



Consensus document regarding cardiovascular safety at sports arenas

Position stand from the European Association of Cardiovascular Prevention and Rehabilitation (EACPR), section of Sports Cardiology

Mats Borjesson^{1*}, Luis Serratos², Francois Carre³, Domenico Corrado⁴, Jonathan Drezner⁵, Dorian L. Dugmore⁶, Hein H. Heidbuchel⁷, Klaus-Peter Mellwig⁸, Nicole M. Panhuyzen-Goedkoop^{9,10}, Michael Papadakis¹¹, Hanne Rasmussen¹², Sanjay Sharma¹¹, Erik E. Solberg¹³, Frank van Buuren⁸, and Antonio Pelliccia¹⁴, writing group, on behalf of the EACPR section of sports cardiology

¹Department of Acute and Cardiovascular Medicine, Sahlgrenska University Hospital, Göteborg, Sweden; ²Sanitas-Real Madrid FC Sports Medicine Department, Madrid, Spain; ³Unite Biologie et Medecine du Sport, Pontchaillou Hospital, Rennes University, Rennes, France; ⁴Department of Cardiac, Thoracic and Vascular Sciences, University of Padua Medical School, Padua, Italy; ⁵University of Washington, Seattle, WA, USA; ⁶Wellness Medical Center, Stockport, UK; ⁷Cardiovascular Rehabilitation Unit, KU Leuven, Leuven, Belgium; ⁸Heart Center NRW, University Hospital, Bad Oeynhausen, Germany; ⁹Heart Center Radboud University Nijmegen, Nijmegen, The Netherlands; ¹⁰Sports Medical Center Papendal, Arnhem, The Netherlands; ¹¹Kings College Hospital, London, UK; ¹²Department of Cardiology, Bispebjerg University Hospital, Copenhagen, Denmark; ¹³Department of Medicine, Diakonhjemmet Hospital, Oslo, Norway; and ¹⁴Institute for Sports Medicine and Science, Rome, Italy

Received 5 December 2010; revised 17 March 2011; accepted 13 May 2011

Mass gathering events in sports arenas create challenges regarding the cardiovascular safety of both athletes and spectators. A comprehensive medical action plan, to ensure properly applied cardiopulmonary resuscitation, and wide availability and use of automated external defibrillators (AEDs), is essential to improving survival from sudden cardiac arrest at sporting events. This paper outlines minimum standards for cardiovascular care to assist in the planning of mass gathering sports events across Europe with the intention of local adaptation at individual sports arenas, to ensure the full implementation of the chain of survival.

Introduction

Mass gathering events in sports arenas create challenges regarding the cardiovascular safety of both athletes and spectators.

The most feared acute cardiovascular event is the occurrence of sudden cardiac arrest (SCA), which could result in sudden death. Sudden cardiac death (SCD) is defined as a 'natural death due to cardiac causes, heralded by abrupt loss of consciousness within 1 h of the onset of acute symptoms; pre-existing heart disease may have been known to be present, but the time and mode of death are unexpected'.¹ The incidence of SCD in the general population (adults >35 years) is estimated to be 1 in 1000 persons per year,² while in young people (<35 years of age) the incidence of SCD is 0.3–3.6 per 100 000 persons per year.^{3,4}

Intense physical activity, also in athletes, will carry a higher risk for acute cardiac events, especially in subjects with an underlying cardiovascular disease.^{3,5,6,7,8} On the basis of earlier studies,⁹ cardiac screening is recommended in competitive athletes by the European Society of Cardiology,¹⁰ as well as by major sporting bodies such as FIFA and UEFA. The catastrophic consequences and public nature of these events provide compelling reasons to implement effective strategies for emergency management in case of SCA. The assistance to players is potentially rapid and readily accessible.

