Medicopter:

An Airborne Intensive Care Unit

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THE VALUE of the helicopter for rapid evacuation of combat casualties has been shown in Korea and further refined in Vietnam. During the past 2½ years principles learned in the Military have been extended to a civilian setting utilizing an integrated team effort of three state agencies including the Ohio Army National Guard, Highway Patrol, and University Hospitals. This report describes the medical aspects of the first 50 patients evacuated by helicopter to the University Hospitals.

Components of System

The term "Medicopter" as used in this report refers to a medically equipped helicopter, large enough to carry two stretchers in an internal configuration along with medical personnel and special radio equipment. As such, the helicopter is just one component, e.g., transportation, in a system that includes the components of emergency medical care and communication.

Transportation. An Ohio Army National Guard UH-19D helicopter (Sikorsky S-55) was designated as the Medicopter and was used on all flights with one exception when a Fairchild Hiller FH-1100 turbine helicopter was utilized. The cabin of the H-19 has ample walk-around room for two or three medical personnel, two stretchers and medical equipment. Very few modifications were needed; a longitudinal pole with hooks was placed along the ceiling to hold the bottles of intravenous fluids.

The landing site at the University Hospital was an athletic field approximately 150 yards from the emergency room entrance. The patients were ordinarily transported by vehicle from the Medicopter to the emergency room. In those patients in whom cardiac arrest had occurred in flight, the Heartmobile (used to transport patients with fresh myocardial infarctions from home to hospital) was used for transfer from the Medicopter to the emergency room (Fig. 1).

Emergency Medical Care. Every flight included an on-board medical team consisting of a surgeon, and often a nurse. Standard monitoring equipment for display of ECG and pulse rate were powered from an auxiliary inverter. Medical equipment included endotracheal tubes, a laryngoscope, pneumatic splints, blood pressure cuffs, Ambu bag, portable electric suction apparatus, etc. The drug box included the standard drugs available for treating cardiac arrest in the hospital. The intravenous fluid used was Ringer's solution, exclusively.

Communication. A Highway Patrol radio was installed in the helicopter for direct communication with the Ohio High-

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FIG. 1. Patient being transferred from Medicopter to the Heartmobile. Cardiac massage is in progress. This is the only patient from the accident scene that did not survive.

way Patrol Communication Center in Columbus, and for direct voice contact with the patrol cruiser at the accident scene.

A portable mobile telephone in a brief case was used by the medical team in the cabin of the helicopter for direct contact with various parts of the hospital, such as the operating room, emergency room, etc.

Types of Response

This project was initiated on November 7, 1967, when a critically ill patient with a dissecting thoracic aneurysm was transferred by Medicopter from a community hospital 60 miles from Columbus to the University Hospital. From the beginning it was apparent that there was need for two types of response; including 1) those patients evacuated directly from the accident scene, and 2) those transferred from community hospitals (Table 1).

TABLE 1. *Types of Response*

	Total	Accident Scene	Community Hospital
All cases	50	25*	25
Day	17	6	11
Night	33	19	14
From base	37	12	25
During patrol	13	13	—

* 6 flights with multiple patients.

Accident Scene to University Hospital (25 Patients). The "scramble" capabilities needed for this type of response were met by assembling the flight crew including the medical team either at the hospital or airport (referred to as Base in Table 1) at the time of peak accidents. In the Highway Patrol District Six around Columbus, 12 per cent of the fatal accidents occurred between the hours of 4:00 p.m. to 2:00 a.m. Friday night, 11 per cent Saturday night and 6 per cent Sunday night. The Medicopter was available for scramble capabilities at least one of these three week-end nights, and often two nights each week end. During these periods the Medicopter was dispatched by the Highway Patrol Communication Center to all reported personal injury or fatal highway accidents at the same time the cruisers were sent. Nineteen of the patients were evacuated at night (Table 1). Because of the time lost (3 to 6 minutes) in getting to the helicopter, warming up the engine, and departing to an accident, the Medicopter with medical team on board patrolled the highways for

periods of 3 to 4 hours. On several occasions the Medicopter was on the scene of an accident within 2 minutes of the radio call. Thirteen of the 25 patients received immediate treatment as a result of these patrolling activities. The landing sites at the accident scenes were in fields adjacent to the highway, on the highway, or on the median strip depending upon local obstructions such as wires, poles, etc. The landing site was generally selected by the Highway Patrolman at the scene who was in radio contact with the Medicopter during the outbound flight. The Medicopter could not land at only one accident scene because of local obstructions.

