Artificial Respiration and Artificial Circulation:

Training Experiences — Principles and Practice of Emergency Resuscitation and Post-Resuscitation Care

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ABSTRACT

A training program in the newer methods of treatment of acute cardiopulmonary emergencies which was developed at the University Hospital, University of Saskatchewan, is reported. Artificial respiration by the chance rescuer, primary and secondary resuscitation, and post-resuscitation measures involving the use of special drugs and equipment by trained personnel are described. Figures and tables designed for wall-mounting and ready reference in an emergency situation are presented. First-aid ventilatory adjuncts for use by trained personnel are classified and critically appraised, and the propriety of their use is emphasized. A plea is made to the medical profession and allied agencies to assume the responsibility of spreading knowledge of the new techniques more widely. Unless effective treatment is instituted early enough to prevent death or permanent anoxic damage to heart and brain, follow-through therapy will often be fruitless.

SOMMAIRE

A l'hôpital universitaire de l'Université de Saskatchewan, on a instauré un programme d'enseignement des nouvelles méthodes de traitement des cas aigus d'urgence cardiopulmonaire. L'article décrit les méthodes de respiration artificielle pouvant être pratiquées par le sauveteur occasionnel ainsi que les moyens de réanimation primaire et secondaire et de post-réanimation, comportant l'emploi de médicaments et d'appareils spéciaux par le personnel spécialisé. On y voit également des illustrations et des tableaux muraux pouvant être consultés immédiatement en cas d'urgence. Les appareils auxiliaires pour la ventilation d'urgence qu'emploie le personnel spécialisé sont classés et évalués avec un esprit critique et leur indication est précisée. L'auteur fait un plaidoyer à la profession médicale et aux organismes connexes pour qu'ils répandent de plus en plus la connaissance des nouvelles techniques. A moins qu'un traitement efficace ne soit instauré assez tôt pour prévenir la mort ou une anoxie cérébrale et cardiaque permanente, tout traitement ultérieur risque d'être inutile.

THE treatment of cardiac arrest has attained the status of a subspecialty during the past decade. A number of textbooks have been published in recent years which deal exclusively with this subject. New editions of favourite standard textbooks have either extensively revised or added new sections on resuscitation. During this period many articles have appeared in leading medical and lay publications describing recent advances in the treatment of acute cardiorespiratory failure. Extensive experiences have been reported by leading investigators to confirm the advantages of the new techniques of artificial respiration and artificial circulation.

Instruction, demonstrations and training sessions in modern cardiopulmonary resuscitative maneuvers, with the aid of films, training manikins, head-neck models, adjunctive devices, etc., were instituted at the University Hospital, University of Saskatchewan, in 1958.[1, 2] In the past few years, at least once each year, the entire attending staff has been invited to attend a symposium presided over by a panel of resuscitation "experts". To this meeting all members of the house staff of each of Saskatoon's three hospitals are invited, in order that this knowledge may be incorporated in their curriculum. Other periodic lectures, demonstrations and training sessions are held for medical and paramedical personnel, including graduate and undergraduate nurses, nursing assistants and aids, and orderlies. Annual seminars are conducted by staff members of the University Hospital to which invitations are issued to ambulance personnel, safety workers, first-aid societies, health and athletic organizations, firefighters, policemen and other groups from principal centres throughout the province. In addition, through the co-operation of the University Hospital staff and the Scientific Program Committee of the Saskatchewan Division, Canadian Medical Association, resuscitation "panellists" are sent to demonstrate the latest approved methods at district medical society meetings in neighbouring regions of the

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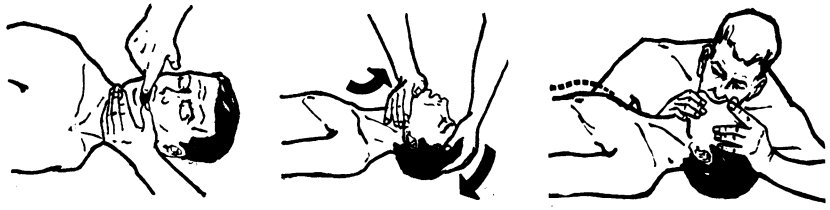
A.



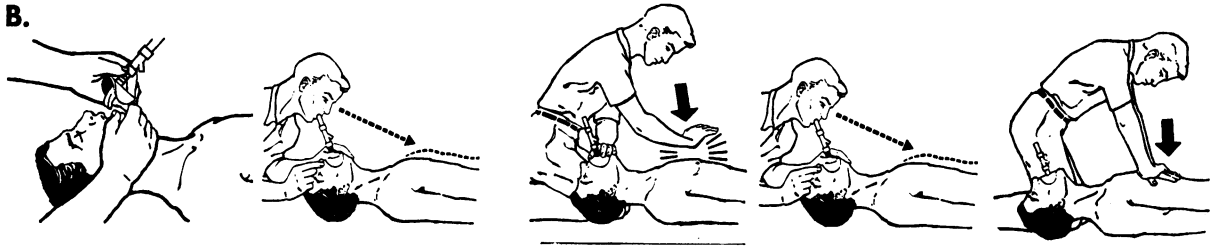
Place victim on back. Clear mouth and throat.

