TREATMENT OF ACUTE ARRHYTHMIAS DURING ANESTHESIA BY INTRAVENOUS PROCAINE

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Previous experimental data have shown that the intravenous or intracardiac injection of procaine into anesthetized dogs having developed serious cardiac arrhythmias with a shift in pacemaker caused a reversal of the pacemaker to the sinus node and recovery (1, 2). During the course of cardiac surgery in one of the Army Chest Centers, * opportunity was afforded to evaluate this effect in human beings; the patients on whom this treatment was used had acute cardiovascular dysfunction.

It is recalled that the intravenous injection of procaine, or other local anesthetic agent, is scrupulously avoided in the conscious patient in whom it may produce cardiovascular collapse or stimulation of the central nervous system to the point of generalized convulsions. The fact that the treatment of such reactions in the conscious subject is to anesthetize him with a rapid-acting anesthetic agent such as pentothal sodium intravenously or the inhalation of chloroform (3) indicates that the tolerance to procaine of the anesthetized subject is different from that of the unanesthetized individual. In the experimental work on dogs anesthetized with cyclopropane, 150 mg. of procaine was injected intravenously without any evidence of untoward effects. In the series on human beings here reported, the single dose of procaine used in the anesthetized patient ranged from 30 mg. to 70 mg. No deleterious effect was ever observed; on the contrary, cardio-circulatory improvement was often effected.

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Report of Cases

Of 14 records available in which procaine was used intravenously, 3 case reports, one with electrocardiographic tracings, are here summarily presented.

Case 1. A Pvt., 24 years of age, had a bullet in relation to his heart; its removal by anterior thoracotomy was proposed. Anesthesia consisted of pentothal sodium intravenously, followed by nitrous oxide-oxygen-ether, using the closed orotracheal technic, with controlled respiration when the chest cavity was open. At operation, the bullet was found to be within the pericardium, impinging onto the left auricle. Removal of the bullet was difficult, necessitating repeated instrumental attempts, during which time the arterial blood pressure fell from 120 to 100 mm. systolic and from 70 to 60 mm. diastolic, while the pulse rate increased from 100 to 160 per minute and became markedly irregular both in rate and in volume. Five cubic centimeters of 1 per cent procaine injected intravenously was followed, a minute later, by a diminution in the pulse rate to 120 per minute, with return to a regular rhythm. Forty-five minutes later when the patient was returned to bed the tachycardia and arrhythmia recurred. Seven cubic centimeters more of 1 per cent procaine was injected intravenously and again the pulse became regular and fuller. It remained regular thereafter and convalescence was uneventful.

This case is merely a clinical impression of improvement in pulse rhythm by intravenous administration of procaine, but it does indicate that relatively large doses of procaine (50 mg., followed by an additional 70 mg. forty-five minutes later) can be injected intravenously into anesthetized subjects without any apparent ill effects.

In the next case electrocardiographic tracings were made throughout the operation.

Case 2. A Pfc., 19 years old, parachutist, was wounded in Belgium on 5 January 1945. At the 60th Field Hospital, a few hours later, a 3-inch laceration of the left kidney was sutured and the twelfth left fractured rib resected. A retained piece of shrapnel, 1 by 2.5 cm. in size, was localized by roentgenogram as being in the midline and 9 cm. anterior to the body of the tenth thoracic vertebra in relation to the lower portion of the ventricular area of the heart.

At the 160th General Hospital, surgical removal of the pericardial foreign body was proposed and the operation was performed on 16 February 1945. Morphine sulfate, 0.016 Gm., and atropine sulfate, 0.0006 Gm., were administered subcutaneously for premedication at 1:00 p.m. Then the patient was brought to the operating room fifty minutes later his pulse rate was 132 per minute and the arterial blood pressure was 120 mm. systolic and 70 mm. diastolic. At 1:57 p.m., anesthesia was induced with 1 Gm. of 4 per cent pentothal sodium intravenously. A cuffed number 10 Magill tube was introduced into the trachea and connected to a closed carbon-dioxide absorption system with a Waters' to-and-fro canister of soda lime. Nitrous oxide and oxygen at 50 per cent concentrations were maintained during induction of inhalation anesthesia. An intravenous drip of blood was started and the operation was begun at 2:07 p.m., at which time the arterial blood pressure and pulse rate were unchanged. The electrocardiographic tracing (fig. 1 (207)) was normal. The use of the
TREATMENT OF ACUTE ARRHYTHMIAS

