RESUSCITATION OF THE STOPPED HEART BY INTRACARDIAC THERAPY *

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No procedure in modern medicine has aroused more controversial thought than the attempt to revive the dead. Hailed on the one hand as a miracle of science and on the other as a useless and dangerous operation,1 the intracardiac injection method of resuscitating the stopped heart has occupied a stage of excited debate.

The dramatic circumstances attending the revival of those supposedly dead readily lends itself to exploitation by both the lay and the medical press. The subject is naturally one of appealing interest, touching as it does on two fundamental concepts of philosophic thought—life and death.

The increasing use of epinephrine for intracardiac injection in emergency conditions arising in the operating room and in the physician's office has been attended with such inconstant results that many surgeons and physicians are at a loss in evaluating the efficacy of this procedure, individual experience having rendered them either enthusiastic advocates or bitter opponents of this method of resuscitation.

In spite of the frequent isolated reports rendered by many authors who have published results of cases in which the patients were treated by intracardiac therapy, the literature contains no systematic study of this problem, and the physician is left confused and not a little bewildered by the loosely worded speculative thought which is often expressed in these cases.

Sensing the need of scientific inquiry into all phases of intracardiac therapy, the Witkin Foundation in 1926, created a special committee to investigate this problem. Through the philanthropic magnanimity of Mr. Witkin, funds were made available for the study of the various questions arising in the procedure of intracardiac manipulation. A correlation of results obtained from the laboratory, clinic and hospital

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in the four year period from January, 1926, to January, 1930, constitutes the source from which this report is made.

HISTORICAL DATA

The intracardiac route for the injection of drugs into the circulation received prominent attention at a symposium held in Munich in 1921. Guthman, Vogt and Frenzel reported their experiences in the use of epinephrine injected into the heart when complete asystole developed during the course of surgical anesthesia. Up to that time, there had been collected from the literature twenty successful cases from seventy-six patients who had been treated by this method.

Prior to 1921, there were isolated reports in regard to the intracardiac route of injection; Vanden Veldin is said to have used this method as early as 1909. Fantus said that the German physiologist Schiff discovered this method of approach to the failing heart more than fifty years ago.

Boden, in 1923, had collected ninety cases with favorable results reported in twenty-three; most of these patients had received intracardiac injection of epinephrine for asystole of the heart occurring during operative procedures performed under general anesthesia. The literature since that time contains more and more reports of intracardiac injections used for resuscitation of the stopped heart.

Meyer, Raeschke, Petzetakis, Garipuy and Mériel, O'Donovan and Fitzpatrick and Sellheim contributed observations made during the attempt to reanimate the asystolic heart by the injection of epinephrine into the circulation. The success of their efforts led to an investigation into its possible use for the development of the circulation in stillborn infants. In 1926, Wachenfeldt and Bardier were able to resuscitate new-born infants when all other measures had failed; the injection of epinephrine directly into the heart met with favorable results.

Within the past three years, there have been reported sixty-two other cases in which the intracardiac injection method of resuscitation has been employed; these reports, together with those previously mentioned, make a total of about 250 cases in about 25 per cent of which a favorable outcome was experienced.

WHAT IS MEANT BY INTRACARDIAC INJECTION

A brief study of the cases reported by various authors quickly reveals the great confusion existing in regard to the procedure called "intracardiac injection." With the exception of obscure references made in regard to the left ventricle, few investigators have even attempted to indicate specifically which part of the heart or adjacent structures they were attempting to reach by the injecting needle.

From a purely anatomic point of view, there are three sites that can be considered in the all-inclusive phrase "intracardiac injection": (1) the pericardium, (2) the wall of the heart and (3) the cavities of the heart.

Of these three sites, the attempt to inject substances into the cavities of the heart, and especially that of the left ventricle, was apparently the intent of many authors. The rationale of this thought seems to be based on the theory that with the heart at standstill the intravenous route of medication is ineffective, but if the injected drug reaches the heart immediately, it may be carried without delay to the easily perishable centers of the brain. Furthermore, injection directly into the left ventricle saves the time required for passage through the lesser circulation and hence enhances the chances of the injected material to reach the brain and other "vital centers" more quickly.

A consideration of this conception of intracardiac therapy would seem to show, however, that it is based on a fallacious theory; it is obvious that if the heart is at a standstill there will be no more circulation within the cavities of the heart than there will be in the venous or arterial circulation. One cannot accept the favorable results noted in resuscitation of the asystolic heart on the fact that the injected drug is placed more quickly into circulation.

