New Aspects of Disaster Medicine

Proceedings of the Asian-Pacific Conference on Disaster Medicine

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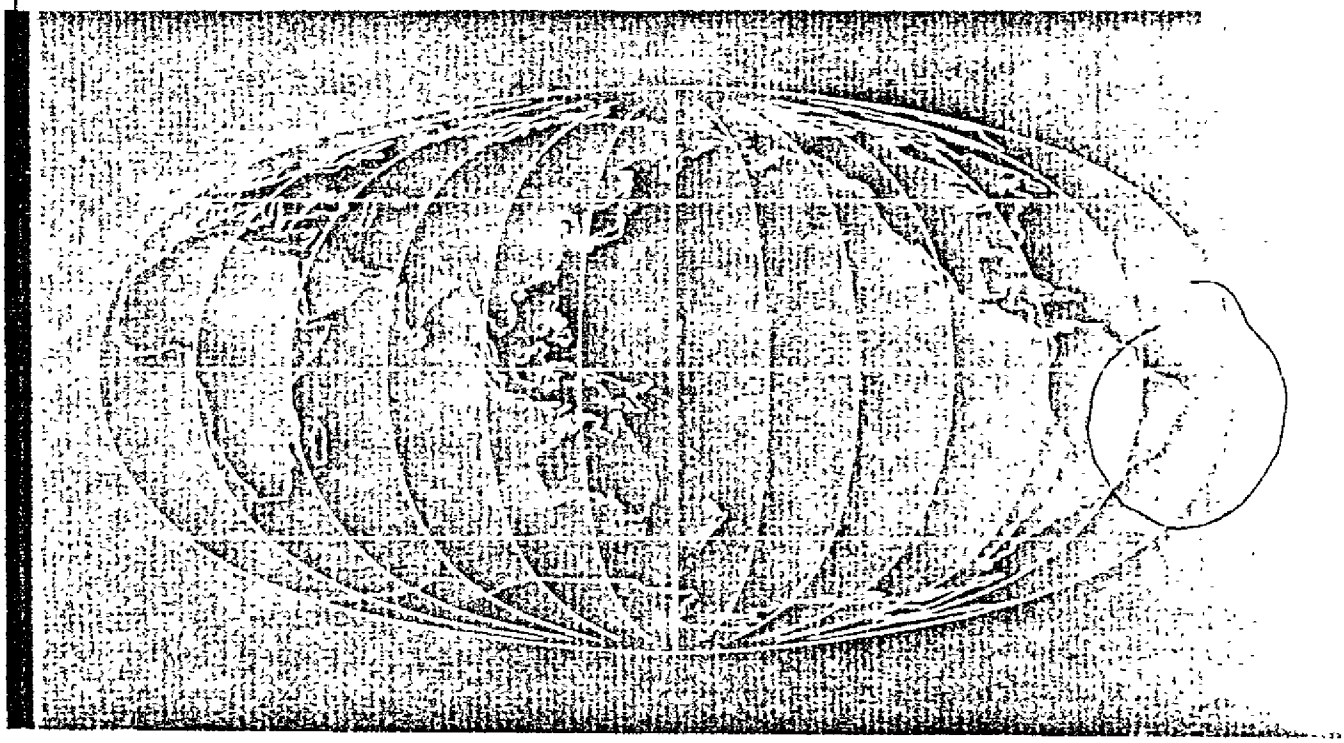

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Training of Search and Rescue Teams for Structural Collapse Events: A Multidisciplinary Approach

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Introduction

A number of significant recent events such as Tangshan, China in which 242000 people were killed, the 1985 Mexico City earthquake, and most recently, the Soviet Armenia earthquake in 1988 demonstrate that the collapse of reinforced-concrete buildings is a significant and continuing problem. Traditionally, search and rescue has been carried out, for the most part, by untrained persons such as relatives, neighbors, or local volunteer groups. It is clear that the increasing frequency of disasters in large urban areas, coupled with the collapse of reinforced concrete buildings, calls for a more professional approach, especially specialized medical and rescue skills.

