The Road to Recovery: The Impact of the Barrow Concussion and Brain Injury Center

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History
Traumatic Brain Injury

Physical

Behavioral

Cognitive
Barrow Concussion and Brain Injury Center

Mission

To improve outcomes of those who suffer from neurological injury through;

- comprehensive, patient centered care
- collaboration
- research
Barrow Concussion and Brain Injury Center

Neurology
Neuropsych
Psychiatry
Prevention
Neurorehab
BIAAZ
Student Athlete Centered Care

- Mom
- Dad
- Athletic Trainer
- PCP
- Teacher
- School Nurse
Why a multidisciplinary model?

Inherited heart disease can be well managed by preventive strategies if detected early. Building on an expanding body of literature on the contribution of hereditary heart disease to sudden cardiac death (SCD)\(^1\)\(^-\)\(^3\) and the well-validated principles of predictive gene testing in other single-gene disorders, the Cardiac Genetics Clinic (CGC) was formally established at the Royal Melbourne Hospital in 2007. Published data have supported the benefit of clinical screening in such clinics.\(^4\) However, detection of a causative mutation, where possible, also allows identification of individuals who are currently clinically unaffected.

The CGC embodies a multidisciplinary model for translating research into international best-practice care.\(^5\) This model exemplifies the translation of genetics to genomics in practice, and also aims to educate and inform individuals, allowing them to assume responsibility for their own ongoing care and health.

The CGC is a joint undertaking by the clinical genetics and cardiology units at the Royal Melbourne Hospital. It is managed by a cardiologist trained in qualitative analysis.

**Abstract**

**Objectives:** To describe patient characteristics, standard operating procedure, and uptake of genetic testing at the multidisciplinary Cardiac Genetics Clinic (CGC) at the Royal Melbourne Hospital during its first 6 years.

**Design:** Database exploration of referral diagnoses, sex, number of clinic visits and incidence of genetic testing in a population of individuals attending the CGC.

**Setting:** Tertiary referral hospital (Royal Melbourne Hospital) providing cardiac genetics services to the state of Victoria.

**Participants:** All individuals initially attending the clinic between July 2007 and July 2013, either as the proband or as an at-risk family member.

**Main outcome measures:** Classification of patients into diagnostic categories, number of probands and at-risk relatives assessed, incidence and outcomes of genetic testing.

**Results:** 1170 individuals were seen for the first time over the 6-year period; 57.5% made only one visit. The median age was 39 years. Most were encompassed within four broad diagnostic categories: cardiomyopathy (315 patients), aortopathy (303 patients), arrhythmia disorders (203 patients) and resuscitated cardiac arrest and/or family history of sudden cardiac death (341 patients); eight patients had “other” diagnoses. Genetic testing (mutation detection or predictive testing) was undertaken in 381 individuals (32.6%), and a pathogenic mutation was identified in 47.6% of tests, representing 15.3% of the total population.

**Conclusion:** The CGC fulfills an important role in assisting clinicians and patients by reviewing genetic cardiac diagnoses. Clinical practice during the study period moved from a selected candidate gene approach to broader gene panel-based testing. This move to next-generation sequencing may increase the detection of mutations and variants of unknown significance. A major contribution by the clinic to the care of these individuals and their families is the provision (or negating) of a diagnosis, and of a plan for managing risks of predictable cardiac disease.
Why a multidisciplinary model?


Establishment of a multidisciplinary concussion program: impact of standardization on patient care and resource utilization.


Abstract

OBJECT: Recent legislation and media coverage have heightened awareness of concussion in youth sports. Previous work by the authors' group defined significant variation of care in management of children with concussion. To address this variation, a multidisciplinary concussion program was established based on a uniform management protocol, with emphasis on community outreach via traditional media sources and the Internet. This retrospective study evaluates the impact of standardization of concussion care and resource utilization before and after standardization in a large regional pediatric hospital center.

METHODS: This retrospective study included all patients younger than 18 years of age evaluated for sports-related concussion between January 1, 2007, and December 31, 2011. Emergency department, sports medicine, and neurosurgery records were reviewed. Data collected included demographics, injury details, clinical course, Sports Concussion Assessment Tool-2 (SCAT2) scores, imaging, discharge instructions, and referral for specialty care. The cohort was analyzed comparing patients evaluated before and after standardization of care.

RESULTS: Five hundred eighty-nine patients were identified, including 270 before standardization (2007-2011) and 319 after standardization (2011-2012). Statistically significant differences (p < 0.0001) were observed between the 2 groups for multiple variables: there were more girls, more first-time concussions, fewer initial presentations to the emergency department, more consistent administration of the SCAT2, and more consistent supervision of return to play and return to think after adoption of the protocol.

