Large-Scale Airmedical Transport from a Peripheral Hospital to Level-1 Trauma Centers after Remote Mass-Casualty Incidents in Israel

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Abbreviations:
MCI = mass-casualty incident
RAEU = Israeli Air Force Rescue and Airmedical Evacuation Unity
YMC = Yoseftal Medical Center

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Abstract

Introduction: Mass-casualty incidents (MCIs) result in the evacuation of many patients to the nearest medical facility. However, an overwhelming number of patients and the type and severity of injuries may demand rapid, mass airmedical transport to more advanced medical centers. This task may be challenging, particularly after a MCI in a neighboring country. The Israeli Air Force Rescue and Airmedical Evacuation Unit (RAEU) is the main executor of airmedical transport in Israel, including MCIs.

Problem: The available data on airmedical transport from remote MCIs are limited. The objective of this study was to evaluate the airmedical transport from a rural hospital after two remote MCIs.

Methods: The study was retrospective and reviewed descriptive records of airmedical transports.

Results: The RAEU was involved in airmedical transports from a peripheral hospital shortly after two remote MCIs that occurred in the Sinai desert near the Egyptian-Israeli border. Nineteen (22.4%) and 25 (100%) of the treated trauma patients from each event were airmedically transported to Level-1 Trauma Centers in Israel within hours of the dispatch. The rapid dispatch and accumulation of medical personnel and equipment was remarkable. The airmedical surge capacity was broad and sufficient. Cooperation with local authorities and a tailored boarding procedure facilitated a quality outcome.

Conclusions: The incorporation of a large-scale airmedical transport program with designated multidisciplinary protocols is an essential component to a remote disaster preparedness plan.

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Introduction

Mass-casualty incidents (MCIs) are a major concern to health systems. While there are different definitions for a MCI, a generally accepted definition is an event in which there are insufficient resources to treat all of the patients involved.[1,2] When a MCI has a large impact, usually on a national scale, a disaster can be declared. The management of MCIs and disasters is complex from the medical and the organizational point of view. Management may be even more difficult when dealing with events that occur far away from advanced medical centers. Studies have shown that the evacuation of trauma victims with severe injuries to Level-1 Trauma Centers improves their clinical outcome.[3,4] Large-scale transport of patients from the incident site to proper medical centers should be part of any disaster preparedness plan. Airmedical transport of trauma victims may be required when an overwhelming number of patients or the type and severity of injuries demand rapid evacuation to remote medical centers.[5] This practice is performed routinely worldwide, yet, the number of reports dealing with the difficulty of managing the airmedical transport of victims of MCIs and possible solutions to successfully perform such missions is limited.[6–11]

Unfortunately, in recent years, there have been many MCIs in Israel, mostly due to terrorist attacks. Most of these incidents have occurred in the northern or central parts of the country, where many Level-1 Trauma Centers are located within short distances, allowing rapid ground evacuation to these centers. In contrast, the southern area of Israel is located relatively far from the nearest Level-1 Trauma Center. This area, which includes the city of Eilat, the Red Sea, and the eastern shores of the Sinai Peninsula, is a popular and rather safe international recreation area that attracts tens of thousands of visitors year-round. Nevertheless, in recent years, several MCIs have occurred in this area, including terrorist attacks and major vehicle accidents. The only medical facility available in this district is a small rural hospital (65 beds) with limited capabilities (minimal general surgical and orthopedic and no neurosurgical) located in the city of Eilat. The nearest major medical center is located 300 km away, a few hours drive on a single lane desert road. In some cases, trauma incidents occur in the nearby Sinai desert, on the Egyptian side of the border, further complicating the evacuation procedure. Thus, in case of a MCI, large-scale airmedical transport of patients from this remote region to senior medical centers was incorporated into the relevant national disaster plan.

The Israeli Air Force Rescue and Airmedical Evacuation Unit (RAEU) is the main provider of military and civilian airmedical transport in Israel. Besides the RAEU, the Israeli national prehospital emergency medicine system has utilized small helicopters for the airmedical transport of a limited number of patients since 2007. The RAEU was established in 1974, and has performed thousands of different and complicated search-and-rescue missions, including airmedical transports. Israeli Air Force Rescue and Airmedical Evacuation Unit teams consist of flight surgeons and paramedics joined with rescue operators trained as medics. Most of the operations are executed on-board helicopters. Fixed-winged aircraft rarely are used. The aircraft in use can carry a large number of patients, medical personnel, and equipment. Teams are on-call 24-hours/day, year-round and can be airborne within 15 minutes. In the majority of missions, only a single team (usually for a single evacuee) is operational. For large-scale airmedical evacuation, a systematic dispatch protocol is activated by the Command and Control Headquarters of the Israeli Air Force, enabling the accumulation and operation of several teams and aircraft. This is an example of designated, planned military assistance to civilian authorities, which is common in Israel.

