

Helicopter evacuation: the Singapore General Hospital experience

直升機的運送：新加坡綜合性醫院的經驗

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Objective: To review the current state of helicopter casualty evacuations (helicasevac) in Singapore. **Methodology:** A retrospective study of helicasevac missions to the Singapore General Hospital over a 12-year period from 1991 to 2002. **Results:** Of the 297 casualties evacuated over 234 missions during the period, 90.2% (268/297) were trauma related and 9.8% non-trauma. The majority of these trauma casualties were military national servicemen with heat injuries (63.4%, 170/268), followed by external injuries (25.0%, 67/268). The most common medical referrals were for cardiovascular or neurological conditions. Most of the patients brought in were critically ill, unconscious or semiconscious. Most were admitted (88.2%, 262/297). None of the 19 patients who collapsed and were without signs of life prior to helicopter transport survived attempted resuscitation at the emergency department. The usefulness of transferring them with helicopter is doubtful. The on-scene diagnosis and inpatient diagnosis for the patients were consistent in 98.6%. The air evacuation mission locations were mainly from the surrounding islands of Singapore – 58%, while 17% were from ships traversing the nearby straits e.g. the Straits of Malacca and South China Sea and 19% were from military camps within mainland Singapore. **Conclusion:** The criteria for despatching helicopters for air evacuation in Singapore have not been established. There are benefits in terms of transport time and bringing on-site medical care to casualties at distant offshore locations. The benefit of evacuating urban patients by helicopter is doubtful, especially if they are already in cardiopulmonary arrest. (*Hong Kong j. emerg.med.* 2004;11:211-219)

目的：評論現時新加坡以直升機運送傷病者的狀況。**方法：**將新加坡綜合性醫院十二年以來(1991-2002)的直升機運送傷病者任務作回顧性研究。**結果：**其間 234 宗飛行任務中有 297 名傷病者被運送，分別有 90.2% (268/297) 與創傷有關及 9.8% 屬非創傷類。大部份創傷者乃男國家軍人，傷者大都是「中暑」受傷不適(63.4%, 170/268)，其次是外傷(25.0%, 67/268)。最常見的內科轉介為心血管或神經病況。大部份送抵的病者都是危殆、昏迷或半昏迷；而且大都需要住院(88.2%, 262/297)。19 名昏倒並於直升機運送前已無生命跡象的病者，在急症室嘗試復甦後無一生還；故此其直升機運送的效用備受質疑。98.6% 病者在現場及住院的診斷是一致的。空中撤離運送任務的地點主要集中在新加坡周圍的島嶼(58%)，17% 是來自橫過附近海峽的輪船(例如馬六甲海峽及南中國海)，及 19% 是來自新加坡大陸的軍營。**總結：**現時新加坡仍未建立一套派遣直升機作空中撤離運送的準則。空中運送的好處在於節省時間，並可為遙

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遠離岸地點的傷病者提供現場醫療照顧；至於直升機運送市區病者，特別是心肺已經停頓時，其好處是存疑的。

Keywords: Air ambulances, emergency medical services, multiple trauma, transportation of patients

關鍵詞：救護飛機、緊急醫療服務、多發性創傷、運送病者

Introduction

The use of helicopters to transport critically ill patients to hospitals in Singapore has been going on at the Singapore General Hospital (SGH) for more than 30 years. No review other than this present one has been done.

The helicopters used for medical air evacuation to SGH are military helicopters only, managed and coordinated by the Republic of Singapore Air Force (RSAF) through the Ministry of Defence Operations Centre (Figure 1). The military team involved in the helicopter case evacuation (helicasevac) consists of one physician (military medical officer), one medical orderly (Emergency Medical Technician I – equivalent), two aircrews and two pilots. These military medical officers have been trained in Advanced Trauma Life Support since 1992. Advanced Cardiac Life Support has been introduced to them since 1996. They also undergo a short course on aviation medicine whereby they receive instruction on the special problems of assessing and monitoring a variety of patients at high altitudes and on equipment problems in a helicopter. There are no civilian helicopters landing at the hospital helicopter pad. In the event that private air evacuations have been used, these jets or helicopters will land at the Seletar Air Base (which is about 18 km from SGH) for subsequent ambulance transfer to SGH.

