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STATEMENT

Summary and Agreement Statement of the 2nd International Conference on Concussion in Sport, Prague 2004

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Preamble

This paper is a revision and update of the Vienna consensus recommendations developed following the 1st International Symposium on Concussion in Sport.[1] The Prague agreement statement is designed to build on the principles outlined in the original Vienna document and to develop further conceptual understanding of this problem. 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.

Background Perspective

In November 2001, the 1st International Symposium on Concussion in Sport was held in Vienna, Austria. This meeting was organized by the International Ice Hockey Federation (IIHF) in partnership with the Federation Internationale de Football (FIFA) and the International Olympic Committee Medical Commission (IOC). As part of the resulting mandate for the future, the need for leadership and updates was identified. To meet that mandate the 2nd International Symposium on Concussion in Sport was organized by the same group and held in Prague, Czech Republic in November 2004.

The original aims of the symposia were to provide recommendations for the improvement of safety and health of athletes who suffer concussive injuries in ice hockey, football (soccer) as well as other sports. To this end a range of experts were invited to both meetings to address specific issues of epidemiology, basic and clinical science, injury grading systems, cognitive assessment, new research methods, protective equipment, management, prevention and long term outcome. At the conclusion of the initial 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. That document was co-published in the British Journal of Sports Medicine, Clinical Journal of Sport Medicine and Physician and Sportsmedicine.[1]

The wider interest base resulting from the first meeting and document was reflected by the expanded representation. New groups at the second meeting included trauma surgeons, sport psychologists and others. This same group has produced the current document as an update of the original Vienna consensus document and includes a sideline assessment form with a pocket sized summary card for use by clinicians.

This protocol represents a work in progress and, as with all other recommendations or proposals, it must be updated as new information is added to the current state of the literature and understanding of this injury.

BACKGROUND ISSUES

Definition of Concussion

Over 35 years ago, the Committee on head injury nomenclature of the Congress of Neurologic Surgeons proposed a 'consensus' definition of concussion.[2,3] This definition was recognized as having a number of limitations in accounting for the common symptoms of concussion. In the Vienna document, a revised consensus definition was proposed as follows:

Sports concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic

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biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilised 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 neurologic 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.

No changes were made to the definition by the Prague Group beyond noting that in some cases post-concussive symptoms may be prolonged or persistent.

Pathophysiological Basis of Concussion

At this time, there is no existing animal or other experimental model that accurately reflects a sporting concussive injury. It is noted that in experimental models of more severe injury a complex cascade of biochemical, metabolic and gene expression changes occur.[4] Whether similar metabolic changes occur in sports concussion however, remains speculative at this time.[5]

Concussion Grading Scales

The Vienna recommendation that injury grading scales be abandoned in favor of combined measures of recovery to determine injury severity (and/or prognosis) and hence individually guide return to play decisions received continued support.

It was also noted that concussion severity could only be determined in retrospect after all concussion symptoms have cleared, the neurologic examination is normal, and cognitive function has returned to baseline.[6] There is limited published evidence that concussion injury severity correlates with the number and duration of acute concussion signs and symptoms and/or degree of impairment on neuropsychological testing.[7–12] The ongoing development of validated injury severity scales continues in the published literature.[13]

Subtypes of Concussion

One of the issues that was speculated upon at the Vienna conference was whether concussion represents a unitary phenomenon with a linear spectrum of injury severity or whether different concussion sub-types exist. These sub-types may represent differences in clinical manifestations (confusion, memory problems, loss of consciousness), anatomic localization (eg, cerebral versus brainstem), biomechanical impact (rotational versus linear force), genetic phenotype (ApoE4 positive versus ApoE4 negative), neuropathological change (structural injury versus 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.[14]

The Significance of Loss of Consciousness

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 sporting concussive injury. Findings in this field describe LOC association with specific early deficits but does not necessarily imply severity.[13,15] As such the presence of LOC as a symptom would not necessarily classify the concussion as complex (see below).

The Significance of Amnesia

There is renewed interest in the role of post-traumatic amnesia and its role as a surrogate measure of injury severity.[13,16] Published evidence suggests that the nature, burden and duration of the clinical post-concussive symptoms may be more important than the presence or duration of amnesia alone.[8,15,17] Further it must be noted that retrograde amnesia varies with the time of measurement post-injury and hence is poorly reflective of injury severity.[18,19]

Pediatric Concussive Injury

The general recommendations outlined in the Vienna document were originally designed for the management of adult sporting concussion. Agreement was reached however, that identified those recommendations as relevant and useful to management of children as well. In broad terms it was felt that the recommendations should be applicable to children (defined as 5–18 years of age) whereby children should not be returned to playing or training until clinically completely symptom free. In addition the concept of "cognitive rest" was introduced with special reference to a child's need to limit exertion with activities of daily living and to limit scholastic activities while symptomatic. There was also a recognition by the group that additional research is needed to better clarify the potential differences between adults and children with regard to recovery from injury and to develop cognitive assessment tools that better evaluate the younger athlete.

