

Sudden death in sport

Commotio cordis

P McCrory

Instantaneous cardiac arrest caused by a blow to the chest depends on the timing of the blow relative to the cardiac cycle

Sudden death following a sharp but seemingly inconsequential blow to the chest is a frightening occurrence known as "commotio cordis" or "concussion of the heart." Although commotio cordis is considered rare by some authors, it represents one of the most common mechanisms of sudden death in sport seen in young athletes.¹

Commotio cordis is generally understood to mean "instantaneous cardiac arrest produced by non-penetrating chest blows in the absence of heart disease or identifiable morphologic injury to the chest wall or heart".^{2,3} Most cases report accidental death of otherwise healthy children or adolescents after chest impact during recreational or competitive sport or, less commonly, during road traffic accidents.⁴⁻⁹

Such fatalities receive extensive media coverage, provoke legal debate, and may stimulate research into the public health aspects of this condition—for example, the capacity of protective gear to prevent commotio cordis or the possibility of developing safer sporting equipment.¹⁰

HISTORY

The current concept of commotio cordis is often ascribed to a review of 70 cases by Maron et al.² Their report portrays commotio cordis as a rare but dangerous condition in which there is usually a poor response to resuscitatory measures. Most of those affected were young (mean age 12 years), male (all but one), and, at the time of accident, engaged in sport (>90%). The event leading to sudden death was a precordial impact, most commonly by projectiles such as baseballs, softballs, or hockey pucks, probably occurring during an electrically vulnerable phase of the cardiac cycle.¹¹

Interestingly, the term commotio cordis was in use as early as 1857.^{12,13} A review from 1896 shows that the term was applied to various forms (both lethal and non-lethal) of cardiovascular disorder caused by mechanical impact to the chest (both in the presence and absence of minor cardiac bruising).¹⁴

Commotio cordis underwent a conceptual modification at the turn of the century whereby a distinction between non-penetrating precordial impact in the presence (contusion) or absence (commotion) of cardiac bruising was

established.¹⁵ In many ways, the concept of commotio cordis paralleled that of commotio cerebri (brain concussion) for which the issue of structural injury has been controversial since the early 1700s and terminological inexactitude has plagued the medical literature up to the present day.¹⁶

PATHOPHYSIOLOGY

The most comprehensive early experimental physiological studies of this condition were performed by Georg Schlomka at Bonn University in the early 1930s.¹⁷ On the basis of more than 800 experiments on anaesthetised animals, he identified three factors that determined the induction of arrhythmias by moderate precordial impact: type of impact, location of impact, and force of impact. Schlomka disproved the vagal reflex theory and proposed the "vascular crisis" concept of mechanically induced coronary vasospasms to explain commotio cordis.

The risk factors identified by Schlomka in the 1930s are still relevant, whereas the identification of a fourth factor (timing of impact) had to wait for technological advances. Contemporary experimental investigations into commotio cordis with anaesthetised pigs confirmed the existence of such a vulnerable period during early ventricular repolarisation and showed the involvement of ATP dependent potassium channels in the electrophysiological genesis of this condition.¹⁸⁻²⁰

When the precordial impacts were delivered within a narrow temporal window between 30 and 15 milliseconds before the peak of the T wave, ventricular fibrillation was reproducibly induced. The vulnerable period of the cardiac cycle amounted to just over 1/100th of a second. Remarkably, ventricular fibrillation was immediate, occurring on the very next heart beat. The arrhythmia was not produced by impacts at any other time during the cardiac cycle, although transient complete heart block was sometimes observed with impacts during the QRS complex. Occasionally, with impacts delivered just outside the 15 millisecond period of vulnerability, unstachyarrhythmia was seen.^{18,19}

The observation that transient rhythm disturbances may occur with chest impact raises the possibility that there may

be "near miss" cases of commotio cordis. This may have happened in 1998 to St Louis Blues hockey captain Chris Pronger, when he collapsed briefly, then spontaneously regained consciousness, after being struck on the left side of his chest by a puck during a playoff game.²¹ It is possible that other near miss cases have gone undetected because the arrhythmias were too brief to cause loss of consciousness.

