Interesting Concussion Case Studies

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Indianapolis, IN
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Case 1 – HS soccer player

- 16 year-old female HS soccer player
- No concussion history
- 5 minutes into Friday afternoon game - sustained a blow to the head from an opposing player’s head while attempting to head a ball
- Athlete down evaluation conducted by ATC
Case 1 – HS soccer player

- No pre-season baseline testing conducted
- TOI:
  - No amnesia or LOC observed
  - Headache reported immediately
  - Dizziness observed
- Athlete removed from game
Case 1 – HS soccer player

• Sideline evaluation (3-5 minutes later)
  – Complaining headache (more significant than on field)
  – Dizziness resolves
  – Complaining of neck pain and some nausea

• What would YOU do?
Case 1 – HS soccer player

- ATC decides to hold player out to monitor S/S; discusses with coach.

- ~15 minutes later athlete reports “feeling better”

- Athlete wants to go back into game

- What have I not told you about this athlete and this game?

- ? What would YOU do?
Case 1 – HS soccer player

• Good News!
  – It’s almost halftime (2:30 left in half)

• ? What would YOU do?

• ATC conducts Romberg test and brief cognitive tasks (serial 7’s, 3 word recall), and athlete appears to be fine.

• Exertional testing (jogging, sit-ups, pushups) just before halftime does not increase S/S
Case 1 – HS soccer player

• ATC monitors athlete during halftime & athlete reports no increase in S/S

• ? What would YOU do?

• ATC clears athlete to play in second half; finishes game without complications

• ? What would YOU do?
Case 1 – HS soccer player

- ATC talks with parents after game and tells parents that the athlete had a “bell ringer,” and that they should be fine, but “keep an eye on her tonight and tomorrow.”
- ATC never gives instructions regarding what to look for or what to do if S/S deteriorate.
- Parents ask if they can give meds for headache.
- ? *What would You say?*
Case 1 – HS soccer player

- ATC recommends “no meds”
- Athlete goes home and goes to bed, only to wake up Saturday morning with severe headache, dizziness (balance deficits), photophobia, and nausea.
- Parents call ATC at home.
- **What would YOU do?**
Case 1 – HS soccer player

• ATC contacts team physician, and asks if he can evaluate athlete at his office.

• Physician is not convinced that she has anything more than a concussion, and sends her home to rest.

• What would YOU do?

• ATC/Physician develop a plan to monitor athlete closely for the next several days.
Case 1 – HS soccer player

- Athlete and athlete do not make contact on Sunday.
- Athlete does not go to school Monday because “symptoms had not changed”:
  - Still experiencing headaches, dizziness, photophobia, and some mild nausea
- ATC finally contacts parents, and arranges appointment with physician.
- Physician orders CT scan which shows no signs of a focal injury.
Case 1 – HS soccer player

- Physician tells athlete that she has had a “significant concussion,” and that she “should not practice for a few days….and to see the ATC each day.”

- What would YOU do?

- Athlete’s symptoms gradually resolve over the next 4 days (asymptomatic on day 7 post-injury)

- What would YOU do?
Case 1 – HS soccer player

• ATC conducted exertional testing on the first day that she was asymptomatic (had been asymptomatic for ~18 hrs), and returned her to practice that day after she reported no S/S.

• As far as we know, she did not have a repeat concussion that season.

• ?What could the ATC and physician done differently?
Case 1 – HS soccer player

*What could be improved?*

- Baseline testing (Symptom checklist, NP, PS)
- Why not conduct brief mental status exam earlier? (SAC)
- Age of athlete (16yrs old)...many people would DQ for day.
- “Bell ringer”… “keep an eye on athlete”
- No mention of follow-up on Saturday
Head Injury Instructions

______________ has sustained a concussion. To make sure he/she recovers, these recommendations are made:

Please remind______________ to report to the training room tomorrow at ____________ for a follow-up evaluation. If any problems develop sooner, please call ________________.