Formal cognitive assessment is currently problematic until late teen years due to the ongoing cognitive maturation that occurs during this period which, in turn, makes the utility of comparison to either the person's own baseline performance or to population norms limited.[20]

Because of the different physiological response during childhood to head trauma a conservative return to play approach is recommended. It may be appropriate to extend the amount of time of asymptomatic rest and/or the length of the graded exertion in children and adolescents. Future research is needed in this area.

A NEW CLASSIFICATION OF CONCUSSION IN SPORT

Historically, concussions have been classified with a number of different grading systems. In the Vienna Statement,

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this approach was abandoned. One of the key developments by the Prague Group is the understanding that concussion may be categorized for management purposes as either simple or complex.

Simple Concussion

In simple concussion, an athlete suffers an injury that progressively resolves without complication over 7–10 days. In such cases, apart from limiting playing or training while symptomatic, no further intervention is required during the period of recovery and the athlete typically resumes sport without further problem. Formal neuropsychological screening does not play a role in these circumstances although mental status screening should be a part of the assessment of all concussed athletes. Simple concussion represents the most common form of this injury and can be appropriately managed by primary care physicians or by certified athletic trainers working under medical supervision.[21] The cornerstone of management is rest until all symptoms resolve and then a graded program of exertion before return to sport. All concussions mandate evaluation by a medical doctor.

Complex Concussion

Complex concussion encompasses cases where athletes suffer persistent symptoms (including persistent symptom recurrence with exertion), specific sequelae (eg, concussive convulsions, prolonged loss of consciousness (>1 minute) or prolonged cognitive impairment following the injury. This group may also include athletes who suffer multiple concussions over time or where repeated concussions occur with progressively less impact force. In this group, there may be additional management considerations beyond simple return to play advice. Formal neuropsychological testing and other investigations should be considered in complex concussions. It is envisaged that such athletes would be managed in a multidisciplinary manner by physicians with specific expertise in the management of concussive injury such as a sport medicine doctor with experience in concussion, sports neurologist or neurosurgeon.

CLINICAL ISSUES

Pre-participation Physical Examination

Recognizing the importance of 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.[22–25] Such a history may preidentify athletes that fit into the "complex" category outlined above and provides an opportunity for the physician to educate the athlete in regard to the significance of concussive injury.

A structured concussion history should include specific questions as to previous symptoms of a concussion not just perceived number of past concussions. It is also worth noting that dependence upon the recall of concussive injuries by teammates or coaches has been demonstrated to be unreliable.[22] The clinical history should also 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 maxillofacial injuries and neck, coexistent concussive injuries may be missed unless specifically assessed. Specific questions pertaining to disproportionate impact versus symptom severity matching may alert the clinician to a progressively increasing vulnerability to injury.

As part of the clinical history it is advised that details regarding protective equipment employed 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.

It is specifically recommended that:

1. Both a baseline cognitive assessment (such as the Prague SCAT test in the absence of computerized neuropsychological testing) and symptom score is performed as part of the preparticipation evaluation.
2. Although formal baseline neuropsychological screening may be beyond the resources of many sports or individuals, it is recommended that in organized high risk sports consideration be given to having cognitive evaluation regardless of the age or level of performance.

Signs and Symptoms of Acute Concussion

The suspected diagnosis of sports concussion made on the sideline is applicable to both medical and non-medical personnel and can include clinical symptoms, physical signs, cognitive impairment and/or loss of consciousness.

If any one of the following symptoms or problems is present, a head injury should be suspected and appropriate management instituted. These will be summarized on the Sideline Concussion Assessment Tool (SCAT) that accompanies this document.

a) Cognitive Features

Unaware of period, opposition, score of game
Confusion
Amnesia
Loss of consciousness

b) Typical Symptoms (see SCAT for standard symptom scale)

Headache or pressure in the head
Balance problems or dizziness
Nausea
Feeling "dinged", "foggy", stunned or "dazed"
Visual problems (eg, Seeing stars or flashing lights, double vision)
Hearing problems (eg, ringing in the ears)
Irritability or emotional changes

Other symptoms such as a subjective feeling of slowness and fatigue in the setting of an impact may indicate that a concussion has occurred or has not fully resolved.[26]

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 inappropriate emotions (eg, laughing, crying)
Vomiting
Vacant stare/glassy eyed
Slurred speech
Personality changes
Inappropriate playing behavior (eg, running the wrong direction)
Significantly decreased playing ability