Tilt head fully back. Raise the chin. Maintain this position throughout.

Take a deep breath and blow. Remove mouth between inflations. Listen for air return. Repeat every 3-4 secs.

Fig. 1.—FIRST-AID: A. Artificial respiration by the chance rescuer. B. Artificial respiration and artificial circulation by the trained rescuer. C. Emergency resuscitation when two or more attendants are present.

B.



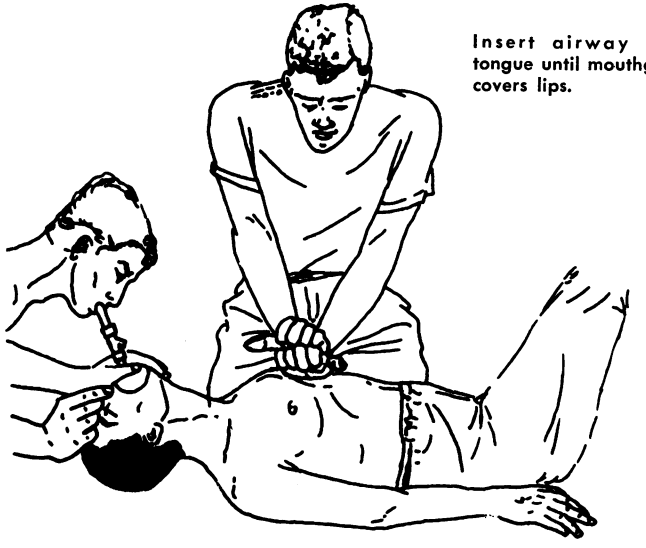
Insert airway over tongue until mouthguard covers lips.

Take a deep breath and blow. Remove mouth between inflations. Listen for air return. Repeat every 3-4 secs.

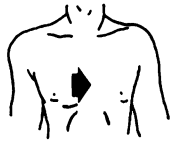
If no response after ½-1 minute, thump breast bone three times.

Inflate chest with two airway breaths. Compress chest over breast bone 15 times, once per second. Alternate two airway breaths with 15 chest compressions.

C.



When two attendants are present, the first ventilates the lungs with two airway breaths and the second compresses the chest 15 times alternately. They may reverse positions to relieve fatigue. A third assistant, if present, elevates the victim's legs to increase the blood supply to the vital organs.



Lower third of sternum.

province. By these means it is felt that a teaching hospital may contribute on a continuing basis to fulfil its obligation in disseminating the knowledge of resuscitative methods which have now received universal acceptance.

At the time of writing a study has been instituted in the city of Saskatoon to determine how Grade seven teachers may best be trained to instruct their students in the principles and practice of mouth-to-mouth resuscitation. This program is being planned through the co-operation of two of the authors (Brook and Brook), a physician assigned to health education in schools by the Department of Health of the Government of Saskatchewan, and a Saskatoon public school principal. In early April 1965, two Grade seven students demonstrated mouth-to-mouth resuscitation, using a training manikin, at the school's "Science Fair". The planners hope to bring this instruction to all Grade seven students, through their own teachers, throughout the province.

Countless lives are lost every year that need not be lost — many tragedies occur which could be averted — when the heart is too good to die; in addition, the nation's economy suffers when men and women in their productive years are lost. It is essential that all physicians, general practitioners and specialists in all fields of medicine familiarize themselves with the principles of the treatment of cardiac arrest, that they may be prepared to take immediate, intelligent and skilful action wherever this emergency may arise. Dentists may also prepare themselves to treat cardiac arrest effectively without delay, should the need arise. To assure the best possible treatment for the injured and the critically ill, the medical profession, public health agencies and allied groups must meet the challenge by assuming the leadership in disseminating this knowledge to everyone.[3] A high salvage rate will be achieved by effective application of artificial respiration and artificial circulation to restore the oxygen transport system to the vital organs within a few minutes, thus avoiding death or permanent disability.[4]

FIRST-AID TREATMENT

First-aid treatment, on the spot, often must be provided by the chance rescuer (Fig. 1A.) The first person at the scene must always remember that in a serious emergency the only equipment of which he can be assured at a moment's notice is his hands and his lips. Education and training are required to use these intelligently and effectively in the performance of mouth-to-mouth resuscitation.[5]

Before beginning mouth-to-mouth breathing, the victim is placed on his back when possible. His neck is then lifted or a pad is placed under his shoulders. Turning his head to the side, his mouth and throat are cleared of foreign matter with the fingers. His head is then straightened, tilted back, and his chin raised. This position is maintained throughout the procedure. The rescuer takes a deep breath and places his lips over the victim's mouth, pinching the nostrils to prevent air leakage. The rescuer then blows until the victim's chest is seen to rise. Adults require deep breaths; infants and small children require only small puffs. Inflation is repeated every three to four seconds (every two to three seconds for a small child). If the chest fails to rise, or if air is not heard returning from the victim between inflations, a check is made for obstruction by clearing the mouth and throat again and starting over. The victim's mouth is held open during and between inflations by drawing down his lower lip. In the case of a small child or infant, the rescuer applies his lips to the mouth and nose of the victim. Mouth-to-mouth breathing is continued until the victim breathes for himself, or until expert assistance is obtained.