In another part of their study, Link et al.¹⁸ examined whether the use of safety baseballs, which are softer than regulation balls, could reduce the risk of arrhythmia in the animal model. They found that the risk was proportional to the hardness of the ball. This finding may have implications for the prevention of commotio cordis in young baseball players, as properly designed safety baseballs are feasible for use in recreational baseball and Little League. Another approach to prevention is the use of chest protectors specifically designed to cushion the precordium. As not all cases will be preventable, it is important to emphasise that rapid cardiopulmonary resuscitation, including a precordial "thump" and immediate defibrillation when possible, may be lifesaving.

Both early and contemporary research into commotio cordis appears to have been motivated by case reports of sudden death. It is sobering that a seemingly minor chest impact at an instant when the heart is suspended in diastole can have such devastating consequences.

Br J Sports Med 2002;36:236-237

Author's affiliations

P McCrory, Centre for Sports Medicine Research and Education and the Brain Research Institute, University of Melbourne, Melbourne, Australia

Correspondence to: Dr McCrory, PO Box 93, Shoreham, Victoria 3916, Australia; pmccrory@compuserve.com

REFERENCES

- 1 McCrory P, Berkovic S, Corder S. Deaths due to brain injury among footballers in Victoria, from 1968 to 1998. *Med J Aust* 2000;172:217-20.
- 2 Maron BJ, Link MS, Wang PJ, et al. Clinical profile of commotio cordis: an under appreciated cause of sudden death in the young during sports and other activities. *J Cardiovasc Electrophysiol* 1999;10:114-20.
- 3 Curfman D. Fatal impact: concussion of the heart. *N Engl J Med* 1998;338:1841-3.
- 4 Frazer M, Mirchandani H. Commotio cordis, revisited. *Am J Forensic Med Pathol* 1984;5:249-51.
- 5 Kaplan JA, Karofsky PS, Volturo GA. Commotio cordis in two amateur ice hockey players despite the use of commercial chest protectors: case reports. *J Trauma* 1993;34:151-3.
- 6 Edlich RF, Jr, Mayer NE, Fariss BL, et al. Commotio cordis in a lacrosse goalie. *J Emerg Med* 1987;5:181-4.
- 7 Dikman G, Hassan A, Luckstead E. Ventricular fibrillation following baseball injury. *Physician and Sports Medicine* 1978;6:85-6.

- 8 Green E, Simpson L, Kellerman H, *et al.* Cardiac concussion following softball blow to the chest. *Ann Emerg Med* 1980;9:155–7.
- 9 Michalodimitrakis EN, Tsatsakis AM. Vehicular accidents and cardiac concussion. A traumatic connection. *Am J Forensic Med Pathol* 1997;18:282–4.
- 10 Froede RC, Lindsey D, Steinbronn K. Sudden unexpected death from cardiac concussion (commotio cordis) with unusual legal complications. *J Forensic Sci* 1979;24:752–6.
- 11 Maron BJ, Poliac LC, Kaplan JA, *et al.* Blunt impact to the chest leading to sudden death from cardiac arrest during sports activities. *N Engl J Med* 1995;333:337–42.
- 12 Casper J. *Practisches handbuch der gerichtlichen Medicin*. 1st ed. Berlin: Verlag von August Hirschwald, 1857.
- 13 Nesbitt AD, Cooper PJ, Kohl P. Rediscovering commotio cordis. *Lancet* 2001;357:1195–7.
- 14 Bernstein R. Über die durch Contusion und Erschütterung entstehenden Krankheiten des Herzens. *Z Klin Med* 1896;29:519–55.
- 15 Riedinger F, Kummel H. Die Verletzungen und Erkrankungen des Thorax und seines Inhaltes. In: von Bergman E, P vB, eds. *Handbuch der praktischen Chirurgie*. 2nd ed. Stuttgart: Enke, 1903:373–456.
- 16 McCrory P, Berkovic S. Concussion: historical development of clinical and pathophysiological concepts and misconceptions. *Neurology* 2001;57:2283–9.
- 17 Schlomka G. Commotio cordis und ihre Folgen. *Ergebn Inn Med Kinderheilkd* 1934;47:1–91.
- 18 Link MS, Wang PJ, Pandian NG, *et al.* An experimental model of sudden death due to low-energy chest-wall impact (commotio cordis). *N Engl J Med* 1998;338:1805–11.
- 19 Link MS, Wang PJ, VanderBrink BA, *et al.* Selective activation of the K(+) (ATP) channel is a mechanism by which sudden death is produced by low-energy chest-wall impact (Commotio cordis). *Circulation* 1999;100:413–18.
- 20 Cooper G, Pearce B, Stainer M, *et al.* The biomechanical response of the thorax to non-penetrating impact with particular reference to cardiac injuries. *J Trauma* 1982;22:994–1008.
- 21 Luecking D. Pronger relives a scary incident. *St Louis Post-Dispatch* 1998 May 12;sect C:1.