Helicopter evacuation would normally be indicated when the transport time of patients from scene to hospital is expected to be prolonged. Such delays may be due to long distances, obstruction to land transport by traffic, or inaccessible sites especially across miles of sea. However, it has to be balanced with the problems and hazards posed to patients during

transport by air. Being a tertiary hospital, SGH receives most of the casualties evacuated to Singapore by helicopter. We embarked on this study to have a clear understanding of the patterns of such evacuations and to identify potential problem areas, with special regards to (i) the profile of patients evacuated, (ii) their outcomes, and (iii) the appropriateness of the helicopter evacuation.

Materials and methods

A retrospective study was conducted on all helicopter evacuation cases brought to SGH over a period of eleven-and-a-half years from 1 January 1991 to 31 July 2002. The information was obtained from the emergency department helicasevac files, the emergency department record books and the relevant inpatient medical records. In addition, basic information on the helicopters, their equipment and the modes of operations were clarified with the RSAF.

The information included the followings: -

- i) Profile of patients – age, sex and race.
- ii) Locality from where the casualty evacuation occurred.
- iii) On-site and en-route life support treatment given to patients such as endotracheal intubation, cardiopulmonary resuscitation, defibrillation and intravenous drugs or fluids.
- iv) Treatment administered at the Emergency Department.
- v) Referring diagnosis and the diagnosis made at the Emergency Department.
- vi) General condition of the casualties.
- vii) Discharge diagnosis, types of injuries and cause of death.

