EMERGENCY MEDICAL CARE:

An Advanced Emergency Medical System for Dallas

GRAND ROUNDS

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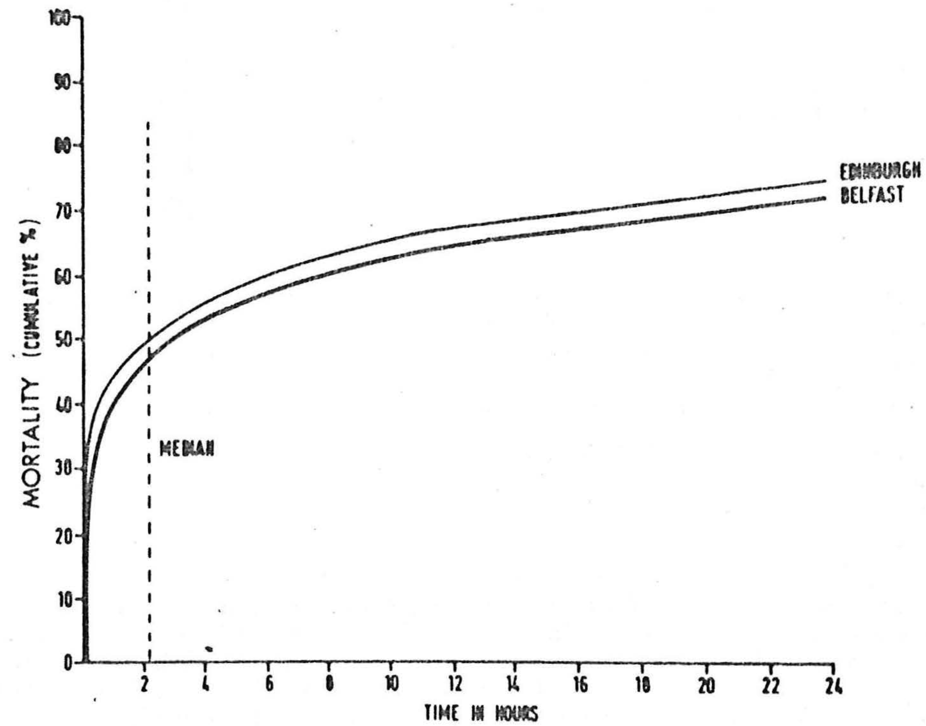
"The pre-hospital phase of acute myocardial infarction poses the greatest single medical problem of our nation in terms of loss of potentially salvageable life. Some advances in management are possible and have been demonstrated based on the current fund of knowledge. These advances consist of various means of foreshortening the pre-hospital or predefinitive care phase to allow earlier application of established technics of arrhythmia control."

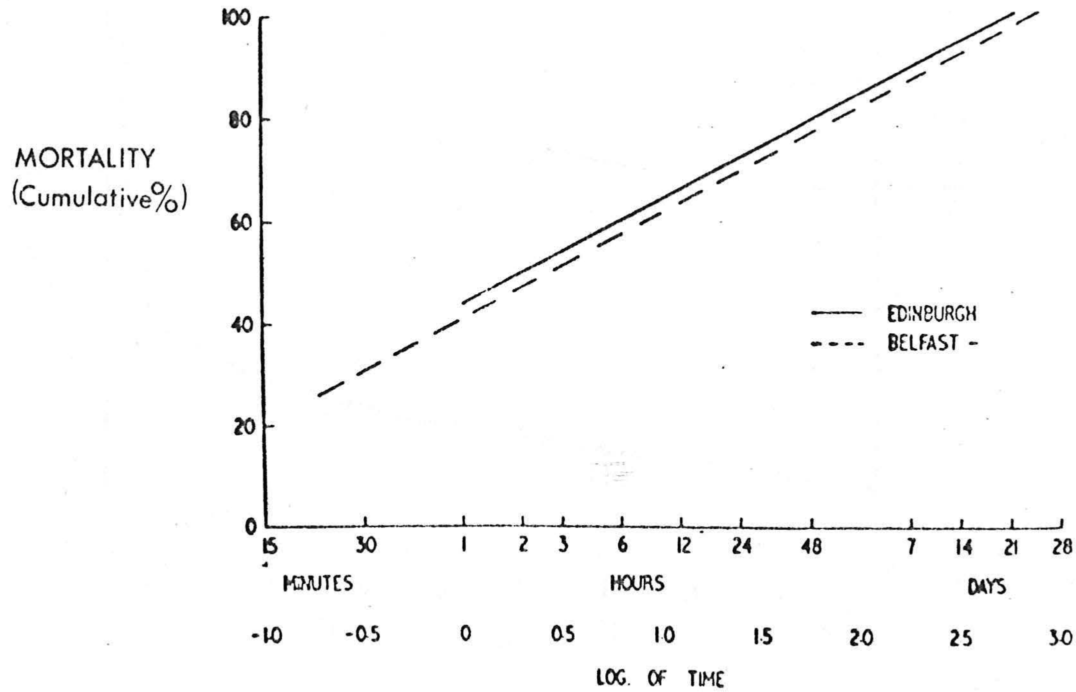
Stuart Bondurant (1)

INTRODUCTION

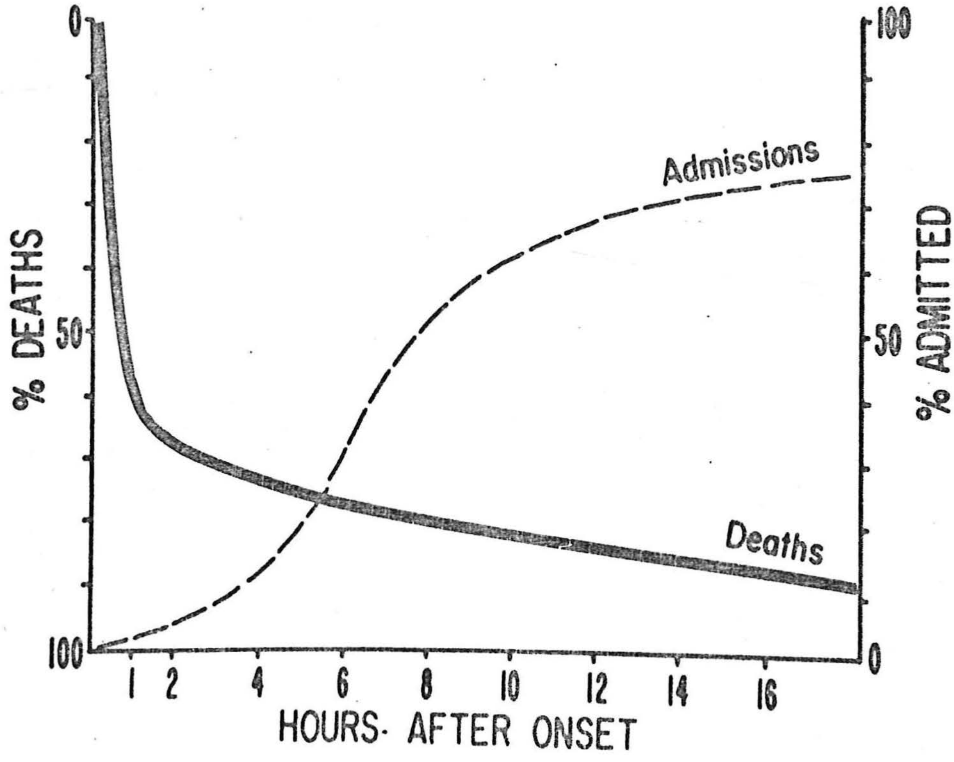
To properly examine the need and efficacy of an emergency medical system, it is necessary to review the natural history of an acute myocardial infarction and of sudden death. From the Edinburgh and Belfast studies as well as others (2-11), 15 to 30% of all patients with an acute myocardial infarction die within one hour of the onset of symptoms. And, if you only look at mortality, 40 to 75% of the mortality from acute myocardial infarction occurred during the first hour. When one looks at the first 24 hours after the onset of symptoms some 30 to 40% of all patients with acute myocardial infarction have died; this represents 60 to 90% of all deaths.