Emergency medical care was initiated while the patient was still in the car when at all possible (Fig. 2). Ringer's solution was given to all patients with obvious blood loss and/or evidence of shock. Patients with head injuries received steroids at the accident scene. Particular attention was given to the airway. Generally only the most severely injured patients were taken on board the Medicopter. However, on five flights two patients were evacuated and on one flight, three children were evacuated. The distance traveled varied between 4 to 42 miles.

TABLE 2. *Types of Cases*

	All Cases	Accident Scene	Community Hospital
Trauma	41	25	16
Vascular	4	—	4
Cardio-respiratory	4	—	4
Gas gangrene	1	—	1
Total	50	25	25

Community Hospital to University Hospital (25 Patients). This type of response was available 24 hours a day. Pilots and medical team were on a recall basis from home at night. The quickest time from call to departure at night was 20 minutes; the longest time was 1½ hours depending on the coldness of the weather. Four patients included in this group were transferred during times that the Medicopter was on scramble capabilities. The departure time was 3 to 5 minutes. Approximately one half of this group of patients were transferred at night (Table 1). All calls for the Medicopter were screened by one of the authors; only those patients with critical illness or injuries that required inflight treatment were brought by the Medicopter. The distance traveled varied from 25 to 100 miles.

FIG. 2. Patient receiving treatment at the accident scene by surgeon from the Medicopter.

Types of Cases

The 50 patients have been divided into four groups as seen in Table 2.

Trauma Cases. This category accounted for most of the patients including all 25 from the accident scenes and 16 of the 25 who were transferred from community hospitals. Automobile accidents accounted for the cause of 75 per cent of the trauma occurrences, although airplane and motorcycle accidents, burns, and gunshot wounds are included (Table 3).

The injuries (Table 4) included ten patients with multiple injuries including head, chest, abdomen and extremity fractures. Sixteen of the 25 patients from the accident scenes had serious injuries and all 16 trauma patients transferred from community hospitals had serious injuries (Table 5). Nine of the 16 seriously injured patients from the accident scenes were in shock, e.g., blood pressure was less than 70 mm. systolic; four had no obtainable blood pressures. The airway category in Table 5 refers to patients requiring intubation; three had voluminous secretions amounting to more than 500 cc. One of the five patients at the accident scene listed as unconscious was still awake in the wrecked automobile where he received steroids. He became decerebrate during the 9-minute inbound flight and 8 days later he regained consciousness and made an uneventful recovery.

Two patients with spinal cord injuries, one with quadraplegia evacuated directly from the accident scene, and one with paraplegia transferred from a community hospital, had reduced morbidity. Both patients are now walking normally (Fig. 3).

TABLE 3. *Trauma Cases—Causes*

	All Cases	Accident Scene	Community Hospital
Auto	31	23	8
Plane	2	1	1
Motorcycle	2	1	1
Burns	2	—	2
Gunshot	2	—	2
Miscellaneous	2	—	2
Total	41	25	16

TABLE 4. *Trauma Cases—Injuries*

	All Cases	Accident Scene	Community Hospital
Head	17	11	6
Chest	16	6	10
Abdomen	11	4	7
Spinal cord	3	1	2
Burns	2	0	2
Lacerations, fracture	25	18	7
Multiple	10	5	5

Vascular Cases. This category includes nontraumatic cases including two patients with dissecting thoracic aneurysms, one with a ruptured abdominal aneurysm, and one with massive hematobilia from a ruptured hepatic artery aneurysm to the common bile duct.

