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Statement

Summary and Agreement Statement of the 1st International Symposium on Concussion in Sport, Vienna 2001

Concussion in Sport (CIS) Group: *Mark Aubry, †Robert Cantu, ‡Jiri Dvorak, §Toni Graf-Baumann, ¶Karen M. Johnston (Chair), ‖James Kelly, **Mark Lovell, ††Paul McCrory, ‡‡Willem H. Meeuwisse, and §§Patrick Schamasch

**International Ice Hockey Federation, Zurich, Switzerland; †Neurosurgery Service & Sports Medicine Service, Emerson Hospital, Concord, Massachusetts, and National Center for Catastrophic Sports Injury Research, Chapel Hill, North Carolina, U.S.A.; ‡FIFA Medical Research and Assessment Center (F-MARC), and Schulthess Clinic, Zurich, Switzerland; §FIFA Medical Research and Assessment Center (F-MARC), Tenningen, Germany; ¶Division of Neurosurgery, McGill University Health Centre (MUHC), McGill University and McGill Sport Medicine Centre, Montreal, Canada; ‖Chicago Neurological Institute, Northwestern University Medical School, Chicago, Illinois; **Sports Medicine Concussion Program, University of Pittsburgh, and National Hockey League Neuropsychology Program, Pittsburgh, Pennsylvania, U.S.A.; ††Brain Research Institute and Center for Sports Medicine Research and Education, University of Melbourne, Melbourne, Australia; ‡‡University of Calgary Sport Medicine Center, and National Hockey League, Calgary, Alberta, Canada; and §§International Olympic Committee Medical Commission, Lausanne, Switzerland*

BACKGROUND

In November 2001, the 1st International Symposium on Concussion in Sport was held in Vienna, Austria. This symposium was organized by the International Ice Hockey Federation (IIHF), the Federation Internationale de Football Association Medical Assessment and Research Centre (FIFA, F-MARC), and the International Olympic Committee Medical Commission (IOC).

The aim of the symposium was to provide recommendations addressing this important topic for the improvement of safety and health of athletes who suffer concussive injuries in ice hockey, football (soccer), and other sports. To this end, a range of experts were invited to address specific issues of epidemiology, basic and clinical science, grading systems, cognitive assessment, new research methods, protective equipment, management, prevention, and long-term outcome, and to discuss a unitary model for understanding concussive injury. At the conclusion of the conference, a small group of experts were given a mandate by the conference delegates and organizing bodies to draft a document describing the agreement position reached by those in attendance at that meeting. For the purpose of this paper, this group will be called the Concussion in Sport (CIS) Group.

Address correspondence to Karen M. Johnston, MD, Phd, Division of Neurosurgery, Montreal General Hospital, 1650 Cedar Ave., Room L7-524, Montreal, Quebec, Canada H3G 1A4.

INTRODUCTION

This review seeks to summarize the findings of the Vienna conference and to provide a working document widely applicable in sport-related concussion. This document is developed for use by doctors, therapists, health professionals, coaches, and other people involved in the care of injured athletes, whether at the recreational, elite, or professional level.

During the course of the symposium, a persuasive argument was made that a comprehensive systematic approach to concussion injury would be of potential benefit to aid the injured athlete and direct management decisions.[1] This protocol represents a work in progress and, as with all other guidelines or proposals, it must undergo revision as new information is added to the current state of the literature and understanding of this injury.

The concussion in sport protocol includes:

1. Clinical history
2. Evaluation
3. Neuropsychological testing
4. Imaging procedures
5. Research methods
6. Management and rehabilitation
7. Prevention
8. Education
9. Future directions
10. Medico legal considerations

A REVISED DEFINITION OF CONCUSSION

Over 35 years ago, the Committee on head injury nomenclature of the Congress of Neurological Surgeons

proposed a "consensus" definition of concussion.[2] The American Medical Association and the International Neurotraumatology Association subsequently endorsed this definition.[3] This definition was recognized as having a number of limitations in accounting for the common symptoms of concussion. In addition, there was an inability to include relatively minor impact injuries that result in persistent physical and/or cognitive symptoms. Seeking to transcend these limitations, the CIS Group has developed the following definition of concussion.