Nearly any person can learn to perform mouth-to-mouth resuscitation easily and effectively. Because it represents a means of saving a life without equipment, oral resuscitation has a versatility not approached by other methods.[6] Manual methods, popular heretofore and adopted following trials in which simulated victims had been provided with artificial airways,[7] cannot, in at least four out of five cases, supply sufficient oxygen to maintain life.[8] Mouth-to-mouth resuscitation is now endorsed by leading authorities as the method of choice in artificial respiration because of the pulmonary ventilation it can achieve.[9, 10] With this method a rescuer breathing instinctively provides an asphyxiated victim with twice the amount of air he normally breathes with each inflation, and his lungs will contain a normal amount of oxygen and carbon dioxide.[8] Training in mouth-to-mouth resuscitation should be instituted everywhere with the aid of manikins, head-neck models, films and demonstrations, at about the Grade seven level. Proficiency in this technique requires repeated instruction through first-aid societies, safety organizations, clubs and associations, scout and guide groups, etc.

Since the supply of oxygen and the removal of carbon dioxide are accomplished by the circulating blood, circulation is part of respiration.[11] Without effective heart action to transport the oxygen (provided by artificial respiration) to the vital centres within three to five minutes, an artificial circulation may be required to prevent death or permanent disability. Concomitant with artificial respiration, external cardiac resuscitation by rhythmic compression of the heart to circulate oxygenated blood has greatly increased the chances of success in treating heart-lung stoppage (Fig. 1B).[12] With the victim on a firm surface or on the floor, mouth-to-mouth resuscitation is performed first for ½ to 1 minute. If there is no response (as evidenced by failure to improve in colour, absence of spontaneous respirations and detectable pulse, and persistent dilatation of the pupils), in the absence of apparent chest injury, the lower third of the breast bone is

TABLE I.—FOLLOW-THROUGH THERAPY OF CARDIAC ARREST

The following procedures are applied successively, if required. Primary resuscitative measures must be continued without interruption, alternating two airway inflations with 15 chest compressions to maintain ventilation and circulation, until the return of spontaneous breathing and effective heart action.

1. **START A CONTINUOUS INTRAVENOUS INFUSION** of 1000 ml. 5% dextrose/water, using a No. 14-16 needle or an indwelling plastic catheter in a venous cutdown, to maintain a venous channel for rapid medication.

2. **COMBAT ACIDOSIS.** Sodium bicarbonate, 3.75 g./50 ml. (44.5 mEq.), is given intravenously at once. Repeat every 10 minutes.

3. **ENHANCE VENTILATION.** Intubate with an endotracheal tube through a laryngoscope, aspirate secretions and ventilate with 100% oxygen. If obstruction persists, or intubation is required beyond two to three days, perform tracheotomy, insert tracheal tube, aspirate secretions, and ventilate with an intermittent positive-pressure machine.

4. **DETERMINE CARDIAC STATUS WITH ELECTROCARDIOGRAM.**

   (a) Ventricular fibrillation
   - (i) Coarse fibrillation: Apply external DC defibrillator, 440v/0.25 sec. (220v/0.25 sec. for infants). If unsuccessful, repeat twice if necessary. If coarse fibrillation persists or if an external defibrillator is not available, give lidocaine 2%, 2-5 ml. intravenously.
   - (ii) Feeble fibrillation: Give adrenaline 1:10,000, 5 ml. intravenously. If unsuccessful, give calcium chloride 10%, 10 ml. intravenously. If coarse fibrillation results, treat as above.

   (b) Ventricular standstill
   - (i) Isoproterenol (Isuprel), 5-10 mg. intravenously.
   - (ii) Insert bipolar electrode catheter through brachial or jugular vein into right ventricle and connect to an external cardiac pacemaker.
   - (iii) Calcium chloride 10%, 5 ml. intravenously.
   - (iv) Adrenaline 1:10,000, 5 ml. intravenously.

   (c) Complete heart block (Stokes-Adams attack)
   - (i) Isoproterenol (Isuprel), 5-10 mg. intravenously.
   - (ii) Observe electrocardiogram. Treat standstill or fibrillation if required, as above.

5. **THORACOTOMY,** in operating theatre, with intermittent positive-pressure ventilation, direct compression of the heart, internal electrical defibrillation or stimulation, and intracardiac injection of drugs as required.

thumped sharply three times with the butt of the hand. This procedure alone has been known to initiate a heart beat. The chest is then inflated twice and the heart is compressed 15 times (the heel of one hand is placed over the lower third of the sternum, the heel of the other hand over the first, the arms are kept straight, the front of the chest is compressed towards the spine 1½ to 2 inches, 60 to 80 times per minute or at least once per second), alternately until spontaneous lung and heart action return or until expert assistance is obtained.[12-14]

To accomplish any worthwhile circulation, the distance the sternum should be compressed may vary from person to person. In skilled hands, effectiveness may be demonstrated by the presence of an adequate pulse on palpation of the carotid vessels or on ophthalmological examination of the retinal vessels. In the case of a child, the chest is compressed with the heel of one hand. In the case of an infant, gentle compression is performed with the thumb over the middle third of the sternum, to avoid injury to the relatively large liver.

