age is available, height as percentage of expected height for age, again based on the Boston standard. This is a measure of retardation and therefore of past malnutrition.

For the qualitative classification of severe cases the Wellcome system is proposed. In each group additional data should be recorded so far as possible. It is essential that the criteria for including children in the classification should be clearly laid down.

International comparisons obtained by these methods would be extremely valuable.

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Accident Flying Squad

ROGER SNOOK

British Medical Journal, 1972, 3, 569-574

Summary

This paper describes the organization, evaluation, and costing of an independently financed and operated accident flying squad. 132 accidents involving 302 casualties were attended, six deaths were prevented, medical treatment contributed to the survival of a further four, and the condition or comfort of many other casualties was improved. The calls in which survival was influenced were evenly distributed throughout the three-and-a-half-year survey and seven of the 10 so aided were over 16 and under 30 years of age, all 10 being in the working age group.

The time taken to provide the service was not excessive and the expense when compared with the overall saving was very small. The scheme was seen to be equally suitable for basing on hospital or general practice or both, and working as an integrated team with the ambulance service. The use of specialized transport was found to be unnecessary. Other benefits of the scheme included use of the experience of attending accidents to ensure relevant and realistic training for emergency service personnel, and an appreciation of the effect of ambulance design on the patient.

Introduction

The concept of this research project developed during the early stages of working in an accident department in 1965, and further impetus came from the experience of chance arrival at the scene of road accidents. In the accident department contact with members of the emergency services was frequent, and I became increasingly aware of the problems that they had to face—in particular, cases for which the resuscitative measures required before admission to hospital were beyond both their training and equipment. This gap between the ambulance and

accident services was widened by the fact that hospital equipment was often incompatible with that of the ambulance service.

The project developed in four related stages—lecturing to the ambulance staff, the organization of an independently financed and operated accident flying squad, the introduction of hospital training for the ambulancemen, and the investigation of ambulance design.

In 1966 there was little literature on the organization of medical attendance at accidents in Britain. Hall¹ and Collins² had described hospital-based teams with medical or nursing staff transported respectively by ambulance and police car, and Easton's scheme involving general practitioners was not started until December 1967.³ The major publication was an English translation⁴ describing Professor Gögler's organization in Heidelberg, West Germany. In this scheme medical treatment at accidents was based on the introduction of a large mobile operating theatre unit in 1957.

These three hospital-based schemes all involved the use of specialized transport. The alternative, therefore, was to investigate the usefulness of one doctor attending accidents in his own car and carrying his own equipment. This paper describes the organization, equipment, and evaluation of medical attendance by me at the scene of accidents and the integration of this within the ambulance service during the three-and-a-half-year period starting in November 1967 after a period of feasibility study. On completion of the research Bath City Council then officially took over the scheme by making it a part of the City Fire and Ambulance Service, including the creation of the appointment of accident medical officer.

Outline of Scheme

ORGANIZATION

Initially my attendance at road accidents was more in the role of an observer, to study how the emergency services organized themselves, how best to organize medical participation, and to build up gradually a relationship with the emergency service personnel. In fact, this approach set the pattern for the relationship that was to continue. From the outset medical aid was organized to be available to the emergency services on request and to combine as part of their team at the scene of the incident—

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FIG. 1—Fire brigade emergency equipment vehicle and accident flying squad car.

a set-up which encouraged a close and personal working relationship in which the ambulance staff would actually participate, to the benefit of all, including the patient. At the same time the ambulanceman could be encouraged to improve his skill in assessing priorities.

It was also policy to initiate any treatment and to stabilize the patient at the scene, and then in most cases to allow the ambulance staff to take over the responsibility for the patient during the journey to hospital while I followed the ambulance independently and so was available in case the patient's condition deteriorated. In practice this policy worked well. Personal and vehicle identification was an important factor in ensuring acceptance when approaching, working at, or leaving the scene. A short over-waistcoat of fluorescent and reflective material was made and worn at all incidents, and the magnetic flashing green light (Mediflash) was developed for use on the car when travelling to emergencies.

Initially the ambulance control room was informed of my whereabouts by the provision of a timetable supplemented by periodic telephone calls. This system was far from satisfactory and involved only the first 12 calls, while awaiting delivery of a radiotelephone; the latter completely transformed the scheme.