Sideline evaluation of cognitive function is an essential component in the assessment of this injury. Brief neuropsychological test batteries that assess attention and memory function have been shown to be practical and effective. Such tests include the Maddocks questions[27] and the Standardised Assessment of Concussion (SAC).[28] It is worth noting that standard orientation questions (eg, time, place, person) have been shown to be unreliable in the sporting situation when compared with memory assessment.[27,29]

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 which is sensitive to detect subtle deficits that may exist beyond the acute episode; nor should they be used as a stand alone tool for the ongoing management of sports concussions. It should also be recognized that the appearance of symptoms may be delayed several hours following a concussive episode.

Convulsive and Motor Phenomena

A variety of acute motor phenomena (eg, tonic posturing) or convulsive movements may accompany a concussion.[30,31] Although dramatic, these clinical features are generally benign and require no specific management beyond the standard treatment of the underlying concussive injury.

Development of the Sport Concussion Assessment Tool (SCAT)

In appendix 1, the SCAT is outlined. The intent was to create a standardized tool that could be used for patient education as well as for physician assessment of sports concussion. The SCAT was developed by combining the following existing tools into a new standardized tool:

1. Sideline Evaluation for Concussion-Colorado Head Injury Foundation, Inc [Society, 1990 (revised May 1991) #6693]
2. Management of Concussion Sports Palm Card-American Academy of Neurology & Brain Injury Association.[32]
3. Standardized Assessment of Concussion-SAC[33]
4. Sideline Concussion Check-UPMC, Thinksafe, Sports Medicine New Zealand Inc and the Brain Injury Association
5. McGill Abbreviated Concussion Evaluation (ACE) (unpublished)
6. National Hockey League Physician Evaluation Form (unpublished)
7. The UK Jockey Club Assessment of Concussion[34]
8. Maddocks questions[27]

The authors gave input through a process of collaboration and iterative review. The SCAT was evaluated for face and content validity on the basis of scientific literature[35] and clinical experience of the authors. The memory questions, specifically, were modified from the validated Maddocks questions to make these questions less football-specific.[27]

INVESTIGATIONAL ISSUES

Neuropsychological Assessment Post Concussion

The application of neuropsychological testing in concussion has been shown to be of value and continues to contribute significant information in concussion evaluation.[10,11,36,37] 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.[12] It must be emphasized however, that neuropsychological assessment should not be the sole basis of a return to play decision but rather be seen as an aid to the clinical decision making. Although neuropsychological screening may be performed or interpreted by other health care professionals, the final return to play decision should remain a medical one in which a multidisciplinary approach has been taken.

Neuropsychological testing should not be done while the athlete is symptomatic since it adds nothing to return-to-play decisions and it may contaminate the testing process by allowing for practice effects to confound the results. In certain cases however, serial post-injury follow up is valuable both as a means to encourage athlete compliance as well as for comparison purposes.

Overriding principles common to all neuropsychological test batteries is the need for and benefit of baseline pre-injury 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.[36] Computerized testing utilizing infinitely variable test paradigms may overcome some of 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 requiring a neuropsychologist for a formal assessment. The strengths and weaknesses of such testing have been recently reviewed.[37]

It is recommended that neuropsychological testing remain one of the cornerstones of concussion evaluation in complex concussion. It is not currently regarded as important in the evaluation of simple concussion. While this modality contributes significantly to both understanding of the injury and management of the individual, neuropsychological testing should not be the sole basis of management decisions, either for continued time out or return to play decisions.

Objective Balance Assessment

Balance testing, either with computerized platforms or clinical assessment, may offer additional information in

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concussed athletes and may be used as a part of the overall concussion management strategy, particularly where symptoms or signs indicate a balance component.[38]

Neuroimaging

It was recognized in he Vienna agreement document that conventional structural neuroimaging is usually normal in concussive injury. Given that caveat, the following suggestions are made: Brain CT (or where available MR brain scan) contributes little to concussion evaluation but should be employed whenever suspicion of an intra-cerebral structural lesion exists. Examples of such situations may include prolonged disturbance of conscious state, focal neurologic deficit or worsening 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 pre-injury neuroimaging data limits the usefulness of this approach in clinical management 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 (eg, PET/SPECT/fMRI) technologies, while demonstrating some compelling findings, are still at early stages of development.[39–41]

Although neuroimaging may play a part in the assessment of complex sports concussions or more severe brain injury, it is not essential for simple concussive injury.