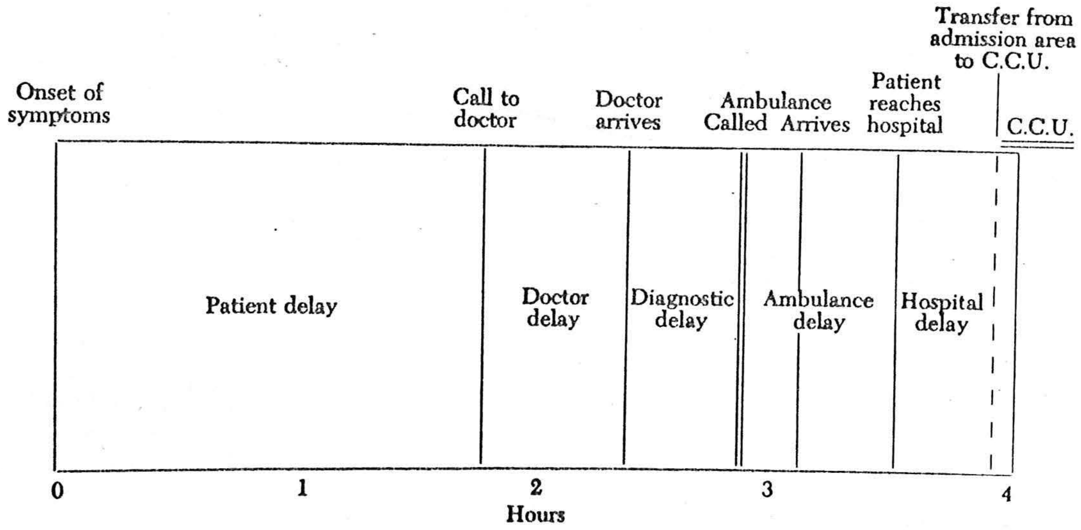
As can be seen from this graph derived from the Edinburgh and Belfast studies (2, 3), most of the mortality has occurred in the first 24 hours; at 24 hours the cumulative mortality was over 70%. The median time for mortality was slightly over two hours. Hence, the rate of mortality is far greater closer to the onset of symptoms than later.



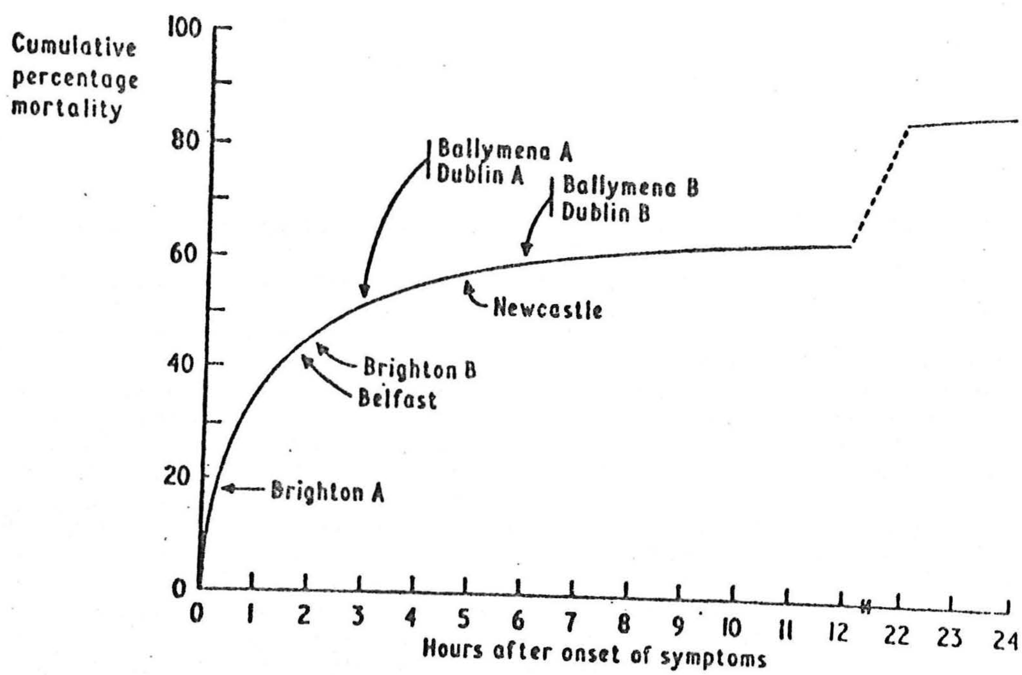
When cumulative mortality is examined over the four weeks after onset of symptoms, it can be seen that cumulative mortality is an exponential function of time, as is shown in the above figure where per cent cumulative mortality is plotted against the log of time. To be effective in reducing this early mortality it is apparent that we must provide entry into an adequate emergency care system as rapidly as possible.



On the figure above is superimposed the cumulative mortality curve after acute myocardial infarction and the cumulative admission curve showing that the majority of the mortality in acute myocardial infarction is outside of the hospital (12).



In this graph are shown the reasons for delay in the Edinburgh study (13). The biggest delay is caused by the time it takes for the patient to call his doctor. Hence, patient education is needed to minimize this time. Some authors (14) have been pessimistic about the role of patient education, believing that it will only cause denial in those patients with acute myocardial infarction and will cause a flooding of the system by patients with other problems. However, use of an early warning signs campaign in several areas of the United States including Dallas has failed to produce these unwanted effects. Though no definitive study has been performed it has been the observation of most emergency room physicians that the early warning signs campaign has shortened the patient decision time. There has been no flooding of hospital emergency rooms by patients with other causes of chest pain; a high majority of calls precipitated by the television, radio, and newspaper campaign has had significant disease. Hence, it does not appear that the fears of the skeptics of public education are warranted and more intensive use of public education would be beneficial. The second portion of the delay is the doctor delay which can be broken into two parts: the time it takes to notify the doctor and the time it takes for the doctor to decide that care is needed. This is one delay that can be considerably foreshortened. Several studies have shown that it is better for the patient to go directly to the hospital or call the ambulance and then call the doctor to meet the patient at the hospital. Ambulance delays can also be shortened considerably with a rapid-response system. With current technology monitoring can be accomplished upon arrival of the ambulance and can be continued through the emergency room to the coronary care unit, hence extending the coronary care unit to the patient.



This graph was accumulated by Orchard from several published reports (15). Plotted on the cumulative mortality curve are the average arrival times of different types of systems. Brighton A represents the median time of rapid-response ambulances dispatched by a direct phone call from the patient to a simple emergency phone number. Brighton B represents the median time of the same ambulances when a physician was notified first. Belfast and Newcastle represent ambulances dispatched from a central hospital with hospital personnel after first being notified by a physician. Ballymena A and Dublin A represent the median time in those cities for response of a hospital-based unit after being notified by a physician. Ballymena B and Dublin B represent the median time if the physician came to the house and ran an electrocardiogram before notifying the ambulance. Hence, mobile coronary care units arriving late would have a low in-ambulance mortality but would not significantly lower over-all mortality. While mobile coronary care units arriving early such as Brighton A would be expected to have a high in-ambulance mortality, they could potentially have a significant effect on lowering over-all mortality. It is important to keep this time relationship in mind when evaluating various studies.

It is important to remember the causes of mortality from acute myocardial infarction as some are more treatable than others.

CAUSES OF DEATH AFTER ACUTE MYOCARDIAL INFARCTION

Arrhythmias	40%
Cardiogenic shock	20%
Congestive heart failure	20%
Other	20%

(16)

As can be seen, arrhythmias account for 40% of the mortality while other causes account for 60% (16). To date we have only been able to make significant inroads into the treatment of arrhythmias. Hence, it would appear that there is a large number of people dying from acute myocardial infarction whose deaths might be preventable with earlier intervention.

In order to shorten the delay in obtaining medical care in an acute myocardial infarction, several methods have been proposed (17). First, patient and general public education to recognize the symptoms of coronary artery disease and to obtain medical care promptly must be accomplished. Second, professional education is needed as in most studies physicians have accounted for a significant portion of the delay in obtaining definitive care. Third, a rapid communications system is needed to obtain care quickly. In order to obtain definitive care at an earlier time than the coronary care unit can provide, three methods have been described (17). First, improvement in the hospital emergency rooms to provide better medical coverage and to provide monitoring preferably in an attached precoronary care area is needed. Second, establishment of life support stations at strategic locations where large numbers of people congregate, *i.e.*, festivals (18), stadia (19-21), large companies (22), etc, would be helpful. And, third, the use of mobile coronary care units to bring care to the patient is needed. Today we will examine this latter method.

It should be noted that another major attack on coronary disease is essential to reduce prehospital sudden death and that is to prevent sudden death by proper identification of those at risk and attempting to prophylactically treat these patients (1, 17).