However, spectators also may have an increased risk for SCA during a sports event due to emotional excitation with increased catecholamine-levels during a game that could trigger a coronary event.^{11,12} The viewing of a stressful sports event has been

* Corresponding author. Tel: +46 31 343 6727, Fax: +46 31 343 5933, Email: mats.borjesson@telia.com

Published on behalf of the European Society of Cardiology. All rights reserved. © The Author 2011. For permissions please email: journals.permissions@oup.com

shown to substantially increase the risk of an acute cardiovascular event,^{13,14} although this increased risk has been questioned.¹⁵ Recent studies^{16,17} suggest an incidence of SCA of 1 per 5–600 000 spectators in major European soccer arenas and in one study as high as 1 per 260 000.¹⁸ In addition, at the Barcelona FC Stadium (capacity of 98 260 spectators), a total of seven episodes of acute coronary syndromes were recorded during a single-season (2000–01).¹⁹ For spectators, more barriers to access may exist to provide a rapid response in case of SCA.

At the time of the first heart rhythm analysis, ~40% of overall SCA victims have ventricular fibrillation (VF).^{20–22} It is likely that many more have VF or rapid ventricular tachycardia at the time of collapse but, when the first electrocardiogram is recorded, their rhythm has deteriorated to asystole.^{23,24} Many SCA victims could survive if bystanders act immediately while VF is present, but successful resuscitation is unlikely once the rhythm has deteriorated to asystole.²⁵ The optimum treatment for VF cardiac arrest is immediate bystander cardiopulmonary resuscitation (CPR) plus electrical defibrillation, as outlined in the latest Guidelines for Resuscitation, by the European Resuscitation Council.²⁶ The 'chain of survival' includes four vital steps needed for successful resuscitation:

- (1) early recognition of the emergency and calling for help, activating the local emergency medical services (EMS) or response system;
- (2) early bystander CPR;
- (3) early defibrillation;
- (4) early advanced cardiac life support (ACLS) and post-resuscitation care.^{24,26}

The major determinant of survival is ultimately the time to defibrillation and should be CPR adequately applied to bridge the gap to defibrillation, with the critical time from onset of a life-threatening arrhythmia to shock delivery being ~3–5 min.^{26,27} Historical survival rates from out-of-hospital cardiac arrest are <5%. Survival following SCA has been greatly improved by public access defibrillation programmes designed to shorten the time interval from SCA to shock delivery. By introducing the 'chain of survival', having trained rescuers in CPR and providing access to early defibrillation, survival from out-of-hospital VFs can be considerably increased to >60%.^{23,28,29}

Rationale for automated external defibrillators in the public settings

Scientific evidence support the placement of automated external defibrillators (AEDs) as part of a strategic emergency plan in public places hosting large mass events, including sports arenas.^{16,18,29–31}

Specifically, public access defibrillation and first responder AED programmes increase the number of victims who receive bystander CPR and early defibrillation, thus improving survival from out of hospital SCA.³² Lay rescuer AED programmes with very rapid response times in airports,³³ on airplanes,³⁴ or in casinos,³¹ and uncontrolled studies using police officers as first responders,^{35,36} have reported survival rates up to 70%.

Public access defibrillation programmes are most likely to improve survival from cardiac arrest if they are established in locations where witnessed cardiac arrest is likely to occur.³⁷ Suitable sites have been suggested to include those who by their size carry the probability of cardiac arrest occurring at least once every 2 years.³² The role of early on-site defibrillation in large public venues is also supported by recent studies.^{16,18,30,38}

Thirteen witnessed SCAs occurred in the Fritz-Walter Stadium, Germany (capacity of 46 600 spectators) in a 80-month period,¹⁶ all in males with documented VF. Basic life support was usually provided within 2 min and defibrillation and advanced life support within 4 min. Of the victims, 77% regained spontaneous circulation and 62% survived without neurological deficits.¹⁶ Another recent retrospective analysis of 36 cases of SCA in US High Schools with on-site AED programmes²⁹ showed a survival benefit for young athletes comparable with adult non-athletes (spectators, coaches, officials) with over 60% of victims surviving.²⁶

The present situation in Europe

The actual availability of AEDs in major soccer arenas in Europe is suboptimal. A recent study from the section of Sports Cardiology,¹⁷ showed inadequacies concerning a written medical action plan (MAP) for delivery of emergency care, availability of AEDs as well as basic 'CPR training' for stadium personnel in a substantial number of ($n = 190$ examined) European soccer sports arenas. Only 64% of arenas reported having a written MAP, 72% had an external defibrillator available, and 65% had a basic CPR training programme. Even in the 79 arenas where the transportation time to hospital exceeded the critical 5 min, 20 of 79 arenas (25%) did not have an AED available to ensure prompt defibrillation, should an SCA occur. This observation emphasizes the urgency for action to ensure an appropriate level of cardiovascular safety at sports arenas in Europe.