Every physician should feel confident that he can apply intermittent cardiac compression in a manner that will sustain life and make successful resuscitation possible. The Committee on Cardiopulmonary Resuscitation of the Council on Community Service and Education, American Heart Association, issued a revised statement in 1964 to the effect that external cardiac resuscitation is an approved and accepted lifesaving technique and should be applied as a first-aid procedure in an emergency by properly trained members of the nursing and allied health professions, and of rescue squads.[11] While various complications have been reported as a result of the improper application of this technique, many lives will be saved through increased nationwide training projects to increase greatly the numbers of knowledgeable and capable life-savers.

When cardiac arrest occurs, first-aid measures must be continued as long as there is any chance for survival, or for at least a period of one hour.[15] "On-the-spot" resuscitation (artificial respiration by the chance rescuer — artificial respiration and artificial circulation by the skilled rescuer) is continued at the site of the emergency and *en route* to hospital until follow-through therapy (second-aid treatment) with the use of special drugs and sophisticated equipment can be started.

SECOND-AID TREATMENT

Hospital personnel must be prepared to institute first-aid treatment for cardiac arrest at all times and at any location in the hospital. Each nursing station and every department should have an emergency depot equipped with a non-rebreathing oral airway, selected emergency drugs, suction and oxygen equipment, and a fibreboard or standard kitchen tray for insertion under the patient's back to facilitate external cardiac compression.[16] In addition, specially trained personnel in hospitals and medical centres must be prepared to institute second-aid measures without delay. For this purpose, every 100-bed hospital should have a cardiopulmonary resuscitation cart in readiness to bring essential equipment and drugs to any area.[17] An intensive-care area brings the resources of highly trained nurses and competent residents and physicians to bear on problems of patients in acute respiratory failure. Medical and surgical intensive-care units should be sufficiently close to one another to take advantage of the same nursing and resident staff and laboratory facilities.[18] An integral part of any intensive-care unit should be a supply of instruments necessary for the determination of arterial oxygen and carbon dioxide tensions and pH.[19]

Since many of the current methods of treatment of cardiac arrest are still in their infancy, choice of drugs and techniques may vary slightly in different areas. Time is of the essence in the prevention of irreversible anoxic damage to heart muscle or brain. To save time, a standard routine is desirable in an emergency situation. Second-aid measures advocated here are those which are considered to be the most important and least controversial. They are presented in Tables I-III in a manner designed for ready reference and wall-mounting.

Follow-through Therapy of Cardiac Arrest (Table I)

The procedures in Table I are applied in succession, if required, concomitant with primary resuscitative measures (artificial respiration and artificial circulation), until the return of spontaneous breathing and effective heart action. To provide a channel for quick administration of emergency drugs by the intravenous route, a continuous infusion of 1000 ml. 5% dextrose in water, through a No. 14-16 needle or an indwelling plastic catheter in a venous cut-down, is started and maintained as long as required.

Metabolic acidosis, an invariable accompaniment of cardiac arrest, whether the heart is in fibrillation or standstill, interferes with the restoration of normal function and contributes to the development of a potentially lethal hyperkalemia.[11] It must be reversed with hypertonic sodium bicarbonate intravenously, which is given as early as possible and repeated at 10-minute intervals as long as the cardiac arrest may last.

The quickest and simplest means of ventilatory assistance is through the use of first-aid adjuncts such as oral airways or self-inflating manually operated bag-mask devices. Ventilation may be enhanced by insertion of an endotracheal tube through a laryngoscope. Secretions are aspirated with suction apparatus and intermittent positive-pressure breathing is continued with 100% oxygen. Tracheotomy may be required if ventilation

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TABLE II.—POST-RESUSCITATION CARE

After breathing and heart action are restored, continuous observation and care are essential. Maintain intravenous infusion of 5% dextrose/water for rapid medication. Insert indwelling urinary catheter to measure urinary output.

1. Shock (Hypotension)

(a) Levarterenol (Levophed), 4-8 mg./1000 ml. infusion.

(b) Metaraminol (Aramine), 50-100 mg./1000 ml. infusion.

(c) Hydrocortisone, 100-400 mg. intravenously as required.

(d) Blood transfusion or substitute.

2. Congestive Heart Failure

(a) Oxygen, 4-6 l./min. per oxygen mask.

(b) Digoxin, 0.5 mg. intravenously, 0.25 mg. hourly to 1.5 mg. in six hours.

(c) In pulmonary edema, intermittent positive-pressure breathing with a pressure-cycled ventilator through an endotracheal tube.

(d) Rotating tourniquets to three extremities (dry phlebotomy), unless shock is present.

3. Cerebral Edema

(a) Urea 30%, 40 g./150 ml. (1.0 g./kg. body weight) intravenously (60 drops per minute).

(b) Hypothermia, to 31-33°C.

