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Guidelines



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Consensus statement on layout and delivery of automatic external defibrillator in China

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1. Introduction

Sudden cardiac death (SCD) refers to sudden death due to a variety of cardiac causes. It is manifested as a sudden loss of consciousness, cardiac arrest, and respiratory arrest and generally shows early symptoms that are atypical and not easily detected[1]. According to a recent study, nearly 544 000 patients suffer from SCD every year in China[2]. Rescue of SCD patients in the shortest time is important as the survival rate will decrease by 7%-10% if the rescue is delayed for one minute[3]. However, SCD mostly occurs in public places outside the hospital, including public sports places, transportation hubs (such as airports, railway stations, and subway stations), shopping centers, factories, and so on. Therefore, out-of-hospital cardiac arrest (OHCA) is a huge threat to people's lives. "Chain of survival" proposed by the American Heart Association in 2015 emphasized the importance of early call for help, rapid implementation of high-quality cardiopulmonary resuscitation (CPR), and immediate use of an automated external defibrillator (AED) in improving the survival rate of OHCA patients. Studies have shown that conducting CPR within 1 min and AEDs defibrillation within 3 to 5 min can achieve a 50% to 70% survival rate for cardiac arrest patients[4]. Therefore, early defibrillation of OHCA patients will markedly increase the survival rate.

Public access defibrillation (PAD) refers to installing AEDs in assembly occupancies with a high risk of OHCA and delivering public CPR training. When a heart attack occurs in an OHCA patient, people could implement defibrillation by AED before the

emergency services arrive, which can improve the pre-hospital resuscitation rate, the success rate of hospital rescue, and the prognosis[5,6]. A study reported 80% of OHCA are caused by ventricular fibrillation[7]. Therefore, it is necessary to install AED in public places reasonably and effectively. At present, PAD projects have been carried out and standard procedures or guidelines for AEDs have been established and implemented in the United States, Europe, Japan, and other countries and regions. In China, scholars also preliminarily explore the application of AEDs, but we still face many challenges like unbalanced development, inadequate installment, and non-standardized procedure. Only a few metropolia like Hangzhou[7], Shanghai[8], Shenzhen[9], and Haikou with a well-developed emergency medical treatment system, have developed regulations on emergency medical services and published AEDs map, while AED application in other cities is still in an initial stage. An Hangzhou-based study on deploy of AED[7] found many

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problems, such as insufficient attention, unstandardized procedures, inadequate quantity in public places, uneven distribution, and low awareness.

The development of PAD in China is relatively lagging due to the absence of uniform regulations, which is one of the reasons for the low rescue success rate of OHCA patients in China^[10]. Therefore, China AEDs Union, Red Cross Society of China, Emergency Medicine Branch of Chinese Medical Association, Emergency Physicians Branch of Chinese Medical Doctor Association, Emergency Medicine Professional Committee of the Chinese People's Liberation Army, Emergency Medicine Branch of Chinese Association of Integrative Medicine, Science Popularization Branch of Chinese Medical Association, China Emergency Medicine Branch of Geriatric Medicine Institute, Cardiopulmonary Resuscitation (CPR) Professional Committee of Chinese Research Hospital Association, CPR Professional Committee of Chinese Aging Well Association provided suggestions about the quantity, layout, location, and relative first-aid equipment based on existing researches and current situation in China to establish a regulation for AED, promote AED application, and further improve emergency medical service system in China.

2. Recommendations for AED layout and allocation

2.1. Strengthen public awareness about PAD projects and promote China-PAD (C-PAD) project step by step

The high popularity of emergency knowledge and practice is a symbol of modern social civilization. The popularization of AEDs not only reflects the attention to the cardiac emergency but also the civilization of a region or a country. The "Healthy China" project primarily requests the improvement of health and morality. Until now, no unanimous and complete PAD plan has been established in China. Thus, it is imperative to push forward the C-PAD project.

The popularization of AED is a milestone of social civilization. The 2017 National People's Congress adopted the Article 184 of the General Principles of the Civil Law of the People's Republic of China, which marks that the AEDs application in emergencies is under the protection of law^[11]. Otherwise, In 2010, Hainan province approved the Regulations of the Red Cross Society of Hainan Branch, making it the first province with AED application as a law regulation in China^[12]. Under the leadership of the local government, Shanghai Red Cross Society installed 800 AEDs in the Pudong New Area at the end of 2018^[13]; In 2019, Anhui Red Cross Society launched a project named "YiLu TongXing (Being Together All The Way)-AED City Distribution" and donated 200 AEDs in Huaibei first^[14]; Guided by the Implementation Plan for AED

Configuration and Usage during the 13th Five-year Plan of Shenzhen (drafted by experts invited by the Shenzhen Municipal Health and Family Planning Commission), Shenzhen Emergency Medical Center purchased 1000 AEDs in 2018, and as of 2020, 5000 AEDs will be deployed. These events indicate that AED popularization has achieved a breakthrough in China.