MOBILE CORONARY CARE UNITS

Though the ability to telemeter physiologic data such as an electrocardiogram has been established for some time, only recently have systems been developed to telemeter data for patients in communities (23-27). Initially, physicians accompanied the unit and provided the therapy (28-37). Recently other personnel such as nurses (38) and paramedics have been utilized to run these units (39-46). Today in the United States most units utilize paramedics or nurses under radio telemetry to provide the therapy. The majority of paramedics come from Fire Department systems.

Most cities use one of two types of mobile coronary care units. Hospital-based units utilizing paramedics or nurses from the emergency room are used in smaller towns and where no centralized system can be developed; these units are usually dispatched after another ambulance or other personnel have arrived at the scene and decided an ambulance was needed. Other centers have tried to triage patients over the telephone. Lately, a second type of system has evolved and that is a fireman-paramedic type unit which responds to all calls. This latter type of unit has the advantage of a shorter response time and ability to care for more than cardiac patients. It is the latter system which we have developed in the City of Dallas.

CITY OF DALLAS SYSTEM

Background

In order to make inroads into sudden death and early care of acute myocardial infarction, a rapid emergency medical system is imperative. The City of Dallas and the 35-member Dallas Hospital Council jointly began to develop a model emergency medical system for a large metropolitan area which covers 300 square miles and has a population of over 850,000. Development of this system began in 1969 with the formation of an ambulance study committee. The committee has as its members representatives of the Dallas County Medical Society, the local trauma committee of the American College of Surgeons, Dallas County Hospital District, the Dallas Hospital Council, and the University of Texas Health Science Center at Dallas, Southwestern Medical School as well as city and county governments. A private consulting firm, Dunlap and Associates of Darien, Connecticut, was contracted to study the over-all situation and to make recommendations. The present program was an outgrowth of the recommendations set forth in the original Dunlap report.

A medical advisory committee was formed to guide the development of the program. This committee includes members of the Departments of Surgery and Medicine of the University of Texas Southwestern Medical School, members of the Dallas County Medical Society, and a hospital administrator representing the Dallas Hospital Council.

After investigation of systems currently available in the United States, a system was designed which was felt to best handle the Dallas situation.

The system selected was to utilize the Dallas Fire Department for personnel to establish and maintain a paramedical system.

It was felt that none of the existing models for distribution of men and equipment was adequate; so the City of Dallas developed a computer format for testing vehicle placement. From records obtained from the police for the year prior to the establishment of the Fire Department ambulance system, we knew the location of each emergency call and the time of day. It was then assumed that each ambulance would be out of service for one hour after each call. The locations of all fire stations were also entered into the computer. Modeling was then performed by the computer and a model was selected that gave an average response time of 6 minutes 34 seconds with less than 3% of the calls taking more than 10 minutes. During the first two years of operation we found that the average response time using this model was 4 minutes 32 seconds and that less than 2% of the calls were requiring more than 10 minutes. When comparing this method to the more common method of drawing maximal response time circles on a city or state map, ambulances are concentrated near the center of the city and more sparse in the periphery using the computer program. The reason for this is that in the center of the city there are frequently multiple calls requiring relatively close second and third-response units to maintain an overall low response time.

Training

An ideal training program includes not only lectures and demonstrations but an adequate amount of clinical experience (47, 48). The clinical experience is not merely observing others doing procedures but includes individual performance of the procedures used in the field under adequate supervision.

Choosing the men to be trained is essential. Strong motivation is an important ingredient, and to insure strong motivation they should receive adequate salaries or be dedicated volunteers. Fire Departments usually contain large numbers of dedicated personnel who are easily recruited to this type of duty. Personnel over 40 years of age require special mention. The older trainees have been longer removed from studying for a course and find it hard to adapt. Older personnel require up to twice the amount of classroom work as younger men, but these people can do a very adequate job if care is taken to properly train them.

Initially 300 men were trained as basic emergency medical technicians (EMT's). This training consisted of 80 hours of lecture and demonstration and 96 hours of clinical experience. Lectures covered anatomy, cardiopulmonary resuscitation, airway management, bandaging and splinting, childbirth, types and management of various medical problems. A typical class schedule is as follows:

WEEK 1

Monday	8:30-9:30	Introduction
	9:30-10:30	Before the emergency (film)

	10:30-11:30	Lung, circulatory, and topographic anatomy
	11:30-12:30	Lunch
	12:30-1:30	Vital signs
	1:30-2:30	Vital signs (practical exercise)
	2:30-3:30	Heart attacks, strokes, hyperventilation
	3:30-4:30	Drowning
Tuesday	8:30-9:30	Skeletal and muscular anatomy
	9:30-10:30	Fractures and dislocations
	10:30-11:30	Pulse of life (film)
	11:30-12:30	Lunch
	12:30-4:30	Bandaging and splinting (practical exercise)
Wednesday	8:30-10:30	Airways, pulmonary arrest, artificial ventilation, chronic lung disease, dyspnea
	10:30-11:30	Cardiac arrest: cardiopulmonary resuscitation (CPR)
	11:30-12:30	Lunch
	12:30-1:30	Prescription for life (film)
	1:30-4:30	CPR (practical exercise)
Thursday	8:30-9:30	Anatomy of abdomen and digestive system
	9:30-10:30	Shock and control of bleeding
	10:30-11:30	Operational procedures
	11:30-12:30	Lunch
	12:30-4:30	CPR (practical exercise test)
Friday	8:30-9:30	Male reproductive system, genitourinary system, injuries to external genitalia
	9:30-10:30	Care of laryngectomies
	10:30-11:30	Bites and stings
	11:30-12:30	Lunch
	12:30-1:30	Female reproductive system, menstrual cycle, injuries to external genitalia
	1:30-2:30	Emergency childbirth (film), miscarriages
	2:30-3:30	Pediatric problems
	3:30-4:30	Examination

WEEK 2

Monday	8:30-9:30	Anatomy of nervous system, injuries of spine
	9:30-10:30	Injuries of skull and brain
	10:30-11:30	Injuries to head, face, and neck; the skin, soft tissue injuries; anatomy and injuries to eye
	11:30-12:30	Lunch
	12:30-2:30	CPR (practical exercise)
	2:30-4:30	Traction splint (practical exercise)
Tuesday	8:30-11:30	Backboard and traction splint (practical exercise)
	11:30-12:30	Lunch
	12:30-4:30	Airway management (practical)

Wednesday	8:30-9:30	Burns
	9:30-10:30	Exposure to cold and heat, explosion injuries
	10:30-11:30	Electrical hazards (film)
	11:30-12:30	Lunch
	12:30-1:30	Autopsy and medical examiner procedures
	1:30-2:30	Protecting the crime scene
	2:30-3:30	Legal aspects
	3:30-4:30	Emergency room procedures
Thursday	8:30-10:00	Poison, diabetes, unconscious state; drug overdose
	10:00-11:00	Care of unruly patients, drug abuse, alcoholism
	11:00-11:30	Communicable diseases
	11:30-12:30	Lunch
	12:30-2:30	Injuries to chest and abdomen, the acute abdomen
	2:30-4:30	Practical exercise (all phases)
Friday	8:30-9:30	EMT interview
	9:30-11:30	Review
	11:30-12:30	Lunch
	12:30-2:30	State registry written examination
	2:30-4:30	Administrative time

The clinical experience for the basic EMT included:

Delivery room	16 hours
PMH medical emergency room	16 hours
PMH surgical emergency room	16 hours
Baylor emergency room	16 hours
Presbyterian emergency room	16 hours
Methodist emergency room	8 hours
Saint Paul emergency room	8 hours
Autopsy	8 hours
Recovery room	24 hours
Inhalation therapy	16 hours
Anesthesia	16 hours

All men now being hired for the Fire Department will become basic EMT's and will be stationed on fire engines to perform rescue work and to assist the advanced EMT's or paramedics.