After two prominent MCIs the Eilat area, airmedical transport from the rural hospital to Level-1 Trauma Centers were performed by the RAEU. The objectives of this study were to analyze the large-scale airmedical transport from those MCIs, evaluate performance, and provide recommendations for better preparedness and execution.

Methods

A retrospective review and analysis of the airmedical transport data collected from two remote MCIs were performed. Patients from both MCIs initially were evacuated to Yoseftal Medical Center (YMC) in Eilat. The first event was a MCI due to the detonation of a car bomb at the Taba Hilton hotel in October 2004. The second was a bus crash near Nueiba in August 2006. Both of these locations are within the Egyptian territory. After each RAEU mission, all operational and medical data are digitally recorded on computerized database programmed with Microsoft Access 2002® (2007, Microsoft Inc., Redmond, WA) software on a SQL server. Data include a time log, details of participants and evacuees, a structured description of the operation, a full medical chart for each evacuee, and the details of equipment utilization during the mission. Data acquired are compared with the Air Force Command and Control Headquarters real-time logs. Quality control of recorded data is performed routinely. Debriefing by a senior authority is performed for all operations on a weekly basis, in which lessons are derived and instructions are directed. Abstraction of all records and debriefing data of all airmedical operations related to the two investigated MCIs was performed. Numerical data were transferred to an electronic data sheet using Microsoft Excel 2004® (Microsoft Inc., Redmond, WA). Data from all airmedical transport flights related to each MCI were combined and evaluated accordingly. As all RAEU activity is under military responsibility and authority, the study and publication of data received approval from the relevant authorities.

Results

Terrorist Attack (Car Bomb) on the Taba Hilton Hotel, 07 October 2004

Nearly 200 people were injured and 32 were counted killed following a car bomb explosion at the entrance of the Taba Hilton Hotel. The explosion destroyed the west wing of the building. The hotel is situated on the Egyptian side of the border with Israel, adjacent to the city of Eilat, and is a popular recreation site for Israelis. Since Israeli ambulances were not allowed to enter Egyptian territory, they waited at the border. Israeli casualties were evacuated to the border by various means of transportation, mostly undesignated and improvised. At the border, the casualties were transferred to ambulances and transported to the YMC, a 10-minute drive. The casualties reached the border in one wave, causing a surge at the YMC. In total, 85 Israeli trauma patients were evacuated from the scene through the border to the YMC. The remaining casualties were Egyptian locals and foreign tourists that were evacuated to Egyptian medical facilities. An Israeli offer to receive and treat non-Israeli casualties was declined.

Several minutes after the explosion, the first on-call RAEU team was dispatched by the Air Force Control Command. Once the magnitude of the incident was understood, more teams were dispatched. Reserve airmedical personnel were called and additional medical equipment was obtained from designated storage. Sixty minutes later, the first team aboard a UH-60 helicopter landed near the YMC. Within three hours, 20 flight surgeons, nine paramedics, and 27 medics had joined the teams. The accumulation of aircraft and medical personnel is provided in Table 1. Not all of these personnel participated in the airmedical transport. Designated reinforcement medical personnel and support for the YMC joined the flights of the airmedical teams as part of the Emergency Activation Program

Number of medics**	Number of paramedics	Number of physicians	Type of aircraft	Time from MCI
4	--	1	UH-60	60
8	--	2	CH-53	75
3	2	7	CH-53	120
4	--	1	UH-60	120
8	7	9	C-130	200

Table 1—Terrorist attack on the Taba Hilton Hotel, 07 October 2004: Accumulation of aircrafts and medical personnel on site*
* The numbers of personnel represent the personnel arriving to the site, not the distribution of personnel on the airmedical transport flights (see Table 2)
** Including rescue operators

