CB Lo 盧志彪
TW Wong 黃大偉
KK Lai 黎景光

Is public access defibrillation needed in Hong Kong?

香港是否需要公共設施除纖顫計劃？

The survival rate for non-traumatic out-of-hospital cardiac arrest in Hong Kong is low (1.25%-1.6%). Despite the reduced time interval between call receipt and first defibrillatory shock to 11.12 minutes during the past decade, the time interval between collapse/recognition and first defibrillatory shock, at 14.25 minutes, is too long. Studies of out-of-hospital cardiac arrest performed in Hong Kong were reviewed to ascertain whether a public access defibrillation programme can improve survival in Hong Kong. Three delays were found in the traditional response by emergency medical service, namely in the collapse/recognise-to-call receipt, call receipt-to-vehicle stops, and vehicle stops-to-first defibrillatory shock time intervals. The first delay is related to public education, while the second and third delays are intrinsic to a dispatched response. A public access defibrillation programme employing responders at scenes of cardiac arrests can eliminate the collapse/recognise-to-call receipt and call receipt-to-vehicle stops time intervals before defibrillation. Possible sites of public access defibrillation could include the airport and other immigration points, which have a high volume of people passing through, with projected figures for out-of-hospital cardiac arrest at these sites supporting this consideration. For successful implementation of public access defibrillation, a comprehensive educational programme and coordination with the emergency medical service are required.

在香港，醫院外非創傷心動停止的存活率偏低，只有1.25%-1.6%。儘管在過去十年間，由接到求救電話到開始除纖顫電擊的時間，已縮短至11.12分鐘；但由患者休克至確認及開始除纖顫電擊所需時間為14.25分鐘，仍屬過長。本文總結本地進行醫院外心動停止的研究，以確定公共設施除纖顫計劃是否有助改善存活率。傳統的緊急醫療召喚服務有三項延誤，分別為：由休克至決定召喚緊急醫療，由接到緊急召喚至急救車到達現場，以及由急救車到達至開始除纖顫電擊。第一項延誤與公民教育有關，其餘兩項則與派遣救護方式的固有時間需求有關。公共設施除纖顫計劃由在場人士即時施救，可能有助消除前兩項延誤。可實施公共設施除纖顫計劃的地方包括有大量人流的機場和其他出入境站，因為在這些地點發生的醫院外心動停止的機會較大。要成功實行公共設施除纖顫計劃，必須配合全面的教育，並與緊急醫療服務機構充分合作。

Key words:
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Accident and Emergency Department, North District Hospital, 9 Po Kin Road, Sheung Shui, Hong Kong
CB Lo, FRCS (Edin), FHKAM (Emergency Medicine)
TW Wong, FRCS (Edin), FHKAM (Emergency Medicine)
KK Lai, FRCS (Edin), FHKAM (Emergency Medicine)

Correspondence to: Dr CB Lo

Introduction

Hong Kong has a total area of approximately 1100 km^2 and a population of 6.7 million.[1] The main provider of emergency medical service (EMS) in Hong Kong is the Fire Services Department Ambulance Command (FSDAC), which has approximately 2200 uniformed staff, 240 ambulances, and 35 motorcycles.[2] The FSDAC started to install automated external defibrillators (AED) in ambulances in 1991[3] and, since 1998, all FSDAC ambulances have been equipped with an AED. The performance pledge of FSDAC for response time, which is the call receipt-to-vehicle stops time interval according to the widely recommended Utstein style of data reporting for out-of-hospital cardiac arrest (OHCA) [Tables 1 and 2],[4] is 12.00 minutes for 92.5% for all calls. The total number of calls in 2001 was 540 976, which was equivalent to 1482 calls per day.[5]

The survival rate for non-traumatic OHCA to hospital discharge remains low at 1.25% to 3.00%, as reported by Wong and Yeung,[6] Lui,[7] and Leung et al.[8]