The advanced EMT's or paramedics after one year of experience on ambuances were given 400 hours of training. This additional training consisted of 120 hours of lecture and 280 hours of clinical experience. The training was predominantly cardiovascular. The training included arrhythmia recognition, intravenous fluid therapy, and pharmacology. A sample lecture schedule is as follows:

WEEK 1

Monday	8:30-9:30	Introduction
	9:30-11:30	Medical terminology and abbreviations

	11:30-1:30	Lunch
	1:30-3:00	Normal heart
	3:00-4:00	Medical terminology and abbreviations
	4:00-5:00	Homework
Tuesday	8:30-11:00	Normal electrical heart
	11:00-12:00	Lunch
	12:00-3:00	Abnormal heart
	3:00-5:00	Coronary artery disease
Wednesday	8:00-9:30	Metric system
	10:00-11:30	EKG machine and applications
	11:30-12:30	Lunch
	12:30-2:30	Cardiogenic shock
	3:00-4:00	Introduction to intravenous fluid administration
	4:00-5:00	Homework
Thursday	8:00-9:00	Quiz and review
	9:30-11:45	Intravenous mannequin practice
	11:45-12:30	Lunch
	12:30-4:00	Supraventricular arrhythmias
	4:00-5:00	Homework
Friday	8:00-9:00	Quiz and review
	9:00-9:30	Break
	9:30-10:30	Hemorrhagic shock
	10:30-11:30	Communication orientation
	11:30-12:30	Lunch
	12:30-4:00	Ventricular arrhythmias
	4:00-5:00	Homework

WEEK 2

Monday	8:00-9:00	Quiz and review
	9:15-10:15	Rationale of intravenous fluid therapy
	10:30-11:30	Diabetes and hypoglycemia
	11:30-12:30	Lunch
	12:30-4:00	Atrioventricular conduction
	4:00-5:00	Homework
Tuesday	8:00-9:00	Quiz and review
	9:15-10:15	Abdominal pain
	10:30-11:30	Sterile techniques
	11:30-1:00	Lunch
	1:00-4:00	IV's
	4:00-5:00	Homework
Wednesday	8:00-9:00	Quiz and review
	9:30-1:00	Ventricular conduction
	1:00-2:00	Lunch
	2:00-4:00	Cardiac arrest
	4:00-5:00	Homework

Thursday	8:00-9:00	Quiz and review
	9:30-11:30	Congestive heart failure
	11:30-12:30	Lunch
	12:30-4:00	Drug treatment of arrhythmias
	4:00-5:00	Homework
Friday	8:00-9:00	Quiz and review
	9:30-11:30	Auscultation of lungs
	11:30-12:30	Lunch
	12:30-4:00	Arrhythmia review
	4:00-5:00	Homework

WEEK 3

Monday	8:00-9:30	Pharmacology
	9:30-11:30	Seizures and coma
	1:00-2:00	Lung disease
	2:15-4:00	Contagious diseases
	4:00-5:00	Homework
Tuesday	8:00-9:00	Quiz and review
	9:30-10:30	Bristoject
	10:30-11:30	SOP
	11:30-12:30	Lunch
	12:30-4:00	Arrhythmias
	4:00-5:00	Homework
Wednesday	½ Class	Cardiopulmonary resuscitation practice
	½ Class	Intubation and defibrillation
Thursday		Reverse of Wednesday's schedule
Friday		Final examination

The clinical experience for advanced EMT's or paramedics included:

Coronary care unit	40 hours
Medical emergency room	64 hours
Surgical emergency room	24 hours
Delivery room	16 hours
Laboratories and blood bank	40 hours
Intravenous teams	36 hours
Anesthesia	40 hours
Practical	16 hours

A total of 128 men have been trained with both the basic and advanced courses and it is these men who man the ambulances. Hence, these men have had a total of 200 hours of lecture and demonstration, 376 hours of clinical experience, and one year of field experience.

Basic EMT - 176 hours	
Lecture and demonstration	80 hours
Clinical experience	96 hours
Advanced EMT - Paramedic - 400 hours	
Lecture and demonstration	120 hours
Clinical experience	280 hours
Total Training	
Lecture and demonstration	200 hours
Clinical experience	376 hours
Field experience	1 year

Emergency medical technician dispatchers were given 80 hours of additional training prior to the inception of this program. This training consisted of telephone techniques, operation of radio equipment, recording equipment, status boards, and the other equipment used in the fire alarm and emergency medical services dispatch center. In addition, men were trained to monitor the base station at the hospital to provide rapid switching.

Ambulance Equipment

New ambulance designs provide sufficient height, width, and depth to provide essential room for trained personnel to perform basic life support, as well as administer fluids and drugs. The Department of Transportation recommendations are now recognized as an absolute minimum (49). The modular type ambulance is advantageous to either vans or "enlarged" vehicles; this type ambulance has more width and storage space and appears to be more stable. In addition, the modules outlast the chassis, making unit replacement far less costly although the initial cost is slightly more. With over two years' experience, we feel the modular ambulance is the best design currently available.

Equipment includes various types of splints, backboards, stretchers, extrication devices, bandages, oxygen, 2-way radio, and advanced life support equipment. A partial list of equipment includes:

4 stretchers - Ferno Washington, scoop, stairchair, collapsible
3 backboards - long, neck and chin straps, 4-foot
Splints - 2 hinged with ring, 6 assorted padded, cervical collar, 2 sandbags
Bandages - 4 x 4's, universal dressings, Kling, adhesive, triangular, universal, shears, safety pins, etc
Hemorrhage control - 4 Penrose drains, 4 assorted hemostats
Ventilation mechanical - bag-mask set, oxygen tank with extension tube, assorted pediatric and adult face masks, Ventimasks, nonrebreather mask
Airways - assorted oropharyngeal, nasopharyngeal, and tracheostomy
Aspiration - portable and truck vacuum types
Linen, blankets, sheets - sterile for burns
Obstetric set
Poison control - Ipecac and activated charcoal
Instruments - stethoscope, aneroid manometer with cuff, tweezers, thermometer, tongue clamp, ring cutter, flashlights

Solutions, packs, basins, and miscellaneous
Rescue equipment - 17 pieces
Defibrillator, monitor, and telemetry radio with phone coupler
IV administration kits, needles, and catheters
IV fluids - Ringer's lactate, 5% dextrose in water
Drugs - sodium bicarbonate, epinephrine, calcium chloride, lidocaine, atropine, isuprel, levophed, 50% dextrose, valium, benadryl
Esophageal airway, endotracheal tube, and laryngoscope

The City of Dallas has 22 fully-equipped ambulances. Normally 16 are in service with the others being in reserve. On Friday and Saturday evenings two extra ambulances are in service to handle the excess trauma.

Dispatch Office

A single telephone number was established for the entire City of Dallas for ambulance calls (744-4444). This number is on a rotation advance system whereby the number is automatically advanced to a clear line when the initial line is busy. Currently five trunk lines are in use with five additional lines of the same rotary reserved for future expansion when necessary. Complete new switchboards were installed to handle this function with additional capabilities of being answered from the fire command board in the event that the operators of the emergency medical system switchboard are talking on other lines. It is the plan of the city that as soon as necessary switching equipment is available to go to a 911 system; this will not be available until a new City Hall is completed in approximately two years. Straight-line telephones are also maintained between the fire department communications center, the Dallas police department, the Dallas County sheriff's office, Dallas Power and Light, Lone Star Gas Company, the Dallas Water Department, Dallas Love Field, Redbird Airport, Texas Instruments manufacturing company (25,000 employees), Southwestern Bell Telephone Services operators, and the Dallas/Fort Worth Regional Airport. Straight-line telephones have been installed from the EMS command center to the emergency departments of the five major hospitals of the city. The emergency medical system dispatchers notify receiving hospitals of impending arrival of all patients being transported to their facility by Fire Department ambulances. Information currently being relayed from the ambulance to the dispatcher to the hospital includes age and sex of patient, initial field diagnosis, condition of the patient, number of patients if more than one, and estimated time of arrival as well as what the patient's electrocardiogram is and what drugs have been administered. Time stamp clocks have been installed to provide an accurate means of recording all pertinent times associated with a particular alarm, *i.e.*, 1) time dispatched, 2) time arrived at location, 3) time left location, 4) time arrived at hospital, 5) time cleared hospital. In addition, special calls for assistance are recorded. Each ambulance is equipped with a four-channel VHF radio with scanner to monitor all channels and has a priority select mode for override on the primary ambulance frequency. A second UHF radio with five channels is available for EKG and voice telemetry to the hospital and voice from the hospital.

Computer terminals are installed between the command center and the Dallas Police Communications Center; these consist of cathode ray tubes for transmission of information from point of origin to the receiver. Receipt of information is also via hard copy magnetic printers. This system is duplicated on the opposite end of the system when the need for ambulance assistance is received by the police department. This system provides for entry into the system without delay or double telephoning. As an example, a call for a cardiac arrest which is received by the Dallas Police Department in mistake is automatically relayed to the Fire Department and the information is received at the EMS dispatching center. The EMS center realizing a cardiac arrest has occurred will dispatch the nearest fire engine which has trained personnel on board as well as the closest ambulance with paramedical personnel.