Number of patients	Number of medics*	Number of paramedics	Number of physicians	Type of aircraft
6	6	-	4	CH-53
6	7	1	2	CH-53
1	3	-	1	UH-60
3	3	1	1	UH-60
3	4	2	2	C-130

Table 2—Terrorist attack on the Taba Hilton hotel, 07 October 2004: Distribution of medical personnel and patients on the airmedical transport flights
* Including rescue operators

Flights (minutes from the MCI)	Type of aircraft
160	CH-53
200	UH-60
320	CH-53
660	C-130
960	UH-60

Table 3—Terrorist attack on the Taba Hilton hotel, 07 October 2004: Time log of the airmedical transport flights (MCI = mass-casualty incident)

Injury	Number of patients
Penetrating head injury, sedated, intubated, ventilated	1
Penetrating chest injury, chest tube	1
Multiple burns, IV fluid, MO, O_2	1
Skeletal fractures	7
Head concussion	2
Deep penetrating injury to limbs	3
Soft tissue laceration and contusions	4

Table 4—Terrorist attack on the Taba Hilton hotel, 07 October 2004: Characteristics of injuries of the airmedical transport patients (IV = intravenous)

of medical reinforcement for the YMC, regulated by the Ministry of Health. The first RAEU team acted as a command and control unit until being replaced by a senior designated team from the RAEU homebase. The Command Team engaged with local hospital management and health authorities. After triage and initial treatment in the YMC, the Command Team coordinated the transfer of patients to airmedical transport. Airmedical teams were organized after staging near the YMC and relocated to aircraft. The distribution of medical personnel and patients are listed in Table 2. Less than three hours after the explosion, the first air-medical transport unit took off from the YMC to a Level-1 Trauma Center. The time log of the airmedical transport is in Table 3. Destinations of airmedical transport were two Level-1 Trauma Centers in Central Israel. In total, 19 victims (22.4% of the patients treated in the YMC) were airmedically transported from the YMC. The characteristics of the injuries of the airmedically transported patients are in Table 4. On-board treatment included ventilation, oxygenation, sedation, administration of intravenous fluids and intravenous analgesics, and monitoring. All patients remained stable during the flights.

Bus Roll-Over Accident near Nueba, Sinai, 24 August 2006
Fifty tourists were in a tour bus when it rolled over. After limited treatment by local Egyptian authorities on-scene, casualties were evacuated to a local medical clinic nearby. Improvised ground transportation (buses), was organized to evacuate 25 Israeli patients to the Israeli-Egyptian border, some 30 km from the accident scene. Israeli EMS ambulances waited on the border and transferred the injured to the YMC in a matter of minutes. The rest of the casualties from the accidents were non-Israeli that were evacuated to Egyptian hospitals.

Initial information regarding the accident and the possible need for airmedical transport was delivered to the Air Force <30 minutes after the event. Two helicopters with reinforced airmedical teams and supplies were dispatched immediately. En route, one of the helicopters was ordered to pick up medical personnel from a medical center to assist the YMC. The first helicopter and airmedical team arrived one hour after being dispatched, and was joined shortly by the second helicopter. Upon learning that the patients had not yet reached the YMC, the helicopters and most of the crew were referred to a nearby Air Force base to await further instruction. Only a command team of three members, including the Operation Commander, Senior Airmedical Officer, and Coordinating Paramedic stayed in the YMC and communicated with local hospital management. Due to the delayed response of local authorities and technical difficulties, all 25 patients arrived at the YMC nearly five hours

Number of patients	Number of medics*	Number of paramedics	Number of physicians	Aircraft
12	7	2	2	CH-53
13	6	3	2	CH-53

Table 5—Bus roll-over accident near Nueba, Sinai, 24 August 2006: Distributions of medical personnel and patients on the airmedical transport flights
* Including rescue operators

after the crash. After triage and necessary treatment in the emergency department, the YMC management requested airmedical transport to central Israel for all 25 patients. All patients were members of a few families traveling together, most of them children. Separating them would have been problematic. In addition, the YMC needed to clear as many beds as possible, as this was the high tourism season in Eilat. Twenty-five patients would occupy almost 40% of all hospital beds at the YMC. After reviewing the possibilities and risks, a decision was made to complete airmedical transport of all patients. The patients were gathered in one hall of the emergency department where they underwent final evaluation by the Senior Airmedical Officer. All of the patients were medically approved for airmedical transport. They were divided into two groups for each helicopter.