Limited recognized standards and/or uniform legislation exist regarding cardiovascular EMS at public mass gatherings in sports events. Most of the articles found in the literature are case reports describing the care at a few large facilities or events.^{16,19} Regarding care to spectators, the National Association of Emergency Medical Services Physicians (NAEMSP) issued a comprehensive document to assist physicians with planning emergency medical care at mass gatherings.³⁹ The goal was to define minimum standards for delivery of EMS to all mass gathering events. In this check-list a MAP defining the responsibilities of a medical director, number of personnel, medical equipment including AEDs, transportation, and communication, were included.

In the USA, an Inter-Association Task Force led by the National Athletic Trainers' Association (NATA) published a consensus statement providing recommendations on emergency preparedness and management of SCA in high school and college athletic programmes.⁴⁰ Moreover, AEDs are already recommended in large US health and fitness facilities when the time of access to defibrillation exceeds the critical threshold of 5 min.⁴¹ On the contrary, no recommendations regarding acute cardiovascular care at sports arenas exist at present in Europe. As 67 cases of SCA were observed in the 190 European arenas of the Arena study in one season only,¹⁷ the potential for saving lives with a proper level of cardiovascular arena care is evident.

Scope of the consensus document

The Sports Cardiology section of the European Association of Cardiovascular Prevention and Rehabilitation (EACPR) aims to introduce a position statement regarding minimum standards for emergency cardiovascular care for both spectators and athletes at sports arenas in Europe.

To maximize the survival in case of SCA occurring, the 'chain of survival' must be applied in each specific case at every arena. These recommendations will hopefully be implemented in the planning of mass gathering events in major sports arenas.

The recommendations from this statement primarily target indoor and outdoor sports arenas with a minimum capacity of 1000 spectators, plus major mass-participation sporting events, such as marathons and cycling races, outside of stadiums, in which at least 1000 individuals are gathered at a specific location for a defined period of time, defined as 'a mass gathering event' by the NAEMSP.³⁹

Several aspects make mass gathering emergency care unique and different from any other standard EMS. Medical personnel may need to navigate large crowds, often without clear landmarks and with frequent barriers to access, which prevents motorized transport being used. Personnel may also be required to work with coincidental multiple casualties, in potentially dangerous environments and occasionally with patients who refuse necessary medical care due to their emotional engagement in the event. Environmental factors (i.e. extreme cold, heat, altitude) can also influence the number of patients that need attention in a short period of time. Additional factors include lack of sufficient resources, prolonged transportation time to hospitals, communication challenges due to distance, and increased risk for acts of terrorism.

These recommendations outline the necessary components to ensure that any patient with a cardiovascular emergency will be taken care of according to the chain of survival. We recognize that mass gathering medical care also will include less acute cardiovascular care and non-cardiac medical care, which is outside the scope of this paper. The recommendations are the result of existing scientific data^{27,30,33,42} together with a consensus of expert opinion in the field of sports cardiology.^{39,40}

Recommendations for cardiovascular arena care

The final common goal for these recommendations is to ensure an organized and timely response to life-threatening cardiovascular events at sports arenas. To achieve this goal, each arena must have a written MAP and a designated medical director to define the specifics for each arena. With wide variation in the size and geographic layout of different arenas, the exact minimum standards for cardiovascular arena safety to achieve the goal of early CPR and defibrillation, such as the number of AEDs and trained responders in CPR, will thus differ between each arena. Adequate equipment and personnel resources to achieve the goal of early CPR and defibrillation should be ensured.