4. Renal Failure

(a) Mannitol 20%, 4 ml./min. intravenously to 100 ml. or until a urine output of 1 ml. per minute is established.

(b) Dialysis.

Attendants must be prepared to reinstitute first-aid and/or second-aid measures when necessary, combat electrolyte imbalance, prevent and treat infections.

cannot be achieved quickly in this way or when upper-airway obstruction prevents endotracheal intubation. Otherwise, tracheotomy is performed when coma is prolonged beyond two to three days. In the tracheotomized patient, intermittent positive-pressure machines provide the most efficient ventilation. Such machines may be automatic, appropriate for patients in whom the chest wall is unstable (e.g. stove-in chest), when respiratory musculature is ineffective (e.g. muscular paralysis), and when controlled hyperventilation is desired (e.g. renal failure). Patient-triggering intermittent positive-pressure machines (pressure-cycled ventilators, e.g. Bird respirator) are desirable for patients in the recovery phases of many conditions. The patient initiates the inspiration, which is then supported and increased by the machine. The machine starts the next inspiration automatically if patient-failure should occur. This time-cycling is discontinued if spontaneous respiration is resumed.[20]

The cardiac status is determined with the aid of an electrocardiographic monitor and electrical and/or drug therapy is provided accordingly. Ventricular fibrillation, if coarse, is best treated by external direct current defibrillation. To ensure intimate contact, electrode jelly is placed on the "paddles", which are firmly applied to the chest, one over the apex of the heart, the other over the manubrium sterni. If defibrillation is not successful or if an external defibrillator is not available, the administration of lidocaine (Xylocaine), an antiarrhythmic drug which depresses ventricular excitability, is recommended. Procaine amide, another potent antiarrhythmic drug, may be used, but the asystole it produces may be irreversible.[21] When feeble ventricular fibrillation is seen, conversion to coarse fibrillation, which is more amenable to electrical defibrillation, is attempted with adrenaline, a sympathomimetic inotropic drug which stimulates alpha and beta receptors, increasing the myocardial contractile force. In addition, calcium chloride, an antiarrhythmic agent which also increases myocardial contractility and converts feeble fibrillation to coarse fibrillation, may be used. When ventricular standstill is seen on the monitor, isoproterenol (Isuprel), an inotropic drug which stimulates beta receptors increasing the force and rate of myocardial contractions, is given. If this is unsuccessful, a bipolar electrode catheter may be passed through a brachial or jugular vein into the right ventricle and connected to an external cardiac pacemaker. Additional measures to initiate myocardial contractions include the administration of calcium chloride and adrenaline. Should ventricular fibrillation result from this treatment, defibrillation may be attempted as above. The most dreaded manifestation of heart block is the Stokes-Adams attack in which syncope may progress rapidly through convulsions to death. Such attacks most commonly result from ventricular standstill or fibrillation.[22] Isoproterenol which enhances the rhythmicity of sinus, subsidiary nodal and ventricular pacemakers should be used initially. In addition, treatment for standstill or fibrillation, as above, may be required.

The most popular alternative measures to the regimen in Table I include the administration of levarterenol (Levophed) 0.02%, adding 8-10 ml. to the intravenous infusion, or adrenaline 1:10,000, 3-5 ml. by intracardiac or intravenous injection. The former is an inotropic and vasotropic drug which acts on alpha adrenergic receptors, increasing myocardial contractility, producing peripheral vasoconstriction and elevating the blood pressure. The use of these drugs, even before the cardiac status can be determined, has been advocated. In standstill their advantages are obvious. In fibrillation their use is said to render even the coarse type more amenable to electrical defibrillation.[21]

If all else fails, thoracotomy may be performed by qualified personnel under ideal circumstances in an operating theatre. While intermittent positive-pressure breathing is continued, artificial circulation is provided by direct manual compression of the heart. Electrical defibrillation or stimulation may be applied directly to the heart. Cardiotonic and antiarrhythmic drugs may be administered directly into the heart.

Post-resuscitation Care (Table II)

Post-resuscitation care is best carried out in an intensive-care area where constant supervision by specially trained nurses is available. It should be continued for approximately 24 hours after the heart begins to beat spontaneously. An intravenous infusion is maintained so that medication can be given rapidly as required. An indwelling urinary catheter is inserted to facilitate observation of urinary output. Serum electrolytes are determined and any electrolyte imbalance is corrected.

To combat shock after cardiac arrest, levarterenol is given for its inotropic and vasotonic effects. Its use is recommended in combination with metaraminol (Aramine), another inotropic and vasotonic drug which is given because of its stable and prolonged action. Hydrocortisone may be beneficial in alleviating shock when adrenocortical insufficiency exists. When replacement therapy is indicated, blood transfusion or a substitute may be given as required.

Congestive heart failure may be treated by administering oxygen to overcome anoxia and decrease the work-load of the heart. Digitalis is given to counteract certain post-resuscitation arrhythmias, to increase the force of myocardial contractility, and to decrease the heart rate. The use of mercurials and benzothiadiazine diuretics is widely practised and will not be discussed here. Pulmonary edema which fails to respond to standard medical treatment may be treated by intermittent positive-pressure breathing through an endotracheal tube, and administration of oxygen in high percen-

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TABLE III.—POST-DROWNING CARE

Survivors of drowning must be hospitalized and given intermittent positive-pressure breathing with 100% oxygen long after the return of spontaneous breathing, until there is radiographic evidence of clearing of the lungs. Additional procedures listed below may be required.