Table 1. Important time points according to the Utstein style

Time points	Details
Collapse/recognise time	Time of collapse—obtained only for a witnessed cardiac arrest Time of recognition—cardiac arrest found but not witnessed
Call receipt time	In Hong Kong, this is the time when the address of the call is recorded for dispatch purpose at the Fire Services Communication Centre
Vehicle mobile time	Time when the emergency vehicle moves
Vehicle stops time	Time when the emergency vehicle stops. In Hong Kong, this is sometimes referred to the 'at scene time', meaning arrival at scene at the 'street level'
Arrival at patient's side time	Time when the emergency medical services personnel arrives at the patient's side
First defibrillatory shock time	Time when the patient receives the first defibrillatory shock

Table 2. Time intervals

Time intervals	From	To
Collapse/recognise-to-call receipt time interval	Time of cardiac arrest witnessed/found but not witnessed	Time when caller produced an address with detail enough for dispatch of emergency vehicle by Fire Services Communication Centre
Collapse/recognise-to-vehicle stops time interval	Time of cardiac arrest witnessed/found but not witnessed	Time when emergency vehicle stops
Collapse/recognise-to-patient's side time interval	Time of cardiac arrest witnessed/found but not witnessed	Time when emergency personnel arrives at patient's side
Collapse/recognise-to-first defibrillatory shock time interval	Time of cardiac arrest witnessed/found but not witnessed	Time when patient receives the first defibrillatory shock
Call receipt-to-vehicle stops time interval	Time when caller produced an address with detail enough for dispatch of emergency vehicle by Fire Services Communication Centre	Time when emergency vehicle stops
Call receipt-to-patient's side time interval	Time when caller produced an address with detail enough for dispatch of emergency vehicle by Fire Services Communication Centre	Time when emergency personnel arrives at patient's side
Call receipt-to-first defibrillatory shock time interval	Time when caller produced an address with detail enough for dispatch of emergency vehicle by Fire Services Communication Centre	Time when patient receives the first defibrillatory shock

Wong and Yeung[6] reported a 3% survival rate for OHCA in the mid-1990s, with an estimated call receipt-to-vehicle stops time interval of 14.00 minutes. Lui[7] reported a territory-wide non-traumatic OHCA survival rate of 1.6% for all rhythms in 1999, with a mean collapse/recognise-to-first defibrillatory shock time interval of 23.77 minutes—53.50% of the arrests were witnessed and 8.90% received by-stander cardiopulmonary resuscitation (CPR). A recent study by Leung et al,[8] performed in three hospitals on Hong Kong Island, found a survival rate of 1.25% with a mean collapse/recognise-to-first defibrillatory shock time interval of 14.25 minutes. The cardiac arrests were witnessed in 42.50% of cases and the bystander CPR rate was 15.60%.

Among the four links in the chain of survival, a short collapse/recognise-to-first defibrillatory shock time interval has been emphasised as important for survival.[9-11] This early link to survival is examined with respect to the situation in Hong Kong to ascertain whether a public access defibrillation (PAD) programme could be a solution.

Do automated external defibrillators improve survival?

Automated external defibrillators allow responders to defibrillate patients without the need to interpret the electrocardiogram, thus enabling EMS personnel to perform prehospital defibrillation. However, several studies have pointed out that installing AEDs as an isolated measure does not increase survival, and survival rates of 1.70% and 1.40% with corresponding collapse/recognise-to-first defibrillatory shock time intervals of 16.00 minutes and 12.40 minutes were recorded in two major American cities.[12,13] A long call receipt-to-first defibrillatory shock time interval has been shown to result in a low survival rate.[14,15] These findings are compatible with the observation that early defibrillation is the most important factor for survival after OHCA.