We are a bit late to start the AED project in China, with the application of AEDs and public awareness about first aid far behind many developed countries. With the stimulation of economic prosperity and initiation of the "Healthy China 2030" project, China is committed to establishing reasonable strategies for C-PAD development based on the reality of China and the successful practice of other countries and promoting the AEDs project step by step.

2.2. Determine the quantity and standardize allocation process in public places based on the principle of "100-200 AEDs per 100000 people"

The concerns about first-aid in public places include allocation quantity, distribution density, and coverage of first-aid resources. It is reported that the United States has deployed 700 AEDs per 100 thousand people^[15,16], and in Japan per 100 thousand has 276 AEDs^[15,17], while it is 17.5, 13, 11, and 5 in Shenzhen, Haikou, Pudong New Area^[13], and Hangzhou^[7], respectively. The data above indicate the huge gap between China and developed countries in terms of the coverage of AEDs. Therefore, local governments and health departments should provide more financial support to conduct a census, and then allocate AEDs to out-of-hospital areas with a high probability of cardiac arrest based on the standard of 100 to 200 AEDs per 100000 people. The recommended allocation standard is based on the lowest level, so if possible, local governments should increase the quantity of AEDs according to the local conditions. But it is still far from enough, the government should encourage the donations from organizations and individuals to support the development of emergency services. In conclusion, we should promote the application and expand the coverage of AED, so that more people could have easy access to the equipment under emergency.

2.3. Location of AEDs based on the principle that the first responder could access AED and start the first aid treatment within 3-5 min

2.3.1. Population density

At least one AED should be installed in the public areas where (1) OHCA occurred in the past 5 years^[4]; (2) Some people have high-risk of OHCA; (3) The probability of cardiovascular accident

is above 1 time per thousand people per year[18,19]; (4) There is average fixed population of 3000 or more, such as schools, troops, and factories[20].

2.3.2. Population flow

At least one AED should be installed in the public area with population flow of at least 250 people over the age of 50 per day[18,19] or with an average flow of 3000 or more people[20].

2.3.3. Distribution distance

The distribution distance should following the below principles:

(1) Increase the quantity of AEDs as many as possible, and one AED should be deployed every 100 m in assembly occupancies[21,22];

(2) The rescuer can access AED and start the first aid treatment within 3 to 5 min[23];

2.4. Deploy AEDs in public places with large populaion and family with member of high risk

2.4.1. Schools

All kindergartens, primary schools, middle schools, and universities should be given priority to equipping with AEDs if they meet one of the following circumstances[23-25]:

- (1) There has been a record of AED usage over past 5 years;
- (2) There are students or teaching staff at high risk of sudden cardiac death;
- (3) The locations are far from emergency medical service.

C-PAD training should be promoted in school. For large scale activities, like sports meetings, at least two persons with the training about CPR and AEDs defibrillation should be on spot and be ready for any accident[19].

2.4.2. Transportation

2.4.2.1. Long-distance transportation

- (1) Every plane, train, and coach should be equipped with at least one AED[20];
- (2) Passenger ships with capacity ≥ 150 or gross tonnage ≥ 100 tons should be equipped with at least one AED[20].

2.4.2.2. Short-distance transportation

- (1) Promote the installment of AED in taxies, online ride-hailings, and buses. Also, drivers should receive professional training about AED and CPR before practice[26];
- (2) Besides, police vehicles and fire engines should be equipped with AEDs[3,26,27] to shorten the rescue time when cardiac arrest occurs[3,26,27];
- (3) Unmanned aerial vehicle (UAV) is a new platform to carry

AEDs. Since UAVs are not restrained by land traffic conditions and can be standby round-the-clock, this vehicle can have a quick response to accidents and improve the survival rate of OHCA patients[28]. Equipped with cameras, UAV can also be used for telemedicine, such as instructing first aiders to perform CPR and AEDs. However, UAV is easily affected by bad weather, thus it needs to be flexibly deployed according to the actual situation[29].