Medical action plan

A well developed and properly executed MAP is essential for effective medical care at any mass sports event. The plan should be in written form, easy to access, reviewed and updated at least annually by all members of an arena medical team. Key components of a MAP are listed in *Table 1*, and discussed in detail below.

Medical director

Ideally, a locally licensed physician should be the responsible medical director at a mass gathering sports event. A physician familiar with local medical resources can positively impact decision-making in the field, transportation, and triage decisions. The medical director should be:

- named and listed in the MAP;
- experienced in out of hospital emergency care and familiar with the local EMS system;
- involved in the organizing committee for major events taking place at the arena;
- responsible for design and implementation of the MAP and medical care at the arena/event;
- involved at an early stage in the planning of any new stadiums, to ensure emergency care aspects are included in the building process (transportation ensured, medical rooms, location of defibrillators, other essential practical considerations);
- responsible for updating the MAP regularly;
- responsible for the continuous training of emergency personnel, including organizing a debriefing meeting for the team, after a resuscitation event;
- responsible for organizing a network of locally licensed physicians and/or trained physicians from a nearby hospital, that could also be the Director's deputies, if needed.

During the event the medical director should be:

Table 1 Check list: written medical action plan of sports arenas with >1000 spectators, should include

Name of medical director at arena
Map of the arena with localization of emergency exits and medical care (for opposing teams and spectators)
Arena and event specific planning
Level of care
Personnel
Medical equipment
Communication
Treatment facilities
Transportation resources
Documentation
Collaboration with local emergency medical system and nearest hospital
Continuous quality improvement
External information

- easily identifiable by uniform or another method (e.g. medical director fluorescent armband);
- present and lead a pre-event medical team meeting;
- continuously available by some form of communication to all EMS personnel and to the nearest hospital;
- responsible for completion and proper storage of any medical documentation relating to emergency events.

Arena and event specific planning

Careful examination of arena specific factors and barriers to care should be made by the medical director and his/her team prior to the event, in order to optimize appropriate treatment should a cardiovascular emergency occur. The analysis should consider:

- location and characteristics of the arena (barriers to crowd access, outdoors vs. indoors, entrance, and exit locations for spectators and participants, time to access victims in different parts of the venue, and transportation routes into and out of the arena for emergency vehicles);
- type of event and its duration;
- expected attendance and weather conditions (warm or cold ambient temperature, precipitation, threat of thunderstorms with lightning);
- crowd's probable demographics (age, language, and familiarity with the venue) and mobility;
- risk for violence or violent group behaviour;
- potential for alcohol and drug use;
- distance and predicted transport times for local EMS to the hospital;
- regular event planning with the local police and fire-brigade.

Level of care

Basic cardiac life support (BCLS) including AED should be considered the minimum acceptable level of care at any mass gathering event. Every effort should be made to deliver adequate CPR to bridge the gap to defibrillation and to ensure early defibrillation within 5 min from the time of collapse to victims of SCA.

Medical care delivered by non-physicians should follow an accepted set of protocols and standard procedures approved by the medical director and consistent with current CPR and BCLS guidelines.²⁶

Personnel

All personnel should be trained and certified in cardiovascular emergency care.²⁶ Recognition of SCA is essential. Misinterpretation of certain signs (involuntary myoclonic jerks as seizures) or inaccurate assessment of pulse and respiration may lead to a delay in the chain of survival,^{43,44} including delayed defibrillation.

The MAP should include as many personnel as needed to guarantee a response within 5 min, for life-threatening medical emergencies. The number of spectators, level of risk of the event, and transport times to higher levels of medical care should be considered when deciding the number and level of training of emergency medical care personnel.

The MAP should define the specific roles of each personnel category and in detail define who is the first responder in case of SCA, to minimize the delay from recognition of SCA to resuscitation/defibrillation.

The arena emergency personnel should be easily identifiable, either by standard uniforms or other identification, to minimize delay for proper emergency care.