CONCLUSIONS: A combination of increased public awareness and legislation has led to a 5-fold increase in the number of youth athletes presenting for concussion evaluation at the authors’ center. Establishment of a multidisciplinary clinic with a standardized protocol led to a significantly decreased variation in management and an improved resource utilization.
Clinic algorithm

When did TBI/concussion occur?

Less than 3 months

Has the patient been evaluated by a neurologist or concussion specialist?

yes

Greater than 3 months

no

Schedule acute injury clinic visit

See in Neuro clinic

See in Neuro clinic
Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016

Twenty-five (12%) athletes reported a recurrence of concussion symptoms while resuming physical activity after having been symptom-free at rest (Table 1). While the same. The critical message may be that rest is important.

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* Investigation performed at Boston Children’s Hospital, Division of Sports Medicine, Boston, Massachusetts, USA

** Days Post Injury

FIGURE 5
Mean PCSS with 95% confidence interval over time. Patients in the intervention group experienced higher total symptoms over the course of follow-up with the greatest difference in mean symptoms on day 4 (13.95 [C] vs 21.51 [I], P < .03).
Recovery: Metabolic needs after concussion

Recovery

Postural Stability Recovery

C. Ran.

BESS Total Score

Days

Assessment Point

Baseline CC 3HR 1 2 3 5 7 45/90

219–229
Concussion Consequences

- Physical
- Behavioral
- Cognitive
Concussion Consequences

- Physical
- Behavioral
- Cognitive
Post-Concussive Symptoms

Physical

Behavioral

Cognitive
Physical Symptoms

• Headache - most common physical symptom. Acutely most like that of migraine (photophobia, phonophobia, etc)

• Dizziness - Second most common physical symptom. Poorly characterized. Postural vs vertiginous.

• Vision change - Convergence abnormalities, tracking, vestibular-ocular.

• *Sleep - hypersomnia, insomnia, generalized fatigue
Behavioral Symptoms

- Irritability - most common behavioral symptom.
- Anxiety - tachycardia, panic attacks
- Depression - lack of motivation, late hypersomnria.
Cognitive Symptoms

• Inability to focus - most common cognitive symptom.

• Memory - short term, not long term. Poorly characterized. When tested, most commonly a reflections of inattention.

• Slow processing speed - Increased time to comprehend and respond.

• Word finding - Mentally searching for words.
Concussion Clinical Subtypes

• Post-injury presentation of concussion patients is not uniform.

• Cluster of symptoms/physical examinations findings may indicate a specific clinical phenotype

• Clinical subtypes of concussion may dictate:
  • - Clinical recovery trajectory
  • - Research Methods
  • - Treatment
Concussion Clinical Subtypes

• Clinical subtype examples:

  • Physiological: "Persistent symptoms and impairments caused by global impairment in cerebral metabolism."
  • Disorder of cellular metabolism, cerebral blood flow, autonomic function.
  • Clinical features: Headache exacerbated by physical or cognitive exertion.
  • Examination findings: non-focal
  • Treatment - initial rest followed by supervised exercise
Concussion Clinical Subtypes

- Vestibulo-ocular subtype
  - Characterized by "symptoms and impairments caused by dysfunction of the vestibulo-ocular system."
  - Disorder of the vestibular, oculomotor, and somatosensory systems
  - Clinical features: Dizziness, vertigo, blurred/double vision, tracking difficulty.
  - Examination findings: Impaired balance and gait, VOR, tracking.
  - Treatment: Vestibular rehab, vision therapy, academic accommodations, light exercise.
## Concussion Clinical Subtypes

