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LETTER TO THE EDITOR

NATO ADVANCED RESEARCH WORKSHOP: HOSPITALS UNDER FIRE - PLANNING AND OPERATING A HOSPITAL UNDER FIRE AND EXTREME CIRCUMSTANCES

In April 2005, an international advanced research **workshop entitled, "Preparedness of Medical Systems: Guidelines for Mass-Casualty Situations"** was convened in Haifa, Israel, under the auspices of NATO. Numerous specialists from various countries addressed the management of problems that arise during the hospital and pre-hospital phases of a medical response to mass-casualty situations, as well as the issue of preparedness for potential toxicological events. Methods for evaluating the quality of care provided during such situations were also discussed (1). In November 2009, the authors and **their team organized the "NATO Advanced Training Course: Best Way of Training for Mass-Casualty Situations"** for specialists from countries participating in the Partnership for Peace (PfP) and Mediterranean Dialogue (MD) programs; once again, the course was held in Haifa, Israel. The aim of the course was to inform its participants (all of whom were experienced protagonists in the field of emergency medical services and hospital management, or ministry of health officials, in their respective countries) about teaching and training methods for preparation for mass-casualty situations (2).

Throughout the next few years, the authors continued to exchange ideas and engage in practical collaborations related to similar, as well as additional, relevant topics (3). Preparations for the workshop's theme, structure and content (including pedagogical, materiel and logistical support) concluded in early 2012, at which time the authors jointly applied for a NATO grant for 2013. After the application was discussed, returned for corrections, and finally approved by the relevant NATO committees in December 2013, the NATO Science for Peace and Security Section awarded grant ESC (2013) 0543 ISEG.MD.ARW 984678 for the organization of the NATO Advanced Research Workshop entitled **"Hospitals Under Fire: Planning and Operating a Hospital Under Fire and Extreme Circumstances"**. It was decided that the 4-day course would take place during November 17-20, 2014.

Figure 1. A lively discussion during the workshop.

Figure 2. Workshop participants approaching fortified areas of the Rambam underground hospital.

Opening Ceremony

The workshop was attended by 23 experts from 10 countries (Table 1). The opening ceremony was held at the Rambam Medical Center auditorium with hospital director **Prof. Rafael Beyar**, and **Mr. Yona Yahav**, Mayor of Haifa, in attendance. Prof. Beyar expressed his delight and gratitude for the confidence vested in him to organize, in cooperation with NATO, the third such workshop during the last 9 years. This facility houses the largest Trauma Center in northern Israel and, as such, has the richest experience pertaining to situations involving mass-casualty management. The hospital has been repeatedly subjected to situations in which its security has been jeopardized, including rocket attacks. In light of these circumstances, the board decided to build a fortified underground emergency hospital capable of withstanding various forms of attack, including direct missile strikes. During his speech, Prof. Beyar discussed the construction process, from conceptual intent to the final stages of actual implementation, which took place between 2008 and 2014. During the course of ordinary daily life, Rambam Medical Center's three subterranean floors serve as parking space for 1,500 vehicles. Should the need arise, this vast area can be converted to a fully equipped hospital with 2000 beds within 72 hours. The Mayor's presentation clearly illustrated city leaders' interest and connection to the existence and activities of this medical, educational and scientific-research complex. During the Second Lebanon War in the summer of 2006, the city (including the hospital vicinity) was subjected to 34 days of rocket attacks. Unable to attend school during the conflict, children continued their education via the internet and e-learning. City leaders expropriated shopping center underground parking areas for the purpose of (among other things) sheltering children during the day, thereby enabling their parents to attend work (at the hospital, for example). These measures were met with a favorable

Table 1. Country and number of participants

Country	Number
Bulgaria	3
Czech Republic	1
Italy	4
Israel	7
Netherlands	1
Norway	1
Romania	1
Sweden	2
Turkey	1
United States	2
TOTAL	**23**

response, and 85% of the population remained in the city throughout the entire 34-day attack. In another presentation, **Dr. Michael Stein** (Israel) and **Ms. Jorie Klein** (USA) commemorated the life and work of the late **Dr. Eric Frykberg** (1951 – 2013) and were joined by all participants in honoring his memory. Dr. Frykberg was a prominent surgeon and traumatologist at the University of Florida College of Medicine (Florida, USA) and served as department head of the university's trauma center. He authored numerous publications of great import within the field of disaster medicine and mass-casualty situations. He was also an excellent professor, and was instrumental in designing the trauma care system infrastructure in the state of Florida. Dr. Frykberg was a close collaborator and lecturer in both preceding workshops and was, above all, a highly respected colleague and friend.