Weakness in the Hong Kong system

In a preliminary study of the introduction of AEDs in Hong Kong, the estimated call receipt-to-vehicle stops time interval was 14.00 minutes.[3] The subsequent studies by Lui[7] and Leung et al[8] identified weaknesses in the first three links of the survival chain, namely delay in EMS access, low bystander CPR rates, and long collapse/recognise-to-first defibrillatory shock time interval (Table 3). The call receipt-to-first defibrillatory shock time interval reported by Lui[7] was 16.37 minutes. This interval was shortened to 11.12 minutes in Leung et al's study,[8] but remained longer than the 5 minutes recommended by the American Heart Association (AHA).[16]

Table 3. Recent studies in Hong Kong

	Lui[7]	Leung et al[8]
Study period	July to December 1995	March to October 1999
No. of patients	744	320
Design of study	Retrospective	Prospective
Area in Hong Kong	Whole of Hong Kong (Hong Kong Island, Kowloon, the New Territories)	Hong Kong Island only
Mean age (years)	62.00 (survivors) 68.82 (non-survivors)	71.50
Site of cardiac arrest	83.0% (home) 12.6% (public place)	66.6% (home) 16.9% (home for the aged) 3.1% (street)
Cardiac arrest witnessed	53.5%	42.5%
Bystander cardiopulmonary resuscitation	8.9%	15.6%
Initial rhythm—ventricular fibrillation or tachycardia	22.5%	14.1%
Collapse/recognise-to-call receipt time interval (minutes)	7.40	3.13
Call receipt-to-vehicle stops time interval (minutes)	6.42	6.42
Vehicle stops-to-first defibrillatory shock time interval (minutes)	9.95	4.70
Call receipt-to-first defibrillatory shock time interval (minutes)	16.37	11.12
Collapse/recognise-to-first defibrillatory shock time interval (minutes)	23.77	14.25
Survival to hospital discharge (all cases)	1.60% (12/744)	1.25% (4/320)
Survival to hospital discharge (ventricular fibrillation/tachycardia)	6.00% (10/167)	4.40% (2/45)

Lui[7] had noted that the long collapse/recognise-to-call receipt time interval of 7.40 minutes constituted a significant delay (although this was reduced to 3.13 minutes in Leung et al's study[8]). Both Lui[7] and Leung et al[8] attributed this delay to the Chinese habit of contacting the relatives before the EMS in a medical emergency. Interestingly, the call receipt-to-vehicle stops time intervals were identical in the two studies (6.42 minutes).[7,8] The vehicle stops-to-first defibrillatory shock time interval was 9.95 minutes in Lui's study[7] compared with 4.70 minutes in Leung et al's study,[8] showing a reduction of 5.25 minutes.

There was no explanation for the 5.25 minutes difference in vehicle stops-to-first defibrillatory shock time interval in the data available. Lui's study[7] was conducted territory-wide and included Hong Kong Island, Kowloon, and the New Territories, while Leung et al's study[8] was only performed in Hong Kong Island. The difference in the types of buildings might have led to differences in vehicle stops-to-patient's side time intervals. In Singapore, Lateef and Anantharaman[17] reported a vehicle stops-to-patient's side time interval of 2.49 minutes for high-rise buildings, whereas the time interval for ground level calls was 1.02 minutes. Further analysis is needed to explain the long vehicle stops-to-first defibrillatory shock time interval in Lui's study[7] (9.95 minutes) compared with Leung et al's study[8] (4.70 minutes).

Leaving aside the unexplained difference in vehicle stops-to-first defibrillatory shock time intervals in Lui's[7] and Leung et al's[8] studies, there have been at least three delays for OHCA identified in Hong Kong, namely the collapse/recognise-to-call receipt time interval, the call receipt-to-vehicle stops time interval, and the vehicle stops-to-first defibrillatory shock time interval. The AHA recommends supporting a PAD programme if the EMS system cannot reliably achieve a 5-minute call receipt-to-first defibrillatory shock time interval.[16] Yet, before committing to a PAD programme, it is essential to analyse how much reduction in the collapse/recognise-to-first defibrillatory shock time interval can be achieved, as this correlates directly with survival rates.