<table>
<thead>
<tr>
<th></th>
<th>Physiologic PCD</th>
<th>Vestibulo-ocular PCD</th>
<th>Cerviogenic PCD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pathophysiology</strong></td>
<td>Persistent alterations in neuronal depolarization, cell membrane permeability, mitochondrial function, cellular metabolism, and cerebral blood flow</td>
<td>Dysfunction of the vestibular and oculomotor symptoms</td>
<td>Muscle trauma and inflammation</td>
</tr>
<tr>
<td><strong>Predominant symptoms</strong></td>
<td>Headache exacerbated by physical and cognitive activity</td>
<td>Dizziness, vertigo, nausea, light-headedness and gait instability and postural instability at rest.</td>
<td>Neck pain, stiffness, and decreased range of motion</td>
</tr>
<tr>
<td></td>
<td>Nausea, intermittent vomiting, photophobia, phonophobia, dizziness, fatigue, difficulty concentrating, slowed speech</td>
<td>Blurred or double vision, difficulty tracking objects, motion sensitivity, photophobia, eye strain or brow-ache, and headache exacerbated by activities that worsen vestibulo-ocular symptoms (i.e. reading)</td>
<td>Occipital headaches exacerbated by head movements and not physical or cognitive activity</td>
</tr>
<tr>
<td><strong>Physical exam findings</strong></td>
<td>No focal neurological findings</td>
<td>Impairments on standardized balance and gait testing</td>
<td>Decreased cervical lordosis and range of motion</td>
</tr>
<tr>
<td></td>
<td>Elevated resting HR</td>
<td>Impaired VOR, fixation, convergence, horizontal and vertical saccades</td>
<td>Paraspinal and sub-occipital muscle tenderness</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Impaired head-neck position sense</td>
</tr>
<tr>
<td><strong>Graded treadmill test</strong></td>
<td>Graded treadmill tests are often terminated early due to symptom onset or exacerbation</td>
<td>Patients typically reach maximal exertion without exacerbation of vestibulo-ocular symptoms on graded treadmill tests</td>
<td>Patients typically reach maximal exertion without exacerbation of cerviogenic symptoms on graded treadmill tests</td>
</tr>
<tr>
<td><strong>Management options</strong></td>
<td>Physical and cognitive rest</td>
<td>Vestibular rehabilitation program</td>
<td>Cervical spine manual therapy</td>
</tr>
<tr>
<td></td>
<td>School accommodations</td>
<td>Vision therapy program</td>
<td>Head-neck proprioception re-training</td>
</tr>
<tr>
<td></td>
<td>Sub-symptom threshold aerobic exercise programs should be considered for adolescent and adult athletes</td>
<td>School accommodations</td>
<td>Balance and gaze stabilization exercises</td>
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PCD, post-concussion disorder; VOR, vestibulo-ocular reflex.
Concussion Clinical Trajectories

Risk Factors:
- Previous Concussions
- Migraine
- LD/ADHD
- Sex
- Age
- Motion sensitivity, Ocular Hx?

Concussion
- Vestibular
- Ocular-motor
- Anxiety/Mood
- Cervical
- Cognitive
- Post-Traumatic Migraine

Treatment and Rehab Pathways
Concussion Clinical Subtypes

• Cognitive/ fatigue subtype

• Characterized by fatigue, nonspecific headache, sleep disturbance exacerbated by cognitive or physical exertion.

• Physical examination is non-specific

• Cognitive testing demonstrates global impairment

• Treatment: initial rest with sleep hygiene, followed by gradual activity. Stimulants at times.
Concussion Clinical Subtypes

- Vestibular subtype
  - Characterized by dizziness, nausea, overstimulation
  - Examination - symptomatic with head movements, VOR suppression. Imbalance present in some.
  - Treatment: Vestibular therapy.
Concussion Clinical Subtypes

• Ocular motor subtype

• Characterized by trouble with visual focus, frontal headaches, blurry vision, pressure behind the eyes. Symptoms exacerbated by computer screens.

• Examination findings: impaired convergence/ accommodation. Neurocognitive testing may reveal deficits in visual memory and reaction time.

• Treatment: Vision therapy
Concussion Clinical Subtypes

• Anxiety/mood subtype

• Characterized by anxiety, ruminating thoughts, hypervigilance, feeling overwhelmed, sleep disturbance.

• Examination: Vestibular/ocular screening may be provoking.

• Treatment: Exercise regimen, structured sleep/academics. Psychotherapy, pharmacology.
Concussion Clinical Subtypes

• Post-traumatic migraine subtype

• Characterized by headache with photophobia, phonophobia, nausea - exacerbated by stress, cognitive effort.

• Examination - vestibulo-ocular screening may be provoking.

• Neurocognitive screening may demonstrate visual or verbal memory deficits.

• Treatment: pharmacology - tricyclics antidepressants, anticonvulsants, calcium channel blockers.
Concussion Clinical Subtypes

• Cervical subtype

• Characterized by neck pain and headaches.

• Examination demonstrates decreased range of motion and tenderness.

• Treatment: physical therapy, pharmacology - analgesics, anti-inflammatories, muscle relaxants.
Critical Evaluation of Clinical Pathways

• Both groups demonstrate institutional bias.

• Both acknowledge vestibular and/or ocular subtype

• Both include cervicogenic subtype

• Physiologic subtype equivalent of migrainous subtype?

• One group includes mood subtype

• Neither group illustrates pathway for further evaluation and/or testing.

• Neither group demonstrates breakdown of subtypes in clinical setting.

• Both highlight need for validation of clinical subtype FOLLOWED by validation of clinical pathway.
Subacute Management

- Red Flags
- Imaging - CTH

- Rest, Rest, Rest
  - Physical rest
  - Cognitive rest

- Anticipatory Guidance
  - Fewer emergency room readmissions
  - Students have better outcomes if teachers are aware of student's concussion

- Restraint!
Recovery

• Prolonged Recovery
• Questions:
  • Was the injury worse than a concussion?
  • Is there a physical or medical condition prolonging recovery?
  • Is there an emotional condition prolonging recovery?
  • Did the concussion exacerbate an underlying condition?
  • Migraine
  • Anxiety
  • Depression
  • ADHD
  • Learning disability
Chronic Management

- Imaging
  - MRI
    - Non-contrast, GRE
Post-traumatic headache

- Concussion
  - 90% have headache
  - Patients with mild TBI were more likely to have headache than patients with moderate or severe TBI.