electrical Bovie unit, to cauterize bleeding points of the chest wall, was discontinued when the pleura was opened, and ether vapor was then added to the anesthetic mixture. Breathing was assisted by “compensated respiration”; i.e., graded manual pressure of 3 to 6 cm. of water on the breathing bag during inspiration, whereas during expiration all pressure was removed. At 2:30 p.m., the arterial blood pressure was unchanged, the pulse rate was 108 per minute and the respiratory rate 24 per minute. At 2:45 p.m., the sternum was split and this maneuver caused the arterial blood pressure to fall to 84 mm. systolic and 60 mm. diastolic, but this was followed by a rapid return to 102 mm. systolic and 70 mm. diastolic.

Exploration revealed that the foreign body was within the pericardium at the base of the heart. The pericardium was incised and the visceral surface was then kept moistened with 1 per cent procaine. It was found necessary to “dislocate” the heart (i.e., to rotate it upwards) in order to obtain access to the foreign body. During this procedure there was visible dilatation of the heart, the arterial pressure fell to 80 mm. systolic and 60 mm. diastolic and the pulse rate diminished to 72 per minute, with palpable extrasystoles. The electrocardiogram now revealed right intraventricular block (strips 254 and 257), as evidenced by slurring and widening of the S wave. Two minutes later, neither pulse nor blood pressure could be obtained. The heart was replaced in its normal position and manipulation ceased, whereupon the arterial blood pressure returned to 80 mm. systolic and 60 mm. diastolic and the pulse rate to 110 per minute. After three minutes, the same maneuver was repeated with similar effects; neither the pulse nor blood pressure could be discerned. The foreign body was now removed. A fluctuant abscess from that vicinity was opened and 15 cc. of thick yellow greenish pus was drained. Penicillin, 150,000 units, was introduced and the heart was returned to its normal position. The heart was dilated, the ventricles appearing to pulsate, but without effective contractions. The electrocardiogram (strips 307) showed a wandering pacemaker with right intraventricular block suggestive of auriculoventricular nodal tachycardia. Surgical manipulation was suspended, but after a rest period of two minutes there was no restitution of blood pressure or pulse. Five cubic centimeters of 1 per cent procaine was then rapidly injected intravenously; a pulse could not be discerned by palpation of both the radial and temporal arteries until thirty seconds after the injection of procaine, when it suddenly became perceptible, of good volume and at a rate of 110 per minute. The arterial blood pressure was then obtained at 86 mm. systolic and 60 mm. diastolic. The electrocardiogram showed a return of the P wave, with restitution of S–A tachycardia (strips 316, 317, 319). Thirty seconds later, the arterial pressure was 120 mm. systolic and 80 mm. diastolic, and remained at that level for the next half hour while the operation was completed. Recovery was uneventful.

The following is a short protocol of another typical case.

Case 3. A Pvt., 25 years of age, had a diagnosis of foreign body in the pericardium. At 12:00 noon, premedication was given consisting of morphine sulfate, 0.016 Gm., and atropine sulfate, 0.0006 Gm. At 1:00 p.m., in the operating room before induction of anesthesia, the patient was apprehensive. The pulse rate was 150 per minute, and the arterial blood pressure 152 mm. systolic and 64 mm. diastolic. Anesthesia was started at 1:08 p.m. Pentothal sodium intravenously and ether by the closed orotracheal technic were given. The pulse became grossly irregular after intubation.
207—Preoperative period; sinus rhythm.
208—Pleura opened; no change.
232—Sternal split; R and S waves smaller, QRS widened, indicative of vagal stimulation.
254—Heart dialoated, right ventricular enlargement observed; slurring and widening of S, QRS 0.12 second; right intraventricular block.