A. FRESH-WATER DROWNING

Effects	Treatment
1. Hypervolemia and hemodilution	— Hypertonic saline solution or concentrated plasma intravenously.
2. Ventricular fibrillation	— Table I, Nos. 2, 3, 4(a), 5.
3. Hemolysis	— Partial exchange transfusion.
4. Renal failure	— Table II, No. 4.
5. Congestive heart failure	— Table II, No. 2.
6. Pneumonia	— Antibiotic and supportive therapy.

B. SEA-WATER DROWNING

Effects	Treatment
1. Hypovolemia and hemoconcentration	— Hypotonic solution (5% dextrose/water) intravenously (Table I, No. 1).
2. Tracheal and bronchial corrosive reaction and edema	— Tracheotomy for tracheal and bronchial toilet; ventilation with 100% oxygen.
3. Ventricular standstill	— Table I, Nos. 2, 3, 4(b), 5.
4. Pulmonary edema	— Table II, No. 2.
5. Pneumonia	— Antibiotic and supportive therapy.

tage with a pressure-cycled ventilator (e.g. Bird respirator).[20] If the patient is not in shock, rotating tourniquets may be applied to three extremities (dry phlebotomy).[22]

In the presence of cerebral edema, urea, an osmotic diuretic, may be given in a 30% solution, to lower cerebrospinal fluid pressure.[11] Mannitol may also be beneficial. Hypothermia reduces cerebral oxygen consumption and allows recovery of the hypoxic nerve tissue. It increases the tolerance of the brain to interruption of its blood supply, reduces intracranial pressure, and limits the processes which cause edema formation.[6] Patients are cooled with a refrigeration blanket or with chipped ice to 31° to 33° C. for two to four days. Beneficial effects are rarely observed beyond this time. With hypothermia, chlorpromazine or promethazine is often necessary to prevent shivering which may increase cerebral metabolism over 100% even at lowered temperatures.[11] Hyperbaric oxygen at three atmospheres pressure augments the transfer of oxygen in the plasma twenty-fold.[22] Its use in saturating hypoxic cerebral cells promises to yield rewarding results.[11]

In the treatment of post-resuscitation oliguria and anuria, mannitol in 20% solution is administered for its diuretic effect. Mannitol causes a fluid shift resulting in a decreased hematocrit, decreased blood viscosity and renal vascular resistance. The resulting increased renal blood flow reduces medullary osmolarity, increasing the output of urine. Hyperkalemia resulting from metabolic acidosis is relieved by administering hypertonic sodium bicarbonate intravenously, in addition to the mannitol diuresis.[11] If diuresis is not produced with mannitol, the patient may be artificially dialyzed.

Post-drowning Care (Table III)

Post-drowning care is especially emphasized because of the wide variation in physiopathological effects seen in fresh-water and sea-water drowning, the difference in treatment for each, and the importance of adequate follow-through therapy after spontaneous breathing is resumed.

FIRST-AID BREATHING EQUIPMENT

Adjuncts to artificial respiration do not relieve the operator of the responsibility of remembering the essential principles of mouth-to-mouth resuscitation. Such adjuncts fall mainly into two groups —airways and masks. Airways are inserted through the mouth. A mask is applied over the mouth and nose.

Airways are short, medium or long, depending on the length of the portion which is placed in the victim's mouth (Fig. 2).

1. *Labio-dental airways* (Rescue Breather, Orotube, etc.): These consist of a short channel through the victim's lips and teeth, and incorporate a mouthguard to provide a seal and a short blowtube for the rescuer. Simple, small and safe for the victim, these do not overcome obstruction in the front of the mouth which may be due to apposition of a large tongue against the palate, and they lack valves to protect the user against cross-contamination.[6]

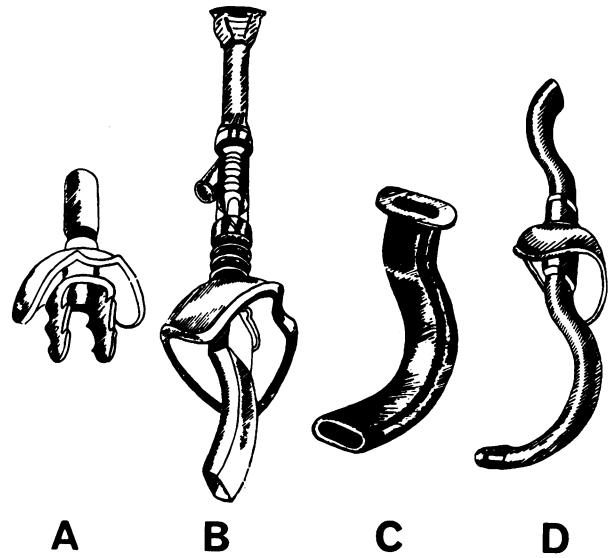

Fig. 2.—AIRWAYS: A. Rescue Breather; B. Brook airway; C. Guedel airway; D. Safar airway.