Revalidation

Revalidation in sport and exercise medicine

D A D Macleod, M E Batt, S Sheard

The proposed annual appraisal of practitioners of sport and exercise medicine is outlined

In 1999 the General Medical Council (GMC) of the United Kingdom agreed that “all doctors must be able to demonstrate regularly that they continue to be fit to practice in their chosen field”.¹ This process is termed revalidation. Doctors who complete revalidation will be granted a “licence to practice”, affording them the rights and privileges currently associated with being included on the general register of the GMC.

Each individual doctor's revalidation will be reviewed every five years by two doctors and a single lay person. This team will be drawn from a local revalidation pool of trained people. Revalidation will be based on the contents of the individual doctor's revalidation portfolio. Each doctor's portfolio, irrespective of their specialty, will follow a standardised format. The relevant guidelines describing appropriate standards of practice will be drawn up by the Medical Royal Colleges. This immediately creates a challenge for sport and exercise medicine which does not have a single parent Medical Royal College and is not widely recognised as a specialty, although a small number of doctors have already been placed on the GMC specialist register.

The Intercollegiate Academic Board of Sport and Exercise Medicine (IABSEM) is responsible to its parent Medical Royal Colleges and Faculties for setting standards in sport and exercise medicine and would seem to be the appropriate body to draw up relevant guidelines to meet revalidation standards.

Doctors who are already Members or Fellows of a Faculty or Medical Royal College recognised by the Academy of Medical Royal Colleges will be able to obtain revalidation with the support of their parent college. All doctors who practice sport and exercise medicine on either a part time or full time basis will have to meet all the GMC requirements. There are many doctors in the United Kingdom who are independent practitioners and currently practice sport and exercise medicine without being Members or Fellows of a Medical Royal College or Faculty. It will be particularly important for this group of sport and exercise medicine practitioners to ensure that they undergo annual appraisal and are in a secure position to meet the requirements of revalidation.

We here outline the contents of the revalidation portfolio recommended by the GMC. Establishing a portfolio and preparing for annual appraisal will become an increasingly important aspect of the professional lifestyle of all doctors.

The revalidation folder recommended by the GMC is divided into four sections.²

SECTION 1: YOUR PERSONAL AND REGISTRATION DETAILS

This section will record personal biographical and educational details, including your current GMC number.

SECTION 2: WHAT YOU DO

This section will describe what you do and where you do it. It must cover all aspects of your medical practice, paid or voluntary, including private practice, insurance and medicolegal work, teaching, research, administration, and management. This section should give a clear outline of your caseload and case-mix in all aspects of your clinical practice. It should include a job description and role profile where available.

SECTION 3: INFORMATION ON YOUR PRACTICE

This section will be based on the GMC publication *Good medical practice* and will require careful preparation and annual review to ensure its accuracy.³

The portfolio should show good professional standards of clinical care, record keeping—for example, contemporaneous, legible, and signed notes—and availability to patients including out of hours and when dealing with emergencies.

You will be expected to demonstrate that you are maintaining and developing good standards of clinical practice by undertaking audits and showing how the audits have influenced your practice. You will be expected to record adverse clinical events and how they were resolved. All complaints should also be documented and their outcome recorded.