A 20-channel tape recorder has been installed to simultaneously record all radio transmission and telephone calls. This unit utilizes a 24-hour tape for informational storage. It has a built-in redundancy of double tape heads to allow one tape to be played back for audible verification of addresses in the event of hysterical callers.

A supply system was established to restock the ambulances without having the in-service units leave their areas of first-due response. A central supply is maintained in the center of the city at the Fire Department headquarters. Each station contains storage of expendable items in especially-constructed cabinets. A representative of each ambulance calls the central supply number each morning and delivers forms that have been filled out on patients seen by the system in the past 24 hours. These sheets not only contain the name, address, and vital information upon the patient but also contain information as to the patient's condition, what the patient's diagnosis was, what drugs were administered, what IV solutions were used, and what procedures were performed on the patient and what the patient's condition was upon arrival at the hospital. The forms are carbonless quadruplicate paper. The original is given to the hospital receiving the patient, the second and third copies are sent to the ambulance division office for processing, while the fourth copy is kept by the paramedic for his records. The second copy of the report is married to the first copy of the ambulance dispatch report using the incident control number. This copy is forwarded to the City of Dallas tax department for billing purposes and for statistical data storage. The medical information is gleaned from the report and placed into data storage for retrieval in computing the monthly activity reports. The third copy of the form and the second copy of the patient form and the second copy of the dispatch forms are filed in the permanent record of the call in the ambulance division office and are available for statistical data.

Current data being collected include the chronological list of ambulance calls with the following information on each: date, time, address, type of call, response time, time spent with patient at scene of alarm, response time to the hospital, total alarm commitment time, number of patients, and hospital receiving patients. Also included are physical examination, history, drugs given, any form of therapy, EKG, type of rhythms that the patient had.

Biomedical Telemetry

An EKG is obtained on the patient monitor either by quick look paddles or a patient cable. A modified lead II configuration is always used. The output of the monitor is connected to a 10-watt, biomedical radio and broadcast on a

UHF frequency to one or more of 7 receiving towers scattered around the city. The receiving towers are connected to Fair Park via dedicated phone lines. A voter at Fair Park finds the receiver with the strongest signal and locks onto this tower and releases the other towers. The signal is then carried via a dedicated phone line to the emergency room of Parkland Memorial Hospital where the base station is operated. From base station data can be sent to remote sites in the coronary care unit, the cardiac catheterization laboratory, the cardiology offices, and the surgery emergency room. Each radio channel has a stereo tape recorder to record both voice and EKG. As the medical orders from the physician are on a different frequency, the hospital and ambulance can speak at the same time as on a telephone.

The physicians can talk to the paramedics in the field from either the remote stations or the main base station. The hospital communication is then carried via dedicated phone lines to Fair Park where it is broadcast on a 250-watt transmitter on the WRR radio tower.

This telemetry system provides excellent coverage of Dallas County. If a unit is out of radio range, they may call via any telephone with their telephone coupler on a private line to the base station and telemeter EKG and voice data. This provides a backup system in case of failure of some component of the main system.

At present there are two biotelemetry channels established. Soon these will be expanded to five channels. The base station has a direct page phone for the emergency room, a private outside phone, a hospital extension phone, and a fire department phone that connects the fire department system and the emergency rooms of the major hospitals.

Standardized Therapy Regimens

Because of limited training and experience, a single method of treatment is best used by ambulance personnel. Standardization of procedures is essential to a good emergency system. For example, there are multiple volume expanders available; however, the relative efficacy of one to another is small and in an ambulance situation one will suffice. Some systems have utilized multiple agents which essentially do the same thing so as to please all physicians, but these require bulky drug lists and lead to confusion by personnel.

Some sample protocols are given below:

VENTRICULAR TACHYCARDIA

Conscious

1. Start IV with D_5W
2. Lidocaine 1% - 50 mg IV push (5 ml - ½ ampule)

If Unsuccessful

3. Repeat #2 every 2 minutes until successful or maximal dose of 300 mg lidocaine in 15 minutes is achieved

If Unsuccessful

4. a. Transport

Unconscious

1. Defibrillate
2. Start IV with D_5W

If Unsuccessful

3. Lidocaine 1% - 50 mg IV push
4. Defibrillate again

If Unsuccessful

5. Repeat #2 and #3 with CPR and

or b. Administer 10-15 mg valium IV push and defibrillate with low energy

When Successful

5. Start lidocaine drip, 2 g 4% lidocaine in 500 ml D_5W, drip 1-4 mg/min via microdrip

$NaHCO_3$ if needed

When Successful

6. Start lidocaine drip, 2 g 4% lidocaine in 500 ml D_5W, drip 1-4 mg/min via microdrip

VENTRICULAR FIBRILLATION

Defibrillator Immediately Available

1. CPR - chest thump
2. Defibrillate 400 watt-seconds
3. Start IV with D_5W

If Defibrillation Unsuccessful

4. Administer 2 amps $NaHCO_3$, 5 ml epinephrine (1:10,000)
5. Defibrillate 400 watt-seconds

Defibrillator Not Immediately Available

1. CPR - chest thump
2. Start IV with D_5W
3. Administer 2 amps $NaHCO_3$, 5 ml epinephrine (1:10,000)
4. Defibrillate 400 watt-seconds as soon as defibrillator available

If Still Unsuccessful

6. 50 mg lidocaine 1% IV
7. Defibrillate 400 watt-seconds

If Still Unsuccessful

Repeat #6 and #7 every minute until 300 mg lidocaine administered

Remember to repeat $NaHCO_3$ (½ initial dose) and epinephrine (initial dose) every 10 minutes

ASYSTOLE - (STANDSTILL) AND ELECTROMECHANICAL DISSOCIATION

1. CPR
2. Start IV with D_5W
3. Administer 2 ampules (100 ml or 89.2 mEq) $NaHCO_3$ IV push
4. Administer 5 ml (½ ampule) epinephrine 1:10,000
5. Administer 5 ml (½ ampule) CaCl 10%

If Unsuccessful After 10 Minutes

6. Repeat #3 with ½ initial dose (1 amp)
7. Repeat steps #4 and #5

BRADYARRHYTHMIAS

Treat If

A. 3° heart block with rate < 60
B. 2° heart block with rate < 60
C. Sinus bradycardia with rate < 60 and

if 1) systolic BP < 90 mm Hg and/or
2) neurological symptoms exist

Treatment

1. Start IV with D_5W
2. Atropine 0.5 mg (5 ml or ½ ampule)
3. a. If rate > 60 - observe - repeat #2 prn
   b. If rate has increased but still < 60, repeat #2
   c. If rate unchanged or rate still < 60 after 1 mg atropine,
      1) Start isuprel drip - 1 mg isuprel in 500 ml D_5W
      2) Use microdrip - drip 10 drops/minute and double rate every two minutes until rate 60-80

SHOCK

1. Start IV with D_5W
2. Rate and rhythm
   a. If rate < 60 treat as bradyarrhythmia
   b. If ventricular tachycardia exists treat rhythm
3. If rate and rhythm are adequate, check for volume loss; if volume loss exists, rapidly infuse Ringer's lactate (1000 ml bags)
4. If rate and rhythm are adequate and volume is adequate, start levophed drip - 4 mg in 500 ml D_5W; use microdrip - drip 10 drops/minute and double every 2 minutes until systolic BP > 90 mm Hg

ALLERGIC REACTIONS

A. Respiration unlabored and blood pressure adequate
   1. Start IV with D_5W
   2. Administer 50 mg benadryl IV push.
B. Dyspnea and/or shock
   1. Start IV with D_5W
   2. Administer 50 mg benadryl IV push
   3. Administer 2-3 ml of 1:10,000 epinephrine by slow IV push

PREMATURE VENTRICULAR CONTRACTION

Treat if any one of the following exists:

1. PVC's in a patient with chest pain
2. 2 PVC's in a row
3. Bigeminy
4. Multifocal PVC's
5. Malignant PVC's (R on T)

Treatment

1. Start IV with D_5W
2. Administer 50 mg 1% lidocaine (5 ml - ½ ampule)

A. If PVC's still exist
   Repeat #2 at 2-3-minute intervals until a maximal dose of 300 mg lidocaine has been achieved

B. Once PVC's controlled, administer lidocaine drip, 2 g of 4% lidocaine (50 ml) in 500 ml D_5W; use microdrip at 1, 2, 3, or 4 mg/min (15, 30, 45, or 60 drops/minute, respectively)