Mobilization of medical aid was therefore through the control room of the City of Bath's joint fire and ambulance service. As the service also operated a special emergency equipment vehicle (see Fig. 1) for releasing casualties trapped in any accident situation, it seemed pointless to restrict medical attendance to road accidents alone. Therefore any incident was attended where medical aid was thought to be required, either on receipt of the initial 999 call or on the arrival of the first emergency vehicle at the incident. Similarly, availability was not limited to the Bath ambulance area, and the area covered was gradually expanded, especially into the Somerset County ambulance area. This latter authority then provided a radiotelephone on the county's service wavelength.

EQUIPMENT

In the early stages medical equipment was carried in several cases. This was not satisfactory, however, and so a resuscitation box was designed to contain and display all the equipment and still be stable in a moving ambulance. Careful choice of equipment kept the total weight down to 51 lb (23 kg) (37 lb (17 kg) without the cardiac monitor), and this arrangement, described in more detail elsewhere,⁵ was most successful in practice. A list of the equipment carried, together with the cost, is given in the Appendix.

COLLECTION OF RESULTS

Detailed records were kept of each call, including the date, timings, distance travelled, diagram of the scene, vehicles and

casualties involved, and equipment used. Case histories were followed up personally until the eventual outcome of treatment was known.

The criteria used to categorize the casualties were those used by the Ministry of Transport—that is, slight, serious, and fatal.

Results

DRIVING

No problems were encountered during the research. The Mediflash green light was found to give adequate vehicle identification at night and during the day to oncoming traffic. A brighter, detachable rotating beacon would, however, be more effective if the lighting regulations were amended to include doctor's cars as emergency vehicles. Where indicated visual identification was supplemented by the use of a pneumatic horn. The car was not involved in any accidents, and in combination with the use of studded tyres in conditions of ice and snow, all incidents were attended without difficulty. Vehicle insurance was discussed with the insurance agency and no extra premium was required for fully comprehensive cover. The principal advantages of using one's own car were avoidance of delay in mobilization due to waiting for transport to arrive and loading equipment, freedom of movement when on call, and elimination of the cost of specialized transport.

Whenever it was necessary to travel to hospital in the ambulance with the patient a spare ignition key was given to the nearest policeman so that the car could be moved when clearing the road. This proved necessary on 12 calls. On five occasions the police drove the car to the hospital and on the other seven the ambulance service returned me to the scene. On all 12 occasions this help was arranged without delay and without any personal intervention.

Special protective clothing against soiling was found to be necessary on only one occasion, although a plastic mackintosh was used in heavy rain.

RADIO

The importance of radio contact with the ambulance service cannot be overemphasized. Poor communications soon create problems in any situation, but even more so when there is a degree of urgency, and can then lead to poor relationships between departments. At first a simple radiotelephone was used, but later a more elaborate installation included a selective calling device to give automatic warning of an emergency call, a portable radio, a "talk-through" switch to enable me to speak direct to the accident ambulance, and a radio link to enable any mobile user or ambulance control to talk direct to the accident department. The complete system was quickly accepted by all users and on one occasion (accident 6) contributed to a patient's survival, as direct communication with the ambulance crew

enabled departure of the ambulance to be delayed until I arrived at the scene. The radio link with the hospital also eliminated the delay in calling out the accident flying squad, which before installation involved at least six calls in delays varying from two to eight minutes.

MEDICAL TREATMENT

Treatment at the scene principally involved having the necessary equipment instantly available very close to the patient, being completely familiar with its use, and having one person to act as informed help. The adaptation of resuscitation techniques to accidents has been described,⁶ as have the special problems with the extrication of trapped casualties.⁷ During the project it was found that the recognition of patterns of injury related to vehicle damage was of value in assessing patients when examination was limited by poor lighting, limited access, or full clothing. Entonox (50% oxygen and nitrous oxide) was used for pain relief at the accident scene during extrication and in the ambulance. Observations including pulse and blood pressure readings were made in 17 cases. Pain relief was effective, rapid in onset, and free from side effects. Muscle spasm was relieved, bleeding from wounds was not promoted, and the pulse and blood pressure readings showed no appreciable change. No difficulties were encountered when Entonox was given to the trapped patient held in the erect position.