Cardio-Respiratory Cases. Two patients in this category had cardiac arrests prior to the request for transfer. In one of these cases, an 18-month-old child with a foreign body in the trachea above the subsequent tracheostomy had two cardiac arrests during the inbound flight. The other patient, a 41-year-old man with a fresh myocardial infarction with cardiac arrest and subsequent complete heart block had a transvenous pacer inserted at the community hospital by one of the on-board medical team and had an uneventful transfer by Medicopter. The third patient with respiratory arrest, following abdominal operation at a community hospital, had an uneventful transfer by Medicopter during endotracheal intubation and respiratory maintenance with an Ambu bag. The last patient in this category had severe shock from phlegmasia cerulea dolens and pulmonary embolus.

Survival

Of the entire series of 50 patients, 37 (74%) survived to leave the hospital.

TABLE 5. *Trauma Cases—Findings*

	All Cases	Accident Scene	Community Hospital
Minor injuries	9	9	0
Serious injuries	32	16	16
Shock	17	9	8
Airway	13	4	9
Cardiac arrest	3	1	2
Unconscious	12	5	7
Paralysis	2	1	1

There was a marked difference in survival according to the site of pickup. From the accident scene, the nine patients with minor injuries all survived. Fifteen of the 16 patients with serious injuries survived (Table 6). From the community hospitals, all 25 patients were in serious condition; only 13 survived (Table 7).

Assessment of Medical Benefit

The survival data do not pinpoint any specific value of helicopter evacuation and treatment during the inbound flight. The assessment of specific medical benefit of this project is documented by patients who arrived alive who otherwise would have been dead on arrival—by the usual means of conveyance. Thirteen patients were in this category; they were either not breathing, had voluminous secretions, cardiac arrest, or were in profound shock. Six of these patients, including four from the accident scenes and two from community hospitals survived and were discharged (Table 8).

Potential DOA's from the Accident Scene. All five patients in this group had multiple injuries; five sustained head and chest injuries and all but one had abdominal injuries in addition to extremity fractures (Table 9).

Two patients were reported as "dead" at the accident scene. One had a brain stem contusion, bilateral pneumothorax with a flail chest, massive abdominal bleeding due to a torn splenic artery and spleen in addition to an extremity fracture. This patient was intubated at the scene and received 3,000 cc. Ringer's solution on the inbound flight. Following operation, he had an uneventful recovery. The other patient reported as "dead" at the scene sustained ventricular fibrillation and required cardiac massage. Thoracotomy and celiotomy were carried out after arrival in the emergency room but all efforts at resuscitation failed. This patient was the only fatality of the 25 patients who were transferred from the accident scenes.

The time sequence was best documented in the fifth patient in Table 9. The Medicopter was at the accident scene within 6 minutes after being alerted (16 minutes after the occurrence of the accident). The patient was unconscious and without respiratory movement. He was intubated, Ringer's solution was started; during the inbound flight the operating rooms were alerted by mobile telephone. The patient was in the operating room, stabilized, with the shattered left lateral segment of the liver resected and diaphragm repaired before the other five patients from the same accident arrived by ambulance. This patient was unconscious for 4 weeks following which he made a gradual recovery and was discharged 12 weeks later. The mental status at the time of discharge was not yet normal but daily improvement was noted.

TABLE 6. *Survival—From Accident Scene*

	#	Survivors
Minor injuries	9	9
Serious injuries	16	15
Total	25	24 (96%)

TABLE 7. *Survival—From Community Hospital*

	#	Survivors
Trauma	16	10
Vascular	4	1
Cardio-respiratory	4	2
Gas gangrene	1	0
Total	25	13 (52%)

TABLE 8. *Assessment of Medical Benefit*
Potential DOA's That Survive

	Accident Scene	Community Hospital
13 patients-potential DOA's of these—	5*	8
6 patients survived to leave hospital	4	2

* 2 patients originally reported as "dead."

TABLE 9. *5 Potential DOA's—Accident Scene*

Head, chest, fracture*
Head, flail chest, spleen, fracture*†
Head, cardiac arrest, spleen, fracture†
Head (bilateral subdural), chest, fracture*
Head (subdural), respiratory arrest, ruptured liver, diaphragm, fracture*

*Survived.
† Originally reported as "dead."