2.4.3. Medical institutions

Despite the presence of professional personnel, it is still necessary to install AEDs at medical institutions to ensure accessibility[4,30]. The following places in hospitals should be equipped with at least one AED:

- (1) Waiting area, outpatient department, clinical laboratory, imaging department, ultrasonography, and other auxiliary departments with an average flow of above 100 patients per day at secondary and tertiary hospitals[20,30];
- (2) Wards without defibrillation devices[30];
- (3) Non-medical areas at secondary and tertiary hospitals, such as canteens and squares;
- (4) Other lower-level medical institutions, such as community health service centers and community health stations;
- (5) Sanitariums, nursing homes with ≥ 120 beds, and other health care institutions.

2.4.4. Other public places with dense population

Other public places with dense population listed below should be equipped with at least one AED:

- (1) Scenic areas, historic sites, parks, resorts, hotels with more than 250 rooms[20].
- (2) Sports facilities, such as health clubs, sports clubs, fitness rooms, etc.[23].
- (3) Places along the race routes of extreme sports, triathlon, and marathon, etc.

2.4.5. Families

Families with a member who has suffered SCD or who is at high risk of SCD are recommended to prepare an AED as a precaution.

2.5. Install AEDs in easily-accessible places with striking mark and regularly maintenance

2.5.1. Suggested locations

- (1) Public amusement parks: At medical station, service counter, toilet, and beside fire hydrant;
- (2) Schools: At gym, medical room, security room, auditorium, canteen and lecture theater;
- (3) Hotels: At lobby, fitness room, meeting room, entertainment center, monitoring room, medical room, swimming pool, and beside

fire hydrant;

(4) Office buildings and factories: At the reception, entrance, monitoring room, medical room, and beside fire hydrant;

(5) Airports, subway stations, and train stations: At inquiry office, monitoring room, ticket office, medical room, and security check (ticket gate);

(6) Communities: At security room, entrance, and beside fire hydrant.

2.5.2. Installation requirements and routine maintenance

(1) As a first-aid device, AED should be available to everyone[31]. The AEDs location should be marked with a unified and distinct sign in the sketch map and should be equipped with a protective frame, and an alarm bell;

(2) AED can be hung against the wall or put on the ground. The location of AED should not impede passage, especially, sidewalk, corridor, etc. The height should be lower than 1.8 m to ensure easy accessibility[31,23], and the adaptability and durability should be improved for diverse public places;

(3) AEDs placement is suggested for vending machines, convenience stores, ATMs, and other all-day places because it is space-saving (no need for more space), of wide coverage (streets, communities, shops, subways, etc.), and striking (visible at night) [32,33];

(4) The application of AED on vehicles should meet the relevant requirements, such as aircraft transfer standards;

(5) Specialized administrators are required to regularly check the battery (except for AED with self-check function), the expiry date of other consumables and their functions (try to choose consumables with high quality), inspect and keep records. After the use of AED, data should be collected, and consumables should be supplemented timely[34]. Besides, cameras should be installed for monitoring and management. Since the device is needed at any time, AED should support remote management systems connecting through 4G/5G, NB-IoT, WiFi, and other wireless transmission modes to ensure the running of the device;

(6) Considering network information security, wireless data transmission should meet the Guidelines for Technical Review of Medical Device Network Security Registration (No. 13 of 2017)[35]. The remote device management system must pass the assessment of the protection level of information security and be filed by the Ministry of Public Security. Any auxiliary electrical equipment to AED should conform to the “National Standard of the People’s Republic of China (GB 9760.15-2008) Medical Electrical Equipment Part I: Safety General Requirements and Safety Requirements for Medical Electrical Systems”[36] and “Guidelines for Technical Review of *in vitro* defibrillation product registration”[37];

(7) The management of AEDs should be the routine work of local health authorities or professional medical societies. The usage and

maintenance of AEDs should be checked and summarize regularly.

2.6. Establish a government-led AED network, manage registration of AED and develop AED map

“Internet based emergency service” refers to integrating the powerful information transmission technology of the internet with the traditional emergency rescue system[38,39]. The widespread use of smartphones with positioning services is the premise of this initiative. The government-led network helps manage the online registration of AEDs and helps combine the internet and emergency service. Through mobile phones, OHCA patients, first responders, and AED are easily located, and then a distress signal coupled with the location of AED will be sent to people nearby so that the patients can get a fast treatment before medical staff arriving. Patients can be transported by taxis, online ride-hailing vehicles, police cars, and motorcycles, which will head for the patients after receiving the distress signal. UAVs with AED will be automatically activated from 4G/5G base stations as well. Guided by the information network, the fixed AED, mobile AED and UAV form a well-developed AED network.

