

Recommendations for lightning protection in sport

Michael Makdissi and Peter Brukner

EACH YEAR MANY PEOPLE are killed or injured by lightning due to misinformation and inappropriate behaviour during thunderstorms.¹ Analysis of the circumstances surrounding lightning strikes shows that, while there has been a large decrease in the number of lightning casualties in farming and outdoor work, there has been a smaller relative increase in sports-related casualties.^{2,3} Moreover, with large crowds gathering to participate in or watch an outdoor event, the potential exists for mass casualties to occur from a lightning strike at any one venue. Hence, there is a need to develop specific approaches for lightning safety at sports events.

In Australia, fatality rates for lightning strikes have fallen from 0.21 per 100 000 population in 1910–1919⁴ to about 0.01 per 100 000 population in the 1990s. From 1990 to 1999, 23 fatalities were directly attributable to lightning (Australian Bureau of Statistics, personal communication). Furthermore, from 1993 to 1998, lightning was responsible for 95 hospital admissions (Dr R Cripps, Research Centre for Injury Studies, Flinders University, 2001, personal communication). From these figures, we can estimate that the mortality rate from lightning strikes in Australia is currently about 10%. This is below the generally accepted mortality rate of 30%,⁵ although other authors have reported mortality rates as low as 5%.⁶

In 1998, the Lightning Safety Group, a group of lightning experts in the United States, developed guidelines for lightning safety,⁷ which have since been applied to a variety of sports and recreational pursuits.^{8–11} However, there have been no clear recommendations for lightning safety at events with large numbers of spectators.

Our aim is to present specific, practical recommendations to reduce the risk of lightning casualties in outdoor sporting and recreational activities in Australia.

General guidelines

The general guidelines presented here are based on the recommendations made by the Lightning Safety Group and those adopted by the US National Athletic Trainers' Association (Box 1).^{6,7}

Centre for Sports Medicine Research and Education, School of Physiology, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Melbourne, VIC.

Michael Makdissi, MB BS, BSc(Hons), PhD Candidate;
Peter Brukner, MB BS, FACSP, Associate Professor in Sports Medicine.
Reprints will not be available from the authors. Correspondence:
Dr M Makdissi, Centre for Sports Medicine Research and Education,
School of Physiology, Faculty of Medicine, Dentistry and Health Sciences,
University of Melbourne, Melbourne, VIC 3010.
m.makdissi@pgrad.unimelb.edu.au

ABSTRACT

- Lightning is an important cause of weather-related morbidity and mortality and is often underrated.
- There has been an increase in the proportion of casualties occurring during outdoor sport and recreational activities over recent years. However, in Australia, there is a deficiency in recommendations for lightning safety at sporting events.
- Organisers of sporting events should have a lightning safety policy that includes a designated weather watcher with the authority to stop or postpone the event, a specific chain of command, and designated safe areas.
- Suspension and resumption of play should follow the "30/30" rule: play should stop when the flash-to-bang count is 30 seconds, and should not resume until 30 minutes after the last lightning.
- At events with large crowds, additional time should be allowed for evacuating all people to safe areas.

MJA 2002; 177: 35–37

Proactive plan

The proactive plan should commence on the day before activity, where weather forecasts provide important warning of possible thunderstorm activity.⁸ Increased awareness of lightning risk should continue on the day of activity until play has finished and the crowd has dispersed.

The most basic level of warning involves observation of the weather in the local area. The first flash of lightning or clap of thunder, no matter how far away, should heighten lightning-awareness. The level of risk depends to a large degree on one's location relative to the storm system, which can be determined by the "flash-to-bang" rule (see below). Further useful information can be obtained by liaison with the Bureau of Meteorology <<http://www.bom.gov.au>>.

In recent years, major advances have been made in technology for identifying and locating lightning. In Australia, there is a network of sensors that enable cloud-to-ground flashes to be mapped to within a few hundred metres. Together with other details about local weather conditions, the Lightning Location System can provide real-time displays of lightning strikes and determine the speed and direction of movement of the thunderstorm. This information can be used to estimate the likely future path of the thunderstorms and their probable arrival times at various venues.

Chain of command

During the formulation of specific lightning safety guidelines, a specific person should be given responsibility for

1: General lightning safety recommendations

- Develop a proactive approach that includes monitoring the local weather from the day before activity until play has finished and the crowd has dispersed.
- Establish a specific chain of command. This includes choosing a designated weather-watcher and specifying the method of warning the people at risk.
- Define and list safe structures and locations.
- Define the criteria for both suspension and resumption of activity.

Safe structures

- Large/substantial building (with electric and telephone wiring and plumbing to provide a safe pathway for the current to the ground).
- Fully enclosed metal vehicle (acts as a Faraday cage and guides the lightning current around the passengers).
- Buses are an excellent shelter and can be strategically placed around a venue to protect larger groups of people.

Unsafe locations and situations

- Open field.
- Close vicinity to the tallest structure in an area (eg, tree, communication tower, light pole).
- Small structures such as rain/picnic shelters, tents, interchange bench.
- Indoor and outdoor swimming pools.
- Use of indoor phones.
- Umbrellas, golf clubs, bats, or any other object that increases an individual's height.