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathological, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include:

1. *Concussion may be caused either by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head.*
2. *Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously.*
3. *Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury.*
4. *Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course.*
5. *Concussion is typically associated with grossly normal structural neuroimaging studies.*

THE CIS GROUP CONCUSSION PROTOCOL

1. Clinical History

Recognizing the importance of a detailed concussion history, and appreciating the fact that many athletes will not recognize all the concussions they may have suffered in the past, a detailed concussion history is of value. The athlete currently at a high performance level in collision sport has seldom had the first concussion on presentation in the consultant's office. The history should include specific questions as to previous symptoms of a concussion not just perceived number of past concussions.[4] It also is worth noting that dependence on the recall of concussive injuries by teammates or coaches has been demonstrated to be unreliable.[5] The finding that there is increased risk of subsequent concussive injuries after a first concussion is documented, although the reasons for this remain controversial. The clinical history also should include information about all previous head, face, or neck injuries, as these may have clinical relevance to the present injury. It is worth emphasizing that, in the setting of faciomaxillary injuries, coexistent concussive injuries may be missed unless specifically assessed.

Specific questions pertaining to disproportionate impact and symptom severity matching may allude to progressively increasing vulnerability to injury (i.e., more pronounced persistent symptoms from smaller hits). The pathophysiological nature of this phenomenon remains unclear.

One of the issues that was speculated upon at the conference was whether concussion represents a unitary phenomenon with a linear spectrum of injury severity or whether different concussion subtypes exist. These subtypes may represent differences in clinical manifestations (confusion, memory problems, loss of consciousness), anatomical localization (e.g., cerebral vs. brainstem), biomechanical impact (rotational vs. linear force), genetic phenotype (Apolipoprotein epsilon-4 [ApoE4] positive vs. ApoE4 negative), neuropathological change (structural injury vs. no structural injury), or an as-yet undefined difference. These factors may operate independently or interact with each other. It is clear that the variations in clinical outcome with the same impact force require a more sophisticated approach to the understanding of this phenomenon than currently available.[6]

The traditional approach to severe traumatic brain injury utilizing loss of consciousness (LOC) as the primary measure of injury severity has acknowledged limitations in assessing the severity of concussive injury. Findings in this field describe LOC association with specific early deficits but does not necessarily imply severity. Further work in this area may help to explain these findings.[7]

There is renewed interest in the role of amnesia (anterograde/retrograde) and its manifestation of injury severity.[8] Published evidence suggests that the nature, burden, and duration of the clinical postconcussive symptoms may be more important than previously recognized.[9–11]

Concussion Grading Scales

The CIS Group recognized the strengths and weaknesses of several existing concussion grading scales that attempt to characterize injury severity, but no single system was endorsed. It was the recommendation of the Group that combined measures of recovery (see below) should be used to assess injury severity (and/or prognosis) and hence individually guide return-to-play decisions.

In the absence of scientifically validated return-to-play guidelines, a clinical construct is recommended using an assessment of injury recovery and graded return to play. The protocol outlined below is adapted from the Canadian Academy of Sport Medicine (CASM) guidelines.[12] Sideline evaluation includes clinical evaluation of signs and symptoms, ideally using a standardized postconcussion symptom scale (see Appendix) for comparison purposes, and acute injury testing as described below under neuropsychological testing.

2. Evaluation

Sideline evaluation including neurological assessment and mental status testing is an essential component in the protocol. These evaluations ideally are developed in language translations for international sporting groups (an example of such a sideline evaluation developed at McGill University is available in English and French [for copy contact author K.M.J.]). In the acute assessment of concussive injury (e.g., concussion diagnosis), brief

neuropsychological test batteries that assess attention and memory function have been shown to be practical and effective. Such tests include the Maddock's questions[13] and the Standardized Assessment of Concussion (SAC).[14] It is worth noting that standard orientation questions (e.g., time, place, person) have been shown to be unreliable in the sporting situation when compared with memory assessment.[13,15]

It is recognized, however, that abbreviated testing paradigms are designed for rapid concussion evaluation on the sidelines and are not meant to replace comprehensive neuropsychological testing that is sensitive in detecting subtle deficits that may exist beyond the acute episode.