2. *Oral airways* (e.g. the Brook airway): This medium-length airway ensures air exchange through the victim's lips, teeth and the front of his mouth.[23] Obstruction by the tongue in the throat is prevented by correct hyperextension of the victim's head. A Nylon bite-block maintains a channel between the teeth. A mouthguard provides a seal. A flexible extension, which facilitates resuscitation when the victim cannot be ideally positioned, is connected to a non-return valve which diverts the victim's expired air from the rescuer's mouthpiece. The blowtube-valve assembly may be detached to permit suction of the victim's throat without removing the oral airway from his mouth. Two models are available. The professional model, with an oral airway with a length of 7.5 cm., is for use by professional personnel on victims over nine years of age. The all-purpose model, 4.0 cm.-length, is for general use at all ages over four years. It may also be used on an infant by removing the mouthguard and applying the victim's lips to the oral airway. Safe for the victim and easy to use, the Brook airway minimizes the danger of cross-contamination.[6, 14]

3. *Pharyngeal airways* (Guedel, double-Guedel, Safar (Resusitube), etc.): These are full-length airways which traverse the victim's mouth and reach the back of his throat. The Guedel has no mouthpiece for the rescuer, and is designed to facilitate spontaneous breathing in the deeply unconscious or anesthetized patient. The double-Guedel is made up of two back-to-back Guedel airways, one of which serves as a mouthpiece for artificial respiration. The Resusitube is similar but contains a larger mouthguard to provide a seal.

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Small and large models are available which provide four lengths of pharyngeal airway for the adult and the infant or child. It is made of a somewhat stiff plastic with a sharp pharyngeal tip.[6] The propriety of use of pharyngeal airways by the untrained public is controversial. Because of their length, retching, vomiting and aspiration of stomach contents may be induced when the victim is not deeply unconscious. An oversized pharyngeal airway may impact the epiglottis and obstruct the larynx. Lacking non-return valves, these airways afford minimal protection against cross-contamination.[6]

The use of nasopharyngeal, endotracheal and tracheotomy tubes as airways requires the skill of experts and is not suitable for first-aid treatment at the scene.

Masks cover the victim's mouth and nose (Fig. 3).

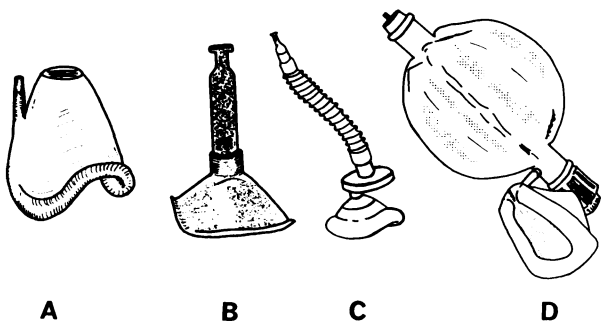

Fig. 3.—MASKS: A. Oro-nasal mask. B. Ventibreather; C. Emerson resuscitator; D. Ambu resuscitator.

1. *Oro-nasal mask*: This is a conventional part of anesthesia equipment. Manual strength and dexterity is necessary to prevent leakage due to variations in facial size, contour, hair growth, etc.[6]

2. *Oro-nasal mask with mouthpiece* (RP mask, Ventibreather, Globe and Emerson resuscitators, etc.): In these devices a mask has a rescuer's mouthpiece and a non-rebreathing valve. The last two have a flexible breathing tube. The Globe apparatus incorporates a rescuer's intake valve, which is optional with the Emerson.

3. *Oro-nasal mask with bag or bellows* (Ambu resuscitator, Kreiselman resuscitator, Emerson bellows resuscitator, U.K. field resuscitator, etc.): The victim is ventilated with atmospheric air by squeezing a bag or bellows. There is no hazard of cross-contamination.

The use of oro-nasal masks, with or without attachments, calls for experience in addition to skill and strength. The inexperienced rescuer may not be able to produce adequate inflation because of mask leakage. Upward traction on the victim's chin to open the airway closes his lips. Inspiration may occur through the nose, depending on the patency of that organ. Expiration may be blocked by a valving action of the soft palate. The expert, therefore, applies a mask with the victim's mouth held partly open and maintains pressure against the face to keep the mouth open. In other instances, the lips are kept apart, by using an airway with the mask. The rescuer must inspect the mouth frequently for vomitus or blood. The efficiency of mask-type devices varies directly with the skill of the operator.[6]

First-aid treatment may also be facilitated by the use of a suction device to remove undesirable secretions which may interfere with ventilation. In the field, aspiration may be quickly and easily accomplished by oral suction on a catheter inserted through an oral airway. A hand or foot suction pump, if available, may be attached to the suction catheter.

Propriety of First-aid Breathing Equipment

Mouth-to-mouth resuscitation is not new. It was widely practised from biblical times until 1530 A.D., when it fell into disrepute because of infections raging in Europe at the time. The method was dealt almost a lethal blow by Pasteur's discoveries and the germ theory of disease.[24] Its resurgence in recent years is due not only to the established adequacy of the ventilation it produces, but also to ineffectiveness of manual methods.[8] The more people who are trained in the mouth-to-mouth technique, the more lives will be saved.