COMA

1. ABC's
2. Look for evidence of trauma
3. If 1 and 2 are ok draw blood sugar and do dextrostix
   If dextrostix < 130, administer 50 ml of 50% dextrose
   Start IV with D_5W

SEIZURE

1. ABC's
2. Look for evidence of trauma
3. Check blood sugar and administer 50 ml of 50% dextrose if dextrostix < 130
4. Valium 5-10 mg IV

ANY NEUROLOGICAL SYNDROME

1. Look for evidence of trauma
2. Check blood sugar and administer 50 ml of 50% dextrose if dextrostix < 130

Operational Studies

During the past year the operational statistics are as listed below:

STATISTICAL INFORMATION - 1974
Dallas Fire Department Ambulance Service

Total alarms	41,246
Average response time on total alarms	4:32
Average alarms per day	113
Average time spent with patient at scene	10:56
Average time from dispatch until patient was in hospital	25:45
Average time from dispatch until ambulance cleared from hospital	41:32

Alarm Source	
Telephone	71%
Police computer	27%
Walk in	1%
Fire Department radio	1%

Problem	Number of Patients	Per Cent of Total
Medical emergency	9166	22.2%
Major accident	7145	17.3%
Heart	3976	9.6%
Cuts/bruises	1458	3.5%
Overdose	1450	3.5%
Maternity	1357	3.3%
Gunshot wound	1276	3.1%
Stabbing	976	2.4%
Stroke	552	1.3%
Epilepsy	538	1.3%
Fracture	507	1.2%
Alcohol	430	1.0%
Fainted	344	0.8%
Psychiatric	172	0.4%
Burn	157	0.4%
Suicide	89	0.2%
Suffocation	71	0.2%
Poison	68	0.2%
Bite/sting	63	0.2%
Drowning	45	0.1%
Electrocution	25	0.06%
Other (False, no injury, sick, etc)	11,381	27.6%

As can be seen, the majority of calls are medical emergencies, major accidents, or heart.

On the next two pages are shown our standard report forms.

DALLAS FIRE DEPARTMENT
EMERGENCY MEDICAL SERVICES

PATIENT FORM

False or No Transport 1 2 3 4 5 6

Incident Number ____ of Patients

Police ☐ On Scene ☐ Requested Date____ Time____ AM PM Charge____

Envelope Issued ☐

Location____ Hospital____

Patient Name____ Birthdate____ M__ F__ Race____

Street____ City & State____ Zip____

Responsible Adult____ Phone____

Medicare #____ Medicaid #____

Employer____

Paramedic/EMT____ No.____ Ambulance____

Paramedic/EMT Dr.____ No.____ Shift____

Vital Signs: B P____ Pulse____ Resp.____ Allergies____

Severity	Type of Injury or Illness		Drugs	Aid Provided By Paramedic/EMT
Consciousness Con Semi Unc	☐ Agg. Assault	☐ Gunshot	☐ Sodium Bicarb	☐ EKG
Bleeding	☐ Alcohol	☐ Heart	☐ Lidocaine 1%	☐ Telemetry
Non Min Mod Sev	☐ Asthma	☐ Hypervent.	☐ Lidocaine 4%	☐ IV
in	☐ Auto Accident	☐ Hypoglycemia	☐ Atropine	☐ Drugs
Non Min Mod Sev	☐ Bite/Sting	☐ Maternity	☐ Isuprel	☐ Defib-Suc.
Location of Injury-Illness	☐ Burn	☐ Medical Emer.	☐ Levophed	☐ Defib-Unsuc.
☐ Head	☐ Convulsions	☐ Muscle/Skelat	☐ Epinephrine	☐ Esoph-Airway
☐ Face	☐ Cuts/Bruises	☐ Overdose	☐ Calcium Chl.	☐ Intubated
☐ Eye	☐ Diabetic	☐ Poisoning	☐ Benadryl	☐ Oxygen
☐ Neck	☐ Drowning	☐ Psychiatric	☐ Valium	☐ CPR-Suc.
☐ Back	☐ Drug Reaction	☐ Shock	☐ Dextrose 50%	☐ CPR-Unsuc.
☐ Chest	☐ Dyspnea	☐ Sickle Cell	☐ ____	☐ Cont. Bleed
☐ Abdomen	☐ Electrocution	☐ Stabbing	☐ ____	☐ Bandaging
☐ Pelvic Region	☐ Emer. Trans.	☐ Stroke	**IV**	☐ Splinting
☐ Upper Extremity	☐ Emphysema	☐ Suffocation	☐ Ringers Lac.	☐ Spine Board
☐ Lower Extremity	☐ Fainted	☐ Suicide	☐ D5W	☐ Anti-Shock
☐ Respiratory	☐ Female Comp.	☐ T.B.	**Response Code to Hospital**	☐ OB-Live Br.
☐ Cardiovascular	☐ Flu	☐ VD	☐ 1	☐ OB-Still Br.
☐ Other	☐ Fracture	☐ None	☐ 3	☐ Rotating TK
	☐ GI Complaint	☐ Other (Specify) ____		☐ Trans. Only
				☐ None
				☐ Other

Remarks____

Air Provided By
Fire Co. #____
Police #____
Doctor's Name____

Preliminary Admitting Diagnosis by Hospital____

Doctor or R.N. signature below does not approve or disapprove above information

Dr. or R.N.____
Signature Accepting Patient

DFD Form 200 Revised Aug. 74

WHITE — HOSPITAL, YELLOW — TAX, PINK — FILE, GOLD — PARAMEDIC

DEFINITIVE THERAPY

Incident #__________ ____________________ Patient's Name

EKG — if telemetered put T after rate in each box — Enter time rhythm noticed or of change to another rh

Sinus rhythm	time						
	rate						
PVC's	time						
	rate						
PAC's	time						
	rate						
Atrial fib-flutter	time						
	rate						
Nodal rhythm	time						
	rate						
Ventricular tach	time						
	rate						
Asystole	time						
	rate						
Ventricular fib	time						
	rate						
2° or 3° HB	time						
	rate						

D_5W — time started________ amount given________ IV-site________

R/L — time started________ amount given________ catheter size________

needle size________

Blood sugar — drawn________ Dextrostix________ $D_{50}W$ time________ amount________

Drugs — Pushes

Sodium bicarb	time						
	rate						
Epinephrine 1:10,000	time						
	rate						
Calcium chloride 10%	time						
	rate						
Atropine	time						
	rate						
Lidocaine 1%	time						
	rate						
Benadryl	time						
	rate						
Valium	time						
	rate						
Other	time						
	rate						

Drugs — IV Drip Amount added to 500 cc D_5W

Isuprel	time						
	rate						
Levophed	time						
	rate						
Lidocaine 4%	time						
	rate						

Defib — # of attempts________ successful________

Endotracheal______ Intubation — easy______ difficult______ traumatic______ # of attempts______

Esophageal______ Type blade — Mac#______ straight#______ Estimated time to intubate______ size______

Condition on arrival at hospital —

Vital signs — BP______ Pulse______ Respiration______ Comatose______ Awake______

Remarks

During the first two weeks of January 231 patients required advanced therapy. These 231 patients are shown in the following table.

Problem	# of Patients	Daily Average # of Patients	Per Cent of Total
Heart	142	9.46	61%
Hypoglycemia	10	0.66	4.3%
Gunshot wound	13	0.86	5.6%
Stab wound	7	0.46	3%
Trauma	28	1.86	12.1%
Required defibrillation	13	0.86	5.6%
Total	231	15.4	

Therapy given to these patients is shown in the following table:

Drug	Number of Patients	Per Cent of Total
D_5W	123	53.2%
Ringer's lactate	50	21.6%
$D_{50}W$	14	6%
Sodium bicarbonate	45	19.5%
Epinephrine	29	12.6%
Calcium chloride	12	5.1%
Atropine	20	8.6%
Lidocaine	56	24.2%
Benadryl	1	0.4%
Valium	9	3.9%
Isuprel drip	4	1.7%
Levophed drip	6	2.6%
Lidocaine drip	25	10.8%

During the first six weeks of the system 13 patients were defibrillated and arrived at the hospital potentially salvageable. Of these 7 patients survived and left the hospital; only one had neurologic impairment.

Case Study #1

Mr [redacted] was a 52-year-old [redacted] male with a history of coronary disease who was in his usual state of health when he suddenly slumped in his chair while watching television. The Fire Department was called. A fire engine arrived first and immediately began CPR. When the ambulance arrived, an EKG was telemetered to [redacted] where it was interpreted as ventricular fibrillation. Electrical countershock was unsuccessful. An IV was started and the patient was given sodium bicarbonate and epinephrine while CPR was continued. Electrical countershock was again unsuccessful. Drugs were continued at appropriate intervals and the patient was given 200 mg lidocaine. On the sixteenth attempt the patient was successfully defibrillated and returned to normal sinus rhythm. The patient awoke the next morning and after therapy for mild aspiration was discharged home in his normal state of health.

