over the veins at the bend of the patient's elbow is rendered aseptic, a bandage is placed around the upper arm to make the veins prominent, the needle of the infusion apparatus inserted into a vein, and the thumb-screw loosened. If the infusion bottle has not been previously elevated, the back flow of blood from the patient into the glass cannula near the arm indicates that the needle is in the vein. The bandage is now removed and the infusion bottle elevated; the salt solution in the tubing, followed by the defibrinated blood, is allowed to run into the patient's arm.

The infusion bottle is elevated about three feet above the patient's arm and the remainder of the rubber tubing is coiled in a vessel of water placed as near the arm as possible. The water in this vessel should be kept at 38° C., in order that the blood may enter the patient at body temperature.

The rate of flow of the defibrinated blood is regulated by the thumb-screw, so that the patient receives 100 c.c. in six minutes, the introduction of the entire 500 c.c. requiring one-half hour.

In patients with unusually small veins, especially in young children, it may be necessary to expose a vein and use a small cannula if the needle cannot readily be introduced into a vein through the skin.

Selection of a Donor. It is preferable that the donor be a vigorous healthy person of approximately normal blood count and hemoglobin percentage. It is important to rule out syphilis by a negative history and Wassermann reaction. No one having an elevation of temperature or recently convalescent from an infectious disease should be used. It is also unwise to use a nephritic patient. I have in a number of instances used as donors subjects of chronic heart disease in whom there was, so far as could be determined, no danger of infection and where a venesection was indicated on the donor's account.

It seems desirable, where possible, to select a donor who belongs to the same group as the patient, as determined by the isoagglutination reaction, in order to prevent the possibility of isoagglutination or isohemolysis. This test is easily performed and does not require more than an hour or two for its application. The method for making this determination has been reported elsewhere.[1]

The Amount of Defibrinated Blood Used. The optimum amount of defibrinated blood for an adult seems to be about 500 c.c.; for children, 200 to 300 c.c.

I have given infants of two years 200 c.c., and adults 800 c.c. without untoward results, but better results may be obtained by giving smaller amounts and repeating the injection, if necessary, in from three to ten days.

General Remarks. The purpose of this communication is mainly to give the technique of the operation, but a few further statements seem desirable.

I have used it during the past three years in about seventy-five cases. It is easy to perform, although the details require careful attention, and some little practice is necessary in order to acquire facility in its use.

There are several obvious advantages over the direct method. It is much simpler of execution and certain of operation. The amount of blood transfused is under absolute control and can be measured exactly. Except in occasional cases, where it is necessary to expose a vessel, as in very small children, no scar is left with either the donor or donee, and the vessels are not obliterated.

On the other hand, one is using defibrinated instead of whole blood, which differs from the latter in that it contains a large quan-

[1] Studies on Isoagglutinins and Isohemolysins, Bull. Johns Hopkins Hospital, 1910, xxi, No. 228; also Paroxysmal Hemoglobinuria, ibid, 1911, xxii, No. 245.

tity of free fibrin ferment and has been deprived of its fibrinogen. Theoretically, lack of fibrinogen may detract from the value of the procedure in those cases in which the patient's blood may be deficient in this constituent. The presence of free fibrin ferment does not seem to constitute a source of danger, as the body is apparently able to withstand the injection of large amounts of fibrin ferment without harm, and in no instance have I observed intravascular clotting following the introduction of defibrinated blood.

In the series of cases transfused by the method here described there has been only one fatality which could be ascribed to the transfusion. The patient was suffering from pernicious anemia of a severe grade, with renal and cardiac insufficiency. After about six weeks of hospital treatment by the usual methods, without improvement, an indirect transfusion was tried as a last resort, and 500 c.c. of defibrinated blood were given intravenously. There was no immediate reaction, but six hours later the patient lapsed into a comatose state and died three hours after the onset of the coma. It may not be altogether fair to ascribe this fatality to the transfusion, as a week or ten days previous to the transfusion the patient had been in coma for about forty-eight hours, from which, however, he rallied.

In a majority of the cases the introduction of defibrinated blood was followed in from fifteen minutes to one hour by a chill of about a half hour's duration. This was accompanied by an elevation of temperature usually reaching 102° to 104° F., or even higher. The temperature returned to normal in a few hours, and there were no other untoward results.

The gain in the blood-count following the transfusion of 500 c.c. of blood varied between 1,000,000 and 2,000,000 cells, and subsequent observations indicated that the cells introduced live and functionate normally in the body of the recipient.

No instance of blood destruction was observed where homologous blood was used, that is, where the donor and donee belonged to the same group as determined by the isoagglutination reaction. In one instance where the donor and donee belonged to different groups, and where the serum of the donor was shown to hemolyze the patient's corpuscles *in vitro*, a transient but well-marked hemoglobinuria followed the transfusion.

It is beyond the scope of this paper to include detailed case reports; it is intended to give those at another time. The results have led me to believe that as much may be accomplished for the patient by indirect transfusion of defibrinated blood as by the more difficult direct transfusion of whole blood, except possibly in patients whose blood is deficient in fibrinogen.

The technique is published at this time in order that the method may have a more extensive trial in other clinics and in private practice.