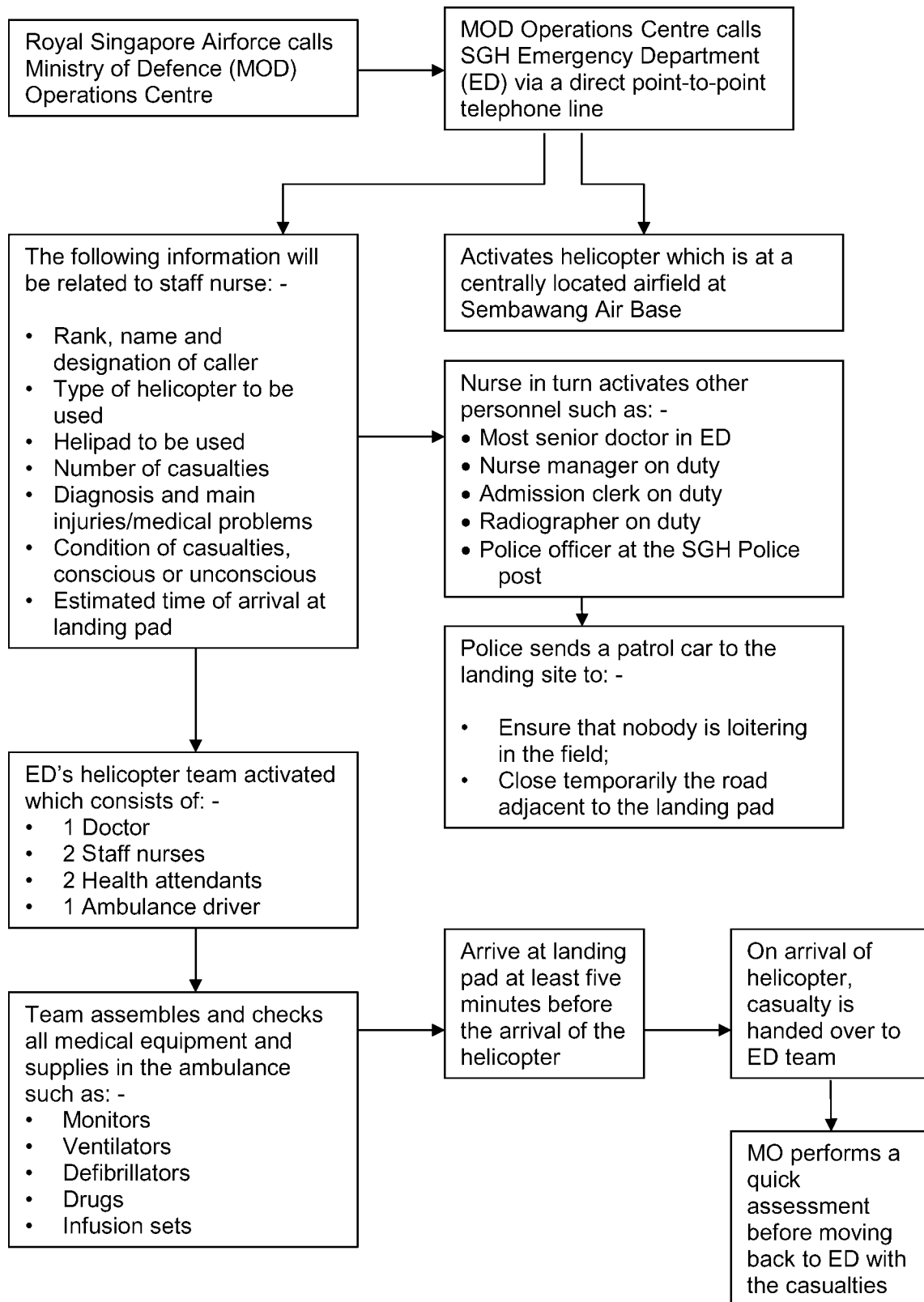


Figure 1. Workflow in the event that the hospital is activated for the arrival of helicasevac cases.

Results

For the period from 1 January 1991 to 31 July 2002, a total of 234 air evacuations were made involving 297 casualties. The case sheets for the entire year of 1996 could not be traced. All the evacuations were by helicopters of the RSAF. There were no recorded instances of aeromedical evacuation by private helicopters direct to SGH during the period of review.

Almost all the casualties were male (98.3% or 292/297), with a greater proportion of Chinese by race (74%). Malays made up 6%, Indians 4% and other races 16%. Since military helicopters were used, it was not surprising that 79.5% (236/297) of the casualties were military with only 20.5% (61/297) civilians. The evacuated casualties' age ranged from 18-73 years. It was highly skewed towards the younger age (median 21). Those in the age group of 18-24 years comprised 79.8% (237/297) of the total. This was obvious as most of them were Singaporean males doing their two-and-a-half years of compulsory military service. Moreover, the fact that the helicopters belonged to the military meant that the latter had free reign on their usage for their own sick army boys.

The incidence locations of these evacuation missions and the median times from notification of the Emergency Department by the Ministry of Defence to the arrival of the helicopter at SGH are shown in Table 1. In some instances, the locations were unclear as the casualties came from luxury liners where the locations were not specified. Civilians' requests came from Pulau Ubin, ships traversing the Straits of Malacca, South China Sea and from other offshore

islands. The 18.9% (56/297) that came from military camps on the main island of Singapore were by and large severe accidents.

An analysis of these cases from the mainland military camps showed that 39 had heat injuries of which 38 were admitted to general wards. These national servicemen usually presented in a semiconscious or confused state at the Emergency Department, but with stable vital signs. One had fits and another migraine. Two had gunshot wounds (whereby one died at scene). Another army personnel had non-traumatic cardiac arrest and was brought in dead. There was a case of poisoning, another with septic shock and six with insect bites. Out of these, only two were admitted to the intensive care unit – one with heat stroke and the other with septic shock.

The various types of anatomical systems involved in these 297 patients are summarised in Table 2. The two commonest kinds of injuries noted were heat and external injuries. Table 2 also details the types of external injury sustained.

The non-trauma referrals were predominantly cardiovascular and neurological. There were four cases of acute myocardial infarction, one with pulmonary oedema and four with angina. The neurological cases were mainly epilepsy (7/10) and three were cerebrovascular accidents. Infections included two patients with septic shock, one with epiglottitis and one with meningitis. There were three gastrointestinal cases – an adhesion colic, a gastritis and a bleeding peptic ulcer. The gynaecological case was an incomplete abortion. The renal referral was a patient

Table 1. Localities of casualties and duration from the time call is received by the Emergency Department until the arrival of the helicopter at SGH

Place of incidence	No. of missions from the specific localities	Median time in minutes (Range)
Pulau Tekong/islands around Singapore	137 (58.6%)	30.0 (7-64)
Military camps (main island)	56 (23.9%)	30.2 (5-65)
Ships in Straits of Malacca and Singapore/South China Sea	41 (17.5%)	64.4 (34-133)
Total	234	-