Lectures

During the first presentation, **Dr. Boaz Lev** (Associate Director General, Health Division, Israeli Ministry of Health) provided a detailed description of the Israeli hospital system in terms of potential threats and preparedness in times of extraordinary emergency situations. State health facilities must be on constant alert, which means that (among other things) each hospital must be capable of increasing its bed capacity for receiving wounded patients by approximately 20%. Preparedness is oriented toward mass-casualty incidents, acute situations resulting from the use of unconventional weapons (e.g. chemical, biological, and radiological events) and natural disasters. In such situations, state health services are controlled by a single central authority (the Supreme Health Authority) which includes representatives from the Israeli Medical Corps (an Israeli Defense Forces (IDF) corps), the Ministry of Health, and the Clalit health services organization. This close interdependence and cooperation between the civilian and military medical systems is key to the effectiveness of the Israeli system. During Operation Protective Edge, Israel's longest military operation to date (08.07 – 26.08, 2014), a total of 72 Israelis perished and 2,343 were wounded. At the same time, more than 500 acute psychological stress reactions were reported; this phenomenon should be anticipated and taken into consideration during the course of planning.

During the next lecture, **Maj. Gen. Eyal Eizenberg** (head of IDF Home Front Command), discussed the same issues from the military medical services perspective. Geographically speaking, Israel is surrounded by Arab countries comprising 270 million inhabitants. In terms of military planning, the country lacks strategic depth and only has limited time to initiate responsive measures. Israel must, therefore, be prepared for all situations ranging from small conflicts to full-scale war. In an effort to reduce casualties and infrastructure damage, several joint civil-military systems have been developed, such as: (i) early warning, (ii) physical protection (reinforced construction is mandatory in all buildings), (iii) public information and guidance, and (iv) rapid incident response.

Figure 3. Underground sector utilized as parking space during peacetime.

Figure 4. Operating theater in action after conversion of the same underground sector.

In an exceptionally pertinent communication, **Dr. Boaz Ganor** (Director of the International Policy Institute for Counter-Terrorism) reported on the threat of terrorism to health care systems and hospitals. Due to their very nature, hospitals have historically been regarded as soft targets for terrorists, whose primary goal is to complicate, or even prevent, the delivery of medical care. Their secondary goal lies in causing structural damage, which means further service interruptions and non-material damages associated with the psychological impact on the public. During the years 1981 – 2013, 43 countries reported roughly 100 terrorist attacks carried out against hospitals, during which 775 people perished. The presentation also included a detailed situation report regarding the activities of the so-called Islamic State (ISIS), in which 10,000 foreign combatants from 60 countries (less than 1,000 of which originate from Europe) operate.

Figure 5. General view of a Rambam underground hospital department.

Figure 6. Two isolation booths for high-risk infection cases.

Reports from Hospitals involved in Operation Protective Edge

In the next group of presentations, 3 hospital directors discussed their experiences in dealing with the issue of threats to hospitals, and their organization and operation under war casualty conditions. These practical findings stemmed from the time of Operation Protective Edge. During that period, 2,648 rockets were fired at Israel, 578 of which were shot down by Israel's "Iron Dome" interceptor missiles. Hospitals in Haifa, Nahariya, and Ashkelon were prepared to provide treatment to an increased number of wounded while being under threat, themselves. Joint measures undertaken at all 3 hospitals involved securing hospital facilities (e.g. blast protection for bottle gas (oxygen), hardening electrical networks, etc., plastic protection of windows, and moving offices to secure locations).