**It is OK to:**
- Use Tylenol for headaches
- Use ice pack on head & neck
- Light diet
- No alcohol

**It is OK to:**
- Return to school
- Go to sleep
- Rest (no strenuous activity or sports)
- No heavy, spicy foods or drink

**There is NO need to:**
- Check eyes with flashlight
- Wake up every hour
- Test reflexes
- Stay in bed
- Use adult strength meds.
Case 1 – HS soccer player

*What could be improved?*

- Physician could have asked for more follow-ups; possibly ordered CT earlier??
- ATC could have waited additional day after exertional testing to clear for participation.
- ATC could have involved physician and parents in RTP decision.
- Overall – should have utilized concussion assessment tools!
Case 2 – Collegiate Football Player
Accelerometry Instrumentation

- Head Impact Telemetry System (HITS)
- Sensors embedded in the padding of helmet
- Measures and records blows to the head:
  - Impact location
  - Impact magnitude
  - Impact duration
  - Linear and angular acceleration components
  - Exact times of impacts
HIT System™
Impact Algorithm

- Determines *magnitude* and *direction* of head c.g. acceleration ($H$) from 6 single axis accelerometers.
- Determines 2 of 3 rotational accelerations depending on impact location (no z-axis rotation).

\[ \sum_{i=1}^{n} \left( \left\| \vec{H} \right\| \left( \cos \alpha_i \cos \alpha_H \cos (\theta_i - \theta_H) + \sin \alpha_i \sin \alpha_H \right) \right)^2 \]

Head Coordinate System
Azimuth = $\alpha$
Elevation = $\theta$
HIT System Hardware

The HIT System™
Accelerometry Instrumentation

HIT System™
Hardware in the Helmet

Telemetry, Data Acquisition, and Sensor Components

Player Units
HIT System™ Equipped
HIT System

- In-helmet units (6 single axis accelerometers, battery, and radio) communicate with a signal receiver and laptop computer system on the sideline (coverage: approx 150 yard radius).
- Positioned around the 50 yard line for games; centrally located between fields for practices.
- **128 on-board memory** – can store up to 128 impacts during one session.
- Battery life – approx. 3-5 days.
Current Player: 53

Length = 125 g

Cumulative Impact

Length = 125 g

Acceleration (g)

Time (s)

Impacts

Riddell SR
Case Study:
UNC Football Player

- 20-year-old Division I football defensive end
- Concussion #1: August 14, 2004
- Concussion #2: October 16, 2004
Concussion #1: August 14, 2004

Clinical Findings

- At the time of injury player reported experiencing 16 of 18 concussion symptoms on the Graded Symptom Checklist (GSC).

- SAC and BESS performed on the sideline revealed moderate deficits. Follow-up computerized neuropsychological (NP) and postural stability (PS) testing revealed moderate deficits through postinjury day 3.
## Post Concussion Symptom Checklist

<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>NONE</th>
<th>MILD</th>
<th>MODERATE</th>
<th>SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Headache</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nausea/ Vomiting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dizziness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Light</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blurred Vision</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Noise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nervousness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbness/ Tingling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeling Slowed Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeling Like “In a Fog”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty Concentrating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty Remembering</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck Pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue/ Drowsiness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty sleeping</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sadness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irritability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Balance Error Scoring System (BESS)

Clinical Test Battery
- Six 20 sec trials using 3 different stances (double, single, tandem) on 2 different surfaces (firm, foam)

Recorded errors
- Hands lifted off iliac crests
- Opening eyes
- Step, stumble, or fall
- Moving into >30 deg. of hip flexion or abduction
- Remaining out of testing position for >5 secs.
Balance Error Scoring System (BESS)
94 Injured & 56 Control NCAA FB players

Repeated measures ANOVA:
Group x Day interaction; F (7,142) = 7.52; p < .0001
(significant differences through day 1 postinjury)

McCrea et al (JAMA 2003)
**SAC**

Standardized Assessment of Concussion

**FORM A**

Name: ____________________________
Age: _______ Sex: _______ Examiner: ____________________________
Nature of Injury: ____________________________
Date of Exam: ____________________________ Time: ____________________________ Exam No. ____________________________

1) **ORIENTATION:**

<table>
<thead>
<tr>
<th>Month</th>
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</thead>
<tbody>
<tr>
<td>Date</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Day of week</td>
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<td>1</td>
</tr>
<tr>
<td>Year</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Time (within 1 hr):</td>
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<td>1</td>
</tr>
</tbody>
</table>

Orientation Total Score: ______ / 5

2) **IMMEDIATE MEMORY:** (all 3 trials are completed regardless of score on trial 1 & 2; score equals sum across all 3 trials)

<table>
<thead>
<tr>
<th>List</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Apple</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Carpet</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Saddle</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bubble</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

Immediate Memory Total Score: ______ / 15

Note: Do not inform the subject that delayed recall will be tested.