- Duration
  - Days to weeks

- Problems
  - Prolonged PCS
    - Sleep
    - Mood
    - concentration
  - Missed work/ school
Post-traumatic Headache

• Acute phenotype is most like migraine
• Chronic phenotype is most like tension-type headaches
• Risk Factors:
  • female gender
  • history of migraine
  • family history of migraine
  • premorbid psychiatric disease
• May present in isolation or part of PCS
Headache Treatment

- Headache comorbidities
- Analgesic overuse (rebound)
- Headache hygiene - caffeine, sleep, skipping meals
- Insomnia
- Imbalance
- Cognitive deficits

Interventions

- Tricyclic anti-depressants
- Topiramate
### Cognitive Management
- Cognitive Therapy
  - Performed by speech therapists
  - Duration varies

### School Accommodations
- Simplify/shorten directions.
- Give both oral and written directions.
- Increase allocated time.
- Provide frequent review.
- Establish rules and review frequently.
- Adapt test items for differing response modes.

### Concussion Return to Activity

<table>
<thead>
<tr>
<th>Student's name:</th>
<th>Date of Birth:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of injury:</td>
<td>Today's date:</td>
</tr>
</tbody>
</table>

#### Returning to School
Concussion can affect cognition and school performance. Academic areas that can be affected include: attention, focus, memory, organization, verbal expression, comprehension, and behavior.

**Return to School** (check all that apply):
- Return to school. No academic adjustments needed.
- No return to school. Return on (date): __________
- Return to school with the following supports:
  - **Shortened day**. Duration: ______
  - **Shortened classes (breaks during class)**. Duration: ______
  - **Extra time to complete assignments and tests**.
  - **Decreased homework**. __%__
  - Recommend formal plan:
    - 504 plan
    - IEP

#### Returning to Sports
1. Student athletes should NEVER return to play on the same day of a concussion.
2. Student athletes should NEVER return to play unless symptoms have returned to baseline.

**Return to Sports** (check all that apply):
- Return to P.E. No adjustments needed.
- Do not return to P.E.
- Do not return to sports.
- Return to sports using gradual return to play protocol (over)

[ ] Christina Kwasnica, M.D.  [ ] Glynnis Ziemer, M.D.
[ ] Javier Cárdenas, M.D.
Postconcussive Syndrome

The current status of postconcussion syndrome
George P. Prigatano and Shawn D. Gale

- Emotional/behavioral
  - Irritable, frustrated
- Cognitive
  - Slowed thinking, distractibility, poor learning and memory

- Lasting up to 3 months
  - Most recover within weeks
  - Up to 15% can have long-lasting or permanent symptoms

- Neuropsychological testing is often indicated

- Accommodations in the classroom are needed for those whose symptoms persist
  - Children perform better overall when their teacher is aware that they have suffered a TBI
Rehab

Physical

Occupational

Speech
Rehab

Neuro-Rehabilitation Center
Take the next step in your recovery.
A pilot study of active rehabilitation for adolescents who are slow to recover from sport-related concussion

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The purpose of this study was to examine the effectiveness of an active rehabilitation intervention for adolescents who are slow-to-recover after a sport-related concussion. Ten adolescents (three girls and seven boys) seen at the Montreal Children’s Hospital Concussion Clinic participated in this case series. Adolescents who were symptomatic more than 4 weeks after the injury were provided with an active rehabilitation intervention (M = 7.9 weeks following injury; range = 3.7 to 26.2 weeks). The rehabilitation program includes gradual, closely monitored light aerobic exercise, general coordination exercises, mental imagery, as well as reassurance, normalization of recovery, and stress/anxiety reduction strategies. The program continued until complete symptom resolution and readiness to begin stepwise return to activities. The primary outcome of the study was evolution of post-concussion symptoms. Secondary outcomes included mood, energy, balance, and cognition. After the intervention, post-concussion symptoms significantly decreased for the group of participants. They also had decreased fatigue and improved mood after 6 weeks of initiating the rehabilitation intervention. This case series shows that postconcussive symptoms and functioning in adolescents following sports-related concussion can be improved after participation in an active rehabilitation intervention. The introduction of graded light intensity exercise in the post-acute period following concussion is safe, feasible and appears to have a positive impact on adolescents’ functioning.
Take Home Messages

- Multidisciplinary models of care are effective
- Treatment should be patient centered and individualized
- Patients should participate in their own recovery