Search and rescue personnel operate under a very constrained time element. Following a catastrophic earthquake, experienced rescuers believe that a maximum of 22 to 24 hours is available for effective lifesaving. The collected data so far indicate that from 85-95% of the live recoveries are made within the first day, and beyond that the rate of recovery of live victims drops off very sharply. In everyday trauma we talk about the "golden hour." For victims of building collapse, we can talk about a "golden twenty-four hours." For those trapped survivors, there are serious problems with limb compression and dust inhalation. Some of these persons will require in-field amputation in order to extricate them. Therefore, search and rescue (SAR) combined with effective emergency medical care are the twin pillars upon which this lifesaving effort will succeed or fail.

Successful search and rescue endeavors consist of rapid location, access, extrication, stabilization and transportation of victims. Since victims of building collapse may be trapped for hours, if not days, it is important that SAR personnel also be trained to resuscitate and stabilize such patients while they are being extricated. In the case of Armenia, hundreds of major buildings were seriously damaged, including many reinforced-concrete structures. It is estimated that more than 50000 people were trapped in collapsed buildings as a result of the earthquake. When comparing the number of injuries to available trained medical personnel, it becomes very self-evident that scarce resources must be used where they will do the most good. In other words, SAR personnel must be able to rapidly determine

approximate number of victims, probable locations of survivors, and potential for survival.

Medical care will of necessity be austere, and conditions usually will not allow for definitive care of minor or moderate injuries. Any field medical intervention should be oriented toward stabilization of immediate life threats (eg. maintenance of airway patency, management of external hemorrhage) and relief of severe pain.

Teams from several different countries, including the United States have been used in past heavy urban rescue operations. Unfortunately, most of these teams had no previous heavy urban rescue experience. This lack of experience points out the need for greater professionalization of search and rescue, better equipment, techniques and training. The ultimate goal should be the development of well-trained, highly specialized heavy urban SAR personnel, preferably located in areas of greatest seismic risk. This lack of experience strongly points out the need for comprehensive training courses in this area of heavy urban search and rescue.

In response to this need, the Johns Hopkins University in collaboration with Virginia Polytechnic Institute have developed a comprehensive training course with faculty representing civil engineering, architecture, epidemiology/public health and emergency medicine. Topics presented in this course include (1) Causes of building collapse (eg. earthquakes, wind, blast), (2) Building types and construction (eg. building typology by structural type, patterns of failure, characteristics of construction materials), (3) Current state of the art in collapsed building search and rescue (eg new developments in search and extrication techniques and equipment), (4) Injury patterns observed in building collapse (eg. distribution of types of injury, morbidity/mortality time trends, crush injury/syndrome), (5) Emergency medical treatment for victims of buildings collapse (eg. First responder responsibilities, on-site treatment/triage, transportation) and (6) Health considerations for rescue and EMS workers (eg. physical hazards in the unstable collapse environment, precautions regarding food and water in less developed countries). (Table 1).

Necessary Knowledge for Effective Search and Rescue

For guiding future rescue operations, it is necessary to have information about the actual location of the victims in the collapsed structure as well as specific details about the extrication process itself. Knowledge of collapse conditions helps set rescue priorities. The construction of a building gives some indication of the way it may collapse as the result of a blast, earthquake, cyclone, or other disaster. Buildings of the same class and type of construction collapse in much the same way, and common factors are present. It is important that rescuers study these factors, since this knowledge will prove helpful when extricating casualties.

For example, almost all types of damaged buildings will contain voids or spaces in which trapped persons may remain alive for comparatively long periods of time. To know where these safe places may be, it is necessary to know the characteristics of various types of construction. Victims are best able to survive in V-shaped and lean-to voids, and by searching there first, SAR personal have a better chance

Table 1. Training course schedule for structural collapse events 8:00 a.m.–4:30 p.m.

8 00	General introduction to the workshop
	Workshop objectives
8:10	Causes of building collapse
	earthquake
	wind
	blast
	snow loading
	poor design, detailing, construction
	global distribution of hazards
	characteristics of hazard phenomena (eg. earthquakes)
8:40	Video of 1985 Mexico City earthquake
	National Bureau of Standards
9:00	Experience in search and rescue in collapsed buildings
	terminology (eg. locate, access, extricate, stabilize, transport)
	search
	extrication
	organizational issues
	international cooperation
9:30	Coffee break
9:45	Building types and construction materials
	building typology by structural type
	patterns of failure (eg. foundation failure, low rise, larger structures).
	characteristics of construction materials (eg. steel, concrete, reinforced concrete, masonry, timber).
	properties of structural materials (eg. strength, ductility, fatigue life).
	structural elements (eg. deams, columns, slabs, walls).
10:15	Current state of the art in collapsed building search and rescue
	Mexico City
	San Salvador
	Bridgeport
	Brownsville
	Soviet Armenia
	Equipment and uses
	Organization and management
	New developments in search techniques, operations
	New developments in extrication
11:45	Discussion and questions
12.00	Lunch

of reaching survivors in time.