Signs and Symptoms of Acute Concussion

If any one of the following symptoms or problems is present, a head injury should be *suspected* and appropriate management instituted. A player does not need to have lost consciousness to suffer a concussion.

a) Cognitive features
   Unaware of period, opposition, score of game
   Confusion
   Amnesia
   Loss of consciousness
   Unaware of time, date, place
b) Typical Symptoms
   Headache
   Dizziness
   Nausea
   Unsteadiness/loss of balance
   Feeling "dinged" or stunned or "dazed"
   "Having my bell rung"
   Seeing stars or flashing lights
   Ringing in the ears
   Double vision

Other symptoms such as sleepiness, sleep disturbance, and a subjective feeling of slowness and fatigue in the setting of an impact may indicate that a concussion has occurred or has not resolved.

c) Physical signs
   Loss of consciousness/impaired conscious state
   Poor coordination or balance
   Concussive convulsion/impact seizure
   Gait unsteadiness/loss of balance
   Slow to answer questions or follow directions
   Easily distracted, poor concentration
   Displaying unusual or inappropriate emotions (e.g. laughing, crying)
   Nausea/vomiting
   Vacant stare/glassy eyed
   Slurred speech
   Personality changes
   Inappropriate playing behavior (e.g., running in the wrong direction)
   Significantly decreased playing ability

3. Neuropsychological Assessment Postconcussion

The application of neuropsychological testing in concussion has been shown to be of value and continues to contribute significant information in concussion evaluation.[16] It has been demonstrated that cognitive recovery may precede or follow clinical symptom resolution suggesting that the assessment of cognitive function should be an important component in any return-to-play protocol.

In the consideration of injury recovery or return to play, such test strategies must assess the cognitive domains of information processing, planning, memory, and switching mental set. Numerous paradigms are in current use. Examples of these include paper and pencil tests (McGill ACE, SAC), condensed batteries (McGill ACE), comprehensive protocols administered by neuropsychologists (NHL, Australian football), and computerized test platforms (e.g., IMPACT, CogSport, ANAM, Headminders).[17]

Overriding principles common to all neuropsychological test batteries is the need for and benefit of baseline preinjury testing and serial follow-up. Recent work with computerized platforms, however, suggests that performance variability may be a key measure for acute concussion diagnosis even in the absence of a baseline test. This strategy is currently the subject of ongoing research. Inherent problems with most neuropsychological tests include the normal ranges, sensitivity and specificity of tests, and practice or learning effect, as well as the observation that players may return to baseline while still symptomatic.[16,18] In part, these may be a problem of the currently available pen and paper tests. Computerized testing using infinitely variable test paradigms may overcome these concerns. Computerized testing also has the logistical advantage that the tests may be administered by the team physician or be web based rather than require the need to source a neuropsychologist for a formal assessment. The strengths and weaknesses of such testing have been recently reviewed.[17]

The consensus of the CIS Group was that neuropsychological testing is one of the cornerstones of concussion evaluation and contributes significantly to both understanding of the injury and management of the individual. Organized sport federations have access to and should attempt to employ such testing as appropriate. To maximize the clinical utility of such neuropsychological assessment, baseline testing is recommended.

4. Neuroimaging

It was recognized by the CIS Group that conventional structural neuroimaging is usually normal in concussive injury. Given that caveat, the following suggestions are made. Brain computerized tomography (or where available, magnetic resonance imaging [MRI] of the brain) contributes little to concussion evaluation but should be employed whenever suspicion of a structural lesion exists. Examples of such situations may include prolonged disturbance of conscious state, focal neurological deficit, seizure activity, or persistent clinical or cognitive symptoms.