The "30/30" rule

- A flash-to-bang count of 30 seconds indicates that lightning is 10 km away. This is associated with significant risk that the next strike could be at the observer's location. Thus, activity should be suspended and people moved to designated safe shelters.
- Wait 30 minutes after the last lightning or thunder before recommencing play.

monitoring the weather for signs of a developing thunderstorm. The nominated "weather watcher" should have the authority to postpone the event and have competitors, officials and spectators moved to safe areas. Appropriate people to nominate as weather watchers include the event supervisor, trainers or other medical personnel, or the ground manager.

When lightning threatens, the weather watcher is responsible for recognising the danger and activating the lightning protection plan. This should include a signal to the referees and umpires, as well as a method of informing those at risk (ie, players, officials and spectators) of the action required.

Safe structures and locations

No place is absolutely safe from the lightning threat; however, some places are safer than others (Box 1).^{1,12}

It is important to have already identified safe structures and the most appropriate way of moving people into these facilities. The best choice is a large, fully enclosed building.

Criteria for suspension and resumption of activities

The "30/30" rule is recommended for lightning safety and serves as a guide for the suspension and subsequent resumption of activity.^{7,13}

The first part of this rule (a flash-to-bang count of 30 s) is a guide to the *suspension* of activity. The flash-to-bang count is one of the most practical techniques for estimating the

distance to lightning activity. It is based on the fact that light travels faster than sound. Given that sound travels at a speed of about one kilometre every three seconds, the time that elapses between the flash of lightning and clap of thunder can be divided by three to give a measure of how far away the storm is in kilometres.^{8,14}

The overall message is to seek shelter when the lightning activity is too close, but how do we define what is meant by too close? Currently, most experts agree that the accepted "safe" distance is no less than 10 km.^{1,7-10,15} This means that as the flash-to-bang count approaches 30 seconds, all people at risk should be seeking or already inside safe shelters.

The second part of the 30/30 rule provides the criteria for *resumption* of play. Here it is recommended that people wait 30 minutes after the last sight of lightning or sound of thunder. This figure is based on the observation that a typical storm moves at about 40 km/h. Thus, waiting 30 minutes allows the thunderstorm to be about 20 km away, minimising the probability of a nearby strike. It is important to emphasise that blue skies and lack of rainfall are not adequate reasons to breach the 30-minute return-to-play rule.^{1,7,9}

Dissemination of Information

It is important that all participants, officials and spectators are warned of the potential dangers of lightning and how to minimise their risk of lightning-related injury. Practical ways in which this can be achieved include:

- reading lightning safety messages over the public address systems; and
- placing notices and safety instructions in event programs and in high-traffic areas at each venue (eg, entrance, change rooms, clubhouse).

The information should contain clear and specific instructions about:

- criteria for suspension and resumption of athletic and recreational activities; and
- locations of the safety shelters and the best way to access them, as well as suitable alternative shelters.

It is important to have a back-up plan in the case of power or equipment failure.

Crowd strategies

The first critical issue in crowd safety is that of safe shelters for large numbers of people. Ideally, crowds should be evacuated to safe areas before the storm is within 10 km of the venue (30-second flash-to-bang count). Given the practical constraints of moving large crowds, it is imperative that a formal assessment is made of existing structures (eg, grandstands, lightning gantries), as simple, cost-effective modifications can dramatically improve the protection offered to the crowd by these structures. Guidelines are provided by the Australian Standard on Lightning Protection.¹⁶

Spectators present in structures that are certified as lightning-safe can be advised to remain seated at times of increased lightning risk. Conversely, spectators present in

2: Three phases of lightning safety for the Sydney 2000 Olympic Games

Yellow: State of increased lightning awareness

- Intended to give 60 minutes advanced warning of a storm front reaching 10 km from a venue. (The direction and speed of travel of the storm front are taken into consideration, so that the anticipated time taken for the storm to reach 10 km from the venue is 60 minutes.)

Orange: Activation of the lightning protection plan

- Intended to give 30 minutes advanced warning of a storm front reaching 10 km from a venue. Depending on the venue's requirements, all competitors should be moved to protected areas.
- Patrons should be advised to remain in position if they are already in a safe area, or move to a protected area as shown on a map.
- Individuals in transit should be advised to complete their transit as soon as possible. People in cars and buses should be advised not to commence transit and to remain in their vehicles.

Red: State of increased lightning risk

- Declared when lightning activity is within 10 km of a venue.
- By this stage, all movements and evacuations should be complete, with the venue now secure from lightning.

(Adapted from Andrews and Mackerras, 2001, personal communication.)

unsafe areas or in structures that have had no formal assessment must be evacuated to safe shelters (Box 1).

The importance and size of the event are also critical in decisions regarding safety of spectators. When larger groups are involved, more time is required to properly secure the area. Thus, as time requirements change, the distance at which lightning is considered a threat must be increased. In their report to the Organising Committee for the Sydney Olympic Games, Andrews and Mackerras (personal communication) recommended three phases of lightning safety (Box 2). Their recommendations, which were based on use of the Bureau of Meteorology's Lightning Location System, should be implemented for major events where large crowds are expected.