Detailed analysis of the 132 calls showed that 17 were to various incidents involving such locations as the river, civil engineering excavations, sewage works, certain home accidents, and a light aircraft crash. The remainder were to road accidents. The outcome of calls received and my location on receipt of the calls are shown in Tables I and II.

TABLE I—Outcome of the 132 Calls

At incident before departure of ambulance	..	..	..	..	83
Rendezvous with ambulance	..	..	..	..	16
No casualties found on arrival	..	..	..	..	9
Casualties slightly injured, rendezvous required	..	..	..	..	4
Malicious false alarm	..	..	..	..	1
Unable to reach accident in time:					
Distance and time delay in call	..	..	..	..	9
Time delay in call	..	..	..	..	5
Distance too great	..	..	..	..	2
Poor communications	..	..	..	..	2
Wrong information from 999 call	..	..	..	..	1

TABLE II—Location at Time of Call and Means by which Call was Received (132 Calls)

On duty in hospital (24 calls)	{ Telephone	..	21
	{ Radio link (from November 1970)	..	3
	{ Telephone at home address	..	55
Off duty from hospital (108 calls)	{ Radiotelephone in car	..	34
	{ Portable radiotelephone	..	1
	{ Telephone at other addresses	..	18

The calls were distributed fairly evenly throughout the project, averaging one call every 9.5 days. The incidence of calls was highest around 12 noon and between 5 p.m. and 7 p.m. and 11 p.m. and 12 midnight, and the incidence of calls was much higher on Fridays and Saturdays (Figs. 2 and 3). The average time taken to deal with each call was 31 minutes, representing an

FIG. 2—Distribution of calls throughout the day.

FIG. 3—Incidence of calls on different days and in different months throughout the year.

average work load of 22 minutes a week. The time taken to clean equipment after use and make a weekly inspection averaged 43 minutes. The average time taken weekly to answer calls and to clean and maintain equipment was therefore 65 minutes. This is to be regarded as a minimum as it does not take into account keeping records, following up case histories, correspondence, and other duties.

The average time taken for the ambulance to reach the scene was 8 minutes and for the accident flying squad 9.5 minutes (Table III). When these figures are compared with the earlier findings relating to the outcome of calls they show that where the

TABLE III—Mean Time spent on Calls and Mean Distance Covered

Time spent on each call	..	..	31	(range 4-143) minutes
Time ambulance took to reach scene	..	..	8	(range 1-20) minutes
Time accident flying squad took to reach scene	..	..	9.5	(range 1-22) minutes
Time spent at scene	..	..	14½	(range 2-132) minutes
Distance travelled to scene	4.7	(range 0.25-13.5) miles	7.5	(range 0.4-21.7) km
Total distance travelled	10.3	(range 0.5-29.5) miles	16.5	(range 0.8-47.5) km

call for medical aid was received at an early stage it was possible to arrive in time to offer medical help in about 90% of the cases. The closeness of the ambulance and accident flying squad attendance times was due to the ability to mobilize rapidly after an immediate alert.

Active medical treatment of casualties was undertaken on 22 occasions. In addition two calls involved meeting the ambulance at hospital for treatment, seven included help in assessment of handling, one concerned advice in the management of bromine burns and inhalation, and one call involved sorting priorities at a coach crash. Advice was given at a further five accidents in which casualties were trapped and injured but did not require medical treatment.

Altogether there were 302 casualties, of whom 140 were slightly injured and 128 seriously injured. Among the latter there were 34 deaths—25 at the scene and 9 in hospital. No patients died in the ambulance. Thirty-three accidents involved 41 casualties being trapped; of these 18 were seriously injured and 8 fatally injured. Of the 37 casualties trapped in road accidents 23 were held by the lower limbs, and the mean time taken to release them was 29 minutes. Although many of the accidents involved two or more seriously injured casualties, only on one occasion was it particularly difficult to cope with the problems encountered. In this instance three casualties were trapped and seriously injured, two in one vehicle and one in the other, and this stretched medical resources to the limit. Medical attendance was therefore of direct value at 38 accidents, or in 1 in 3.5 calls.