Injection of the drug into the wall of the heart has been the intent of several more careful observers. Their conception of the process is based on certain facts demonstrable in the experimental laboratory; the isolated mammalian heart may be stimulated to automatic contraction after a period of standstill when epinephrine and other substances are injected into the myocardium. The local effect of epinephrine on the heart muscle has been widely studied by many investigators; the increase in the capillary circulation makes possible a quicker metabolic exchange in the myocardial fibers with a resulting renewal of automatic contrac-
tion. Other substances, when injected into the myocardium of such laboratory heart preparations will also cause a renewal of rhythm after standstill.

In attempts to resuscitate the stopped heart, injections into the pericardial cavity apparently have not been made intentionally. This, however, has been done inadvertently several times during attempts to inject substances into the heart. Failure to use needles of sufficient length, incorrectly placed needles and injections made before the needle had passed into the heart itself have been responsible for the injection of substances into the pericardial cavity. Neureiter\(^{16}\) had an opportunity to examine several subjects that had received “intracardiac injection” in the attempt at resuscitation; at the postmortem table he found that the injected material was in the pericardial cavity in two cases, and from a pathologic point of view no specific reaction could be discovered. Apparently, the injection of substances into the pericardial cavity has little or no effect on the heart at standstill.

A review of these facts would thus tend to indicate that as far as resuscitation is concerned, the procedure of injection into the heart seems to be most effective when the drug is placed in the heart muscle; it is very much less effective when injected into the cavities of the heart, and it apparently has no value when injected into the pericardial cavity.

**DRUGS USED IN INTRACARDIAC INJECTIONS**

While epinephrine has enjoyed widespread use as the drug *par excellence* for use in cardiac standstill, many authors have shown that this substance may not be used without great danger. Johnson and Siebert\(^{17}\) demonstrated that severe myocardial damage occurred in nearly all of their forty-seven animals that had been used in the study of this problem. Hume,\(^{18}\) Smirnow,\(^{19}\) and Lucchetti\(^{20}\) have also shown that there may be extensive cardiovascular involvement following the use of epinephrine, more especially when it is injected during anesthesia. Neureiter\(^{16}\) confirmed many of these observations from autopsy material.

Many other drugs have been used for the resuscitation of the arrested heart. Bolton\(^{21}\) was successful in restoring contraction of the heart by the intracardiac injection of ether; in his case, the heart

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20. Lucchetti, Prat. méd. franç. 6:113 (March) 1927.
responded promptly to the injection when all of the usual methods of reanimation had failed.

Caffeine has been used with favorable results by several investigators. Bianchetti 22 injected relatively small amounts in his case, while Wiechowski 23 tried huge doses of the drug; both authors were equally enthusiastic about its immediate action in moribund patients, one of them having been dead for about twelve minutes.

Dextrose was first used by Imerman, 24 he injected 10 cc. of a 20 per cent solution of dextrose directly into the heart of a patient suffering from insulin shock. With the patient apparently dead, the response to the intracardiac injection was prompt, and subsequent recovery occurred rapidly.

Sodium thiosulphate was utilized in an attempt to save a patient who had tried to commit suicide by taking a large amount of potassium cyanide; with the patient moribund, Zimman 25 injected this chemical directly into the left ventricle, with a favorable outcome. He reported no untoward results from the injection.

Many combinations of substances have also been used for intracardiac injection; Ronzini’s solution 20 is probably the best known of this group. This solution contains epinephrine, atropine, pituitary extract, and lobeline and is injected in doses of from 2 to 4 cc.

Camphor, digitalis, strophanthin, metrazol, coramin, strychnine and hypertonic salt solution, either alone or in combination with each other and epinephrine, have been used for intracardiac injection. Vogt 3 studied the effect of many of these substances, and his conclusion seemed to be that all of them are more or less valuable for resuscitation of the asystolic heart.

The wide variety of substances used for intracardiac injection suggests that the response of the heart is probably not specific to any pharmodynamic action, but that other factors, to be discussed later, are responsible for the resuscitation of the heart.