Potential DOA's from Community Hospitals. Only two of the eight patients in this category had long-term survival and were discharged (Table 10).

One, a patient with a transection of the thoracic aorta (Fig. 4) had an aortogram at the community hospital during the outbound flight. During the 39-minute inbound flight he received four liters of Ringer's solution and the cardiopulmonary bypass team was alerted by mobile telephone. This patient made an uneventful recovery after repair of the transected aorta with a Teflon graft utilizing partial cardiopulmonary bypass.

Of the four patients with multiple injuries none survived. We learned an important lesson from one occurrence; the patient was semiconscious with a blood pressure of 60 when the Medicopter arrived at the community hospital. Before placing the patient on board the helicopter, he was intubated and the scalp vein needle was replaced by two large bore plastic catheters and dextrose intravenous fluids were replaced by Ringer's solution. Approximately 15 minutes into the 40-minute inbound flight and just *before* the second bottle of Ringer's solution was hung in the helicopter, cardiac arrest occurred. It was impossible to restart the heart and it was noted that the intravenous fluids were cold (outside temperature 23°). Subsequent to this experience the bottles of intravenous fluids were arranged in front of the heater outlet in the cabin.

Inflight Treatment. In order to elucidate the role of the medical team, the inflight treatment of potential DOA's is summarized in Table 11. The treatment can be grouped into two categories including airway, e.g., intubation and aspiration of secretions, and cardiovascular support, e.g., Ringer's solution and cardiac massage. All 13 patients required intubation and 12 patients were given intravenous Ringer's solution in large quantities (1,500 to 3,000 cc.). Three patients required cardiac massage during flight; the heart was restarted in two instances.

Discussion

Several lessons have been learned from this project. The need for an integrated team effort was recognized from the beginning. Each of the three state agencies

TABLE 10. *8 Potential DOA's—Community Hospital*

Respiratory arrest
Cardiac arrest
Transected aorta, fracture*
Chemical burn*
4-multiple injuries (head, chest, abdomen, fracture)

* Survived.

TABLE 11. *Potential DOA's—Inflight Treatment*

	All Cases	Accident Scene	Community Hospital
Airway	1	1*	0
Airway and i.v. fluids	9	3***	6**
Airway and i.v. fluids and cardiac massage	3	1	2
	—	—	–
	13	5	8

* = No. of survivors.

FIG. 3. X-ray showing fracture dislocation of lumbar spine. This patient underwent immediate open reduction and fusion following which she had an uneventful recovery.

contributed to the initiation of the project in an equal way. Then as it became apparent that lives were salvaged because of team work, enthusiasm was even greater.

In discussing the Army "Dustoff" helicopter evacuation of battle casualties in Vietnam, General Neel[1] stated that "the helicopter is not a form of treatment; it is but a machine." Unlike the Army Medical Service Corpsmen, civilian rescue squad personnel are restricted from administering intravenous fluids and drugs and ordinarily do not insert endotracheal tubes. For this reason we chose a physician to be part of the medical team. It became clear that support of the respiratory and cardiovascular systems, which required emergency medical care, influenced survival in critically injured patients with multiple systems involved. Until such time that state laws will permit qualified rescue squad personnel to administer intravenous fluids and drugs, a surgeon will remain part of the medical team in this project.

The authority for use of military helicopters on the highways appears in the National Search and Rescue Plan of 1961.[4] The expense is likely to be a major factor in relying on military forces for helicopters and crews.[3,4] The Army National Guard pilots involved in this project were all local residents and as such were familiar with the network of highways which can become particularly confusing at night.

As surgeons, utilizing a variety of instruments for various jobs, we agree with Igor Sikorsky's statement[2] that the "helicopter is a major instrument for saving lives."