Table 2. Diagnosis at site

Systems involved	No. of non-trauma cases	%	No. of trauma cases	%	
Gynaecology	1	3.45	Drowning	5	1.87
Cardiovascular	9	31.03	Poisoning	14	5.22
Infection	3	10.34	Heat injuries	170	63.43
Gastrointestinal	3	10.34	External injuries	67	25.00
			• Hand grenade explosion injuries	7	
			• Fall from height	6	
			• Gunshot wounds	3	
			• Penetrating injuries	3	
			• Road traffic accident	3	
			• Crush injuries	3	
			• Blunt injuries	40	
			• Amputated limbs	2	
Musculoskeletal	1	3.45	Others (insect sting/bites)	12	4.48
Neurological	9	31.03			
Diabetic ketoacidosis	1	3.45			
Renal	1	3.45			
Respiratory	1	3.45			
Total	29	100.00		268	100.00

of chronic renal failure with fluid overload. The musculoskeletal case was a patient with acute lower limb ischaemia. There was a patient with pneumothorax. The chest tube was inserted at the Emergency Department.

Comparing the on-scene diagnosis and the hospital discharge diagnosis for these patients, inconsistencies were made in only four patients (1.3%) (Tables 2

& 3). Most of the patients brought in were critical, unconscious or semi-conscious. There were 19 patients in cardiac arrest on arrival at the Emergency Department. Eleven of them were pronounced dead in the department after resuscitation. Fourteen of these cardiac arrests were the result of multiple injuries with Injury Severity Score ranging from 16-43. One of these 14 also had 94% full thickness burns from an aircraft crash. Of the remainder, there was one death from

Table 3. Diagnosis at discharge from inpatients wards

Systems involved	No. of non-trauma cases	%	No. of trauma cases	%	
Gynaecology	1	3.23	Drowning	5	1.88
Cardiovascular	9	29.03	Poisoning	15	5.64
Infection	4	12.90	Heat injuries	169	63.53
Gastrointestinal	3	9.68	External injuries	67	25.19
Musculoskeletal	1	3.23	Others	10	3.76
Neurological	10	32.26			
Diabetic ketoacidosis	1	3.23			
Renal	1	3.23			
Respiratory	1	3.23			
Total	31	100.00		266	100.00

gunshot wounds and one in a landslide accident. Three had non-traumatic cardiac arrests. There were 15 ventilated patients, three via endotracheal tube inserted at scene by the military physicians. Two intubated patients were victims of drowning and the third one was poisoned by phosphorus inhalation on board a ship at the South China Sea. There were 12 patients intubated at the Emergency Department – three heat stroke, one acute pulmonary oedema, one status epilepticus, two multiple injuries, one head injury, three poisoning and one septic shock. One patient had chest tube insertion at the Emergency Department for spontaneous pneumothorax. Almost all had intravenous access inserted at scene, with or without fluid infusion.

Of the 297 casualties, 262 (88.2%) were admitted – 216 of them (82.4%) to general ward, 9 (3.4%) to intermediate care ward and 37 (14.1%) to intensive care unit (ICU). Two patients admitted to ICU died. The rest of the admitted patients were discharged alive. Twelve patients were discharged from the Emergency Department; 11 of these were personnel evacuated together in the same incident. One was discharged after a 4-hour observation and diagnosed as musculoskeletal chest pain secondary to push ups. There were three transfers to private hospitals, upon patients' requests. They were all foreigners who had been victims of accidents aboard their ships in the surrounding seas of Singapore.

Discussion

The concept of aeromedical evacuation originated from the need for transportation of wounded soldiers during war. The impact of aeromedical transportation in decreasing the mortality of wounded soldiers increased tremendously from World War II, to the Korean War and the Vietnam War.^{1,2} They provided a means for severe casualties to be transported long distances in a short span of time to receive life-saving treatment. With the military experience as a model, civilian use of helicopters to transport patients has grown rapidly throughout the world. Hospital-based helicopter evacuation services have become major

players in aeromedical evacuation in certain environments. Many of them play important roles in pre-hospital care especially in countries with long pre-hospital times such as the United States of America, and the European countries.