Case Study #2

Ms [redacted], an 83-year-old [redacted] woman with multiple episodes of dizziness and weakness who had been worked up frequently with normal EKG's, again developed weakness. A thready pulse was noted by the paramedics. A telemetered EKG revealed ventricular tachycardia. The ventricular tachycardia was controlled on 100 mg of lidocaine. After discharge on antiarrhythmic therapy the patient is asymptomatic.

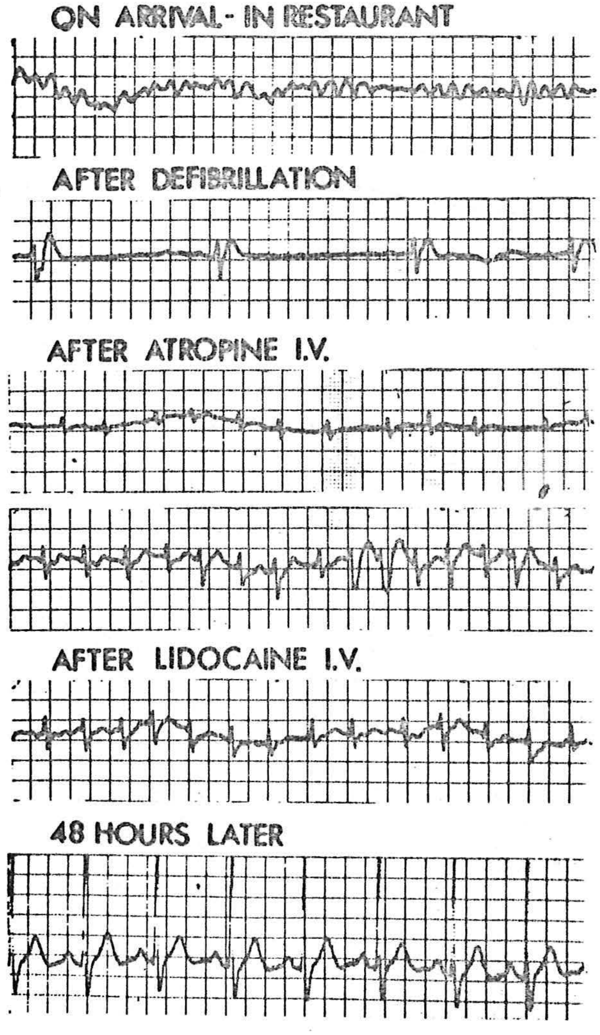
Case Study #3

Mr [redacted], a 52-year-old [redacted] male, called an ambulance after the onset of crushing chest pain. An initial EKG revealed normal sinus rhythm with a rate of 70. An IV with D_5W was started. While in transit, the patient suddenly lost consciousness and an EKG revealed complete heart block with a rate of 30. The patient responded to 1.0 mg of atropine and had an uneventful recovery.

Case Study #4

Mr [redacted], a 35-year-old physician with triple-vessel coronary disease and a history of two previous cardiac arrests, suddenly lost consciousness while watching television. His wife, a nurse, began CPR. On arrival of the ambulance, the patient was successfully defibrillated and recovered consciousness. While en route to the hospital the patient fibrillated twice more and was successfully defibrillated on both occasions. However, upon arrival at the hospital the patient fibrillated for a fourth time and resuscitation was unsuccessful.

Case Study #5


ON ARRIVAL - IN RESTAURANT
AFTER DEFIBRILLATION
AFTER ATROPINE I.V.
AFTER LIDOCAINE I.V.
48 HOURS LATER

Effectiveness of Mobile Coronary Care Units

Though mobile coronary care units are relatively new, considerable data have been generated in the last two years (30, 33, 47, 51-72). It appears that the incidence of major arrhythmias is higher at the scene and en route than in CCU's. The incidence of potentially lethal arrhythmias from several studies is as follows:

INCIDENCE OF ARRHYTHMIAS

		Number of Patients (Per Cent)						
Author	Total	PVC's	VT	VF	Idiovent Rhythm	Supravent Brady	3° Block	Asystole
Lewis (47)	162	51 (31%)	18 (11%)	39 (24%)	22 (14%)	25 (15%)	7 (4%)	21 (13%)
Grace (33)	33	14 (42%)	0 (0%)	3 (9%)	4 (12%)	6 (18%)	1 (3%)	1 (3%)
Sandler (30)	370	103 (28%)	8 (2%)	12 (3%)	12 (3%)	32 (9%)	33 (9%)	11 (3%)
Adgey (68)	284	163 (57%)	87 (31%)	54 (19%)	17 (6%)	108 (38%)	28 (10%)	
Total	849	331 (39%)	113 (13%)	108 (13%)	55 (6%)	171 (20%)	69 (8%)	33 (5%)

We can see from these data that there is a high incidence of arrhythmias early in myocardial infarction which may count for a large proportion of the mortality.

When the arrhythmias are examined by time after onset of symptoms, it appears that major arrhythmias are most likely in the first hour and tend to decrease after the first hour (68).

INCIDENCE OF ARRHYTHMIAS RELATED TO ONSET OF SYMPTOMS

	Number of Patients (%) Seen Within 1 Hr	Number of Patients (%) Seen Within 2 Hr	Number of Patients (%) Seen in 3-4 Hr	Number of Patients (%) Seen After 4 Hr	Total Number of Patients (%)
Bradyarrhythmia	88 (31%)	10 (4%)	6 (2%)	21 (7%)	125 (44%)
Vent ectopics	70 (25%)	36 (13%)	16 (6%)	41 (14%)	163 (57%)
Vent tachy	10 (4%)	16 (6%)	6 (2%)	55 (20%)	87 (31%)
Vent fib	28 (10%)	12 (4%)	2 (1%)	12 (4%)	54 (19%)
Atrial fib/flut	11 (4%)	0	0	15 (5%)	26 (9%)
Supravent tachy	1 (0.4%)	0	0	10 (4%)	11 (4%)
Sinus or nodal bradycardia	75 (26%)	9 (3%)	5 (2%)	19 (7%)	108 (38%)
With AMI (% of AMI)	24 (18%)	5 (4%)	1 (1%)	2 (2%)	32 (24%)
With PMI (% of PMI)	48 (36%)	4 (3%)	3 (2%)	16 (12%)	71 (53%)
AV block-2° or 3°	17 (5%)	2 (1%)	1 (0.4%)	8 (3%)	28 (10%)
With AMI (% of AMI)	1 (1%)	0	1 (1%)	1 (1%)	3 (2%)
With PMI (% of PMI)	15 (11%)	2 (2%)	0	7 (5%)	24 (18%)

Hence it is very apparent that a high number of patients have significant arrhythmias within the first hour of onset of symptoms.

When the incidence of successful resuscitation from cardiac arrest in ambulance units is examined in those patients who had onset of resuscitation within 5 minutes of arrest, the results are surprisingly good (20, 53-61).

PREHOSPITAL CORRECTION OF CARDIAC ARREST IN ACUTE MYOCARDIAL INFARCTION

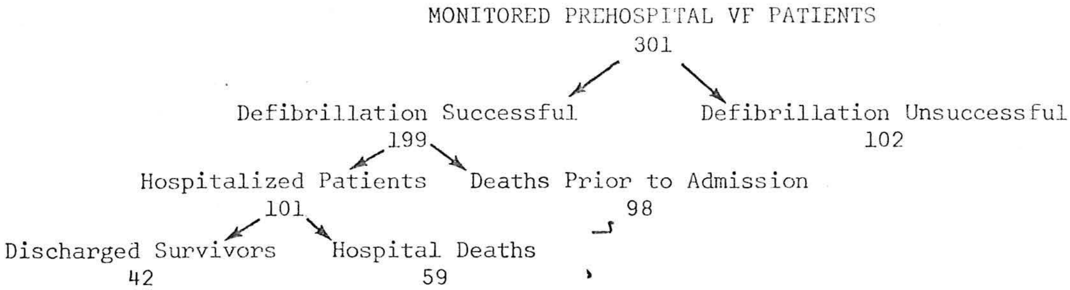
Source	Onset Resuscitation Under 5 Minutes After Arrest (Number)	Left Hospital to Resume Normal Life	
		Number	Per Cent
Belfast (53)	36	24	66.6
Ballymena (54)	5	3	60.0
Dublin (55)	20	11	55.0
Portland (56)	14	7	50.0
Brighton (57)	8	5	62.5
Seattle (58)	24	21	87.5
Charlottesville (59)	15	10	66.6
Columbus (60)	15	8	53.3
Waynesboro (61)	3	2	66.6
Lincoln (20)	8	7	87.5
Total	148	98	66.2

It is of interest to note that the success was the same whether a physician and nurse were at the scene or the arrest was handled by paramedical personnel. Therefore, paramedics appear to perform very adequately in this role.