Recommendations for personnel include

- Presence of at least 1–2 physicians (not including team physicians) per 50 000 spectators is strongly encouraged.⁴⁵ On-site physicians should (ideally) be certified in CPR/ACLS.
- Presence of at least one nurse per 10 000 spectators to deliver first aid and be ambulatory as an additional first responder to a cardiovascular emergency.
- Medical technicians (MTs), primarily utilized as mobile emergency responders, numbering at least 2 per 10 000 spectators.⁴⁶
- Other event volunteers utilized in positions throughout the arena for purposes other than direct patient care should be aware of how to alert on-site trained emergency care providers and the EMS system. Ideally at least 50% of non-medical volunteers should be trained in basic CPR and first-aid, in case patient contact is required.

Medical equipment

Proper equipment for ACLS, including AEDs and oxygen, and emergency care medication are required. The number of AEDs should be calculated for each arena, for example, by using the suggested algorithms by Motyka⁴⁷ and Crocco.⁴⁸ Specifically, the mean response-time for the longest distance needed to be covered in case of SCA, in each sports arena should be measured. The number of AEDs required is then calculated to make possible a 3 min retrieval and response time.⁴⁷

In summary, AEDs should be widely distributed throughout the arena or on mobile emergency responders to achieve the goal of first defibrillation within 5 min of a witnessed collapse. Furthermore, the location of the AEDs should be clearly marked, visible, and adequately signed. If necessary, AED battery life should be regularly checked.

Medications for ACLS should be included and consistent with protocols of the local EMS. Also consider the availability of stretchers, wheelchairs, and stair chairs to assist in patient transport. A readiness check of all equipment should occur prior to each event.

Communication

An efficient communication system is essential to ensure quick response times. An effective and reliable radio system may be the best choice for all emergency personnel to carry. Mobile or land-line phones also could help if available. For large arenas, an emergency operations centre is recommended as a central command centre to control communications.

The communication system should be tested prior to each event. The MAP should list all relevant phone numbers.

Treatment facilities

Treatment facilities or on-site medical rooms are important for large volumes of patients, as well as in locations with prolonged transport times. The number of rooms needed, will depend on the size and characteristics of the arena.

Treatment facilities should be highly visible, located for best possible access for spectators and marked on a map of the arena included in the official event programme.

Transportation resources

The number and type of transportation resources should be individualized according to internal and external local logistics and the size of the arena, and described in the MAP. Ground ambulances, golf carts, and/or modified mini ambulances as well as helicopters could be used. Parking areas should be reserved and all emergency vehicles should be clearly described in the MAP and marked on the map of the arena.

Internal

The time for transporting a patient to the nearest emergency room at the arena should be timed in a full capacity stadium. Safe and relatively unimpeded routes should be created inside the stadium and clearly marked to minimize transport times.

External

The distance and duration for transportation to the nearest emergency hospital with ACLS capability should be timed and stated in the MAP, considering external factors such as traffic congestion. The fastest evacuation routes should be designed in coordination with local EMS authorities.

The exact number of ambulances should be defined in the MAP for each arena/event, but a minimum of one ambulance should be present during the event if >10 000 spectators/competitors are expected (Table 2).

Documentation

All emergency care performed in the arena must be documented in a standardized format and records saved, ensuring confidentiality and patient safety. The medical director is responsible for this. Medical forms must include at least basic demographic information, location and time of incident, focused history and physical exam, treatment, and final diagnosis.

Collaboration with the local emergency medical services and nearest hospital

It is essential to collaborate with the local EMS system in developing a MAP so on-site emergency responders complement the resources available. This includes the logistics regarding proper medical equipment and transportation to the arena medical room or directly to the hospital, plus where and how the local

EMS will take over care from the arena medical staff in specific cases. In general, all critically ill patients and SCA victims should be transported to the hospital, except in special circumstances where the capabilities of the arena medical team are greater or more time-urgent than those at a remote hospital.

In addition, the nearest hospital should be alerted of the event and the expected number of spectators in time to be adequately prepared.

Continuous quality improvement

Proper training of personnel is the responsibility of the medical director and should be stated in the MAP, including certification in basic or ACLS of the arena/event staff.

Training drills of emergency care at different locations inside the arena and practice and review of the MAP should be carried out involving all the emergency personnel and the local EMS at least annually. Emergency incidents should be reviewed, with revision of the MAP as needed. Debriefing of the emergency team after a resuscitation event is equally important.