Hotredt et al³ compared the outcome of helicopter-evacuated patients with surface ambulance patients. They assessed 370 case reports of helicopter evacuation from rural areas and showed 69 minutes earlier arrival time for air-transit than ground-transit. For 283 cases, there was no additional benefit in life years gained compared with that obtainable by ground-ambulance transport. The main reason was that no treatment was given during the flight or early on in hospital. They concluded that the emergency helicopter service could provide considerable health benefits for severely ill patients in the rural setting who could be rushed for appropriate management in the fastest possible time. They found obstetric and paediatric patients and patients with severe trauma most likely to benefit from air transport. However, given the cost and risk of such a service, the benefits for most patients were small.

Baxt and Moody⁴ showed a 52% reduction in predicted mortality in a group of blunt trauma patients transported to a trauma centre by a rotorcraft aeromedical service compared with those transported to the same trauma centre by a land-ambulance service. In this study, the response time from time of injury to arrival at the trauma centre was longer for the aeromedical group (58 minutes), as compared to 35 minutes for the land transportation group. The reduced mortality in the aeromedical group was attributed to early on-scene treatment of patients by teams of highly trained-flight physicians and nurses. Comparing the results of mortality between blunt trauma patients treated by flight physician/flight nurse-staffed helicopters with those treated by flight paramedic/flight nurse staffed helicopters, Baxt and Moody⁵ again in a later study showed a 35% decrease in predicted mortality for flight physician/flight nurse staffed helicopters. A study done in Phoenix⁶ however suggested that in metropolitan areas where Advanced Life Support (ALS) land ambulance services and rapid transport to trauma centre are routinely feasible, there

is little need for helicopter response to the scene of injury.

In Singapore, the bulk of trauma patients evacuated by helicopters are heat exhaustion or heat stroke patients from the island of Pulau Tekong. These were usually military recruits unaccustomed to prolonged exertion in the tropical heat despite of taking initial precautions. To date no study has evaluated the impact of aeromedical evacuation on outcome of patients with heat stroke. The lack of a scale to objectively denote the severity of heat injury has contributed to the lack of such a comparison. Cooling is the cornerstone for the treatment of heat stroke. All patients with heat disorders in our study received some form of body cooling and intravenous fluids before being loaded onto the helicopter. While these patients are being managed by body cooling units of the various military medical centres throughout Singapore, helicopter evacuation can be activated by units making appropriate requests to the Ministry of Defence Operations Centre.

Singapore is a small island of 683 square km in area with a population of 4 millions. The average time taken to travel from most parts of the island to a restructured/government hospital usually takes less than 30 minutes for land ambulances during good traffic conditions.

Air travel times to sites within the main island are short (always less than ten minutes). There is also an on-scene time of five minutes, a further evacuation time to the hospital helipad of about ten minutes and a further five minutes before the patient enters the Emergency Department with a total of about 30 minutes for main island evacuations. Hence the benefits of a few minutes saved, if any, for such urban helicasevac missions must be balanced against the cost of each helicasevac mission and the effect of multiple transfers of casualties from the site to the ambulance and then to the helicopter, from the helicopter to ambulance and from the ambulance to the Emergency Department. The authors, however, recognise the value that professional helicopter rescue teams can bring on-site care to severe accidents.

Hotvedt et al³ in his study said that the risk of life-years of crew members in helicopter crashes almost outweighs the potential life-year-gain in some patient subgroups. Fatalities for helicopter ambulances in Norway was 6.5 per 100,000 hours flown with accidents almost two-and-a-half times more, occurring at 15.5 per 100,000 hours flown. Hence for the 56 cases of air evacuation from mainland military camps, the indication was not strong. However the Singapore Armed Forces might be using it to show to the public that they were willing to use all available resources to manage their severely ill staff.

For the 178 helicasevac missions to pick-up casualties from the various offshore islands, the busy sea-lanes and the distant reaches of the South China Sea, there is definite benefit in terms of time savings in the use of helicopter as the main vehicle of evacuation.