It is not enough to know only where to find potential survivors. Search and rescue personnel must know what to do once these persons are located. They must have some knowledge of what specific types of injuries to expect as well as how to estimate relative injury severity and prognosis. The latter is essential for effective triage. Severe dust inhalation with resultant pneumonitis is an important problem for victims of building collapse. Therefore SAR personnel should be well-versed in techniques of airway management and oxygen administration. Optimally, they should know how to start intravenous lines and administer life-saving fluids and medications. They must also be able to recognize and treat problems of prolonged

1:00	Video of emergency health care issues from Mexico City, El Salvador and Armero, Columbia Pan American Health Organization
1.30	Injury patterns following major events involving building collapse distribution of types and severity of injury injury outcome characteristics characteristics of affected populations distribution of injuries globally relationships of disaster agent, response morbidity and mortality time trends information on deaths and hospitalizations to evaluate selected factors that may influence why some people die from their injuries, while others do not.
2:30	Coffee break
2:45	Emergency medical treatment for victims of building collapse mass casualty management typical injuries of building collapse victims first responder responsibilities (access, extrication, stabilization, BCLS, BTLS) on-site treatment and triage transportation of victims crush injury and syndrome treatment of hypothermia health considerations for rescue workers
3.45	Discussion and questions
4:00	Panel review and summary research needs relationship of research to improve search and rescue practice
4.30	Conclusion

limb compression such as compartment syndrome and crush syndrome. These conditions require immediate attention and cannot wait until the victim has been completely extricated and transported to a treatment area.

Efforts to remove occupants from a collapsed building may expose rescuers to more dangers than are faced by the victims. Rescue personnel must constantly observe all safety precautions to protect themselves from injury. For example, the destruction of buildings and industrial facilities by any catastrophe will invariably result in ruptured electrical, water, gas, and sewer lines. Other hazards will be escaping gases and chemicals used in refrigeration units and in certain industrial operations. These utilities create serious problems for casualties and rescue personnel. Each person on the team must be knowledgeable regarding these potential hazards and trained to be alert to any change in conditions at the collapse site that could raise an additional threat to their safety. Rescue personnel should also be instructed in the proper method of shutting off water, gas, and electricity and informed of the probable locations of shut off valves and master switches.

Unfortunately, it is difficult to develope and practice search and rescue techniques. During a major disaster such as an earthquake or even at a single building collapse site, concentration is usually focused on maximizing the capabilities of existing SAR techniques. Little or no time is available for enhancement or experi-

mentation with new ideas and equipment. The comprehensive training course described above attempts to address some of these difficulties in a positive and practical way. In addition to addressing the problem of heavy urban search and rescue in a unique multidisciplinary manner, we hope to spawn new research into both search techniques and rescue methods. For example, a systematic comparison of the many existing techniques of search and rescue is clearly needed, including a controlled evaluation of SAR equipment (eg. efficacy of dog teams, remote sensing equipment, portable seismographs, bore-hole cameras, infrared detectors, carbon dioxide sensors, etc). Such research should also look at the functional requirements of search and extrication devices, including the development of performance specifications for devices which will penetrate a collapsed structure to detect or reach a victim.

Conclusion

It has been apparent in past building collapse events such as in Mexico City and Armenia that political divisions between various national SAR "teams" tend to surface and hamper the rescue effort. In many cases, it has been evident that international teams effectively "compete" for SAR successes, rather than working in a complementary fashion, exploiting the relative strengths of the various approaches. It is clear that some principle for effective collaboration and compatible organization of response teams needs to be developed. Ultimately, it is hoped that courses such as the one developed by Johns Hopkins University and Virginia Polytechnic Institute can serve as the basis for the development of training and education standards for search and rescue personnel. The development of standard SAR terminology, methods, techniques and equipment should lead to greater coordination between the various international teams.

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