Newer structural MRI modalities including gradient echo, perfusion, and diffusion-weighted imaging have greater sensitivity for structural abnormalities; however,

the lack of published studies as well as absent preinjury neuroimaging data limit the usefulness of this approach in clinical studies at the present time. In addition, the predictive value of various MR abnormalities that may be incidentally discovered is not established at the present time. Promising new functional imaging (e.g., PET [positron emission tomography]/SPECT [single photon emission computed tomography]/fMRI [functional MRI]) technologies, while demonstrating some compelling findings, are still at early stages of development.[19]

Although neuroimaging may play a part in postconcussive return-to-play decisions or for the assessment of moderate-to-severe brain injury, it is not essential for otherwise uncomplicated concussive injury.

5. Research Methods

A number of research protocols and data evaluating concussion injury assessment, injury susceptibility, and brain function postinjury were presented at the Vienna conference. All of these techniques, while offering great potential for injury assessment, must be considered experimental at this time. As much as possible, elite and professional teams are well placed to contribute to these efforts through athlete recruitment for studies demonstrating the scientific value of such approaches.

Electrophysiological recording (ERP [event-related potential], EEG [electroencephalogram]) demonstrated reproducible abnormalities in the postconcussive state in brain function.[18] Similarly, balance testing demonstrated postinjury impairment, although the mechanism for this is not established. Biochemical serum markers of brain injury (including S-100b, NSE [neuron-specific enolase], MBP [myelin basic protein]) were proposed as means by which cellular damage may be detected if present.

Genetic phenotyping has been demonstrated to be of benefit in traumatic brain injury. Published studies have demonstrated that ApoE4 is a risk factor for adverse outcome following moderate-to-severe brain injury.[20] Similarly ApoE4 has been shown to be a risk factor for the development of chronic traumatic encephalopathy in boxers.[21] The significance of ApoE4 in concussion risk or injury outcome is unclear. Other published studies have noted the association of a particular calcium subunit gene abnormality with brain swelling following minor head trauma.[22]

Such research is vital in contributing to the science of concussion and will potentially provide valuable information for such important issues as clinical management, return-to-play guidelines, and long-term outcome. Therefore research should be continued and encouraged by sporting organizations.

6. Management and Rehabilitation

i) Acute response

When a player shows ANY symptoms or signs of a concussion:

1. The player should not be allowed to return to play in the current game or practice.
2. The player should not be left alone; regular monitoring for deterioration is essential.
3. The player should be medically evaluated following the injury.
4. Return to play must follow a medically supervised stepwise process.

A player should never return to play while symptomatic. "When in doubt, sit them out!"

ii) Rehabilitation

It was the consensus of the CIS Group that a structured and supervised concussion rehabilitation protocol is conducive to optimal injury recovery and safe and successful return to play. The rehabilitation principles were common to all identified programs and are outlined below. Important principles state that the athlete be completely asymptomatic and have normal neurological and cognitive evaluations prior to the start of the rehabilitation program. Therefore the more prolonged the symptom duration, the longer the athlete will have sat out. The athlete will then proceed stepwise with gradual incremental increases in exercise duration and intensity, and pause or backtrack with any recurrence of concussive symptoms. It is appreciated that, although each step may take a minimum of 1 day, depending on the duration of symptoms, proceeding through each step may take longer in individual circumstances.

iii) Return-to-Play Protocol

The return to play following a concussion follows a stepwise process:

1. No activity, complete rest; once asymptomatic, proceed to level 2
2. Light aerobic exercise such as walking or stationary cycling.
3. Sport-specific training (e.g., skating in hockey, running in soccer)
4. Noncontact training drills
5. Full-contact training after medical clearance
6. Game play

With this stepwise progression, the athlete should continue to proceed to the next level if asymptomatic at the current level. If any postconcussion symptoms occur, the patient should drop back to the previous asymptomatic level and try to progress again after 24 hours.