257—The same, with QRS 0.13 second.
260—No blood pressure recorded; right intraventricular block continues, two ventricular extrasystoles.
302—Wandering pacemaker.
307—No pulse or blood pressure obtainable; wandering pacemaker with right intraventricular block suggestive of auriculoventricular nodal tachycardia. Procaino now injected.
309—S. A. tachycardia.
313—S. A. tachycardia.
315—Nodal tachycardia with absent P wave.
316—P wave beginning to return.
317—P wave back.
319—Same; S. A. tachycardia.
332—S. A. tachycardia.
Operation was started at 1:14 p.m. The arterial blood pressure was 128 mm.
systolic and 86 mm. diastolic and the pulse rate 140, with persistent marked ar-
rythmia. At 1:27 p.m. 40 mg. of procaine was rapidly injected intravenously.
The pulse became regular within two minutes and remained regular.

COMMENT

Cardiac hyperirritability may be expected during the course of surgical intervention upon the heart from direct stimulation of sensitized cardiac tissue. Various other accessory factors are also to be considered.

Of 121 cardiac or paracardiac operations recently performed in our service, 47 were pericardial, 2 were for myocardial foreign bodies, 15 for intracardiac foreign bodies, and 57 for foreign bodies within or in relation to the great vessels of the heart. Of this group, those which exhibited marked cardiac arrhythmia with alarming arterial blood pressure and pulse changes were mainly pericardial interventions. Incision and manipulation of the myocardium caused slight or no cardio-
circulatory derangement. The preponderance of dysrhythmias from pericardial stimulation is probably explained by the fact that the peri-
cardium is richly supplied by a plexus of nerve fibers.

Other factors which may contribute in determining cardiac hyper-
irritability are the psychic emotional state of the patient, the anesthetic agent used, the anesthetic technic employed, and the injection of certain drugs. Apprehension or other emotional excitement, with the incident outpouring of epinephrine into the circulation, is a definite contributing factor in causing hypersensitization of the cardiac conducting mecha-
nism. This is well exemplified in Cases 2 and 3 in which the preopera-
tive pulse rates were 132 and 150 per minute, respectively, despite the usual preanesthetic sedative medication with morphine sulfate, 0.016 Gm., and atropine sulfate, 0.0006 Gm., one hour previously. Induction of anesthesia to such apprehensive patients may cause further sensitization, with resulting arrhythmia. When the anesthetic agent used for induction is chloroform, ethyl chloride, or cyclopropane, the cardiac conducting mechanism is particularly sensitized and minute amounts of epinephrine or circulating epinephrine may cause ventricular fibrillation (4, 5).

Endotracheal intubation, which is the preferred technic for intra-
thoracic operations, may cause cardiac disturbances during the act of passing the endotracheal tube. This has been shown to be due to a vago-vagal reflex (6) wherein the afferent stimulus is caused by irritation of the vagal fibers in the larynx and trachea during intubation and the efferent pathway is directed along the cardiac branches of the vagus, causing cardiac vagal stimulation with extrasystoles or even prolonged asystole. This reflex is particularly dominant when the an-
esthetic agent used is one which is itself cholinergic, such as cyclopro-
pane (7) or the intravenous barbiturates (8). To obviate such vago-
Tonic effects sprays the larynx with 10 per cent cocaine prior to intubation has been recommended.

The administration of so-called analeptics or stimulating drugs should be carefully weighed in acute cardiac emergencies. This is particularly essential during anesthesia since many anesthetic agents alter the effects of certain drugs, such as epinephrine, pitressin (9), and coramine. The intracardiac injection of epinephrine is occasionally resorted to in the presence of apparent cardiac arrest. Administration of epinephrine should be avoided when the subject is under general anesthesia. It has already been pointed out that when the anesthetic agent used is chloroform, ethyl chloride or cyclopropane, smaller than therapeutic doses of epinephrine can so sensitize the cardiac conducting mechanism that fatal ventricular fibrillation may ensue. With other anesthetic agents—including ether—various cardiac arrhythmias may also occur. Coramine is another drug which is misused during anesthesia. Whatever stimulating properties it may have in the unanesthetized state may not only be lost during anesthesia but this drug may further enhance respiratory and circulatory depression (10, 11).