**NEUROLOGICAL SCREENING:**

- Loss of Consciousness (presence, duration)
- Recollection of Injury (pre- or post-traumatic amnesia)
- Strength:
- Sensation:
- Coordination:

3) **CONCENTRATION:**

Dedits Backward: (If correct, go to next string length. If incorrect, read trial 2. Stop after incorrect on both trials)

- 4-9-3
- 3-8-1-4
- 6-2-9-7-1
- 7-1-8-4-6-2

Monte in Reverse Order: (Order reverse sequence correct for 8 pt.)

Dec-Nov-Oct-Sep-Aug-Jul
Jun-May-Apr-Mar-Feb-Jan

Concentration Total Score: ______ / 5

**EXERTIONAL MANEUVERS**

- 5 jumping jacks
- 5 push-ups
- 5 sit-ups
- 5 knee-bends

4) **DELAYED RECALL:**

<table>
<thead>
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<tr>
<td>Saddle</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bubble</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Delayed Recall Total Score: ______ / 5

**SUMMARY OF TOTAL SCORES:**

- Orientation ______ / 5
- Immediate Memory ______ / 15
- Concentration ______ / 5
- Delayed Recall ______ / 5

Overall Total Score: ______ / 30

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Cognitive Recovery: Standardized Assessment of Concussion (SAC)

Concussion #1: August 14, 2004

Clinical Findings

- An MRI conducted on postinjury day 2 revealed no abnormalities, so the player was instructed to rest and attend team meetings as tolerated until symptoms resolved.

- Symptoms resolved over the course of 5 days, and he was returned to restricted participation, followed by full participation at postinjury days 6 and 7 respectively.
Impact Data: Concussion #1

- First impact
  - 9:55 a.m.
  - 79.18 g acceleration
Impact Data: Concussion #1

- Second impact
  - 10:06 a.m.
  - 97.97 g acceleration
Impact Data: Concussion #1

- Third impact
  - 7:30 p.m.
  - 64.51 g acceleration
Impact Data: Concussion #1

*Fourth impact*
  - 7:33 p.m.
  - 63.95 g acceleration
Impact Data: Concussion #1

- All 4 significant impacts
  - 2 in morning session (79.18 & 97.97 g)
  - 2 in evening session (64.51 & 63.95 g)
Impact Data: Concussion #1

- 31 total impacts for both sessions
- Between 2.87 g to 97.97 g (mean = 28.95 g)
Cumulative Effects: Concussion #1
Concussion #2: October 16, 2004

Clinical Findings

• Reported 13 of 18 concussion symptoms at the time of injury. Symptoms lingered for 10 days, with drowsiness, fatigue, and dizziness being the most persistent symptoms.

• Sideline SAC and BESS scores were again moderately depressed, however, serial assessments of NP and PS tests were significantly depressed during the initial 4 days postinjury.
Concussion #2: October 16, 2004

Clinical Findings

• An MRI was not conducted as part of the treatment, however, the player was evaluated by the team physician daily to insure detection of any neurological deterioration.

• Player withheld for 15 days before being permitted to return to full participation.
Relationship Between Concussion Symptoms and Postural Stability

- Case Study con’t

![Graph showing the relationship between concussion symptoms (GSC) and postural stability (SOT) over different post-injury days.](image)
Impact Data: Concussion #2

- Impact in warm-up
  - 9:35 p.m.
  - 76.13 g acceleration
Impact Data: Concussion #2

- Impact in game
  - 10:08 p.m.
  - 102.39 g acceleration
Impact Data: Concussion #2

- 6 total impacts
- Between 13.10 g to 102.39 g (mean = 40.78 g)
Cumulative Effects: Concussion #2

Linear Acceleration, HIC, and GSI

Magnitude

Time


ImpMag(g)  HIC  GSI
Conclusions

*Raises several intriguing questions with respect to sport-related concussion:*

1) was there a cumulative effect on the initial injury day, since there were two significant impacts during the morning practice?

2) could the threshold for injury be lowered because of these repetitive loads to the brain? “*Acute cumulative effect of sub-concussive impacts*”

3) was the delayed symptom recovery and depressed NP and PS scores following the repeat concussion a result of a more chronic cumulative effect, or simply a result of the increased magnitude (102 g)?