Even for the nearby offshore islands of Pulau Tekong and Pulau Ubin if surface evacuation is envisaged, it takes at least five to seven minutes to move a casualty from the island's medical centre to the island jetty, a five minute trans-loading time, twenty minutes of boat ride followed by nearly five minutes of transloading time to the awaiting ambulance on the main island and another five to thirty minutes ride to one of the major public general hospitals in Singapore resulting in a total of around sixty minutes before the arrival at hospital. The multiple transfers that occur also make surface transportation not an acceptable option compared to a usual net time not exceeding thirty-five minutes for helicopter evacuation from these nearby offshore islands. Therefore unless the medical condition of the casualty permits such multiple transfers, helicopter evacuation as carried out currently may continue to remain the better option for life-threatening problems.

The time saving is even greater when considering evacuation from the shipping straits and the South China Sea. Sea-rescue boats from these sites would have led to casualties arriving at the SGH a number of hours later. In addition, the level of care that can be provided in such rescue boats are often inferior to that available in RSAF helicopters on helicasevac

missions. In these situations, aeromedical evacuation has not only had the added advantages of rapidly transporting professional medical care to the scene with the possibility of early accessibility to Advanced Life Support for the casualty, it has also ensured that the needy patients reach definitive tertiary medical centres in as short a time as possible.

We noted that many of the evacuations from distant offshore locations were civilian patients. Only a 15% use of Mindef helicopters for civilian casualties may be due to a variety of reasons. For ships traversing the seas in the Singapore Search and Rescue Region, major medical emergencies occurring on board that require urgent helicopter evacuations are extremely uncommon.⁷ In instances where such urgent situations do arise, casualties are usually evacuated to the nearest port of call either in Malaysia or Indonesia by search and rescue helicopters of these neighbouring countries. In addition, the authors have occasionally been involved in accepting patients brought by civilian helicopters landing not at the Singapore General Hospital, but at a civilian airport and then transported to the Hospital by private ambulance services. These instances have not been included in this report as the casualties had not been heli-lifted directly to the Hospital.

This study indicated that patients who developed cardiopulmonary arrest prior to helicopter transport are unlikely to survive in spite of rapid aeromedical transport by helicopter. This has also been confirmed by Lindbeck et al.⁸ However the outcomes could possibly be different if there were facilities for prompt identification of cardiac arrest and institution of on-site resuscitation. One needs to consider carefully whether patients without vital signs in the field after on-site resuscitation will be likely to benefit from helicopter transportation.

The variety of trauma and non-trauma medical problems of casualties evacuated by helicopter requires that medical professionals in helicopter be well versed not only in cardiopulmonary resuscitation but also in Advanced Life Support techniques and in various aspects of providing emergency care in the pre-hospital

environment.⁹ In our study 285/297 (96.0%) of the patients had intravenous access with or without intravenous fluids upon arrival at the Emergency Department. Cardiopulmonary resuscitation, Advanced Cardiac Life Support such as cardiac defibrillation (1 case) and intravenous adrenaline (3 patients) were carried out where applicable. Farnell and Sachs¹⁰ in Mayo Clinic said that a small pool of personnel with repeated exposure to the emergency situations and hence enhanced experience is preferable to one where flight nurses are drawn from a large pool of available nurses, none of whom has a great deal of experience in this unique pre-hospital care environment.

This study showed that all the heli-evacuations were performed by military helicopters. The development of regional growth triangles, the rapid pace of industrialisation in the regions surrounding Singapore and the materialisation of Singapore as the medical centre for the region would create a demand for the rapid evacuation of civilian casualties from these regions to Singapore.

Civilian helicopters can begin to play an increasing role in these areas and private or civilian heli-evacuation services are potentially viable options.

Conclusion

Helicopter evacuation of casualties from offshore areas will speed up evacuation of casualties to definitive medical treatment centres in Singapore from about 3-5 hours to an average of 64 minutes. There is definite benefit of helicopter casualty evacuation in this aspect in terms of time saving. Locally these are being carried out promptly and increasingly by trained professionals. There is so far no evidence to suggest that helicopter transport of urban patients is beneficial especially in Singapore where land transport times to hospitals are relatively short. More work is required to assess the need for urgent helicopter evacuation of patients already in cardiac arrest. On a regional basis, there is scope for expansion of helicopter casualty evacuation services to Singapore. Perhaps a prospective study with

objective scoring of severity of injury and proper audit on the process and outcome of helicasevac cases will determine more appropriate utilisation of helicopters for evacuation.

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