Pantridge has reported that the success of resuscitation is related to the time between arrest and onset of therapy and the efficiency of therapy (34, 68, 69).

	Total	Vent Fib		Asystole	
		No	Survivors	No	Survivors
No resuscitation within 4 min	106	21	1	85	0
Resuscitation within 4 min (inefficient)	37	27	14 (52%)	10	0
Resiscitation within 4 min (efficient)	50	46	40 (87%)	4	0

Of the 55 initial survivors, 38 left the hospital. From these data several things are apparent. First, resuscitation is more successful the earlier it is started. Second, patients with asystole have a far worse prognosis than ventricular fibrillation. And, third, the initial rhythm is usually ventricular fibrillation while asystole tends to occur later; hence, most patients probably initially have ventricular fibrillation and if resuscitation is not started they go into asystole in 3-4 minutes.

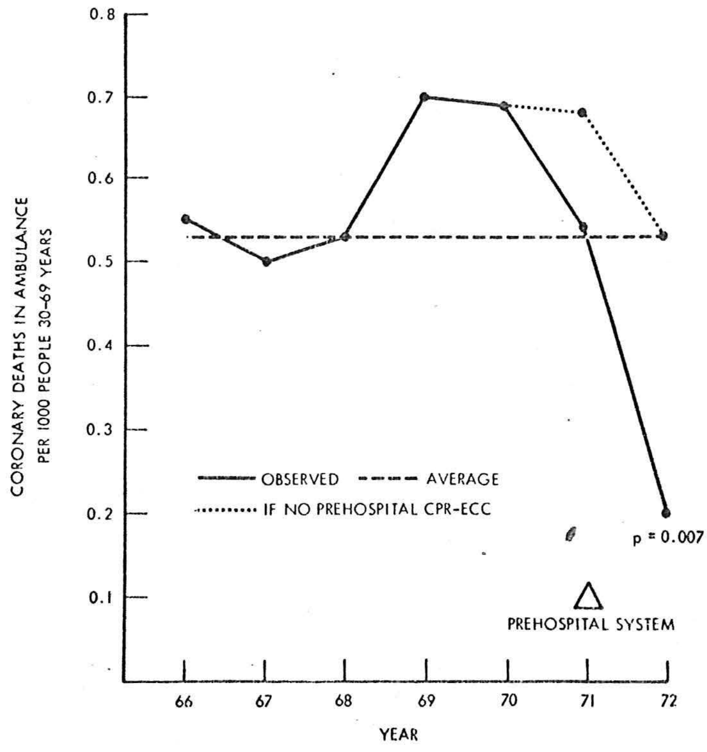


Hence, it appears that one of six patients with prehospital ventricular fibrillation can survive with an adequate mobile coronary care unit.

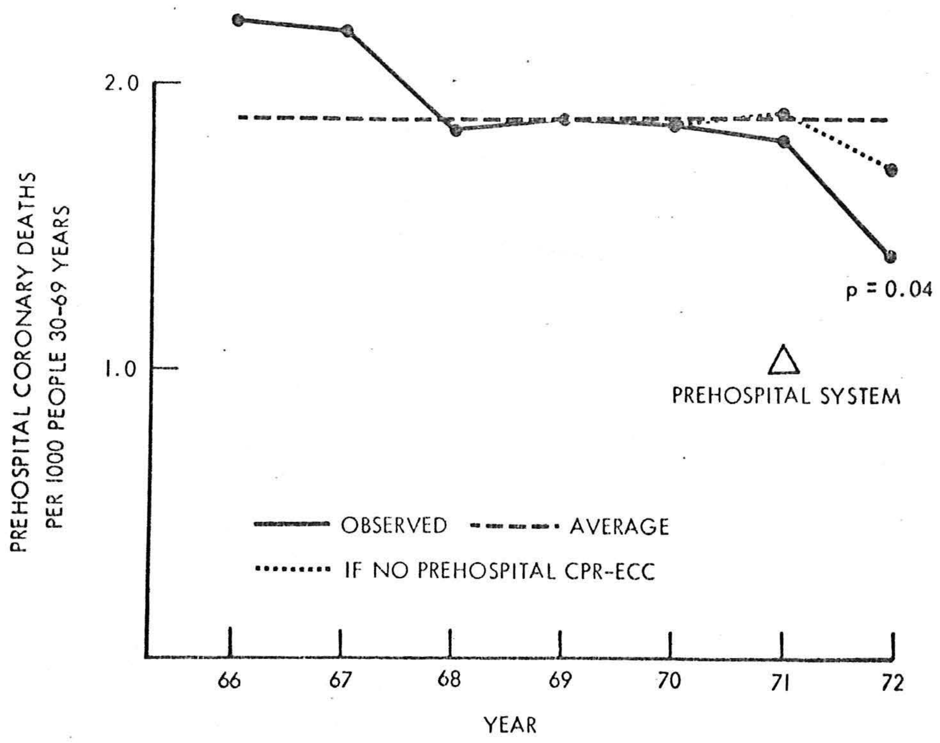
Surprisingly, the incidence of acute myocardial infarction in this group is lower than expected (45, 46, 72). In Nagel's series (46) only 35% of patients had electrocardiographic and/or enzyme incidence of acute myocardial infarction after successful defibrillation. Cobb (72) reported a 51% incidence of acute myocardial infarction after successful defibrillation. The majority of the patients without myocardial infarction had ischemia but no damage. Cobb (72) has shown that long-term prognosis depends upon whether the patient had infarction or not. Of patients successfully defibrillated with acute myocardial infarction the one-year mortality was 8%. Of patients successfully defibrillated with no evidence of acute myocardial infarction, only ischemia, the one-year mortality was 32%, the major mode of death being sudden death in spite of antiarrhythmic agents. This group of patients may warrant cardiac catheterization and consideration for coronary bypass surgery; however, no definitive trial has been undertaken.

Nagel (45) has shown that the majority of patients successfully resuscitated who had infarction had anterior infarctions (52%), while only 35% had inferior infarctions. This is of interest when compared to pathological series which show that when an infarction can be identified after sudden death 51% have inferior infarctions and 20% have anterior infarctions (45). Nagel has suggested that anterior infarctions may fibrillate early before pathologic signs have developed while inferior infarctions fibrillate later after pathologic changes have developed; this, however, is only an assumption.

The most important factor in evaluating these systems is the influence of the system on whole community survival. Crampton *et al.* (70, 71) have recently reported studies involving communitywide mortality.



In 1971 and 1972 an advanced prehospital system was utilized. The dotted line represents mortality if no resuscitation was available. The solid line represents the observed mortality. There was a significant reduction of mortality in the ambulance while the patient was being transported.



There was also a significant reduction in community mortality in the 30-69 year range. Crampton (70, 71) has shown that the system has saved 15.2 lives/100,000 people aged 30 to 69 years per year. Of total population the salvage rate was 6.4 lives/100,000 population. Webb (73) has found a salvage rate of 8.6 lives/100,000 population annually. When extrapolating these data to the City of Dallas, the system should be able to save 77 to 103 people per year who have ventricular fibrillation.

Of more importance is the reduction in mortality by prevention of ventricular fibrillation in patients with premature ventricular contractions. To date there is no adequate data on this subject.

Finally, the inhospital course has apparently been altered by prehospital stabilization. Inhospital mortality in those patients stabilized has been 8-10%

which is significantly lower than the 18-25% mortality reported in patients *not* receiving prehospital care either in other cities or in the same city (2, 4, 5, 74). The incidence of cardiogenic shock was also significantly less in those patients with prehospital care -- 3.5%. However, it is important to note that though statistically significant the number of patients studied is relatively low and no controlled study has been performed.

In conclusion, the acute care of acute myocardial infarction has been significantly altered resulting in a lower morbidity and mortality. These units also make major contributions in patients with overdoses, trauma, and hypoglycemia.

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