MECHANICAL STIMULATION OF THE HEART

Accidental standstill of the heart is not an unfamiliar occurrence in the surgical amphitheater; this unfortunate experience can be related by every practicing physician. The attempt to resuscitate the heart by direct or indirect manipulation has been practiced during such emer-

gencies for at least the past seventy-five years, and the literature contains many reports of the favorable results obtained by this method.

When the emergency has developed during the course of a laparotomy, the surgeon has attempted to massage the heart by direct pressure on the diaphragm; squeezing, pinching or otherwise mechanically irritating the heart to recontract has been the theory behind such procedures (Cook 27). Indirect methods of cardiac massage by pressure applied on the thorax have often been resorted to. Krantzfeld 28 recently reviewed the various methods of mechanically stimulating the heart in such cases. Many devices and machines have also been devised to accomplish the same purpose.

Condorelli 29 described a case in which he kept the heart beating for more than two hours by thumping on the precordium; every time the heart was percussed a contraction occurred, but when the percussion was stopped the heart would immediately cease contracting, and the patient would become unconscious and moribund. The impossibility of continuing this procedure resulted in the death of the patient.

Eisenmenger 30 described a pumping apparatus which is applied to the abdomen; this device consists of a small motor which alternately massages the abdomen while a pump forces sodium chloride solution into the blood vessels. With this machine he was able to maintain a circulation in patients who had died; if the apparatus was used not more than ten minutes after cardiac standstill, favorable results might be expected. The machine, however, is so complicated that it has been difficult to make use of it clinically; Eisenmenger has therefore been devoting his attention to demonstrating the chemical changes that take place in the body during the time that artificial circulation has continued. His picturesque description of corpses that regain natural color and bodies that continue to show automatic movements has recently challenged the credulity of all Europe.

While the mechanical methods of resuscitating the asystolic heart still enjoy considerable vogue, the widespread attention given to the intracardiac injection procedure has made the latter method the one more widely used at the present time, so that the reports now appearing in the literature are concerned less and less with the mechanical theory of reanimating the stopped heart.

THE RESUSCITATION PERIOD

Physiologists have long maintained that a sudden stopping of the circulation results in an unequal response on the part of different tissues of the body. Certain centers of the brain are apparently quickly effected, while simple glandular structures like those of the hair follicles in the skin have been demonstrated to exhibit signs of activity even seventy-two hours after the heart has stopped beating. The easily perishable centers of the brain, however, are said to be irreparably damaged after from five to eight minutes of cerebral anemia.

The question as to how long asystole of the heart may exist and yet be responsive to intracardiac therapy apparently bears no relation to the physiologic thought previously expressed. Many cases of cardiac arrest have been reported which have greatly exceeded the maximum of eight minutes laid down by the experimental physiologist.

The period during which resuscitation may be possible has been found by different authors to be as long as from fifteen to twenty minutes, the longest case being that reported by Truzzi,31 in which a man, aged 70, was effectively treated by intracardiac injection more than half an hour after all signs of cardiac activity had ceased. Kleinberg 32 recorded a case in which the patient was successfully treated twenty minutes after standstill of the heart; his patient was unquestionably dead before intracardiac therapy was resorted to. Johnson’s 33 patient was a child, who was resuscitated twelve minutes after apparent death; Lutand’s 34 patient recovered after ten minutes of cardiac standstill.

To these cases may be added two of our own; one, that of a man, aged 36, with cardiac arrest while on the operating table. Epinephrine injected into the heart eleven minutes afterward caused prompt recovery. The other case was that of a child who suffered from asystole of the heart during tonsillectomy; fourteen minutes after apparent death, 3 cc. of metrazol was injected into the left ventricle with a favorable result, the child showing no untoward results.

To describe the interval during which restoration of cardiac activity may be possible, we have used the phrase "resuscitation period." This period seems to be much longer than that previously conceived, and further experimental study is required to determine what its actual duration may be in relation to the various factors of age, sex, anesthesia, shock, hemorrhage and disease.

Sufficient facts are at hand, however, to indicate that some attempt should be made to reestablish cardiac activity even if there has been a long period of cardiac arrest; if the procedure of injection is performed in the manner to be described later, a favorable outcome may be expected in cases in which the patients might otherwise have succumbed.

**INDICATIONS FOR INTRACARDIAC INJECTIONS**

Any procedure fraught with so many sequela, both good and bad, must be intelligently understood before its performance is undertaken; a consideration of the use of intracardiac injections must be made to determine the indications and contraindications in its selection as a method of resuscitating the stopped heart. Widespread utilization and poorly selected cases have done much to discredit this mode of reanimating the asystolic heart.