The principles of division included severity of injury and family relations. First, the more severely injured patients were assigned to the helicopters. Then, their family members were put in the same helicopter. Patients were allocated to specific locations in each helicopter using a specific boarding registration chart. Helicopters were called to land at the YMC one at a time. Flight surgeons from each helicopter entered in turns and after being debriefed by the Senior Airmedical Officer, received the patient status for each patient for whom they were responsible, and their designated location in the helicopter. The distribution of patients and airmedical personnel on-board the helicopters is presented in Table 5. Two of the patients were more seriously injured. One had sustained a pelvic fracture with suspicion of internal hemorrhage. Administration of fluids and blood in the emergency department temporarily stablized the patient for transport. Another patient had a chest injury and a thoracostomy tube was inserted in the YMC. The YMC did not have the surgical capabilities to provide definitive care to these patients. The characteristics of injuries of the airmedically transported patients are listed in Table 6. On-board treatment included oxygenation, intravenous fluid, blood, analgesics, and monitoring. The conditions of all patients remained stable during the flights.

Main Injury	Number of patients
Pelvic fracture, hemodynamically compromised	1
Chest injury, chest tube	1
Ribs and skull fracture (no internal injury)	1
Combined upper and lower limbs fractures	1
Upper limbs fractures	1
Lower limbs fractures	4
Soft tissue lacerations	5
Blunt soft tissue contusions	11

Table 6—Bus roll-over accident near Nueba, Sinai, 24 August 2006: Characteristics of injuries of the airmedical transport patients

Discussion

Through the RAEU, the Israeli Air Force was engaged in providing airmedical transports from a rural peripheral hospital (YMC) shortly after two remote MCIs to Level-1 Trauma Centers. Airmedical teams were dispatched immediately and reached the scene before most of the patients had arrived at the YMC. For both operations, the RAEU implemented a planned method for large-scale airmedical transports, including engagement and coordination with local management and organized loading of trauma patients to aircraft. Evaluation of the data enlightens the RAEU capabilities to summon quickly large numbers of medical personnel and to provide them with enough supplies.

When a MCI or a sudden-onset event occurs, a greater amount of medical resources is needed quickly. This enlarged demand is called surge. The ability to obtain these additional medical resources is called medical surge capacity or patient care capacity.[12,13] The term *airmedical surge capacity* should be used to define the ability to rapidly expand the capacity beyond those carried during the normal airmedical services in order to meet the increased demand in the event of large-scale health emergencies or disasters. This definition dictates the need for large-scale airmedical transport planning. This need is derived from the inablity to evacuate trauma patients directly to Level-1 Trauma Centers using ground transport. Recognizing remote areas from relevant medical centers, where the quantity of people is significant and the risk for MCI of any kind is not scant, is the first step for preparedness of an airmedical transport activation program.

Planning for such a program at a national scale is essential. Quantifying the proper planning requires the incorporation of relevant parameters or metrics of surge.[14] Medical surge capacity is composed of three essential components: (1) staff; (2) stuff (equipment); and (3) structure (physical and organizational). The same can be applied to airmedical surge capacity. It is paramount to define metrics for these various components of surge in terms of severity, acuity, duration, magnitude, volume, and nature of the event.[13] A proper program would include basic definitions, protocols, and methods of operation for each step, detailed supplements of medical personnel on-call, lists of supplies, aircraft configuration schemes, a communication appendix, and command and control orders. This program determines when and where to delegate authority to capable providers and how to define new tasks and teams.[15] Beyond this plan, maintenance of knowledge and capability is performed routinely by drills to test medical, administrative, logistical, and workforce risk communication. All is part of a comprehensive preparedness plan of the national supreme health authority.[15]

A key step is to contact local medical authorities to incorporate them into the plan. Procedures should be coordinated and integrated with them. A framework of practice drills should be devised. Flexibility is a mandatory feature for all plans, to ensure relevance in different scenarios. On the other hand, definitions of procedure, activation, and key formulas of resources proportions are fixed.