Will employment of fire-fighters and policemen as first responders increase survival?

Studies of first responders (FRs), namely fire-fighters and policemen, using AEDs (FR[AED]s) show conflicting results.[18-26] Much debate on the subject has been stimulated.[27-29] Most studies showed a reduction in call receipt-to-vehicle stops time interval or call receipt-to-first defibrillatory shock time interval, but did not show a statistically significant improvement in survival rate. Some studies were affected by factors such as low rate of bystander CPR, delays in collapse/recognise-to-call receipt time interval, or the Hawthorne effect in the EMS after implementation of FR[AED] programmes.

The AHA classifies fire-fighters and policemen as level I FRs.[16] Since there are 6000 fire-fighters and 28 000 policemen in Hong Kong, it appears to be worthwhile to look into the possibility of employing them in PAD programmes.[5,30] The collapse/recognise-to-call receipt time interval can only be resolved by public education, however. If 14.25 minutes is taken as the collapse/recognise-to-first defibrillatory shock time interval for calculation and guessing that FR[AED]s are able to shorten the call receipt-to-vehicle stops time interval by approximately 1 minute due to a greater number of personnel and dispatch points than the EMS, and the vehicle stops-to-first defibrillatory shock time interval is shortened by 0.5 minutes due to the reduced amount of equipment to carry, the estimated collapse/recognise-to-first defibrillatory shock time interval will be shortened to approximately 12.75 minutes. If an optimistic assumption is made that the collapse/recognise-to-call receipt time interval be shortened by 2.5 minutes through public education, the collapse/recognise-to-first defibrillatory shock time interval could be 10.25 minutes.

If a PAD programme is introduced into the current dispatch system, which can be accessed by any member of the public with a single number (999), there can only be minimal effect on the survival rate, with little impact on the collapse/recognise-to-first defibrillatory shock time interval, as the call receipt-to-vehicle stops and vehicle stops-to-first defibrillatory shock time intervals are only slightly improved. This would be especially true with cardiac arrests occurring in people in residential blocks, which, in both Lui's[7] and Leung et al's[8] studies, amounted to more than 80% of incidents.

In Lui's study,[7] 12.60% of cardiac arrests occurred in public places, to which shorter collapse/recognise-to-call receipt and vehicle stops-to-first defibrillatory shock times, and thus the collapse/recognise-to-first defibrillatory shock time interval, can presumably be achieved by fire-fighters or policemen implementing FR[AED]. A stranger witnessing a cardiac arrest is more likely to call the EMS immediately and the vehicle stops-to-first defibrillatory shock time interval could be reduced, especially if the public place is a street. Thus cardiac arrests in easily accessible sites might obtain benefit from employing FR[AED]. In Leung et al's study,[8] however, only 3.1% of cardiac arrests occurred in streets, reducing the number of cardiac arrests for the maximal benefit of a dispatched FR[AED]. The number of out-of-hospital non-traumatic cardiac arrests in Hong Kong is approximately 240 per month, thus the estimated number of cardiac arrests in streets will be only 90 or so per year (personal communication). There are issues to consider when fire-fighters and policemen take on PAD. Their response to usual tasks such as the time to respond to fire calls may become impaired.[5] Resources will be drawn for training and skills maintenance as the AHA recommends conducting routine skills reviews and practice sessions at least every 6 months, which implies that a large number of training hours is required.[16] There will be a wider scope of issues for consideration and more detailed analysis required before implementation of a FR[AED] programme by fire-fighters and policemen. Another possibility for shortening the call receipt-to-vehicle stops time is by graded dispatch in the EMS system, whereby the calls are divided into urgent and less urgent cases, and a shorter time pledge is given for urgent calls, leaving a longer time interval for less urgent calls. Although EMS personnel face the same constraints as fire-fighters and policemen, graded dispatch in EMS is a prioritisation process, and should not affect the overall service commitment to the public, while bringing about a shorter response time for patients with conditions requiring more urgent care.