Conclusion

The important components of any lightning safety policy include a proactive approach; vigilant monitoring of the local weather; a specific chain of command; a method of delivering the message to those at risk; definition of safe

structures; and definition of the criteria for both suspension and resumption of activity.

Large events require careful consideration of crowd numbers, length of time required to ensure protection for all present, and appropriate shelters. The more far-reaching the event and the more people involved, the more economical it may be to use formal lightning location systems in early-warning surveillance.

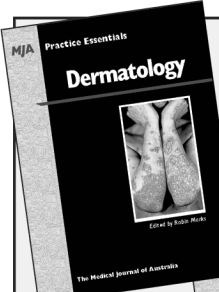
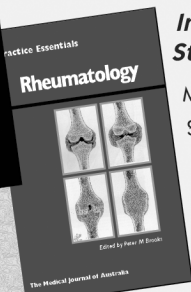
Acknowledgements

We are indebted to Chris Andrews and Mary Ann Cooper for their inspiration, guidance and generous provision of resources during the writing of this article. We would also like to thank Chris Andrews and David Mackerras for their lightning safety guidelines, Raymond Cripps (Research Centre for Injury Studies, Flinders University of South Australia) for recent information on lightning injuries in Australia, Phil Alford (Bureau of Meteorology, Australia) for his guidance, and the Centre for Sports Medicine Research and Education (University of Melbourne) for their support.

References

- Holle RL, Lopez RE, Zimmerman C. Updated recommendations for lightning safety — 1998. *Bull Am Meteor Soc* 1999; 80: 2035-2041.
- Cherington M. Lightning injuries. *Ann Emerg Med* 1995; 25: 516-519.
- Prentice SA. Lightning fatalities in Australia. *IEA Electrical Eng Trans* 1972; 8: 55-63.
- Coates L, Blong R, Siciliano F. Lightning fatalities in Australia, 1824-1991. *Natural Hazards* 1993; 8: 217-233.
- Cooper MA. Lightning injuries: prognostic signs for death. *Ann Emerg Med* 1980; 9: 134-138.
- Elsom DM. Surviving being struck by lightning: a preliminary assessment of the risk of lightning injuries and death in the British Isles. *J Meteorol* 1996; 21: 197-217.
- Cooper MA, Holle RL, Lopez RE. Recommendations for lightning safety [letter]. *JAMA* 1999; 282: 1132-1133.
- Holle RL, Lopez RE, Howard KW, et al. Safety in the presence of lightning. *Semin Neurol* 1995; 15: 375-380.
- Walsh KM, Bennett B, Cooper MA, et al. National Athletic Trainers' Association position statement: lightning safety for athletics and recreation. *J Athletic Training* 2000; 35: 471-477.
- Cherington M. Lightning injuries in sport: situations to avoid. *Sports Med* 2001; 31: 301-308.
- Cherington M, Breed DW, Yarnell PR, Smith WE. Lightning injuries during snowy conditions. *Br J Sports Med* 1998; 32: 333-335.
- Rakov VA. Lightning protection of structures and personal safety. International Lightning Detection Conference. 2000 Nov 7-8; Tucson, Arizona; 2000.
- Cooper MA, Andrews CJ, Holle RL, Lopez RE. Lightning injuries. In: Auerbach PS, editor. *Wilderness Medicine: Management of wilderness and environmental emergencies*. 4th ed. St Louis: Mosby, 2001; 73-110.
- Vavrek J, Holle RL, Allsopp J. Flash to bang. *Earth Scientist* 1993; 10: 3-8.
- Lopez RE, Holle RL. The distance between successive lightning flashes. Norman, Okla: National Severe Storms Laboratory; 1999.
- Standards Australia. *Lightning safety*. AS 1768-1991. Sydney: Standards Australia, 1991.

(Received 4 Jan, accepted 2 May 2002)

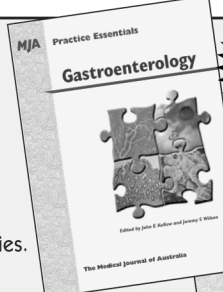
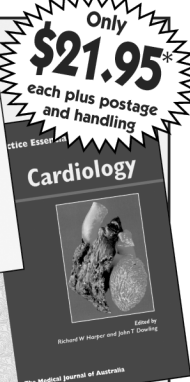



MJA Practice Essentials

Invaluable aids for General Practitioners, Medical Students and Graduates in Training.

MJA Practice Essentials are up-to-date and concise evidence-based guides to assist GPs in diagnosis and management. They provide practical approaches, reflecting current practice of leading authorities. These guides also provide an accessible and valuable educational resource for undergraduate or postgraduate healthcare programs.

To ORDER, or for further information, contact the Sales Coordinator: AMPCo
Ph 02 9562 6666 • Fax 02 9562 6662 • Email: sales@ampco.com.au

Only \$21.95

each plus postage and handling