Communication skills will be assessed by administration of patient surveys, the results of which will be incorporated in the portfolio. Sport and exercise medicine practitioners involved with a team

Section 3: Information on your practice

- Good professional practice
- Maintaining good clinical practice
- Relations with patients
- Working with colleagues
- Teaching and training
- Honesty
- Health

or group of athletes may find that surveys of the manager, coach, or sports participant for whom they are responsible will be expected.

You must record continuing professional development covering all aspects of your professional activities as outlined in Section 2 of your folder. The Academy of Medical Royal Colleges has issued a framework on this aspect of the portfolio.⁴

The Academy believes its framework will improve the safety and quality of medical practice by encouraging life long learning and making transparent the processes required for successful implementation of continuing professional development and audit.

The GMC places great emphasis on the ability of every doctor to work effectively in teams with colleagues, nurses, professions allied to medicine, clerical staff, and other professionals as well as lay people. This includes placing responsibility on colleagues to be aware of each other's standards of practice, conduct, or health if they may in any way be putting patients at risk.

Any doctor who teaches or trains junior medical staff, or other professionals, will be expected to show a commitment to developing educational standards and recording feedback on the teaching programmes in which they are involved.

Good medical practice also identifies honesty in clinical, research, and financial matters as being criteria against which revalidation will be measured. This includes honesty in writing reports and in the provision of references.

Finally this section of the revalidation portfolio requires the doctor to confirm that his or her own health, whether physical or psychological, is such that they are fit to practice in their chosen field(s).

SECTION 4: APPRAISAL

Mandatory annual appraisal of all aspects of every doctor's practice will be the basis of the revalidation process. The quality of the annual appraisal should highlight deficiencies or potential problems that may restrict or prevent revalidation, thereby giving the doctor concerned the opportunity to ensure that they are addressed before any subsequent appraisal.

Section 2 of the revalidation folder will outline all aspects of medical practice for which information must be recorded in Section 3.

The person to be appraised will be expected to ensure that their folder is accurate and up to date. The appraiser, who would normally be appointed by either a primary health care or employing hospital trust, would be expected to ensure that appropriate audits or surveys of the doctor's team working and communication skills have been completed.

The appraiser would be a doctor trained and experienced in this aspect of maintaining professional standards of practice. The appraisal interview will become a crucial component of every doctor's professional development and will be based on a 360° review of every aspect of a doctor's practice.⁵

At the end of the interview the doctor and his or her appraiser should record the outcome, highlighting any areas of concern that may interfere, in due course, with revalidation. Potential solutions for any problems should be outlined. Significant concerns identified by an appraiser should be forwarded to the relevant trust or other appropriate bodies.

CONCLUSION

All doctors involved in sport and exercise medicine on a full or part time basis need

Preparing for appraisal

- How good a doctor am I?
- How well do I perform?
- How up to date am I?
- How well do I work in a team?
- What resources and support do I need?
- How well am I meeting my service objectives?
- What are my development needs?

to establish a revalidation portfolio as outlined above and identify how their annual appraisal will take place.

Br J Sports Med 2002;36:237-238

Authors' affiliations

D A D Macleod, Intercollegiate Academic Board of Sport and Exercise Medicine, Edinburgh, Scotland, UK
M E Bait, Centre for Sports Medicine, University Hospital, Department of Orthopaedic and Accident Surgery, Queens Medical Centre, Nottingham NG7 2UG, UK
S Sheard, BMI Health Services, Greyfriars, 10 Queen Victoria Road, Coventry CV1 3PJ, UK

Correspondence to: Dr Macleod, Chairman of the Intercollegiate Academic Board of Sport and Exercise Medicine, Nicolson Street, Edinburgh EH8 9DW, Scotland, UK; y.gilbert@rcsed.ac.uk

REFERENCES

- 1 General Medical Council. *Revalidating doctors*. London: General Medical Council, 2000.
- 2 General Medical Council. *Pilot revalidation folder and piloting guidance*. London: General Medical Council, 2001.
- 3 General Medical Council. *Good medical practice*. 3rd ed. London: General Medical Council, 2000.
- 4 Academy of Medical Royal Colleges and their Faculties. *A Framework for Continuing Professional Development*. London: Academy of Medical Royal Colleges and their Faculties, 2001.
- 5 J King. 360° appraisal. *BMJ* 2002;324:s195.