Patients who received definitive medical treatment can be further subdivided to show where it was probably possible to prevent a fatal outcome. Six of the casualties would virtually certainly have died had they not received this early medical treatment, and in a further four cases medical treatment made a major contribution to survival. In six instances resuscitation was unsuccessful, and in six medical treatment was of value. The type of treatment and advice given at the scenes of the 22 accidents is shown in Table IV.

TABLE IV—Frequency of Treatment and Advice given at Scenes of 22 Accidents

Morphine injection	2
External cardiac massage	2
Cardiac monitoring	4
Endotracheal intubation	4
Intermittent positive-pressure respiration	5
Intravenous infusion	6
Surgery	1
Amputation	1
Handling exposed brain	1
Manipulation of fractures	4
Entonox administration	9
Aspiration of airway	11
Oxygen administration	11
First aid before arrival of ambulance	14
General advice	15

Case Reports

MEDICAL TREATMENT RESPONSIBLE FOR SURVIVAL

Accident 1.—A 56-year-old driver collapsed in his car. A displaced denture plate partially obstructed his airway at first, then completely, with deep cyanosis and muscle spasm holding the teeth together. A gag, laryngoscope, and other instruments were used to remove the obstruction, and the aspirator and oxygen were also used. Final diagnosis: myocardial infarction. He was eventually discharged.

Accident 2.—A 16-year-old motorcyclist was found unconscious beside his motorcycle and lying on his back on a steep incline. Before the arrival of the ambulance and just after being turned on to his side he vomited and the aspirator was required to clear his airway. Outcome: complete recovery.

Accident 3.—A 51-year-old driver was trapped in a van after a collision with a lorry (Fig. 4). Injuries were: compound fracture dislocation of talonavicular joint; compound comminuted fracture of left tibia and fibula, with extensive soft-tissue lacerations; haemarthrosis of left knee; compound comminuted fracture of left femur; fractured acetabular rim, acetabulum, and pubic rami; fractured ribs; lacerations of face, scalp, left hand, and right knee. Treatment at scene: transfusion of 1 l. of Macrodex, use of

FIG. 4—Accident 3, showing rescue and resuscitation. (By kind permission of *Bath Evening Chronicle*.)

aspirator and oxygen, manipulation of trapped and fractured leg to permit earlier release, and application of long leg inflatable splint. Outcome: full recovery after treatment, which included transfusion of 2 bottles of plasma and 11 bottles of blood.

Accident 4.—A pedestrian aged 20 was struck by a car at night and thrown through a hedge into a field. He sustained compound fractures of the mandible and right tibia and fibula. He was unconscious and cyanosed and the airway was full of frothy blood. Immediate use of the aspirator followed by intubation and tracheal aspiration cleared the airway without stimulation of reflexes. Oxygen was also given. He regained consciousness on the third day and recovered fully.

Accident 5.—Three casualties aged between 25 and 35 were trapped and seriously injured, two in one vehicle and one in the

other. Medical aid included handling of displaced compound fractures and the use of the aspirator and oxygen. One patient was given 1 litre of intravenous Macrodex (and 5 bottles of blood later) for injuries which included fractures of the right radius and ulna, femur, tibia and fibula, ankle, and foot, closed fractures of the ribs, and lacerations on the left lower leg, right arm, and scalp. The patients made good recoveries.

Accident 6.—A pedestrian aged 22 was in collision with a car. He was unconscious, and his injuries included a compound fracture of the left tibia and fibula, gross disorganization of the soft tissues and right tibia and fibula, a compound comminuted fracture of the right femoral shaft and pertrochanteric fracture of the neck of femur, fractures of the scapula, ribs, and hand, and multiple face and scalp lacerations. The ambulance was instructed personally to await my arrival. An infusion was set up and 500 ml of Macrodex pumped in. The severely damaged leg was wrapped in a sterile sheet and placed in an inflatable, full-leg splint applied at maximum pressure. During the journey to hospital the ambulance had to be stopped when the systolic blood pressure dropped from 70 to 50 mm Hg, and a further 500 ml of Macrodex was transfused rapidly. Further infusion in hospital included 2 bottles of plasma and 7 bottles of blood. Amputation of the right leg below the knee was followed by full recovery.