In terms of hospital operations, less ill patients were either discharged or transferred, and elective surgery and outpatient examinations were cancelled; only acute surgery and oncological treatment continued as normal. Each director emphasized the necessity of increased care for their own personnel, who performed their duties with maximum commitment. For example, hospitals enabled flexible working hours, provided employees and their families with transportation from home to school; or to the hospital and back; or provided day care for children in the hospital itself. In addition, psychological support was continuously available to all employees, along with the possibility of extended leave when needed. All three directors stressed the importance of communication with the media, as hospitals tend to be under pressure from media interest. The media must be allowed to perform their work, but the simultaneous preservation of patients' rights to privacy and protection of personal data must be maintained (e.g., when filming wounded as they arrive at hospital, etc.). The debriefing of individual teams after each event is equally important, as well. Staff from the Soroka University Medical Center in Be´er Sheva confirmed similar experiences during their lectures, which were presented on the final day of the workshop.

Rambam Underground Hospital Tour

During the afternoon hours of the first day, we closely inspected the newly-constructed fortified underground hospital, including demonstrations of operating room and intensive care unit (ICU) activities. The emergency hospital occupies three underground floors, has a capacity of up to 2,000 beds, and ensures work continuity of the hospital, even during extraordinary mass-casualty conditions, and even when the hospital is under threat. Emergency rooms, operating rooms, and intensive care units are

Figure 7. Artificial windows on ceilings reduce psychological stress for patients and personnel inhabiting underground spaces for long periods of time.

readily available; all trauma center disciplines are represented to the highest degree. Underground facilities also include a well-considered and purposefully arranged system of laboratory and diagnostic equipment, with logistical and technical support (e.g. air conditioning, independent power sources and water supply, etc.). Even when the emergency hospital is not actively in use, it is in a permanent state of readiness to serve as a super-specialized isolation facility for particularly dangerous situations (e.g. during cases of suspected Ebola, etc.). In terms of the effective use of equipment (technological background) the principle of dual usage is applied; i.e., most of the technology is used to ensure hospital operation under normal conditions. Aside from the economic perspective, this also ensures continuous serviceability and ongoing maintenance. The underground hospital tour held on day-1 was not only attended by our own workshop participants, but also included a large group of approximately 80 health care workers from all over Israel.

Figure 8. Prepared beds in an underground wing of Galilee Medical Center in Nahariya.

Figure 9. A physician and two paramedics: an ambulance crew prepared to render prehospital care.

Evening Lecture of the Israeli Defense Forces (IDF) Surgeon General

During an evening social event, IDF **Surgeon General Brig. Gen. (Prof.) Yitshak Kreiss**, head of the IDF Medical Corps, delivered a particularly intriguing presentation. After an introduction focusing on the concept of combat casualty care (CCC), the Surgeon General devoted the remaining time to describing his direct personal experience with CCC implementation during Operation Protective Edge. The doctrine objective is to “eliminate preventable death" in all those who have a chance of survival, thereby reducing the ratio between the number of wounded and number of deaths (i.e. case fatality rate (CFR)). For example, the U.S. Medical Corps currently achieves an average CFR of about 10% in Afghanistan. Thus, when creating their doctrines, the Israelis approached the task while keeping in mind the well-known fact that 90% of CCC deaths in the field are the result of hemorrhage.

The soonest possible implementation of hemostasis, particularly through means of a tourniquet, it is the most crucial moment of providing first aid. In Israel, great emphasis is placed on the practical training of each individual soldier, as well as the so-called "life-saver" medics assigned to each unit. During Operation Protective Edge, of 704 wounded, a tourniquet was correctly applied in nearly 100 cases. This is clear evidence of good training of all soldiers, including reservists. Another favourable outcome pertained to the early administration of freeze-dried plasma while still in the prehospital phase. This method has been fully proven in Israel and, since February 2013, has replaced crystalloid solutions and is now the standard point of injury treatment. Of all those wounded, 67 patients (64 of whom were soldiers) eventually died, which indicates an achieved CFR ratio of 9.1%.