As long ago as 1924, Meyer 8 suggested that all hearts in which cardiac arrest has occurred could be divided into two groups: (1) the healthy asystolic heart and (2) the heart in acute or chronic disease.

In the first group may be placed the heart that stops under narcosis, anesthesia, shock, accidents, injuries and collapse; while in the second group may be placed hearts suffering from those cardiovascular conditions leading to or associated with decompensation or general vasomotor breakdown. To the second group Vogt 3 added arterial sclerosis, muscular degeneration of the heart, hyperthyroid disease with cardiac complications and nephrosis. Van den Velden 5 thought that collapse from the acute infectious diseases should be considered; Hesse 35 suggested the incorporation of peritonitis from perforations, epidemic meningitis, diphtheria, pneumonia, pulmonary tuberculosis, typhus and typhoid. Finally, Blau 36 added poisoning by chemicals or gases.

A review of these conditions suggests that intracardiac injection should be more effective in the first than in the second group. There can be no question that when the heart is normal and unaffected by disease process in itself or in other parts of the body, the efficacy of this method of resuscitation must be much better than in the other group. This is readily borne out by an analysis of the successful cases that have been reported in the literature; most, if not all, of these have been made of cases appearing in the first group. The unsuccessful and poor results have been found almost exclusively in the second group, and it has been in the latter group that most of the serious complications, like hemopericardium, pericardial infection, embolism and general septicemia, have occurred.

Intracardiac injection should be reserved, therefore, with few exceptions, for the normal healthy heart that has stopped for the reasons enumerated in group one. To these, however, may be added another group of conditions occurring in childhood and infancy which seem to be peculiarly responsive to this method of therapy—asphyxia of the newly born or premature infant, thymic death and collapse from chronic nutritive disorders.

Occasionally, intracardiac therapy may be indicated in serious decompensation of the heart when all other methods of administering drugs are ineffective. Schultze\(^37\) reported a case in which a girl, aged 7 years, was given fifteen intracardiac injections of strophanthin with successful results. We have used a digitalis product by the intracardiac route three times with a favorable outcome in one case.

In selecting cases for intracardiac injection in the hope of restoring cardiac activity, attention must thus be paid to the general condition of the patient. When the patient is suffering from serious systemic disease and when the heart has stopped as the result of myocardial degeneration, it is obvious that such cases are unsuited for intracardiac attempts at resuscitation; failure will be the rule.

On the other hand, when a patient is undergoing a surgical operation or when shock and injury have rendered an otherwise normal person moribund as the result of cardiac arrest, the intracardiac mode of stimulating automatic contraction of the heart should be attempted, as this procedure offers a favorable outcome if performed in a satisfactory manner.

**Present Status of Intracardiac Therapy for Resuscitation of the Stopped Heart**

From the foregoing data, the present status of intracardiac injection for reviving the stopped heart may be summarized briefly as follows:

1. A sufficiently large number of persons have been resuscitated after apparent death by the use of intracardiac injections to make this method worthy of further study.

2. Considerable confusion exists in regard to the procedure called “intracardiac injection,” little if any attempt being made to determine the actual site of the injection—whether pericardial, myocardial or into the chambers of the heart itself.

3. From an experimental point of view, the procedure is unquestionably more effective when the drug is injected into the heart muscle alone, and least effective when it is placed in the pericardial cavity.

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Injections into the cavities of the heart appear to rank in effectiveness about half way between these two.

4. The procedure is more successful in the normal asystolic heart (group 1) than in hearts suffering from disease processes (group 2).

5. While epinephrine has been used most often, there is a wide selection of drugs that has proved to be effective in the resuscitation process.

6. The resuscitation period apparently bears no relation to the time limits of hazardous cerebral anemia set down by the experimental physiologist.

7. Little or no damage is suffered by the myocardium if the operation of intracardiac injection is performed with the same care and skill exhibited in any other sterile surgical puncture.

8. Many cases have been reported in which resuscitation has been successfully brought about, only to have the patient collapse suddenly and die a few minutes or hours afterward without apparent cause.

9. In properly selected cases, such as those in group 1, a favorable outcome may be expected in about 25 per cent of patients who are apparently dead when treated by the intracardiac injection method.