MEDICAL TREATMENT CONTRIBUTING TO SURVIVAL

Accident 7.—A member of the emergency services collapsed near a ruptured gas meter when on an emergency fire call and was unconscious and breathing irregularly when brought out of the gas-filled building. He was ventilated with oxygen and connected to a cardiac monitor, which showed ischaemic changes. The aspirator was used to keep the airway clear and oxygen was given by mask. A period of heavy, central chest pain was followed by full recovery.

Accident 8.—A 19-year-old motorcyclist was in collision with a pedestrian and was seen before the arrival of the ambulance. He was unconscious and bleeding from the nose, chin, and broken front tooth sockets. The airway was cleared with the aspirator (the attending county ambulance was not equipped with an aspirator). He eventually made a full recovery.

Accident 9.—Two motorcyclists were in collision. One aged 4 was unconscious from head injuries, and both had compound fractures of the lower limbs. One required the use of the aspirator before arrival of the ambulance.

Accident 10.—A car driver aged 20 received severe facial injuries in a collision with a lorry and was unconscious. Repeated use of the aspirator maintained the airway in the presence of compound malar and mandibular fractures, displacement of teeth, and severe facial lacerations. Oxygen was also used. The patient made a full recovery.

COMMENT

The opinion that lives can be saved by early medical treatment is supported by several necropsy studies. Mackay⁸ suggested that 43% of fatally-injured casualties might have had a greater chance of survival if medical treatment had been available at the scene of the accident within 10 minutes. A World Health Organization report estimated that 15% of early road deaths were due to respiratory obstruction. Lauppi,⁹ in a series of 300 necropsies on road-accident casualties dying within 48 hours of injury, reported that in 14.3% respiratory obstruction was the sole cause of death. In another series Ruffel-Smith¹⁰ showed the incidence to be 5%. To the last three series could be added casualties dying of blood loss and other reversible causes.

In a series of 34 fatalities it might be reasonably expected that some deaths would be due to asphyxia or blood loss in the absence of injury incompatible with survival. In reviewing the necropsy series of this project no such evidence was found, though if medical treatment had not been available at all the 132 accidents probably examples would then have been seen. Should the figure of six casualties saved seem a high proportion allowance must be made that not only is this a selected group of accidents but also that it contains accidents in situations besides those occurring on the road.

Not all accidents in the hospital clinical area were attended, and so cases not involved in this project could be regarded as a form of "control." A review of all the necropsies in this series was not possible, but from cases seen during normal hospital employment there were three examples of patients who died from reversible causes, one from asphyxia and two from blood loss.

Cost

The running expenses for the three-and-a-half-years are shown in Table V.

When the capital cost of £927.19½ for all the equipment (see Appendix) is added to the running expenses for the three-and-a-half-year period the total cost is £1,086.71½. Nevertheless,

TABLE V—Running Expenses over the Three-and-a-half-year Period

	£
Medical equipment and drugs	20.93
Radio licence	8.75
Radio maintenance	38.75
Insurance	17.85
Batteries	16.80
Petrol	56.44
Total	159.52

as all the items of equipment could reasonably be expected to last for seven years at least, the capital cost could more realistically be spread over that time. If the running expenses were to continue at the same level the cost per year would be reduced from £310.49 (over three-and-a-half-years) to £178.03 (over seven years). Even the latter could be reduced to £103.60½ by exclusion of six non-essential items (cardiac monitor, dictaphone, camera, selective call option on radiotelephone, traffic-light switch, and studded tyres).

To these figures would have to be added the cost of medical staffing. This is not easy to assess, however, as only 15% of calls occurred when I was on duty. A more realistic comparison could be made with the fees payable to a police surgeon. With an average of 38 calls a year and an arbitrary fee of £5 a call this would represent an attendance expense of £190 a year and an annual retaining fee of £100 (at B.M.A. recommended rates). This would result in a total cost per call of £15.86, which compares very favourably with the average cost per emergency ambulance call, calculated by the Department of the Environment to be £15. Using the Road Research Laboratories costings of road accidents^{11 12} a comparison can be made between the actual cost of saving a life by the provision of medical aid and the overall saving to the community as a result of reclassifying that casualty as a serious injury instead of a fatal injury. The 1970 costings for fatal injury are £16,809 and for serious injury £910. These figures represent medical expenses, loss of output, and subjective losses, and the difference of £15,899 represents the financial saving that results from preventing a fatal outcome.