A public access defibrillation programme in immediate environment

Although the AHA classifies policemen, fire-fighters, security guards, sports marshals, and flight attendants as level I FRs, it should be noted that there are fundamental differences between dispatched FR[AED] such as fire-fighters and policemen, and personnel who work in an environment where cardiac arrests can be immediately recognised such as flight attendants and boat crews. The collapse/recognise-to-call receipt, call receipt-to-vehicle stops, and vehicle stops-to-patient's side time intervals are eliminated. The collapse/recognise-to-first defibrillatory shock time interval will depend on two time intervals—the collapse/recognise-to-'get AED machine' and the 'get AED machine'-to-first defibrillatory shock time intervals. Recent studies show encouraging results for people using AED in their immediate working environment. A 40% survival rate for patients in ventricular fibrillation (VF) has been achieved by flight attendants.[31] Valenzuela et al[32] reported that the use of PAD for 105 patients in casinos by security officers resulted in a survival rate of 53% for patients in VF with a mean collapse/recognise-to-first defibrillatory shock time interval of 4.40 minutes (standard deviation [SD], 2.90 minutes). The mean time for a paramedic to arrive at the scene in this study was 9.80 minutes (SD, 4.30 minutes). A total of 86% of the collapses were witnessed. If the patients in VF were divided into those who were defibrillated within 3 minutes and those for whom the time to defibrillation was longer, the survival to hospital discharge rates were 74% and 49%, respectively, emphasising the importance of a short collapse/recognise-to-first defibrillatory shock time interval.

It is perhaps more appropriate for Hong Kong to follow the recommendation made by the AHA at the Second Public Access Defibrillation Conference, as reported by Nichol et al.[33] Level II of this classification is of particular interest in Hong Kong. Level I FR is called 'traditional FR[AED]s' as this level is operated by fire-fighters and policemen. This system has the benefit of accessibility by any member of the public but incorporates two inadvertent time intervals between collapse/recognise-to-vehicle stops time. Level II is termed 'non-traditional FR[AED]s'. People such as lifeguards and flight attendants who, because of the nature of their job, are required to respond to emergencies in their immediate vicinity and, if allowed to use AED, can virtually eliminate the collapse/recognise-to-call receipt and the call receipt-to-vehicle stops time intervals. One may be concerned about the training of lay persons, and members of the disciplined forces are thought to be more easily trained. Studies have shown, however, that lay persons, including sixth-grade children, can be trained to use AED.[34,35] Results from studies performed at the Chicago airports has further proved that lay persons can use AED effectively, as some defibrillations were done by travellers.[36-39]

Where should public access defibrillation programmes be implemented for maximum cost-effectiveness?

Becker et al[40] divided public locations of cardiac arrest into high and low incidence sites. High incidence refers to an annual incidence of cardiac arrest of 0.03 or more per site (≥1 arrest per 30 sites in 1 year), and low incidence is 0.01 or less per site (≤1 arrest per 100 sites in 1 year).[40] Some of

the higher incidence sites identified by Becker et al[40] are airports, prisons, shopping malls, and sports venues. Gratton et al[41] also found that airports, casinos, hotels, and nursing homes had a higher frequency of cardiac arrests.