A NEW CONCEPTION OF RESUSCITATION OF THE STOPPED HEART
BY INTRACARDIAC METHODS OF TREATMENT

In considering the large and varied number of substances successfully utilized in intracardiac injection for reanimation of the stopped heart, it appeared to us that the response of the heart was not specific for any one chemical substance. The single constant factor in each injected substance was apparently its irritant action, and this action is effective only as far as the muscle of the heart alone is concerned. When the same drug was injected into the pericardium no effect was noted, while injection into any of the chambers of the heart was only moderately successful.

Closer scrutiny of all of the facts in the problem emphasized the differences seen in the reaction to the injection operation exhibited by the hearts of the two groups discussed before, wherein the normal asystolic heart of group 1 can be more readily stimulated to recontraction than the pathologic heart of group 2.

There is abundant clinical and experimental evidence to show that the asystolic heart of group 1 can be resuscitated by simple mechanical irritation. Condorelli’s case 29 is a splendid example of this; each tap on the precordium elicited a pulse beat at the wrist. Korbler’s experiments 30 on rabbits showed that while intracardiac injections did little or

no damage to the myocardium, sometimes a puncture wound alone would reactivate a stopped heart.

With this thought in mind, it occurred to us that the success of the intracardiac injection theory of resuscitation depended more on the puncture of the heart by the injecting needle than on the substance injected.

The truth of this statement is easily verified. If one returns for a moment to a consideration of cardiac physiology, it can be demonstrated that while the heart is made up of specialized mechanisms, each part of the heart retains some vestige of a common embryologic tissue in which the factors of irritability, conductivity, contractility and stimulus production may be latent. In a recent textbook on electrocardiography,39 we pointed out the teleologic significance of this observation as a potential life-saving mechanism when the orderly sequential phenomena of the cardiac cycle are disturbed.

When such disturbances occur, any myocardial fiber may assume the rôle of the pacemaker of the heart; any point that temporarily becomes more irritable than the sino-auricular node may initiate a stimulus for contraction of the entire heart. This is, in brief, the current theory of the extrasystolic arrhythmias of the heart.

When such a point of irritability becomes effective, it occurs before the normal pacemaker has an opportunity to discharge its impulse for the cardiac cycle and a premature beat occurs. If, however, the pacemaker is unable to release its stimulus, some other part of the auricle may become irritable and excite the heart to contract, or the atrio-ventricular node of Tawara may assume the rôle of the pacemaker.40

Thus, nature has attempted to prevent standstill of the heart by providing other mechanisms for stimulating contraction. The myocardium of the normal heart at standstill tends to become very irritable and responsive to any stimulus that is intensive enough to initiate discharge of the electrodynamic factors necessary for contraction of the heart muscle.

This explains the mechanism of resuscitation of the stopped heart by intracardiac injection; the prick of the needle alone may be, and usually is, sufficient to initiate the stimulus required for contraction.

In carefully controlled experiments it can be demonstrated that the first beats of the resuscitated heart are extrasystoles. If the heart has not been too badly damaged by the period of anoxemia through which it has passed during asystole, a normal sinus rhythm may be promptly instituted. On the other hand, when the irritability factors of the

myocardium have been grossly disturbed, the puncture wound made by the injecting needle may initiate a series of extrasystoles that occur so rapidly that ventricular fibrillation supervenes with immediate collapse of the heart and death.

This is what probably happens in the cases mentioned in section 8 under the heading "Present Status of Intracardiac Therapy for Resuscitation of the Stopped Heart," in which resuscitation has occurred and the heart has commenced to beat again, only to stop suddenly within a few moments or hours. Liang's 41 patient lived for five hours after intracardiac injection and then "the circulation collapsed"—an apt description.

More accurate observers have suggested that the "second death" has been the result of ventricular fibrillation (Smith 42). In a case of complete heart block with unconsciousness due to the Stokes-Adams syndrome, Levine and Matton 43 noted a period of ventricular fibrillation following the intracardiac injection of epinephrine; their patient made a favorable recovery, due, perhaps, to the peculiar pathologic changes occurring in auricular and ventricular dissociation.