Only five of the six casualties saved in this series were in fact involved in road accidents, representing an annual saving of 1.43 lives. If the figure of £15,899 is multiplied by this factor and then the total cost of providing these special medical services, including fees and retainer, is then deducted the net annual saving to the community in providing this service can be calculated as £22,135. (The validity of this costing interpretation has been confirmed with the Road Research Laboratory.)

Conclusions

This scheme was easily organized, inexpensive, and effective. Its organization would allow it to be based on a hospital or general practice and did not interfere with other employment. Moreover, the earlier involvement with the patient often made the diagnosis and treatment less time consuming on return to the hospital.

The success of the scheme depended on rapid mobilization,

free passage through traffic, and good communications. The policy of organizing medical aid to be available on request, working at the scene with the ambulancemen, and training them to help rather than taking a team of assistants was also important. The area covered was principally that of one ambulance service, though in the instance of accidents involving multiple or trapped casualties the area that could be covered was shown to be greatly extended. The average distance to the accident scene was under 5 miles (8 km), indicating that certain patients could still benefit from medical attendance even though the ambulance journey time to hospital was relatively short. Such a scheme, if hospital-based, could usefully act as the nucleus of a scheme involving and supporting peripheral general-practitioner schemes and would also have application in the field of motorway and "major accident" incidents.

The organization of such a scheme is seen as a logical development of the properly established and independent accident and emergency specialty, and shows that the patient's arrival at the accident department is not the earliest stage at which medical involvement should be directed.

This research is based on an M.D. thesis accepted by the University of Bristol in 1972 and supported by a grant from the Peel Medical Research Trust. Acknowledgement is also due to the support of the Bath City Council and the medical officer of health, Dr. R. M. Ross, and the consultants and staff of the accident departments of St. Martin's and the Royal United Hospitals, Bath, and the many firms that donated equipment to the scheme.

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Appendix

Cost of Equipment (at Time of Purchase)

	£
Resuscitation box painted white with reflective Scotchlite band and doctor label	4.92½
Sterile cut-down and surgical set in linen pouch including: 2 linen towels, scalpels, scissors, aneurysm needle, artery clips, forceps, suture holders, mosquito forceps, and bone saw	14.92½
Disposable syringe and needle, prepacked swabs, Mersutures, local anaesthetic, and adhesive surgical drape	1.00
Intubation set in roll-up linen pouch including: endotracheal tubes, laryngoscope, syringe, clip, gag, tongue depressor, infant aspirator (disposable), catheter mount, and Cobb's connector	26.00
Ambu sucker and two Yankauer suction mounts	17.99½
Laerdal Resusci bag including extra oxygen nipple and endotracheal adaptor, mask, and airways	12.41
Portogen oxygen cylinder	19.00
Brook airway	1.50
Pulpet electronic aneroid sphygmomanometer	24.15
Portex intravenous cannulae and suction catheters	0.55½
Angiocath intravenous cannulae (× 6)	0.96
Baxter pumping drip set (× 3)	0.81
Macrodex plasma volume expander (× 6)	5.70
M.S.A. elbow immobilizer	2.50
Refrigerated box containing O Rh-negative blood (Blood Transfusion Service property)	—
Keeler practitioner ophthalmoscope	22.00
Ever Ready flat torch	0.36
D.D.A. register	1.34
Drugs	2.48
Syringes and needles	0.25
Blood cross-match tubes (hospital property)	—
Wakeling battery rechargeable cardiac monitor and Multi-point dry electrodes	277.47½
Philips 85 miniature dictation recorder	23.65
Kodak Instamatic camera and flashcubes	3.56

Additional Equipment Carried:

Entonox (premixed nitrous oxide/oxygen inhalant analgesic gas), cylinders, valve, mask, and mouthpiece	27.50
Pneumatic splints	7.50
Rochampton burns dressings	4.25
Spinal boards and straps plus Plastazote cervical collar	2.72½