On the second day of the workshop, participants listened to lectures. **Dr. Nelson Olim**, Senior Surgeon from the International Committee of the Red Cross (ICRC), discussed the dangers that threaten healthcare professionals when fulfilling their tasks in crisis areas and situations. He gave a brief summary of the history and development of the Red Cross, legal aspects of the Geneva Conventions, and their applications (e.g. humanitarian law, etc.) in practice.

Figure 10. Lyophilized plasma is predominantly used for volume resuscitation at the point of injury.

There is a clear threat to medical facilities and their personnel, as evidenced by the fact that 1,809 international incidents (which resulted in 2,456 victims) were reported between January 2012 and December 2013. The 3 most common types of attacks are (i) on health professionals themselves, (ii) on health care facilities or (iii) blockage of health care access as a whole. When compared with patients, health care professionals are more frequently intimidated, rather than killed. The aim of these actions is either to gain military superiority, or to propagate terror and extortion.

Ms. Jorie Klein, Director of Trauma and Preparedness at Parkland Hospital (Texas, USA), discussed risk factor analysis models for health care facilities, which stem from a long history of American hospital experience. In principle, it establishes a list of potential risks from the perspective of their impact on staff and patients, as well as potential structural damage and its impact on hospital operations. This is followed by priority planning and preparedness training for each risk factor. Critical thinking is necessary for both natural disasters (e.g. earthquakes, tornadoes, and floods), and risks inadvertently or intentionally caused by man. Communication methods are crucial, as is maintaining hospital work activities; and it is equally important to ensure provisions of human resources and material support, security, and infrastructure.

Dr. Mauricio Lynn, a former IDF Flight Surgeon who currently resides and works in Florida (USA), discussed the possibilities and methods of increasing the surge capacity of health care facilities. He emphasized diversity in "progressively-increasing disasters" (e.g., hurricanes, which are known several days in advance, and for which preparation can progress incrementally). This is in contrast to acute events (e.g. earthquakes and explosions), where the response must be immediate. Dr. Lynn is attempting to implement the Israeli system of planning, and especially training, for such situations in health care facilities in Florida. Such an undertaking is no simple task in the USA, however; the economic consequences related to departmental disruptions associ-ated with training can be significant.

Ms. Sara Tzafrir, from Rambam Medical Center's Division of Information Technology and

Communication Services, spoke to the importance and function of computer systems during extraordinary circumstances. She described the hospital management computer system, which allows one to know the precise situation at any given moment. Available data includes, for example, information related to incoming mass-casualties and all aspects of their treatment, as well as the overall situation of the hospital itself (e.g. bed capacity, material and personnel status). In Israel, all such computer systems in public hospitals are interconnected, which is of great importance. A backup data storage system is located off-premises, tens of kilometers away. In cases of mass disaster, incoming wounded (e.g. unconscious patients of unknown identity) are immediately photographed upon admission and family members can contact other hospitals to obtain information about a relative's possible hospitalization. Access to such information is, of course, restricted to authorized personnel.

Dr. Maurizio Foco reported on the security of the healthcare system during mass disasters in Rome and northern Italy. Two projects currently underway will result in the establishment of a major trauma center, as well as a training simulation center. Discussions about the possible construction of an underground hospital are in progress.

Prof. Luke Leenen discussed his experience with a large underground hospital in Utrecht, Netherlands. The hospital has a capacity of up to 300 beds and is in a permanent state of readiness. Only 15 – 30 minutes preparation is needed prior to the first patient's arrival. It is also used, as needed, in day-to-day operations when the hospital receives a greater number of casualties. In addition, it is utilized for staff trainings, which are numerous, and are conducted in close collaboration with a nearby military hospital. The hospital: 1) helps identify needs in times of crisis, conflict, or situations of war, 2) serves Dutch citizens involved in accidents abroad, and their repatriation, 3) offers coordination and treatment during mass disasters and accidents in the Netherlands, 4) provides international assistance to victims from abroad, and 5) aids in the quarantine needs of repatriated patients, including adequate isolation of patients with, for example, suspected Ebola.