In Hong Kong, there is only one international airport. During the periods, March to August 2000 and September 2001 to February 2002, this airport recorded three non-traumatic OHCAs, amounting to a projected arrest incidence of six per site per year (personal communication). With this number of OHCAs, Hong Kong International Airport should be classified as a 'high incidence site' as described by Becker et al, [40] and falls into the AHA's recommendation for a PAD programme. North District Hospital is situated approximately 10 minutes by car from the border between Hong Kong and mainland China, and receives all the ambulances from the immigration ports. A search for OHCAs during a half-year period from February to July 2001 revealed three cases of OHCA, amounting to an estimated arrest incidence of six per year. Thus, immigration ports, with a high volume of people flowing through, are also likely to fall into the recommendations by the AHA. Alternatively, some sites may not have a high volume of people, but the people will have a higher-than-usual frequency of cardiac arrest such as homes for the aged and may be worth a study on the need for a PAD programme. In Hong Kong, approximately 17% to 25% of OHCAs occur in homes for the aged.[8] One might argue about the cost-effectiveness of installing a PAD programme for a group of people whose premorbid state is poor, but there are homes in Hong Kong that accommodate mobile residents who only require minimal care. Thus, for individual homes for the aged, a PAD programme may be worth considering.

Legal issues

In the US, the Cardiac Arrest Survival Act (CASA) became law in November 2000 and directed the placing of AEDs in federal buildings and offers 'Good Samaritan' protection against liability to any person using AED to save lives.[42] In Hong Kong, medical practice is governed by the Medical Registration Ordinance, which states that "any person who not being registered, or provisionally registered, or exempted from registration, practises medicine or surgery commits an offence and is liable on summary conviction to a fine at level 6 and to imprisonment for 3 years".[43] The Ordinance also states, however, that the restriction "shall not apply to any treatment by way of first aid". Thus the key argument will then be whether AED is viewed as 'medical' or 'first-aid' equipment. The laws in Hong Kong do not state what kind of instruments are only to be used by registered persons. Therefore, it is unclear whether the use of AED by lay persons is viewed as a 'first-aid technique' or a 'medical treatment'. On the other hand, when a life-saving tool is expected but not available when needed, litigation may result, as noted from the Lufthansa Airlines case that the company has to pay damages for not having an AED on site when required.[44] This has raised concern about the need to provide a minimum level of care.[45] Although not mandatory, the recommendation from CASA has given clear guidance to people in the US. A similar legal clarification by the Hong Kong Government would certainly be beneficial for the development of a PAD programme in the region.

For quality assurance, it is preferable that the authoritative bodies set a standard for such programmes, as the AHA and the American College of Emergency Physicians have done.[46,47] Initial training and certification, skills maintenance, and recertification should be planned well in advance of the introduction of such programmes. The AHA recommends that the initial training for a FR in a PAD programme should be approximately 4 hours. Skills maintenance with drills or CPR demonstrations and AED utilisation should be conducted every 1 to 3 months. Retraining is recommended every 2 years. Although newer AEDs are user-friendly, procedures to ensure good condition of the machines is necessary. Co-ordination with the EMS must be included as an important element for the success of the PAD programme.[47]

Conclusion

The survival rate of OHCA in Hong Kong remains low despite a shortening of the collapse/recognise-to-first defibrillation time interval, which still stands at 14.25 minutes. Means to reduce the various time intervals include public education, graded dispatch by ambulances, and a FR programme by fire-fighters or policemen. Based on the present call and dispatch system, however, a PAD programme relying on dispatched FR[AED]s is unlikely to shorten the collapse/recognise-to-first defibrillatory shock time interval to less than 10.00 minutes for the majority of cases. On the other hand, a PAD programme operated by trained people in their immediate environment can significantly shorten this time interval. Thus, in contrast to the recommendation by the AHA, these two types of responders should be considered separately for Hong Kong.

A PAD programme is worth considering in sites with a high volume of people, notably the international airport and immigration ports, where the number of OHCAs make them 'high incidence' sites for use of AED. Sites such as homes for the aged with a low flow of people but a higher-than-usual frequency of cardiac arrest may also consider a PAD programme. More detailed study of these sites will clarify the situation. A law such as CASA will help to protect lay people who stop to help and alleviate uncertainties in this area. Medical direction, standards for training, schedules for skills, maintenance, retraining, and coordination with the EMS are essential elements for a successful PAD programme.

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