There are a few reports of large-scale airmedical transports from MCIs. Another large-scale airmedical transport performed by the RAEU previously was reported by Marmor *et al*.[6] Following a terrorist attack using a car bomb in the Paradise Hotel in Mombassa, Kenya, 12 people were killed, including three Israelis, and 80 were wounded (22 of them were Israeli). All Israeli patients were evacuated to Israel by airmedical transport. There was redundancy in the medical crew and medical equipment sent. Similarly, the number of aircraft and teams dispatched after the terrorist attack on the Taba Hotel was more than required. Improvement of the proper response was accomplished during the second MCI in the current study. A proportional and professional mode of operation for similar missions is advised. Unlike the MCIs in this study, the airmedical transport from the Mombassa terrorist attack had a much longer timeframe (many hours to days).

Hampson *et al* reported on the Australian Defense Force response to the Bali bombing on 12 October 2002.[7] Two separate operations were described in their report. The first was the airmedical transport of 66 critically ill patients from Bali to Darwin that required >21 hours. The second was the airmedical transport of 35 patients from Darwin to four separate senior medical centers involving 50 medical staff. While the magnitude of this event was much larger than the airmedical transport described in the current report, the time response of the Australian Defense Force was longer; the first aircraft reached Bali almost one day after the bombing. The RAEU and the Israeli Air Force has the capability to dispatch a high number of aircraft quickly, with dedicated personnel and equipment. Hampton *et al* addressed their equipment difficulties in the initial stages of the mission. Future improvement in equipment readiness and update, combined with proper training, was recommended.

Canchio reported on the US Army airmedical evacuation response to the airplane crash in Guam on 06 August 1997.[8] Twelve burned survivors were transported to Korea and later to the US, treated en route by a US Army Burn Team and the Air Force Care Air Transport. During this combined mission, many difficulties arose including limited administrative oversight, uncoordinated communication procedures, limitations in equipment, and low team readiness. Recommendations were directed to training procedures, equipment and communications protocols. Canchio did not discuss fully the issues of engagement and management of the patients prior to airmedical transport and during boarding.

Vassallo *et al* reported on two MCIs in which large-scale airmedical transport was performed.[9–11] Both were military helicopter crashes. The first was in Bosnia on 08 January 1998 and involved 21 casualties, of which, 17 were airlifted to a nearby military hospital and were transferred using airmedical transport to a senior hospital in Prague the next day. The second crash was on 28 January 2002 in Afghanistan; it involved 16 casualties who all were airmedically evacuated from a rural medical facility to a Level-1 Trauma Center. In both incidents, the airmedical transport was a joint effort of military airmedical forces of two different countries: the UK and Czech armies and the UK and US armies, respectively. Vassalo *et al* emphasized the importance of common and agreed protocols and combined training. They did not elaborate on the boarding and engagement procedures.

Interestingly, in all the reported incidents, the large-scale airmedical transport was performed by military organizations. High-capacity aircraft with proper airmedical transport configuration mainly are used for military purposes. Military organizations also are capable of rapidly deploying and dispatching sufficient airmedical teams and equipment. A successful solution for a national large-scale airmedical transport plan for remote MCIs and disasters is reliance on military assistance. If this solution is selected, the plan should define protocols for cooperation, engagement, and communications. Reimbursement of the military for its assistance must be optimal. In Israel, the military assistance to civilian authorities during disasters and peacetime in various aspects is part of the military's national duties and is budgeted accordingly in advance.

During a MCI, the need for secondary airmedical transport should be acknowledged as soon as possible. Then, the emergency plan should be activated. Initial data should be collected including the scale and type of the event, and the predicted number and condition of patients to be transferred. Based on these data, the specific resources (aircraft, personnel, equipment) for the mission are determined in accordance with the planned key formulas. One should not improvise; planned definitions and protocols must be used. The first team with command and control capability should be dispatched immediately to engage with the local authorities. Important partners, such as Level-1 Trauma Centers intended to receive patients must be notified and coordinated; usually through the Ministry of Health.

Beyond the preparedness for the airmedical transport mission, there are secondary missions for the airmedical teams and aircraft. If backup medical equipment for the peripheral hospital is needed, it can be transported rapidly on board the incoming aircraft. Professional personnel reinforcement for remote areas is a key element in a national emergency program. En route pickup of medical personnel intended to join the peripheral hospital is another secondary mission for the airmedical transport teams. Although this transport of personnel and equipment is intended to increase the medical surge capacity of the peripheral hospital, its facilities (operating rooms, critical care units, imaging machines, specialized laboratories) still are too modest to waive the airmedical transport of patients to senior hospitals.