The use of procaine during anesthesia to diminish cardiac irritability is based upon a number of findings. Several investigators have shown that procaine applied locally to the heart reduces irritability of the myocardium (12, 13, 14). It has also been established that during chloroform anesthesia the injection of procaine protects against the development of ventricular fibrillation produced by epinephrine (15, 1). Cardiac arrhythmias produced by epinephrine during cyclopropane anesthesia in dogs can be prevented by the use of procaine (2, 16); they can also be remedied by the intravenous or intracardiac injection of procaine after such arrhythmias have been established. In this regard, it is confirmed that arrhythmias with pacemaker derangements causing auricular tachycardia, auriculoventricular tachycardia or ventricular tachycardia can be reverted to the sinus node by procaine. Some disagreement exists as to the efficacy of similar treatment in ventricular fibrillation. We have shown that even when ventricular fibrillation has set in during cyclopropane anesthesia, the intracardiac injection of procaine may be followed by a return to a sinus rhythm (2). Another group of investigators, however, were unable to obtain similar results (17). Yet, to condemn the use of procaine because it was found to be a “failure in reversing cyclopropane-epinephrine ventricular fibrillation” may deprive certain cases of a life-saving treatment. Case 2 illustrates this point: when the heart was dilated and contractions seemed doubtful while arterial blood pressure and pulse were not obtainable, ventricular fibrillation seemed plausible. The rapid intravenous injection of 50 mg. of procaine was followed in thirty seconds by a return of pulse and normal blood pressure while the heart resumed normal contractions. Examination of the electrocardiographic trac-
ings showed that at the critical period there had been an auriculo-
ventricular tachycardia with bundle-branch block and that following the
injection of procaine the pacemaker reverted to the sinus node. It is
possible that this patient would have recovered without procaine
therapy; it is also possible that he might have gone on to ventricular
fibrillation and death. The response to procaine was so sudden and
the return to normal so dramatic that the efficacy of this treatment
seems plausible.

In all our cases the procaine solution was rapidly injected intra-
venously into one of the large antecubital veins of the arm through
which fluid therapy was already in progress. The distance between
this point of injection and the heart is relatively short and direct so
that it was considered to be an effective route. Whether the direct
intracardiac injection is to be preferred is as yet undetermined. In
our series of cases, preparation was always made to inject procaine
directly into the heart if there should have been no response forty-five
seconds after the intravenous injection, but it has not been found
necessary to do so.

SUMMARY

Procaine in doses of 30 to 70 mg, as a single dose was injected intra-
venously into 14 anesthetized patients with acute arrhythmias during
intrathoracic operations. No untoward effects on the nervous system,
respiration or circulation were observed. The dysrhythmias always
improved, often dramatically. This confirms the experimental reports
which indicate that the systemic administration of procaine diminishes
the hyperirritability of the cardiac conducting system and can revert
a shifted pacemaker to the sinus node. General anesthesia probably
affords specific protection against the stimulating action of procaine
on the central nervous system. Further studies are needed to de-
termine the optimal dose.

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their interpretation.

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THE PITTSBURGH SOCIETY OF ANESTHESIOLOGISTS

The physician anesthetists representing the leading hospitals in Pittsburgh met on Thursday, January 3, 1946, and organized "The Pittsburgh Society of Anesthesiologists." The purpose of this organization is to improve and broaden the field of anesthesiology through its various educational processes. Scientific sessions will be held at 8:00 P.M. the last Thursday of each month. These meetings will be open to anyone who is interested in the subject being presented. The following officers were elected:

President: Dr. George J. Thomas
Vice-President: Dr. Robert L. Patterson
Secretary: Dr. Irene Shank
Treasurer: Dr. J. Earl Remlinger, Jr.

The next scientific meeting will be held at Mercy Hospital on April 25, 1946. Dr. Earl Remlinger will present a paper on Intocostrin, and the discussion will be opened by Dr. James Zewe.