An AED map should be developed with the functions of automatical positioning, updating, and sharing to integrate online and offline resources and to form a whole combining communities, hospitals, and other public places.

2.7. Supplementary guideline for AED

2.7.1. First aid kits or boxes

First-aid kits or boxes are important accessorial first-aid equipments to AED. They are easy to carry and preserve, which is conducive to the unified and standardized configuration of AED. A unified logo and notes on the package are needed, which should be eye-catching and informative. Basic first-aid equipments include gloves, thermal blankets, masks, bandages, and triangular towels, etc.[40].

2.7.2. Cervical collar

A cervical collar is basic first-aid equipment and can be used with AED to prevent the secondary injury of the cervical spine[40]. The simple cervical collar could also be used in public places because of the practicability and economy.

2.7.3. Other first-aid equipment

Trauma occurs in many emergencies. Therefore, new first-aid equipments, such as self-adhesive tourniquet, artificial respiration membrane, disposable cleaning pack, fracture splint, and saline are recommended to be applied with AEDs[40].

2.7.4. Auxiliary tools

Auxiliary tools such as fluorescent rods, whistles, emergency

lighting tools, and medical waste disposal bags are recommended to be included in the AED package, especially in public places with heavy traffic and dense population. Fluorescent rods, whistles, and emergency lighting tools help to evacuate people and locate patients[40]; while medical waste disposal bags could be used to deal with the medical waste and collect scattered items of patients.

2.8. Clarify the legal liability of AED application and improve relevant laws

Lack of legal support is an important reason for the limited development of AED in China. Some local governments have issued relevant regulations for the installation and use of AEDs in public places, but these terms are not compulsive. We have made some progress in China in recent years. In 2017, the National People's Congress passed Article 184 of the General Principles of the Civil Law of the People's Republic of China[11], which means that the use of AED under emergencies have been protected by the law, and it is legal for non-medical personnel to use AED after receiving training. The legality of installation and application of AED still needs to be clarified by the legislature and relevant laws need to be improved.

2.9. Deploy AEDs in public places under the lead of the government, encourage donations from enterprises and individuals and institutions to install AED by themselves.

AEDs are mainly deployed by the government, but it is far from enough to just rely on the government. More donations by enterprises, charities, individuals, etc. should be encouraged. The donated AEDs should be managed in the same way as these deployed by the government. Besides, organizations are also encouraged to install the AEDs on their own.

2.10. Promote PAD in China through developing system, delivering training, and improving public recognition

(1) Guided by the government-led C-PAD, different cities should set their standards according to their situations. To implement C-PAD, we need to make the budget and estimate the quantity of AED, and then establish system of personnel training and certification;

(2) After deploying, we should push forward the training of AED and CPR to make sure that AED can be used properly;

(3) Training of AED should be carried out in universities and colleges to cultivate more qualified personnel;

(4) Organizations and institutions with training qualifications, including the Red Cross Society of China, 120 emergency system, hospitals, and medical universities and colleges, are candidate hosts of AED training;

(5) Patients with a high risk of SCD and their relatives should also

receive CPR and AED training;

(6) Publicity departments of the government and social media should promote AED through TV, radio, newspapers, and internet, and spread the basic knowledge about AED and first aid[41];

(7) AED deployment should be included in city planning and design.

3. Summary

The low efficiency of pre-hospital first aid and low utilization rate of AED is partly due to the unbalanced development of the PAD project, the insufficiency quantity of AEDs, and rough deployment guidelines. With high sensitivity and specificity to SCD, AEDs are easy to carry and operate. Taking population, distance, and location into account, we would establish deployment strategy of AED, take advantage of the internet and new technologies, and expand AED coverage to improve the general recognition and usage rate. Carrying AED with UAV is the full embodiment of this thought. UAV paves an "air road" for AED transportation and increases the efficacy of AEDs application. We should allocate all available resources properly, which can increase the rescuing time and survival rate to improve the emergency service.

Authors' list

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Conflict of interest statement

The authors report no conflict of interest.

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Authors' contributions

The corresponding authors organized and drafted the consensus. Other members made comments and suggestions on the final version of this consensus.

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