Opportunity for the clinical demonstration of the mechanical irritation theory of resuscitation of the stopped heart has been afforded in two cases, the first of which is presented here. A boy, aged 12 years, suffered from cardiac collapse while under anesthesia; after all other methods of resuscitation had failed, a long needle was inserted into the left ventricle. The heart contracted promptly, and the patient made an uneventful recovery. No drug was injected, although a syringe containing epinephrine had been prepared for use if the experiment failed. In this case, the mere prick of the needle was apparently enough to start automatic contraction of the heart.

The success of this demonstration led us to a further study of the extrasystolic arrhythmias, in an attempt to develop measures for the prevention of ventricular fibrillation and secondary collapse of the heart after resuscitation.

When the ectopic focus of extrasystoles lies in the auricles, the ventricular response is normal in all respects, with the sole exception of its prematurity. The ventricular rate may be very rapid, but the protecting mechanism provided by the junctional tissue and bundle system tends to reduce or filter out many of the stimuli; physiologic block develops and the ventricle beats slower. This is seen clinically in rapid auricular flutter or paroxysmal auricular tachycardia, in which the auricular con-

tractions may be as high as 300 beats per minute while the ventricular response may run as low as 80.44

The sequential development of auricular extrasystoles, auricular flutter and auricular fibrillation is familiar to every cardiologist; such conditions are not incompatible with an active life on the part of the patient.45 The prognosis of auricular disturbances of the heart is far more favorable than when such conditions affect the ventricles, the difference depending on the hemodynamic factors involved. Whereas irregularities of rhythm and output of the auricles may embarrass filling of the ventricular chambers, the same type of irregularities when occurring in the ventricles disarranges the entire circulation of the body, with immediate hazardous and sometimes fatal results.

A consideration of these facts would tend to indicate, therefore, that the dangers inherent from ventricular fibrillation following the intracardiac injection procedure for resuscitation of the stopped heart might be avoided, if not entirely eliminated, if the puncture was made in the auricles instead of in the ventricles.

A familiar laboratory experiment demonstrates that of the two, the auricles are far more sensitive to mechanical stimulation than the ventricles. In the resuscitation procedure, the auricles should thus be the portion of the heart best adapted physiologically for the reception of the injecting needle. The development of extrasystoles or even fibrillation of the auricles would be relatively unimportant for the reasons previously indicated.

Approach to the right auricle is not difficult. Experiments on cadavers showed that a slightly curved needle could be passed through the third interspace as close to the right sternal margin as possible and penetrate the right auricle. The needle must be directed toward the midline so that the curve carries the point under the sternum; after a little practice, the interns of the hospital found it no more difficult to penetrate the right auricle than to reach the left ventricle at the point generally recommended for intracardiac injection.

In children up to about the age of 12, the right auricle lies within 2 inches (5 cm.) of the anterior surface of the sternum, but in adults this depth may be greatly increased. Average figures obtained in a series of about forty cadavers showed that in thin persons this depth was about 3½ inches (8.87 cm.), while in wide-chested persons the inserted needle must be at least 4½ inches (11.43 cm.) long. In about 60 per cent of the cadavers examined, the injecting needle approached the right auricular appendage first. At this point there is little or no

danger of penetrating the great vessels, as they lie at least 3 inches (7.6 cm.) above and below this level.

The clinical demonstration of this method of approach to the right auricle was attempted in four cases in which the patients had died as the result of various ailments; the first two had died of pneumonia. Injection into the right auricle was attempted after mere penetration had failed to elicit cardiac activity; no result was obtained. The third case was that of a woman who had died of general carcinomatosis; insertion of the needle into the right auricle in this case was followed by weak, irregular contractions of the heart after there had been complete cardiac standstill for about nine minutes. The heart continued to beat for about seventeen minutes, and then all sounds disappeared.

Results in the fourth case were especially gratifying. The patient, a woman, aged 45, who was suffering from mitral stenosis and with severe decompensation, succumbed to a complete collapse after having had several sinking spells during the previous twenty-four hours. Seven minutes after she had been pronounced dead by the intern on service, a needle was inserted into the right auricle. There was an immediate response on the part of the heart; a very rapid, irregular rate suggesting auricular fibrillation occurred. The needle was quickly withdrawn and in about an hour the patient began to show voluntary movements, although still semiconscious. At this time an intravenous injection of strophanthin and dextrose was given, and after a rather stormy six hour period she became conscious and could speak to those around her. This patient lived for about eight days, finally dying of her cardiovascular disease. No attempt was made to resuscitate her the second time.