Mr. Jakob Pansell from Stockholm, Sweden discussed the Emergo Train System method of training for emergency situations; it is a simulation tool for use in training and analyzing the capabilities of each department (especially the Emergency department). It is an inexpensive tool that can be used for small or large groups within a department, and during working hours. However, it does not substitute for an actual training drill, which should always occur shortly after completion of any theoretical training.

At the conclusion of this section, **Prof. Francesco Della Corte** (University of Eastern Piedmont, Novara, Italy) discussed his 15 years of experience teaching in the CRIMEDIM disaster medicine program. Course certificates have been awarded since 1998, and a Master's degree program has been available since 2005.

In the following part of the program, workshop participants were divided into 3 work groups that addressed specified issues (e.g. risk analysis, surge capacity, and possible solutions for hospitals under extreme circumstances). Following a discussion and critical evaluation, a final document was prepared for presentation.

Field Study Trip

Practical demonstrations were organized for the third day of the workshop and were conducted during a visit to the Galilee Medical Center in Nahariya. We received a briefing from the hospital director, **Dr. Masad Barhoum**, characterizing the particularities of their facilities, which are located 9 km from the border with Lebanon and have, in the past, experienced repeated rocket attacks. In the summer of 2006, approximately 800 rockets fell within a 1 km radius of the hospital. The facility has 700 beds and provides healthcare for a region with 600,000 inhabitants. For about two decades, they have had an underground, fortified unit with 8 operating rooms, a dialysis unit, etc. In the context of humanitarian aid, the hospital has treated 440 patients from Syria, 30% of whom were women and children. The other three hospitals in northern Israel have treated approximately 650 Syrian citizens. One-third of the treatment costs were covered by the Ministry of Health, one-third by the Ministry of Defense, and one-third by the hospital itself.

Next, the group visited an IDF field hospital in the Golan Heights providing Role 1 medical support, and located directly on the border with Syria. It is positioned just a few hundred meters from the Blue Line, which is monitored by UN forces