Summary

1. A total of 50 patients have been evacuated by Medicopter to University Hospital during the past 2½ years.

2. Twenty-four of the 25 patients (96%) evacuated directly from the accident scene survived.

3. Thirteen of 25 patients (52%) transferred by Medicopter from community hospitals survived.

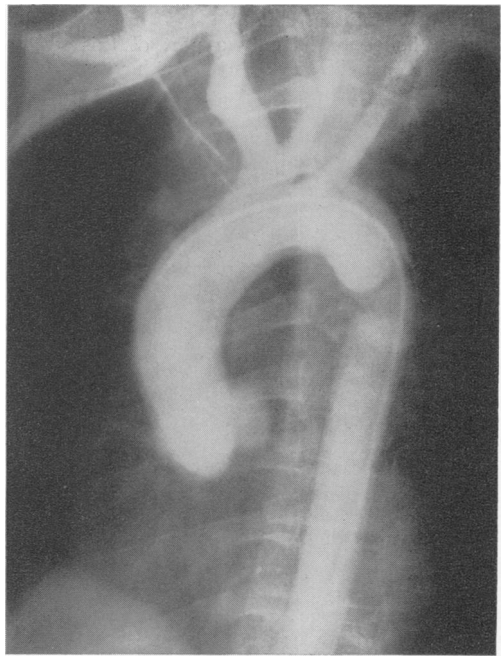

FIG. 4. Aortogram showing a transection of the thoracic aorta just distal to the origin of the left subclavian artery. This patient received 4,000 cc. Ringer's solution during the inbound flight and had an uneventful recovery after repair of the aorta utilizing cardiopulmonary bypass.

4. Six of 13 patients that would potentially be dead on arrival by usual means of transfer survived to leave the hospital.

5. Two patients with spinal cord trauma had reduced morbidity.

6. The medical aspects of treatment at the scene and during inbound flight are discussed.

Acknowledgment

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Discussion

Dr. Thomas J. Whelan, Jr. (The Surgeon General's Office, Department of Army): Dr. Roberts and his group are to be congratulated upon describing an entire system for the emergency care of seriously ill or injured people in the region of Columbia, Ohio.

The helicopter is only a part of this system, albeit the common denominator without which the remainder of the system would be neither necessary nor applicable.

The U. S. Army Medical Department has had broad experience in this field. The wounded man in our system, at the time of helicopter pickup, has usually already received emergency medical care, including the initiation of intravenous fluid. The helicopter in this setting, therefore, is used primarily for rapid transportation.

In contrast, at the civilian accident scene, the medicopter serves as a forward medical facility as well as a machine for rapid evacuation.

Although the helicopter with its deafening noise and vibration is not the optimal intensive care location, there would appear to be no alternative in the civilian setting at the accident scene.

In order to reduce further the delay from accident to hospital, prepositioning of helicopters close to accident-prone loci may be looked for in the future, perhaps at highway patrol stations. However, prior to such a change in positioning, the full use of paramedical personnel must be approved. The presence of a doctor and nurse with such a prepositioned helicopter is too wasteful of a scarce and skilled resource. Therefore, the necessity of a corpsman or a physician's assistant with the helicopter becomes clear. Further, the necessity of correction of legal constraints upon the use of such individuals is mandatory.

The institution of this medical evacuation system has changed the practice of surgery at forward hospitals. Patients which were seen only in the morgue in earlier wars now survive to undergo operation. With the early arrival of severely wounded men to the hospital, the necessity for earlier operation as an integral part of resuscitation becomes more frequent.

The presence of outstanding, young, well-motivated surgeons at all times in these hospitals and the sense of urgency in well-equipped emergency and receiving areas are essential ingredients of this system.

I should like to ask Dr. Roberts if there was an excessive time lag between injury and pickup in those cases coming from community hospitals and if any of these patients were transferred after initial operation at the community hospital?

Were there other late cases of sepsis in addition to the case of gas gangrene?

I am certain that this group represents a selected group, selected upon the basis of severe illness or injury, but I wonder if there are other factors such as excessive time lag to explain the less favorable results.

Dr. Roberts will soon be going to Vietnam as surgical consultant to the U. S. Army for one year. In this capacity, he will have direct access to an effective system of emergency medical care from which new ideas and innovations for the delivery of emergency medical care will be derived.

Dr. Francis C. Jackson (Aspinwall): I would like to emphasize that emergency medical services are essentially provided in three phases.

Phase I exists prior to the Emergency into the Department. Phase II is within the hospital and Phase III consists of rehabilitation or the maxi-