To these four cases, which properly belong in group 2 and therefore cannot be considered as suitable for this method of resuscitation, may be added the case of a patient who suffered from cardiac standstill following the manipulation of a fractured femur. The patient was a man, aged 31, who collapsed under anesthesia while the surgeons were attempting reduction. As artificial respiration proved futile, a needle was inserted into the right auricle about six minutes after cardiac arrest. After a very short interval, heart sounds were heard and in about ten minutes the pulse was easily palpable at the wrist and running regular at a rate of 88. The patient made an uneventful recovery.

The total number of resuscitations by the method of stimulating the right auricle by a needle puncture is now about nine cases and includes the unpublished reports of Dr. Joseph B. Wolfe of Philadelphia and Dr. A. E. Parsonnet of Newark, both of whom have undertaken an investigation of this method in their respective cities.

A word in regard to the type of needle used may not be amiss; it has been found that a number 19 gage, all steel needle measuring at least 4½ inches in length is best adapted for intracardiac injections of any
kind. Any gage finer than this becomes too flexible for penetration through the muscles of the chest, while gages larger than 19 become difficult to use. For the resuscitation procedure alone a hollow needle is unnecessary and a solid needle like a long hatpin can be utilized. A hollow needle has generally been used in our cases, since an associated study of intracardiac therapy for certain diseases of the heart has also been carried on by the committee investigating the resuscitation process.

CONCLUSIONS IN REGARD TO THE RESUSCITATION OF THE STOPPED HEART

1. The success of the intracardiac injection procedure for the resuscitation of the stopped heart is apparently due more to the effect of the puncture wound made in the wall of the heart than to the chemical substance injected.

2. The myocardium of the normal asystolic heart rapidly becomes irritable with the onset of anoxemia.

3. Under these conditions, any mechanical stimulation may irritate the heart to automatic contraction, and the success of massage and percussion of the heart for resuscitation can be explained on this basis.

4. The puncture wound made by the injecting needle becomes a focus of increased irritability from which a stimulus for myocardial contraction may be developed.

5. The first contractions of the heart after injection are always extrasystoles.

6. The initial extrasystolic arrhythmia may give way quickly to a normal sinus rhythm with prompt recovery on the part of the patient.

7. However, when the period of anoxemia has been so prolonged or so intense that there is considerable disturbance in the electrodynamic factors controlling myocardial contraction, the initial extrasystolic arrhythmia may persist and may be quickly followed by a rapid sequence of ectopic beats.

8. Such a condition leads to pathologic fatigue of the ventricles which may be followed by ventricular fibrillation.

9. Ventricular fibrillation is an extremely hazardous disturbance of the heart and is usually accompanied by immediate collapse of the circulation and death of the patient. This phenomenon explains the secondary collapse of the circulation often seen following what has apparently been a successful resuscitation of an asystolic heart.

10. It is suggested, therefore, that the intracardiac puncture be made into the right auricle instead of into the ventricles as is now practiced.
11. Intra-auricular puncture is no more difficult to perform than intraventricular injection; a slightly curved 4 inch needle is inserted into the third interspace at the right sternal margin. The point should be directed downward and toward the midline.

12. The auricles are more responsive to mechanical stimulation than the ventricles; a mere prick of the needle may be sufficient to initiate contraction.

13. Here, as in the ventricles, the first contractions are extrasystolic, the exception being that auricular extrasystoles are followed by normal ventricular contractions; hence the immediate establishment of the normal cardiovascular mechanism of circulation.

14. The sequential development of a rapid auricular extrasystolic arrhythmia, auricular flutter and finally fibrillation may not be of special significance so far as the ventricular output to the circulation is concerned, since the phenomenon of physiologic block slows the ventricular rate.

15. Intra-auricular puncture should be attempted in every case of death that occurs as the result of the asystolic heart. The cases most favorable for resuscitation are those not affected by general or cardiovascular disease. In deaths occurring on the operating table, after hemorrhage, shock, anesthesia or other ill defined conditions, like "status lymphaticus," prompt resuscitation may result from this procedure, either alone or combined with other life-saving measures—artificial respiration, transfusion, etc. In asphyxia neonatorum, it may be specific in its prompt initiation of automatic contraction of the heart.

16. Intra-auricular puncture is a procedure that every member of the medical profession should be able to perform quickly and skilfully when emergencies arise in which this life-saving operation may be indicated.