Importantly, for both referees and coaches it should be mandatory to undergo basic life support training preferably as part of coaching and refereeing courses for diploma in continuous education. During the game (and training) they could be the first responder to an athlete, and should be able to act accordingly in case of suspected or confirmed SCA.

External information

The MAP should be available to referees and visiting teams prior to the event. Different leagues or the sporting bodies (for example, UEFA, FIFA in soccer) may consider organizing and distributing league arena MAPs to all teams. The spectators and public should also be properly informed and updated on the relevant contents of the MAP of the arena, by information boards, match programmes and by the internet.

In conclusion, the inadequacies in basic emergency planning recently observed in major European soccer arenas¹⁷ emphasize the need to ensure an appropriate and equal level of cardiovascular care at all sports arenas. This paper outlines suggested minimum standards for cardiovascular care to assist in the planning of mass gathering sports events across Europe. Ideally, these recommendations will be addressed and implemented by the specific sporting bodies, organizations, and local officials to increase cardiovascular safety at sports arenas.

Table 2 Recommendations for minimum level of care at sports arenas/events with >1000 spectators/competitors

Arena size	AEDs no	Physicians	Nurses	MTs	Ambulances
<10 000	1–2	1	1	2	0–1
10–50 000	4	2	1–5	2–10	1–2
>50 000	8	2–4	>5	>10	>2

These figures are to be seen as recommendations. As discussed in the consensus document, a specific arena may need a different number of AEDs and personnel, to ensure the chain-of survival in every case of SCA in the arena, within <5 min.