Genetic Testing

Genetic genotyping 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 all levels of brain injury.[42–48] Similarly ApoE4 has been shown to be a risk factor for the development of chronic traumatic encephalopathy on boxers.[49] The significance of ApoE4 in sports 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.[50] Although still in the early stages of understanding, routine genetic screening cannot be recommended at the present time and furthermore physicians are urged to be mindful of the ethical implications of such testing.

Experimental Concussion Assessment Modalities

Different electrophysiological recording techniques such as. evoked response potential (ERP) and electroencephalogram (EEG) have demonstrated reproducible abnormalities in the post concussive state.[51–53] However; not all studies reliably differentiated concussed athletes from controls.[54–57] The clinical significance of these changes remains to be established.

In addition, biochemical serum markers of brain injury (including S-100b, NSE, MBP, GFAP) have been proposed as means by which cellular damage may be detected if present.[58,59] However, there is currently not sufficient evidence to justify the use of these markers clinically.

CONCUSSION MANAGEMENT

Acute Injury

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; and regular monitoring for deterioration is essential over the initial few hours following injury.
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!"

Return to Play Protocol

As described above, the majority of injuries will be simple concussions and such injuries recover spontaneously over several days. In these situations, it is expected that an athlete will proceed rapidly through the stepwise return to play strategy.[60]

During this period of recovery in the first few days following an injury, it is important to emphasise to the athlete that physical AND cognitive rest is required. Activities that require concentration and attention may exacerbate the symptoms and as a result delay recovery.

The return to play following a concussion follows a step wise process:

1. No activity, complete rest. Once asymptomatic, proceed to level.[2]
2. Light aerobic exercise such as walking or stationary cycling, no resistance training.
3. Sport specific exercise (eg, skating in hockey, running in soccer), progressive addition of resistance training at steps 3 or 4.
4. Non-contact 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 post concussion symptoms occur, the patient should drop back to the previous asymptomatic level and try to progress again after 24 hours.

In cases of complex concussion, the rehabilitation will be more prolonged and return to play advice will be more circumspect. It is envisaged that complex cases should be managed by physicians with a specific expertise in the management of such injuries.

An additional consideration in return to play is that concussed athletes should not only be symptom free but also should not be taking any pharmacological agents/medications that may effect or modify the symptoms of concussion. Where antidepressant therapy may be commenced during the

management of a complex concussion, the decision to return to play while still on such medication must be considered carefully by the clinician concerned (see below).

In professional sport, where there are team physicians experienced in concussion management as well as access to immediate (ie, sideline) neuro-cognitive assessment, return to play management is often more rapid however must still follow the same basic principles; namely full clinical and cognitive recovery before consideration of return to play.

The Role of Pharmacological Therapy

Pharmacological therapy in sports concussion may be applied in two distinct situations. The first of these is the management of specific symptoms (eg, sleep disturbance, anxiety) in complex concussion and the second situation is where drug therapy is used to modify the underlying pathophysiology of the condition with the aim of shortening the duration of the concussion symptoms.[61]

In broad terms, this approach to management should be only considered in complex sports concussions and by clinicians experienced in concussion management.

Sports Psychology

In addition sport psychology approaches may have potential application in this injury, particularly in complex concussion.[62] Care givers are also encouraged to evaluate the concussed athlete for affective symptoms such as depression as these may be common in concussion.[60]

OTHER ISSUES

Prevention

There is no clinical evidence that currently available protective equipment will prevent concussion. In certain sports, protective equipment may prevent other forms of head injury which may be an important issue for those sports.

Consideration of rule changes (ie, 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.

An important consideration in the use of protective equipment is the concept of risk compensation.[63] This is where the use of protective equipment results in behavioral change such as the adoption of more dangerous playing techniques, which can result in a paradoxical increase in injury rates. This may be a particular concern in child and adolescent athletes where head injury rates are often higher than in adult athletes.[64]

Medical Legal Considerations

While agreement exists pertaining to principal messages conveyed within this document, the authors acknowledge that the science of concussion is at early stages and therefore management and return to play decisions remain largely in the realm of clinical judgment on an individualized basis.

Education

As the ability to treat or reduce the effects of concussive injury after the event is minimal, education of athletes, colleagues and 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 web-based resources, educational videos and international outreach programs such as Think First (www.thinkfirst.ca) are important in delivering the message. In addition, concussion working groups plus 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.

Research Methods

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

Such research is essential 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, both by academics and by sporting organizations.

Future

The issue of sports concussion management is continually evolving and the usefulness of expert consensus in establishing a standard of care has been demonstrated by the Vienna agreement. The consensus group established at that meeting has provided ongoing leadership in this field based on the initial mandate established at that time.[1] We expect that this Prague agreement will be revised and updated at future meetings.

APPENDIX

Sport Concussion Assessment Tool (SCAT)

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