Recent advances in resuscitative maneuvers have enabled professional personnel with sophisticated equipment to take quick, effective action when respiratory or heart stoppage occurs under ideal circumstances. The vast majority of heart-lung catastrophes, however, occur outside the operating theatre—elsewhere in the hospital, on the street, in the home, in the factory, on the beach, or in a mine. If many of these victims are to be kept alive to reach hospital, effective treatment must be applied promptly at the scene of the emergency—by the first persons to arrive or respond.

Mouth-to-mouth resuscitation can be applied without delay. Often, restoration of a victim's oxygen exchange by this means alone will save a life even when the heart merely flickers.[24] The fear of acquiring disease through intimate oral contact with apparently dead strangers is not unwarranted, however. This vital first-aid procedure is in danger of falling into disrepute again because of objections based on hygienic, sexual, racial or psychological grounds. These objections can be removed by the provision, on a wide scale, of a suitable airway to those likely to need these devices.[4, 6, 8, 9, 25-27]

A suitable airway will improve airway patency and will provide an effective seal against leakage, which is difficult to obtain when one's lips are applied to the victim's mouth which must be kept open to permit air exchange. Ideally, such a device must also be simple, inexpensive, portable, easily applied, safe for the victim and protective for the user. For this purpose the Brook airway (Fig. 2B) has received widespread acceptance as a useful first-aid adjunct.[5, 6, 10, 14-17, 23, 28, 29]

SUMMARY

The educational program in the treatment of cardiac arrest, undertaken during recent years by the University Hospital, University of Saskatchewan, is described. The techniques of artificial respiration and artificial circulation are taught to general practitioners, to specialists of the attending staff, and to the house staff of all the city hospitals. In addition, lay groups concerned with first-aid receive instruction through annual seminars. Through the co-operation of the University of Saskatchewan College of Medicine and the Provincial Division of The Canadian Medical Association, the newest techniques are brought to physicians in neighbouring medical districts.

The members of the medical profession, public health agencies and allied groups are urged to assume the responsibility of spreading this knowledge more widely. It is suggested that education in mouth-to-mouth resuscitation through the use of training aids be included in the health studies of all students in grade seven. Annual refresher courses should be provided thereafter, augmented by additional instruction through health, first-aid, safety, scout and other associations. In this way, many lives will be saved that might otherwise be lost.

The first-aid treatment of cardiac arrest is described, as is the follow-through (or "second-aid") therapy by experts, using sophisticated equipment and special drugs.

While enthusiasm for mouth-to-mouth resuscitation has waxed and waned through the centuries, its efficacy in an emergency situation has been established scientifically only in the last decade. Those who are repeatedly faced with emergencies involving resuscitation must be protected from the danger of cross-infection through the provision of suitable adjuncts to resuscitation.

Irreversible damage to heart muscle and brain may result unless skilful and intelligent treatment is instituted immediately to sustain oxygenation. The second-aid treatment which is available in medical centres and community hospitals will otherwise often be fruitless.

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PAGES OUT OF THE PAST: FROM THE JOURNAL OF FIFTY YEARS AGO

INFECTED WOUNDS: AN UNSOLVED PROBLEM

In the present war the wounds that come under treatment in the base hospitals are, in one respect at least, very similar to those met with in the American Civil War and the Franco-Prussian War: they are all infected, and for the most part heavily infected. They are the inevitable consequence of trench warfare, where strict personal hygiene is an impossibility, where the severely wounded may remain unattended for hours or even days, and where the seat of strife is in districts long under cultivation. There is little scope for primary aseptic surgery; and in major injuries antiseptics fail to prevent the development of infections deeply implanted at the time of injury. We are thus hurled back to the pre-listerian era; to the era of unsutured wounds, early amputations, spreading cellulitis, and gangrene. Many cases of fracture and of injury to the knee-joint have had to be subjected to amputation.

Shrapnel and shell produce lacerated and contused wounds; frequently carry in dirt and fragments of clothing; and are invariably the conveyers of infection, either gas or tetanus bacilli or the common pyogenic organisms. If seen early, excision of the lacerated and devitalized tissue and cauterization have had some vogue. Swabbing with 2 per cent alcoholic solution of iodine, or irrigation with tincture of iodine 2 drachms to the pint of water, carbolic acid 1:20 to 1:40, lysol 1 drachm to the pint, and peroxide of hydrogen, have proved useful. Peroxide appears to be especially indicated in sloughing or gangrenous wounds; but once the infection has made headway, the use of antiseptics has, in the opinion of many, proved utterly futile.

For gas bacillus infections no specific treatment has yet been found. The best results, however, are obtained by early amputation, leaving the stump wide open, and applying peroxide of hydrogen. In addition to the above methods heavy cauterizations are advocated by others. The mastery of the disease is for the future.—*Res Judicatæ, Canad. Med. Ass. J.*, 5: 717, 1915.