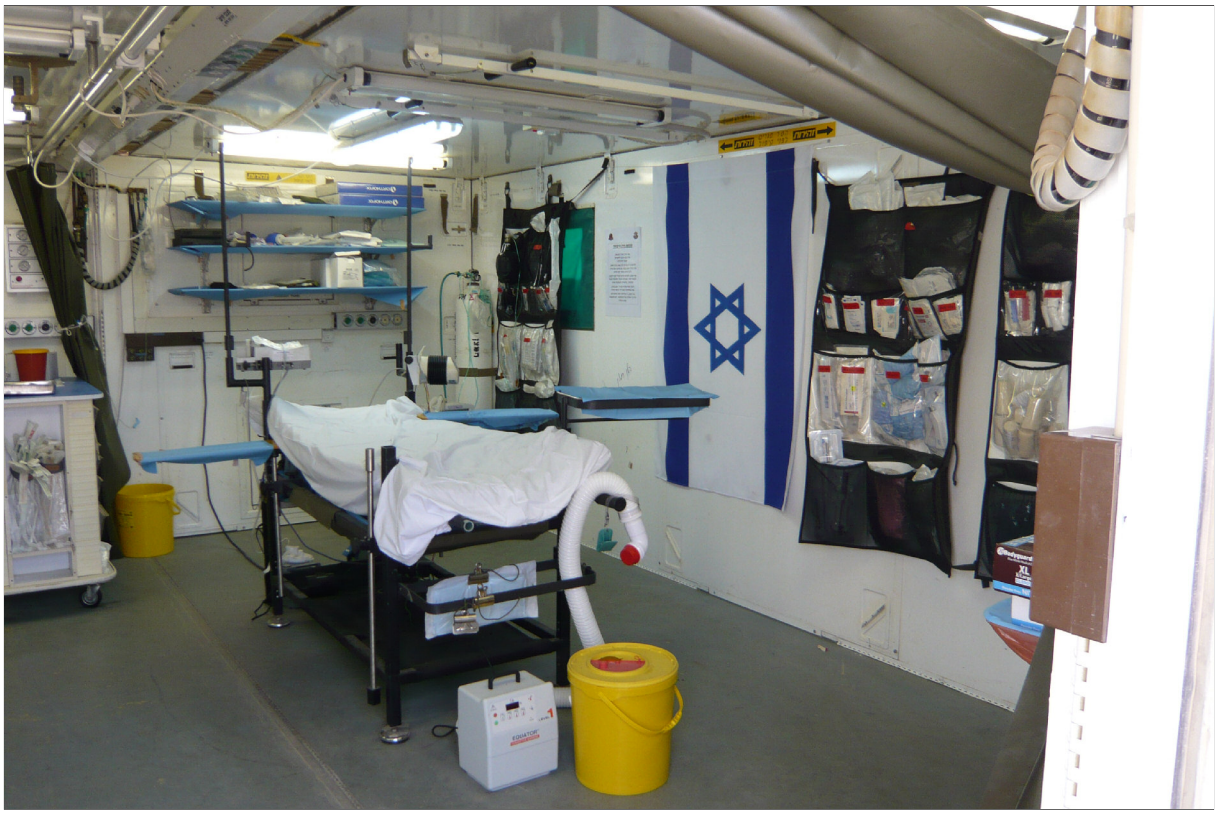

Figure 11. ICU bed in a Role 1 container room.

that continuously patrol the border in vehicles. Throughout the entire visit, artillery fire, grenade explosions, and machine gun fire could be heard from across the border (approximately 30 km away) in connection with battles that have been ongoing (within Syria) for the past 3 years. We were able to examine the facilities in great detail and talk with all of the healthcare professionals, who willingly shared their experience with providing medical care in the field. Our experiences at the IDF field hospital reinforced the concept of good training for health care professionals, especially paramedics, who provide first aid (including cricothyrotomy, thoracentesis, and hemostasis) directly at the point of injury in the field. The staff also confirmed positive experiences with freeze-dried plasma infusions when administering first aid.

On the fourth and final day, workshop participants continued to work in small groups. This was followed by a collective communication presented by **Dr. Chen Kugel**, head of the Israeli National Institute for Forensic Medicine. It included a meticulous overview of modern methods of forensic medicine, which enables identification of deceased during mass disasters or terrorist attacks. Emphasis is placed on maximizing the amount of ante-mortem medical data for comparison with post-mortem data using computer analysis. The best identification method is, of course, a determination of the victim's DNA; however, this requires the existence of a comparison DNA sample obtained prior to the victim's death.

Next, we heard from **Mr. David Ratner**, Rambam Medical Center's Spokesman, and Director of Public Affairs. His presentation dealt with the issue of public information, and how hospitals should deal with the media in mass-casualty situations. The optimal method is still being sought, but cooperation is generally recommended over attempting to prevent media access. On the other hand, the media is expected to respect certain ethical principles, particularly with regard to privacy, protected data, and the identities of the wounded and their families. In the USA and Great Britain, there is an unwritten custom wherein the media does not publish the faces of the wounded during transport or admission to a hospital, nor do they publish drastic, gory images from these situations.

The closing lecture was presented by Swedish surgeon **Dr. Louis Riddez**, who dealt with the issue of field hospitals being mobilized to various disaster-affected areas in other countries. More specifically, he discussed his own experience working with Doctors Without Borders (Medecins Sans Frontieres) in Haiti, Iran, Indonesia and Pakistan. His lecture stressed the correct timing of aid, the organization of work after arriving on site, and collaboration with the local health care infrastructure.

All lectures were followed by rich discussions and an exchange of experiences among participants. After the final lecture, all 3 groups presented the results of their collaborative efforts from the second day. A summary of these results is expected, and will be issued separately, as the final recommendations of this successful, specialized training event.

During the closing of the workshop, after a brief appreciation and acknowledgment of the organizers, both Chairmen presented certificates of participation to all participants.

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