Blankets (1 wool and 1 heat-retaining foil)	2.90
First-aid kit of dressings, bandage, slings, etc.	1.50
Reflective waistcoat-type jacket	5.00
4 Warning triangles (special purchase—normally £2.47½ each) .. .	2.00
Large hand-torch	2.15
Minor rescue equipment including: hacksaw, jemmy bar, tools, rope, and asbestos gloves	2.00
Fire extinguisher	0.92½
12-volt floodlight	12.00
Mediflash	6.30

Pneumatic horns	12.60
Radiotelephone (selective calls, 10 channels)	343.75
Portable radiotelephone (short-term trial)	—
Photographic equipment (personal property)	—
Information on poisons	1.00
Selective vehicle detector remote traffic-light switch	5.00
Studded snow tyres	24.55
Total	927.19½

Medical Aspects of Ambulance Design

ROGER SNOOK

British Medical Journal, 1972, 3, 574–578

Summary

Various observations have shown that the interior layout of many ambulances leaves much to be desired. The lighting levels are inadequate, heat loss could be prevented, vehicle identification and passage through traffic could be improved, and measurable differences exist between the ride characteristics of commercially available ambulances, a prototype purpose-built ambulance, and a private car. Moreover the condition of some patients may be affected by the motion of the vehicle either directly or indirectly. Even though they form a small percentage of the total number carried, they represent a very considerable financial risk. A personally conducted survey of ambulance chief officers showed a deep interest and involvement in the upgrading of the service with a general dissatisfaction with many of the vehicles currently available. Hence there is a market for the purpose-built ambulance, which would benefit the patient and the ambulanceman alike.

The inadequacies of many vehicles currently in use as ambulances have been shown to work against the interests of the patient requiring life support treatment, and it is suggested that this warrants urgent attention and action. A more extensive research project involving medical observations on the supine sick and injured, attendant task performance, and instrumentation analysis of linear and angular vehicle motions should enable the harmful effects of ride motion to be identified.

None of these investigations, however, will be of any value unless they are used in developing future ambulances. Such development must also parallel an increase in the awareness of the importance of ambulance design and its relation to the increased comfort and chance of survival of the patients carried.

There has been relatively little research into medical aspects of ambulance design. With the notable exception of Bothwell's patented ambulance specification^{1,2} most of the published papers relate to general or outline specifications of future design requirements or simply draw attention to the inadequacy of existing design. London³ has said, "although the need for special ambulances is negligibly small on a commercial scale this fact does nothing to ease the discomfort of the person travelling in a vehicle designed without the least regard for the effects of illness and injury." The Committee on Acute Medicine of the American Society of Anaesthesiologists⁴ reported that

"most vehicles presently in use are unsatisfactory for life support."

Experience with travelling with patients in the ambulance during the research project on providing medical aid at an accident⁵ and on interhospital emergency transfers indicated that further investigations of the ambulance environment were needed. This paper describes the results of personal observations and investigations of such factors as the heating, lighting, sound insulation, identification, and vehicle motion with reference to the treatment, comfort, or condition of the patient. The observations were made on a variety of commercially available ambulances in service with several local authorities.

The positions in the ambulances at which various instrument readings were taken are indicated in Fig. 1.

FIG. 1—Positions in ambulances at which various instrument readings were taken. Measurements taken at positions indicated were: 1. Temperature. 2. Light and sound. 3. Vibration over axle. 4. Vibration within wheelbase. 5. Vibration on patient's leg. 6. Hot air curtain updraught.

General Design

Ambulances transport a variety of patients, including sitting cases and routine and emergency stretcher cases, and so the interior requirements of the vehicles vary correspondingly. The interior layout of most ambulances is inflexible and makes treatment of the patient during transit unnecessarily difficult. For example, when resuscitation or supportive measures are required during a journey it is an advantage to have the stretcher centrally mounted. In most presentday ambulances the attendant either stands or kneels on the floor alongside the stretcher, which is mounted along the sidewall of the patient compartment (Fig. 2).

Ideally the attending ambulanceman or doctor should be able to sit at the patient's head to operate aspiration or ventilation equipment. To place this attendant's seat so that it faces rearward involves moving the patient nearer to or directly over the rear axle. By reversing the position of patient and attendant the former would remain within the wheelbase and the latter would be able to see where he was going. This would make it easier to perform delicate tasks such as inserting an aspirator mount into the patient's pharynx, besides reducing the likeli-