Determining a waiting site for aircraft and personnel is mandatory. Most often, MCI patients are not ready to board the aircraft immediately upon arrival. Time is needed to process the patients and prepare the airmedical transport. The waiting site (staging area) should be close, but not too close (a few minutes flight away). The aircraft and its airmedical transport team can reach that site and wait to be called by the Command and Control Team to the local hospital landing site.

Establishing modes of command and control is cardinal. Designations of managers include an overall operational manager, overall medical manager, and each aircraft team leader. On site, a command and control unit should become operational as quickly as possible, with the responsibility of coordinating all airmedical transports. It usually is stationed adjacent to the local triage hospital, preferably in the emergency department with connection to local management. Back in the homebase, an operational headquarters for coordination, feedback, and supervision is cardinal.

A communication protocol must be defined. All managers, team leaders, and pilots should be connected with the proper communications. In previous RAEU missions, multi-channel wireless headphones have proven to be ideal. Backup instruments and enough batteries are essential.

Designated and ever-ready medical and operational equipment should be kept close to the aircraft intended for airmedical transport. This equipment is beyond what every airmedical team carries for regular missions. It includes additional monitoring, oxygen, and ventilation devices, sufficient litters, enough batteries, and modes of energy for all devices. Additional electricity adapters for medical equipment also should be ready.

Engagement and transfer protocols are important. The RAEU has specific definitions for various modes of engagement and transfer. The first condition to be confirmed is the level of risk for the airmedical personnel and aircraft. When a threat (terrorism, war, disaster due to natural hazards) is valid, adapted protocol is applied. The aircraft should circle at a safe distance and the communicate with the local medical authority. Patients can be transported on the ground to a safer landing site where the final engagement and transfer should occur. When it cannot be performed, the possibility of landing in a threatened landing site is evaluated in a risk-benefit mode. If this type of landing is performed, the transfer of patients to the aircraft will be quick without any medical information transferred. The information can be delivered through communications. In non-threatening situations, the airmedical personnel should disembark from the aircraft and engage with local medical authorities. A detailed transfer protocol of medical information must be completed.

After engaging with local authorities in the peripheral hospital and the completion of initial patient processing, the decision of which patients need airmedical transport to a Level-1 Trauma Center is made. Not all patients need to be transferred, although this can be the case as in one of the MCIs in the current study. The transfer of these patients to the airmedical transport teams is a delicate stage. After triage and treatment, all airmedical transport patients should be located in a designated space in the peripheral hospital. The senior medical manager of the airmedical transport unit should engage with the local hospital event manager. The latter presents the patients in terms of diagnosis, treatment, and current status. The medical manager would approve the selection and readiness of patients to be transferred. The operational and medical managers then determine the order of boarding, and select the medical teams and aircraft for each group of patients.

The use of boarding cards and charts is recommended. Each patient is designated to a location/seat in an aircraft, and this location should be marked on a master boarding chart. A boarding card would then be attached to the patient. This card will guide the on-board personnel where to put the patient. The locations and order of boarding is derived from the patient's medical severity, and the desire to put family members, especially children and parents, together. Mildly-injured patients are boarded first. Medical escort is matched to the patients by their severity; severely-injured casualties would receive a closer and more intense escort to the aircraft.

During a medical emergency, many limitations regarding boarding aircraft are lifted. The Israeli Air Force allows airmedical transport of all patients in need, regardless of their identity. The need for airmedical transport is approved by a qualified airmedical officer. Airmedical transport is not enforced on patients declaring clearly their refusal to board the aircraft. When a hostile patient needs an airmedical transport, a proper security escort will be applied. Pediatric patients are escorted routinely by an adult, preferably one of their parents.

Aircraft configuration should be defined for each mission. As such, flexibility must be a main feature. High-capacity aircraft are preferred. For large-scale airmedical transports, the Israeli Air Force uses the CH-53 helicopter and the C-130 airplane. These aircraft are capable of carrying dozens of casualties. Other high-capacity aircraft are found in various countries. Places for sitting and lying should be designated depending on patient severity and medical needs during transport. Each place is given a code and the aircraft is divided into departments (sitting/mild, lying/mild–moderate, severe, critical). A schematic (diagram) of the aircraft should be drawn with the locations for patients (departments and their codes/numbers).