References

- Myerburg RJ, Castellanos A. Cardiac arrest and sudden cardiac death. In Braunwald E, ed. *Heart Disease: A Text-book of Cardiovascular Medicine*. New York: WB Saunders Publ Co; 1997, p742–749.
- Sen-Chowdry S, McKenna WJ. Sudden cardiac death in the young: a strategy for prevention by targeted evaluation. *Cardiology* 2006;**105**:196–206.
- Borjesson M, Pelliccia A. Incidence and aetiology of sudden cardiac death in athletes: an international perspective. *Br J Sports Med* 2009;**43**:644–648.
- Wren C. Screening children with a family history of sudden cardiac death. *Heart* 2006;**92**:1001–1006.
- Corrado D, Basso C, Rizzoli G, Schiavon M, Thiene G. Does sports activity enhance the risk of sudden death in adolescents and young adults?. *J Am Coll Cardiol* 2003;**42**:1959–1963.
- Chevalier L, Hajjar M, Douard H, Cherief A, Sedze F, Ricard R, Vincent MP, Corneloup L, Gencel L, Carre F. Sports-related acute cardiovascular events in a general population: a French prospective study. *Eur J Cardiovasc Prev Rehabil* 2009;**16**:365–370.
- VanCamp SP, Bloor CM, Mueller FO, Cantu RC, Olson HG. Non traumatic sports death in high school and college athletes. *Med Sci Sports Exerc* 1995;**27**:641–647.
- Faber L, van Buuren F. Athlete screening for occult cardiac disease: no risk, no fun?. *J Am Coll Cardiol* 2008;**51**:1033–1039.
- Corrado D, Basso C, Pavei A, Michieli P, Schiavon M, Thiene G. Trends in sudden cardiovascular death in young competitive athletes after implementation of a pre-participating screening program. *JAMA* 2006;**296**:1593–1601.
- Corrado D, Pelliccia A, Bjornstad HH, Vanhees L, Biffi A, Borjesson M, Panhuysen-Goedkoop N, Deligiannis A, Solberg EE, Dugmore D, Assanelli D, Delise P, van Buuren F, Anastakis A, Heidbuchel H, Hoffmann E, Fagard R, Priori SG, Basso C, Arbustini E, Blomstrom-Lundqvist C, McKenna WJ, Thiene G. Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: proposal for a common European protocol. *Eur Heart J* 2005;**26**:516–524.
- Mittleman MA, Maclure M, Sherwood JB, Mulry RP, Tofler GH, Jacobs SC, Friedman R, Benson H, Muller JE. Triggering of acute myocardial infarction onset by episodes of anger. Determinants of myocardial infarction onset study investigators. *Circulation* 1995;**92**:1720–1725.
- Chi JS, Kloner RA. Stress and myocardial infarction. *Heart* 2003;**89**:475–476.
- Katz E, Metzger J-T, Marazzi A, Kappenberger L. Increase of sudden cardiac deaths in Switzerland during the 2002 FIFA World Cup. *Int J Cardiol* 2006;**107**:132–133.
- Wilbert-Lampen U, Leistner D, Greven S, Pohl T, Sper S, Völker C, Güthlin D, Plasse A, Knez A, Küchenhoff H, Steinbeck G. Cardiovascular events during World Cup soccer. *N Engl J Med* 2008;**358**:475–483.
- Barone-Adesi F, Vizzini L, Merletti F, Richiardi L. It is just a game: lack of association between watching football matches and the risk of acute cardiovascular events. *Int J Epidemiol* 2010;**39**:1006–1013.
- Luiz T, Kumpch M, Metzger M, Madler C. Management of cardiac arrest in a German soccer stadium. Structural, process and outcome quality. *Anaesthesist* 2005;**54**:914–922.
- Borjesson M, Dugmore D, Mellwig KP, van Buuren F, Serratos L, Solberg EE, Pelliccia A. Time for action regarding cardiovascular emergency care at sports arenas: a lesson from the arena study. *Eur Heart J* 2010;**31**:1438–1441.
- Leusveld E, Kleijn S, Umans VA. Usefulness of emergency medical teams in sport stadiums. *Am J Cardiol* 2008;**101**:712–714.
- SerraGrima R, Carreno MJ, Tomas AL, Bossa V, Ligerio C, Pons J. Acute coronary events among spectators in a soccer stadium. *Rev Esp Cardiol* 2005;**58**:587–591.
- Cobb LA, Fahrenbruch CE, Olsufka M, Copass MK. The chain of survival follows the vital steps needed for successful resuscitation of SCA victims. *JAMA* 2002;**288**:3008–3013.
- Rea TD, Eisenberg MS, Sinibaldi G, White RD. Incidence of EMS-treated out of hospital cardiac arrest in the United States. *Resuscitation* 2004;**63**:17–24.
- Waalewijn RA, deVos R, Koster RW. Out of hospital cardiac arrests in Amsterdam and its surrounding areas: results from the Amsterdam resuscitation study (ARREST) in "Utstein" style. *Resuscitation* 1998;**38**:157–167.
- Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the chain of survival concept. A statement for health professionals from the advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation* 1991;**83**:1832–1847.
- Waalewijn RA, Nijpels MA, Tijssen JG, Koster RW. Prevention of deterioration of ventricular fibrillation by basic life support during out of hospital cardiac arrest. *Resuscitation* 2002;**54**:31–36.
- Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out of hospital cardiac arrest: a graphic model. *Ann Emerg Med* 1993;**22**:1652–1658.
- Nolan JP, Soar J, Zideman DA, Biarent D, Bossaert LL, Deakin C, Koster RW, Wyllie J, Böttiger B. European Resuscitation Council Guidelines for Resuscitation 2010. Section 1. Executive summary. *Resuscitation* 2010;**81**:1219–1276.
- AHA. The American Heart Association in collaboration with the International Liaison Committee on Resuscitation. Guidelines 2000 for cardiopulmonary resuscitation and emergency cardiovascular care, part 4: The automated external defibrillator. Key link in the chain of survival. *Circulation* 2000;**102**(Suppl. 8):160–176.
- Bobrow BJ, Zuercher M, Ewy GA, Clark L, Chikani V, Donahue D, Sanders AB, Hilwig RW, Berg RA, Kern KB. Gasping during cardiac arrest in humans is frequent and associated with improved survival. *Circulation* 2008;**118**:2550–2554.
- Drezner JA, Rao AL, Heistand J, Bloomingdale MK, Harmon KG. Effectiveness of emergency response planning for sudden cardiac arrest in United States high schools with automated external defibrillators. *Circulation* 2009;**120**:518–525.
- Fedoruk JC, Paterson D, Hlynka M, Pung KY, Gobet M, Currie W. Rapid on-site defibrillation versus community program. *Prehosp Dis Med* 2002;**17**:102–106.
- Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spate DW, Hardman RG. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. *N Engl J Med* 2000;**343**:1206–1209.
- Hallstrom A, Ornato JP. Public-access defibrillation and survival after out-of-hospital cardiac arrest. The public access defibrillation trial investigators. *N Engl J Med* 2004;**351**:637–646.
- Caffrey SL, Willoughby PA, Pepe PE, Becker LB. Public use of automated external defibrillators. *N Engl J Med* 2002;**347**:1242–1247.
- Page RL, Joglar JA, Kowal RC, Zagrotsky JD, Nelson LL, Ramaswamy K, Barbera SJ, Hamdan MH, McKenas DK. Use of automated external defibrillators by US airline. *N Engl J Med* 2000;**343**:1210–1216.
- White RD, Bunch TJ, Hankins DG. Evolution of a community-wide early defibrillation programme experience over 13 years using police/fire personnel and paramedics as responders. *Resuscitation* 2005;**65**:279–283.
- Mosesso VN Jr, Davis EA, Auble TE, Paris PM, Yealy DM. Use of automated external defibrillators by police officers for treatment of out of hospital cardiac arrest. *Ann Emerg Med* 1998;**32**:200–207.
- Becker L, Eisenberg M, Fahrenbruch C, Cobb L. Public locations of cardiac arrest: implications for public access defibrillation. *Circulation* 1998;**97**:2106–2109.
- Wassertheil J, Keane G, Fisher N, Leditschke JF. Cardiac outcomes at the Melbourne Cricket Ground and Shrine of Remembrance using a tiered response strategy—a forerunner to public access defibrillation. *Resuscitation* 2000;**44**:97–104.
- Jaslow D, Yancy A, Milstein A. *Mass Gathering Medical Care: The Medical Director's Checklist for the NAEMSP Standards and Clinical Practice Committee*. Lenaxa, Kansas: National Association of Emergency Medical Services Physicians; 2000.
- Drezner JA, Courson RW, Roberts WO, Mosesso VN, Link MS, Maron BJ. Inter-association Task Force Recommendations on emergency preparedness and management of sudden cardiac arrest in high school and college programs: a consensus statement. *J Athletic Training* 2007;**42**:143–158.
- ACSM/AHA. Joint position statement: automated external defibrillators in health/fitness facilities. *Med Sci Sports Exerc* 2002;**34**:561–564.
- Priori SG, Bossaert LL, Chamberlain DA, Napolitano C, Arntz HR, Koster RW, Monsieurs KG, Capucci A, Wellens HJJ. ESC-ERC recommendations for the use of automated external defibrillators (AEDs) in Europe. *Eur Heart J* 2004;**25**:437–445.
- Eberle B, Dick WF, Schneider T, Wissner G, Doetsch S, Tzanova I. Checking the carotid pulse check: diagnostic accuracy of first responders in patients with and without a pulse. *Resuscitation* 1996;**33**:107–116.
- Drezner JA, Rogers KJ. Sudden cardiac arrest in intercollegiate athletes: detailed analysis and outcomes of resuscitation in nine cases. *Heart Rhythm* 2006;**3**:755–759.
- Shayne P, Holliman CJ, Wang NE, Parrillo SJ. International emergency medicine reference list. *J Emerg Med* 1999;**17**:159–161.
- Parrillo SJ. EMS and mass gatherings. *EMedicine* 2004;1–9.
- Motyka TM, Winslow JE, Newton K, Brice JH. Method for determining automatic external defibrillator need at mass gatherings. *Resuscitation* 2005;**65**:309–314.
- Crocco TJ, Sayre MR, Liu T, Davies SM, Cannon C, Potluri J. Mathematical determination of external defibrillators needed at mass gatherings. *Prehosp Dis Med* 2004;**8**:292–297.