7. Prevention

As part of the clinical history, it is advised that details regarding protective equipment used at time of injury be sought, both for recent and remote injuries. The benefit of this approach allows for modification and optimization of protective behavior and an opportunity for education. That said, there are relatively few methods by which concussive brain injury may be minimized in sport. The brain is not an organ that can be conditioned to withstand injury. Thus, extrinsic mechanisms of injury prevention must be sought.

Helmets have been proposed as a means of protecting the head and theoretically reducing the risk of brain injury. In sports with high speed collisions or that have the potential for missile injuries (e.g., baseball) or falls onto hard surfaces (e.g., gridiron, ice hockey), there is pub-

lished evidence for the effectiveness of sport-specific helmets to be of benefit in reducing head injuries.[3] For other sports such as soccer and rugby, no sport-specific helmets have been shown to be of proven benefit in reducing rates of head injury.[23] Some believe that the use of protective equipment may alter playing behavior deleteriously so that the athlete actually increases his or her risk of brain injury.[24]

Although the use of correctly fitting mouth guards can reduce the rate of dental orofacial and mandibular injuries, the evidence that they reduce cerebral injuries is largely theoretical, and clinical evidence for a beneficial effect in reducing concussion rates has not yet been demonstrated scientifically.[25]

Consideration of rule changes (i.e., no head-checking in ice hockey) to reduce the head injury rate may be appropriate where a clear-cut mechanism is implicated in a particular sport. Similarly, rule enforcement is a critical aspect of such approaches, and referees play an important role.

Neck muscle conditioning may be of value in reducing impact forces transmitted to the brain. Biomechanical concepts dictate that the energy from an impacting object is dispersed over the greater mass of an athlete if the head is held rigidly. Although attractive from a theoretical standpoint, there is little scientific evidence to demonstrate the effectiveness of such measures.

Rule changes and rule enforcement play a key role in reducing and preventing concussions.

8. Education

As the ability to treat or reduce the effects of concussive injury after the event is minimal, education of athletes, colleagues, and those working with them, as well as the general public, is a mainstay of progress in this field. Athletes and their health care providers must be educated regarding the detection of concussion, its clinical features, assessment techniques, and principles of safe return to play. Methods to improve education including various web-based resources (for example: www.concussionsafety.com), educational videos, outreach programs, concussion working groups, and the support and endorsement of enlightened sport groups, such as FIFA, IOC, and IIHF, who initiated this endeavor have enormous value and must be pursued vigorously.

The promotion of fair play and respect for opponents are ethical values that should be encouraged in all sports and sporting associations. Similarly coaches, parents, and managers play an important part in ensuring these values are implemented on the field of play.

9. Future

Efforts to evaluate long-term outcome and any association with repeated concussion, molecular markers, imaging, and functional deficits must guide ongoing investigation in this work. Efforts to expand knowledge of injury that may or may not be associated with particular maneuvers inherent to the game (e.g., heading in soccer) must be elucidated.

A proposal was made that this concussion working group be identified and given a mandate to provide ongoing leadership in the continued development and updating of guidelines and maintenance of pursuit of standard of care in concussion.

10. Medical Legal Considerations

While agreement exists pertaining to principal messages conveyed within this document, the authors acknowledge that the science of concussion is at the early stages and therefore management and return-to-play decisions remain largely in the realm of clinical judgement on an individualized basis. It is the intention of the Group to analyze the medico legal aspect of concussions in sports and to offer here a summary of the state of the art and direct future efforts.

Acknowledgment: The Vienna CIS Group thanks the other participants of the symposium for their input and enthusiasm, which generated discussion of these ideas. We also thank Darlene Scheurich whose expert organizational abilities contributed to the success of this symposium.

APPENDIX

(Adapted from Lovell and Collins, *Journal of Head Trauma and Rehabilitation* 1998;13:9–26.)

Postconcussion Symptoms Scale

	Rating						
	None			Moderate		Severe	
Headache	0	1	3	3	4	5	6
Nausea	0	1	2	3	4	5	6
Vomiting	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Numbness or tingling	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sleeping more than usual	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling as if "in a fog"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional than usual	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervousness	0	1	2	3	4	5	6
Other	0	1	2	3	4	5	6

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