Inside the aircraft, the medical personnel are divided between the different "departments" in the aircraft. For sitting and mild patients only a few caregivers/medics will suffice. For the more serious and critical patients, more physicians and paramedics are needed. Working in small teams of one physician, one paramedic and one medic was optimal during RAEU's long-distance air-medical transport missions.

The decision to perform airmedical transport from remote hospitals is derived from medical reasons and from organizational needs. The same capabilities and methods of large-scale airmedical transport can be applied, no matter the scenario. In all the reports of large-scale airmedical transport, patients were airmedically transported from remote medical facilities due to organizational and medical reasons. Justified non-medical reasons for large-scale airmedical transport include clearing a small hospital rapidly, transferring casualties to a centralized hospital close to their families, and moving casualties from threatened remote areas. Furthermore, the need to transfer patients to senior medical centers is not only derived from life-threatening injuries, but also from the need for early definite orthopedic and other surgical treatment that improves outcome and reduce morbidity. The lack of advanced, definite, multi-disciplinary surgical capabilities in the remote hospital mandates an early transfer.

The mode of transportation to the aircraft from the hospital is variable. A landing site adjacent to the hospital enables reaching it on-foot. A distant landing site or

airstrip mandates motorized transportation, which is coordinated with local authorities.

The medical competence of airborne teams is a major issue. Proper protocols, qualified personnel, and adequate equipment are necessary. Medical protocols of the RAEU are derived from the well-accepted protocols (Advanced Trauma Life Support, Prehospital Trauma Life Support, Advanced Cardiac Life Support, and Pediatric Advanced Life Support) with proper adaptation to the airmedical environment (for example, almost no reliance on auscultation due to the noise and vibrations during the flight). Emphasis is given to airway management, respiratory support, external hemorrhage control, and comprehensive monitoring. Medical airborne teams include experienced and qualified flight surgeons and paramedics. Onboard, they have relevant medical equipment which resembles a mobile critical care unit, including advanced airway management (intubation, laryngeal mask, surgical airway), respiratory support (oxygen, automated ventilators), chest drainage, bleeding control, fluids, different affixing accessories (for neck, pelvis, extremities), a range of medications (resuscitation, narcotics, antibiotics), a defibrillator, and several monitors (electrocardiogram, blood pressure, pulseoxymeter, capnograph, temperature). In addition, the RAEU teams have O+ red packed cells units, basic surgical damage control equipment, and specialized heat convectors to warm patients on-board. Onboard configuration enables care to be given, including proper designated litters and suspending solutions. Special electricity adaptors to the aircraft are available. In the described incidents, the patients were fully monitored, warmed, and given fluids, analgesics and sedatives as needed. Affixing accessories were applied as required.

Medical records are a major concern. All records of the patients transferred should be brought with them. During airmedical transport, designated medical records can be used. All relevant data (personal, injury, monitoring, treatment) are recorded. The use of clipboards and personal digital assistants is recommended.

Contrary to a classic on-scene airmedical evacuation, the main principle of airmedical transport from a remote hospital after a MCI is quality of performance, not speed. The organizational and logistical challenges of a large-scale airmedical transport can be overcome if it is done without a sense of haste.

After each airmedical transport mission, quality assurance is performed. The RAEU has a specific protocol for quality assurance. Systematic feedback forms are filled out by all relevant personnel. Data are reviewed by a senior authority. Later, a designated forum is assembled to further review and comment. An external, un-biased expert leads this forum. A final report with conclusions and future tasks is the end product. A digitalized registry of all operative and medical activities of the RAEU is operational and active. Such a registry should be created to identify airmedical surge capacity metrics as a by-product of routine work.[12]

The study had a few limitations. It is retrospective and relies on reports and debriefings of personnel in a pressured mission. The recommendations are based on only two incidents with a relatively small number of patients. Nevertheless, there are limited reports on large-scale airmedical transport from remote MCIs that account for the gaps in the knowledge of this subject. This study broadens the perspective and contributes an organized scheme for large-scale airmedical transport. The recommendations derive from deep insight and vast airmedical experience beyond the MCIs reported here, which serve as sentry examples.

Conclusions

Remote MCIs warrant the use of large-scale airmedical transport to advanced medical centers. Meticulous and coordinated planning, full preparedness with sufficient resources, and flexible activation with professional handling are key points for successful coping with this challenge. The experience of the RAEU and relevant recommendations were reported and addressed. Proper adjustments are needed for the implementation of large-scale airmedical transport in different countries.

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